THE ORIGIN OF THE INDIANA FLORA.

BY JOHN M. COULTER AND HARVEY THOMPSON.

It is only in recent times that any other place of origin was proposed for plants than that in which they are now found growing. It was thought that plants were absolutely fixed, and that they must either endure or succumb to any changes of climate which were unfavorable to them. The notion was derived, of course, from the fixedness of the individual plant, and so far as that was concerned it was correct. It has always been known that animals have migrated before unfavorable conditions, but in most people's minds these migrations have taken the form of actual and long marches of individuals, as of buffaloes, searching for water. Such migrations of individuals would be caused by some sudden and very radical change in climate, and of course under such circumstances plants would be helpless. But since cataclysms or sudden catastrophes have ceased to be a part of the geological creed, and have been replaced by a belief in very gradual changes, so gradual as to have been inappreciable except at long intervals of time, the whole idea of migration must be changed. By the term migration, then, in geology at least, is meant, not an individual movement, but a slow shifting of range from generation to generation, and in this kind of movement plants can participate. This question, then, opened up by Charles Darwin in his "Origin of Species," and more fully elaborated by Alfred Wallace in his "Island Life," has become a very prominent one to-day. We must consider the present plants and animals of a country, not as truly indigenous, but as emigrants driven before unfavorable physical changes, or permitted to enter by the removal of barriers. Just as Europe has been the meeting-place of streams of migration from several points of the compass, which thus met and contended with each other and with the natives for mastery, so the plants or animals of any country must be considered as the resultant of such a conflict between invaders from every direction and the native forms. The object of the present paper is to consider this question with regard to the plants of Indiana, to discover what plants are to be considered invaders, and from what directions they have come, and to what extent they have

been driven back or have succeeded in maintaining a foothold. In this way plants may become proofs for or against the prevalent geological changes, for they must tell of climate and land connection, and if their testimony corroborates that of geology it places historical geology upon a surer basis. The entombed remains of plants that have now been examined to a considerable extent, enable us to carry the history of plants back into the remote past, and we find the fossil remains of the ancestral forms of our present plants witnesses of their former distribution and subsequent movements. Such a subject demands a large acquaintance not only with the flora of Indiana in particular, but with the distribution of the plants in general, both those of to-day and those of former ages. It is believed that we have just now arrived at a point that we can ask of the Indiana flora: "What was its origin?" While future discoveries will undoubtedly modify many statements made in this paper, the general principles stated will probably hold, and the changes to be made will be those of detail rather than of generalization.

TOPOGRAPHICAL FEATURES OF INDIANA.

To an understanding of the geographical distribution of Indiana plants, it is necessary to bring some general knowledge of the topography of the State. Indiana is a plane, sloping toward the west and south-west, making the lowest levels in the south-western counties, lying between the Ohio and the Lower Wabash. These counties have an elevation above the sea of about 300 feet, while the highest land in the State lies in its central and eastern part, in the region of Delaware, Wayne, Randolph and Jay counties, called by Prof. Collett the "Alpine region of Indiana," and having a general elevation between 900 and 1,300 feet above the level. From this elevated region the streams run and the land slopes in every direction, and this rather isolated character gives to our "highlands" a very characteristic vegetation. The whole northern region has been deeply covered over with Drift deposit, and thus modified in soil and vegetation, while the extreme north-western counties, Lake, Porter, Newton, Jasper, and parts of the adjoining counties, are more or less covered by Drift sand and the deposits of old Lake Michigan, which once extended far south of its present position. Such a condition of soil as is found in these latter counties brings us the stunted and scanty growth of "barrens." In the western counties of the State are to be found the rich prairie lands, which are but an eastern extension of a much more general condition of things in Illinois. The northern counties, from Laporte and Starke eastward, are characterized by the abundance of lakes, in which regions are found the characteristic water-loving plants and many northern forms which find in these cool and damp regions the proper conditions of growth. The southwestern counties, Posey, Vanderburgh, Gibson and Knox, lying

along the low and southwardly opening valley of the Wabash, form the most tropical part of the State, a fact which will become apparent in the enumeration of its characteristic plants. The remaining Ohio River counties and those of the southern interior, are quite diversified in features and present an extremely varied flora. The numerous well-shaded ravines along the Ohio permit the growth of moisture and shade-loving plants, and in such localities there are still living a few species lingering from a colder climate.

The drainage of this State is in four directions: Through the St. Joseph to Lake Michigan, through the Maumee to Lake Erie, through the Kankakee to the Mississippi, and through the Wabash to the Ohio. The order given represents, in inverse order, the importance of these streams to the State. As streams enter so largely into the question of migration, it is important to keep these facts before us. It will thus he seen that about five-sixths of the State is drained through the Wabash and Kankakee eventually into the Mississippi, while but a small part, the north-eastern counties, enter into the lake drainage, and so to the St. Lawrence.

The impress that these two great drainage systems have left upon our flora will be seen further on.

As the geological structure of a country largely determines the nature of its soil, in considering the plant life it becomes important to have an outline of the geology of the State. In our State, chiefly throughout the northern part, the nature of the soil has largely been modified by the abundant deposits of Drift which, bringing material from widely separated localities, and frequently from the best of soil-making rocks, has rendered very fertile much land which otherwise would have been extremely unproductive. Remembering, then, that Northern Indiana is overlaid by this Drift, the following synopsis is given of the outline of the geology of Indiana, prepared by Professor Collett, for the Thirteenth Annual Report of the State Geologist, to accompany his geological map of the State:

In the south-eastern counties are found the rocks of the Lower Silurian age, known as the Hudson River or Cincinnati group. These rocks form the surface of all or parts of Clark, Jefferson, Switzerland, Ohio, Ripley, Dearborn, Franklin, Fayette, Union and Wayne counties. They also extend throughout large portions of Ohio and Kentucky, the Ohio River having cut its way through this Silurian area.

Lying immediately west, and especially north-west of the Lower Silurian, are the rocks of the Upper Silurian formation, covering the whole or parts of Allen, Adams, Wells, Huntington, Wabash, Miami, Jay, Blackford, Grant, Howard, Delaware, Madison, Tipton, Hamilton, Randolph, Henry, Wayne, Fayette, Rush, Shelby, Decatur, Franklin, Bartholomew, Ripley, Jennings, Jefferson and Clark couuties. From these counties these strata extend north and north-west to the northern bound-

ary of the State. For the most part, however, they are there covered by Drift deposits, except in the north-western counties, Porter, Lake, Newton, and parts of Jasper and Laporte.

The Devonian rocks occupy a large portion of the northern part of the State, and are continued as a narrow band through the central part of the State to the Ohio River. The rocks of the Devonian age are found in in Steuben, Lagrange, Elkhart, St. Joseph, Laporte, Starke, Marshall, Kosciusko, Noble, DeKalb, Allen, Whitley, Wabash, Fulton, Pulaski, Jasper, White, Cass, Miami, Carroll, Howard, Tippecanoe, Clinton, Tipton, Hamilton, Boone, Marion, Hancock, Henry, Rush, Shelby, Johnson, Decatur, Bartholomew, Jennings, Jackson, Jefferson, Scott, Clark and Floyd counties. The northern part of this region is more or less covered with Drift, especially those counties north of Wabash and Cass.

The rocks of the Lower Carboniferous series lie on the west and adjoining the narrow strip of Devonian extending through the central part of the State. They constitute parts or all of Boone, Marion, White, Benton, Tippecanoe, Clinton, Montgomery, Hendricks, Putnam, Johnson, Morgan, Owen, Monroe, Brown, Bartholomew, Jackson, Lawrence, Washington, Orange, Scott, Clark, Floyd, Harrison and Crawford counties. The eastern part of this region is composed of shales and sandstones, while the western part is the great limestone region of the State.

The rocks of the Coal-Measures make up all the south-western part of the State, including all of the lower Wabash valley and extending two-thirds of the way up the western boundary of the State. These rocks come to the surface in Benton, Warren, Fountain, Vermillion, Parke, Vigo, Clay, Owen, Sullivan, Greene, Daviess, Knox, Martin, Orange, Crawford, Dubois, Pike, Perry, Spencer, Warrick, Vanderburgh, Gibson, and Posey counties. The northern part of these Coal-Measures is not continuous, but interrupted by alternations of the Lower Carboniferous.

These divisions, of course, are based entirely on the outcrops of these different strata, as beginning with the Coal-Measures each series successively overlaps the one adjoining it until we reach the Silurian, which is the lowest.

THE PRESENT FLORA OF INDIANA.

In view of all these facts concerning its topography and geological formations, our State can be divided into seven distinct botanical regions, each differing from all the others in conditions of soil, moisture, topography and, consequently, in climate and vegetation. These regions are as follows:

I. *The Lower Wabash Valley Region*, including all or parts of Posey, Vanderburgh, Gibson, Pike, Knox, Daviess, Green, Sullivan, Clay and Vigo counties.

II. *The Prairie Region*, extending over all or parts of Vermillion, Fountain, Montgomery, Warren, Tippecanoe, Benton, Newton and White counties.

III. *The Region of "Barrens,"* for the most part in the north-western counties, Porter, Lake, Laporte, Starke, Pulaski, Jasper and Newton, and also small portions of the southern part of the State.

IV. *The Lake Region*, including most of the northern and north-western part of the State. This region is thickly covered with small lakes, and embraces all or parts of Steuben, Lagrange, Elkhart, St. Joseph, Laporte, Starke, Marshall, Kosciusko, Noble, DeKalb, Allen, Whitley, Fulton, Pulaski, Cass and Wabash counties.

V. *The Highland Region*, covering the eastern central part of the State, and including all or parts of Adams, Wells, Huntington, Jay, Blackford, Grant, Madison, Delaware, Randolph, Henry, Wayne, Fayette and Union counties.

VI. *The Region of the "Knobs," or Ohio Valley Region.* This region includes all the rough, broken country of the Ohio valley, and extends through Franklin, Dearborn, Ohio, Switzerland, Ripley, Jefferson, Jennings, Clark, Scott, Jackson, Washington, Floyd, Harrison, Crawford, Orange, Lawrence, Martin, Perry, Dubois, Spencer and Warrick counties.

VII. *The Central Region*, including all the remaining counties in the central part of the State, which, to some extent, partake of all the topographical features of the other six regions, being composed, for the most part, of woodlands with streams of various sizes and their valleys, and gently-rolling land between.

The following brief lists give the most characteristic plants of each one of these regions:

I. THE LOWER WABASH VALLEY REGION.

Clematis Pitcheri,
Myosurus minimus,
Cocculus Carolinus,
Nuphar sagittifolia,
Arabis dentata,
Hypericum adpressum,
Hibiscus grandiflorus,
Amorpha fruticosa,
Wistaria frutescens,
Desmodium ciliosa,
Phaseolus pauciflorus,
Gleditschia monosperma,
Prunus Chicasa,
Agrimonia parviflora,
Actinomeris squarrosa,
Coreopsis discoidea,
Lactuca sanguinea,
Forestiera acuminata,
Amsonia Tabernæmontana,
Asclepias variegata,
Gonolobus lævis,
Phacelia bipinnatifida,
Ipomœa coccinea,
Ipomœa hederacea,
Physalis viscosa,
Conobea multifida,
Seymeria macrophylla,
Pycnanthemum muticum,

Pirus angustifolia,
Passiflora lutea,
Eulophus Americanus,
Spermacoce glabra,
Diodia teres,
Elephantopus Carolinianus,
Rudbeckia subtomentosa,
Monarda Bradburiana,
Aristolochia Serpentaria,
Aristolochia tomentosa,
Callitriche Austini,
Quercus lyrata,
Taxodium distichum.

These plants, which so distinguish the Lower Wabash Valley from all other regions of the State, have, in general, a southern range, the greater part of them extending from Florida to Mississippi or Texas and Illinois or Indiana. They have found here, in the low grounds and protected ravines, a climate very similar to the highlands of southern latitudes.

II. THE PRAIRIE REGION.

Erysimum asperum, var. Arkansanum,
Viola delphinifolia,
Petalostemon violaceus,
Petalostemon candidus,
Amorpha canescens,
Solidago Missouriensis,
Silphium laciniatum,
Silphium terebinthinaceum,
Silphium integrifolium,
Ambrosia bidentata.

This region is especially characterized by the very great abundance of the representatives of the two families Leguminosae and Compositae, especially the latter. But while these are so abundant, there are very few species that are not found occasionally in other regions, and therefore can not be put into the above list as belonging distinctively to the prairies. In range the plants of this region are very widely distributed, some extending far north, and others south to Texas and Louisiana.

III. THE REGION OF "BARRENS."

Cardamine rhomboidea,
Drosera rotundifolia,
Arenaria stricta,
Linum sulcatum,
Lathyrus maritimus,
Potentilla fruticosa,
Potentilla palustris,
Epilobium palustre,
Cicuta bulbifera,
Linnœa borealis,
Artemisia Canadensis,
Vaccinium Oxycoccus,
Pyrola chlorantha,
Trientalis Americana,
Menyanthes trifoliata,
Corispermum hyssopifolium,
Polygonum tenue,
Polygonum sagittatum,
Shepherdia Canadensis,
Betula papyracea,
Alnus incana,
Salix myrtilloides,
Pinus Banksiana,
Sparganium minimum,
Triglochin maritimum,
Arethusa bulbosa,
Liparis Lœselii.

This region is distinguished by its stunted and scanty growth, as only those plants flourish here which are adapted to a dry, sandy soil and cool climate. For this reason the flora of the "Barrens" ranges far north, north-east and north-west, many species reaching the regions around Hudson Bay, and even extending to the Arctic Circle.

IV. THE LAKE REGION.

Arabis lyrata,
Lechea major,
Elodea campanulata,
Oxalis Acetosella,
Potentilla argentea,
Ribes rubrum,
Myriophyllum spicatum,
Aster longifolius,
Solidago stricta,
Lobelia Kalmii,
Vaccinium Pennsylvanicum,
Ruellia ciliosa,
Scutellaria galericulatâ,
Betula pumila,
Larix Americana,
Cypripedium acaule,
Tofieldia glutinosa,
Maianthemum Canadense,
Lilium superbum,
Allium cernuum.

The range of the flora of this region is very similar to that of the "Barrens;" in fact, the general appearance of the vegetation is much the same, the characteristic difference being in the large number of water plants in the lake region suited only to swampy as well as cold regions, while in the "Barrens" there is a dry, sandy soil and only plants suited to such conditions.

V. THE HIGHLAND REGION.

Delphinium exaltatum,
Delphinium azureum,
Actæa spicata, var. rubra,
Arabis Canadensis,
Arenaria laterifolia,
Malvastrum angustum,
Galactia glabella,
Prunus Pennsylvanica,
Myriophyllum scabratum,
Gaura filipes,
Archangelica atropurpurea,
Conioselinum Canadense,
Lonicera flava,
Rudbeckia fulgida,
Helianthus rigidus,
Helianthus tomentosus,
Asclepias phytolaccoides,
Onosmodium Virginianum,
Calamintha Nuttallii,
Lophanthus anisatus,
Carex conjuncta,
Carex Davisii,
Carex riparia,
Carex hystricina,
Carex lupuliformis,
Carex utriculata,
Poa alsodes.

As one would expect, the flora of the "Highland region" is entirely distinct from all the others of the State in having a larger percentage of mountain forms. Most of these forms which are peculiar to this part of the State are common on the mountains and foot-hills of Pennsylvania,

New York, Vermont, and to higher latitudes. Some, found in the neighborhood of ponds and small lakes, are also found in similar environments but lower altitudes in Michigan. The range, therefore, of these plants is east, north, and north-east, with a very large proportion east. Another noticeable fact concerning this region is the absence of very many genera and species found abundantly in other parts of the State. The *Ericaceæ* found in almost all parts of the State have here only two species, *Monotropa uniflora*, and *Vaccinium macrocarpon*, and the former of these is almost extinct. The *Naiadaceæ* have all disappeared, although very abundant in other places where they can find plenty of water. The *Orchidaceæ*, formerly so abundant here, and now very abundant in other places, especially in the lake region, have all been exterminated but two species, *Orchis spectabilis* and *Habenara psycodes*. Species of *Cypripedium* are said to have been plenty when the country was first settled (Dr. A. J. Phinney.) The *Coniferæ*, found in the highlands of the south and in the sphagnous swamps of the north, have not a single representative in this highland region.

VI. THE REGION OF THE "KNOBS."

Ranunculus multifidus.
Coptis trifolia.
Magnolia acuminata.
Jeffersonia diphylla.
Corydalis flavula.
Nasturtium sessiliflorum.
Leavenworthia Michauxii.
Arabis Ludoviciana.
Viola pedata.
Lechea minor.
Ascyrum Crux-Andræa.
Silene regia.
Sagina decumbens.
Hibiscus militaris.
Tilia heterophylla.
Rhus venenata.
Vitis indivisa.
Polygala Nuttallii.
Psoralea Onobrychis.
Psoralea melilotoides.
Desmodium canescens.
Desmodium viridiflorum.
Lespedeza repens.
Phaseolus perennis.
Philadelphus grandiflorus.
Sullivantia Ohionis.
Circæa alpina.
Epilobium molle.
Ammannia humilis.
Aralia spinosa.
Aralia racemosa.
Cornus asperifolia.
Aster Tradescanti.
Aster prenanthoides.
Diplopappus linariifolius.
Solidago neglecta.
Solidago Shortii.
Helianthus microcephalus.
Bidens cernua.
Cnicus Virginianus.
Physalis Philadelphica.
Cunila Mariana.
Pycnanthemum linifolium.
Calamintha glabella.
Scutellaria pilosa.
Euphorbia Ipecacuanhæ.
Croton capitatus.
Croton monanthogynus.

Baptisia australis.
Cassia Tora.
Desmanthus brachylobus.
Gillenia stipulacea.
Phyllanthus Carolinensis.
Microstylis monophyllos.
Corallorhiza innata.
Juncus scirpoides.

The flora of this region is not only widely different from that of any other part of the State, but is peculiar in itself. Here we find plants, whose natural home seems to be in the far north, growing in close proximity to those of semi-tropical latitudes. On one side of a hill, or "knob," *Ranunculus multifidus*, a decidedly arctic species, will be found, and only a short distance on the other side *Nasturtium sessiliflorum* will flourish as luxuriantly as in Florida or Mississippi, where it finds its natural climate. Or, on the northern side of a ravine, *Vitis indivisa*, of the Gulf States, will cling to the bushes and rocks and spread over them a beautiful covering of dark green, while on the other, or shady side of the same ravine, especially if near some spring, *Epilobium molle* finds a climate very similar to that of Northern British America. But while there is this mixture of arctic and tropical forms, somewhat the larger proportion of the flora is southern in its range.

VII. THE CENTRAL REGION.

Arenaria patula,
Stellaria longipes,
Napœa dioica,
Flœrkea proserpinacoides,
Trifolium reflexum,
Lespedeza reticulata,
Pyrola secunda,
Monarda punctata.

Naturally, this central region possesses very few plants peculiar to itself, but has many forms in common with each of the other regions, and every year this is becoming more and more a general collecting ground for all the species of the State. Seeds are being daily transported into this region by the streams which traverse it, and by railroads which enter from all directions, and wherever these seeds find a favorable condition of soil, climate and moisture, they spring up and grow as long as these conditions remain.

From these lists, and explanations following, it will be seen that our State has received contributions to its flora from every direction, and that the flora of any region is not entirely dependent upon its latitude, but also greatly upon its altitude, condition of soil, exposure and protection, and abundance or scarcity of bodies of water. In comparing the floras of the Wabash and Ohio valleys, we find that of the lower Wabash distinctly southern, with but a few species from the north, while that of the Ohio has abundant representatives from every direction, accounted for both by difference in elevation and the wide range of its tributaries.

Also, the central western, or prairie region, has a flora very different from that of the central eastern, or highland region. That of the prairie

region ranges, for the most part, south, west and north, while that of the highlands ranges north and east, some of its species extending far north.

In the region of the "barrens," and in the "lake region," we find about the same range, but in the one are plants of dry, sandy soil, and in the other water-loving plants, with a slight predominance of extreme northern forms in the "lake region."

MIGRATION OF PLANTS.

It becomes necessary now to discover what causes will induce or permit plants to migrate, and thus spread far beyond their original boundaries. Two kinds of migration must be considered, viz.: That which is compulsory, and that which is simply allowed. In the former case some slowly accumulating physical change has destroyed in the original homes of certain plants the conditions necessary for their development, and they have been compelled to extend their range, generation after generation, in the direction of more favorable conditions. In the course of time this will transfer a flora from one region to another. In the latter case a newly-made land connection may allow plants to extend their range, or their seeds may be transported by a great variety of causes, hereafter to be enumerated. In the compulsory migration, therefore, we have the slow advance of a flora, never at any rate faster than the plants can disperse their own seeds. In the permitted migration their seeds may be carried to great distances by a variety of causes, and so cause their appearance in widely separated localities. In every case, though, the same principle must hold good, viz.: That plants will only develop amidst favorable surroundings, so that from whatever cause they have been removed from their former habitations, they become delicate indicators of similar conditions of climate and soil.

I. PERMITTED OR ACCIDENTAL CAUSES OF MIGRATION.

1. *Land Connection.* It is well understood that the dry land of the earth has been the slow accumulation of geological time; that only parts of it have been brought above water at any time, either to remain dry land or to be again submerged. While, then, as a general proposition, the land surface has been constantly increasing in extent, it is equally true that there has been as constant changing. If, therefore, lands before separated by water are brought together, it will permit their plants to enter each other's domain, and the resulting flora will be a mixture of both, or rather a compromise between them. So well is this recognized as a fact, that when the plants of an island are very similar to those of a neighboring continent, it is taken as a proof that the two were connected

at some comparatively recent time. On the contrary, if the flora of an island is radically different from that of a neighboring continent, it is good proof that the two have been separated for a long time. Thus the West Indian Islands contain a flora in common with South America, which tinctures also the peninsula of Florida, indicating a much more continuous land connection than exists there now. Also many plants of our own country, particularly those of the North-west, being identical with those of Eastern Asia, would indicate a comparatively recent land connection. On the other hand, the flora of Madagascar is radically different from that of Africa, indicating a long separation, as is also true with regard to the Galapagos Islands, off the western coast of South America. In the Bermudas, however, there is not a single peculiar plant, all the types being North American. This will serve to illustrate how a land connection, which did not previously exist, will permit migration and thus seriously modify the floras of the lands thus connected.

2. *Streams.* About the greatest carriers of seeds within a country are its streams. During times of flood seeds are carried by them in countless numbers and deposited in the rich alluvium. Those which find the proper conditions for their growth spring up, often persist, and frequently spread extensively, even exterminating the native plants. For this reason the range of the plants likely to be found in any country can be measured by the extent of the drainage of the streams which pass through it. Thus, our southern counties have the widest range of plants, brought to them by the extensive drainage of the Ohio River. As its tributaries extend nearly to the lake region on the north, the Alleghany Mountains on the east, and the Gulf States on the south, we have seeds brought to us from all these widely separated regions, and in the diversity of our soil and exposure plants from the northern Alleghanies and Alabama may be found growing near each other. Our other streams belong to ourselves, and serve chiefly to distribute our own plants more uniformly over the State, though southern plants, as has already been noticed, have worked their way well up the Lower Wabash.

3. *Wind.* With a very large majority of our seeds ordinary winds have very little, if any, influence in distribution, owing to the weight of the seeds and to the absence of any appendages for suspension in the air. Yet, in violent storms or hurricanes, one can suppose, and no doubt it is true, that even our heaviest seeds are carried to great distances. But many seeds, especially those of some of our largest families, are especially adapted for transportation by even ordinary winds. Some of these are provided with wing-like appendages, as maples, which allow comparatively heavy seeds to be easily carried for miles even by ordinary winds, and to immense distances by storms. Others are furnished with down or hairy outgrowths, and are wafted far and wide over the country in the autumn and winter. Notable among this class are thistles, and in fact

most of the very large family of Compositæ. Every one who has noticed thistle-down floating everywhere through the air in the fall can not help but realize the importance of the wind as a transporting agency. Other seeds, while not provided with any kind of appendages to assist in their flight, are, nevertheless, so light as to be easily distributed over limited areas. A repetition of this year after year will, in time, spread a species over large areas. Thus, as Alfred Wallace says, "An immense number of seeds are especially adapted to be carried by the wind, through the possession of down or hair, or membranous wings or processes, while others are so minute, and produced in such profusion, that it is difficult to place a limit to the distance they might be carried by gales of wind or hurricanes."

4. *Birds*, as seed carriers, might be divided into two classes. First, those which are fruit-loving and carry seeds in the alimentary canal for great distances. Many of these seeds will pass through the whole digestive apparatus of a bird without in the least injuring the powers of germination. This united with the fact of the great variety of fruit eaten by birds, affords a means of plant dispersal of great importance. The second class includes those birds which carry seeds from place to place in mud attached to their feet or attached directly to the feathers by awns, hooks or prickles. Mr. Darwin, in speaking of the distribution of plants by birds, in his "Origin of Species," says: "Although the beaks and feet of birds are generally clean, earth sometimes adheres to them. In one case I removed sixty-one grains, and in another case twenty-two grains of dry argillaceous earth from the foot of a partridge, and in the earth there was a pebble as large as the seed of a vetch. Here is a better case; the leg of a woodcock was sent me by a friend, with a little cake of dry earth attached to the shank, weighing only nine grains, and this contained a seed of the toad-rush (*Juncus bufonius*), which germinated and flowered. Mr. Swaysland, of Brighton, who during the last forty years has paid close attention to our migratory birds, informs me that he has often shot wagtails (*Motacillæ*), wheat-eaters and whin-chats (*Saxicolæ*) on their first arrival on our shores before they had alighted, and he has several times noticed little cakes of earth attached to their feet. Many facts could be given showing how generally soil is charged with seeds. For instance, Prof. Newton sent me the leg of a red-legged partridge (*Caccabis rufa*), which had been wounded and could not fly, with a ball of earth adhering to it, and weighing six and a half ounces. The earth had been kept for three years, but when broken, watered and placed under a bell glass no less than eighty-two plants sprung from it. These consisted of twelve monocotyledons, including the common oat, and at least one kind of grass and of seventy dicotyledons, which consisted, judging from the young leaves, of at least three distinct species. With such facts before us, can we doubt that the many birds which are

annually blown by gales across great spaces of ocean, and which annually migrate, must occasionally transport a few seeds imbedded in dirt adhering to their feet or beaks?"

II. COMPULSORY MIGRATION.

One of the prime causes of the movements of plants is change in climate. That this has frequently occurred in the history of the earth is well known, and with every such change there has come as one result great movements of plants and animals. All the causes of changes in climate need not be discussed here, but one demands our attention, namely: changes in the elevation of the land. If a land lies near the ocean level it will have a moderate and equable climate, but if it becomes elevated, either over a great extent of its surface, or into mountain ranges over a part of its surface, these elevated portions become sources of extremes in temperature. Land elevated toward the north will be a source of extreme cold, and if depressed toward the north will moderate the cold. It is generally thought that what is called the "glacial period" was accompanied, if not caused, by a general elevation of land towards the north. At least snow and ice accumulated to such an extent that a most rigorous climate followed. It was but a continuation of the present polar ice-cap down into what are now temperate latitudes. A part of this ice mass extended across Indiana, finding its lower limit near our southern borders. As this cold came on gradually, the warmth-loving plants could migrate before it, while those of higher latitudes would be driven in to take their places. Thus, by the advance of this polar ice-cap the flora about the northern parts of Europe, Asia and America was driven southward and extended into the southern parts of these continents. The coming on of warmer conditions, which would result in the melting of this ice mass, and hence its retreat, would both permit and compel plants to move northward again. In these alternate movements, which may have taken place several times, we have probably the most important explanation of the origin and composite nature of our flora.

ORIGIN OF THE NORTH AMERICAN FLORA.

In studying the flora of North America one can not help being impressed with the fact of the identity of many of our genera, and even species, with those of Europe, and especially of Eastern Asia. In the number of identical species there seems to be a closer resemblance between the floras of Eastern United States and Eastern Asia than between the flora of Eastern United States and the Pacific slope. The following list of plants, taken from Gray's Manual, are found to be common to North-eastern United States and Europe.

Anemone patens,
Anemone nemorosa,
Hepatica triloba,
Ranunculus divaricatus,
Ranunculus aquatilis, var. trichophyllus,
Ranunculus sceleratus,
Ranunculus repens,
Myosurus minimus,
Caltha palustris,
Coptis trifolia,
Actæa spicata, var. rubra,
Nuphar luteum,
Nasturtiun palustre,
Cardamine bellidifolia,
Cardamine pratensis,
Cardamine hirsuta,
Arabis hirsuta,
Arabis perfoliata,
Barbarea vulgaris,
Erysimum cheiranthoides,
Draba incana,
Draba nemorosa,
Draba verna,
Subularia aquatica,
Viola palustris,
Viola Selkirkii,
Viola canina,
Drosera longifolia,
Drosera rotundifolia,
Silene acaulis,
Arenaria lateriflora,
Arenaria peploides,
Stellaria longifolia,
Stellaria longipes,
Stellaria uliginosa,
Stellaria crassifolia,
Stellaria borealis,
Stellaria humifusa,
Cerastium arvense,
Sagina procumbens,
Sagina apetala,
Sagina nodosa,
Spergularia rubra,
Spergularia salina,
Spergularia media,
Oxalis acetosella,
Oxytropis campestris,
Vicia Cracca,
Lathyrus maritimus,
Lathyrus palustris,
Spiræa salicifolia,
Spiræa Aruncus,
Dryas integrifolia,
Geum macrophyllum,
Geum strictum,
Geum rivale,
Sibbaldia procumbens,
Potentilla Norwegica,
Potentilla frigida,
Potentilla anserina,
Potentilla fruticosa,
Potentilla palustris,
Ribes rubrum,
Saxifraga oppositifolia,
Saxifraga rivularis,
Saxifraga aizoides,
Saxifraga tricuspidata,
Saxifraga Aizoon,
Saxifraga stellaris,
Sedum Rhodiola,
Myriophyllum spicatum,
Myriophyllum verticallatum,
Hippuris vulgaris,
Circæa alpina,
Epilobium angustifolium,
Epilobium alpinum,
Epilobium palustre,
Ludwigia palustris,
Lythrum Hyssopifolia,
Ligusticum Scoticum,
Sium angustifolium,
Galium Aparine,
Erigeron acre,
Solidago Virgaurea,
Achillea millefolium,
Artemisia borealis,
Artemisia Canadensis,
Gnaphalium uliginosum,

Gnaphalium supinum,
Senecio palustris,
Taraxacum Dens-leonis,
Campanula rotundifolia,
Vaccinium Oxycoccus,
Vaccinium Vitis-Idæa,
Vaccinium uliginosum,
Arctostaphylos Uva-ursi,
Arctostaphylos alpina,
Cassandra calyculata,
Cassiope hypnoides,
Andromeda polifolia,
Calluna vulgaris,
Phyllodoce taxifolia,
Rhododendron Lapponicum,
Ledum latifolium,
Loiseleuria procumbens,
Pyrola rotundifolia,
Pyrola secunda,
Pyrola minor,
Moneses uniflora,
Chimaphila umbellata,
Monotropa Hypopitys,
Primula Mistassinica,
Lysimachia thyrsiflora,
Glaux maritima,
Centunculus minimus,
Samolus Valerandi,
Utricularia vulgaris,
Utricularia minor,
Utricularia intermedia,
Scrophularia nodosa,
Veronica anagallis,
Veronica officinalis,
Veronica scutellata,
Veronica alpina,
Veronica serpyllifolia,
Castilleia pallida,
Euphrasia officinalis,
Rhinanthus Crista-galli,
Lycopus Europæus,
Calamintha Clinopodium,
Brunella vulgaris,
Scutellaria galericulata,
Mertensia maritima,
Myosotis arvensis,
Polemonium cœruleum,
Diapensia Lapponica,
Calystegia sepium,
Gentiana detonsa,
Blitum capitatum,
Atriplex patula,
Corispermum hyssopifolium,
Salicornia herbacea,
Salicornia Virginica,
Salicornia fruticosa,
Suæda maritima,
Salsola Kali,
Polygonum viviparum,
Polygonum lapathifolium,
Polygonum Hydropiper,
Polygonum amphibium,
Polygonum aviculare,
Polygonum maritimum,
Oxyria digyna,
Rumex maritimus,
Ceratophyllum demersum,
Callitriche verna,
Callitriche autumnalis,
Empetrum nigrum,
Humulus Lupulus,
Castanea vesca,
Myrica Gale,
Alnus viridis,
Alnus incana,
Salix myrtilloides,
Salix herbacea,
Juniperus communis,
Corallorhiza innata,
Calla palustris,
Acorus Calamus,
Lemna trisulca,
Lemna polyrrhiza,
Typha latifolia,
Typha angustifolia,
Sparganium minimum,
Naias major,
Naias flexilis,

Zannichellia palustris,
Zostera marina,
Ruppia maritima,
Potamogeton rufescens,
Potamogeton gramineus,
Potamogeton prœlongus,
Potamogeton perfoliatus,
Potamogeton compressus,
Potamogeton crispus,
Potamogeton obtusifolius,
Potamogeton pectinatus,
Triglochin maritimum,
Scheuchzeria palustris,
Alisma Plantago,
Vallisneria spiralis,
Habenaria hyperborea,
Habenaria obtusata,
Goodyera repens,
Calypso borealis,
Microstylis monophyllos,
Liparis Lœselii,
Tofieldia palustris,
Streptopus amplexifolius,
Allium Schœnoprasum,
Narthecium ossifragum,
Luzula pilosa,
Luzula parviflora,
Luzula campestris,
Luzula arcuata,
Luzula spicata,
Juncus effusus,
Juncus filiformis,
Juncus stygius,
Juncus trifidus,
Juncus bufonius,
Juncus Gerardi,
Juncus alpinus,
Eriocaulon septangulare,
Cyperus flavescens,
Eleocharis palustris,
Eleocharis acicularis,
Scirpus pauciflorus,
Scirpus cæspitosus,
Scirpus pungens,
Scirpus maritimus,
Scirpus sylvaticus,
Eriophorum alpinum,
Eriophorum gracile,
Rhynchospora fusca,
Rhynchospora alba,
Carex gynocrates,
Carex scirpoides,
Carex capitata,
Carex pauciflora,
Carex disticha,
Carex teretiuscula,
Carex muricata,
Carex chordorhiza,
Carex tenella,
Carex tenuiflora,
Carex vitilis,
Carex Norvegica,
Carex stellulata,
Carex rigida,
Carex vulgaris,
Carex limula,
Carex aquatilis,
Carex salina,
Carex maritima,
Carex limosa,
Carex rariflora,
Carex irrigua,
Carex Buxbaumii,
Carex atrata,
Carex livida,
Carex vaginata,
Carex panicea,
Carex pallescens,
Carex capillaris,
Carex lævigata,
Carex fulva,
Carex extensa,
Carex flava,
Carex Œderi,
Carex filiformis,
Alopecurus aristulatus,
Phleum alpinum,
Agrostis canina,

Agrostis vulgaris,
Agrostis alba,
Muhlenbergia arenaria,
Spartina juncea,
Spartina stricta,
Kœleria cristata,
Glyceria aquatica,
Glyceria fluitans,
Glyceria maritima,
Glyceria distans,
Poa annua,
Poa compressa,
Poa alpina,
Poa laxa,
Poa cæsia,
Poa serotina,
Poa pratensis,
Festuca ovina,
Phragmites communis,
Trisetum subspicatum,
Aira flexuosa,
Aira cæspitosa,
Aira atropurpurea,
Hierochloa borealis,
Hierochloa alpina,
Phalaris arundinacea,
Milium effusum;
Equisetum Telmateia,
Equisetum pratense,
Equisetum sylvaticum,
Equisetum palustre,
Equisetum limosum,
Equisetum hyemale,
Equisetum variegatum,
Equisetum scirpoides,
Polypodium vulgare,
Pteris aquilina,
Asplenium Ruta-muraria,
Asplenium Filix-fœmina,
Scolopendrium vulgare,
Phegopteris polypodioides,
Phegopteris Dryopteris,
Aspidium Thelypteris,
Aspidium spinulosum,
Aspidium cristatum,
Aspidium Filix-mas,
Aspidium Lonchitis,
Aspidium aculeatum,
Cystopteris fragilis,
Struthiopteris Germanica,
Woodsia Ilvensis,
Woodsia glabella,
Osmunda regalis,
Botrychium Lunaria,
Botrychium simplex,
Botrychium lanceolatum,
Botrychium Virginicum,
Ophioglossum vulgatum,
Lycopodium Selago,
Lycopodium inundatum,
Lycopodium annotinum,
Lycopodium clavatum,
Lycopodium complanatum,
Selaginella selaginoides.

In addition to these three hundred and forty-two distinct species, there are in our flora many varieties which are indigenous to Europe, and in Europe varieties very close to some in this country. Also there are many species in this country so very near European forms that no doubt they will eventually be considered the same species, or at least varieties. Indeed, Joseph F. James supposes that one-third of the species found in Gray's Manual resemble forms in Europe. When we take into consideration the fact that the Manual covers only a very small portion of North America, it is a natural inference that when the whole flora of North America is compared with that of Europe, there will be found many other species common to both. But even from this list it will be seen

that nearly every family of plants has representatives common to both countries. Not only is this true, but almost all the large genera, if we except those of *Compositæ*, have species common to both. As before said, the resemblances between this flora and that of Asia are still more remarkable. After speaking of the close relationship between the forest trees of Eastern North America and Eastern Asia, Prof. Asa Gray says: "Extending the comparison to shrubs and herbs, it more and more appears that the forms and types which we count as peculiar to our Atlantic region, when we compare them, as we first naturally do, with Europe and with our West, have their close counterparts in Japan and North China; some in identical species (especially among the herbs), often in strikingly similar ones, not rarely as sole species of peculiar genera or in related generic types. Evidences of this remarkable relationship have multiplied year after year, until what was long a wonder has come to be so common that I should now not be greatly surprised if a *Sarracenia* or a *Dionæa*, or their like, should turn up in Eastern Asia. Very few of such isolated types remain without counterparts. It is as if Nature, when she had enough species of a genus to go around, dealt them fairly, one at least, to each quarter of our zone; but when she had only two of some peculiar kind, gave one to us and the other to Japan, Manchuria or the Himalayas; when she had only one, divided this between the two partners on the opposite sides of the table." Also, it must be noted that many species have been introduced from Asia, and more especially from Europe, through lines of commercial intercourse, which have flourished in our climate and soil as well as the native plants, and in some cases have driven out the original indigenous species.

It would be very easy to account for this wide distribution of species if there were not so many facts to disprove the theory advanced by Meyen in 1846, that "there is indeed nothing more easy to perceive, in the distribution of organic beings over the globe, than the universal law, that nature, in similar circumstances, has always produced similar or perfectly the same creatures." If we could believe this theory it would be very easy to explain the resemblance between the floras of the Eastern and Western continents. In fact, if such a theory were true they ought to be much nearer alike, for there is not as much difference now in soil and climatic surroundings as there is in the floras, nor do we think there ever has been. This theory also leaves us to infer that plants of Europe are not found here simply because they will not grow here, but we know that numbers of species have been introduced and have found here all the conditions of soil and climate suited to their best development. Hence we find the scientific thought of the day to be, as expressed by Alfred Wallace, that "every species has come into existence, coincident both in space and time with a pre-existing, closely-allied species." All research of late years, especially in the line of geology, tends to establish

this fact, that no species has had different birth-places, distant in space, and perhaps also in time, but that each distinct species has come into existence separately and in one particular place, and from that place has spread as far as the natural barriers of differences in soil, climate, mountain chains, and oceans would permit. "Therefore, when we find identical species in two different quarters of the globe, we believe the individuals in both localities to be descended from a common parent." This being true, we must look for some line of natural communication between the two hemispheres, and naturally we look to the north for this highway between the two continents; for there is now very close connection with Asia on the north-west, and the connection with Europe is not very distant on the north-east, through Greenland and Iceland, but no doubt too distant at present for the passage of many plants or their seeds. However, having evidence of former land elevation in high latitudes, or accepting Croll's theory in regard to the displacement of the earth's center by a polar ice-cap, which would result in the ocean having a lower level in these latitudes in the Tertiary period than now, in either event the continental masses would be nearer together at that time, if not in actual connection. Coupling this with the results of Mr. Darwin's experiments, in which he proves that the seeds of fourteen-hundredths of the plants of any country may be floated 924 miles by sea currents and then germinate under favorable circumstances, we have no difficulty in accounting for the migration of plants from one continent to another, if the temperature and other conditions for growth are favorable at the place of crossing. However, recent Arctic explorations relieve us of the necessity of resorting solely to Croll's theory and Darwin's experiment to account for the passage of plants between America and Europe. As yet much of the region in the vicinity of the North Pole is unknown, but enough has been discovered to prove that there is much land within a short radius of the Pole, perhaps enough to almost connect the two continents, and to make the passage easy it is only necessary for the plants to reach these high latitudes. Of all the list of plants given as common to Europe and North-eastern United States, but very few now get farther north in America than 50 degrees latitude, or 70 degrees in Europe. The question might be very pertinently asked then: "How could these plants reach these high latitudes to cross over from America to Europe or in the opposite direction?" This was an inexplicable mystery, scarcely presenting facts enough to found a theory or conjecture upon, until in 1848 Sir John Richardson found in latitude 65 degrees north, along the McKenzie River, beds of coal and shales full of leaves of forest trees now found in the temperate climes. Again, in 1854, Dr. Lyall found fossils of the same nature in Greenland, latitude 70 degrees north, and in 1853 Sir Alexander Armstrong found pine cones and acorns in Banksland in latitude 75 degrees north. Similar fossils have been found in Spitzbergen, in Siberia, and in

other places within the Arctic Circle, up to within ten degrees of the North Pole. These collections of fossil plants were examined by Prof. Heer, of Zurich, and they proved to be remains of trees common to the temperate climes of Europe, Asia and America, such as maples, poplars, Taxodium, oaks, planes, beeches, ashes, etc., and those of the rarer genera, such as Sequoia, Liquidambar, magnolias, tulip-trees, etc. Along with these forest trees which have been preserved must have grown the shrubs and herbs which we now find co-existing with them in temperate climes, but owing to their herbaceous character these have been lost.

As stated in the early part of this paper, plants have come to be recognized as most delicate indicators of climatic conditions; for no matter how slight the changes in climate or how gradually they may be produced, either artificially or naturally, plants will either migrate or perish. Hence, we must conclude that in the earliest geological ages the temperature of these high latitudes was virtually that of North America to-day, between latitude thirty degrees and fifty degrees north. Our beautiful singing birds poured forth their melodies in the shades of temperate and even tropical forests around the Arctic Circle. Here, in the region which we now think of as a world of eternal snow and ice, in earlier ages flourished the immense sequoias, the beautiful magnolia, and many of our humbler yet sweeter herbs and flowers. The area of certain death now, then teemed with the life of hundreds of animals, suited only to a temperate or tropical clime. For the fossil fauna of this zone indicates a temperate climate as distinctly as the flora. In other words, to get a true idea of the Tertiary and immediately preceding periods, we must imagine the climate of North-eastern United States, with it all its vegetable and animal life, transferred from twenty to thirty degrees farther north. The trans-Atlantic highway between Europe and America, however, must have been at the northern limit of this belt which corresponds to our temperate latitudes to-day; for, as will be seen from the list of common plants given, about three-fifths of them are mountain and highland forms in the United States, and extend into Canada as lowland forms. About one-third are inhabitants of low sphagnous swamps and marshes, while the remaining small fraction might be called lowland species. On the other hand, the family Compositæ, which comprises about one-seventh of the whole number of species given in Gray's Manual, has only nine species common to both continents, this family being distinctly southern. Hence, we conclude that these plants crossed far north and over low ground, or where there was alternate sea and land.

Now, how has this flora of the north become dispersed over all North America, Europe and Asia? Has it been by permitted or by forced migration? According to our definition of these terms it was evidently by forced migration. This migration is gradually produced through the influence of increased development in favorable situations and fail-

ure to germinate and diminished growth in unfavorable circumstances. This diminished growth and consequent loss of vitality allows the invasion of more vigorous floras, which will in time drive out the preceding flora. Thus, by means of permitted dispersion in front and forced extinction behind, we will have vast waves of plant life moving north or south whenever the temperature of a country becomes warmer or colder. This is exactly what has happened to this extreme northern flora during the geological period known as the Quaternary. Up to that time this temperate flora surrounded the North Pole, extended as far down into each of the continents as climatic conditions would allow, and crossed from continent to continent wherever and whenever possible. The Quaternary period was ushered in by the glacial epoch, during which great changes in the position of the fauna and flora of the world were produced by the formation of an immense ice-cap in the north and its movement toward the south. The general effect of this glacial movement upon the flora of the world has been spoken of under the title of "Forced Migration." In North America as these immense fields of ice moved southward they pushed all the original and introduced flora before them, forcing highland forms into lowlands, and all forms farther south. Very gradually these forms, seeking for a suitable climate, extended farther and farther south, and were encroached upon by others coming on from behind until no doubt many were exterminated along the shore of the then Great Southern Sea, being literally trampled to death by the hordes coming on from the north. Others survived in sheltered places and by very slow adaptation to climate and awaited changes, which should give them a broader field and more favorable circumstances for a better development. No doubt this gradual change, produced by an attempted adaptation to climate and surroundings, will account for many of the very nearly related species and varieties in North America and the Eastern Continent.

Gradually this change in temperature took place at the beginning of the Champlain epoch. The land of the north, which had been elevated some two thousand feet during the glacial epoch, gradually sank again, accompanied by a rise in temperature. The time for retaliation upon these northern invaders had come, and the hard-pressed flora of the seashore begin to encroach upon their oppressors, who were being driven back toward their original home. But as the warm climate of the Champlain epoch drove these plants northward, many of them found congenial stopping places by the way. Not only could they find a cooler climate by moving north, but also by ascending mountains, highlands, about springs and lakes of spring water, and the shady sides of cliffs and ravines. Here they could escape the heat of a warm climate, and, as this was their purpose in moving, they took the first opportunity offered to gain their end. Hence, we find in our Northern States lowland forms common to the mountain regions of the south, and highland forms and water-loving

species extending along protected valleys and lowlands as far north as Labrador, and in a few cases to Greenland. While these great movements were along general north and south lines, they also had an easterly and westerly direction. These were caused, for the most part, by natural spreading through permitted movement. Many species moved in a north-easterly direction, as they still retain a range from south-west to north-east, shaped by the general configuration of the Appalachian system.

Hence we must conclude that our North American flora has originated in the far North, and once flourished around the North Pole; that it was driven south by the cold of the glacial epoch, and again north by the Champlain climate, and eastward by the trend of the continent, and that in each of these movements many species have lodged by the way where favorable stopping places have been found, and have remained in these places as far as their surroundings would permit.

ORIGIN OF INDIANA FLORA.

All that has been said is necessary to an understanding of the origin of the Indiana flora, and the question is now raised, What part has Indiana played in these great movements, and what have been the results upon her flora? Lying, as the State does, in the very central northern part of the country, it became the common meeting ground of migrations from various directions. What its flora was during the Tertiary period we have not found recorded within our boundaries, but the inference is safe that with an extensive temperate flora existing at the far North, our plants were more tropical in their nature than now, probably comparing well with those of our Gulf States. As the glacial times were beginning, and streams of migration began to set in from the north, the hardy invaders began to take possession of the soil, and the more tender natives retired southward before the same conditions. Two distinct streams of northern migration have been made out, one from the north-east, the other from the north-west, the former being the first in point of time, and apparently the most important in results. Geology gives us evidences of the same two movements and directions of glacial advance, the testimony of geology and botany thus coinciding in a remarkable way. This advance of glacial conditions brought to us northern plant forms which can not exist under present conditions. So that the change from cretaceous times was from a more tropical to a more arctic flora. The pendulum seemed to swing to both extremes, and only gradually to settle into the present temperate condition of things. We find within our boundaries good and abundant evidence of the existence of this more arctic flora. Lurking in some of our deep and cool valleys, in the presence of constantly dripping water, some of these far northern species have managed to linger, but they are only relics of a much more universal condition of things. Buried under our

glacial deposits are remains of this old flora, and among the fragments of trees discovered, the tamarack is found to be the most abundant. This species is found to have existed throughout the southern part of the State, while now its existence within our borders is confined to a very precarious one in the cold swamps of our northern counties. Such evidences of the former existence in Indiana of an arctic flora, and hence arctic climate, could be multiplied, but it is not necessary. With the coming on of warmer conditions, and the consequent melting and retreat of the glaciers, these arctic plants were compelled to move northward again, some, as has been said, finding suitable conditions of growth in our deep valleys or highlands. The more southern forms spread northward again within the State, but never regained the foothold they had lost, for the almost tropical climatic condition never returned, and the final result was that middle ground between tropical and arctic conditions, such as we find in our temperate climate of to-day. In this way, to summarize, the ancestors of most of the present plants of Indiana came to us from the north in two directions, were driven through the State and beyond by glacial conditions, and then returned to us from the south, and have remained.

Plants from the east and south that have since come in, and are still coming to us, have mostly reached us by the great river systems of the Ohio and Mississippi. Plants from the west, the most recent of our invaders, have come chiefly along lines of railroad, most important lines for plant advance. At least five distinct directions have thus been clearly made out from which our plants have come to us. First, from the north-east; second, from the north-west; third and fourth, from the east and south; and fifth, from the west. The order given also represents the general order of time. The following lists are meant to include most of the plants which have come to us distinctly from these various directions. Of course there are many plants of wide range, which are not included, as they can not well bear testimony in reference to migrations; also, in giving plants concerned in the north-eastern and north-western movements many species must be included which really range all over the north, and probably must be considered as having come in with both advances. In considering advances from the east and south, the topography must be borne in mind. By the former are meant chiefly Alleghany and New England forms, some of which have extended southward along the mountains even into North Carolina and Alabama. By southern, are meant the immigrants from the Lower Mississippi and gulf region, but whose range may extend along the lowlands of the Atlantic coast even to New Jersey. With this borne in mind, it will no longer seem anomalous to list plants as coming from the east, which also extend into Alabama, or as coming from the south when they are to be found in New Jersey.

I. LIST OF PLANTS FROM THE NORTH-EAST.

Clematis Virginiana,
Anemone Virginiana,
Anemone nemorosa,
Trautvetteria palmata,
Ranunculus abortivus,
Ranunculus sceleratus,
Ranunculus fascicularis,
Caltha palustris,
Coptis trifolia,
Dicentra Cucullaria,
Dicentra Canadensis,
Nasturtium palustre,
Arabis lyrata,
Arabis lævigata,
Draba verna,
Polanisia graveolens,
Viola blanda,
Viola rostrata,
Hypericum corymbosum,
Cerastium oblongifolium,
Sagina decumbens,
Oxalis acetosella,
Zanthoxylum Americanum,
Vitis riparia,
Celastrus scandens,
Lathyrus maritimus,
Lathyrus paluster,
Gymnocladus Canadensis,
Potentilla Canadensis,
Potentilla argentea,
Rubus Canadensis,
Rosa Carolina,
Rosa nitida,
Cratægus tomentosa,
Ribes Cynosbati,
Ribes oxyacanthoides,
Ribes floridum,
Ribes rubrum,
Saxifraga Pennsylvanica,
Mitella diphylla,
Tiarella cordifolia,
Myriophyllum spicatum,
Heracleum lanatum,
Cicuta bulbifera,
Osmorrhiza longistylis,
Osmorrhiza brevistylis,
Aralia nudicaulis,
Aralia quinquefolia,
Cornus circinata,
Cornus paniculata,
Cornus alternifolia,
Lonicera parviflora,
Galium boreale,
Aster longifolius,
Aster prenanthoides,
Erigeron annuum,
Solidago neglecta,
Solidago arguta,
Gnaphalium uliginosum,
Lactuca leucophæa,
Lobelia Kalmii,
Pyrola chlorantha,
Fraxinus sambucifolia,
Asclepias Cornuti,
Asclepias quadrifolia,
Gentiana alba,
Hydrophyllum Canadense,
Hydrophyllum apendiculatum,
Lithospermum latifolium,
Utricularia intermedia,
Stachys palustris,
Polygonum dumetorum,
Betula pumila,
Alnus incana,
Salix myrtilloides,
Pinus Banksiana,
Pinus Strobus,
Larix Americana,
Thuja occidentalis,
Juniperus communis,
Symplocarpus fœtidus,
Sparganium simplex,

Sparganium minimum,
Naias flexilis,
Potamogeton lonchites,
Potamogeton compressus,
Triglochin maritimum,
Habenaria hyperborea,
Habenaria lacera,
Habenaria psycodes,
Arethusa bulbosa,
Microstylis monophyllos,
Liparis liliifolia,
Liparis Lœselii,
Corallorhiza odontorhiza,
Cypripedium spectabilis,
Smilax hispida,
Trillium erectum,
Smilacina stellata,
Lilium superbum.
Juncus pelocarpus,
Juncus nodosus,
Eriocaulon septangulare,
Cladium mariscoides,
Carex disticha,
Carex aurea,
Carex gracillima,
Carex umbellata,
Carex viridula,
Carex Pseudo-Cyperus,
Carex Tuckermani,
Triticum violaceum,
Aspidium Noveboracense,
Aspidium Goldianum,
Aspidium Filix-mas,
Osmunda Claytoniana.

II. LIST OF PLANTS FROM THE NORTH-WEST.

Thalictrum purpurascens,
Ranunculus multifidus,
Cardamine pratensis,
Cardamine hirsuta,
Erysimum asperum,
Viola cucullata,
Stellaria longifolia,
Petalostemon violaceus,
Petalostemon candidus,
Symphoricarpos occidentalis,
Achillea millefolium,
Artemisia biennis,
Anaphalis margaritacea,
Menyanthes trifoliata,
Hydrophyllum Virginicum,
Veronica Anagallis,
Utricularia vulgaris,
Mentha Canadensis,
Plantago major,
Corispermum hyssopifolium,
Polygonum amphibium,
Betula papyracea,
Sparganium eurycarpum,
Tofieldia glutinosa,
Lilium Philadelphicum,
Allium cernuum,
Cyperus Schweinitzii,
Carex microdonta,
Carex retrorsa,
Calamagrostis longifolia,
Phalaris arundinacea,
Equisetum robustum,
Polypodium vulgare,
Adiantum pedatum.

III. LIST OF PLANTS FROM THE EAST.

Clematis Viorna,
Anemone cylindrica,
Anemone acutiloba,
Ranunculus Pennsylvanicus,
Delphinum tricorne,
Magnolia acuminata,
Nymphæa tuberosa,
Stylophorum diphyllum,

Arabis dentata,
Thelypodium pinnatifidum,
Ionidium concolor,
Hudsonia tomentosa,
Elatine Americana,
Silene nivea,
Arenaria patula,
Sagina apetala,
Anychia dichotoma,
Talinum teretifolium,
Napœa dioica,
Linum striatum,
Linum sulcatum,
Flœrkea proserpinacoides,
Æsculus glabra,
Polygala Nuttallii,
Polygala ambigua,
Polygala Senega,
Desmodium Dillenii,
Cassia nictitans,
Prunus pumila,
Spiræa lobata,
Ribes rotundifolium,
Heuchera villosa,
Cuphœa viscosissima,
Erigenia bulbosa,
Viburnum acerifolium,
Fedia radiata,
Aster tenuifolius,
Aster oblongifolius,
Solidago Ohioensis,
Silphium trifoliatum,
Cacalia reniformis,
Hieracium Canadense,
Nabalus crepidineus,
Vaccinium vacillans,
Steironema longifolium,
Asclepias purpurascens,
Mertensia Virginica,
Collinsia verna,
Veronica officinalis,
Gerardia auriculata,
Lophantus scrophulariæfolius,
Scutellaria serrata,
Scutellaria nervosa,
Polygonum Careyi,
Rumex altissimus,
Rumex maritimus,
Callitriche heterophylla,
Euphorbia obtusata,
Ulmus fulva,
Ulmus racemosa,
Urtica gracilis,
Carya microcarpa,
Carya sulcata,
Quercus macrocarpa,
Quercus Muhlenbergii,
Quercus imbricaria,
Salix candida,
Salix discolor,
Salix sericea,
Salix petiolaris,
Populus monilifera,
Sagittaria graminea,
Habenaria tridentata,
Habenaria peramœna,
Corallorhiza multiflora,
Cypripedium candidum,
Trillium grandiflorum,
Trillium nivale,
Allium tricoccum,
Juncus marginatus,
Juncus Greenii,
Heteranthera reniformis,
Cyperus diandrus,
Eleocharis olivacea,
Eleocharis rostellata,
Scirpus subterminalis,
Scirpus debilis,
Scirpus Smithii,
Scirpus atrovirens,
Scirpus polyphyllus,
Scirpus lineatus,
Carex Willdenovii,
Carex alopecoidea,
Carex fœnea,
Carex virescens,
Carex oligocarpa,

Carex pubescens,
Carex Grayii,
Carex monile,
Glyceria elongata,
Glyceria pallida,
Poa trivialis,
Poa brevifolia,
Lycopodium complanatum.

IV. LIST OF PLANTS FROM THE SOUTH.

Clematis Pitcheri,
Myosurus minimus,
Nasturtium sessiliflorum,
Leavenworthia Michauxii,
Cardamine rhomboidea,
Arabis Ludoviciana,
Cleome pungens,
Hypericum prolificum,
Silene regia,
Hibiscus grandiflorus,
Vitis æstivalis,
Vitis indivisa,
Acer dasycarpum,
Polygala sanguinea,
Desmodium canescens,
Lespedeza repens,
Lespedeza hirta,
Phaseolus pauciflorus,
Cercis Canadensis,
Cassia Tora,
Cassia Chamœcrista,
Gleditschia monosperma,
Desmanthus brachylobus,
Prunus Chicasa,
Agrimonia parviflora,
Geum vernum,
Hydrangea arborescens,
Liquidambar Styraciflua,
Œnothera rhombipetala,
Ammannia latifolia,
Passiflora lutea,
Hydrocotyle umbellata,
Polytænia Nuttallii,
Archemora rigida,
Thaspium trifoliatum,
Eulophus Americanus,
Aralia spinosa,
Cornus asperifolia,
Spermacoce glabra,
Diodia teres,
Veronica fasciculata,
Liatris pychnostachya,
Conoclinium cœlestinum,
Brachychæta cordata,
Solidago stricta,
Silphium lacinatum,
Silphium integrifolium,
Silphium perfoliatum,
Rudbeckia subtomentosa,
Helianthus mollis,
Helianthus hirsutus,
Actinomeris helianthoides,
Coreopsis aristosa,
Leptopoda brachypoda,
Cnicus Virginianus,
Nabalus asper,
Lobelia puberula,
Campanula Americana,
Vaccinium stamineum,
Dodecatheon Meadia,
Forestiera acuminata,
Amsonia Tabernæmentana,
Acerates longifolia,
Gonolobus lævis,
Sabbatia brachiata,
Obolaria Virginica,
Phlox paniculata,
Ipomœa hederacea,
Cuscuta glomerata,
Solanum Carolinense,
Physalis angulata,
Conobea multifida,

Seymeria macrophylla,
Bignonia capreolata,
Tecoma radicans,
Ruellia ciliosa,
Ruellia strepens,
Verbena stricta,
Verbena Aubletia,
Lippia lanceolata,
Lycopus rubellus,
Salvia lyrata,
Scutellaria pilosa,
Aristolochia serpentaria,
Iresine celosioides,
Phoradendron flavescens,
Callitriche Austini,
Euphorbia corollata,
Euphorbia Ipecacuanhæ,
Croton capitatus,
Croton mononthogynus,
Carya olivæformis,
Quercus falcata,
Quercus nigra,
Quercus Phallos,
Taxodium distichum,
Trillium recurvatum,
Nothoscordum striatum,
Juncus dichotomus,
Carex debilis,
Muhlenbergia capillaris,
Paspalum fluitans.

V. LIST OF PLANTS FROM THE WEST.

Viola delphinifolia,
Trifolium stoloniferum,
Astragalus Plattensis,
Erigeron divaricatum,
Solidago Riddellii,
Solidago Missouriensis,
Ambrosia bidentata,
Helianthus doronicoides,
Dysodia chrysanthemoides,
Hieracium longipilum,
Gentiana puberula,
Phlox bifida,
Lithospermum angustifolium,
Ipomœa coccinea,
Veratrum Woodii,
Carex Nuttallii,
Sporobolus heterolepis,
Aristida ramosissima.

The following table presents, in a condensed form, the number of plants from each of these directions and their relations to the entire flora of the State:

Direction.	Number.	Proportion to Whole Number in State.
North-east	116	About 9.7 per ct.
North-west	34	" 2.9 "
Northern total	150	" 12.6 "
East	104	" 8.7 "
South	102	" 8.6 "
West	18	" 1.5 "

It will be seen that this includes not quite one-third of the plants of the State, and a question might arise as to the origin of the remaining two-thirds. They have been omitted from the above table simply because

their range is so general that it would be quite difficult now to determine the directions of their movement. It is claimed, however, that the proportions of the above table can be applied to all our flora, or that more than one-third of our flora is distinctly northern.

Entering a little more fully into details of direction and range of the Indiana flora, the following table is given, taking into account all the plants of the State:

Direction.	Limited by Indiana.	Extending Beyond Ind.	Proportion to No. in State.	No. in State.
South-east	72 per ct.	28 per ct.	About 23 per ct.	274
From Canada to Florida along the coast and westward	51 "	48 "	" 17.9 "	213
North	54 "	46 "	" 15.5 "	184
East	53 "	47 "	" 12.9 "	154
North-east	41 "	59 "	" 12.3 "	147
Common to all U. S. and northward	.....	.....	8.2 "	98
Local	.....	.....	3.2 "	38
South	77 "	23 "	2.2 "	26
Along the Mississippi R'vr	.....	.....	1.7 "	20
North-west	21 "	79 "	1.6 "	19
South-west	89 "	11 "	1.5 "	18
Total number of plants in the State	.....	.....	.....	1,191

In this table all plants which have escaped from cultivation have been omitted. The first of these tables gives the direction from which the species entered the State, while the other gives the direction in which they are now most abundant; thus many plants evidently entering our State from the south by natural lines of migration, which really have the greatest range toward the south-east. This will explain any seeming inconsistencies in the two tables.

From these tables it will be seen that a little more than four-fifths of our plants have a range north and east of our State. Hence, we conclude that the temperature of the Arctic regions, where our flora originated, was a little cooler than that of our State at present. All the families of plants have approximately the same ratios from each of these directions, except the *Rosaceæ*, which are distinctly northern in range, and the *Cyperaceæ* and *Gramineæ*, which have a very large proportion common to all Central North America, caused, no doubt, by their mode of growth and reproduction.

The following tables are given to illustrate the directions in which the different groups, and some of the larger families, are most abundant, the number of each in the State, and the proportion of this number to that of the whole number in the State:

DIRECTION.	Polypetalæ.	Leguminosæ.	Gamopetalæ.	Compositæ.
South-east	25.2 per ct.	40.2 per ct.	26.1 per ct.	27.8 per ct.
From Canada to Florida and westward	23.5 "	20.9 "	22.3 "	22.5 "
North	12.0 "	3.2 "	17.8 "	7 7 "
East	10.3 "	6.8 "	9.9 "	5 9 "
North-east	17.2 "	5.1 "	11.4 "	14.2 "
Common to all United States and north	1.1 "	0.0 "	0.5 "	2.0 "
Confined to adjoining States	3.4 "	8.7 "	3.5 "	3.2 "
South	3.2 "	19.3 "	2.5 "	11.6 "
Along the Mississippi River	1.4 "	0.0 "	2.5 "	0.6 "
North-west	1.7 "	3.3 "	1.0 "	2 6 "
South-west	1.0 "	1.7 "	2.5 "	1.9 "
Total number in the State	349	57	394	156

DIRECTION.	Apetalæ.	Monocotyledons.	Cyperaceæ.	Gramineæ.
South-east	31.8 per ct.	14.2 per ct.	17.6 per ct.	11.2 per ct.
From Canada to Florida and westward	9.7 "	9.6 "	4.9 "	0.0 "
North	15.0 "	16.6 "	19.6 "	10.2 "
East	21.2 "	16.6 "	20.6 "	9.2 "
North-east	7.1 "	10.2 "	5.9 "	8.2 "
Common to all United States and north	5.3 "	25.9 "	21.7 "	58.1 "
Confined to adjoining States	2.7 "	2.7 "	1.0 "	3.1 "
South	0.9 "	1.2 "	2.9 "	0.0 "
Along the Mississippi River	2.7 "	0.3 "	0.0 "	0.0 "
North-west	1.8 "	2.1 "	3.9 "	0.0 "
South-west	1.8 "	1.2 "	1.9 "	0.0 "
Total number in the State	113	332	102	98

From the first of these tables it will be seen that the *Leguminosæ* are distinctly south-eastern United States species, and the *Compositæ* are most abundant along the Atlantic Coast and south-east. Among the *Monocotyledons* the *Cyperaceæ* are eastern or common to all Central North America, and the *Gramineæ* are decidedly cosmopolitan.

Enough has been said to show the composite character of our flora, and that the chief lines of invasion have been from the north and east, principally the former, or that at least these invaders have been the most successful in maintaining their foothold. And it has also been demonstrated that there were two lines of northern advance—one from the north-east and the other from the north-west—presumably coincident with separate glacial advances.