Flora of a Diked and an Undiked Southwestern Lake Erie Wetland[1]

David E. Sherman, Roy W. Kroll, and Tracy L. Engle[2], Winous Point Shooting Club, 3500 South Lattimore Road, Port Clinton, OH 43452 and School of Natural Resources, The Ohio State University, 2021 Coffey Road, Columbus, OH 43210

Abstract. **Undiked wetlands in Lake Erie experience fluctuating water levels, and diked wetlands are isolated from these natural hydrologic events. Growth and survival of vegetation within the two wetland types is influenced by different water level regimes. Our objective was to report the occurrence and abundance of flora in a 100 ha diked wetland (DW) and an adjacent 100 ha undiked wetland (UW) at Winous Point Shooting Club in southwestern Lake Erie (SWLE) during September 1991. Randomly sampled aquatic macrophytes were identified to species and number of stems was recorded. Water depth and land elevation readings were also made. Forty-six species of aquatic macrophytes were identified in the DW while no plants were found in the UW. The controlled water depth of the DW (28.40 ± 2.39 [SE] cm) was significantly lower (P <0.0001, t = 11.95) than the uncontrolled depth in the UW (95.41 ± 5.07 cm). Although the basin elevation of the DW was higher (P = 0.01) than the elevation of the UW, the mean difference in water depth between the two wetlands was much greater (P <0.0001) than the mean elevation differences. Thus, higher water levels were primarily responsible for floristic differences between the two wetlands. Because most ecological functions of wetlands are derived from processes requiring aquatic macrophytes, we suggest that unvegetated wetlands, such as undiked wetlands in SWLE, provide few of their potential ecological benefits. We propose that the relative ability of a SWLE wetland to advance landward is the most important factor in determining the need to construct dikes and control water levels for aquatic plant restoration. We generally recommend that dike systems should only be constructed on SWLE wetlands with restricted upland borders.**

OHIO J. SCI. 96 (1): 4-8, 1996

INTRODUCTION

Before Caucasian settlement, Ohio's southwestern Lake Erie (SWLE) wetlands were comprised of a transient zone of aquatic vegetation that periodically established landward or lakeward with respective fluctuations of Lake Erie water levels (Langlois 1954). After 1900, landward advance of wetlands was progressively blocked by construction of roads, railways, and flood-control dikes for agriculture and municipal development (Campbell 1979). Subsequently, during sustained (>3 yrs) high lake levels, most aquatic macrophytes perished unless the plants grew in wetlands protected from high water levels by naturally-formed sandbars (Herdendorf 1987). These wetland losses prompted marsh owners to construct additional dikes (lakeward) to maintain existing vegetation for muskrat production or waterfowl hunting (Andrews 1952). Since 1920, these diked wetlands have used pumps, underground flumes, and gravity-flow gates to manage water levels for germination and growth of aquatic macrophytes.

Naturally existing aquatic macrophytes (undiked wetland) of SWLE are subject to long-term cyclic (Fig. 1), seasonal (Fig. 2), and wind-induced water level fluctuations (seiches). Seiches occur approximately 160 days per year (Herdendorf 1987), with average amplitudes of 9 cm per day (Krecker 1928) that range to 4.8 m per day (U.S. Army Corps of Engineers 1994a). Also, aquatic macrophyte establishment and survival in undiked wetlands is directly influenced by sediment accretion rates and subsequent frequency of mudflat exposure. Emergent aquatic macrophytes require an initial growing season of semipermanent mudflat exposure for germination, and survive under maximum sustained water levels of ≤1 m (Bookhout et al. 1989).

No research has concurrently documented the flora of a diked and an undiked Lake Erie wetland. Our objective was to report the occurrence and abundance of flora in two such wetlands.

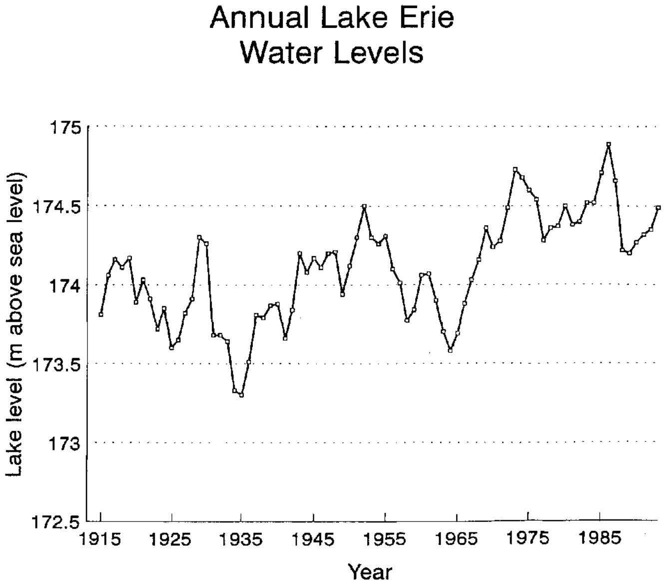

Figure 1. Mean annual Lake Erie water levels recorded at Toledo, OH, from 1915 to 1993. (U.S. Dept. of Commerce 1992, Don Swierk pers. comm.)

---

[1] Manuscript received 1 May 1995 and in revised form 29 January 1996 (#95-09).

[2] Present Address: URS Consultants, 800 West St. Clair Avenue, Cleveland, OH 44113

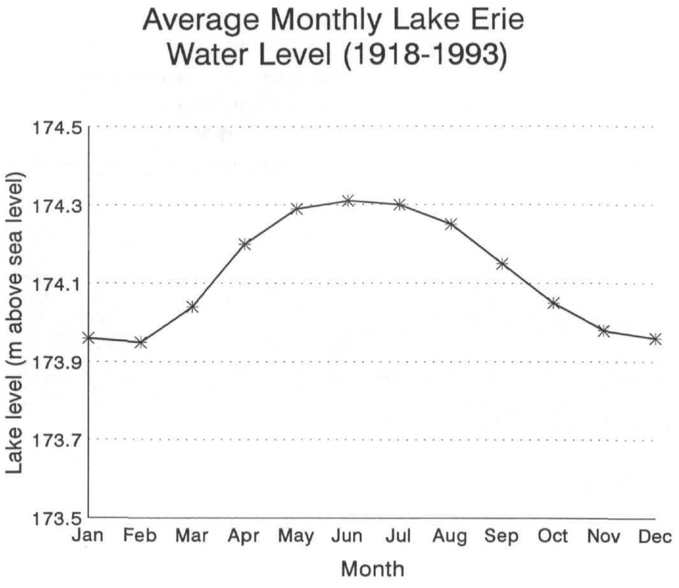

FIGURE 2. Mean monthly Lake Erie water levels from 1918 through 1993 (U.S. Army Corps of Engineers 1994b).

MATERIALS AND METHODS

Study Area

The 1,775 ha Winous Point Shooting Club (WPSC), located on the southwestern shore of Lake Erie near Port Clinton, OH, encompasses Muddy Creek Bay at the confluence of Muddy Creek, Sandusky River, Green Creek, and South Creek (Fig. 3). WPSC maintains approximately 775 ha of diked wetlands and 1,000 ha of undiked wetlands. The present study was conducted at two adjacent, 100 ha wetlands at WPSC. Original surveys (Bourne 1820) and vegetation maps from 1873 and 1894 (WPSC unpubl. data) indicate that both wetlands existed as palustrine emergent wetlands with persistent vegetation (Cowardin et al. 1979) prior to impacts of human settlement (Fig. 4). The diked wetland (DW) has been managed as an impounded wetland intermittently since 1920, and continuously since 1978. Recent water level management in the DW has consisted of maintaining 15-25 cm of water across the basin from mid-May through late August. Approximately 30 cm of winter-accumulated precipitation was gradually removed by pumping in April and May, and replaced by gravity reflooding in late August. Intermittent (mean = 3 per summer) refloodings were conducted to compensate for evapotranspiration. The undiked wetland (UW) has remained exposed to the natural fluctuations of Lake Erie water levels since 1957. A remnant of a previous (1937-1957) dike exists as a low (approximately 0.5 m) submerged, discontinuous rock wall along the east and south borders of the UW (Fig. 3).

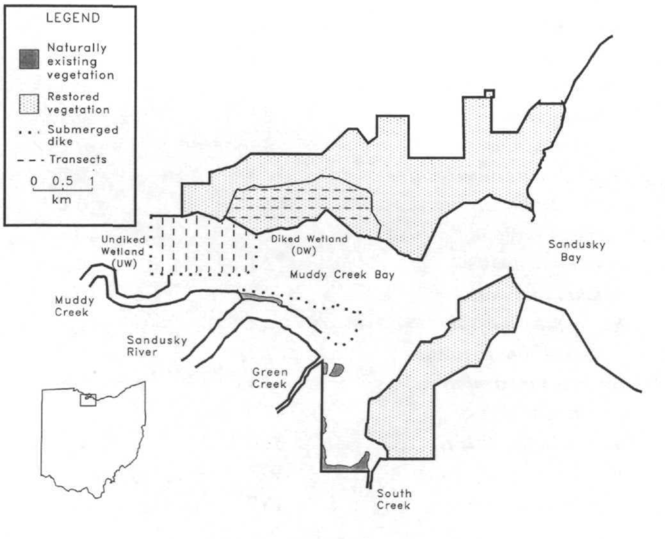

FIGURE 3. Location of study areas and present (1994) extent of aquatic macrophytes at Winous Point Shooting Club, Port Clinton, OH.

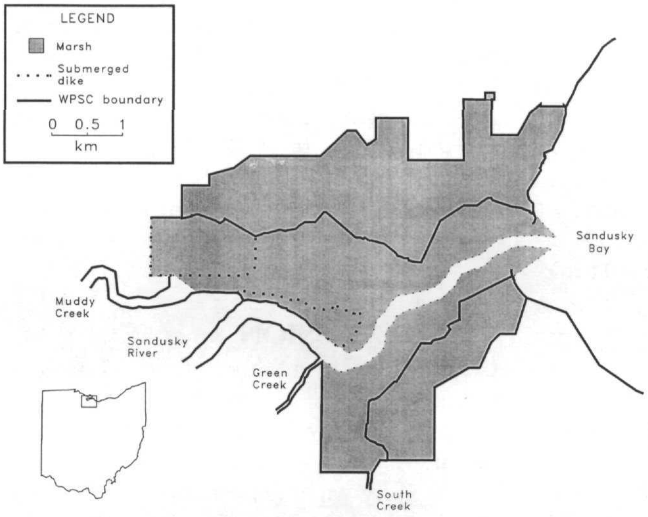

FIGURE 4. Former (ca. 1880) extent of aquatic macrophytes at Winous Point.

Methods

Aquatic plants were sampled at 200 m intervals on randomly located transects during 3-5 September 1991. Our prior long term (15 yrs) observations indicated that sampling in one season would be adequate to describe the recent temporal presence or absence of aquatic macrophytes. Also, perennial wetland vegetation persists for years or decades under higher-than-optimal water levels and reestablishes in one season with adequate conditions (e.g., shallow, clear water or summer mudflat exposure). Thus, sampling in a single season encompasses either scenario (long term presence or short term establishment of wetland plants).

The first transect was randomly located; subsequent parallel transects were placed 75 m apart. Four transects totaling about 7.3 km were established in the DW; 8 transects nearly 6.4 km in total length were located in the UW. Plants occurring in a 0.25 m^2 sampling frame were identified to species (Fassett 1957), and number of stems was recorded. Presence of floating aquatic plants was recorded, and water depth measured to nearest cm. A surveyor's transit was used to obtain elevation readings at 30 random locations in both areas. To maintain consistent elevation measurements, the elevation rod was suspended once it touched the substrate, and prior to settling. *T*-tests were used to determine if significant differences occurred between the DW and the UW.

RESULTS

Forty-six aquatic plant species were identified at 48 sampling points in the DW; no plants were found at 44 sampling points in the UW. Walter's millet (*Echinochloa walteri*) and narrow-leaved cattail (*Typha angustifolia*) were the most abundant species sampled (Table 1). The species with the highest stem densities in our samples were yellow nut-grass (*Cyperus esculentus*) and reed-canary grass (*Phalaris arundinacea*) (Table 1). The controlled water depth of the DW (28.40 ± 2.39 [SE] cm) was significantly lower ($P < 0.0001$, $t = 11.95$) than the uncontrolled depth in the UW (95.41 ± 5.07 cm). The basin elevation of the DW (173.51 ± 0.03 m) (International Great Lakes Datum) was significantly higher ($P = 0.01$, $t = 2.58$) than the elevation of the UW (173.35 ± 0.05 m). The ranges of elevations of the UW (172.96-174.00) encompassed those of the DW (173.22-173.82 m). The mean difference in water depth between the two wetlands (0.67 ± 0.06 m) was significantly greater ($P < 0.0001$, $t = 7.09$) than the mean elevation difference (0.16 ± 0.04 m).

DISCUSSION

The marked difference in aquatic plant occurrence between the two study units was primarily caused by higher water levels in the UW. Emergent plants could not tolerate the increased water levels; submergent plants were eliminated by wave action and by increased turbidity caused by suspension of clay soils. Correspondingly, the UW water levels mainly resulted from higher Lake Erie water levels, rather than basin elevation differences between the adjacent areas.

Although we did not quantify sediments, it is likely that erosion of the organic layer in the UW accounts for most of the difference in average elevation between the adjacent areas. We observed a hard clay (Toledo Silty Clay, Musgrave and Derringer 1985) bottom surface across the UW basin, and a deep (10-20 cm) organic muck bottom throughout the DW.

Our observations of sedimentation trends in the UW do not support the hypothesis of Bedford (1992), who proposed an accretion rate of 4 cm per year for the region of Sandusky Bay encompassing the UW (i.e., Muddy Creek Bay). A remnant, submerged rock wall of the UW was erected in 1937 and abandoned from management in 1957. Currently, the wall is approximately 4,500 m in length, 0.4 m above the basin elevation, and 0.5 m below 1994 water levels. In the last 15 years, we have observed no gross accretion on the rock wall of the UW, which is frequently visible during seiches. Based on accretion rates of 4 cm per year since 1957, the top of the wall should be buried under more than 1.0 m of sediment, less compaction.

Ecological deficiencies of diked SWLE wetlands and associated water control practices have been previously reported (Robb 1989). These diked wetlands are considered to have unnatural hydroperiods and nutrient

TABLE 1

Frequency of occurrence and stem density of plants sampled in undiked (UW) and diked (DW) wetlands at Winous Point Shooting Club, Ottawa County, OH, during 3-5 September 1991.

Area/Plant	Frequency of Occurrence (%)	No. of Stems per m^2 (Σ plots)
Undiked Wetland (UW)		
None	0	0
Diked Wetland (DW)		
Echinochloa walteri	35.4	15.8
Typha angustifolia	29.2	9.5
Echinochloa pungens	22.9	9.3
Polygonum lapathifolium	22.9	5.3
Cyperus esculentus	20.8	19.2
Panicum virgatum	20.8	15.8
Phalaris arundinacea	16.7	19.0
Leersia oryzoides	14.6	11.6
Hibiscus palustris	12.5	1.1
Pontederia cordata	10.4	4.5
Polygonum pensylvanicum	10.4	2.4
Nelumbo lutea	10.4	0.8
Myriophyllum spicatum	8.3	2.1
Ceratophyllum demersum	8.3	1.0
Sparganium eurycarpum	8.3	0.8
Potamogeton foliosus	6.3	10.3
Eleocharis obtusa	6.3	5.3
Polygonum coccineum	6.3	1.8
Cyperus ferruginescens	6.3	0.4
Potamogeton crispus	6.3	0.3
Penthorum sedoides	6.3	0.3
Najas minor	4.2	1.8
Scirpus fluviatilis	4.2	0.9
Cyperus strigosus	4.2	0.8
Utricularia vulgaris	4.2	0.2
Lycopus europaeus	4.2	0.2
Abutilon theophrasti	4.2	0.2
Polygonum hydropiperoides	2.1	2.8
Bidens frondosa	2.1	0.6
Salix interior	2.1	0.5
Melilotus alba	2.1	0.4
Xanthium strumarium	2.1	0.3
Bidens cernua	2.1	0.3
Scirpus validus	2.1	0.2
Amaranthus tuberculatus	2.1	0.2
Lycopus americanus	2.1	0.1
Verbena hastata	2.1	0.1
Populus deltoides	2.1	0.1
Lippia lanceolata	2.1	0.1
Phragmites australis	2.1	0.1
Potamogeton pectinatus	2.1	0.1
Asclepias incarnata	2.1	0.1
Lemna minor	47.9	*
Spirodela polyrhiza	39.6	*
Wolffia columbiana	18.8	*
Azolla caroliniana	16.7	*

*Stem density was not determined for floating plants.

cycles, and to exclude access to some breeding fishes (Bookhout et al. 1989, Jude and Pappas 1992). However, our study demonstrates that large (e.g., 100 ha), diked wetlands sustain aquatic macrophytes, and that large, undiked SWLE wetland do not. Because most ecological functions of wetlands are derived from processes requiring aquatic macrophytes (Mitsch et al. 1989, Herdendorf 1992), unvegetated wetlands provide few of their potential ecological benefits.

The benefits to wetland biota provided by diked SWLE wetlands are well documented. Robb (1989) reported diked SWLE wetlands have less turbid water, greater vegetative diversity, and nearly twice the net biomass production of undiked wetlands. Riley and DeRoia (1989) and Koneff (1992) reported shallowly flooded, decaying smartweeds (*Polygonum* spp.), millets (*Echinochloa* spp.), and other grasses (*Panicum* spp. and *Leersia* spp.) of diked SWLE wetlands comprise the preferred detrital habitats for many indigenous aquatic macro-invertebrate taxa. Increased secondary production in diked SWLE wetlands benefits organisms at higher trophic levels (DeRoia 1989). Vegetation and water management strategies in diked SWLE wetlands provide rare, optimum habitats for a wide variety of wetland birds, reptiles, and mammals, and harbor the largest concentration of migrating black ducks (*Anas rubribes*) in North America (Tori et al. 1990). Currently, 20 species of Ohio-endangered wildlife are dependent on vegetation complexes found primarily in diked SWLE wetlands (Table 2).

TABLE 2

Wetland dependent endangered wildlife species in Ohio†.

Common Name	Scientific Name
River otter	*Lutra canadensis*
American bittern	*Botaurus lentiginosus*
Least bittern	*Ixobrychus exilis*
Bald eagle	*Haliaeetus leucocephalus*
Northern harrier	*Circus cyaneus*
King rail	*Rallus elegans*
Sandhill crane	*Grus canadensis*
Piping Plover	*Charadrius melodus*
Common tern	*Sterna hirundo*
Black tern	*Childonias niger*
Sedge wren	*Cistothorus platensis*
Copperbelly water snake	*Nerodia erythrogaster neglecta*
Eastern spadefoot	*Scaphiopus holbrooki*
Swamp metalmark	*Calephelis idalia*
Mitchell's satyr	*Neonympha mitchellii*
Graceful underwing	*Catocola gracilis*
Pointed sallow	*Epiglaea apiata*
*	*Spartiniphaga inops*
	Hypocoena enervata
	Melanchra assimilis

†Ohio Div. Wildl., unpubl. data., 1996.
*Common names are not established.

MANAGEMENT IMPLICATIONS

Wetland resource managers need to acknowledge the ecological role of diked SWLE wetlands. Diked wetlands provide optimum conditions for many, but not all, SWLE wetland biota and functions. Resource managers will be challenged to determine the relative significance of each species or process, prior to adopting ecosystem management strategies to SWLE wetlands. However, no comprehensive research data currently exist for fisheries, nutrient cycles, and hydrologies of diked and undiked SWLE wetlands.

Wetland researchers must identify critical needs of species and processes that are not provided by diked wetlands, and determine realistic modifications in diked wetland management that can alleviate these problems. These strategies must incorporate the dynamics and diversity of the systems involved. Thus, specific research will be required on SWLE wetlands of various geomorphological types (e.g., wetlands protected by sandbar barriers, wetlands protected by dikes, or unprotected wetlands [Herdendorf 1987]) existing under a wide range of successional stages (e.g., sedge meadow), and environmental (e.g., lake levels), or management conditions (e.g., hemi marsh [Bookhout et al. 1989]). Previous strategies using broad comparisons to other wetland systems, which assume identical processes and functions, are not germane. For example, processes of aquatic macrophyte establishment on the north shore of Lake Erie can be nearly opposite those of the southwest shore. Keddy and Reznicek (1986) indicated that landward advance of Canadian wetlands was less impeded by development, and sand-dominated soil substrates minimize effects of turbidity. Therefore, fluctuating water levels increased the area of shoreline vegetation and vegetative diversity. However, the landward advance of marshes on the southwest shore is substantially restricted by development, and abundance and diversity of vegetation declines as water levels rise and become more turbid.

We suggest that the relative ability of a SWLE wetland to advance landward is the most important factor in determining the need to construct dikes and control water levels for aquatic plant restoration. We generally recommend that dike systems should only be constructed on SWLE wetlands with restricted upland borders.

CONCLUSIONS

The high Lake Erie water levels in the UW resulted in eradication of vegetation in this wetland by eliminating the life-history requirements of aquatic macrophytes. Conversely, water level management in the DW resulted in a dense and diverse wetland flora. Aquatic macrophytes that have been steadily destroyed since the 1880s (Fig. 4) have been unable to subsequently reestablish (Fig. 3). High Lake Erie water levels, wave action, water turbidity and lack of sediment accretion likely prevent germination and growth of aquatic macrophytes in this large, naturally-existing wetland.

ACKNOWLEDGEMENTS. We thank D. Case, R. Pederson, and G. Tori for pre-submission reviews of the paper. Several anonymous referees also contributed helpful comments. This paper is a contribution of the Winous Point Research Committee.

LITERATURE CITED

Andrews, R. 1952 A study of waterfowl nesting on a Lake Erie marsh. M.S. Thesis, The Ohio State Univ., Columbus, OH. 85 pp.

Bedford, K. W. 1992 The physical effects of the Great Lakes on tributaries and wetlands. A summary. J. Great Lakes Res. 18: 571-589.

Bookhout, T. A., K. E. Bednarik, and R. W. Kroll 1989 The Great Lakes marshes. *In*: L. M. Smith, R. L. Pederson, and R. M. Kaminski (eds.), Habitat Management for Migrating and Wintering Waterfowl in North America. Texas Tech Univ. Press, Lubbock, TX. pp. 131-156.

Bourne, S. 1820 Survey of Winous Point and Ottawa Shooting Clubs. Wareham, MA.

Campbell, L. W. 1979 Lake plain. *In*: M. B. Lafferty (ed.), Ohio's Natural Heritage. Ohio Acad. of Sci., Columbus, OH. pp. 274-281.

Cowardin, L. M., V. Carter, F. C. Golet, and E. T. LaRoe 1979 Classification of wetlands and deepwater habitats of the United States. U.S. Fish Wildl. Serv., FWS/OBS-79/31. 103 pp.

DeRoia, D. M. 1989 Spring and autumn feeding ecology of blue-winged and green-winged teals on the Lake Erie marshes. M.S. Thesis, The Ohio State Univ., Columbus, OH. 97 pp.

Fassett, N. C. 1957 A manual of aquatic plants. Univ. Wisconsin Press, Madison, WI. 405 pp.

Herdendorf, C. E. 1987 The ecology of the coastal marshes of western Lake Erie: A community profile. U.S. Fish Wildl. Serv. Biol. Rep. 85(7.9). 171 pp.

—— 1992 Lake Erie coastal wetlands: An overview. J. Great Lakes Res. 18: 533-551.

Jude, D. J. and J. Pappas 1992 Fish utilization of Great Lakes coastal wetlands. J. Great Lakes Res. 18: 651-672.

Keddy, P. A. and A. A. Reznicek 1986 Great Lakes vegetation dynamics: The role of fluctuating water levels and buried seeds. J. Great Lakes Res. 12: 25-36.

Koneff, M. D. 1992 Spring macroinvertebrate production in hemi-marsh and flooded moist-soil plant litter in a diked Lake Erie marsh. M.S. Thesis, The Ohio State Univ., Columbus, OH. 161 pp.

Krecker, F. H. 1928 Periodic oscillations in Lake Erie. The Ohio State Univ., Franz Theodore Stone Lab, Put-in-Bay, OH. Contrib. 1. 22 pp.

Langlois, T. H. 1954 The western end of Lake Erie and its ecology. Edwards Brothers, Inc., Ann Arbor, MI. 479 pp.

Mitsch, W. J., B. C. Reeder, and D. M. Klarer 1989 The role of wetlands in the control of nutrients with a case study of western Lake Erie. *In*: W. J. Mitsch and S. E. Jorgensen (eds.), Ecological Engineering: An Introduction to Ecotechnology. John Wiley and Sons, Inc., New York, NY. pp. 129-158.

Musgrave, D. K. and G. D. Derringer 1985 Soil survey of Ottawa County, Ohio. Natl. Coop. Soil Surv. 104 pp.

Robb, D. M. 1989 Diked and undiked freshwater coastal marshes of western Lake Erie. M.S. Thesis, The Ohio State Univ., Columbus, OH. 145 pp.

Riley, T. Z. and D. M. DeRoia 1989 Early decomposition and invertebrate colonization of nodding smartweed leaves. Wetlands 9: 219-225.

Tori, G. M., J. R. Robb, and J. L. Weeks 1990 American black ducks staging in Ohio's Lake Erie marshes. Presented at fifty-second Midwest Fish Wildl. Conf., Minneapolis, MN.

U.S. Army Corps of Engineers, North Central Division 1994a Great Lakes Update 107: 5.

—— 1994b Monthly Bulletin of Lake Levels for the Great Lakes, May 1994.

U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Ocean Service 1992 Great Lakes Water Levels, 1860-1990. 243 pp.