SPECIES ISOLATION AND A PROGLACIAL LAKE IN SOUTHERN OHIO[1]

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The diverse geographic affinities of the Ohio flora have long been recognized and a large number of investigators have contributed to our knowledge of them. From the viewpoint of floristics alone, the complexity of the history of the primary vegetation of the region is strikingly illustrated by the presence of numerous disjunct species characteristic of prairie, plains, hemlock-hardwood and boreal plant formations.

That the arrival of plants characteristic of northern formations was associated with the advance of continental ice sheets of the Pleistocene has long been accepted. The persistence of boreal relic species in bogs, coves, on cliff tops and sand dunes is a conspicuous feature of many habitats in the state. Likewise, a pre-historic event in the form of a post-Wisconsin dry period accounts for the occurrence of continuous migration routes through the previous deciduous forest and the ultimate arrival in Ohio of many western species. An impressive set of data supporting the existence of a long dry period has been published by Transeau (17). Moreover, the areas where conspicuous assemblages of prairie species were dominant at the time of settlement in the state have been mapped.

In his ecology lectures for 20 years and in a recent paper, Transeau (18) has recognized still another group of plants growing in Ohio that have definite affinities southward; but the time and route of their migration into this region is not so clear. Braun (1), Thompson (15), and Schaffner (11), of the more recent writers, have also recognized this element. Griggs (3) listed some of these plants known in Hocking County 30 years ago. Transeau (18), however, has attempted to relate certain events in the physiographic history of the Alleghany and Cum-

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berland plateaus to the arrival and present distribution of these disjunct species which include "flowering plants, conifers, ferns, mosses, lichens, and algae."

It is the purpose of this paper to list these southern and Appalachian species and to further examine the pre-historic factors which appear to have been associated with their migration into the area, and also with their later isolation. The following is a list of plants occurring at one or only a few isolated stations in the unglaciated plateau. The more widely distributed species have been omitted.[2]

Algae

Mesotaenium aplanosporum Taft. Known only at Lloyd Bridge mine, Jackson county (14).

Fungi

Scleroderma geaster Fr. Hamilton, Ross and Jackson counties.

Lichens

Sticta feei Del. *Fide* C. W. Dodge.

Gyrophora dillenii (Tuck.) Müll. Arg. Several other species might be included on the basis of our present knowledge of distribution, but they are inconspicuous crustose plants such as *Lecanora deplanans* Nyl., known in West Virginia, but elsewhere only in Hocking County, Ohio. The *Gyrophora* however, is a large rock tripe and has been thoroughly searched for in southern Ohio. It has been found in Hocking, Fairfield, Vinton, Meigs and Lawrence counties. The *Sticta* is known only from Highland county and according to C. W. Dodge of The Missouri Botanical Garden, is known elsewhere only along the Atlantic Coastal plain.

Mosses

Atrichum crispum (James) Sull. Jackson county.

Brothera leana (Sull.) C. Mull. Fairfield, Hocking, Jackson and Pike counties.

Campylopus flexuosus Brid. Jackson county.

C. introflexus (Hedw.) Brid. Jackson county.

Dichelyma capillaceum Bry. Eur. Jackson and Ross counties.

Dicranum condensatum Hedw. Hocking, Jackson and Adams counties.

D. spurium Hedw. Hocking, Jackson and Athens counties.

Grimmia pilifera Beauv. Hocking, Jackson and Scioto counties.

Fabronia ravenelii Sull. Ross county.

Fissidens garberi Lesq. & James. Hocking and Jackson counties.

Pleuridium acuminatum Lindb. Hocking, Jackson and Ross counties.

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[2]Nomenclature followed in these lists is that of Fink (2) for the lichens; Grout (5) for the mosses; Schaffner (11) for the ferns and flowering plants. All of the plants listed are in the Ohio State University Herbarium and have been seen by the writer, unless otherwise indicated.

Pogonatum brachyphyllum (Rich.) Beauv. Hocking county.
Nanomitrium austinii (Sull.) Lindb. Jackson county.
N. synoicum (James) Lindb. Jackson county.
Philonotis longiseta (Rich.) E. G. Britton. Hocking county.
Sciaromium lescurii (Sull.) Broth. Hocking and Jackson counties.
Syrophodon taxanus Sull. Hocking, Jackson and Pike counties.
Weisia tortilis (Schwaegr.) C. Müll. Adams county.
Zygodon viridissimus (Dicks.) R. Br. Jackson county.

Ranges of all the above species are indicated by Grout (4).

Ferns

Lygodium palmatum (Bernh.) Sw. Hocking and Athens counties; only two stations in Ohio.
Trichomanes boschianum Sturm. Spruce Run, Hocking county.
Polypodium polypodioides (L.) A. S. Hitchc. Reaches northern limit in Ohio in Hocking county. Also in Meigs, Hamilton and Gallia counties.
Asplenium resiliens Kunze. A single station in Adams county.

Flowering Plants

Wolffia papulifera Thomps. In a small pool, Salt Creek, Jackson county. Possibly entered state via the Mississippi embayment but persisted only in this locality.
Cyperus refractus Engelm. Jackson county.
C. retrofractus (L.) Torr. Jackson and Hocking counties.
C. lancestriensis Port. Jackson and Meigs counties.
C. torreyi Britt. Jackson county.
Muhlenbergia capillaris (Lam.) Trin. Jackson county.
Gymnopogon ambiguus (Mx.) B. S. P. Jackson county.
Panicum verrucosum Muhl. A single station in Adams county.
P. yadkinense Ashe. Jackson and Scioto counties.
P. anceps Mx. Jackson county.
Paspalum longipedunculatum Le Conte. Jackson county.
Erianthus divaricatus (L.) Hitchc. Scioto county.
Iris verna L. Scioto county.
Stenanthium robustum S. Wats. Fairfield, Jackson and Scioto counties. Taken also in Stark county, on a steep hillside in open field.
Hexalectris spicata (Nutt.) Barnh. Adams and Scioto counties.
Magnolia macrophylla Mx. Jackson county.
M. tripetala L. Hocking, Jackson, Vinton and Scioto counties.
Ranunculus alleghaniensis Britt. Morgan and Vinton counties.
Draba cuneifolia Nutt. Adams county.
Polygala curtissii A. Gr. Jackson county.
Hibiscus oculiroseus Britt. Lawrence, Jackson and Pickaway counties. Another species that may have reached Ohio from the Mississippi embayment region.
Triadenum longifolium Sm. Jackson and Vinton counties.
Passiflora incarnata L. Lawrence county.
Silene rotundifolia Nutt. Jackson, Hocking, Ross and Pike counties; on ledges and in crevices in deep gorges.

S. wherryi Sm. Highland, Adams, Pike and Scioto counties.
Calycanthus nanus (Loisel.) Sm.
Robinia hispida L. Jackson, Athens, Meigs, Highland and Muskingum counties.
Clitoria mariana L. Jackson, Fairfield, Adams and Scioto counties.
Galactia volubilis (L.) Britt. Jackson, Scioto and Adams counties.
Ilex opaca Ait. Gallia and Lawrence counties.
Heuchera villosa Mx. Gallia, Adams and Lawrence counties.
Rhamnus caroliniana Walt. Adams and Scioto counties.
Euonymous americanus L. Jackson, Vinton and Gallia counties.
Pachystima canbyi Gr. Highland county.
Quercus prinoides Willd. Adams county.
Q. ilicifolia Wang. Not known in Ohio, but grows across the river from Lawrence and Scioto counties.
Q. triloba Mx. Lawrence and Scioto counties.
Kneiffia linearis (Mx.) Spach. Jackson, Scioto and Meigs counties.
Azalea lutea L. Jackson, Fairfield and Lawrence counties.
A. nudiflora L. Lawrence, Scioto, Ross and Jackson counties; also in northern Ohio in Portage, Geauga and Ashtabula counties.
Rhododendron maximum L. Jackson, Fairfield, Scioto, Lawrence and Hocking counties. Numerous stations in western Hocking county.
Xolisma ligustrina (L.) Britt. Gallia and Ross counties. Grows in a bog in Gallia county.
Styrax grandifolia Ait. Near "Buffalo Beat" in Athens county, "on an outcropping ledge of limestone."
Halesia carolina L. Scioto county.
Phlox stolonifera Sims. Hocking, Jackson and Athens counties.
Chionanthus virginica L. Jackson, Gallia, Meigs, Lawrence and Scioto counties.
Asclepiadora viridis (Walt.) A. Gr. Adams, Meigs and Highland counties.
Gentiana villosa (L.) Sm. Adams, Scioto, Jackson and Gallia counties.
Anisostichus capreolata (L.) Bureau. Adams, Scioto and Lawrence counties.
Ruellia parviflora (Nees.) Britt. Meigs and Gallia counties.
Scutellaria serrata Andr. Hocking, Jackson, Athens and Gallia counties.
S. integrifolia L. Hocking, Vinton, Jackson, Ross, Scioto and Lawrence counties.
S. saxatilis Ridd. Scioto county.
Koellia pyncnanthemoides (Leav.) Ktz. Scioto and Jackson counties.
Meehania cordata (Nutt.) Britt. Hocking, Gallia, Scioto, Meigs and Athens counties.
Diodia virginiana L. Adams county.
Viburnum venosum Britt. Jackson county.
Coreopsis major Walt. Gallia, Lawrence and Scioto counties.
Antennaria solitaria Rydb. Ross, Jackson, Hocking, Lawrence, Adams and Vinton counties.
Chrysopis mariana (L.) Ell. Scioto, Gallia, Jackson, Vinton and Hocking counties.
C. graminifolia (Mx.) Ell. Adams county.

Seriocarpus linifolius (L.) B. S. P. Scioto, Adams and Jackson counties.
Eupatorium album L. Scioto and Jackson counties.
E. torreyanum Short. Jackson county.
E. rotundifolium L. Jackson, Hocking and Fairfield counties.
E. pubescens Muhl. Hocking county.
E. aromaticum L. Scioto, Fairfield and Jackson counties.
E. incarnatum Walt. Lawrence county.
Vernonia noveboracensis (L.) Willd. Gallia county.

The above lists include species of plants which are definitely disjuncts, or in a few instances, species which are at the northern edge of their range in Ohio. They occur at stations in 14 southern Ohio counties, but it is notable that all of them grow in, or *adjacent to*, areas of considerable elevation in western Gallia and eastern Lawrence counties, Adams and Scioto counties, the rock shelter region in western Hocking county, and Liberty Township in Jackson county. Moreover, over 60 per cent of the vascular plants listed occur in the Hocking or Jackson county stations. More than half of them have been taken in Liberty Township.

To account for the localized distribution of these plants, several phenomena should be taken into consideration. These are:

1. The migration of southern species into the area.
2. The isolation of assemblages of southern plants in several clearly delimited areas.
3. The conspicuous absence of flood plain, swamp forest, and other lowland species from the list.
4. The survival of these species since the time of their arrival. This is a distinct problem which can be solved only by a detailed study of edaphic and microclimatic conditions in the places of survival.

Southern plants probably have reached Ohio along the hilltops and ridges of the Cumberland Plateau across the route of the present Ohio River, and by way of the flood plains and adjacent bluffs of the preglacial Teays River system, the headwaters of which were far to the southeast in western North Carolina. By which route the individual species arrived is uncertain, but it seems reasonable that the Teays and other rivers with headwaters in the plateaus and mountains have been effective agencies of migration and that many southeastern species were living in the plateau of Ohio long before the coming of Pleistocene ice. The arrival in this region of these species is, in fact, far more likely to have occurred during the long time the Teays River was in existence than later. If a southeastern

flora had not arrived in the area during the 60,000,000 years of the Tertiary when these streams were potent propagule-carrying agencies, then it is not likely that these plants would have arrived in postglacial time after the elimination of these agencies.

Thus it may be assumed that the southern and southeastern flora was well established in the region at the close of the Pliocene and that the present occurrence of individual species in Ohio, and the absence of others, may be accounted for by events since that time. The story of drainage changes as first assembled by Tight (16) and more recently summarized by Rich (21), and Stout and Lamb (12), is probably incomplete. Nevertheless, the major events seem well enough understood to associate their effects with the history of Ohio vegetation. These events may be listed as follows:

1. Advance of an early continental ice sheet.
2. Blocking of northwestward flowing streams by this advance.
3. Ponding of drainage water from the plateau in the valleys of the Teays and Licking (Ky.) systems and the accumulation of slackwater deposits in them.
4. Development of new outlets by the ponded water across low divides, and the reversal of drainage.
5. Withdrawal of the early ice sheet and subsequent re-advances of continental ice.
6. Modification of silts and clays by subsequent drainage from the glaciers.
7. Establishment for a time of a Deep Stage during an interglacial period by the pronounced downcutting of the newly-formed Ohio River and its tributaries.
8. Carving of terraces in the filled valleys and partial removal of slackwater deposits by interglacial and present-day streams.

With the blocking of the northwestward flow of the Teays river by ice, a vast lake, with a complex of irregular branches was formed. An estimate of one stage in the extent of this ponded water is presented in Figure 1. "Lake Tight" existed for a considerable time as is indicated by the 80 foot depth of the lacustrine deposits in many of the preglacial valleys of southern Ohio (13, 21). That its level was subject to periodic and great fluctuations prior to the establishment of an outlet across a low divide, is indicated by the presence of lake shore terraces (16) and the occurrence of a number of erratics in Kentucky (7, 9), some more than 50 miles south of the known glacial boundary. One glacial boulder, weighing approximately

16 tons (7, 8), is located at an elevation of 1009.3 feet. All of the erratics have been found within the area of ponding at or near the heads of preglacial valleys, where it is reasonable to suppose icebergs would be more likely to accumulate. All of the lake deposits, on the other hand, are at, or below, the 860 foot level.

According to the records obtained during the floods of recent years in the Ohio valley, the Ohio River with its present outlet, rose 80.1 feet at Cincinnati, as a result of heavy precipitation on the snow-covered mountains in the Ohio basin to the east. Lake Tight existed for a long time with no outlet comparable to that of the present Ohio, and was supplied with water not only from the plateau, but also by meltwater from the vast ice sheet and snow fields to the north.

EFFECTS ON VEGETATION

This and subsequent events seem to have been decidedly significant in their effect on existing vegetation and on the later development of vegetation in the following ways:

1. The destruction of all lowland plants in the area of ponding. The absence in these areas of plants limited in their distribution to flood plains, swamps and other lowland habitats is significant.

2. Isolation of certain upland species on islands and peninsulas within the ponded area (Fig. 1). It is not assumed that these plants are necessarily still restricted to these upland areas. Many are now found at lower levels in coves, on ledges and steep slopes, and even in gorges within the areas previously mentioned.

3. The destruction of an important agency of migration with the elimination of the Teays River and the subsequent drainage changes which occurred with the reversal of the preglacial streams of Ohio.

4. Modification of air temperatures and lengthening of the frost-free season over and adjacent to the ponded area due to the high specific heat of water and the increase of atmospheric moisture. Present day effects of much smaller water areas (*e. g.*, Ohio River, Lake Erie) is well known (10).

5. Degradation of deep gorges with the ultimate overflow of the ponded water over a low divide somewhere to the west. This produced a great diversity of plant habitats, with a wide range of local climatic conditions,[3] some favorable to the requirements of southern species. Other factors favored boreal species which arrived later. Thus it is not uncommon in western Hocking county to find a number of southern plants and as many boreal species in the same gorge.

[3]Measurement of some of these microclimatic conditions in one valley over a continuous period, an investigation now in its third year, is being carried on by three members of the Department of Botany, Ohio State University. Significant data are being obtained, but are too detailed for presentation here.

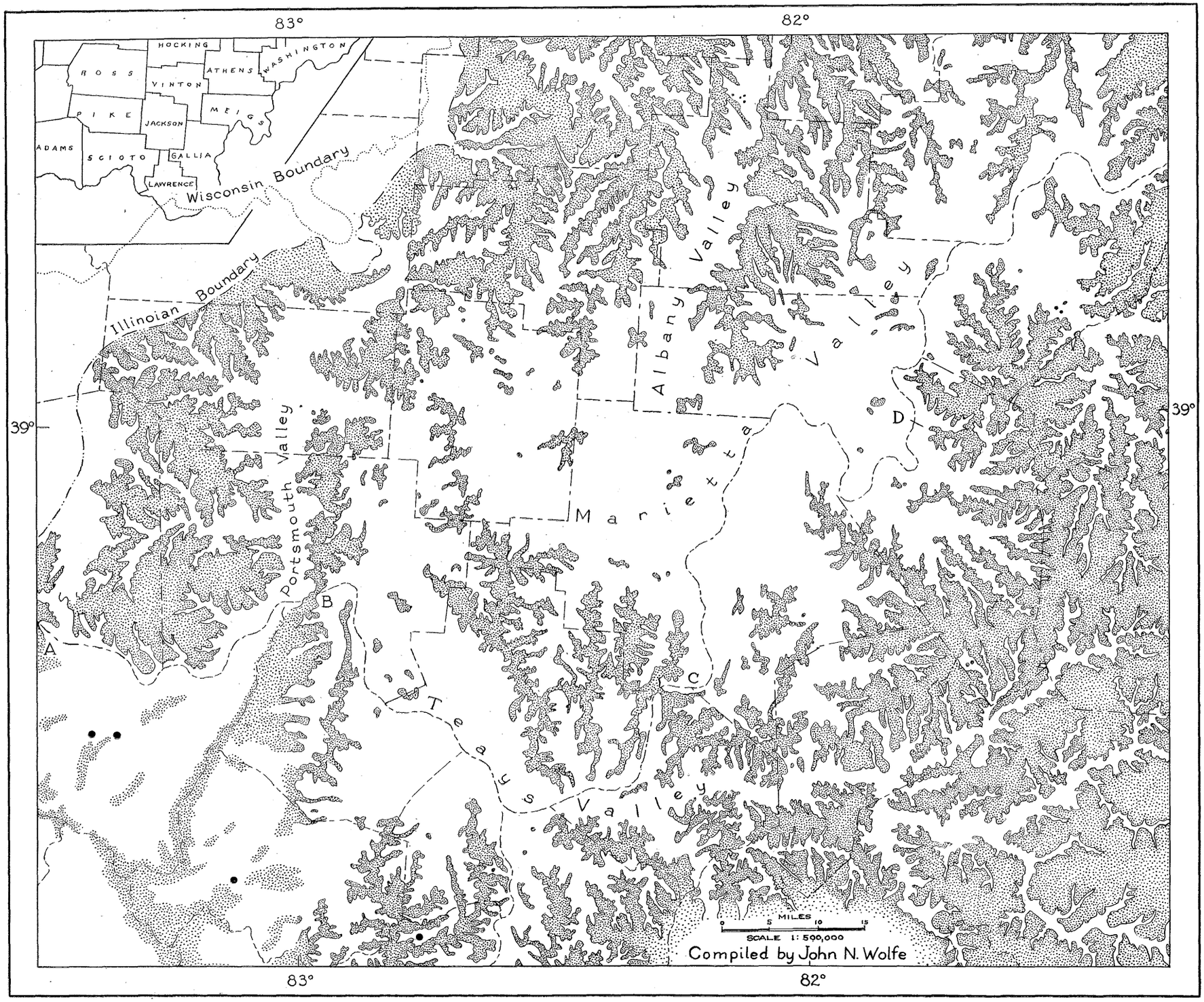

FIG. 1. Sketch map showing one possible stage in the extent of proglacial Lake Tight in southern Ohio and adjacent parts of Kentucky and West Virginia. Also indicated are the principal valleys of the Teays System in Ohio, and the preglacial divides across what is now the Ohio River (A, B, C, D). The large dots show the location of four glacial boulders outside the drift boundaries. Inset: County map of southern Ohio.

This estimate of Lake Tight was compiled from 50 U.S.G.S. topographic maps of the area, the 900 foot contour line being used in outlining the flooded area. Some allowance has been made for post-glacial erosion and some of the important preglacial divides have been reconstructed.

6. Filling of valleys with valley train gravels by subsequent glaciation, and the deposition of calcareous clays over vast areas, conspicuously modified local edaphic conditions. The migration of plants, favored by conditions associated with alkalinity, far into the highly acid Blackhand sandstone region of Hocking county, along the lower slopes and valley bottoms, illustrates this point. Examples: Fringed Gentian and Redbud.

7. Carving of terraces in the valley fills further modified conditions by removal of lacustrine deposits and valley train gravels, and resulted in better drainage on the terraces.

CONCLUSION

Thus, on the basis of available data, the presence of a large number of isolated Appalachian and southern species of plants are known in the southern Ohio area. The arrival of these species, their isolation in three or four rather well-defined areas, and their persistence may be associated with a succession of events in the physiographic history of the region.

It should be understood, of course, that the list of plants as published, is tentative. Some names may be removed altogether and the arrival and distribution of some of the species may later be accounted for by a different combination of events. The writer is not unaware of the fact that an understanding of the vegetation of Ohio is dependent upon a detailed knowledge of the historical factors. This story has not yet been written and the discovery of its successive episodes will require the combined efforts of geologists, pedologists, zoologists and botanists.

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