

THE PHYTECOLOGY OF PEAT BOGS NEAR RICHMOND, INDIANA.

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LITERATURE USED FOR REFERENCE.

- (¹) Transeau, E. N., On the geographical distribution and ecological relations of the bog plant societies of northern North America. *Bot. Gaz.* 36: 401-420, 1908.
(²) Leverett, F., The glacial formations and drainage features of the Erie and Ohio basins. *Mon.* 41, U. S. G. S.
(³) Dachnowski, M., A cedar bog in central Ohio. *Ohio Naturalist*, 11: No. 1, 1910.

While the peat bog is a common feature of the landscape in northerly latitudes, the presence of a bog as far south as Central Indiana or Ohio excites considerable interest. It is the belief of modern botanists (¹), that these bogs originated during the period immediately following the glacial period, when the area abutting on the edge of the ice approximated arctic conditions, and gradually emerged from this condition after the recession of the ice. Since the retreat of the ice began at its southern border, areas retaining any of the primitive conditions incident to the original arctic climate increase in rarity southward. In Indiana and Ohio, the Ohio river formed the approximate southern boundary of the ice sheet at the time of its greatest extension; so these bogs are within sixty or seventy miles of the southernmost limit of glacial action and even nearer the edge of the most recent ice sheet. No doubt many bogs formerly existed in central Indiana and Ohio, but, with changed conditions, practically all have disappeared.

The principal features of interest involved in an ecological study of the vegetation of peat bogs are, first, the presence of a large number of xerophytic forms, a situation not to be inferred from the well-watered condition of the habitat; second, the existence of many plants characteristic of arctic and subarctic regions. Little study was made of the anatomy of these xerophytic forms, as they are not nearly so well represented here as in the northern bogs.

The presence of boreal forms may be accounted for as follows: During the glacial period, the flora of the area bordering on the ice was arctic, such a flora having been able to retreat southward before the slowly-advancing ice, and consisted of such forms as were able to withstand the many north-

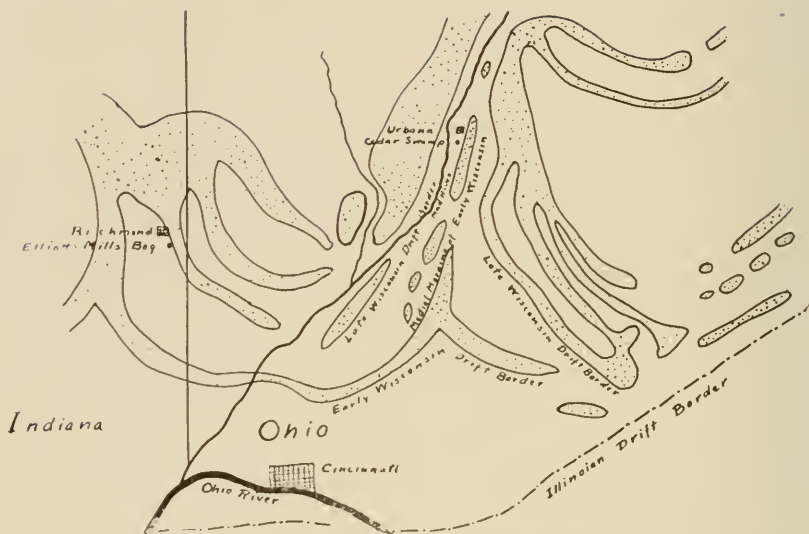


FIG. 1. Map of part of southeastern Indiana and southwestern Ohio, showing glacial moraines of the Early and Late Wisconsin Ice Sheets and the boundary of the Illinoian drift; also the location of the bogs near Richmond, Indiana and Urbana, Ohio. Adapted from Leverett and supplemented by observation.

and-south oscillations of the ice. When the ice finally retreated, the plants followed. As any area became warmer and drier, some species perished. The southern flora, long held in check by the glacier, began to crowd in and where conditions were favorable for its growth, replaced the arctic flora, which remained only in such situations as were unsuitable for the growth of the southern plants, such as bogs and cool, shady ravines. Such places as these are islands of northern plants left in our now southern and south-eastern flora.

The physiographic cycle of a bog differs from that of an ordinary swamp in several particulars; while both are ephemeral features of the landscape, soon being destroyed by sedimentation or by drainage, they differ in the manner in which they are filled; a swamp fills up from the bottom by the gradual accumulation of sediment deposited by incoming streams and that formed by decaying plant and animal matter; while a bog fills largely from the top by the formation, beginning at the edge, of a gradually thickening and settling floating mat of partially decayed vegetation, which is finally capable of supporting a rich flora. Bogs are more likely to develop in undrained or poorly drained depressions, though there are partially drained bogs and undrained swamps.

The glacial age was not a unit, but was characterized by alternate advances and recessions of the ice, repeated no one knows how often. The last few advances were, in general, less extensive than their predecessors, so the terminal moraine of each was not, in every case, destroyed by its successor. The moraines of three of these successive advances of the ice can be distinguished in Ohio (2). The oldest, the Illinoian, extended almost to the Ohio river. The second, the Early Wisconsin, extended nearly as far, and was divided by an elevation of land into two lobes, the Scioto on the east and the Maumee-Miami on the west. The Late Wisconsin sheet followed the same course as did its predecessor. The terminal moraines of the two sheets are roughly parallel. The medial moraine of the two lobes of the Early Wisconsin Sheet was not destroyed by the Late Wisconsin, and the outwash plain between the medial moraine of the Early Wisconsin and the lateral moraine of the Late Wisconsin formed a broad valley, now drained by the Mad river. In this valley is located a bog, known locally as the Cedar Swamp. See accompanying map, Fig. 1.

Cedar Swamp is in Champaign county, Ohio, about five miles south of Urbana. It is between the river and the east bluff of the valley. There is

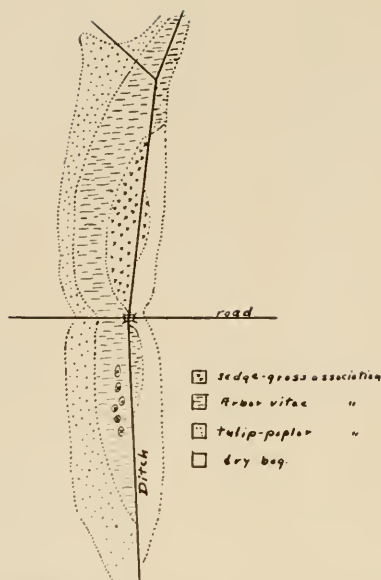


FIG. 2. Map of Cedar Swamp, showing relation of the plant associations. The birch-alder association is not shown.



FIG. 3. Panoramic view of Cedar Swamp, looking northward from near the road. Made from two photographs. Sedge-grass association in foreground, arbor vitae association in background, with birch-alder association between. The sedge-grass association had recently been burned over.

no evidence that it occupies a former bed of the stream. The bog probably occupies what was originally a small lake on the valley floor, fed by springs in the underlying gravel. The former area of the bog was no doubt much greater than its present area, as is shown by extensive outlying deposits of peaty soil. The area of the bog has been greatly reduced during the last few years by artificial means. From natives of the vicinity, it was learned that the bog was formerly much wetter and more impenetrable. A story is told of an "herb-doctor" who entered the bog on a collecting expedition and never returned. A skeleton recently unearthed was supposed to be that of the unfortunate doctor.

The bog is now artificially drained by a large ditch, but the natural drainage was evidently very sluggish.

The bog in its present condition throws no light on the question of the origin of the floating mat of plants characteristic of the earlier stages. Four rather distinct plant associations, representing four stages in the plant succession in a bog formation, are represented here. These are the sedge-grass association, the birch-alder association, the arbor vitae association and the maple-tulip association.

The quaking mat, occupied by the sedge-grass association, has almost disappeared, and exists only in isolated patches, the largest of which is shown on the accompanying map, Fig. 2. One of the smaller patches appears in a photograph, Fig. 7. The areas that are left are quite typical. Walking about over the mat is to be conducted with some caution, especially in the wetter seasons. By jumping on the mat, one can shake it for many feet around. A stick can be thrust down with little resistance to a depth of four to six feet. The burning over of the largest of these areas has destroyed many of the typical plants. The principal species found in the association are as follows:

- Drosera rotundifolia.*
- Parnassia caroliniana.*
- Carex* spp.
- Lophiola aurea.*
- Solidago ohioensis.*
- Solidago Riddellii.*
- Calopogon pulchellus.*
- Liparis Loeselii.*
- Habenaria paramoena.*



FIG. 4. Arbor vitae trees two feet in diameter with the logs upon which they germinated still remaining. The ends of the logs near the trees do not show. The hatchet is stuck in the nearer log. Cedar Swamp.

Equisetum arvense.

Typha latifolia.

Utricularia minor.

Lobelia Canbyi.

Cardamine bulbosa.

Scirpus americanus.

Genm rivale.

Aspidium thelypteris.

The birch-alder association occupies the smallest area of any of the associations, since it forms merely a narrow fringe between the areas of quaking mat and the areas occupied by the arbor vitae association. Some of the same plants are found intermingled with the trees and others on the mat. The tendency is for these bordering shrubs gradually to close in upon the mat areas they enclose until the mat is covered. The shrubs may gain a foothold upon higher points in the mat association from which they spread outward. The principal plants of the birch-alder association are as follows:

Potentilla fruticosa.

Aldus incana.

Betula pumila.

Hypericum prolificum.

Salix cordata.

Physocarpus opulifolius.

Cephalanthus occidentalis.

Steironema quadrifolia.

Silphium terebinthinaceum.

Ulmaria rubra.

Phlox glaberrima.

By far the largest part of the bog is occupied by the arbor vitae association. The association is noticeable from a distance, on account of the presence of these trees of arbor vitae, or white cedar, which gave the bog its name. Trees two feet in diameter are common. A stump, oblong in cross-section, was found to be twenty feet in circumference and five by eight feet in diameter. The stump was hollow, so that its age could not be determined, but the outer six inches showed about one hundred growth rings, so the tree must have been several hundred years old. Under natural conditions, this association would probably persist for a very long time, as invasion from without goes on very slowly. The Thuyas have very com-



FIG. 5. Stump of an arbor vitae tree 40 years old, and the log upon which it germinated. Cedar Swamp.

plete possession of the habitat. Shade conditions are such as to exclude light-demanding forms. First attempts at photography under the arbor vitae resulted in failures, on account of uniform under exposures. The vegetation of the forest floor is not abundant, except in early spring. The herbs are largely shade-enduring species. The mat of roots and fallen branches and leaves is another factor that deters invasion from without. If the toxicity of the substratum is a factor, it exerts its maximum influence here, under present conditions. Then, too, the plants of the association are reproducing themselves very efficiently, all stages of seedlings and saplings being found. Nearly all the Thuyas germinate on stumps and logs. A specimen four or five inches in diameter and twenty-five feet in height was found growing on a stump four feet high. Even the oldest trees, which must be hundreds of years old, are still grasping in their roots the partially decayed remains of the logs upon which they germinated. The fact that the logs are lying in a position that subjects them to the greatest exposure to decay shows the resistant qualities of arbor vitae wood. The logs shown in the photograph (Fig. 4) are still fairly sound, though the trees which grew upon them are two feet in diameter.

One of the commonest undergrowth shrubs is *Taxus canadensis*, which is here a prostrate, creeping shrub, seldom more than one or two feet in height. No traces of seed formation were observed, but the plant reproduces abundantly by layering. What at first glance seems to be a group of plants is found to be a series of layered branches from a common central plant. This habit is of considerable ecological importance here, since it seems to be the only means of reproduction of the species.

As the accompanying list shows, the arbor vitae association is the habitat of a large number of species of ferns, which form a prominent part of the flora of the association. *Camptosorus* was found in four widely-separated situations, growing luxuriantly upon fallen logs. Plants of *Pteris* more than four feet in height are rather common. *Osmunda cinnamomea* is common, but only two specimens of *O. regalis* were seen. *Botrychium virginianum* is abundant. *Prothallia* of *O. cinnamomea* are common.

A single plant of *Lycopodium lucidulum*, probably the last representative of its species, was found. The disappearance of this species is indicative of what has occurred in the case of many other northern forms and of the eventual fate of those that remain. Another disappearing species is



FIG. 6. A fallen arbor vitae tree, showing shallow rooting. Trees are frequently uprooted. Cedar Swamp.

Vaccinium corymbosum, only one specimen of which was seen. The principal species of the association are as follows:

- **Thuya occidentalis*.
- **Taxus canadensis*.
- **Alnus incana*.
- Populus deltoides*.
- **Populus tremuloides*.
- Rhus vernix*.
- Rhus cotinus*.
- Rhus glabra*.
- Lindera benzoin*.
- Ribes Cynosbati*.
- Rubus idaeus*.
- **Rubus triflorus*.
- **Vaccinium corymbosum*.
- Cornus paniculata*.
- Cornus alternifolia*.
- Acer rubrum*.
- Pyrus arbutifolia*.
- Ampatiens biflora*.
- Laportea canadensis*.
- Aselepias incarnata*.
- Caltha palustris*.
- Symplocarpus foetidus*.
- Cypripedium parviflorus*.
- Cypripedium hirsutum*.
- Aralia racemosa*.
- Polygonatum biflorum*.
- Dioscorea villosa*.
- Polymnia canadensis*.
- Mitchella repens*.
- Anemonella thalictroides*.
- Anemone quinquefolia*.
- Pedicularis lanceolata*.
- Polemonium reptans*.
- Uvalaria perfoliata*.
- Mitella diphylla*.



FIG. 7. One of the small areas occupied by the sedge-grass association, with *Silphium* and *Typha* in the foreground, and *Thuja* in the background. The birch-alder association is not well developed here. Cedar Swamp.

Hydrophyllum appendiculatum.
Hydrophyllum virginianum.
Arisema diphylla.
Trillium grandiflorum.
Trillium cernuum.
 **Trientalis americana.*
 **Maianthomum canadense.*
Senecio aureus.
Botrychium virginianum.
Osmunda regalis.
Osmunda cinnamomea.
Pteris aquilina.
Cystopteris fragilis.
Aspidium spinulosum.
Aspidium cristatum.
Aspidium thelypteris.
Adiantum pedatum.
Anoclea sensibilis.
Camptosorus rhizophyllus.
Asplenium acrosticoides.
 **Lycopodium lucidulum.*

On the west side of the arbor vitae association is an almost undisturbed tree association, differing greatly in composition from that just described. The arbor vitae zone is made up largely of plants of northern origin or plants characteristic of bogs, while the plants of the other group, called the maple-tulip association, are those typical of the climax mesophytic forest of the region and are distinctly southern in their origin. A comparison of the distribution of the more distinctly boreal forms of the arbor vitae association, indicated thus (*) in the list, with those given below for the maple-tulip association, will make the difference in origin very striking. Practically all these boreal forms occur outside the limits of distribution given by the best manuals. The beech is usually a member of the climax mesophytic forest of this region, but since for some reason it is absent from all the forests of this vicinity for several miles around, it is also absent in the bog. The principal trees of the maple-tulip association follow:

Liriodendron tulipifera.
Acer saccharinum.
Acer rubrum.
Fraxinus nigra.
Fraxinus americana.
Juglans cinerea.
Ulmus americana.
Ulmus racemosa.
Platanus occidentalis.
Lindera benzoin.
Xanthoxylum americanum.
Pilea pumila.
Urticastrum sp.
Thalictrum dasycarpum.

We have in the cedar swamp a formation of plants of a decidedly boreal aspect, maintaining itself, but for the influence of man, in the midst of a flora predominantly southern. Ability to maintain itself in the struggle with the southern flora was probably due originally to differences in the habitat. Just what the factors are that make bog conditions unsuitable for the growth of most plants have not been fully determined; but some combination of edaphic conditions permitted the northern plants to remain and removed them very largely from competition with the southern forms. In the later stages of the development of the bog, many of these conditions have probably been modified or removed. Many of the southern plants could undoubtedly maintain themselves under the present conditions; but the bog plants have such complete possession of the habitat that invasion is practically precluded. But for the influence of man, the formation would no doubt have been able to maintain itself for many centuries to come.

About two miles southeast of Richmond, Ind., lies a small remnant of a formerly much more extensive peat bog. It is known as the Elliott's Mills bog and is in such an advanced state in the physiographic cycle of bogs that little resemblance to a typical bog remains. But the characteristic peat soil and the presence of certain bog and boreal plants indicate its former character. The bog lies in a broad, shallow valley between morainic hills. It evidently occupies a shallow, undrained depression scooped out in a softer part of the underlying Niagara limestone. The bog is crossed by a public

highway and is now drained by the roadside ditch. It was necessary to blast through rock in order to get an outlet for the bog, showing that it is a rockbound depression. Tile drains from the bog carry streams of cold water throughout the year. Galleries supplying part of the water for the city of Richmond occupy a drier part of the bog.

The very advanced state of the bog is due, no doubt, to its nearness to the southern limit of glaciation and its consequent great age. Few typical bog plants remain. The following, however, are more or less characteristic of bogs: *Rhus vernix*, *Salix pedicellaris*, *Hypericum prolificum*, *Parnassia caroliniana*, *Potentilla fruticosa*. Only one specimen of *Rhus vernix* remains and it is dying—a fate typical of that of many bog plants which must formerly have existed here.

Nearly all boreal forms have likewise disappeared. The following species have a range reaching far into the north: *Potentilla fruticosa*, *Salix rostrata*, *Populus tremuloides*. Only one specimen of *Salix rostrata* was found. No other specimen is known in the region. *Populus tremuloides* occurs sparingly thru central Indiana, but is common in the bog.

A very striking fact is the presence of a large number of species characteristic of prairies. This is somewhat strange when it is remembered that the prairie is a formation not at all characteristic of eastern Indiana, which was originally heavily forested. Eastern Indiana is, however, not far from the tension line between the forest formation characteristic of the east and southeast and the prairie formation characteristic of the west and southwest. No doubt after the retreat of the glacial ice there was a migration of plants of both of these formations and a consequent struggle between them for the possession of the new territory. In some instances the pond-swamp-prairie succession or the pond-bog-prairie succession may have occurred, while in other cases the pond-swamp-forest or the pond-bog-forest succession may have taken place. The last named is the succession that occurred at Cedar Swamp. In Eastern Indiana, the condition that finally prevailed over the entire area was the mesophytic forest, but it is not likely that the patches that may have followed the succession toward the prairie would have entirely disappeared. This hypothesis would account for such islands of prairie plants in a forested area as we find in this bog. This is not an isolated case, for other such situations are found in eastern Indiana and western Ohio and are known locally as "quaking prairies." The writer hopes to make further studies of these areas.

The following plants occur in the Elliott's Mills bog:

Rhus vernix.
Cornus stolonifera.
Potentilla fruticosa.
Parnassia caroliniana.
Hypericum prolificum.
Salix pedicellaris.
Salix rostrata.
Gerardia paupercula.
Populus tremuloides.
Aster Nova-Angliae.
Aster oblongifolius.
Phlox glaberrima.
Physostegia virginica.
Ulmaria rubra.
Solidago ohioensis.
Solidago Ridellii.
Solidago stricta.
Solidago rugosa.
Rudbeckia hirta.
Desmodium paniculata.
Monarda fistulosa.
Rosa setigera.
Koellia virginica.
Chelone glabra.
Cirsium muticum.
Salix nigra.
Salix cordata.
Lobelia syphilitica.
Lobelia Kaluii.
Aspidium thelypteris.
Selaginella apus.
Physocarpus opulifolius.
Inula Helenium.
Geum canadense.
Symplocarpus foetidus.
Eupatorium perfoliatum.

Eupatorium purpureum.

Sagittaria latifolia.

Alisma plantago.

Carex spp.

Cuscuta sp.

Ludwigia palustris.

Bidens trichosperma.

Oxypolis rigidior.

Campanula americana.

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