THE GEOGRAPHIC SOCIETY OF CHICAGO
BULLETIN NO. 2

THE PLANT SOCIETIES OF CHICAGO AND VICINITY

BY

HENRY C. COWLES

Associate Professor of Plant Ecology, the University of Chicago

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BY
THE UNIVERSITY OF CHICAGO PRESS
CHICAGO, ILLINOIS

AGENTS
THE BAKER & TAYLOR COMPANY, New York
THE CAMBRIDGE UNIVERSITY PRESS, London and Edinburgh

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PREFACE

This bulletin is designed to accompany the first bulletin of the Chicago Geographic Society by Prof. Rollin D. Salisbury and Mr. William C. Alden, and in many places it is assumed that the geographic features of the Chicago area, as there outlined, are known to the reader. The matter here presented has been gathered by the author in the course of the past five years, and has recently been published in the BOTANICAL GAZETTE, essentially as presented here.

The author desires to express his indebtedness to Mr. W. B. McCallum, who has taken most of the photographs with which this paper is illustrated. These illustrations, by common agreement, have also appeared in the BOTANICAL GAZETTE. *Figs. 7* and *13* were contributed by Prof. J. J. Allison of Joliet. *Figs. 34*, *35* and *36* have been previously published by the author. The map shown in *fig. 39* appeared in the first bulletin of the Chicago Geographic Society.

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INTRODUCTION.

In recent years a great impulse has been given to the study of plants in their environment by the works of Warming, Schimper, and other European botanists. The subject that deals with this part of the botanical field is now called plant ecology—the science of plant house-keeping, or, as some would say, plant sociology. One phase of ecology deals with the meaning of plant structures, such as leaves, roots, flowers; the variation of these organs is investigated in relation to the influence of external agents, and attempts are made to work out the causes which determine plant forms. This phase of the subject is presented in Kerner and Oliver's Natural History of Plants and in Dr. Coulter's Plant Relations.

A second phase of ecology, and the one that concerns us here, has to do with plants not as individuals, but as grouped in societies. Very superficial observation shows that certain plants grow in swamps, others in forests, and still others on sand dunes. Warming, in his Ecological Plant Geography, published at Copenhagen in 1895, gave the results of a long series of investigations as to the causes determining these diversities in the distribution of plants. He divided the plants of the world into four great groups: hydrophytes, or plants which grow in water or wet places; xerophytes, or plants which grow in dry habitats; mesophytes, or plants which grow in places of medium moisture, such as ordinary forests and meadows; and halophytes, or plants which grow in salt-water or alkaline soil. It will be seen that all of these groups except the last are related to water, which is commonly regarded as the most important factor in determining local differences in plant societies. Most botanists have accepted Warming's classification of plant societies as a more or less complete organization of this part of the ecological field.

The present paper attempts to relate the plant societies not only to water, but also to soil, and more especially to the physiography. The geographic and physiographic features of the Chicago region have been admirably presented in papers by Leverett,[1]

[1] LEVERETT, F.: The Pleistocene features and deposits of the Chicago area. Chicago. 1897.

and Blatchley,[1] and more recently in a bulletin of the Chicago Geographic Society by Salisbury and Alden.[2] As the map shown in *Fig. 39* indicates, the topographic and soil areas in the vicinity of Chicago are of three types: morainic deposits, chiefly bowlder clay; the Chicago plain, representing the area covered by the glacial Lake Chicago; and beach or dune sands, connected with the present or former beach lines. Speaking generally, the Chicago district has three great vegetation types connected with these three soil and topographic types: the mesophytic upland forests of the morainic clays, the hydrophytic lakes and swamps or mesophytic prairies of the Chicago plain, and the xerophytic forests of the dunes and beaches.

A close analysis shows that the types of plant societies are numerous in each of the three general areas named above. In the morainic areas there are several forest types, as will be shown in the body of the paper, and it is here that the various phases of stream activity with their characteristic plant societies are best seen. The types of vegetation on the plain are fewer, including in the main only the various transitions between ponds, swamps, and prairies. The ancient beach lines present some, but not much variety, but the dune area of the present beach line presents a rich diversity of plant societies.

The keynote of this paper is that each particular topographic form has its own peculiar vegetation. This is due to the fact that the soil conditions upon which plants depend are determined by the surface geology and the topography From the standpoint of the vegetation the topographic relations are more important than the geological. As will be shown later, all kinds of soils may have the same vegetation when placed in similar topographic conditions, whereas the same soil may show many diverse types of vegetation. The topographic conditions determine the exposure, the presence or absence of drainage, and the humus content of the soil, and are thus of overshadowing importance.

Having related the vegetation largely to topography, we must recognize that topography changes, not in a haphazard manner, but according to well-defined laws. The processes of erosion ultimately

[1] BLATCHLEY, W. S.: The geology of Lake and Porter counties, Indiana. Reprint from the Twenty-second Annual Report of the Department of Geology and Natural Resources of Indiana. Indianapolis. 1897.

[2] SALISBURY, R. D., and ALDEN, W. C.: The geography of Chicago and its environs. Chicago. 1899.

cause the wearing down of the hills and the filling up of the hollows. These two processes, denudation and deposition, working in harmony produce planation; the inequalities are brought down to a base level. The chief agent in all these activities is water, and no fact is better established than the gradual eating back of the rivers into the land and the wearing away of coast lines; the material thus gathered fills up lakes, forms the alluvium of flood plains, or is taken to the sea. Vegetation plays a part in all these processes, the peat deposits adding greatly to the rapidity with which lakes and swamps are filled, while the plant covering of the hills, on the contrary, greatly retards the erosive processes. Thus the hollows are filled more rapidly than the hills are worn away. As a consequence of all these changes, the slopes and soils must change; so, too, the plant societies, which are replaced in turn by others that are adapted to the new conditions.

There must be, then, an order of succession of plant societies, just as there is an order of succession of topographic forms in the changing landscape. As the years pass by, one plant society must necessarily be supplanted by another, though the one passes into the other by imperceptible gradations. One thing more must be recognized, and that is that environmental influences are normally cumulative. A plant society is not a product of present conditions alone, but the past is involved as well. For example, a hydrophytic plant society may be seen growing in a mesophytic soil; the author has seen a mesophytic tamarack swamp which can be explained only in this way. We have in this phenomenon a lagging of effects behind their cumulative causes, just as the climax of the heat in summer comes long after the solstice.

In a classification like this great emphasis is placed on border lines or zones of tension, for here, rather than at the center of the society, one can best interpret the changes that are taking place. Of course the order of succession referred to above is a vertical or historical one. One plant society is said to follow another if it is actually superimposed upon the one preceding. In many cases, if not in most, there is a horizontal order of succession at the present time that resembles the vertical succession of which we now have only the topmost member. Instances of similarity between vertical and horizontal orders of succession are well shown in peat swamps and along shores and flood plains. Along a sandy shore it is only by studying the horizontal succession that one can get any idea of the vertical, since all fossil traces of preceding plant societies have passed away. In peat swamps one can sometimes verify the results of a horizontal zonal study by investigating the fossil remains beneath.

We may now outline the main features of a physiographic classification of plant societies. Speaking in the large, the tendency of the erosive processes is to reduce the inequalities of the topography and produce a base level. This base level may not soon be reached, though geological history furnishes instances of extensive base leveling. Crustal movements interfere with the erosive agencies, and a mature base level topography may become rejuvenated by a great uplift of the land, or sinking, on the other hand, may check the rapid action of erosion. Yet even with the crustal movements there go these topographic changes, and with them the plant societies must change. Putting the facts of physiography in the terms of ecology, the conditions become more and more mesophytic as the centuries pass. In a young topography such as the recently glaciated areas of Michigan, Wisconsin, and Minnesota, there is a great variety of topographic conditions and of plant societies. Among these are many hydrophytic lakes and swamps and many xerophytic hills. The hills are being denuded and the swamps and lakes are being filled, so that the hydrophytic and xerophytic areas are becoming more and more restricted, while the mesophytic areas are becoming more and more enlarged. In passing from youth to old age, then, a region gradually loses its hydrophytic areas, and also its xerophytic areas, though in the latter case there is usually at first an increase in the xerophytic areas, which is due to the working back of the young streams into the hills. These latter conditions are well shown in Iowa; in the comparatively recent Wisconsin drift of northern central Iowa the topography is much less diversified and there are fewer xerophytic areas than in the older Iowan drift farther south, which has been greatly dissected by stream erosion. Later, however, the inequalities are removed and we find great mesophytic flood plain areas, such as are seen along the lower Mississippi.

From what has been stated it will be seen that the ultimate stage of a region is mesophytic. The various plant societies pass in a series of successive types from their original condition to the mesophytic forest, which may be regarded as the climax or culminating type. These stages may be slow or rapid; some habitats may be mesophytic from the start; undrained lakes and swamps fill up and become mesophytic with great rapidity, whereas granite hills might take many centuries, or even geological epochs, in being reduced to the mesophytic level. Again, the stages may be direct or tortuous; we have already seen how the first consequences of stream erosion may be to make mesophytic areas xerophytic. So, too, in flood plains, the meanderings of the river may cause retrogressions to the hydrophytic condition such as are seen in oxbow lakes, or the river may lower its bed and the mesophytic flood plain become a xerophytic terrace. But through all these changes and counterchanges the great mesophytic tendency is clearly seen; mesophytic areas may be lost here and there, but many more are gained, so that the approach to the mesophytic base level is unmistakable. Moreover, the retrogressive phases are relatively ephemeral, while the progressive phases often take long periods of time for their full development, especially in their later stages. The statements made in this paragraph have reference only to such regions as the one in which Chicago is located. In desert regions, and also in arctic or alpine districts, the ultimate stage cannot, of course, be mesophytic under the present climatic conditions.

THE PLANT SOCIETIES.

A. THE INLAND GROUP.

I. THE RIVER SERIES.

A. *The ravine.*—No topographic forms lend themselves so well to a physiographic sketch of the vegetation as do those that are connected with the life history of a river. Beginning with the ravines, which are deep and narrow, because of the dominance of vertical cutting, we pass to the broader valleys, where lateral cutting becomes more pronounced. From this stage on we have to deal with two phases of river action, the destructive, which is concerned with the life history of the bluff, and the constructive, which has to do with the development of the flood plain.

Wherever there is an elevated stretch of land adjoining a body of water, such as a lake bluff, one is apt to find excellent illustrations of the beginning of a ravine. *Fig. 1* shows an embryonic ravine of a type that may be seen frequently along the clay bluffs between Evanston and Waukegan. A ravine of this type is essentially a desert, so far as plant life is concerned. The exposure to wind and to alternations of temperature and moisture is excessive. The lack of vegetation, however, is due chiefly to the instability of the soil; this instability is particularly great in the case of clay bluffs such as these, where the seepage of water causes extensive landslide action. No plants can get a foothold in such a place, unless it be a few species that may be able to make their appearance between periods of landslide action; among these plants annuals particularly predominate. The perennials that may be found in such places are almost entirely plants which have slid down the bank. Near the center of *fig. 1* is a clump of shrubs that have slid down in this way. Ravines of a similar type may also be seen at many places inland, and wherever found the poverty of vegetation on the slopes is the most striking character.

As a ravine extends itself inland the conditions outlined above may be always seen about its head, but toward the mouth of the ravine the slopes are less precipitous. Torrents cut down the bed of the ravine until a depth is reached approaching the water level at its mouth.

From this time on the slopes become reduced and the ravine widens more than it deepens, by reason of lateral cutting, landslide action, and side gullies. After a time a sufficient stability is reached to permit a considerable growth of vegetation. If the erosion is slight enough to allow a vegetation carpet to develop, a high degree of

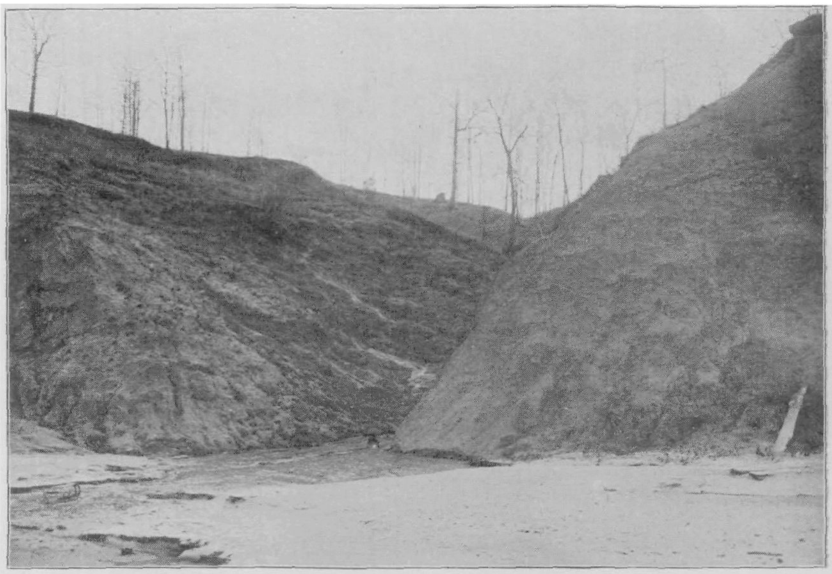

FIG. 1.—Embryonic ravine in the lake bluff at Glencoe. Entire absence of vegetation on the unstable clay slopes, with the exception of shrubs and grasses that have slid down from the top.

luxuriance may be attained. In fact, ravine conditions are usually extremely favorable for plants, after the initial stages have passed. In a comparatively few years the vegetation leaps, as it were, by bounds through the herbaceous and shrubby stages into a mesophytic forest, and that, too, a maple forest, the highest type found in our region. Nothing shows so well as this the brief period necessary for a vegetation cycle in a favored situation as compared with an erosion cycle.

Of such interest are the facts just noted that it is worth while to mention some of the characteristic ravine plants. Perhaps the most characteristic trees of the Glencoe ravines are the basswood (*Tilia Americana*) and the sugar maple (*Acer saccharinum*), though the ash, elm, and other trees are frequent. The most characteristic under-shrub is the witch hazel (*Hamamelis Virginiana*). The herbaceous plants are notoriously vernal forms, such as Hepatica, Thalictrum, Trillium, Mitella, Dicentra, Sanguinaria (Bloodroot); mosses abound and liverworts are frequent. A ravine with the above vegetation is shown in *fig. 2*. We can explain this flora only by regarding it as

FIG. 2.—Ravine at Glencoe with a mesophytic forest vegetation on the slopes (temporary climax). Presence of erosive forces indicated by leaning trees. Water commonly present in the stream bed.

having reached a temporary climax. Ravine conditions are more favorable for plants than those that precede or follow. The instability and exposure of the gully have gone; in their place there is protection from wind and exposure. The shade and topography favor the collection and conservation of moisture, and as a result there is a rapid development into a high-grade forest, as outlined above.

Rock ravines are much less common in the Chicago area than are those of clay, since the underlying limestone rarely comes near the surface. Excellent illustrations of stream gorges are to be seen at Lockport, and also in various tributaries of the Illinois river near Starved Rock. A striking difference between these rock gorges or cañons and the clay ravines is in the slope of the sides. The physical nature of the rock excludes landslide action, hence the sides are often nearly vertical for a long time. Lateral cutting is also relatively slow as compared with clay. Thus the conditions for vegetation at the outset are much more favorable than in a clay ravine. Rock-bound

FIG. 3.—Head of a cañon in the St. Peters sandstone at Starved Rock. Erosive forces prominent, and vegetation slight on the dripping slopes.

gorges are very shady and often dripping with moisture, hence liverworts and many mosses find here a habitat even more congenial than in the clay. Among the higher forms are found the most extreme shade plants that we have, such as Impatiens, Pilea, and shade-loving ferns, plants whose leaves are broad and remarkably thin. *Figs. 3* and *4* represent cañons of the above description, whose rocks drip with moisture.

The stages of development pass much more slowly in cañons than in clay ravines, largely because the primitive conditions of shade and moisture remain for a long period of time. Nor do the steep slopes permit the development of a wealth of trees and shrubs, since a secure foothold is not easily found. However, as the cañon broadens out and the slopes become less steep, shrubs and trees come in, though a typical mesophytic forest is rarely seen. The Starved Rock ravines are cut in St. Peters sandstone, those at Lockport in the Niagara lime-

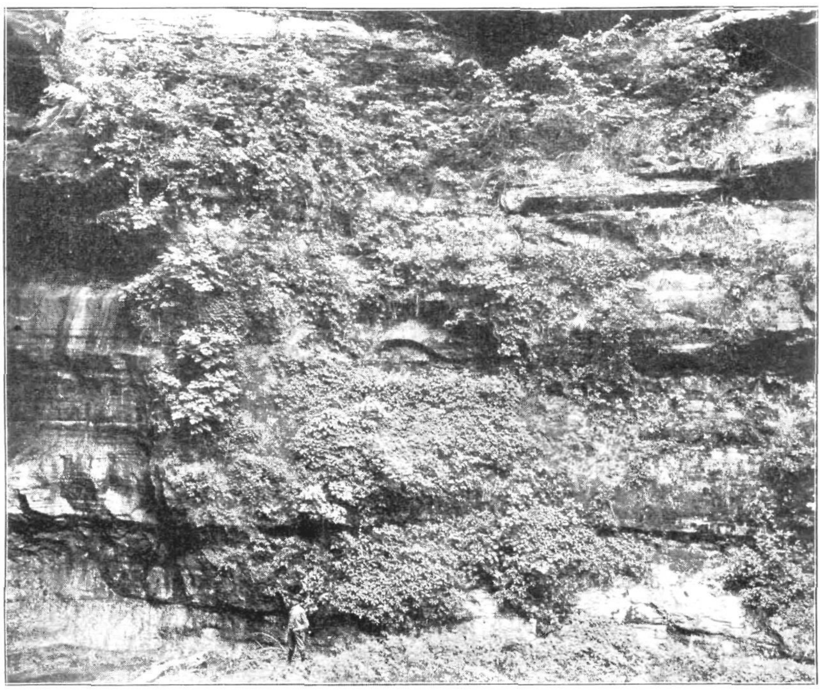

FIG. 4.—Side of a cañon in the St. Peters sandstone at Starved Rock. Herbaceous shade vegetation on the precipitous slopes.

stone, yet the vegetation in the two places is essentially alike; at any rate, the resemblances are greater than the differences. Much has been written on the physical and chemical influences of rocks upon the vegetation. The facts seen here seem to show that the physiographic stage of a region is more important than either. The flora of a youthful topography in limestone, so far as the author has observed, more closely resembles the flora of a similar stage in sandstone than a young limestone topography resembles an old limestone topography. A limestone ravine resembles a sandstone ravine far more than a limestone ravine resembles an exposed limestone bluff, or a sandstone ravine resembles an exposed sandstone bluff. We may make the above statements in another form. Rock as such, or even the soil which comes from it, is of less importance in determining vegetation than are the aerial conditions, especially exposure. And it is the stage in the topography which determines the exposure.

All of the preceding statements as to topographic stages, whether young or old, refer not to times but to constructional forms. Two ravines, equally youthful from the topographic standpoint, may differ widely as to actual age in years or centuries, since erosion is more rapid in one rock than in another. In our region, however, elements of actual time are not very important, except as between rock and clay, since the limestone is less soluble and the sandstone is more easily eroded than is often the case.

B. *The river bluff.*—As a valley deepens and widens, the conditions outlined above undergo radical changes. From this point it will be necessary to discuss two phases in the growing river, the bluff phase and the bottom phase. We have left the clay ravine bluffs in a state of temporary climax, clothed with luxuriant mesophytic forest trees and with a rich undergrowth of vernal herbs. More and more the erosive processes are conspicuous laterally, and widening processes prevail over the more primitive deepening. As a result, the exposure to wind, sunlight, and changes of temperature increases; the moisture content of the slopes becomes less and less. The rich mesophytic herbs, including the liverworts and mosses, dry up and die. The humus oxidizes more rapidly, and a xerophytic undergrowth comes in. In place of Hepatica and its associates, we find Antennaria, *Poa compressa* (Wire grass), *Equisetum hyemale* (Scouring rush), and other xerophytic herbs; Polytrichum also replaces the mesophytic mosses. The first signs of the new xerophytic flora are seen at the top of the ravine slope; indeed, the original xerophytic plants may never have been displaced here by the ravine mesophytes. As the ravine widens, the xerophytic plants creep down the slope, often almost to the water's edge. Some of the young ravines between Evanston and Waukegan show xerophytes at the summits of the slopes. *Fig. 5* shows a widening ravine at Beverly Hills; the vegetation is much less luxuriant than that shown in the young ravine of *fig. 2*.

After a few years have passed, xerophytic shrubs appear on the bluff in place of the witch hazel and its associates. And it is not long until xerophytic or semi-xerophytic thickets prevail, in place of the former mesophytic undershrubs. Among the more characteristic of these shrubs are the hop tree (*Ptelea trifoliata*), bittersweet (*Celastrus scandens*), sumachs (*Rhus typhina* and *R. glabra*), chokecherry

FIG. 5.—Open ravine at Beverly Hills, showing gentle slopes covered with a less mesophytic vegetation than is shown in *fig. 2*. Dominance of oaks in place of maples and basswoods.

(*Prunus Virginiana*), nine-bark (*Physocarpus opulifolius*), wild crab (*Pyrus coronaria*). Two small trees are common on stream bluffs, the service berry (*Amelanchier Canadensis*) and the hop hornbeam (*Ostrya Virginica*); this last species is perhaps the chief character tree of river bluffs, and is rarely absent. Perhaps the best examples of xerophytic stream bluffs near Chicago are along Thorn creek. One of the most interesting things about these bluff societies is the frequent presence of basswoods and sugar maples. Doubtless these trees look back to the mesophytic associations that have otherwise disappeared. As would be expected, the last of the mesophytes to die are trees, because they are longer-lived than herbs and shrubs, and also because their roots reach down to the moisture. But they cannot be succeeded by their own kind, inasmuch as the critical seedling stages cannot be passed successfully.

The life history of the rock ravines, or cañons, is somewhat different. When the ravine vegetation is at its height, the moisture and shade are greater here than in the clay, hence the high development of

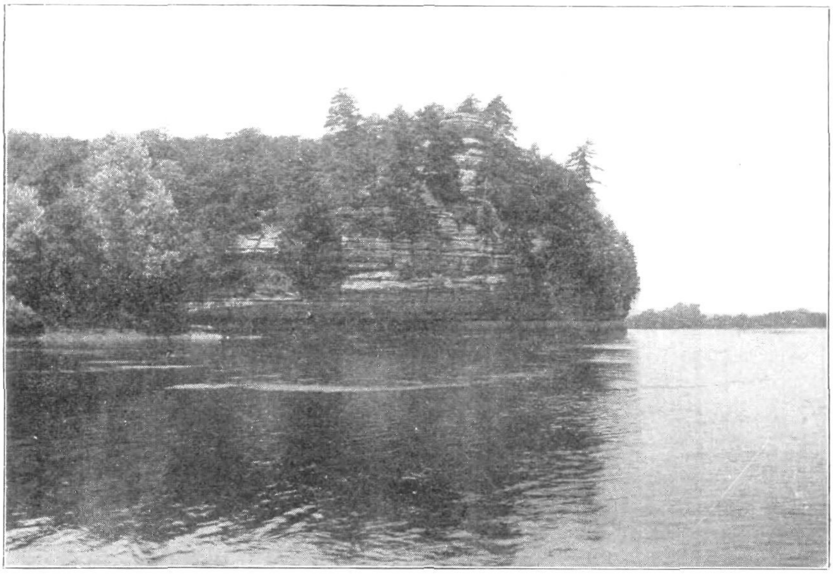

FIG. 6.—Xerophytic bluff of St. Peters sandstone at Starved Rock on the Illinois river, showing conifers and other plants of dry rocks. Influence of erosive forces seen at the base.

liverworts and their associates. As the ravine widens, these extreme shade forms are doubtless driven out almost immediately by xerophytes, since intermediate or mesophytic conditions are seldom seen where the soil is rock. Furthermore, the xerophytic conditions become much more extreme on rock bluffs than on clay bluffs. This is well illustrated at Starved Rock (see *fig. 6*), where the dominant tree vegetation is coniferous, consisting especially of the white pine (*Pinus Strobus*) and the arbor vitæ (*Thuya occidentalis*). The herbs and undershrubs here are also pronouncedly xerophilous, resembling the vegetation of the sand dunes, *e. g.*, *Selaginella rupestris*, *Campanula rotundifolia*, *Pellæa atropurpurea*, *Talinum teretifolium*, *Opuntia Rafi-*

nesquii, etc. The entire bluff flora down to the river's edge is xerophytic, except in shaded situations.

When a stream in its meanderings ceases to erode at the base of a bluff, increased opportunity is given for plant life. Through surface wash the slopes become more and more gentle. Mesophytic vegeta-

FIG. 7.—Ravine in the Niagara limestone at Lockport, showing the beginnings of a flood plain.

tion comes in at the foot of the bluff and creeps up as the slopes decrease. Finally the xerophytes are driven from their last stronghold, the top of the slope, and the mesophytes have come to stay, at least until the river returns and enters upon another stage of cliff erosion. The growth of a ravine into a valley with xerophytic bluffs is rapid, when expressed in terms of geology, but far less rapid when expressed in terms of vegetation. A ravine in the vigor of youth may develop so slowly that forest trees may grow to a considerable size without any perceptible change in the erectness of their trunks. Thus, in *figs. 2* and *5* it will be seen that most of the trees stand approximately vertical. But the activity of the erosive forces, slow as it may be, is nevertheless revealed by occasional leaning, or even falling, trees. From the above it is easy to understand that cycles of vegetation often pass much more rapidly than cycles of erosion, but never more slowly. During one erosion cycle the mesophytic forest develops at least twice —once on the ravine slopes, and then finally on the gentler slopes that betoken approach toward base level.

C. *The flood plain.*—We may now follow the successive stages in the development of the flood plain vegetation. While the ravine is still young, as in *fig. 2*, there is no permanent stream, but merely torrents, which remain but a short time. As the ravine deepens, widens, and lengthens, thus approaching the underground water level and increasing the drainage area, the water remains for a longer and longer time after each rainfall. As the ravine conditions thus become more and more hydrophytic, the original flora, perhaps of shade mesophytes (as Impatiens), becomes replaced by amphibious shade plants, such as the common buttercup (*Ranunculus septentrionalis*), *Plantago cordata*, various mosses, etc. Together with these forms algæ of short vegetative period may be found in the wet seasons. When the ravine at last is sufficiently developed to have a permanent stream, a definite hydrophytic flora appears, consisting largely of algæ (*e. g.*, Batrachospermum), aquatic mosses, and seed plants with finely dissected leaves and strong holdfast roots (such as Myriophyllum), though these latter plants are more characteristic of ponds. In the early phases of a stream the currents are rapid and the vegetation (apart from lower forms) is sparse, by reason of the difficulty which plants have in securing and retaining a foothold on the stream bed. This difficulty is due to the rapid erosion and consequent instability of the substratum, as well as to the direct destructive action of the currents. *Fig. 7* shows one of these young streams whose flora is sparse.

Springs and spring brooks may be classed with ravine streams, but differ from them in the relative absence of erosion phenomena. This type of stream is uncommon in the Chicago area, though there are a few spring brooks near Chesterton. The water supply is much more constant than in ravine streams, and the shade of the ravines is often lacking. Besides the aquatics, there may be mentioned a characteristic brookside flora, including such plants as *Symplocarpus fœtidus* (Skunk cabbage), *Asclepias incarnata* (Swamp milkweed), *Chelone glabra*, *Poly-*

gonum sagittatum, and two or more species each of Eupatorium, Lobelia, Mentha, Lycopus, and Bidens. The most characteristic spring brook shrub is the alder (*Alnus incana*), though the extensive northern development of alder thickets has no parallel here.

As the energy of the developing stream is checked, the conditions

FIG. 8.—General view of the Illinois valley near Starved Rock, showing islands and an extensive flood plain with trees along the margin. Young islands in the foreground, older islands in the background.

for plant life become more favorable. In the quiet pond-like waters of an older stream there may be found many of the aquatics that frequent the ponds and lakes. In fact, the flora that is given later as characteristic of half-drained ponds and lakes (such as Calumet lake) may be transferred almost bodily to sluggish streams, such as the Calumet and Desplaines rivers.

When streams are old enough, and therefore slow enough, to support a pond vegetation, they have become essentially depositing rather than eroding streams, and we find there the development of a flood plain. While the river is still confined within narrow walls, and may thus be called young, there may be embryonic patches of flood plain, representing alternations of erosion and deposition in the stream. *Fig.* 7 shows such a condition of affairs; though the stream is young and more destructive than constructive at that point, there are to be seen small flood plain areas with their typical tree inhabitants.

There is no place where flood plain development can be better studied than on growing islands in relatively rapid and yet essentially depositing streams, such as the Illinois river at Starved Rock. *Fig. 8*

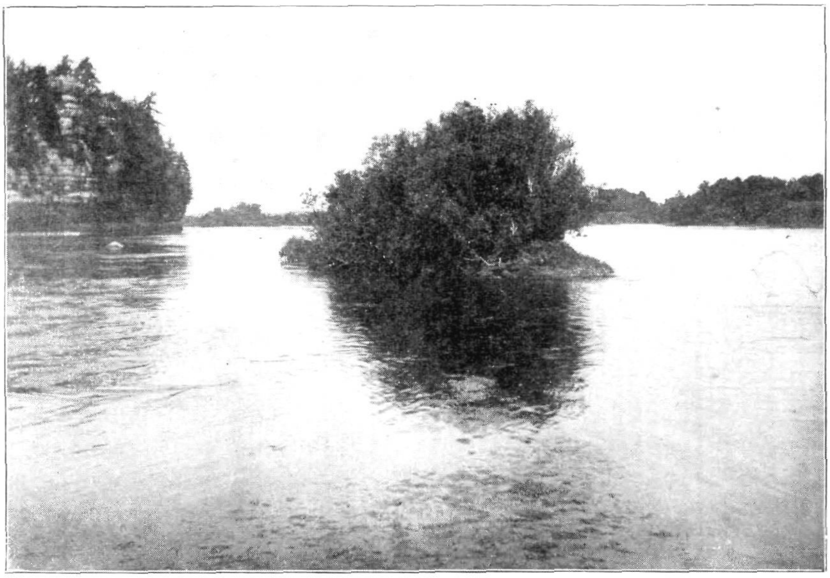

FIG. 9.—Young island in the Illinois river at Starved Rock (close view of island in foreground of *fig. 8*), seen from above, and showing the destructive action of the river.

gives a general view of the Illinois islands and flood plain. In *figs. 9* and *10* the lower island (foreground of *fig. 8*) is seen close at hand. Any obstacle, such as a partially submerged tree trunk, serves to check the river current and cause a deposition of sand or silt, and before long a sand bar originates. As in the case of a sand dune, the bar itself becomes an obstacle to the currents, and hence continually grows larger.

The first vegetation, as on the lake beach, consists largely of annuals, especially the giant ragweed (*Ambrosia trifida*); rushes and sedges, some annual and some not, are also present, but are less conspicuous. The perennials that manage to survive one season are largely washed away in the winter and spring, so that in reality the vegetation is almost exclusively annual. The first woody plants to get a more or less permanent foothold here are willows (*Salix nigra* and *S. longifolia*).

While islands of the above type gain more soil than they lose, a comparison of *figs. 9* and *10* shows that the river erodes above and deposits below. As a consequence, these islands migrate down the river, as well as grow in area year by year. Hence the upper part of the island is the oldest, as the vegetation well shows. *Figs. 8* and *10*

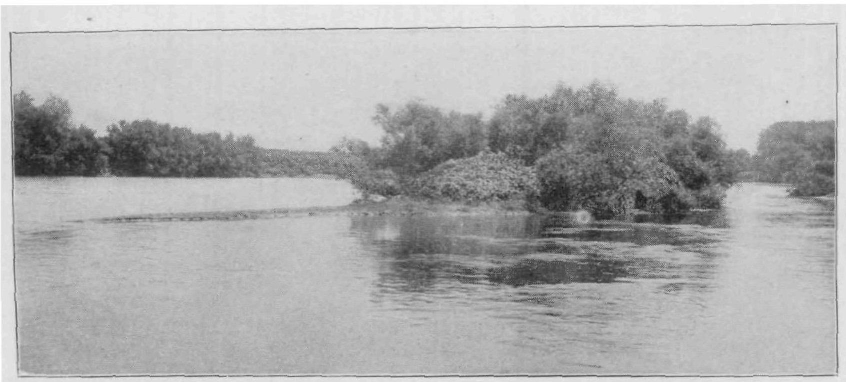

FIG. 10.—Same island as shown in *fig. 9*, but seen from below, and showing the constructive action of the river. Naked sand bar recently formed at the lower end of the island (left hand). Ambrosia farther toward the right, willows on the older part of the island (extreme right).

show at the lower end the sand bar, which comes to a point, and is so young or so exposed to submergence as to be barren of vegetation. Next comes the Ambrosia, then the willows, and finally a characteristic flood plain forest (background of *fig. 8*). The asymmetry of the river island vegetation is in striking contrast with the zonal symmetry of pond islands, as will be shown later (see *fig. 19*). The cause is evident, viz., the relative lack of symmetry in river currents as compared with pond currents.

The gradual encroachment of the land upon a stream through continuous deposition is well shown along the Desplaines river, and to a less complete degree along the Chicago river and Thorn creek. In the Desplaines bottoms the sand bar and island formations of the Illinois are largely absent, the currents being much less rapid. In the shallow water near the margin of the river are various hydrophytes, such as Sagittaria (Arrowhead), *Rumex verticillatus* (Swamp dock), etc.

The outermost fringe of land at ordinary low water is often almost as barren of vegetation as are the islands, but the soil is fine, and hence makes a mud flat instead of a sand bar. Immediately after the spring freshets have gone, an alga vegetation is frequently found on these flats, consisting especially of Botrydium and Vaucheria. Later in the

FIG. 11.—Flood plain of the Des Plaines river at Glendon Park, showing encroachment on the river. Willows in the foreground, cottonwoods farther back.

season, annuals, or even scattered perennials, may occur here, though the winter and spring floods uproot or bury most of this vegetation. The Ambrosia and willow vegetation soon appears, as described above. The river maple (*Acer dasycarpum*) usually appears with or soon after the willows. After the willows the cottonwood (*Populus monilifera*) and the ash (*Fraxinus Americana*) soon come in. *Fig. 11* shows an advancing flood plain of this type; willows are seen on the margin and cottonwoods farther back.

Gradually the growing flood plain becomes dry enough to permit the germination and development of a true mesophytic flora. The trees named above, especially the willows, are largely replaced by others that seem better adapted to the changed conditions; among these are the elms (*Ulmus Americana* and *U. fulva*), the basswood (*Tilia Amer-*

icana), the walnut and butternut (*Juglans nigra* and *J. cinerea*), the pig-nut (*Carya porcina*). In this rich flood plain forest there are many lianas climbing over the trees, *e.g.*, greenbrier (*Smilax hispida*), grape (*Vitis*—various species), Virginia creeper (*Ampelopsis quinquefolia*), and poison ivy (*Rhus Toxicodendron*).

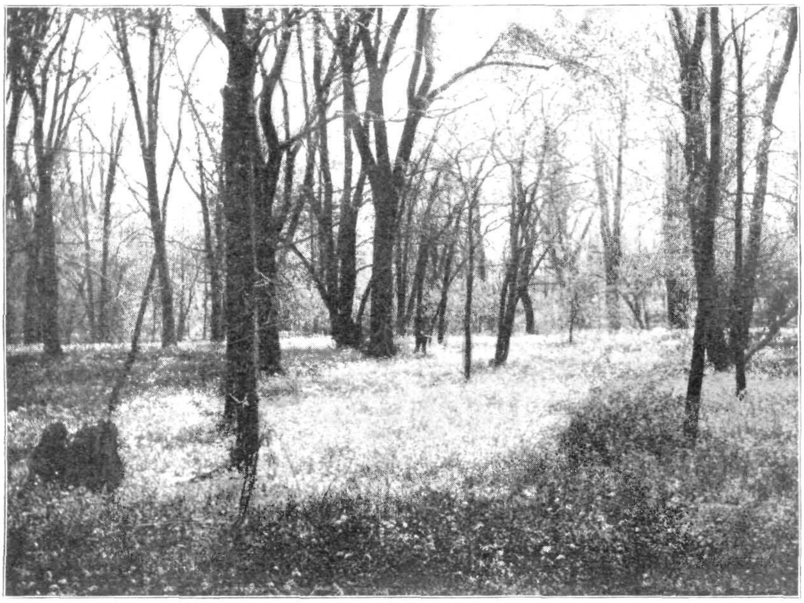

FIG. 12.—Mesophytic flood plain forest in the bottoms of the Des Plaines river at Riverside. Elms and basswoods. Rich herbaceous vegetation, consisting largely of Phlox.

The undergrowth in these river woods is very dense and luxuriant, the alluvial character of the soil making it very fertile. Among the shrubs are the thorns (various species of Cratægus), the gooseberry (*Ribes Cynosbati*), and many others. The herbaceous vegetation is dominantly vernal, the shade being too dense for a typical estival flora. Prominent among the spring flowering herbs are *Trillium recurvatum*, *Phlox divaricata*, *Polemonium reptans*, *Hydrophyllum Virginicum* (Waterleaf), *Mertensia Virginica* (Lungwort), *Collinsia verna*, *Claytonia Virginica* (Spring beauty), *Erythronium albidum* (Dogtooth violet), *Arisæma triphyllum* and *A. Dracontium* (Indian turnips), *Nepeta Glechoma* (Ground ivy), *Isopyrum biternatum*, *Caulophyllum thalic-*

troides (Cohosh), *Viola cucullata, Galium Aparine.* Other characteristic herbs are the nettles (*Urtica gracilis, Laportea Canadensis*), various umbellifers (Heracleum, Cryptotaenia, Sanicula, Osmorrhiza), and the parasitic dodder (*Cuscuta Gronovii*). *Fig. 12* shows a characteristic mesophytic flood plain forest along the Desplaines river; underneath

FIG. 13.—Flood plain forest along a small stream at Lockport, showing a rather striking collection of southern trees (see text). Coffee tree in the foreground.

the elms and basswoods is seen a rich herbaceous flora, consisting largely of Phlox, which the picture shows in full bloom.

In some of the bottom lands there is a rather striking collection of trees, whose chief range is mainly southward. *Fig. 13* shows a flood plain tree group near Lockport, most of whose members are largely southern, viz., the coffee tree (*Gymnocladus Canadensis*), seen in the foreground; the pawpaw (*Asimina triloba*), the sycamore (*Platanus occidentalis*), and the hackberry (*Celtis occidentalis.*) In other flood plains there may be found the mulberry (*Morus rubra*), the red bud (*Cercis Canadensis*), the buckeye (*Æsculus glabra*), and the tulip (*Liriodendron tulipifera*).

None of these trees are common in our district, and only Celtis may be regarded as frequent. These relatively southern trees are found not only along the Desplaines and its tributaries, where there is supplied a continuous habitat along the river southward, but also along

FIG. 14.—Flood plain of the Calumet river near Chesterton, showing the beginnings of terrace formation, indicated more by the falling elm than by the topography.

the Calumet and its tributary, Thorn creek. The occurrence of the tulip is full of interest, since it has been found thus far chiefly (perhaps only) in the vicinity of the dunes. Its occurrence has been noted especially at Chesterton along a small stream which empties into Lake Michigan at that point; the tulip has also been found away from present streams, but apparently in old valleys whose streams have been diverted by dune activity. The confinement of these southern trees to flood plains is not strange, since in such habitats are given the most congenial conditions that can be found in our area.

The vegetation on flood plains is not always as described above. Sometimes meadows are found instead of forests; this condition is particularly well shown along Thorn creek. *Fig. 18* shows a stretch of meadow of this type. Besides various grasses, such as *Poa pratensis*

(Blue grass) and *Agrostis alba vulgaris* (Red top), there are often other plants in abundance, *e. g.*, *Thalictrum purpurascens* (Meadow rue), *Fragaria Virginiana* (Strawberry), and *Anemone Pennsylvanica*. The ecological meaning of the meadow is not clear. Probably mowing or grazing is responsible for the failure of a mesophytic forest to develop.

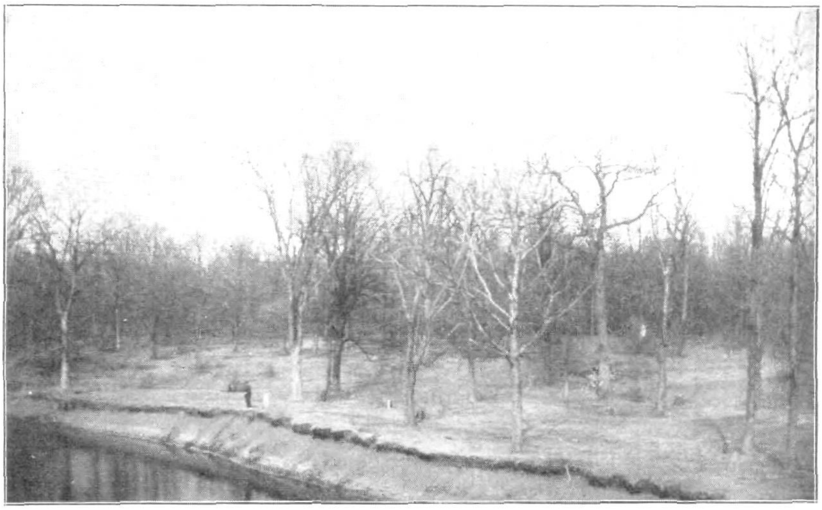

FIG. 15.—Terrace in the flood plain of the Des Plaines river at Glendon Park, showing how a mesophytic flood plain may become xerophytic. The opposite bank shows deposition and flood plain enlargement (*fig. 11*).

Extensive thorn (Cratægus) thickets sometimes occur in these meadows, and probably betoken the beginning of a mesophytic forest. Extensive and apparently natural meadows are found in the Calumet valley.

As we have seen, the climax type of vegetation on the flood plain is the mesophytic forest; but here, as well as on the river bluffs, the climax may be but temporary. Retrogression is almost sure to come in connection with terrace formation. While it is true that deposition is the main feature of flood plains, it is also true that erosion has not ceased; the downward cutting of the river once more causes vertical banks, though this time in its own flood plain. This action is seen in *fig. 14*, which shows the beginning of the new erosive phase, and its indication in the falling elm. There has doubtless been lateral erosion here also, since elms are not usually marginal trees. *Fig. 15* shows the erosion of the flood plain still farther advanced; this bank is just opposite the willow vegetation shown in *Fig. 11*, hence there is deposition on one side and cutting on the other. A river may thus swing quite across its flood plain, destroying all that it has built, including the mesophytic forest. Not only is the vegetation destroyed directly,

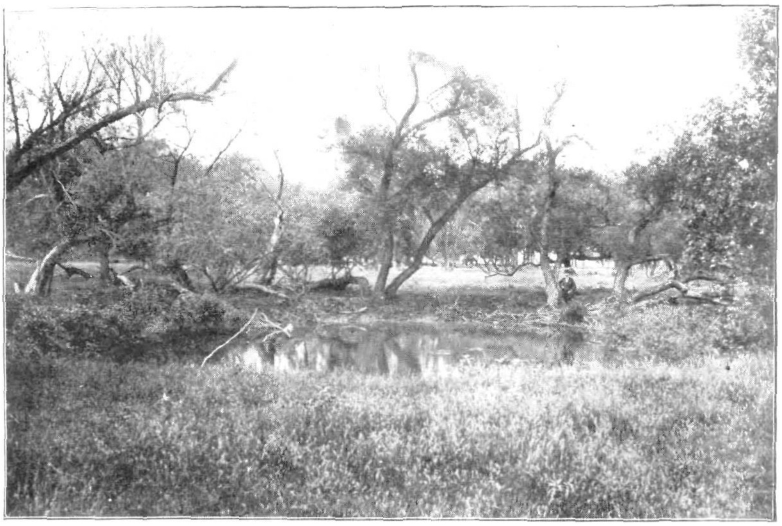

FIG. 16.—An oxbow lake in the flood plain of Thorn creek. The willows are antecedent, dating back to a stream margin, while the shrub (Cephalanthus) and herb vegetation is associated with the present undrained condition.

as shown in *fig. 14*, but also indirectly, since the lowering of the river causes the banks to become more xerophytic. In place of the herbaceous mesophytes, Equisetum and other relatively xerophytic forms may appear, though the trees usually live until directly overthrown by the river.

One more phase of river activity may be briefly sketched. In meandering over a flood plain, serpentine curves, or oxbows, are frequently formed. In time the river breaks across the peninsula, and the oxbow remains as a crescentic lake. The conditions radically change almost immediately, and the river life is replaced by pond life. The change is even more striking on the margins, where the old plants pass away and the forms of undrained swamps come in. *Fig. 16* shows the remnant of one of these oxbows; on the farther side are old and dying willows, trees that look back to the well-drained river margin. On either side of the pond are seen clumps of the button bush (*Cephalanthus occidentalis*), one of the most characteristic plants of undrained swamps. Thus the willows are antecedent and the button bush subse-

Fig. 17.—A dead oxbow lake in the flood plain of Thorn creek. A willow still remains at the right, while the shrubs (Cephalanthus) have closed in upon the lake.

quent to the formation of the cut-off. *Fig. 17* shows a portion of the same, in which the willows, and even the pond itself, have gone, and only the marginal button bush is left, though in this case the margin occupies the center of the original pond. Near Starved Rock an extinct oxbow lake on the flood plain of the Illinois river contains an extensive patch of Sphagnum and Osmunda, among the most characteristic plants of undrained swamps. There are many undrained swamps, some with tamaracks, in the Calumet valley. The future of these swamps is like that of other swamps, and will be described in the next section. *Fig. 18* shows a morainic island in the Thorn creek flood plain; the stream has meandered, but has thus far left this detached fragment of the morainic mainland with a large part of its original flora.

In closing the section on rivers, all that is needed is to emphasize again the idea that the life history of a river shows retrogression at many points, but that the progressions outnumber the retrogressions. Not only this, but retrogressive phases are relatively ephemeral. Thus a river system, viewed as a whole, is progressive, and through all its

FIG. 18.—Flood plain of Thorn creek near Glenwood, showing a meadow instead of a forest. At the center is an uneroded island, detached from the morainic mainland, seen at the left. The vegetation of the island is similar to that of the morainic upland.

vicissitudes there is an ever-increasing area of mesophytic forest. When the theoretical base level is reached, there seems to be no apparent reason why mesophytic forests should not be developed throughout most of the great plain.

2. THE POND-SWAMP-PRAIRIE SERIES

A. *The pond.*—There are all gradations between rapid streams and completely undrained ponds, and corresponding with these various gradations are characteristic plant species. It will be convenient to subdivide the series under discussion into two parts, the first dealing with undrained ponds and swamps, the second with half-drained ponds and swamps.

No two floras can be more unlike in species or in adaptations than are the typical brookside and swamp floras. Though each type may be called hydrophytic, so far as the water is concerned, the vegetation is really hydrophilous in the first case, but pronouncedly xerophilous in the second. Peat bogs, which may be taken as the type of undrained swamps, have a remarkable assemblage of xerophytic adaptations, such as leathery or hairy leaves, and special structures for water absorption. Schimper believes that these structures are due to the difficult absorption in peaty soil, the humus acids and the lack of oxygen being detrimental to normal root activities. For similar reasons the normal soil activities of bacteria and fungi are lessened, and as a result of this relative lack of decay great quantities of peat accumulate. All of these peculiarities of peat bogs may be referred to the lack of drainage, since the stagnant conditions prevent oxidation and the removal of the humus acids. The lack of drainage is of course due to topographic conditions. Peat bogs and undrained lakes, therefore, are features of a young topography, since several agencies combine to cause their rapid destruction. Rivers may work back and tap the undrained lakes or inlets may fill them up. Probably the most important agent in the death of undrained lakes, however, is the vegetation, as will be seen later. The great abundance of lakes and ponds in the young glaciated regions as compared with older regions to the south is a striking proof of their short life.

In the immediate neighborhood of Chicago typical peat bogs are scarce. They find their best development in the depressions of the dune region, where they may be called abundant. Wherever a sag between two dunes is low enough to retain moisture for the greater part of the season, the conditions favor the development of an undrained swamp flora. If the depression is so low that the water level outcrops throughout the year, then there is an undrained pond or lake. The first flora in this latter case consists of plants that are able to exist with little or no change in the water of the pond except through rain and evaporation. Among these plants the alga Chara takes a prominent place. The water lilies (Nymphæa and Nuphar) are an exceedingly important constituent of this first vegetation, as is also Utricularia, which is represented by several species. The above species, together with others, play a great part in filling up lakes, since their remains accumulate with almost no decay. Chara in particular is a soil former of great importance. The rapidity with which these filling processes are carried on is striking; in pools of known age among the rubbish heaps of Jackson park the author has noticed accumulations of Chara peat amounting to one or two inches per year.

B. *The undrained swamp.*—It is obvious that the processes outlined in the preceding paragraph must eventuate in the death of the lake or pond involved and its replacement by a marsh, entirely apart from ordinary erosive activities. Indeed, as has been stated, these activities are relatively unimportant here; this fact is shown by the absence of ordinary sediments from most peat beds. As the aquatics make the pond shallower and shallower, they make it more and more unfit for themselves and fit for their successors, viz., those plants which grow along pond margins. Among the first plants of this type are various sedges (Carex), also the bulrush (*Scirpus lacustris*), though this latter species is more characteristic of the half-drained margins than of those under discussion here. Other marginal plants of our peat bogs are *Menyanthes trifoliata* (Buckbean) and *Potentilla palustris* (Swamp cinquefoil).

The vegetation that follows may be called typical of peat bogs. The dominant plants are usually shrubs, especially the leather leaf (*Cassandra calyculata*); this plant may be so abundant as to give tone to the landscape. *Fig. 19* shows some Cassandra islands in a sedge swamp. It is clear that the islands represent places where in the original lake the water was shallow. The present remnant of the lake is shown at the left. Not only have the sedge zones advanced upon it from all sides, but centers of sedge growth appear also in shallow places in the lake itself. Just as the sedge zone encroaches upon the lake, when conditions become favorable, so the Cassandra zone advances on the sedges. Again, a tree zone advances on the shrubs, as will be seen farther on. The zonal arrangement of plant societies that has just been seen is a feature of most peat bogs, and is due to the symmetry of lake and bog conditions. It will be observed that along the lake margin the zones advance toward a common center, while on the islands the advance is from a center. Eventually, of course, the marginal and island zones will merge.

Besides Cassandra many other plants are commonly found in the shrub zone. Other shrubs are the swamp blueberry (*Vaccinium corymbosum*), the cranberry (*Vaccinium macrocarpon*), the dwarf birch (*Betula pumila*), the alder (*Alnus incana*), the hoary willow (*Salix candida*), and the poison sumach (*Rhus venenata*). Characteristic herbs, especially in the open places, are the pitcher plant (*Sarracenia purpurea*), the sundew (*Drosera rotundifolia*), various orchids, as *Calopogon pulchellus*, Pogonia, and Cypripedium; sedges, as Eriophorum and Dulichium; *Woodwardia Virginica*, and *Elodes campanulata*. One of the most typical plants of these places is the peat moss, Sphagnum.

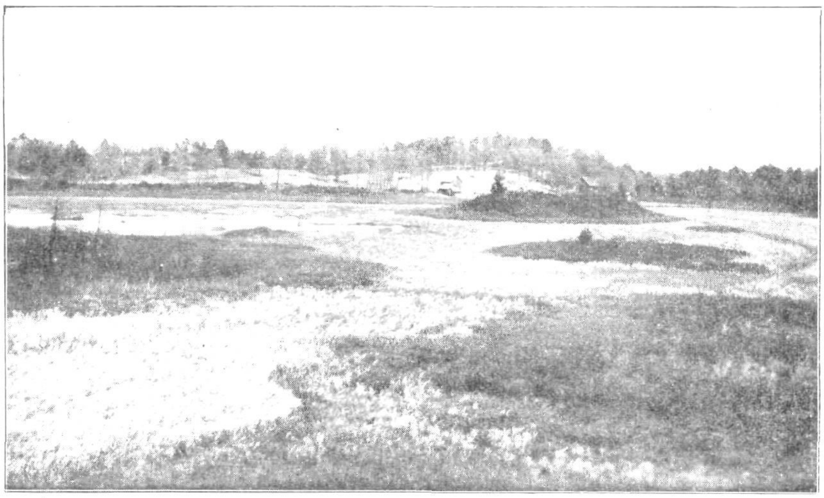

FIG 19.—Typical peat bog in a depression between established dunes at Miller. Relict of the original pond at the left. Sedges (light-colored vegetation) are encroaching on the lake, while shrubs, mainly Cassandra, are encroaching on the sedges. Cassandra islands toward the right. Advance of conifers on Cassandra (seen in its beginnings on the islands) shown at the extreme right.

The flora just mentioned has many interesting features which are well known and may be passed over briefly. The highly xerophytic character of this plant society has already been noticed, and the reasons for it briefly given. The xerophytic structures are well illustrated in the leathery leaves of Cassandra and the absorption and storage adaptations of Sphagnum. Many bogs of this type are very spongy and unstable, whence the name quaking bogs; this feature is due to the rapid growth of the vegetation and the absence of ordinary inorganic soils for a considerable depth. The similarity of the peat bog vegetation throughout the northern hemisphere is one of its most striking features. Not only the adaptations but the species themselves are similar over vast areas; the conditions are unique and the flora also. None of our plant societies, not even the lakeward dune slopes, have such a pronounced northern flora as do the peat bogs. No contrast could be more striking than that between the southern vegetation of the flood plains and the northern flora of the bogs.

Fig. 19 shows that a coniferous vegetation, now represented by

FIG. 20.—Tamarack swamp in an undrained portion of the Calumet flood plain at Miller. Peat bog herbs and shrubs in the foreground.

but two or three small trees at the centers of the islands, is to follow the Cassandra Such an advance of conifers on Cassandra is shown in the background at the right. The most typical conifer in such cases is the tamarack (*Larix Americana*); with this the arbor vitae (*Thuya occidentalis*) is sometimes found. Larix and Thuya swamps reach but an imperfect development in our region, and little need be said about them. The shade in these forest swamps is so dense that bare patches of soil are often seen. The vegetation consists largely of shade plants, among which may be mentioned Mnium and other similar mosses, *Coptis trifolia* (Goldthread), *Cornus Canadensis*, *Viola blanda* (White violet), and Impatiens. The tamaracks appear to be succeeded by the pines (*Pinus Strobus* or *P. Banksiana*), and they in turn by oaks, as the soil becomes drier and better drained, and thus more adapted to deciduous trees. *Fig. 20* shows a tamarack swamp near Miller, Ind.

Not all peat bogs have a history like the above. Just as some flood plains are forested and others not, so some peat bogs grow up to shrubs and trees, while others are dominated, for a long time at least,

FIG. 21.—Shallow, undrained swamp (peat bog) at Dune Park. In the foreground the relict of the original pond, with water lilies, then in order, encroaching zones of bulrushes, sedges, willows, and pines. The oaks in the background are on an established dune, and are not encroaching on the swampy soil.

by herbs and grasses. *Fig. 21* shows a swamp of this character. Bulrushes are seen to be encroaching upon the water lily vegetation, while back of the bulrushes, instead of Cassandra, is a zone with sedges and grasses and scattered willows. Among the species other than sedges and grasses in a plant society like this are *Viola sagittata* and *V. lanceolata*, *Potentilla Anserina*, *Fragaria Virginiana* (Strawberry), *Parnassia Caroliniana*, *Sabbatia angularis*, *Gentiana crinita*, *Gerardia purpurea*, *Castilleia coccinea* (Painted cup), *Aletris farinosa*, *Iris versicolor*, *Sisyrinchium angustifolium* (Blue-eyed grass), *Hypoxys erecta* (Yellow-eyed grass), *Xyris flexuosa, Triglochin maritima.* The shrubs in such places are chiefly *Salix glaucophylla* (Glaucous willow), *Cornus stolonifera* (Osier dogwood), *Potentilla fruticosa* (Shrubby cinquefoil), *Hypericum Kalmianum.* The conditions that determine this type of bog, as contrasted with the Cassandra type, are not clear. The soil is hard, compact, shallow, and usually sandy; it may be that this type develops in shallow depressions, while the type with spongy, quaking ground develops in deeper depressions. This second type much more closely resembles the half-drained swamps in its flora than does the Cassandra type, although so far as drainage is concerned it agrees with the Cassandra bogs.

There is yet a third type of swamp which still more closely resembles the half-drained swamp in its flora. It is found along the edge of the Calumet valley near Dune Park, also at West Pullman. In this case the soil is rather deep and rich, in which respects there is agreement with the first type rather than the second. Grasses and sedges, but of a more luxuriant type, dominate here also, and with them are found such plants as *Cephalanthus occidentalis* (Button bush), *Aspidium Thelypteris, Onoclea sensibilis* (Sensitive fern), *Saxifraga Pennsylvanica, Caltha palustris* (Marsh marigold), *Viola blanda, Polygala sanguinea.* Sphagnum occasionally occurs here, as it never does in the second type. Here again there is doubt as to the determining conditions, but it may be that things can be explained by the difference in the drainage. The ultimate fate of the second and third swamp types is not known. The relative absence of trees and shrubs is certainly natural and in no wise due to man. Possibly local prairies will be the final type, or it may be that the forest will come in. *Fig. 21*, which shows pines encroaching upon the grassy areas, favors the latter view. So do some of the facts seen in the Calumet valley.

All of the peat bog types have a characteristic marginal flora, *i. e.*, the vegetation at the margin of the original lake is essentially alike in all cases. These plants, as well as those of Cassandra bogs, are the same over wide areas. The most common members of the bog margin flora are the sour gum (*Nyssa sylvatica,*) the aspen (*Populus tremuloides*), *Ilex verticillata, Pyrus arbutifolia* (including var. *melanocarpa*), *Spiraea salicifolia and S. tomentosa, Rubus hispidus, Gaultheria procumbens* (Wintergreen), *Osmunda cinnamomea, O. Claytoniana, O. regalis, Betula papyrifera* (Paper birch), and *Polytrichum commune.* This vegetation originates outside the swamp, and may be regarded as xerophytic; however, it often encroaches upon the swamp as the latter develops. At Thornton there is a dead swamp which is now almost entirely occupied by this xerophytic bog margin flora, only a few of the original swamp plants now remaining. Near Morgan Park is a bog margin flora without a bog; a shallow trench has been dug and in this trench there have appeared various peat bog plants, *e. g.*, Sphagnum. These con-

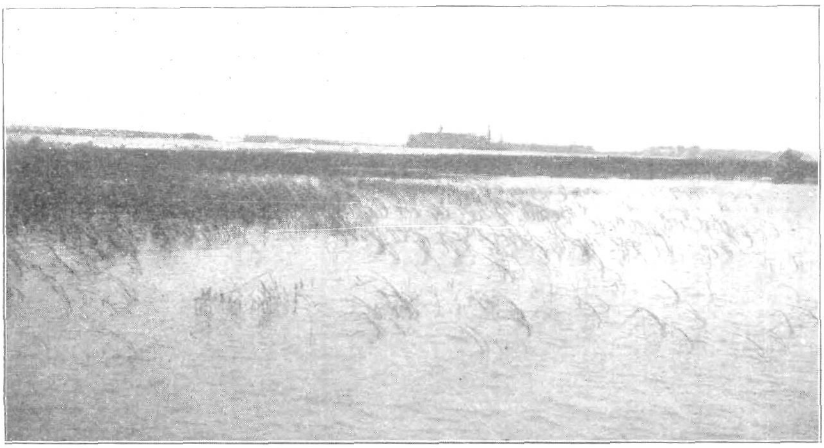

FIG. 22.—Encroachment of bulrushes on Calumet lake, showing how plants may destroy lakes.

siderations show that bog margin floras, though associated with most bogs, are not necessarily genetically connected with them.

A word may be said about undrained swamps among the active dunes. The conditions here, of course, are far more severe than in ordinary peat bogs and only a few species are able to endure in such a habitat. The most typical herb is *Juncus Balticus littoralis*. Seedlings of the cottonwood, as well as the long-leaved and glaucous willows, germinate in these wet depressions. Reference will be made to these plants in connection with the dunes.

In the morainic portions of our territory there are few if any peat bogs as described above, although they are usually more typical of moraines than of other topographic areas. On account of the clay soil which characterizes the morainic uplands there are many patches of swampy woods throughout the district. Shallow depressions of this type in sandy soil would not have a swamp developed. Morainic forest swamps are characterized by several trees, viz.: the bur oak, swamp white oak, and scarlet oak (*Quercus macrocarpa*, *Q. bicolor*, and *Q. coccinea*), the red maple (*Acer rubrum*), the elm (*Ulmus Americana*), and the ash (*Fraxinus Americana*). Other species are *Cephalanthus occidentalis* (Button bush), *Salix discolor*, *Ribes floridum* (Wild currant), *Cardamine rhomboidea purpurea* (Spring cress), *Ranunculus septentrionalis*

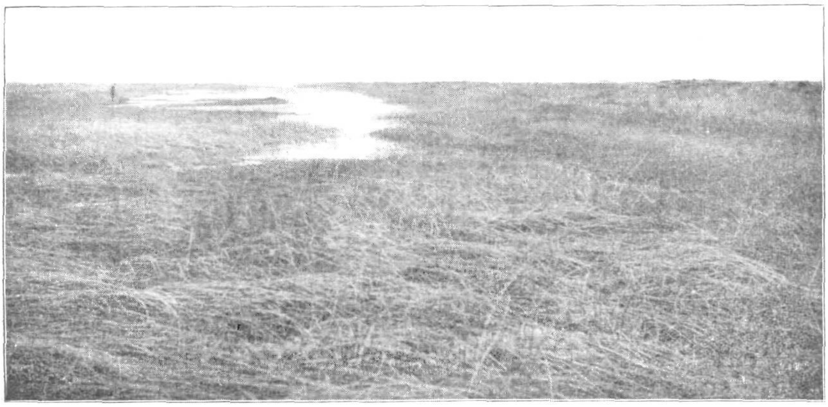

FIG. 23.—Pond at Waukegan almost destroyed by bulrushes.

(Buttercup). This vegetation is ultimately supplanted by the mesophytic forest. A vegetation allied with that of swamps is the amphibious ditch flora with such plants as *Nasturtium palustre* (Ditch cress), *Penthorum sedoides* (Ditch stonecrop), *Proserpinaca palustris* (Mermaid weed), *Ludwigia palustris*, *Polygonum Hydropiper* (Water pepper), etc.

Calumet lake and Grand Calumet river may be taken as types of half-drained waters. We have here conditions that are midway between those of peat bogs and those of ordinary rivers. The vegetation is subject neither to the currents of the rivers nor to the stagnant conditions of the peaty lakes, and hence the luxuriance of the flora is far greater than in either of the other instances. The aquatic vegetation is rich both in species and individuals. Here is to be found a great wealth of alga vegetation, including such forms as Cladophora, Spirogyra, Oedogonium, Hydrodictyon. Among the floating plants are Riccia, Ricciocarpus, the duckweeds (Spirodela, Lemna, and Wolffia). There are also a large number of attached plants, including many species of Potamogeton (Pondweed), *Ranunculus aquatilis* (White buttercup), Brasenia, Nelumbo (Lotus), Myriophyllum (Water milfoil), Ceratophyllum (Hornwort), Elodea (Waterweed), Vallisneria (Tape grass), and Naias. This rank growth of vegetation fills the lake up rapidly, since the currents are not sufficient to carry off the plant remains. There is a rapid advance of marginal plants upon the lake, a phenomenon that is shown in *fig. 22*,

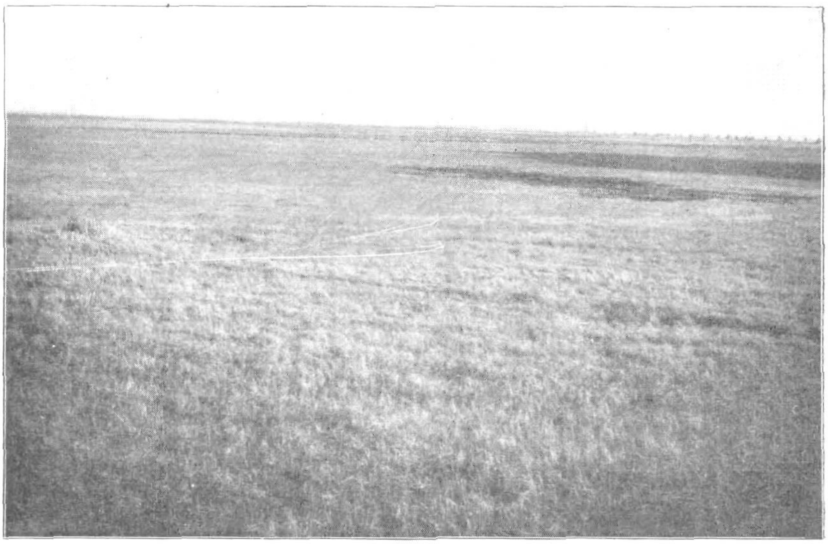

FIG. 24.—Typical grass prairie near Pullman. This prairie has been reclaimed naturally from Lake Calumet, and has passed through bulrush and sedge stages.

where the scattered bulrushes (*Scirpus lacustris*) are seen to be soon followed by a dense bulrush society. With or soon after the bulrushes are a number of marginal plants, especially *Typha latifolia* (Cattail), *Pontederia cordata* (Pickerel weed), *Sparganium eurycarpum*, *Sagittaria variabilis* and *S. heterophylla* (Arrowheads), *Zizania aquatica* (Wild rice), *Phragmites communis* (Reed), *Acorus Calamus* (Sweet flag), and *Eriophorum cyperinum*. *Fig. 23* shows a stage in which a lake has been all but destroyed by a rank bulrush vegetation.

C. *The prairie.*—Sedges encroach rapidly upon the bulrushes as the new soil becomes raised more and more above the lake, and grasses in turn encroach upon the sedges, forming a prairie. *Fig. 24* shows an expanse of grassy prairie which has developed through these successive stages from Calumet lake. Skokie marsh and Hog marsh are undergoing transformations of this character also. Sometimes with the prairie grasses are a number of coarse xerophytic herbs, largely composites, as *Silphium laciniatum* (Compass plant), *S. terebinthinaceum* (Prairie dock), *S. integrifolium* (Rosin weed), Lepachys, *Solidago rigida*, Aster, Liatris (Blazing star), with some legumes, as *Amorpha canescens* (Lead plant),

FIG. 25.—Prairie at Pullman in which the compass plant (Silphium) grows with the grasses. This prairie is much older and drier than that shown in *fig. 24*.

Petalostemon (Prairie clover), Melilotus (Sweet clover), and Baptisia, Eryngium, Dodecatheon (Shooting star), Phlox, *Allium cernuum* (Wild onion). A Silphium (Compass plant) prairie is shown in *fig. 25*. The prairies of our area are in the basin of the glacial Lake Chicago, and hence all may be referred to a lake or swamp origin, exactly as prairies are developing from Calumet lake today. This explanation of the prairie, an undoubted explanation for the cases in hand, must not be applied to the great climatic prairies farther west. Whether the Chicago prairies will ever become forested is a question not easily answered. There are signs of it in some places, as at Stony Island, but this topic needs more detailed treatment than can be given here.

The processes outlined in this section are rapid. The mesophytic prairie or forest develops from the lake or marsh, while the region as a whole still retains a young topography. Thus this mesophytic assemblage, like that of the ravine slope, is bound to pass away, though its life tenure is much longer. Sooner or later river action will enter; there will be developed ravines, xerophytic bluffs, and ultimately flood plains, again with a mesophytic flora. A broad survey then shows a rapid development to a somewhat prolonged temporary climax, and finally, after ravine and bluff vicissitudes, there appears the true and more enduring climax of the mesophytic flood plain.

3. THE UPLAND SERIES.

A. *The rock hill.*—While all of a land area is eventually worked over by stream activities, and can thus be referred to the river series, other activities are at work in a young topography. The swamp series which has just been discussed is one illustration. So also there are hills which are not due to erosive processes, but to other causes, notably, in our region, morainic hills and sand hills. There are rock hills, also, which are not connected with the present erosion cycle. All of these hill types have their peculiar vegetation features, and must be discussed apart from river activities, since they have an interesting history before they are attacked by stream erosion.

We may speak first of rock hills, which in the vicinity of Chicago are quite rare, and consist entirely of dolomitic Niagara (Silurian) limestone. Not only are hills of this limestone quite rare, but surface outcrops of any kind are uncommon, because of the heavy drift. Hence the rock vegetation of the Chicago area is not very important. Perhaps the most interesting outcrop is at Stony Island, where it is quite easy to trace the various stages in the development of the vegetation. This rock, like most limestone, is subject to chemical as well as mechanical erosion, but is much more resistant than most limestones, on account of its strongly dolomitic character. The first vegetation that gets a foothold is composed of lichens, but the lichen flora appears to be rather sparse, perhaps because of the chemical nature of the rock, since lichens are commonly supposed to shun calcareous soils. The relative poverty of lichens may be due, however, to the easy solution of the surface rock layers and the consequent difficulty in retaining a foothold. The limestone is considerably jointed and fractured, and there is in consequence a rich crevice vegetation, composed of several mosses, especially Ceratodon and Bryum, and also various grasses. *Fig. 26* shows a vegetation of this nature, and among the other crevice plants is an abundance of *Solidago nemoralis*. Other species growing in the crevices or on the first soil which is formed on the rock face are *Potentilla arguta*, *Verbascum Thapsus* (Mullein), *Heuchera hispida* (Alum root), *Poa compressa* (Wire grass), etc. At Thornton there is a rock

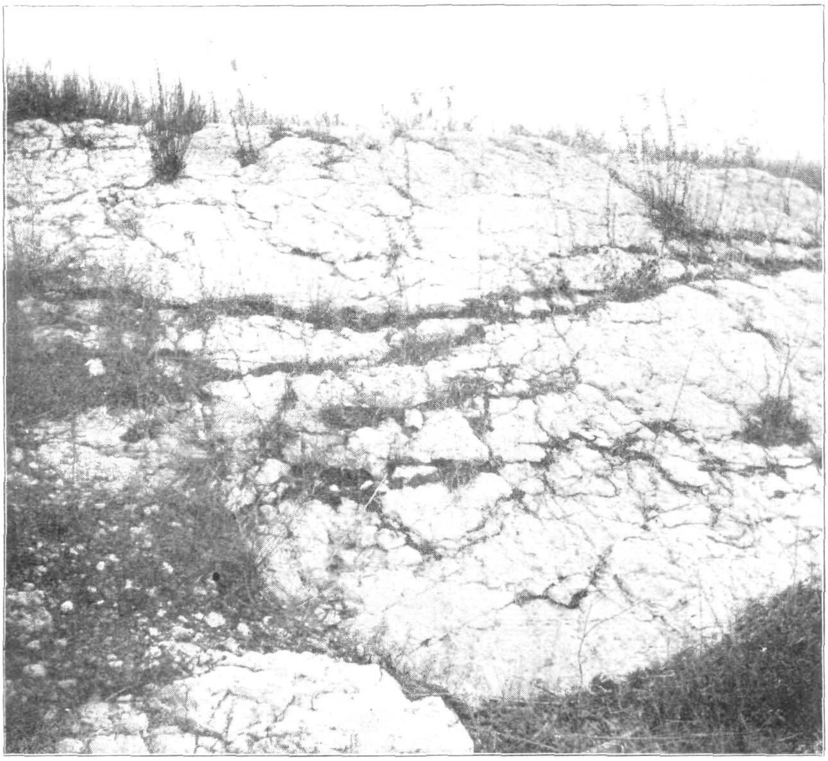

FIG. 26.—Slope of limestone ledge at Stony Island, showing mosses and higher plants establishing themselves in the crevices.

outcrop which gradually recedes from the surface, and it is possible to tell by the vegetation where the rock surface dips considerably under the surface of the soil. Where the soil is shallow the dominant plant is *Poa compressa*, but as the soil layer deepens it becomes gradually replaced by *Poa pratensis* (Blue grass). Similarly, at Stony Island, crevices can be distinguished in a covered horizontal rock surface by a sudden change from the xerophytic plants of the shallow soil, that hides most of the rock, to the mesophytic plants of the deeper soil which lies over the crevices.

Through rock decay and the accumulation of organic matter a considerable soil comes to be developed where there was at first an outcrop of bare rock. The opportunity for a shrubby vegetation eventually

FIG. 27.—Limestone ledge at Stony Island, showing vegetation farther advanced than in *fig. 26*. The crevice shrubs here are chokecherries (*Prunus Virginiana*).

arrives, especially in the crevices. *Fig. 27* shows such a vegetation getting a foothold. Among the shrubs in such places are the chokecherry (*Prunus Virginiana*), ninebark (*Physocarpus opulifolius*), poison ivy (*Rhus Toxicodendron*), *Rosa humilis*, sumach (*Rhus typhina*), hop tree (*Ptelea trifoliata*), wild crab (*Pyrus coronaria*). Still later the way is open for a tree vegetation, at first xerophytic, but ultimately mesophytic, as the author has frequently observed in the Alleghanies. There can be no doubt but that a temporary mesophytic climax can be reached even on rock hills, though the probability of this is much greater where the hill is composed of limestone than in the case of sandstone or granite.

B. *The clay hill.*—Morainic hills are common in the Chicago region, and almost without exception they are covered with a mesophytic forest, in which the dominant trees are usually the white oak (*Quercus*

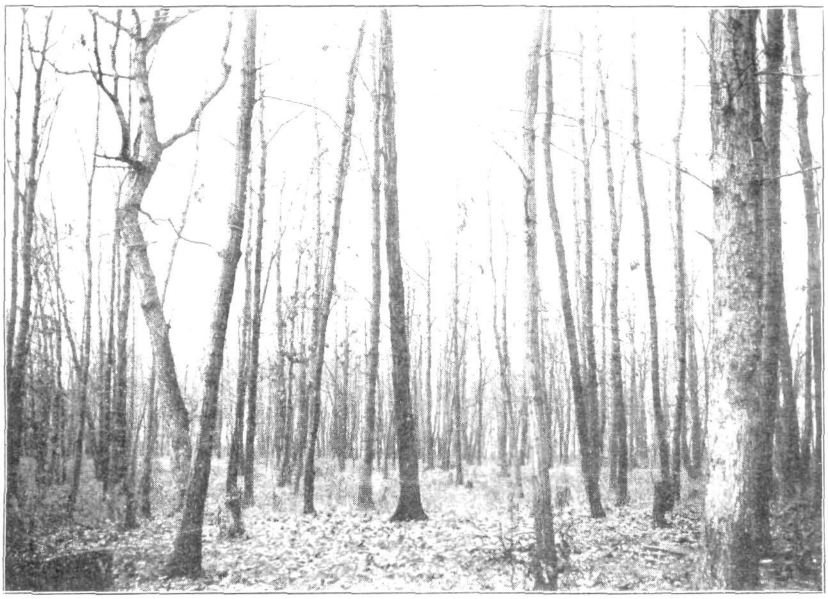

FIG. 28.—Typical upland clay (morainic) forest at Beverly Hills. The dominant trees here are red oaks (*Quercus rubra*), though a white oak (*Q. alba*) is shown at the extreme right.

alba), the red oak (*Quercus rubra*), and the shell-bark hickory (*Carya alba*). This is easily the dominant forest type of the Chicago region, and is remarkably characteristic of morainic areas. The soil in all cases is a glacial clay or till, heterogeneous in composition, but rich in food salts. Of all our plant society life histories these are about the most difficult to unravel, and it is due to the favorable conditions under which they have developed. After the continental glacier left this region for the last time, it was doubtless on these low morainic hills that the first mesophytic forests were developed. And they have been developed for so long that almost no traces of their history are left behind; we have only the completed product, the mesophytic forest.

Where these mesophytic forests are disturbed we may perhaps get some notion of what took place in the first postglacial centuries. On the clay banks along the drainage canal, and also on recent river bluffs, one may follow in rapid succession a series of plant societies leading to the forest. There is here no pronounced lichen or moss stage as on rock hills, but the first vegetation consists of xerophytic annuals and perennial herbs. Xerophytic shrubs, especially Salix and Populus, soon appear. It is not long before there is an extensive thicket formation with an herbaceous undergrowth. Humus accumulates with great rapidity, and we soon have almost a mesophytic vegetation in which the dominant thicket species are likely to be the aspen (*Populus tremuloides*), wild crab (*Pyrus coronaria*), red haw (*Cratægus punctata*, *C. coccinea*, etc.). Such a thicket is the immediate forerunner of the oak-hickory type of mesophytic forest. When a forest of oak and hickory is cut down or destroyed by fire, it returns after a comparatively short interval, but the first stages in the clearing are thicket stages much like those just described. Of course it takes much longer to develop a forest from naked clay soil than from a forest land that has been cleared. Whether the stages that led up to the first postglacial forests are such as have been described is very doubtful. It is much more likely that the first forests were of slow growth and were coniferous in character, such as are found farther north. *Fig. 28* shows a typical morainic hill forest of the above type. Here the dominant tree is the red oak; a white oak is seen at the right.

Among the shrubs of these morainic forests there may be mentioned, apart from the crabs and haws, the hazel (*Corylus Americana*), and various species of Viburnum. Many herbaceous plants are found, among which are Podophyllum (May apple), Claytonia (Spring beauty), various species of Aster, Trillium, *Geranium maculatum*, *Viola pubescens* (Yellow violet), *Anemone nemorosa*, etc. Sometimes the bur oak (*Quercus macrocarpa*) is the dominant tree in these morainic forests, though in such cases the habitat is usually more moist or else the drainage is less perfect. A bur oak forest is shown in *fig. 29*. The transition from this type to the morainic swamp forests, already mentioned, is an easy one, and bur oaks are often found with the swamp white oak and other species characteristic of such places.

In spite of the abundance of the type of morainic forest described above, it is scarcely probable that it is anything more than a very slowly passing forest stage. The fact that in all directions from Chicago the ultimate forest type on morainic uplands is not the oak-hickory but the maple-beech forest leads us to expect that here. This latter type seems to be of a higher order in all respects. It is found in richer soil, where the humus content is very great. Seedlings of the

FIG. 29.—Typical forest of low morainic clay soil, made up chiefly of bur oaks (*Quercus macrocarpa*).

beech or maple can easily grow in the relatively light oak forest, whereas oaks cannot grow in the denser shade of the maple or beech. Furthermore, oak forests have been seen with a pronounced undergrowth of beech. It would seem that one of the chief factors in determining the order of succession of forests is the light need of the various tree species, the members of the culminating forest type being those whose seedlings can grow in the densest forest shade. There are evidences that the oak forests about Chicago are being succeeded by the beech or maple. The best instance of this which the author has seen is on the low moraines along the Desplaines river west of Deerfield. The sugar maple (*Acer saccharinum*) has already been mentioned as a character plant of the temporary mesophytic forests of ravines. Here we see it in the more permanent forest of the morainic hills. The beech (*Fagus ferruginea*) is much rarer than the sugar maple, though it is a rather important constituent of the mesophytic forests about Chesterton. Why the beech-maple forest has lagged so far behind in the region about Chicago is a question not yet settled. If these forests elsewhere have had an oak stage it indicates that the development here is very slow.

Though the forests just described, whether of the oak-hickory or the maple-beech type, are of a high degree of permanence, it can be seen that this permanence is but relative. Sooner or later stream action will enter these districts and base leveling processes will begin on a more rapid scale. But for these activities the lowering of hills would be very slow indeed, so slow as hardly to interfere at any point with a luxuriant development of the vegetation. The destruction of these morainic forests by stream erosion is well shown near the shore north of Evanston, and also along Thorn creek. *Fig. 18* shows a morainic island in a flood plain, the sole remnant of an extensive stretch of upland mesophytic forest. We must therefore regard upland forests as temporary also, though they endure for a much longer time than do the temporary mesophytic forests of the ravines.

C. *The sand hill.*—A third type of upland is found in the sand hills, but since most of these in our district are of dune origin, their treatment will be deferred until later.

B. THE COASTAL GROUP.

1. THE LAKE BLUFF SERIES.

The plant societies that have been discussed hitherto may be found in many if not in most inland districts. The societies that follow, on the other hand, are best worked out only in connection with the coasts of oceans or great lakes. Theoretically a bluff may be composed of any kind of rock or soil, but those of our area are composed of morainic clays, and the life histories that follow will not hold good in other conditions. It may be noted here that there is a short stretch of rocky shore with lithophytic algæ at Cheltenham, but there is nothing that in any way approaches a rock cliff.

Wherever a sea or lake erodes rather than deposits, there is commonly developed a sea cliff of greater or less dimensions. The material which is thus gathered may be deposited elsewhere in the form of beaches, and later the wind may take up the sands from the beach and form dunes. The Chicago area gives splendid examples of these two types of sea activity; to the north of the city is an eroding coast line with its bluffs, and to the south and southeast is a depositing coast with extensive areas of beach and dune.

The lake bluffs at Glencoe give an excellent opportunity for the study of the life history of a sea-cliff vegetation. There can be almost no other habitat in our climate which imposes such severe conditions upon vegetation as an eroding clay bluff. The only possible rival in this regard is a shifting dune, and even here the dune possesses some points of advantage so far as the establishment of vegetation is concerned. In the first place, the conditions as to exposure are almost identical with those of a dune; the heat of midday and of summer and the cold of night and winter are extremely pronounced; the intensity of the light and the exposure to wind make the conditions still more severe. In other words, the only plants that can grow on these lake bluffs, at least in the earlier stages, are pronounced xerophytes. Again, the character of the soil is unfavorable, for while the clay is wet in the autumn, winter, and spring, it dries out in the summer and becomes almost as hard as rock. In the heat of summer the conditions for vegetation are no better on the hard, dry slopes of a clay bluff than on the hot, dry sands of a dune. Finally, as to instability: it is doubtless the constant shifting of the sand which in the last analysis accounts for most of the poverty of the dune vegetation. It is similar on clay bluffs, for when the waves undermine the cliff at its base, the action of gravity causes great masses of material to fall down from the entire cliff face. Furthermore, when the clay is saturated with water, great portions of the cliff face slide down, entirely apart from the action of the sea or lake. At no time, then, is an eroding bluff any more stable than a naked dune.

It becomes evident from a survey of the bluff conditions that all vegetation is impossible so long as active erosion by the lake continues. Not only this, but vegetation at the top of the bluff is soon destroyed. *Fig. 30* shows a naked cliff of this character; at the top there can be seen overhanging turf, giving evidence both of the destructive action of the lake and also of the tenacity with which a grass mat holds its place in the presence of adverse conditions. Near the center of *fig. 31* may be seen a white oak which was almost overthrown by the erosive activities, but which has been preserved through the cessation of erosion at this point. The gully shown near the center of *fig. 30* is seen in closer view in *fig. 1*; the absence of vegetation, save that which has slid down from above, is very striking.

If for any reason the lake activities at the base of the cliff are stopped, an opportunity is offered for the development of vegetation. At Glencoe the cliff erosion has been checked to some extent by artificial means, and one can see various phases of cliff life within a small

FIG. 30.—Sea cliff along the eroding shore at Glencoe, exposing the morainic clay. Vegetation almost entirely absent. Projecting turf mats at the top show the tenacity with which the vegetation holds its ground in the face of the erosive forces.

area. When the erosion at the base of the bluff ceases, conditions become much more stable, though landslide action may still occur. In time the slope gradient becomes so low that the cliff soil is essentially stable; when this time arises vegetation develops with great rapidity in spite of the xerophytic conditions, which are still as pronounced as before. It is very obvious, therefore, that it is the instability of the eroding cliff and not its xerophytic character which accounts for the absence of plant life.

The first vegetation is commonly made up of xerophytic herbs, both annual and perennial. Among these are the sweet clover (*Melilotus alba*), various annual weeds, various species of Aster, especially

A. laevis, *Equisetum hyemale* (Scouring rush), various grasses, etc. Soon there develops a xerophytic thicket vegetation, such as is shown in *fig. 31*. This may be called the shrub stage of the captured cliff, and among the dominant species are the juniper and cedar (*Juniperus communis* and *J. Virginiana*), *Salix glaucophylla* (Glaucous willow), the

FIG. 31.—Sea cliff at Glencoe, at a place where lake erosion has ceased. Shrubs (largely cedars and willows) prominent as well as herbs. Absence of lake erosion also indicated by the gentle slope, as compared with *fig. 30*. The leaning oak at the top bears witness to former erosive forces.

osier dogwood (*Cornus stolonifera*), *Shepherdia Canadensis*, various sumachs (*Rhus typhina* and *R. glabra*). The following tree stage is dominated by various poplars (*Populus tremuloides*, *P. grandidentata*, *P. monilifera*), the hop hornbeam (*Ostrya Virginica*), the white pine (*Pinus Strobus*), the red cedar (*Juniperus Virginiana*), and some of the oaks (probably *Quercus rubra* and *Q. coccinea tinctoria*). *Fig. 32* shows a tree-clad cliff in which most of the above trees are to be found.

Whether a mesophytic forest would develop on a lake bluff is something of a question. It seems likely that semi-xerophytic trees will dominate there for a long time to come on account of the xerophytic atmospheric conditions. Particularly at the top of the bluff do the conditions remain severe, by reason of the great exposure, and also the dryness of the soil. If the lake should recede for some distance,

FIG. 32.—Sea cliff at Glencoe, where lake erosion has been absent for a long period. Xerophytic trees and shrubs, especially conifers, dominate, *e. g.*, white pine, red cedar, juniper.

a mesophytic forest could certainly develop on the bluff before it is reduced to anything like the common level. This is shown on the ancient lake bluff at Beverly Hills. Here there is an old cliff about forty feet above the country level, representing a lake bluff of the Glenwood stage of Lake Chicago. This bluff has long had a mesophytic forest on its slopes, and yet it will be many centuries before the erosive forces remove all traces of this ancient sea cliff. A still more striking case is to be seen north of Waukegan, where an ancient lake bluff, higher than that at Beverly Hills and only a mile back of the present lake shore, is tenanted by a high grade type of mesophytic forest.

It will be instructive to make a few comparisons between lake bluffs and other plant societies. Closest to the lake bluff in a physiographic sense is the river bluff. When a stream has banks of clay, the conditions seem decidedly similar, and yet the flora is not the same. A comparison of the lake bluffs at Glencoe with the bluffs along Thorn creek shows that some species are common, notoriously Ostrya, Rhus, Quercus, Populus. Yet the differences are still more striking, for the bluffs along Thorn creek do not show *Salix glaucophylla* nor Shepherdia; most striking of all, however, is the entire absence of conifers. When we compare the lake bluffs with the rock bluffs of the Illinois river, we find that the resemblances are greater than the differences, since the river bluffs have conifers, though even here some of the lake bluff forms are absent. When, however, we compare the Glencoe bluffs with the dunes, we find that all of the dominant shrubs and trees of the bluff are found also on the dunes; not only this—the dominant bluff forms are dominant on the dunes also.

The facts of the preceding paragraph are pregnant with significance. One obvious corollary is that, given similar soils but dissimilar conditions of atmospheric exposure, as at Glencoe and Thorn creek, the vegetation is unlike. Another and more striking corollary is that, given the most dissimilar soils possible, viz., the Glencoe clay and the dune sand, we still have similar vegetation, because the atmospheric conditions are the same in the two cases. The evidence of the Illinois river bluffs is less clear; they are more xerophytic than the bluffs along Thorn creek; but whether this is chiefly due to rock as against clay, or to greater exposure, is not certain. At all events, these facts show that it is not enough to know about chemical or physical conditions in the soil. We cannot divide plants into those of clay, rock, and sand, but must take into account that most plants have a wide range of life, so far as soil is concerned, provided the atmospheric conditions are congenial. The chief exception to this statement seems to be found, not in the original soils, but in the superimposed humus. There are many plants that require humus for their occurrence in nature, but it makes no difference whether the subsoil is rock, sand or clay, provided alone that the humus is present in sufficient quantity. It is by reason of this last fact that the mesophytic forest can appear in all conditions in this climate, since the mesophytic forest is associated to a high degree with humus.

2. THE BEACH-DUNE-SANDHILL SERIES.

A. *The beach.*—The author has previously discussed in considerable detail the dynamics of the dune societies,[1] and it will not be necessary to do more here than to summarize the chief conclusions, and add

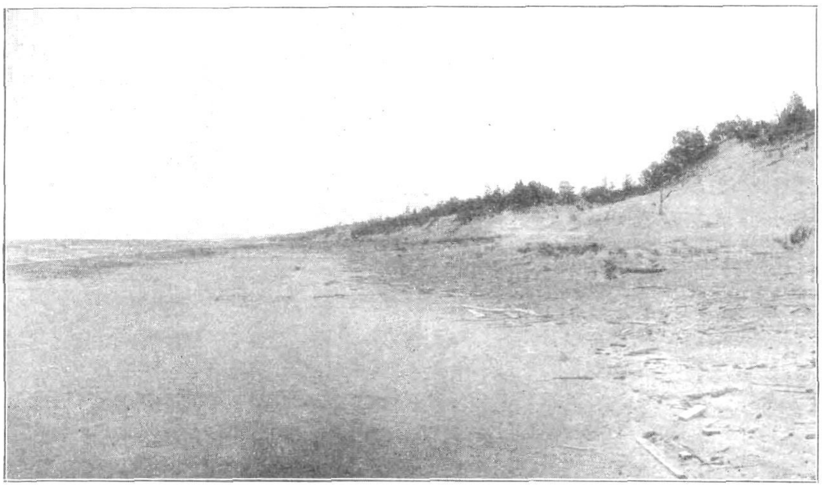

FIG. 33.—Beach at Dune Park, showing the smooth and naked lower beach, the middle beach with its line of débris, the upper beach with scattered shrubs, and the dunes.

a few new data. Before long it is expected that a paper will appear giving the changes that have taken place since the first observations were made in 1896.

The beach in the Chicago area is xerophytic throughout. There is nothing analogous to the salt marshes of the Atlantic coast, nor to the hydrophytic shores farther north along Lake Michigan. The lower portion of the beach is exposed to alternate washing by the waves and desiccation in the sun, and is devoid of life. The middle beach, which is washed by winter waves, though not by those of summer, has in consequence a vegetation of xerophytic annuals, the most prominent of which is *Cakile Americana* (Sea rocket). The upper beach is beyond

[1] COWLES, H. C.: The ecological relations of the vegetation on the sand dunes of Lake Michigan. BOT. GAZ. 27: 95-117, 167-202, 281-308, 361-391. 1899. Also reprinted separately.

present wave action, and is tenanted by biennials and perennials in addition to the annuals. *Fig. 33* shows a beach of this type, the lower beach being smooth and even, the middle beach covered with débris, while the upper beach has a scattered perennial vegetation.

The beach at the base of cliffs shows similar subdivisions, though the zones are much narrower as a rule. The vegetation, too, is much the same, though some forms, as Strophostyles, have not been seen as yet on the beaches of the dune district. At the foot of cliffs there often occur alluvial fans of sand, which have been deposited by the torrents during and following rain storms. These fans have a comparatively rich vegetation, and species sometimes occur here that are not found elsewhere on the beach.

B. *The embryonic or stationary beach dunes.*—Wherever plants occur on a beach that is swept by sand-laden winds, deposition of sand must take place, since the plants offer obstacles to the progress of the wind. If these plants are extreme xerophytes and are able to endure covering or uncovering without injury, they may cause the formation of beach dunes. Among the dune-forming plants of this type are *Ammophila arundinacea* (Sand reed), *Salix glaucophylla* and *S. adenophylla* (Glaucous and glandular willows), *Prunus pumila* (Sand cherry), and *Populus monilifera* (Cottonwood). The shapes of these beach dunes vary with the characteristics of these dune-forming plants. Ammophila dunes are extensive but low, because of strong horizontal rhizome propagation. Prunus and Populus dunes are smaller but higher, because of the relative lack of horizontal propagation and the presence of great vertical growth capacity. Dunes are formed more slowly in protected places, and here the dune-forming species may be plants that are ill adapted to the severest beach conditions, such as the creeping juniper. A beach dune of the type just described is shown in *fig. 34*.

C. *The active or wandering dunes. The dune complex.*—The stationary embryonic dunes on the beach begin to wander as soon as the conditions become too severe for the dune-forming plants. The first result of this change is seen in the reshaping of the dune to correspond with the contour of a purely wind-made form. The rapidity of this process is largely determined by the success or failure of the dune-formers as dune-holders. The best dune-holders are Calamagrostis, Ammophila, and Prunus.

There are all gradations between a simple moving dune and a moving landscape; the latter may be called a dune-complex. The complex

FIG. 84.—Embryonic dune on the beach at Cheltenham, formed by the sand reed, Ammophila.

FIG. 35.—General view at Dune Park, showing the encroachment of a dune on swamps and forests.

is a restless maze, advancing as a whole in one direction, but with individual portions advancing in all directions. It shows all stages of dune development and is forever changing. The windward slopes are gentle and are furrowed by the wind, as it sweeps along; the lee slopes are much steeper. The only plant that flourishes everywhere on the complex is the succulent annual, *Corispermum hyssopifolinm* (Bugseed), although *Populus monilifera* (Cottonwood) is frequent. The scanty flora is not due to the lack of water in the soil, but to the instability of the soil and to the xerophytic air.

The influence of an encroaching dune upon a pre-existing flora varies with the rate of advance, the height of the dune above the country on which it encroaches, and the nature of the vegetation. The burial of forests is a common phenomenon. The dominant forest trees in the path of advancing dunes are *Pinus Banksiana* (Scrub pine) and *Quercus coccinea tinctoria* (Black oak). These trees are destroyed long before they are completely buried. The dead trees may be uncovered later, as the dune passes on beyond. A pine forest upon which a dune is encroaching is shown in *fig. 35*, while such a forest after the dune has passed is shown in *fig. 36*.

In the Dune Park region there are a number of swamps upon which dunes are advancing. While most of the vegetation is destroyed at once, *Salix glaucophylla*, *S. adenophylla*, and *Cornus stolonifera* (Osier dogwood) are able to adapt themselves to the new conditions, by elongating their stems and sending out roots from the buried portions. Thus hydrophytic shrubs are better able to meet the dune's advance successfully than any other plants. The water relations of these plants, however, are not rapidly altered in the new conditions. It may be, too, that these shrubs have adapted themselves to an essentially xerophytic life through living in undrained swamps. Again, it may be true that inhabitants of undrained swamps are better able to withstand a partial burial than are other plants. A swamp upon which a dune encroaches is shown in *fig. 35*.

Vegetation appears to be unable to capture a rapidly moving dune. While many plants can grow even on rapidly advancing slopes, they do not succeed in stopping the dune. The movement of a dune is checked chiefly by a decrease in the available wind energy, due to increasing distance from the lake or to barriers. A slowly advancing slope is soon captured by plants, because they have a power of vertical growth greater than the vertical component of advance. Vege-

FIG. 36.—Pine graveyard at Dune Park; these trees grew on a lakeward continuation of the ridge shown in *fig. 35*. Thus these two figures represent a pine society before and after a dune has passed over it.

tation commonly gets its first foothold at the base of lee slopes about the outer margin of the complex, because of soil moisture and protection from the wind. The plants tend to creep up the slopes by vegetative propagation. Antecedent and subsequent vegetation work together toward the common end. Where there is no antecedent vegetation, Ammophila and other herbs first appear, and then a dense shrub growth of Cornus, Salix, *Vitis cordifolia* (Frost grape), and *Prunus Virginiana* (Chokecherry). Capture may also begin within the complex, especially in protected depressions, where *Salix longifolia* is often abundant.

D. *The established dunes.*—No order of succession in this entire region is so hard to decipher as is that of the established dunes. There are at least three types of these dunes so far as the vegetation is concerned, and it is not yet possible to figure out their relationships. The continuation of the conditions as outlined in the preceding paragraph results in a forest society on the lee slope, in which is found the basswood, together with a most remarkable collection of mesophytic trees, shrubs, and climbers, which have developed xerophytic structures. These dunes are evidently but recently established, as is shown by the absence of a vegetation carpet; furthermore, the slopes are almost always steep.

Again, there are forest societies in which the pines dominate, either *Pinus Banksiana* or *P. Strobus* (White pine). These arise from a heath, composed in the main of Arctostaphylos (Bearberry) and Juniperus. The heath appears to originate on fossil beaches or on secondary embryonic dunes or other places where the danger of burial is not great. It will be noted that both the heath and the pine forest are dominated by evergreens. These societies commonly occur near the lake or on lakeward slopes, which are northern slopes as well. On these coniferous dune slopes there is to be found another notable collection of northern plants, resembling ecologically the peat bog plants already mentioned. Heaths and coniferous forests also occur on sterile barren sand and in depressions where the conditions are unfavorable for deciduous forests. A slight change in the physical conditions may bring about the rejuvenation of the coniferous dunes, because of their exposed situation. This rejuvenation commonly begins by the formation of a wind sweep, and the vegetation on either hand is forced to succumb to sand-blast action and gravity.

A third type of established dune is that in which the oaks predominate, and especially *Quercus coccinea tinctoria.* The oak dunes are more common inland and on southern slopes. Probably the oaks follow the pines, but the evidence on which this is based is not voluminous. The pines certainly have a wider range of habitat than the oaks, occurring in wetter and in drier soil, and also in more exposed situations. The mutual relations of the pines and oaks are certainly

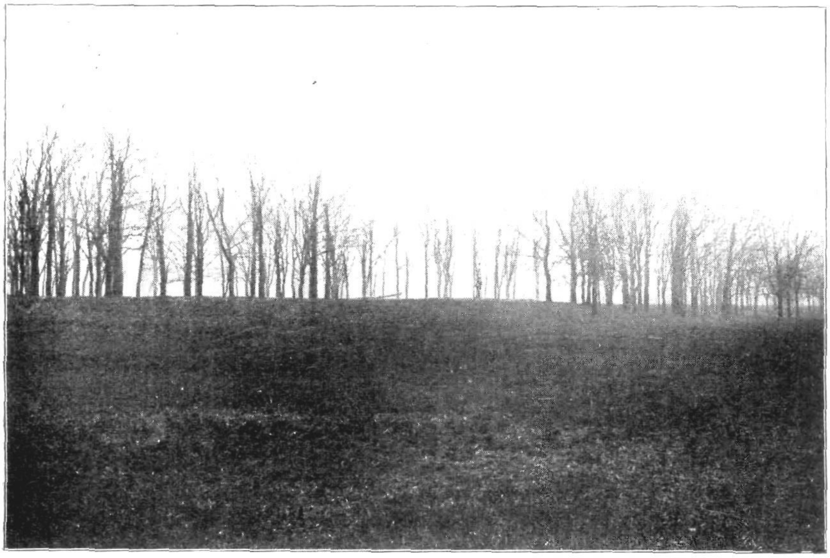

FIG. 37.—Portion of an ancient beach line (Calumet beach) at Summit, showing the characteristic oak vegetation, in this case chiefly bur oaks (*Quercus macrocarpa*).

interesting and deserve some very careful study. Pine forests prevail on the north or lakeward slopes, and oak forests on the south or inland slopes. With the pines are other northern evergreen forms, such as Arctostaphylos, while with the oaks are Opuntia, Euphorbia, and other more southern types. The density of the vegetation on the north side is also in contrast with the sparser and more open vegetation of the south side. The cause for this radical difference on the two slopes is doubtless complex, but it is obvious that the north slope has greater moisture, shade, and cold, and probably more wind. Which of these is the more important is not certain, but the presence of the northern species seems in favor of cold or wind as the chief factor.

There are a number of interesting sand hills and ridges at some distance from the lake. Some of these are fifteen miles from the present lake shore, while others are found at various intervals nearer and nearer the lake. It has been found that these can be grouped for the most part into three series, representing three beach lines of Lake Chicago, as the glacial extension of Lake Michigan has been called.

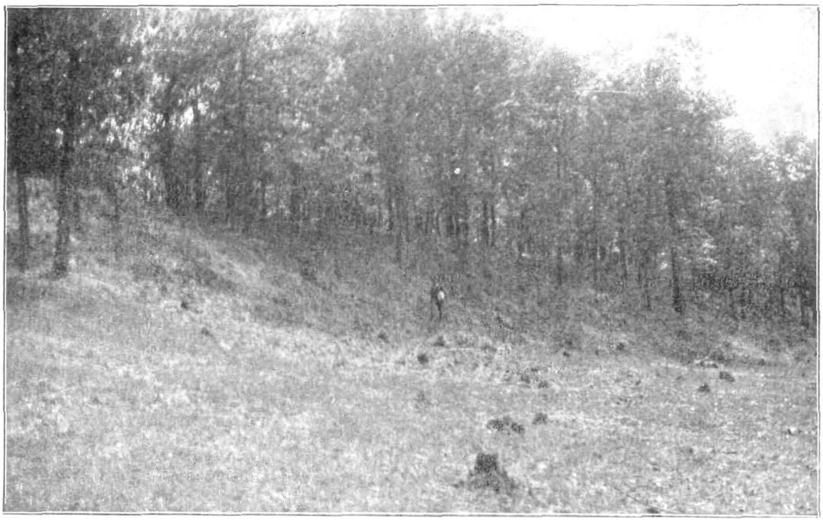

FIG. 38.—Portion of an ancient beach (Glenwood beach) near Thornton. The trees here are chiefly black oaks (*Quercus coccinea tinctoria*); the beach is higher, and the trees more luxuriant than usual.

The upper and oldest of these ridges has been termed the Glenwood beach, the intermediate ridge the Calumet beach, and the lower and younger ridge the Tolleston beach. The geographical relations of these beaches is well discussed by Leverett, and also by Salisbury and Alden, and nothing need be said here except as to the vegetation. In general these ridges and hills have a xerophytic forest flora, dominated by the bur, black, and white oaks (*Quercus macrocarpa*, *Q. coccinea tinctoria*, *Q. alba*). The proportions between these trees varies strikingly, though the bur or black oak is usually the chief character tree. No satisfactory reason can yet be given for these variations, though the bur oak appears to be more abundant on the lower and less drained ridges, while the black oak is more abundant on the higher ridges. The shrub undergrowth is commonly sparse, and the most frequent members of this stratum are the hazel (*Corylus Americana*), Rosa, the New Jersey tea (*Ceanothus Americanus*), *Salix humilis*, the low blueberry (*Vaccinium Pennsylvanicum*), and the huckleberry (*Gaylussacia resinosa*). Among the commoner herbs are *Silene stellata, Antennaria plantaginifolia, Heuchera hispida, Rumex Acetosella* (Field sorrel) *Carex Pennsylvanica, Potentilla argentea* (Silvery cinquefoil), *Poa compressa, Pteris aquilina* (Brake), *Ceratodon purpureus*. In open places there are often almost pure growths of Poa or Potentilla. *Figs. 34* and *35* show portions of these ancient beaches in which the oaks dominate; *fig. 34* shows, perhaps, the more common condition, *i. e.*, a rather low beach with a sparse tree growth.

The future of the vegetation on the established dunes and beaches is somewhat problematical. From analogy with other plant societies in this region, and from established dunes in Michigan, we should expect a mesophytic forest, probably of the white oak-red oak-hickory type at first, and then followed by a beech-maple forest. There are evidences that some such changes are now taking place. On many of the oak dunes, especially where protected from exposure, there is already a considerable accumulation of humus. Herbaceous ravine mesophytes, like Hepatica, Arisæma, and Trillium, are already present, and with them mesophytic shrubs and trees, including the sugar maple itself, though the beech has not been found on the dunes of our area, as it has in Michigan. One might expect that the flora of the older Glenwood beach would have advanced more toward the mesophytic stage than has the flora of the younger Tolleston beach. Such, indeed, seems to be the case, especially at Glenwood, where the white oaks are more numerous, and the black oaks much larger and more luxuriant. The humus is richer, and most things look as if the age of this beach were notably greater than that of the Calumet or Tolleston beaches. This subject, however, needs much further investigation. In any event, one character of the sand hill stands out in bold relief, viz., its great resistance to physiographic change. Not only is its erosion slower than that of the clay hill, but the advance of its vegetation is vastly slower at all points along the line. The slowness of humus accumulation accounts for this, perhaps, more than all else.

APPENDIX.

THE PRINCIPAL LOCALITIES ABOUT CHICAGO FOR THE STUDY OF PLANT SOCIETIES.

In the following list of localities it will be convenient to discuss the various districts about Chicago in regular order from north around to southeast, using the various railroads and suburban street-car lines as bases for discussion. The figures in parentheses after the various towns indicate the railway mileage from the Chicago terminal station of the particular railroad involved. References to pages are inserted, showing where the various plant societies mentioned are described in the body of the text. The accompanying maps show the geographic and physiographic features of the places mentioned.

A number of the interesting localities about Chicago, as indicated below, can be reached at small expense by utilizing the suburban street-car lines. From the standpoint of expense, and often of convenience, though not of time, the street-car lines are perhaps the best means of transportation for the points which they reach. However, some of the railroads, notably the Illinois Central and the Chicago Terminal Transfer, sell suburban tickets for but slightly more than street-car rates. Most of the railroads sell cheap ten and twenty-five ride tickets, good for bearer, to the various points named below. These tickets are usually good for one year from date of sale, though on the Michigan Central and Lake Shore and Michigan Southern railways these tickets are good for but one month. On some railroads, especially the Wabash, Chicago and Eastern Illinois, and Chicago, Rock Island and Pacific, the above-named tickets are good until used. All of the railroads make rates for parties of sufficient size.

The places that can be reached by street-cars are briefly mentioned in connection with the various railroads, but it may be well to make a general statement about the suburban street-car system of Chicago and vicinity. The Evanston street-car line passes near the dune, beach, and swamp region about Edgewater. (See C., M. & St. P. below.) The Chicago, Waukegan and Milwaukee car line reaches all the districts along the north shore, as described on the line of the C. & N. W. railway. The suburban service northwest is not good. Oak

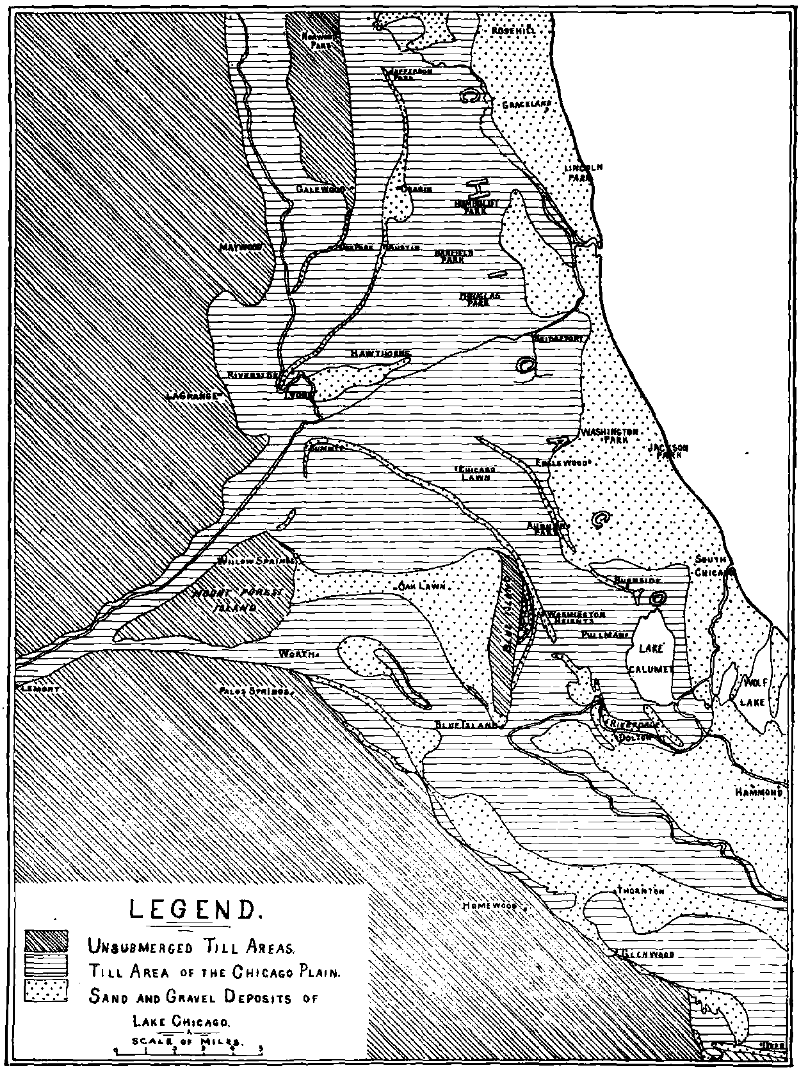

FIG. 39.—Map showing the general distribution of the morainic uplands, prairie and swamp areas, and postglacial beach deposits of the Chicago area (Salisbury and Alden).

Park, River Forest, and Maywood (see C. & N. W.) can be reached by the Cicero and Proviso street-car line. The La Grange suburban car line passes through Riverside and Grossdale (see C., B. & Q.). The Chicago and Joliet line, southwest, reaches all points described on the C. & A. or A., T. & S. F. railways. On the south side, the Chicago General and Chicago City railways run for a short distance along the drainage canal. The Chicago City railway also reaches the prairie districts west of Englewood (see C. T. T. and C. & G. T. railways). The Morgan Park and Blue Island street railway enters an interesting territory (see C., R. I. & P. and C. T. T. railways). This line now terminates at Harvey (I. C. R. R.). The Calumet street railway reaches Hog Island (P., F. W. & C. Railway; Stony Island (reached only by street-cars); Calumet lake, Pullman, and West Pullman (see I. C. R. R.). The South Chicago city railway reaches Cheltenham (I. C. R. R.), Irondale (Calumet lake and low prairies), Roby, Whiting, Hammond, and East Chicago (P., F. W. & C. Railway); this last named line traverses a country rich in lakes, swamps, and ancient beach lines.

North.—The most interesting localities north of Chicago are along the line of the CHICAGO AND NORTHWESTERN railway, Milwaukee division; all of these points can also be reached by the Waukegan and Milwaukee street-car line, which starts from Evanston. In the vicinity of *Rose Hill* (8) and *Rogers Park* (9) there are numerous old beach lines of the Tolleston stage, with their characteristic oaks (p. 64); between the ridges are old lake basins, with peaty soil, commonly utilized for truck farming. At *Wilmette* (14) the ground is low and flat, but well forested, with the characteristic trees of low moraines (p. 48) and morainic swamps (p. 40). From *Winnetka* (17) to *Lake Bluff* (30) there are magnificent places for study: clay ravines in all stages of development (p. 13); lake bluffs, now naked, now grown up to shrubs and trees (p. 50) and upland morainic forests (p. 47). The ravines and lake bluffs are particularly fine, and are nowhere else so well developed. West of Winnetka and Glencoe is Skokie marsh, which shows all the stages between swamp and prairie (p. 35). North and south of *Waukegan* (36) are small but interesting dunes (p. 57) and many dying ponds and swamps; an ancient lake bluff at this point also presents interesting features.

At *Edgewater* (7), which may be reached by the CHICAGO, MILWAUKEE AND ST. PAUL railway, Evanston line, or by the Chicago and Evanston street-car line, there are some excellent dunes with a natural

FIG. 40.—Map showing the various localities in the Chicago area that are mentioned in the text. Scale: about 7.2 miles to the inch.

vegetation (p. 57), also old beach lines (p. 64), and dying swamps (p. 35). Along the Milwaukee division of the C., M. & St. P. railway, there are good opportunities for the study of the river series along the north branch of Chicago river. There is an excellent flood plain forest (p. 22) at *Forest Glen* (10), and from here to *Oak Glen* (16) there are good river conditions, and also upland forests. Two miles west of *Deerfield* (24) there is an extensive forested country, oaks dominating for the most part, but with many maples towards the Desplaines river (p. 49).

Northwest.—The WISCONSIN CENTRAL railway runs rather close to the Desplaines river for many miles; studies of flood plain forests (p. 25) may be made by walking about a mile east at *Franklin Park* (15), *Desplaines* (23), *Wheeling* (30), and *Prairie View* (34). From this latter point the splendid forests referred to in the preceding paragraph can be reached as conveniently as from Deerfield. The CHICAGO AND NORTHWESTERN railway, Wisconsin division, crosses the Desplaines river at *Desplaines* (17), at which point there is a fair place for flood plain study. At *Barrington* (32) there are interesting morainic forests; three miles northeast is Lake Zurich.

The most interesting country northwest of the city is along the CHICAGO, MILWAUKEE AND ST. PAUL railway, Elgin line. At *Galewood* (9) the Glenwood beach is very prominent, and a marked contrast is shown between the tree vegetation of the beach (p. 64), and the prairie to the east (p. 42). West of *Glendon Park* (12), where the railroad crosses Desplaines river, is one of the finest forest districts near Chicago; the flood plain flora (p. 25) merges gradually into the flora of the flat moraine (p. 48), with morainic swamps (p. 40). At *Woodale* (19) the railroad crosses Salt creek; along this stream there are upland forests (p. 47), as well as various phases of stream vegetation. There are extensive morainic forests with oaks and hickories west of *Bartlett* (30).

West.—The CHICAGO AND NORTHWESTERN railway, Galena division, passes through an extensive prairie district in the west part of Chicago, now largely built up. The Calumet beach is crossed at *Austin* (7) and the Oak Park spit at *Oak Park* (8), but the original oak vegetation has largely been destroyed. At *River Forest* (10) an excellent flood plain forest is still preserved (p. 25). Northwest of *Elmhurst* (16) there are some morainic forests (p. 47), which grade into flood plain forests along Salt creek. Near *Glen Ellyn* (22) there are interesting morainic forests, especially in association with the east branch of Dupage river. The places mentioned in this paragraph, except Elmhurst and Glen Ellyn, can be reached by street-cars.

The CHICAGO GREAT WESTERN railway passes through essentially the same territory as the Chicago and Northwestern. The Oak Park spit is crossed at *Forest Home* (10), and the natural vegetation shows fairly well at this point (p. 64). The Desplaines river is crossed between Forest Home and Maywood, but the flood plain vegetation has been somewhat altered by artificial agencies. The morainic country west of *Maywood* (12) is largely tilled. The ILLINOIS CENTRAL railroad, Omaha line, also passes through the country just described. Interesting studies of the first vegetation on clay soil (p. 48) can be made along the drainage canal at *Lawndale Ave.* (7), *Crawford Ave.* (8), or *Hyman Ave.* (9); this part of the canal can also be reached by the street-car lines. The Calumet beach, which shows the usual oak vegetation (p. 64), is crossed at *Parkway Ave.* (12). At *North Riverside* (13) the Desplaines is crossed and a good flood plain forest can be observed (p. 25). At *Hillside* (17) there is a limestone cut, a rare feature about Chicago; rock vegetation (p. 44) can be finely studied here. From *Addison* (24) the forests along Salt creek, referred to in the preceding paragraph, can be easily reached.

The CHICAGO, BURLINGTON AND QUINCY railroad passes through a country of much interest. Extensive prairies are seen from Chicago to *Riverside* (11); at this latter place is a splendid field for study, the bottoms of the Desplaines river being covered with a luxuriant flood plain forest (p. 25). On the east bank of the river the Calumet beach (p. 64) and the xerophytic river banks (p. 18) show the usual features. At *East Grossdale* (12) the Salt creek flood plains may be seen; this stream empties into the Desplaines about half a mile from the station. Between *Western Springs* (15) and *Hinsdale* (17) is an excellent region for study; the headwaters of Flag creek are in a rather poorly drained swamp (p. 35); west of this is a typical morainic topography with considerable areas of forest (p. 47). North of Hinsdale there are also morainic forests and a number of interesting places along Salt creek. Morainic forests with maples as well as oaks may be seen at *Downer's Grove* (21). There are forests along the branches of the Dupage river at *Lisle* (24) and *Naperville* (28).

Southwest.—The CHICAGO AND ALTON railway, the ATCHISON, TOPEKA AND SANTA FE railway and the Chicago and Joliet street-car line pass through identical territory and may be considered together. The drainage canal is accessible for its entire length on all of these lines. Within the city limits, especially near *Corwith* (7), the development of a new vegetation can be well studied on the great clay piles along the canal (p. 48). From *Summit* (12) to *Joliet* (37) the railroads follow the Desplaines river, as well as the canal, and at various points the underlying limestone comes closer to the surface than is usually the case, permitting the study of its influence on the vegetation (p. 44). At Summit the Calumet beach shows the characteristic beach line vegetation (p. 64). At *Willow Springs* (18) is an excellent place for the study of morainic forests (p. 47), ravines (p. 13), and flood plain vegetation (p. 22). The rock débris from the canal has an interesting vegetation here also. At *Sag Bridge* (22), besides the morainic forests, the difference between the well-drained plant societies along the river and the poorly drained societies (p. 35) along the Feeder is well shown. The vegetation of rock outcrops can be especially well seen near *Lemont* (25). Along Fraction run, a mile south of *Lockport* (33), are to be seen perhaps the best rockbound ravines near Chicago (p.); the beginnings of the flood plain vegetation are well shown here, as well as the later stages along the river (p. 15).

The WABASH railway, St. Louis line, passes through the usual prairie district (p. 42) between *Englewood* (7) and *Oak Lawn* (15); at this latter place the Calumet beach is crossed and the characteristic trees may be seen (p. 64). Between Oak Lawn and *Worth* (18) the Feeder is crossed, which shows the transitions between swamp and prairie (p. 35). At Worth morainic forests occur, although this area was submerged in the earlier lake stages. South of Worth there are more areas of swamp and prairie along a tributary of the Feeder, also a beach line with the customary oaks. At *Palos Springs* (20) is one of the finest places in the Chicago area for the study of all phases of vegetation in a morainic region which has been eroded. About two miles northwest of the station are to be seen all types of morainic forests (p. 47) and morainic swamps (p. 40). All phases of river activity from the ravine to the flood plain may also be studied here (p. 13). A short distance north is the Sag, with its extensive swamps. At *Orland* (24) and *Alpine* (27) the morainic societies are also well developed.

The CHICAGO, ROCK ISLAND AND PACIFIC railway crosses the Calumet beach at *Washington Heights* (13), at which point the oak vegetation is well developed (p. 64). This beach is followed to *Blue Island*

(16); otherwise the vegetation between Englewood and Blue Island is chiefly prairie. A branch line of this railroad passes through Beverly Hills and Morgan Park, joining the main line again at Blue Island. All along this branch there are fine opportunities for the study of morainic forests (p. 47), beach line forests, and prairies. At *Beverly Hills* (12) there are interesting ravines (p. 13), and also a fairly well developed flood plain (p. 22). All the points thus far mentioned in this paragraph, except Beverly Hills, can be reached by street-cars. Beyond Blue Island are low prairies. At *Dupont* (21) sharp transitions are seen between the prairie, beach line, and morainic forest. At *Tinley Park* (23) and *Mokena* (30) are morainic forests (p 47). *New Lenox* (34) is an excellent place for study, showing morainic forests of the maple type as well as oak, and also fine flood plain forests along Hickory creek. This railroad furnishes the most direct route to *Starved Rock, Utica* (94); see pp. 15, 20, 24.

South.—The ILLINOIS CENTRAL railroad, main line south, crosses a region of swampy prairie between *Grand Crossing* (9) and *Burnside* (12); at this latter place the Tolleston beach is crossed, showing the typical vegetation (p. 64). *Pullman* (14) is perhaps the most convenient point from which to study Lake Calumet, together with the swamp and prairie derived therefrom (p. 33). At *Riverdale* (17) the Little Calumet river, which shows flood plain forests (p. 22) and xerophytic bluffs (p. 18), is crossed, as is also the Tolleston beach for the second time. At *North Harvey* (19) the river is again crossed. In the neighborhood of *Harvey* (20) are extensive prairies. Between *Hazel Crest* (22) and *Homewood* (23) the Calumet and Glenwood beaches are crossed, showing very interesting conditions, especially east of Homewood; ancient dunes of considerable size and dying peat bogs (p. 39) are found in profusion. South of *Flossmoor* (25) morainic (p. 47) and flood plain forests are well shown along Butterfield creek. The Blue Island branch of the I. C. R. R. passes through *West Pullman* (17), where are to be found splendid illustrations of beach line vegetation, and also undrained swamps; about a mile to the south is the Little Calumet river, with a well developed flood plain forest. The South Chicago branch of this railroad crosses numerous recent beach lines, and at *Cheltenham* (11) runs close to the lake shore, where a recent beach and dune flora (p. 56), and also the vegetation of a rocky shore, may be studied. All the places named in this paragraph can be reached by street-cars, except Riverdale, Hazel Crest, Homewood, and Flossmoor.

The CHICAGO AND EASTERN ILLINOIS railroad. At *Auburn Park* (9) the Tolleston beach shows the usual beach features (p. 64). A low prairie is crossed beyond *Kensington* (14). At *Dolton* (17) the same features are shown as at Riverdale (I. C. R. R.). Near *South Holland* (19) are extensive low prairies, also the Little Calumet river, with low xerophytic bluffs. *Thornton* (22) and *Glenwood* (23) are points of great interest; nowhere about Chicago are there to be found better illustrations of the various phases of stream history than along Thorn creek (pp. 19, 25). West of Thornton are the ancient dunes and swamps already mentioned (see Homewood, I. C. R. R.). At *Chicago Heights* (27) there are morainic forests (p. 47) and swamps (p. 40), and also the various stream phases.

The CHICAGO TERMINAL TRANSFER railroad crosses the prairie district west of Englewood. At Sixty-ninth street (also reached by street-cars), is one of the best places for a prairie study (p. 42). Between Ninety-first street and *Morgan Park* morainic swamps (p. 40) and forests (p. 47) are well displayed. West of Morgan Park there are interesting ancient dunes and beach lines (p. 64), which may also be reached by street-cars. This road then passes through Blue Island, Harvey (see I. C. R. R.), Glenwood, and Chicago Heights (see C. & E. I. R. R.).

The CHICAGO, INDIANAPOLIS AND LOUISVILLE railway (Monon Route) follows along the Tolleston beach between Auburn Park and Burnside, passes near *Stony Island* (p. 44); this interesting point can be conveniently reached only by street-cars; then through extensive low prairies to the east of Lake Calumet. After crossing the Calumet river, beach lines and swamps are seen on all sides (see Hegewisch and Hammond, P., F. W. & C. Railway). Beyond *Hammond* (21), also reached by street-cars, are many oak-clad ridges (p. 64) and undrained swamps (p. 35), mostly connected with the Tolleston beach. South of the Little Calumet river the Calumet beach line is crossed near Maynard; south of *Maynard* (26) are great areas of swamp and prairie. At *Dyer* (29) the Glenwood beach, with interesting ancient dunes, is seen. Beyond this are extensive morainic forests (p. 47). At *Cedar Lake* (40) lake and forest vegetation are well shown.

Southeast. — THE CHICAGO AND GRAND TRUNK railway passes through much the same country as the C. T. T. R. R. (see above) between Chicago and Blue Island. All types of prairie vegetation are excellently shown at *Chicago Lawn* (10), also reached by street-cars.

Beyond Blue Island this road passes through Harvey (see I. C. R. R.), and crosses Thorn creek (see C. & E. I. R. R.). At *Oak Glen* (28) the Calumet beach shows ancient dunes with the usual vegetation (p. 62). Beyond *Maynard* (31) are extensive swamps. At *Griffith* (36) are beach lines, and at *Ainsworth* (45) and beyond this road passes through a morainic country.

The PITTSBURG, CINCINNATI, CHICAGO AND ST. LOUIS railway (Pan Handle Route) traverses the prairie district west of Englewood, crosses beach lines at Washington Heights (see C., R. I. & P. Ry.), West Pullman and Riverdale (see I. C. R. R.), and Dolton (see C. & E. I. R. R.). After crossing the Little Calumet river the Calumet beach is quickly reached at *Lansing* (27; see Oak Glen, C. & G. T. Ry.). Beyond *Maynard* (29) are swamps and low prairies, and at *Schererville* (34) are extremely interesting ancient dunes connected with the Glenwood beach. Beyond this the country is morainic.

The CHICAGO AND ERIE railroad uses the the same tracks as the C. I. & L. as far as *Hammond* (21). Beyond Hammond, also, the same features are to be seen as on the road just mentioned. The Calumet beach is crossed at *Highlands* (26), and beach lines are well developed at *Griffith* (29).

The PITTSBURG, FORT WAYNE AND CHICAGO (Pennsylvania) railway. At *Constance* (11) are extensive prairies, showing the stages of development (p. 42); Hog Island, with a small area of morainic swamp forest (p. 40) is a short distance southwest. At *Roby* (15) Wolf lake shows all stages of development between lake and prairie, as at Calumet lake (I. C. R. R.); there are also many beach lines with oaks in this neighborhood (p. 64). Constance and Roby can also be reached by street-cars. Between *Whiting* (17) and *Hobart* (34) this railroad crosses a great number of swamps and beach lines. Among the best places for study are *Clarke* (24), where forested beach lines and undrained swamps are finely shown; the Grand Calumet river is close by, with a rich aquatic and marginal vegetation. The Tolleston beach line is well displayed at *Tolleston* (27), and the Calumet beach may be seen at *Liverpool* (31). A branch line of the P., F. W. & C. Ry. passes through *Hegewisch* (18), from which place Wolf lake (see above) and various beach lines can be studied. *Hammond* (22) and *East Chicago* (23), also reached by street-cars, are the best places near Chicago for studying the typical swamps and sandy ridges of the dune region; Grand Calumet river, with its interesting aquatic and marsh vegetation, is accessible from either town.

The New York, Chicago and St. Louis (Nickel Plate) railroad passes through the same territory as the C. I. & L. as far as Hammond, but has a station at Hegewisch (see P., F. W. & C. Ry.). The country beyond Hammond has the beach lines and swamps as described on other roads. The swamps and ancient dunes are well displayed at *Glen Park* (30). West of *Hobart* (35) is an interesting morainic island in the lake plain.

The Lake Shore and Michigan Southern railway passes through one of the most interesting districts about Chicago, and is the most convenient route to the dune region. As far as Whiting this road runs parallel to the P., F. W. & C. Ry. Beyond *Whiting* (17) are many low sand ridges with pines and depressions with water lilies; farther on are higher ridges with oaks (p. 62) and depressions with swamps (p. 35) instead of pools; these types of vegetation can be well studied at *Pine* (23). *Miller* (30) is a place of great interest, showing living dunes and the rich aquatic and marsh vegetation of Grand Calumet river (p. 41) to the north, the ancient dunes of the Tolleston beach, Cassandra and tamarack swamps to the south and southeast. *Dune Park* (35) is far the best place to study living dunes in all phases (p. 57); established dunes and undrained swamps are also well displayed at this point. *Chesterton* (41) is, all things considered, the most interesting place in the vicinity of Chicago, since it shows types of nearly all plant societies discussed in this paper; all phases of the river series from the ravine to the flood plain; all stages from pond to prairie; all types of dune activity, past and present; and morainic forests. Spring brooks are best shown at this point, also the beech-maple forests.

The Michigan Central railway diverges from the I. C. R. R. at *Kensington* (13), passes across the swamps and prairies associated with Lake Calumet, crosses an oak ridge and Little Calumet river. Beyond *Hammond* (20) are the numerous swamps and ridges as described above. At *Tolleston* (29) the Tolleston beach is finely displayed (p. 62), and a remarkably sharp transition is shown between this ancient line of dunes and the broad marshes associated with the Little Calumet river (p. 41). At *Lake* (35) the Calumet beach and Deep river are interesting fields for study; the railroad follows the beach line for a number of miles. *Porter* (44) corresponds with Chesterton on the L. S. & M. S. Railway (q. v.), and is a place of the greatest botanical and physiographic interest. Between Porter and *Michigan City* (56) the railroad crosses a peninsular portion of morainic territory and then follows somewhat closely the present shore, affording a splendid view of the dunes.

The Baltimore and Ohio railroad passes through the same general territory as the L. S. & M. S. Railway between *Whiting* (25) and *Miller* (38); see above), but somewhat nearer the lake. Dunes, both living and dead, as well as swamps, can be seen at *Edgemoor* (30) and *Grand Calumet Heights* (35). Beyond Miller this road passes through a very interesting swamp region, including Cassandra and tamarack swamps (p. 35); ancient dunes of the Tolleston and Calumet beaches are also well displayed.

The Wabash railway, Buffalo line, uses the same tracks as the C., I. & L. Railway to *Hammond* (21); here, as well as at *East Chicago* (22) and *Tolleston* (29), the conditions are as noted above for the P. F. W. & C. Railway. *Aetna* (33) corresponds to Miller on the L. S. & M. S. Railway. Near *Crocker* (42) the various stream phases (p. 13) are well illustrated along Salt creek.