

VASCULAR FLORA OF THE MILLER BLUE HOLE AND STREAM, SANDUSKY COUNTY, OHIO¹

DONALD J. PINKAVA

Department of Botany and Plant Pathology, The Ohio State University, Columbus 10

The Miller Blue Hole is located approximately six miles west of the similar but commercially famous Castalia Blue Hole and near the junction of U.S. Route 6 and Sandusky County Route 290. In 1932, the Ohio State Division of Conservation purchased from the Miller family a 13-acre tract of land surrounding the nearly 2-acre, elliptically shaped hole (Langlois, 1958). The outlet stream overflows the hole's northeastern rim, journeys eastward a short distance, then 2 miles northward, and empties into Sandusky Bay (fig. 1). The hole and stream lie entirely within Sections Four and Nine of Townsend Township.

METHODS

Care was taken in an effort to collect members of all vascular species along the entire watercourse including the hole, the stream, and the banks within 6 ft of the shore line, a total area of approximately 6 acres. The catalogue of plants of this paper is substantiated by voucher specimens deposited in The Ohio State University Herbarium, Columbus. Collections and observations were made during 1959-1962.

GEOLOGY

The source of water is apparently rainfall on the uplands to the south. The water enters numerous sinkholes and a system of subterranean passageways corroded through or beneath Silurian dolomites of the Bass Island Group (Orton, 1899; Stout, 1941). The water level in these caverns nears the surface as its slope grades gently toward Sandusky Bay until a contour is reached such that any penetration, natural or artificial, into the caverns results in a spring (Wolfe, 1931).

After their uplift during the Appalachian revolution (Orton, 1899), these rocks were sculptured by acid-charged water that had entered the widened cleavage planes. They occupy their present-day position after the recessions of the Pleistocene glaciers and ensuing tiltings of the land mass (Moseley, 1899). The glaciers deposited a coating of drift in thickness probably not more than 25 ft (Stout, 1941). According to the elevations of post-glacial lake beaches listed by Forsythe (1959), the Miller Blue Hole area was covered by Lakes Maumee, Wittlesey, and Warren. This level topography lies within the Erie Lake Plain of the Central Lowlands (Ver Steeg and Yunck, 1932).

SOILS

The substrate of the vegetation of this region is comprised of Toledo silty clay and Warner's loam soils. Toledo silty clay is derived basically from Lake Maumee deposits (Allen et al., 1920). It occurs on level land including most of the stream banks. Since it is of very poor drainage, extensive ditches and tiling systems abound in the area. Warner's loam regions (fig. 1) appear as overflow deposits of the Miller Blue Hole covering approximately one square mile and as marl deposits of Castalia Blue Hole and Upper Springs forming the extensive nearby

¹Contribution No. 680 of the Department of Botany and Plant Pathology, The Ohio State University. Derived from thesis submitted to Graduate School in partial fulfillment of requirements for the degree Master of Science; completed while a National Science Foundation Co-operative Fellow.

Castalia prairie. Warner's loam is composed of a dark-gray to black silty marly loam surface layer, a whitish to light-gray loose marl subsurface layer, and a subsoil of a yellowish-brown calcareous clay (Allen et al., 1920). Solidified marl deposits called tufa are strewn over the surface, displaced by agricultural practices.

Tufa is a porous travertine formed as a deposit of calcium carbonate that has been separated from calcium bicarbonate contained in the underground supply of water. Tiny particles of calcium carbonate held in suspension account for a milky appearance of the water (Langlois, 1958). Upon settling out, the carbonate encrusts those objects with which it comes in contact. The deposit here is largely upon *Chara*, the thalli of which are often clearly outlined in the tufa.

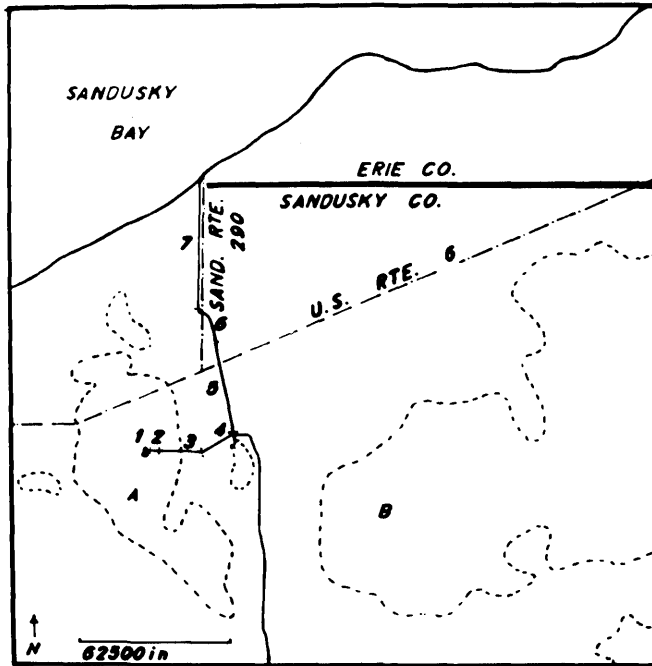


FIGURE 1. Map of Miller Blue Hole region. The collection stations at the hole (1) and along the overflow stream (2-7) are described in text. Warner's loam is within dotted enclosures A and B about the Miller Blue Hole and the Castalia Blue Hole respectively. (Modified with permission of U.S. Government Printing Office).

CLIMATE

The climate at Miller Blue Hole is less modified by Lake Erie than at lake-shore cities such as Sandusky. At Vickery, a few miles southeast of the hole, the frost-free season averages 163 days, notably less than Sandusky City's 197 frost-free days (Pierce, 1959). The mean annual temperature at Vickery is 49.8 F (Marvin, 1936); at Sandusky City, 51.3 F (Pierce, 1959). Extreme temperatures at Vickery from 1893 to 1930 are 107 F in August, 1918, and -24 F in February, 1918 (Alexander, 1923; Marvin, 1936). Freezing temperatures have been recorded for all months except June, July, and August (Marvin, 1936).

The rainfall, averaging between 33 and 34 inches annually at Vickery, is quite well distributed throughout the year, the months of greatest rainfall coinciding with those early in the growing season, namely May, June, and July (Marvin, 1936).

ORIGINAL VEGETATION

The vegetation as viewed by pioneers is difficult to ascertain, particularly since man has drained and tilled much of the land. Prior to disruptions by man, the region of Warner's loam probably supported a vegetation similar to that then growing in the Castalia wet prairie. The gradual slope to Sandusky Bay makes possible the flooding of large areas both here and at Castalia, resulting in marl beds, some reaching 15 ft thick (Stout, 1949). From the straightness and great depth of the stream bed, it appears that the stream is essentially a man-made drainage system. Originally the water probably spilled over the very low northern rim and flooded the area now occupied by the loam. The trees currently found in the area are mostly likely recent invaders after artificial drainage had become effective.

The larger trees of the immediate area, in size and species, indicate early nearby forests to be of a swamp forest type. The largest, an American elm, measures 61.5 inches DBH. Specimens over 40 inches DBH are represented by bur oak; over 30 inches, by hackberry, cottonwood, sycamore, red oak, black willow; and over 20 inches, by boxelder, green ash, red ash, and slippery elm. Moseley (1899, 1904) reports local residents recalling prairie, often under water, at Castalia and such trees as ash, oak, elm, and hickory as common in northeastern Sandusky County. Orton (1899) also remarks of an extensive marsh or swamp from Castalia Blue Hole to Sandusky Bay.

Surrounding the wet prairie at the hole were an elm-ash-oak-hickory forest to the north, the Great Black Swamp along the lake and bay to the west, the Castalia wet prairie to the east, and more mesic forests on the uplands to the south.

PRESENT-DAY VEGETATION

The Blue Hole

The surface of the spring is essentially elliptical with a north-south major axis of approximately 300 ft and a minor axis of about 220 ft (Hille, 1955). The water, only inches deep above the encircling 5- to 10-ft-wide marl shelf, suddenly deepens into a funnel basin averaging about 25 ft deep. The orifice(s) near the south shore has been plumbed at 62 ft below the surface (Wolfe, 1931). The water level fluctuates during the year. The volume of water varies from 800 to 1000 gal/min at a flow rate of 0.5 to 0.7 ft/sec (Hille, 1955).

The surface temperatures of the hole vary with the season, reaching a maximum of 28 C in August (Hille, 1955) and a minimum of 8.5 C in winter. The temperature decreases as much as approximately one-half degree per 6-ft increase in depth of water (Wolfe, 1931). There is no thermocline. Water entering the hole is nearly devoid of oxygen, but contains large quantities of carbon dioxide. The buffering effect of high concentrations of bicarbonates probably accounts for the near neutral pH readings. The water does not freeze here or along the immediate eastward flow of the stream except at shore lines in insignificant quantities.

The vegetation about Miller Blue Hole (fig. 2) may be conveniently divided into five nearly concentric zones (fig. 5). The open water or innermost zone includes free-swimming and unattached algae, predominantly greens and blue-greens.

The second vegetation zone is a complex one. *Spirogyra* develops rapidly early in spring and forms a bright-green ring above the marl shelf. *Chara contraria*, attached to the marl shelf and to the steeply sloping sides of the hole, grows upward to the surface. Eventually the *Spirogyra* becomes entwined about the *Chara*, the two together forming green pinnacles stringing to or near the surface. These pinnacles, characteristic of the hole during the summer months, form the foundation of a mat that includes mosses, diatoms, *Spirogyra*, *Chara*,

and other algal forms. As the growing season progresses, the mat becomes thickened, protrudes slightly above the surface, and is subject to action of the wind blowing across the surface. Sections of the mat break loose and reform on the eastern shore line, particularly near the stream outlet. Portions of the mat may persist through much of the winter, but by spring the mat is restricted to the stream where it accumulates against obstacles in the water.

This mat supports water cress, *Nasturtium officinale*, in the stream and, according to Wolfe (1931), in the hole also. Where dogwoods and other plants overhang the water, the mat thins and disappears near the shore. Here the water is open and clear, harboring *Chara contraria*, *Lemna minor*, *L. trisulca*, and *Utricularia vulgaris*.

Next is the zone of emergent plants comprised mostly of grasses and sedges, the roots of which are embedded in the calcareous deposits. Hillocks of *Eleocharis calva* project above the shallow waters along the lightly shaded southern and eastern shores. Associated with *Eleocharis* are representatives of several species of which *Gerardia purpurea*, *Muhlenbergia glomerata*, and *Triglochin palustris* are of calcareous bog association.

The fourth zone is composed of plants growing upon the banks. Dogwoods and entanglements of lianas are interspersed with overtopping trees. Underneath the canopy of cottonwood and black willow is a more extensive subcanopy of red ash, green ash, white mulberry, and choke cherry. The dense shrub layer of *Cornus obliqua*, *C. racemosa*, *C. stolonifera*, *Prunus virginiana*, *Sambucus canadensis*, and *Viburnum lentago* is draped with such vines as *Convolvulus sepium*, *Echinocystis lobata*, *Parthenocissus inserta*, *Polygonum scandens*, *Solanum dulcamara*, and *Vitis riparia*. On mud flats of the northern and western banks are found *Galium triflorum*, *Glyceria striata*, *Muhlenbergia mexicana*, *Pilea pumila*, and *Ranunculus abortivus*. The less shaded southern and eastern banks having a more pronounced drop to water level are inhabited by *Ambrosia trifida*, *Asclepias incarnata*, *Carex blanda*, *Cicuta bulbifera*, *Dryopteris thelypteris*, *Solidago canadensis*, and *Urtica procera*.

Nearly encircling the dogwood zone is a red ash - green ash - white mulberry community. Hackberry and boxelder also appear in the canopy. The shrub layer consists of dogwoods, *Ribes americanum*, and *Xanthoxylum americanum*. There is much seasonal variation in the rather scant herbaceous layer. Some of the more common herbs are *Cryptotaenia canadensis*, *Eupatorium rugosum*, *Hackelia virginianum*, *Osmorhiza longistylis*, *Senecio obovatus*, and *Smilacina stellata*. The ash-mulberry zone quickly grades out into open grassy fields spotted with small ash individuals and dogwoods.

The Stream

The overflow stream area was divided into six collecting stations (fig. 1). The width of the stream varies from approximately 12 ft at its source to less than 4 ft at the first bridge (edge of state-owned land) and at various locations where fallen logs and debris have formed natural obstructions. The average width is estimated to be 6 ft. In cross-section, the stream bed is broadly U-shaped with steep banks rising 4 to 5 ft at angles of 45 to 60 degrees or more to the horizontal. In some areas the banks overhang the water. Slumping of banks is not uncommon

EXPLANATION OF FIGURES

- FIGURE 2. Westward view across Miller Blue Hole (Station One.) Vegetation zones I-V described in text.
 FIGURE 3. Miller Blue Hole Stream, looking eastward from bridge at edge of state-owned land (Station Three).
 FIGURE 4. Miller Blue Hole Stream, looking eastward from bridge, Sandusky County Route 290 (Station Six).



during the wet seasons. The depth of the water may be more than 2 ft near bridges and obstructions but is usually less than 1 ft. Flooding after rains may more than double these values.

Brungs (1959) reports a steady increase in average temperature of stream water (measured midway of the depth) from 12.9 C at source to 19.8 C at mouth during summer months. I found 1960–1961 winter temperatures as low as 8.5 C at source and 4.5 C at mouth. Hence, stream temperatures fluctuate most nearest the mouth. The oxygen content and pH values increase as water flows along the stream's course, while the amounts of carbon dioxide and bicarbonates decrease (Brungs, 1959).



FIGURE 5. Vegetation zones of Miller Blue Hole (Station One).

The stream banks from the hole to the first bridge (station two) bear many woody taxa including *Celtis occidentalis*, *Cornus racemosa*, *C. stolonifera*, *Crataegus*, *Fraxinus pennsylvanica*, *Platanus occidentalis*, *Populus tremuloides*, *Prunus virginiana*, *Rhamnus lanceolata*, *Sambucus canadensis*, and *Xanthoxylum americanum*. Vines, brambles of *Rubus occidentalis*, shrubs and saplings make thickets nearly impenetrable, particularly where openings appear in the canopy. The herbaceous layer is very sparse; seldom can be found more than a few individuals of a limited number of species. The only liverwort found, *Conocephalum conicum*, inhabits a 20 ft² section of the southern bank near the first bridge. The mat of moss,

Chara, and other algae is found floating in the stream, usually abutting fallen logs and branches. Water cress is common on the mat.

From the above-mentioned bridge one-quarter mile eastward to a point at which the stream angles northeastward (station three), *Chara*, *Spirogyra*, water cress, and diatoms constitute most of the vegetation of the stream. *Batrachospermum* sp., a red alga, was found trailing in the shallow, swift water. Patches of mat occasionally occur entangled with overhanging grasses and sedges, the predominant plants on the banks. Scattered are some herbs, vines, and a few saplings, but no trees (fig. 3).

The site from station three to the junction of Miller Blue Hole Stream with another stream of subequal size flowing westward and with a small temporary stream from the south (station four), supported, until cleared of its woody vegetation in the winter of 1960-1961, plants most closely resembling the original woody vegetation believed to have occupied the region. Probably best described as an elm-ash-oak-hickory complex, the canopy included *Acer negundo*, *Carya ovata*, *Fraxinus pennsylvanica*, *Gleditsia triacanthos*, *Platanus occidentalis*, *Quercus alba*, *Q. bicolor*, *Q. macrocarpa*, *Q. rubra*, *Ulmus americana*, and *U. rubra*. Shrubs and small trees were abundant, including *Carpinus caroliniana*, *Cornus obliqua*, *C. racemosa*, *Prunus virginiana*, and saplings of canopy species. Vines and briars added to the density of the undergrowth. The herbaceous layer was represented by *Anemone quinquefolia*, *Aster sagittifolius*, *Erythronium americanum*, *Galium concinnum*, *Geranium maculatum*, *Hystrix patula*, *Thaspium trifoliatum*, and others.

North of the junction of streams, a notable change of aquatic vegetation occurs. *Chara* and the mat are replaced by leafy pondweed, *Potamogeton foliosus*, which in July and August may cover from 40 to 80 per cent of the stream bottom. During the cold months, *Vaucheria* forms pads covering as much as one third of the stream bed. A mud bottom, interrupted by patches of stones especially near the stream mouth, replaces the marl characteristic of the first four stations. The adjoining streams also have mud bottoms. The stream becomes wider with shallower, more turbid water bounded by less steep banks than at previous stations.

Except for the depauperate swamp forest area of station six (fig. 4) in the bend of the stream prior to its paralleling Sandusky County Route 290 to Sandusky Bay (station seven), the stream banks are largely grass-covered with interspersed herbs, saplings, and a few large elms and oaks. Thus stations five and seven and portions of six are not very unlike station three except for the aquatic flora. All are bordered by cultivated fields, pasture, or human dwellings. The swamp forest, largely removed during the winter of 1961-1962, was composed primarily of *Gleditsia triacanthos*, *Fraxinus pennsylvanica* and its variety *subintegerrima*, *Acer saccharinum*, *Ulmus americana*, and *U. fulva*.

SUMMARY

The original vegetation of the unique environ of the Miller Blue Hole appears to have been an elm-ash-oak-hickory swamp forest of the Deciduous Forest Formation. Areas too wet for the invasion and establishment of trees supported a wet prairie, a relict probably surviving since the eastward extension of prairies during xeric times following the Wisconsin glacier and the recession of early post-glacial lakes. The wet prairie was apparently best developed on sites now occupied by Warner's loam in the immediate vicinity of the hole and also on more extensive areas eastward centered about the Castalia Blue Hole. Present-day indicator species such as *Asclepias tuberosa*, *Rudbeckia lanciniata*, *Calamagrostis canadensis*, *Ratibida pinnata*, *Sorghastrum nutans*, *Quercus macrocarpa*, *Silphium terebinthinaceum*, *Heliopsis helianthoides*, and *Spartina pectinata* reflect the rapidly disappearing wet prairie situation.

Carex prairea, *Chara contraria*, *Gerardia purpurea*, *Muhlenbergia glomerata*,

CATALOGUE OF VASCULAR PLANTS OF MILLER BLUE HOLE REGION

The vascular flora of the Miller Blue Hole region includes representatives of 281 species in 73 families (table 1). Scientific names and sequence of families follow *Gray's Manual of Botany*, eighth edition. Numbers following common

TABLE 1

Summary of vascular plants by major taxa

Taxon	Orders	Families	Genera	Species
Pteridophyta	3	3	3	4
Spermatophyta	30	70	195	277
Gymnospermae	0	0	0	0
Angiospermae	30	70	195	277
Monocotyledonae	4	11	45	67
Dicotyledonae	26	59	150	210
Vascular plants	33	73	198	281

name refer to collecting stations at which plants were found. Taxa marked with an asterisk (*) were found in the immediate vicinity but outside the limits of six feet from the watercourse.

PTERIDOPHYTA

EQUISETACEAE

- Equisetum arvense* L.
Field Horsetail. 3,4,7.
Equisetum kansanum Schaffner
Scouring-rush. 3.

OPHIOGLOSSACEAE

- **Botrychium virginianum* (L.) Sw.
Rattlesnake Fern.

POLYPODIACEAE

- Dryopteris thelypteris* (L.) Gray,
var. *pubescens* (Lawson) Nakai
Marsh Fern. 1,3.

SPERMATOPHYTA-
MONOCOTYLEDONAE

TYPHACEAE

- **Typha angustifolia* L.
Narrow-leaved Cat-tail.

SPARGANIACEAE

- **Sparganium eurycarpum* Engelm.
Bur-reed.

ZOSTERACEAE

- Potamogeton foliosus* Raf.
Leafy Pondweed. 5,6,7.

JUNCAGINACEAE

- Triglochin palustris* L.
Arrow-grass. 1.

ALISMATACEAE

- **Alisma subcordatum* Raf.
Water-plantain.

GRAMINEAE

- Agropyron repens* (L.) Beauv.
Witch Grass. 3,5,6,7.
Agrostis alba L.
Redtop. 2,7.
Avena sativa L.
Oat. 6.
Bromus inermis Leyss.
Awnless Brome Grass. 5,6,7.
Bromus racemosus L.
Brome Grass. 6,7.
Calamagrostis canadensis (Michx.) Nutt.
Bluejoint. 3,5,6,7.
Dactylis glomerata L.
Orchard Grass. 5,6,7.
Digitaria sanguinalis (L.) Scop.
Common Crab Grass. 6,7.
Echinochloa crusgalli (L.) Beauv.
Barnyard Grass. 5,6,7.
Eleusine indica (L.) Gaertn.
Wiregrass. 2.
Elymus canadensis L.
Canada Wild Rye. 5,6,7.
Elymus virginicus L.
Terrell Grass. 5,6,7.
Glyceria striata (Lam.) Hitchc.
Fowl-meadow Grass. 1,2,3,4.
Hordeum jubatum L.
Squirrel-tail Grass. 5,6,7.
Hystrix patula Moench
Bottle-brush Grass. 4.
Leersia oryzoides (L.) Sw.
Rice Cutgrass. 5,6,7.
Lolium perenne L.
Perennial Rye Grass. 5,6,7.
Muhlenbergia glomerata (Willd.)
Trin. Muhlenbergia. 1.
Muhlenbergia mexicana (L.) Trin.
Muhlenbergia. 1,5,6,7.

Panicum capillare L.
Old-witch Grass. 6,7.
Panicum dichotomiflorum Michx.
Panic Grass. 6.
Phalaris arundinacea L.
Reed Canary Grass. 6,7.
Phleum pratense L.
Common Timothy. 3,5,6,7.
Poa compressa L.
Canada Bluegrass. 3,5,6,7.
Poa pratensis L.
Kentucky Bluegrass. 2,3,4,6.
Secale cereale L.
Rye. 3.
Setaria faberii Herrm.
Foxtail. 3.
Setaria glauca (L.) Beauv.
Yellow Foxtail. 3,5,6,7.
Setaria viridis (L.) Beauv.
Green Foxtail. 5,6.
Sorghastrum nutans (L.) Nash
Indian Grass. 2,5.
Spartina pectinata Link
Slough Grass. 7.
Triodia flava (L.) Smyth
Tall Redtop. 7.

CYPERACEAE

Carex amphibola Steud., var. *turgida* Fern.
Sedge. 7.
Carex blanda Dew.
Sedge. 1.
Carex brevior (Dew.) Mackenz.
Sedge. 7.
Carex frankii Kunth
Frank's Sedge. 5.
Carex hystericina Muhl.
Porcupine Sedge. 1.
Carex lanuginosa Michx.
Woolly Sedge. 1,3.
Carex prairea Dew.
Sedge 1.
Carex sparganoides Muhl.
Bur-reed Sedge. 4.
Carex spicata Huds.
Sedge. 3,7.
Carex stipata Muhl.
Awl-fruited Sedge. 6.
Carex vulpinoidea Michx.
Fox Sedge. 1,3.
Cyperus odoratus L.
Galingale. 1.
Eleocharis calva Torr.
Spike-rush. 1,3.
Scirpus atrovirens Willd.
Dark-green Bulrush. 5,6,7.
Scirpus validus Vahl
Great Bulrush. 1,3,7.

LEMNACEAE

Lemna minor L.
Small Duckweed. 1.
Lemna trisulca L.
Star Duckweed. 1.

JUNCACEAE

**Juncus balticus* Willd.
Rush.

Juncus dudleyi Wieg.
Dudley's Rush. 3.
Juncus torreyi Coville
Torrey's Rush. 1,5,7.

LILIACEAE

Allium canadense L.
Wild Garlic. 4.
Allium vineale L.
Field Garlic. 4,7.
**Asparagus officinalis* L.
Garden Asparagus.
Erythronium americanum Ker
Yellow Dog's-tooth-violet. 4.
Hemerocallis fulva L.
Common Orange Day-lily. 7.
Lilium michiganense Farw.
Michigan Lily. 4.
Smilacina stellata (L.) Desf.
Starry False Solomon's Seal. 1,2,3,4.
Smilax tannoides L. var.
hispida (Muhl.) Fern.
Bristly Greenbrier. 1,4.

IRIDACEAE

Iris versicolor L.
Iris. 5.
Sisyrinchium angustifolium Mill.
Blue-eyed-grass. 4.

SPERMATOPHYTA-
DICOTYLEDONAE

SALICACEAE

Populus deltoides Marsh.
Cottonwood. 1,4.
Populus tremuloides Michx.
Quaking Aspen. 2,4.
Salix nigra Marsh.
Black Willow. 1.
Salix humilis Marsh.
Small Pussy Willow. 1,7.

JUGLANDACEAE

Carya ovata (Mill.) K. Koch
Shagbark Hickory. 4.

CORYLACEAE

Carpinus caroliniana Walt.
American Hornbeam. 4.
Corylus americana Walt.
American Hazelnut. 4.

FAGACEAE

Quercus alba L.
White oak. 4.
Quercus bicolor Willd.
Swamp White Oak. 4.
Quercus macrocarpa Michx.
Bur Oak. 4,7.
Quercus rubra L.
Red Oak. 4.

ULMACEAE

Celtis occidentalis L.
Hackberry. 1,2,4,5,7.
Ulmus americana L.
American Elm. 1,3,4,5,6,7.

Ulmus rubra Muhl.

Slippery Elm. 4,5,6,7.

MORACEAE

Maclura pomifera (Raf.) Schneid.
Osage-orange. 7.

Morus alba L.
White Mulberry. 1,2,4,5,7.

CANNABINACEAE

Humulus lupulus L.
Common Hop. 3,4,5,6,7.

URTICACEAE

Pilea pumila (L.) Gray
Clearweed. 1,5,6.

Urtica procera Muhl.
Nettle. 1,2,3,5,6,7.

SANTALACEAE

**Comandra umbellata* (L.) Nutt.
Bastard-toadflax.

POLYGONACEAE

Polygonum aviculare L.
Doorweed. 3.

Polygonum convolvulus L.
Black Bindweed. 5.

Polygonum lapathifolium L.
Water Persicaria. 3,5,6,7.

Polygonum pennsylvanicum L.
Pinkweed. 3,5.

Polygonum persicaria L.
Lady's-thumb. 6.

Polygonum scandens L.
Climbing False Buckwheat. 1,4,5,6,7.

Rumex altissimus Wood
Pale Dock. 5,7.

Rumex crispus L.
Yellow Dock. 3,7.

Rumex obtusifolius L.
Blunt-leaved Dock. 2,5,7.

CHENOPODIACEAE

Atriplex patula L.
Orach. 7.

Chenopodium album L.
Lamb's-quarters. 4,5,7.

AMARANTHACEAE

Amaranthus hybridus L.
Green Amaranth. 2,5,7.

PHYTOLACCACEAE

Phytolacca americana L.
Pokeweed. 1,3,5.

PORTULACACEAE

Portulaca oleracea L.
Common Purslane. 3.

CARYOPHYLLACEAE

Cerastium nutans Raf.
Nodding Mouse-ear Chickweed. 5.

Lychnis alba Mill.
White Champion. 7.

Saponaria officinalis L.
Soapwort. 7.

Silene cucubalus Wibel
Bladder Campion. 1.

RANUNCULACEAE

Anemone quinquefolia L.
Wood Anemone. 4.

Anemone virginiana L.
Thimbleweed. 1,2,7.

Clematis virginiana L.
Virgin's-bower. 1,7.

Ranunculus abortivus L.
Kidney-leaf Buttercup. 1,2,4.

Thalictrum dasycarpum Fisch. & Lall.
Purple Meadow-rue. 3,4,5,6,7.

BERBERIDACEAE

Podophyllum peltatum L.
May-apple. 4.

MENISPERMACEAE

Menispermum canadense L.
Moonseed. 4.

CRUCIFERAE

Arabis canadensis L.
Sicklepod. 2.

Barbarea vulgaris R. Br.
Yellow Rocket. 3,4.

Brassica kaber (DC.) L.C. Wheeler
Charlock. 6,7.

Brassica nigra (L.) Koch
Black Mustard. 6,7.

Capsella bursa-pastoris (L.) Medic.
Shepherd's Purse. 4,7.

Descurainia pinnata (Walt.) Britt.,
var. *brachycarpa* (Richards.) Fern.
Tansy Mustard. 3.

Lepidium campestre (L.) R. Br.
Cow-cress. 3,5,7.

Lepidium virginicum L.
Poor Man's Pepper. 2.

Nasturtium officinale R. Br.
True Water Cress. 2,3,4.

Thlaspi arvense L.
Field Penny-cress. 5.

CRASSULACEAE

Sedum telephium L.
Garden Orpine. 7.

SAXIFRAGACEAE

Ribes americanum Mill.
Wild Black Currant. 1,2,4.

PLATANACEAE

Platanus occidentalis L.
Sycamore. 1,2,4.

ROSACEAE

Agrimonia parviflora Ait.
Small-flowered Agrimony. 1.

Crataegus sp.
Hawthorn. 2,4.

Crataegus sp.
Hawthorn. 2,4,6.

Fragaria virginiana Duchesne
Strawberry. 1,2,3.

- Geum canadense* Jacq.
White Avens. 1,6.
- Potentilla norvegica* L.
Rough Cinquefoil. 3.
- Prunus americana* Marsh.
Wild Plum. 4.
- Prunus virginiana* L.
Choke Cherry. 1,2,4.
- Pyrus coronaria* L.
Wild Crab. 4.
- Rosa palustris* Marsh.
Swamp Rose. 6,7.
- Rubus flagellaris* Willd.
Common Dewberry. 4.
- Rubus occidentalis* L.
Black Raspberry. 1,2,7.
- LEGUMINOSAE
- Amphicarpa bracteata* (L.) Fern.
Hog-peanut. 7.
- Cassia hebecarpa* Fern.
Wild Senna. 1,2.
- Desmodium perplexum* Schub.
Tick-trefoil. 1,2.
- Gleditsia triacanthos* L.
Honey-locust. 4,5,6,7.
- Lathyrus palustris* L.
Vetchling. 3.
- Medicago lupulina* L.
Black Medick. 3,7.
- Medicago sativa* L.
Alfalfa. 6.
- Melilotus alba* Desr.
White Sweet Clover. 3,5,6,7.
- Melilotus officinalis* (L.) Lam.
Yellow Sweet Clover. 5,7.
- Trifolium hybridum* L.
Alsike Clover. 3.
- Trifolium pratense* L.
Red Clover. 3,7.
- OXALIDACEAE
- Oxalis europea* Jord.
Wood Sorrel. 1,5,6,7.
- GERANIACEAE
- Geranium maculatum* L.
Wild Cranesbill. 4.
- RUTACEAE
- Xanthoxylum americanum* Mill.
Prickly-ash. 1,2,4.
- EUPHORBIACEAE
- Acalypha virginica* L.
Three-seeded Mercury. 7.
- Euphorbia dentata* Michx.
Toothed Spurge. 3.
- Euphorbia maculata* L.
Eyebane. 3,6.
- ANACARDIACEAE
- Rhus glabra* L.
Smooth Sumac. 4.
- Rhus radicans* L.
Poison-ivy. 1,2,3,4,5,6,7.
- Rhus typhina* L.
Staghorn Sumac. 4,7.

CELASTRACEAE

- Celastrus scandens* L.
Climbing Bittersweet. 2,3,4.
- Euonymus atropurpureus* Jacq.
Wahoo. 4.

ACERACEAE

- Acer negundo* L.
Box-elder. 1,2,4,7.
- Acer saccharinum* L.
Silver Maple. 6,7.

BALSAMINACEAE

- Impatiens capensis* Meerb.
Spotted Touch-me-not. 3,5,6,7.

RHAMNACEAE

- Rhamnus lanceolata* Pursh
Buckthorn. 2.

VITACEAE

- Parthenocissus inserta* (Kerner) K. Fritsch
Woodbine. 1,2,3,4,7.
- Vitis riparia* Michx.
River-bank Grape. 1,2.

TILIACEAE

- Tilia americana* L.
Basswood. 4.

MALVACEAE

- Abutilon theophrasti* Medic.
Velvet-leaf. 3,5.
- Malva neglecta* Wallr.
Common Mallow. 7.

VIOLACEAE

- Viola papilionacea* Pursh
Common Blue Violet. 2,7.

ONAGRACEAE

- Gaura biennis* L.
Gaura. 6.
- Oenothera biennis* L.
Common Evening-primrose. 5,6,7.

UMBELLIFERAE

- Angelica atropurpurea* L.
Alexanders. 7.
- Chaerophyllum procumbens* (L.) Crantz
Spreading Chervil. 5,6.
- Cicuta bulbifera* L.
Bulb-bearing Water-hemlock. 1,3.
- Cicuta maculata* L.
Spotted Water-hemlock. 7.
- Cryptotaenia canadensis* (L.) DC.
Honewort. 1.
- Daucus carota* L.
Wild Carrot. 3,5,6,7.
- Osmorhiza longistylis* (Torr.) DC.
Anise-root. 1,4.
- Pastinaca sativa* L.
Parsnip. 7.
- Sanicula canadensis* L.
Black Snakeroot. 2,6.
- Sanicula gregaria* Bickn.
Black Snakeroot. 1,4.
- Thaspium trifoliatum* (L.) Gray
Meadow-parsnip. 3,4.

CORNACEAE

- Cornus drummondii* Meyer
Dogwood. 1,7.
Cornus obliqua Raf.
Silky Dogwood. 1,2,4,7.
Cornus racemosa Lam.
Panicked Dogwood. 1,2,4,7.
Cornus stolonifera Michx.
Red Osier. 1,2.

PRIMULACEAE

- Lysimachia ciliata* L.
Loosestrife. 3,5,6,7.

OLEACEAE

- Fraxinus pennsylvanica* Marsh.
Red Ash. 1,2,4,6.
Fraxinus pennsylvanica Marsh., var.
subintegerrima (Vahl) Fern.
Green Ash. 1,2,4,6,7.
Syringa vulgaris L.
Lilac. 7.

APOCYNACEAE

- Apocynum cannabinum* L.
Indian Hemp. 3,7.

ASCLEPIADACEAE

- Asclepias incarnata* L.
Swamp Milkweed. 1,5,6,7.
Asclepias syriaca L.
Common Milkweed. 2,3,5,6,7.
**Asclepias tuberosa* L.
Butterfly-weed.

CONVOLVULACEAE

- Convolvulus sepium* L.
Hedge Bindweed. 1,5,7.
**Cuscuta campestris* Yuncker
Dodder on *Trifolium pratense* L.

BORAGINACEAE

- Hackelia virginiana* (L.) I. M. Johnston
Stickseed. 1.
Lithospermum arvense L.
Corn Gromwell. 3,7.

VERBENACEAE

- Verbena hastata* L.
Blue Vervain. 1,3,5,6,7.
Verbena urticifolia L.
White Vervain. 1.

LABIATAE

- Agastache nepetoides* (L.) Ktze.
Yellow Giant Hyssop. 6.
Glechoma hederacea L.
Ground-ivy. 6.
Lamium amplexicaule L.
Common Henbit. 5.
Lycopus americanus Muhl.
Water-horehound. 1,5,6.
Mentha arvensis L.
Mint. 5.
Mentha piperita L.
Peppermint. 1,2,3.
Nepeta cataria L.
Catnip. 2,7.

- Prunella vulgaris* L.
Heal-all. 3,6.
Pycnanthemum virginianum (L.) Durand &
Jackson
Mountain-mint. 2.
Scutellaria lateriflora L.
Mad-dog Skullcap. 5.
Stachys tenuifolia Willd.
Hedge-nettle. 5.
Teucrium occidentale Gray
Hairy Germander. 5.

SOLANACEAE

- Datura stramonium* L.
Common Jimsonweed. 2,6.
Physalis heterophylla Nees
Ground-cherry. 3,5.
Physalis subglabrata Mackenz. & Bush
Ground-cherry. 5.
Solanum dulcamara L.
Bittersweet Nightshade. 1,2,3,5,7.
Solanum nigrum L.
Black Nightshade. 5.

SCROPHULARIACEAE

- Gerardia purpurea* L.
Gerardia. 1.
Mimulus ringens L.
Monkey-flower. 5,6,7.
Scrophularia marilandica L.
Carpenter's-square. 6.
Verbascum blattaria L.
Moth Mullein. 7.
Verbascum thapsus L.
Common Mullein. 2,3.

LENTIBULARIACEAE

- Utricularia vulgaris* L.
Bladderwort. 1.

PLANTAGINACEAE

- Plantago lanceolata* L.
English Plantain. 6.
Plantago major L. x *P. rugelii* Dcne.
Plantain. 7.

RUBIACEAE

- Galium aparine* L.
Common Cleavers. 1,2,3,4,5,6,7.
Galium concinnum T. & G.
Shining Bedstraw. 4.
Galium triflorum Michx.
Fragrant Bedstraw. 1,2,4.

CAPRIFOLIACEAE

- Lonicera tatarica* L.
Tartarian Honeysuckle. 2.
Sambucus canadensis L.
Common Elder. 1,2,3,7.
Triosteum perfoliatum L.
Tinker's Weed. 4.
Viburnum lentago L.
Sweet Viburnum. 1,2.

VALERIANACEAE

- Valerianella umbilicata* (Sulliv.) Wood
Corn-salad. 5,6,7.

DIPSACACEAE

- Dipsacus sylvestris* Huds.
Wild Teasel. 3,6,7.

CUCURBITACEAE

- Echinocystis lobata* (Michx.) T. & G.
Wild Cucumber. 1,5,6,7.

CAMPANULACEAE

- Lobelia siphilitica* L.
Great Blue Lobelia. 2,5,6.
Lobelia spicata Lam.
Pale-spike Lobelia. 2.

COMPOSITAE

- Ambrosia artemisiifolia* L.
Common Ragweed. 2,5,6.
Ambrosia trifida L.
Great Ragweed. 1,5,6,7.
Anthemis cotula L.
Stinking Chamomile. 6.
Arctium minus (Hill) Bernh.
Common Burdock. 4,5,6.
Aster junciformis Rydb.
Aster. 1.
Aster novae-angliae L.
New England Aster. 2,4,5,6,7.
Aster pilosus Willd.
Aster. 7.
Aster sagittifolius Wedemeyer
Arrow-leaf Aster. 4.
Aster simplex Willd.
Aster. 7.
Bidens cernua L.
Stick-tight. 5,7.
Bidens connata Muhl.
Beggar-ticks. 1,4,5,7.
Bidens frondosa L.
Beggar-ticks. 5,6,7.
Cichorium intybus L.
Chickory. 7.
Cirsium arvense (L.) Scop.
Canada Thistle. 3,5,6,7.
Cirsium vulgare (Savi) Tenore
Bull Thistle. 3,5,6,7.
Erigeron annuus (L.) Pers.
Daisy Fleabane. 2,7.
Erigeron canadensis L.
Horse-weed. 3.
Erigeron philadelphicus L.
Philadelphia Fleabane. 2.
Eupatorium maculatum L.
Joe-Pye-weed. 3,5,7.
Eupatorium perfoliatum L.
Common Boneset. 1,3,5.
Eupatorium rugosum Houtt.
White Snakeroot. 1,2,3,6.
Galinsoga ciliata (Raf.) Blake
Galinsoga. 7.
Helianthus giganteus L.
Sunflower. 3,6,7.
Heliopsis helianthoides (L.) Sweet
Ox-eye. 5,6,7.
Lactuca floridana (L.) Gaertn.
Blue Lettuce. 5,7.
Lactuca scariola L.
Prickly Lettuce. 5,6,7.
Prenanthes alba L.
White Lettuce. 2.
Ratibida pinnata (Vent.) Barnh.
Prairie-coneflower. 2,6.
Rudbeckia laciniata L.
Coneflower. 5,6,7.
Rudbeckia triloba L.
Coneflower. 1,3,6,7.
Senecio aureus L.
Golden Ragwort. 3.
Senecio obovatus Muhl.
Ragwort. 1.
Silphium terebinthinaceum Jacq.
Prairie-dock. 3,7.
Solidago altissima L.
Goldenrod. 4.
Solidago canadensis L.
Canada Goldenrod. 1,4,5,6,7.
Solidago gigantea Ait., var. *leiophylla* Fern.
Goldenrod. 6.
Solidago graminifolia (L.) Salisb.
Grass-leaved Goldenrod. 5,7.
Sonchus oleraceus L.
Common Sow-thistle. 5.
Taraxacum officinale Weber
Common Dandelion. 2,4,5,6,7.
Vernonia altissima Nutt.
Tall Ironweed. 5,6,7.
Xanthium pensylvanicum Wallr.
Cocklebur. 1,3,7.

ACKNOWLEDGEMENTS

Deep appreciation is expressed to Dr. T. R. Fisher who advised this study and to Dr. Clara Weishaupt who kindly aided me in the identification of specimens. Assistance in photography is to be credited to John Speer.

LITERATURE CITED

- Alexander, W. H. 1923. A climatological history of Ohio. The Engineering Exp. Sta. The Ohio State Univ. Bull. 28(5): 590-592.
Allen, E. R., G. Conrey, W. C. Borman, O. P. Gossard, G. K. Sivaslian, and C. N. Mooney. 1920. Soil survey of Sandusky County, Ohio. U. S. Dept. Agric. Government Printing Office, Washington, D. C. 64 p.
Brungs, W. A. 1959. Physical and chemical factors and the distribution of some aquatic organisms in the Miller Blue Hole Stream, Sandusky County, Ohio. Unpub. M.S. Thesis. The Ohio State Univ., Columbus. 81 p.
Fernald, M. L. 1950. Gray's manual of botany. Eighth edition. Amer. Book Co. New York. 1632 p.

- Forsythe, Jane L.** 1959. The beach ridges of northern Ohio. Div. Geol. Survey Inf. Circular No. 25. Columbus. 10 p.
- Hille, K. R.** 1955. A limnological investigation of the Miller's Blue Hole, Sandusky County, Ohio. Unpub. M.S. Thesis. Bowling Green State Univ. Bowling Green, Ohio.
- Langlois, T. H.** 1958. Another Blue Hole. The Columbus Dispatch Sunday Magazine. Sept. 21. p. 26-27.
- Marvin, C. F.** 1936. Climate summary of the United States, Sect. 68, Northern Ohio. U. S. Dept. Agric. Weather Bur. U. S. Government Printing Office. Washington, D.C. 30 p.
- Moseley, E. L.** 1899. Sandusky flora, a catalogue of the flowering plants and ferns growing without cultivation, in Erie County, Ohio, and the Peninsula and Islands of Ottawa County. Ohio State Academy of Sci. Spec. Papers No. 1. Clapper Printing Co. Wooster, Ohio. 167 p.
- . 1904. The formation of Sandusky Bay and Cedar Point. Thirteenth Annual Report of the Ohio State Academy of Science IV(V): 179-236.
- Orton, E.** 1899. The rock waters of Ohio. Nineteenth Annual Report of the Survey, 1897-1898. U. S. Government Printing Office. Washington, D.C. p. 633-717.
- Pierce, L. T.** 1959. Climatography of the United States, No. 60-33, Climates of the States—Ohio. U. S. Dept. of Commerce Weather Bur. U. S. Government Printing Office. Washington, D.C. 19 p.
- Stout, W.** 1941. Dolomites and limestones of western Ohio. Geol. Sur. of Ohio. 468 p.
- . 1949. The Blue Hole, Ohio's most unusual natural spring. Water Works Eng. 102(2): 138.
- Ver Steeg, K and G. Yunck.** 1932. The Blue Hole of Castalia. Ohio. J. Sci. 32(5): 425-435.
- Wolfe, R. E.** 1931. A biological survey of the Miller Blue Hole. Unpub. M.S. Thesis. The Ohio State Univ., Columbus. 60 p.
-