Aerial view of Old Woman Creek estuary showing land utilization (NOAA/NOS/National Geodetic Survey, June 1997).

CHAPTER 10. CONCLUSIONS

SYNOPSIS

The Coastal Zone Management Act of 1972, as amended, established a system of National Estuarine Research Reserves (NERR) which are funded cooperatively by the National Oceanic and Atmospheric Administration (NOAA), Office of Ocean and Coastal Resource Management and the host States or Territories, and managed by the States or Territories. The NERR System (NERRS) has two missions: (1) to establish and maintain, through Federal-State cooperation, a national system of Estuarine Reserves that are representative of various biogeographic regions in the U.S. and (2) to conduct long-term research, educational, and interpretive activities in support of national coastal zone management priorities.

NERRS sites have been selected to represent the range of biogeographic regions and estuarine types occurring throughout the United States. To date, NOAA has designated 27 National Estuarine Research Reserves which collectively comprise 1,137,833 acres of estuaries and their associated terrestrial habitats (Figure 10.1). Two additional sites are in the designation process.

The Old Woman Creek National Estuarine Research Reserve (OWC NERR) was officially designated by NOAA in 1980. The Reserve is administered by the Division of Wildlife within the Ohio Department of Natural Resources. OWC NERR is the smallest Reserve in the national system, comprising 571 acres of protected lands and water along the southwestern shore of Lake Erie. Facilities at this site include a visitor center, trail network, research laboratories, teaching rooms, reference library, dormitories, boat house, and maintenance/storage buildings (Figure 10.2).

The OWC NERR represents the only Great Lakes estuary within the NERR System. Several important estuarine, lacustrine, and terrestrial habitats are located within the Reserve. These include open estuarine waters, remnant embayment marshes, mudflats, oak-

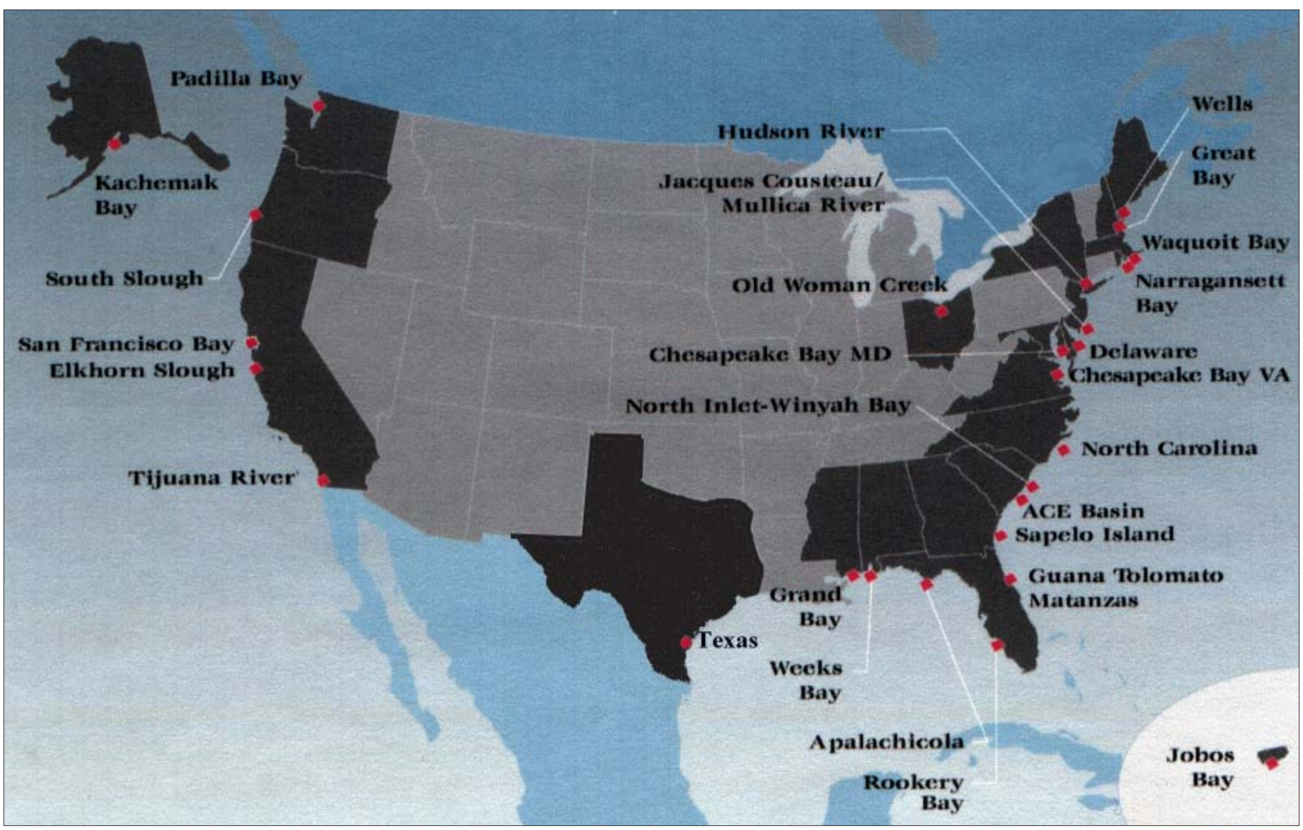

Figure 10.1. United States National Estuarine Research Reserve System (NOAA).

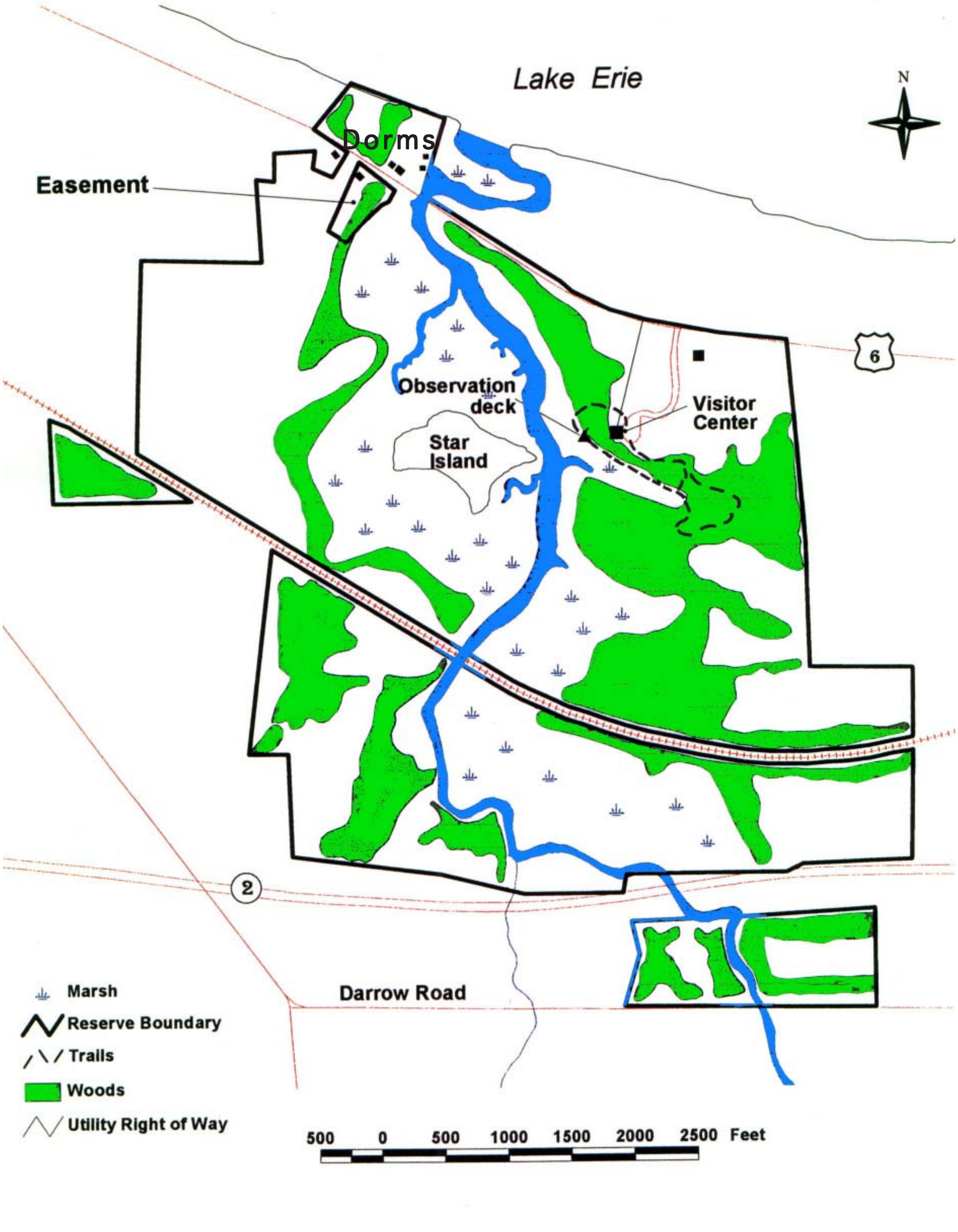

Figure 10.2. Old Woman Creek State Nature Preserve and National Estuarine Research Reserve.

hickory upland hardwood forests, a swamp forest, a sandy barrier beach, and the waters of Lake Erie (Figure 10.3).

The advance and retreat of the glaciers and the resulting glacial lakes during the Wisconsinan Period were instrumental in determining the soils and land form of the Old Woman Creek (OWC) watershed. In the nineteenth century, the virgin forests in the watershed were harvested, land was cleared, and farms were established. Today, agricultural pursuits account for approximately 65% of land use in the watershed. The high proportion of agriculture over the past 150 or so years has resulted in an estuary that is nutrient rich. Despite this overabundance of nutrients, the estuary still traps or transforms the majority of phosphorus and nitrogen pollutants that enter.

Within the boundaries of the OWC Reserve, a diverse assemblage of plants and animals reside. This assemblage is representative of the terrestrial and coastal wetland habitats that were once prominent in the lower Great Lakes. Table 10.1 provides an inventory of the natural features and resources that have been documented for this area.

The goal of the OWC NERR research program is to develop a better understanding of the freshwater estuarine system. The objective of studies undertaken in OWC is to determine the role of freshwater estuaries and other coastal wetland areas in the Great Lakes ecosystem. Results from these studies provide useful information to coastal zone managers and decision-makers in the Lake Erie area and the Great Lakes region.

Research conducted at OWC NERR to date has demonstrated that the estuary is a very dynamic system which is constantly changing. Two separate processes—changing Lake Erie water levels and storms—largely control these changes in the estuary.

CHANGING LAKE LEVELS

Unlike traditional marine estuaries where water level changes are generally predictable, water levels in the five Great Lakes are erratic and fluctuate not only daily, but also seasonally and annually. Changes in Lake Erie water levels are mirrored in the Old Woman Creek estuary. The impact of seasonal and annual changes in Lake Erie water level on the aquatic

Figure 10.3. Bird's-eye view of Old Woman Creek estuary (Linda Feix).

TABLE 10.1. INVENTORY OF NATURAL FEATURES AND RESOURCES WITHIN OLD WOMAN CREEK WATERSHED AND ADJOINING LAKE ERIE

GEOLOGY	
Bedrock Formations	**Age (YBP)[1]**
Ohio Shale (Devonian)	370 million
Bedford Shale (Mississippian)	360 million
Berea Sandstone (Mississippian)	350 million
Glacial Deposits	
Wisconsinan Ground Moraine (Till)	15,000–25,000
Wisconsinan Outwash Deposits	15,000–18,000
Glacial Lakes Sediments, Deltas, & Beach Ridges	
Glacial Lake Maumee (elevation 800 ft)	14,440–13,800
Glacial Lake Arkona (elevation 700 ft)	13,800–13,660
Lake Ypsilanti–low stage (elevation 260 ft)	13,600–13,000
Glacial Lake Whittlesey (elevation 740 ft)	13,000–12,800
Glacial Lakes Warren (elevation 680 ft)	12,800–12,700
Glacial Lake Wayne (elevation 660 ft)	12,700–12,600
Glacial Lake Grassmere (elevation 640 ft)	12,600–12,500
Glacial Lake Lundy (elevation 620 ft)	12,500–12,400
Post-Glacial Deposits	
Lacustrine (Lake) Sediments	
Early Lake Erie (elevation 490 ft)	12,400–8,000
Middle Lake Erie (elevation 525 ft)	8,000–4,000
Modern Lake Erie (elevation 570 ft)	4,000–present
Estuary Sediments & Wetland Deposits	4,000–present
Floodplain Alluvium	4,000–present
Modern Soils	**Soil types (no.)**
Bedrock Parent Materials	3
Glacial Till Parent Materials	14
Glacial Outwash Parent Materials	12
Ancient Beach Ridge Parent Materials	8
Lacustrine Deposits Parent Materials	23
Delta Deposits Parent Materials	3
Floodplain Alluvium Parent Materials	3

[1] YBP—years before the present

TABLE 10.1. INVENTORY OF NATURAL FEATURES AND RESOURCES WITHIN OLD WOMAN CREEK WATERSHED AND ADJOINING LAKE ERIE (cont'd)

CLIMATOLOGY

Average Weather Conditions

	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec
Sunny Days:	32	49	59	36
Rainy Days:	16	20	15	14
Thunderstorm Days:	1	14	15	1
Snowy Days (> 1 inch):	7	0	0	3
Hot Days (> 90°F):	0	11	8	0
Cold Days (< 32°F):	70	10	0	42

Average Air Temperature

	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec
Minimum Daily (°F):	24°	51°	62°	36°
Maximum Daily (°F):	38°	69°	80°	51°

Average Lake Temperature (°F):

Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec
35°	55°	72°	46°

Total Precipitation

	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec
Rainfall Equivalent (inches):	7.4	10.7	9.6	6.3
Snowfall (inches):	19.1	1.1	0.0	8.6

TABLE 10.1. INVENTORY OF NATURAL FEATURES AND RESOURCES WITHIN OLD WOMAN CREEK WATERSHED AND ADJOINING LAKE ERIE (cont'd)

HYDROLOGY

- Drainage Basin
  - Watershed (Surface Drainsge Basin) Area: 27 sq miles
  - Groundwatershed (Subsurface Drainage) Area: 900 sq miles
  - Ponds (Total No.: 45) Surface Area: 2.3 million sq ft
- Estuary (Average for Summer 1998)
  - Area: 5.7 million sq ft; Volume: 10.5 million cu ft; Depth: 1.8 ft
- Old Woman Creek (Total Stream Length: 46.6 miles)
  - West Branch
    - 1st Order Tributaries (No.: 13; Total Length: 6.8 miles)
    - 2nd Order Tributaries (No.: 3; Total Length: 7.1 miles)
    - 3rd Order Tributaries (No.: 1; Total Length: 1.2 miles)
  - East Branch
    - 1st Order Tributaries (No.: 11; Total Length: 17.5 miles)
    - 2nd Order Tributaries (No.: 3; Total Length: 4.2 miles)
    - 3rd Order Tributaries (No.: 1; Total Length: 4.7 miles)
  - Main Stem & Estuary
    - 1st Order Tributaries (No.: 4; Total Length: 1.8 miles)
    - 4th Order Tributaries (No.: 1; Total Length: 3.3 miles)
- Lake Erie
  - Water Levels (above Atlantic Ocean, IGLD 1985)
    - Low Water Datum: 569.2 ft
    - Mean Lake Level: 571.3 ft
    - Average Lake Level for 1998 Summer: 573.2 ft
    - Flooding Potential at Estuary Mouth
      - Once Every 10 Years: 574.9 ft
      - Once Every 50 Years: 575.8 ft
      - Once Every 100 Years: 576.0 ft; 500 Years: 576.6 ft
  - Extreme Offshore Lake Waves (height above still water level)
    - Northwest Storms
      - Once Every 10 Years: 7.9 ft
      - Once Every 50 Years: 10.8 ft
      - Once Every 100 Years: 12.7 ft
    - Northeast Storms
      - Once Every 10 Years: 9.5 ft
      - Once Every 50 Years: 14.1 ft
      - Once Every 100 Years: 15.7 ft

TABLE 10.1. INVENTORY OF NATURAL FEATURES AND RESOURCES WITHIN OLD WOMAN CREEK WATERSHED AND ADJOINING LAKE ERIE (cont'd)

BOTANY

- Plant Species: 2,169 species
  - Algae: 682 species
    - Kingdom Monera – 49 species
      - Cyanobacteria (blue-green algae) – 49 species
    - Kingdom Protista (plant-like) – 633 species
      - Rhodophytes (red algae) – 1 species
      - Chrysophytes (golden & yellow-green algae) – 351 species
        - Chrysophyceae (golden-brown algae) – 32 species
        - Xanthophyceae (yellow-green algae) – 6 species
        - Bacillariophyceae (diatoms) – 313 species
      - Pyrrhophytes (fire algae) – 10 species
      - Cryptophytes (crytomonads) – 21 species
      - Euglenophytes (euglenoids) – 77 species
      - Chlorophytes (green algae) – 173 species
  - Fungi: 472 species
    - Kingdom Fungi – 472 species
      - Myxomycetes (slime molds) – 50 species
      - Phycomycetes (algal fungi & water molds) – 61 species
      - Ascomysetes (yeasts, molds & cup fungi) – 52 species
      - Basidiomycetes (mushrooms & rusts) – 147 species
      - Deuteromycetes (imperfect fungi) – 51 species
      - Mycophycohytes (lichens) – 111 species
  - Vascular Plants (estuarine and upland): 1,015 species
    - Kingdom Plantae – 1,015 species
      - Bryophytes (mosses & liverworts) – 156 species
      - Lycopodiophytes (clubmosses) – 2 species
      - Equisetophytes (horsetails) – 2 species
      - Filicophytes (ferns) – 18 species
      - Pinophytes (gymnosperms/conifers) – 8 species
      - Magnoliophytes (angiosperm/flowering plants) – 829 species

TABLE 10.1. INVENTORY OF NATURAL FEATURES AND RESOURCES WITHIN OLD WOMAN CREEK WATERSHED AND ADJOINING LAKE ERIE (cont'd)

ZOOLOGY

- Animal Species: 1,968 species
  - Kingdom Protista (animal-like): 318 species
    - Protozoans – 318 species
      - Sarcomastigophora - 198 species
      - Ciliophora - 120 species
  - Kingdom Animalia: 1,650 species
    - Invertebrates: 1,055 species
      - Poriferans (sponges) – 2 species
      - Cnidarians (hydrozoans) – 2 species
      - Turbellarians (flatworms) – 5 species
      - Annelids (segmented worms & leeches) – 46 species
      - Rotifers – 34 species
      - Nematodes (roundworms) – 3 species
      - Gastrotichs – 2 species
      - Mollusks (clams & snails) – 33 species
      - Tardigrades (water bears) – 1 species
      - Bryozoans (moss animals) – 5 species
      - Arthropods: 922 species
        - Arachnida (spiders & water mites) – 77 species
        - Crustaceans – 87 species
        - Insects – 758 species
    - Vertebrates: 595 species
      - Fishes: 121 species
        - Jawless Fishes (lampreys) – 2 species
        - Bony Fishes – 119 species
      - Amphibians: 27 species
        - Salamanders – 16 species
        - Frogs & Toads – 11 species
      - Reptiles: 25 species
        - Turtles – 8 species
        - Snakes – 17 species
      - Birds: 370 species
      - Mammals: 51 species
        - Marsupials (opossums) – 1 species
        - Insectivores (moles & shrews) – 5 species
        - Bats – 8 species
        - Carnivores – 9 species
        - Rabbits – 1 species
        - Rodents (squirrels, muskrats & mice) – 14 species
        - Ungulates (deer & bison) – 2 species
        - Primates (man) – 1 species

vegetation in the estuary can be both rapid and dramatic. During the period of high Lake Erie water levels (1980-1999) *Nelumbo lutea* (American water lotus) was the dominant plant in the estuary, often covering up to 35% of the estuary with the remaining area being open water (see Figures 7.11 and 7.12). Emergent vegetation was confined to a very narrow band along the shoreline of the estuary. When Lake Erie water levels dropped in 1999, more than half of the open water areas, previously under water, became exposed during the following spring. These exposed areas were quickly colonized by emergent vegetation. In 2000, more than 50% of the estuary was dominated by emergent plants, while open water areas had diminished from greater than 65% to less than 35% of the estuary. Based on our work at OWC, and from earlier studies, the changes in vegetation caused by changes in water level are cyclical. When high lake levels return, conditions in the estuary are expected to revert to those conditions observed from 1980 to 1999.

Storm Events

Storm events have a major impact on water quality and quantity in OWC estuary as well as on the biota inhabiting the estuary. Strong wind events and resulting seiches can drive lake water up into the estuary or can drain the estuary. Wind activity on the lake over time will deposit sand in the estuary mouth and close the barrier beach isolating the estuary from the lake proper.

Rain storms in the watershed result in storm waters flowing into the estuary. If the mouth is closed, it is stormwater that will breach the barrier beach and re-connect the estuary with the lake. These stormwaters can be turbid and laden with excess nutrients and other pollutants. As these waters pass through the estuary many of these pollutants are either trapped or transformed.

The biotic populations, particularly planktonic communities, are strongly impacted by storm events. An influx of lake water brings lake populations into the estuary. Stormwater inflow from the watershed can result in the estuarine plankton populations being washed out into Lake Erie. These inflows can act as a two-edged sword. On one hand, they flush out the bulk of the existing estuarine populations; on the other hand, they bring into the estuary nutrients that are necessary for rapid re-colonization.

When the mouth is open the populations in the estuary are regulated primarily by physical factors, particularly water level and water flow. However, when the mouth is closed, biological interactions such as competition and predation become much more important.

Future Research Initiatives

Since 1980, the OWC research program has focused on descriptions of biological communities in the estuary and of major processes that impact the estuary. In compiling this document we have synthesized our understanding of a freshwater estuary and noted areas where critical information is missing in that understanding of OWC in the Lake Erie ecosystem and the ecology of the estuary and its watershed. Five areas for potential research are identified below.

Macrophyte Detritus

The recent decline in Lake Erie water levels has had major ramifications in the ecology of the estuary. The impact of these changes on the estuary and the nearshore zone of Lake Erie should be studied. An obvious result of declining water levels in the estuary has been the proliferation of aquatic macrophytes (Trexel-Kroll 2002). Work by Francko and Whyte (1995) suggested that macrophyte production now dominates the carbon production in the estuary. Therefore, studies on: (1) the significance and fate of macrophyte detritus and (2) the resulting breakdown processes with the estuary should be addressed.

Organic Contaminants

Organic pollution of the Great Lakes became a concern in the past decade and has every indication of remaining a major problem for the foreseeable future. Studies by Chin et al. (1998), Everett et al. (1999), and Miller and Chin (2002) have demonstrated the role that wetland areas along the Great Lakes may play in mitigating this pollution. Their work should be expanded to provide information to coastal managers on the impact and fate of organic contaminants in coastal wetlands and the receiving Great Lakes.

BACTERIAL COMMUNITIES

The impact of bacterial communities—and the food webs that develop around these microorganisms—has received little attention. However, research by Lavrentyev et al. (1998) has reinforced the importance of bacteria to food webs and chemical cycling in the estuary.

LAND USE

The impact of major changes in land use activities in the watershed should be further investigated and a planning model developed as an aid in identifying possible management concerns. Different land use activities result in different stresses on the creek and the estuary.

With the completion of a major highway corridor and the initiation of plans for the installation of water lines in the watershed, the potential for low-scale urban development has become both real and immediate. The potential effects of these changing land use patterns on the creek and the estuary make this one of our top research priorities.

GROUNDWATER

Past studies on physical and chemical parameters have provided an understanding of surface water quality; however, relatively little is known of groundwater abundance, quality, and pathways. Studies such as Matisoff and Eaker (1992) suggest that groundwater may be a minor component in the estuarine hydrologic budget. Although a minor component in the estuary, this may not be the case in the watershed, where many home sites still depend upon water wells for their water. Therefore, a study of groundwater quantity and quality would be critical to good management planning, particularly in light of the potential for increased urbanization within the watershed.

As these research objectives are addressed and results forthcoming, compelling educational programs should be developed to communicate this information to students, citizens, and coastal managers (Figures 10.4 and 10.5). Out of this information transfer and a broadening understanding of the role of estuaries and other coastal wetlands in the Great Lakes ecosystem, enlightened management initiatives will likely develop.

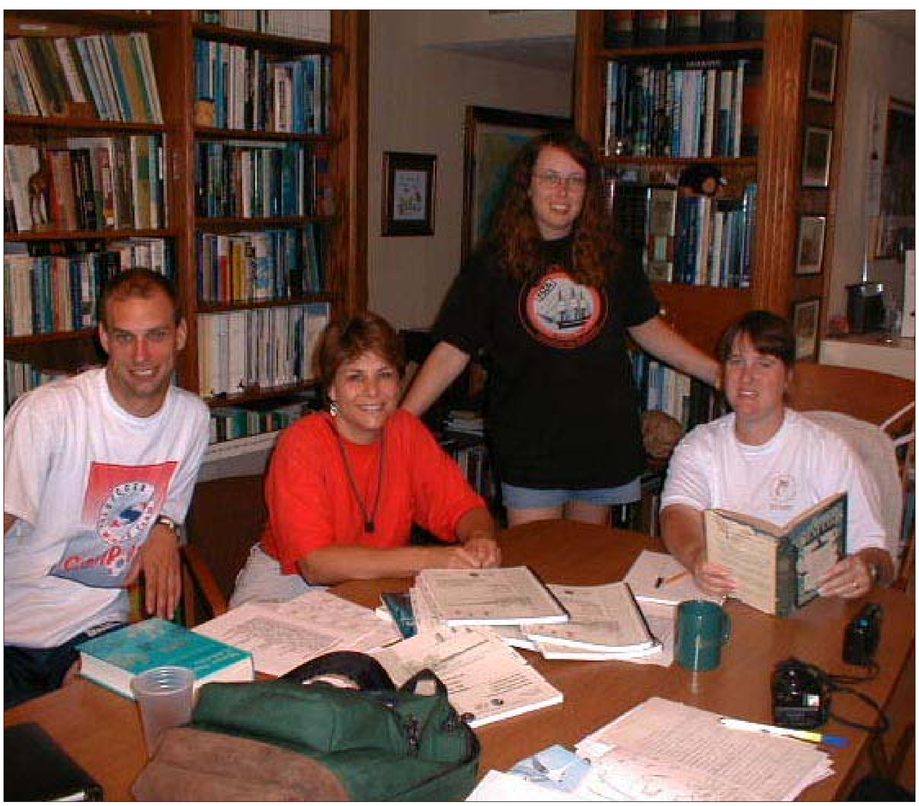

Figure 10.4. Teacher training workshop focused on the value of coastal wetlands (Charles E. Herdendorf).

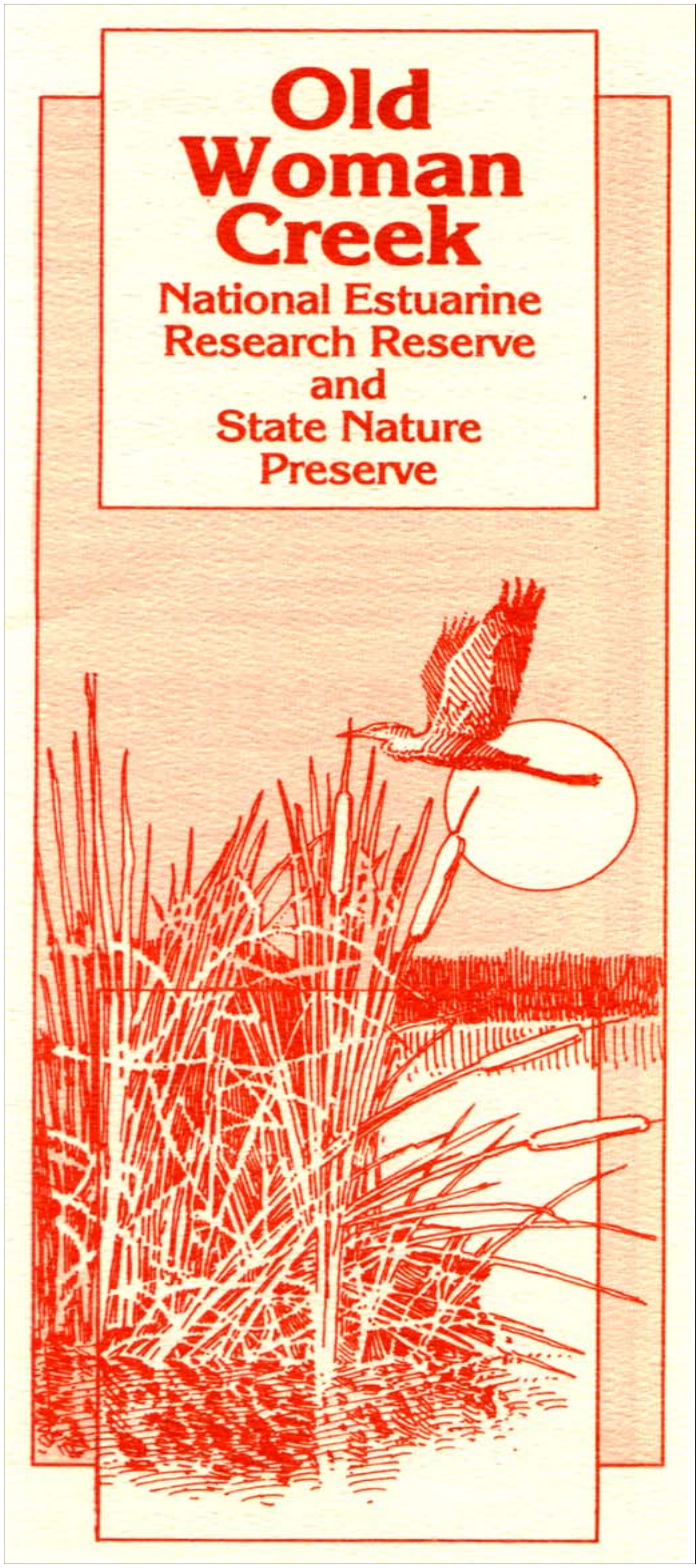

Figure 10.5. Old Woman Creek National Estuarine Research Reserve and State Nature Preserve brochure (ODNR).