CHANGES IN THE MARSH AND AQUATIC VASCULAR FLORA OF EAST HARBOR STATE PARK, OTTAWA COUNTY, OHIO, SINCE 1895[1]

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Abstract. Numerous changes in the marsh and aquatic flora of East Harbor State Park have occurred since 1895. Of the 89 species collected and identified before 1900, 22 are no longer present. This represents a loss of approximately 25% of the species originally reported by Moseley (1899) and Pieters (1901). The species lost would rise to 42%, if those species formerly abundant, but now rare, or occurring as one or two small, isolated populations disappear. Probable causes for these changes are wind and water erosion, fluctuating water levels, dredging, establishment and spread of species new to the park, and increase or decrease in abundance of species already present.

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Since it was purchased in 1946 as a site for an outdoor recreational facility, East Harbor State Park has undergone both natural and artificial changes. The park is located on the south shore of Lake Erie, 81 miles west of Cleveland and 45 miles east of Toledo, near Sandusky, at the junction of State Routes 163 and 269 in Danbury Township, Ottawa County, Ohio (fig. 1). The site is an extensive sand beach behind which is swamp, woods, marsh, and open water. The water portions are divided by a causeway into East and Middle Harbors, although a seven foot culvert permits mixing of the water masses.

Pieters' (1901) enumeration and description of the plants present at East Harbor provide a reference point from which to judge the changes occurring there since 1898. The following year, Moseley (1899) published a catalogue of the flowering plants and ferns growing in Erie County and the islands and peninsula of Ottawa County. These two papers provide a basis for estimating floristic changes at East Harbor since 1895.

METHODS

Eleven study sites (table 1) were selected for study, including most of the park area where vascular marsh or aquatic plants occurred. These sites were visited at two week intervals from June to August 1972, with additional collections in April, May, September, and October. Plant specimens representing all the vascular taxa present were collected by traversing the study sites on foot in paths parallel to the shoreline of both Middle and East Harbor, until the entire study site had been covered. The water surfaces of study sites III, IV, V, and VI were surveyed by canoe. A drag hook was employed to sample the submersed aquatics. Two aerial photo flights were used to map the study sites and shoreline as well as to plot large communities of aquatics. Voucher specimens were dried, mounted, and deposited at the Ohio State University Herbarium after identification was completed. Pieters (1901), Moseley (1899), and 14 other investigators (see Moore, 1973) had studied the same area and their data was used for comparison with my own study. An analytical list of collected species appears as table 2.

RESULTS AND DISCUSSION

The park lies at the extreme eastern end of the Prairie Peninsula (Transeau, 1935) just beyond the northeastern extremity of the Mississippi embayment (Gleason, 1922), and exhibits an assemblage of plant species with western and southern geographic distributions not seen at the eastern end of Lake Erie. Moseley (1899) discusses the unique floristic diversity seen in the Sandusky region (of which East Harbor is an integral part), noting that, "the region contains 305 native plants not known to grow within fifty miles of Buffalo which lies at the eastern end of Lake Erie: The

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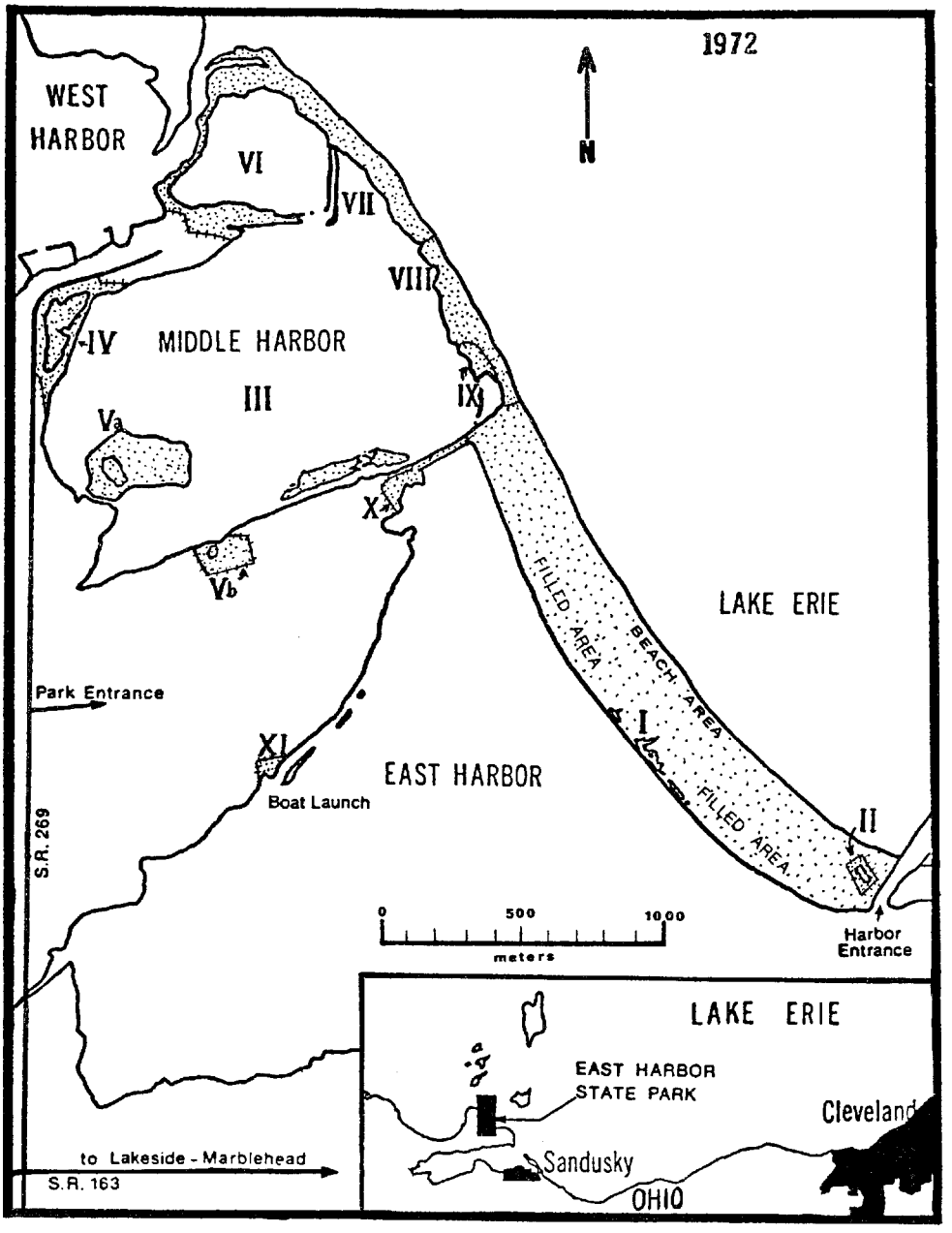

FIGURE 1. Outline map of East Harbor Area. Stippled areas are study sites as labeled, except for study site III which includes the open water of Middle Harbor, and study site VI which includes the shallow water and shoreline adjacent to West Harbor (Drawn from aerial photos, 1972).

lake's shore and marshes furnish quite a number of species not found in the interior of the state . . . Owing to the long summer enjoyed by places situated on the south shore of Lake Erie, many plants grow here which are not found farther north . . . quite a number of species appear to reach their eastern limit." He lists some 80 species of which only 25 were recorded at East Harbor, in this study.

In the spring of 1945, causeway construction made Middle Harbor a landlocked lake. An unusually large number of carp were confined within the harbor since this was the height of the spawning season (Anderson, 1950). Their feeding habits effected an almost complete loss of *Myriophyllum exalbescens*, *Najas flexilis*, *Potamogeton crispus*, *P. foliosus*, *P. natans*, *P. pusillus*, *P. richardsonii*, and *P. zosteriformis*. *Vallisneria americana* was absent. Prior to 1945 vigorous growth of *Vallisneria americana* was reported along with *Potamogeton pectinatus*, *Myriophyllum exalbescens*, and *Scirpus validus*. In October, 1948 rotenone was sprayed on Middle Harbor's 250 acres in a effort to reduce the excessive carp population (Wier and Starr, 1950). After spraying, a semiqualitative survey of plant species abundance was taken in September, 1949 (Anderson, 1950). The most noticeable change was in the clarity of the water. In one year *Potamogeton pectinatus* increased to about 28% dry weight of the sampling. About 6000 *Vallisneria americana* tubers were planted in April, 1949 by park personnel, and by the time the survey was taken in September, substantial growth of these plants had taken place. This growth of *V. americana*, however, was not as prolific as in other areas of the park and exhibited only rare seed production. *Myriophyllum exalbescens* increased only to about 5% of the sampling, but today is one of the community dominants. *Najas flexilis* was reported as quite rare, and *Najas marina* and *N. minor* composed 2% of the sampling (Anderson, 1950). No significant change in the amount of *Potamogeton crispus* was observed, but it now shares community dominance with *Myriophyllum exalbescens*.

Stabilization of the plant communities is intimately associated with fluctuating water levels and, in low water years, extensive mudflats were available where propagules of emersed species colonized. In high water years, the abundance of typical mudflat species was reduced, concomitant with decreased available habitat space. Occasionally floating mats developed with communities of *Pontederia cordata*, *Sagittaria latifolia*, *Bidens* spp., *Polygonum* spp., *Rorippa paulstris*, and *Cardamine* spp., *Carex* spp., *Scirpus* spp., and grasses. Erosion has become a serious problem within the harbor area because of high water, and power boats contribute to increased turbulence of the water in the shallower margins and cause disturbances of the shoreline.

Some emersed species that were reported by Pieters (1901) as abundant are now considerably reduced in abundance or are quite rare. Examples are *Eleocharis smallii*, *Justicia americana*, *Nelumbo lutea*, *Nuphar advena*, *Phragmites australis*, *Pontederia miles australis*, *Pontederia cordata*, *Sagittaria latifolia*, *Sagittaria rigida*, *Scirpus acutus*, and *Typha latifolia*. Certain pioneer species of open areas on mudflats, which were rare in Pieters' time, are still rare or have even disappeared. Among these are *Ammannia coccinea*, *Atriplex patula*, *Boltonia asteroides*, *Leucospora multifida*, *Sagittaria graminea*, *Scirpus smithii*, and *Scirpus torreyi*. Rooted submersed or floating-leaved species which are now rare or absent include:

Elodea canadensis
Heteranthera dubia
Megalodonta beckii
Najas flexilis
Najas guadalupensis
Nymphaea tuberosa
Potamogeton amplifolius
Potamogeton gramineus
Potamogeton illinoensis
Potamogeton natans
Potamogeton nodosus
Potamogeton perfoliatus
Potamogeton richardsonii
Potamogeton robinsii
Potamogeton zosteriformis
Ranunculus longirostris
Zannichellia palustris

The reduction in the populations of many of these species was most likely caused by the dredging of the harbor, resulting in

increased turbidity of the water, loss of suitable habitats, and increased use of the area by man.

During the first season following dredging, 1968, the mudflat was photographed and a record of the flora made by Dr. Ronald L. Stuckey and Mr. Alan Wentz of the Ohio State University. They noted a total of 93 species (denoted by a † in table 2). By the summer of 1972, the number had dropped to 73, a loss of 21.4% of the species noted in 1968. If rare species occurring in only one or two small populations are included, the loss would rise to 40% reflecting inundation of nearly half of the mudflat because of the high water in 1969 and subsequent years, placement of crushed rockfill along the harbor shoreline resulting in the loss of suitable shoreline habitat, and gradual invasion or expansion of the areas occupied by species such as *Typha angustifolia*, *Populus deltoides*, *Salix interior*, and *S. nigra*. However, 26 additional species had invaded the mudflat by 1972.

The marsh at the southwest end of the causeway (study site X) has been greatly reduced, both directly and indirectly, by dredging, since exposure to wave action and higher water levels restricts the growth of *Typha angustifolia*. By the fall of 1974 only a tiny portion of this marsh remained. Similar observations have been made by Dr. Milton Trautman of the Ohio State University, from his extensive field experience.

Typha latifolia was the only cattail noted in East Harbor by Pieters (1901). *T. angustifolia* was listed by Moseley (1899) as scarce, occurring in the Castalia stream, Portage River, and on North Bass Island, as opposed to the common occurrence of *T. latifolia* in the Sandusky area. In 1972 only a few isolated colonies of *T. latifolia* at East Harbor State Park were found, three of which were in temporary ponds behind the crushed rockfill in study site I. Conversely, *T. angustifolia* is dominant throughout study sites II, IV, Va, Vb, VI, VII, VIII, and XI (table 1).

Since 1900, several non-indigenous species have become established and are spreading in the park. Among these are:

Butomus umbellatus
Echinochloa walteri
Epilobium hirsutum
Lycopus asper
Lycopus europaeus
Lysimachia numularia
Lythrum salicaria
Najas minor
Potamogeton crispus
Solanum dulcamara

Butomus umbellatus, first reported by Core (1949) and subsequently by Stuckey (1968), has become more common as have *Lycopus europaeus* (Stuckey and Phillips, 1970) and *Epilobium hirsutum* (Stuckey, 1970). Other species that

TABLE 1
Description and Code of Study Sites in East Harbor State Park

Study Site	Table 2 Code	Description
I	a	Original sand beach area south of causeway, and all filled area created when East Harbor was dredged (1967–68).
II	b	Shallow (2 meters), sandy bottom pond at south end of beach area.
III	c	Open water surface of Middle Harbor excluding shoreline.
IV	d	Pond with dense vegetation and separated from Middle Harbor by a narrow dike; surrounded by trees.
V a	e	Dike-enclosed marsh and pond with sparse floating and submersed aquatic plants.
V b	f	Small pond near park exit road; usually densely filled with emersed aquatic plants.
VI	g	Shallow marsh and shoreline separated from West Harbor by a narrow roadway and earthen dike; extensive emersed aquatic vegetation in low water years.
VII–IX	h	Shoreline and shallow portions of Middle Harbor.
X	i	Cattail marsh with large populations of Cyperacea and Juncacea.
XI	j	Small marsh (240 square meters) behind public boat launch facility.
	k	Refers to species occurring in more than four of the above study sites.

have been seen or reported in isolated locations but do not appear to be spreading are *Chenopodium ambrosioides, Chenopodium glaucum, Najas marina, Rorippa sylvestris,* and *Rumex maritimus.*

The pond in study site II is floristically unique. Heavy waves deposit debris and propagules, and the site has some of the non-indigenous species including *Butomus umbellatus, Epilobium hirsutum, Lysimachia numularia, Lythrum salicaria,* and *Rorippa sylvestris.* With the drier summer, a widening sandy mudflat provides suitable habitat for numerous mudflat species including:

Boltonia asterioides
Eleocharis olivacea
Cyperus diandrus
Lysimachia quadrifolia
Lycopus asper
Lycopus europaeus
Juncus balticus
Juncus alphinus
Lophotocarpus calycinus
Cyperus engelmannii.

When Adrian J. Pieters described East Harbor at the turn of the century, he referred to 49 species of aquatic and marsh plants growing along or within the channels and adjacent shores of the entrance to the harbor. Edwin L. Moseley's (1899) collections and citations include 79 species for the harbor area. The combination of these two collectors' observations and records provide a base of 89 different species, with which we compare the work of subsequent collectors and my 1972 study (table 2). Of the 89 species noted above, 22 are no longer present. This loss represents 25% of the species originally reported by Moseley and Pieters. The percentage of species lost would rise to 42% of those species originally reported if those species which were formerly more abundant, but are now rare as a single small population or as one or two small, isolated populations are included. This substantial reduction or loss in species has probably come about by the dramatic changes that have occurred in the aquatic habitats at East Harbor State Park.

The disappearance of particular hydrophytes, occurrence of species new to the

TABLE 2

Aquatic vascular plants from East Harbor State Park based on Moore (1973) and compared with previous studies.[1]

Taxa	Before 1971*	1972**	Taxa	Before 1971*	1972**
Typhaceae			†*Potamogeton pectinatus* L.	1A3C45A	Ak
†*Typha angustifolia* L.	4A5A	Ag	*Potamogeton perfoliatus* L.	12A	B
Typha latifolia L.	1A2A5R	Ra	*Potamogeton pusillus* L.	1R2A34R	B
Sparganiaceae			†*Potamogeton richardsonii* (Ar. Benn.) Rydb.	1A2A3A 4C5R	B
†*Sparganium eurycarpum* Engelm.	235C	Ak	*Potamogeton robinsii* Oakes	1R	B
Potamogetonaceae			*Potamogeton zosteriformis* Fern.	1C2C3 4C	Ra
Potamogeton amplifolius Tuckerm.	1R	B	Zannichelliaceae		
†*Potamogeton crispus* L.	3C45C	Ak	†*Zannichellia palustris* L.	34R5R	B
†*Potamogeton foliosus* Raf.	24R5R	Cab	Najadaceae		
Potamogeton gramineus L.	1	B			

Earlier Collectors
1—Pieters (1901)
2—Moseley (1899)
3—Core (1937–1949)
4—Others (1904–1950)
5—Stuckey (1968–1971)

Relative Abundance
A—Abundant
B—Absent
C—Common
O—Occasional
R—Rare
N—No record given

**See table 1 for lower case letter code of study sites.

[1]The complete synonomy is not included in this list, but may be obtained from Moore (1973, pp. 155–167).

†Plants occurring on the mudflat during the 1968–1969 season as listed in the field notebooks of Ronald L. Stuckey and W. Allan Wentz. These plants are discussed in Moore (1973).

TABLE 2. *Continued.*

Taxa	Before 1971*	1972**
†*Najas flexilis* (Willd.) Rostk. & Schmidt	12A3 4R5R	Ra
Najas guadalupensis (Spreng.) Magnus	12O	B
Najas marina L.	4	B
†*Najas minor* All.	4A5C	Cabe
Alismataceae		
†*Alisma plantago-aquatica* L.	2A35A	Ak
†*Lophotocarpus calycinus* (Engelm.) J. G. Sm.	25R	Ak
Sagittaria cuneata Sheldon	5O	B
Sagittaria graminea Sheldon	1	B
†*Sagittaria latifolia* Willd.	12A3	Ak
†*Sagittaria rigida* Pursh	123 45R	Ra
Butomaceae		
†*Butomus umbellatus* L.	45C	Ck
Hydrocharitaceae		
Elodea canadensis Michx.	1A2A3A	Ri
†*Vallisneria americana* Michx.	12A3A 45R	Ak
Gramineae		
†*Calamagrostis canadensis* (Michx.) Nutt.	134 5C	Ck
†*Enchinochloa crusgalli* (L.) Beauv.	5C	Ok
Echinochloa pungens (Poir.) Rydb.	N	Ok
†*Echinochloa walteri* (Pursh) Nash	45C	Ck
Eragrostis hypnoides (Lam.) BSP.	N	Ck
Glyceria striata (Lam.) Hitchc.	N	Ck
Leersia oryzoides (L.) Sw.	5	Ak
†*Lolium* sp. (planted)	5	Ck
†*Phalaris arundinacea* L.	135C	Ck
†*Phragmites australis* (Cav.) Steud.	1A2A3C 5C	Ck
†*Spartina pectinata* Link	45C	Ck
†*Zizania aquatica* L.	1245R	B
Cyperaceae		
Carex annectans (Bickn.) Bickn.	N	Cbhi
Carex atherodes Spreng.	N	Ri
Carex blanda Dewey	N	Rij
Carex comosa Boott.	5R	Rgi
Carex davisii Schw. & Torr.	2O	Ri
Carex frankii Kunth.	5R	Ri
Carex garberi Fern.	N	Ck
Carex granularis Willd.	2O	Ck
Carex haydenii Dewey	N	Ri
Carex hystricina Willd.	2A	Ok
Carex lacustris Willd. var. *laxiflora* Dewey	N	Rij
Carex laevivaginata (Kunth.) Mackenz.	N N	Reij
Carex languinosa Michx.	N	Ohi
Carex lupulina Willd.	N	Rei
Carex muskingumensis Schw.	2R	Rij
Carex stipata Muhl.	2A	Ck
Carex vulpinoidea Michx.	N	Ck
†*Cyperus diandrus* Torr.	2A5O	Ck
†*Cyperus engelmannii* Steud.	5R	Cah
†*Cyperus erythrorhizos* Muhl.	5R	Cabdh
†*Cyperus esculentus* L.	5C	Ch
†*Cyperus ferruginescens* Boeckl.	5C	Ck
†*Cyperus rivularis* Kunth.	45C	Ak
†*Cyperus strigosus* L.	2A5C	Ck
†*Eleocharis erythropoda* Steud.	5C	Cah
†*Eleocharis obtusa* (Willd.) Schultes	5A	Cagh
Eleocharis olivacea Torr.	5R	Rb
Eleocharis ovata (Roth.) R. & S.	N	Ck
†*Eleocharis smallii* Britt.	5O	Cab
†*Scirpus acutus* Muhl.	345C	Ck
†*Scirpus americanus* Pers.	12A35C	Ok
Scirpus atrovirens Willd.	12A	Ck
†*Scirpus cyperinus* (L.) Kunth.	5R	Rj
†*Scirpus fluviatilis* (Torr.) Gray	12A4 5C	Ak
Scirpus pendulus Vahl.	N	Rj
†*Scirpus smithii* Gray	2	B
Scirpus torreyi Olney	2	B
†*Scirpus validus* Vahl.	45C	Ck
Juncaceae		
†*Juncus alpinus* Vill.	5C	Ck
Juncus alpinus Vill. var. *rariflorus* Hartn.	2A4	Oabh
Juncus articulatus L.	N	Ra
Juncus balticus Willd. var. *littoralis* Engelm.	5O	Oah
Juncus dudleyi Wieg.	5C	Ck
†*Juncus effusus* L.	2A5O	Ck
†*Juncus nodosus* L.	2A35O	Ck
†*Juncus torreyi* Cov.	345O	Ck
†*Juncus torreyi* Cov. x *J. alpinus* Vill.	345O	Oabi
Iridaceae		
Iris versicolor L.	N	Ck
Salicaceae		
†*Salix interior* Rowlee	12A	Ak
†*Salix nigra* Marsh	12A	Ck
Salix rigida Muhl.	5	Obh
†*Populus deltoides* Marsh	12A5A	Ak
Lemnaceae		
†*Lemna minor* L.	12A5	Ak
Lemna trisulca L.	N	Oih
†*Spirodela polyrhiza* (L.) Schleid.	12A	Ceki
Wolffia columbiana Karst.	N	Oi
Pontederiaceae		
†*Heteranthera dubia* (Jacq.) MacM.	12A3A 45	Ri

TABLE 2. *Continued.*

Taxa	Before 1971*	1972**
†*Pontederia cordata* L.	12A3C45C	Ck
Urticaceae		
†*Boehmeria cylindrica* (L.) Sw.	2A5O	Ck
Pilea pumila (L.) Gray	2A	Oabh
Polygonaceae		
†*Polygonum coccineum* Muhl.	15O	Ck
†*Polygonum lapathifolium* L.	25C	Ak
†*Polygonum pensylvanicum* L.	5O	Ck
†*Polygonum pensylvanicum* L. var. *eglandulosum* J. C. Myers	5R	Ra
Polygonum persicaria L.	5R	Oabg
†*Polygonum punctatum* Ell.	5C	Ck
†*Polygonum scandens* L.	5C	Ck
Polygonum virginianum L.	5O	Oehj
†*Rumex maritimus* L.	5R	B
Rumex verticillatus L.	2C	Ra
Chenopodiaceae		
†*Atriplex patula* L.	5C	Ra
†*Chenopodium ambrosioides* L.	5R	B
Chenopodium glaucum L.	5R	B
Amaranthaceae		
Amaranthus tuberculatus (Moq.) Sauer	2	B
Ceratophyllaceae		
Ceratophyllum demersum L.	1A2A3C 4C5C	Ck
Nymphaceae		
Nelumbo lutea (Willd.) Pers.	1A23A 45C	Ccdgh
Nuphar advena (Ait.) Ait.	134	Rcd
Nuphar varigatum Engelm.	5R	Ocd
†*Nymphaea tuberosa* Paine	12A34	Rc
Ranunculaceae		
Ranunculus longirostris Godr.	12A	Ri
†*Ranunculus sceleratus* L.	25C	Ck
Cruciferae		
Cardamine bulbosa (Schreb.) BSP.	2A	Ra
Cardamine pensylvanica Muhl.	2A5O	Ck
†*Rorippa palustris* (L.) Bess. var. *fernaldiana* (Butt. & Abbe.) Stuckey	5O	Ck
†*Rorippa palustris* (L.) Bess. var. *hispida* (Desv.) Gray	5O	Ck
Rorippa sylvestris (L.) Bess.	N	Ri
Saxifragaceae		
†*Penthorium sedoides* L.	25C	Cabdi
Rosaceae		
Potentilla palustris (L.) Scop.	N	Ri
†*Potentilla anserina* L.	45O	Ok
Rosa palustris Marsh	5O	Ok
Leguminosae		
†*Strophostyles helvola* (L.) Ell.	45O	Ck
Euphorbiaceae		
†*Acalypha rhomboidea* Raf.	5O	Ck
Balsaminaceae		
†*Impatiens capensis* Merrb.	5C	Ak
Malvaceae		
†*Hibiscus palustris* L.	12345C	Ck
Gutifferae		
Hypericum punctatum Lam.	N	O abgi
Lythraceae		
Ammannia coccinea Rothb.	5R	B
Decodon verticillatus (L.) Ell.	2C5O	Ck
†*Lythrum dacotanum* Niew.	5O	Ck
†*Lythrum salicaria* L.	5R	Oag
Onagraceae		
Epilobium glandulosum Lehm.	5O	B
Epilobium hirsutum L.	5C	Ck
Ludwigia palustris (L.) Ell.	45O	Oab
Ludwigia polycarpa Short & Peter	5R	Rbh
Haloragidaceae		
†*Myriophyllum exalbescens* Fern.	1A2A3A 45A	Ak
Umbelliferae		
†*Sium suave* Walt.	245O	Ck
Primulaceae		
Lysimachia nummularia L.	2	Oabi
Lysimachia quadriflora Sims.	2	Rb
Lysimachia thyrisflora L.	N	Ra
Cornaceae		
Cornus drummondi Meyer	N	Ak
Cornus stolonifera Michx. Michx.	45C	Ck
Asclepiadaceae		
Asclepias incarnata L.	12A5C	Ck
Verbenaceae		
†*Lippia lanceolata* Michx.	45O	Ck
†*Verbena hastata* L.	5O	Ck
Verbena urticifolia L.	5O	Obi
Labiatae		
Lycopus asper Greene	5R	Oa
†*Lycopus europaeus* L.	5	Ck
Lycopus uniflorus Michx. Michx.	5	Oabj
Mentha arvensis L.	5O	Ok
†*Monarda fistulosa* L.	5	Ok
Physostegia virginiana (L.) Benth.	4	Ok
Scutellaria epilobiifolia A. Hamilton	12A4 5C	Ak
Scutellaria lateriflora L.	2A5C	Ak
†*Stachys palustris* L.	5C	Ck
†*Stachys palustris* L. var. *pilosa* (Nutt.) Fern.	5C	Ok

TABLE 2. *Continued.*

Taxa	Before 1971*	1972**
Solanaceae		
†*Solanum dulcamara* L.	5C	Ck
†*Solanum nigrum* L.	5C	Ck
Scrophulariaceae		
†*Gerardia purpurea* L.	5R	Cab
Gerardia tenuifolia Vahl.	N	Oab
Gratiola neglecta Torr.	N	Cab
†*Lindernia dubia* (L.) Pennell	5O	Ck
†*Mimulus ringens* L.	45C	Ck
†*Lindernia dubia* (L.) (Michx.) Benth.	5O	Ck
Lentibulariaceae		
†*Utricularia vulgaris* L.	12A45A	Cabgi
Acanthaceae		
†*Justicia americana* (L.) Pahlers	12R3 45R	B
Rubiaceae		
Cephalanthus occidentalis L.	45C	Ck
Houstonia nigricans (Lam.) Fern.	5R	Ck
Caprifoliaceae		
Sambucus canadensis L.	2A5O	Ck
Cucurbitaceae		
Echinocystis lobata (Michx.) T. & G.	N	Ra
Sicyos angulata L.	5O	Ok
Campanulaceae		
Campanula aparinoides Pursh.	5R	Rab
Lobelia kalmii L.	N	Rgj
†*Lobelia siphilitica* L.	N	Oabh
Compositae		
†*Bidens bipinnata* L.	N	Oh
†*Bidens cernuus* L.	2R5C	Ak
Bidens comosa (Gray) Wieg.	2A	Ck
†*Bidens connata* Muhl. var. *anomala* Farwell	N	Ck
Bidens coronata (L.) Britton	N	Ck
Bidens frondosa L.	2A5C	Ck
Bidens heterodoxa (Fern.) Fern. & St. John	N	Ra
Bidens vulgata Greene	N	Oabi
†*Boltonia asteroides* (L.) L'Her.	2C5O	Oab
†*Eclipta alba* (L.) Hassk.	2R5O	Ck
Erechtites hieracifolia (L.) Raf.	5O	Ra
Megalodonta beckii (Torr.) Greene	12R	B
Solidago graminifolia (L.) Salisb.	5C	Ck

area, and changes in species abundance may have been determined by several factors: physical removal or suitable habitat substrate, increased sediment loads and coating of hydrophyte leaves, decreased light penetration as a result of increased turbidity, increased wave action and shore erosion, and effects of other organisms. The influence of physical factors in both area distribution and species abundance has been discussed by numerous authors including Misra (1938), Penfound (1953), Pieters (1894), Rickett (1921, 1924), Sherff (1912), Stookey, *et al.* (1964), and Wylie (1920). The influence of fluctuating water levels, bottom substrate character, wave action, and water depth on hydrophyte distribution in Lake Okoboji have been pointed out by Wylie (1920). Pieters (1894) used the same parameters plus the effect of currents in this study of Lake Saint Clair. The interaction between plants affecting distribution has been studied by Sherff (1912), and the effects of animals on the spreading of aquatic plant species, by Bromley (1967).

During this study (Moore, 1973) a total of 189 species of hydrophytes were recorded for East Harbor State Park. Of these, 30 species are very rare and 17 additional species occur only as small populations. This includes 25% of all the hydrophyte species in the park area. This loss has been a reflection of the changes and is a result of both natural and artificial or man-made disturbances. Non-indigenous species are generally becoming more common. The kinds of changes noted in the aquatic flora and the possible factors responsible for these changes at East Harbor State Park are in many respects similar to the observed floristic changes that have been reported recently in Ohio for Buckeye Lake (Judd and Taub, 1973), Put-in-Bay harbor (Stuckey, 1971), Winous Point at the western end of Sandusky Bay (Lowden, 1969), in New York for Otsego Lake (Harman and Doane, 1970), and in Iowa

for Lake East Okoboji (Volker and Smith, 1965; Crum and Bachmann, 1973). Although the percentage of species lost at East Harbor State Park is lower than in most of the above studied areas, a principle reason for this lower percentage is that man's influence has only been operating at East Harbor since about 1945, whereas these other bodies of water have generally been under the direct influence of man since about 1900 or earlier.

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LITERATURE CITED

Anderson, John M. 1950. Some aquatic changes following fish removal. J. Wildlife Manage. 14: 206–209.

Bromley, Dennis D. 1967. Some observations on spreading of aquatic flowering plants in deep water of Douglas Lake, Michigan. Mich. Bot. 6: 75–80.

Core, Earl L. 1949. The plants of western Lake Erie after fifty years. Unpublished Manuscript Rept. Stone Inst. Hydrobiology, The Ohio State Univ., 28 pp.

Crum, G. H. and R. W. Bachmann. 1973. Submersed aquatic macrophytes of the Iowa Great Lakes region. Iowa State J. Res. 48: 147–173.

Gleason, Henry A. 1922. The vegetational history of the Middle West. Ann. Assoc. Am. Geogr. 12: 39–85.

Harman, Willard N. and Thomas R. Doane. 1970. Changes in the aquatic flora of Otsego Lake between 1935–1969. New York Fish Game J. 17: 121–123.

Judd, John B. and Stephen H. Taub. 1973. The effects of ecological changes on Buckeye Lake, Ohio, with emphasis on largemouth bass and aquatic vascular plants. Ohio Biol. Surv. Biological Notes No. 6. 51 pp.

Lowden, Richard M. 1969. A vascular flora of Winous Point, Ottawa and Sandusky Counties, Ohio. Ohio J. Sci. 69: 257–284.

Misra, R. D. 1938. Edaphic factors in the distribution of aquatic plants in the English Lakes. J. Ecol. 26: 411–451.

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 Acad. Sci. Special Papers No. 1, 167 pp.

Moore, David L. 1973. Changes in the aquatic vascular plant flora of East Harbor State Park, Ottawa County, Ohio since 1895. M.S. Thesis, The Ohio State Univ., Columbus. 193 pp.

Penfound, W. T. 1953. Plant communities of Oklahoma Lakes. Ecology 34: 561–583.

Pieters, Adrian J. 1894. The plants of Lake St. Clair. Mich. Fish. Comm. Bull. No. 2. 12 pp.

——— 1901. The plants of western Lake Erie, with observations on their distribution. Bull. U. S. Fish Comm. 21: 57–79.

Rickett, H. W. 1921. A quantitative study of the larger aquatic plants of Lake Mendota, Wisconsin. Trans. Wisc. Acad. Sci. Arts Letters. 20: 501–527.

——— 1924. A quantitative study of the larger aquatic plants of Green Lake, Wisconsin. Trans. Wisc. Acad. Sci. Arts Letters. 21: 381–414.

Sherff, Earl E. 1912. The vegetation of Skokie marsh. Bot. Gaz. 53: 415–435.

Stookey, D. G., P. L. Fore and R. H. Mohlenbrock. 1964. Primary aquatic succession and floristics of Devil's Kitchen Lake, Illinois. Castanea 29: 150–155.

Stuckey, Ronald L. 1968. Distributional history of *Butomus umbellatus* (flowering-rush) in the western Lake Erie and Lake St. Clair region. Mich. Bot. 8: 134–142.

——— 1970. Distributional history of *Epilobium hirsutum* (great hairy willow herb) in North America. Rhodora 72: 164–181.

——— 1971. Changes of vascular aquatic flowering plants during 70 years in Put-in-Bay harbor, Lake Erie, Ohio. Ohio J. Sci. 71: 321–342.

——— 1975. A floristic analysis of the vascular plants of a marsh at Perry's Victory Monument, Lake Erie. Mich. Bot. 14: 144–166.

Stuckey, Ronald L. and W. Louis Phillips. 1970. Distributional history of *Lycopus europaeus* (European water-horehound) in North America. Rhodora 72: 351–369.

Transeau, Edgar N. 1935. The Prairie Peninsula. Ecology 16: 423–437.

Volker, Roger and S. Galen Smith. 1965. Changes in the aquatic vascular flora of Lake East Okoboji in historic times. Proc. Iowa Acad. Sci. 72: 62–72.

Wier, J. L. and Donald F. Starr. 1950. The use of rotenone to remove rough fish for the purpose of improving migrating waterfowl refuge areas. J. Wildlife Manage. 14: 203–205.

Wylie, Robert B. 1920. The major vegetation of Lake Okoboji. Proc. Iowa Acad. Sci. 27: 91–97.