*Shagbark hickory (*Carya ovata*) on a bluff overlooking Old Woman Creek estuary (Charles E. Herdendorf).*

Chapter 6. Biology

Non-Vascular Plants

The non-vascular plants of the Old Woman Creek estuary and watershed include the algal flora and the lower plants. For the purposes of the Site Profile, "algal flora" is considered as those chlorophyll-bearing, aquatic organisms that lack vascular systems, true tissues, and root, stem, and leaf organs (Gray 1970) and "lower plants" include the fungi, lichens, mosses, horsetails, and ferns—those aquatic and terrestrial plant-like organisms with less complex vegetative and reproductive morphology than the gymnosperms (conifers) and angiosperms (flowering plants). In this profile, the grouping of species into divisions, classes, orders, and families follows the classification system presented in *Synopsis and Classification of Living Organisms* (Parker 1982), except where noted.

TABLE 6.1. CLASSIFICATION OF ALGAL FLORA AND LOWER PLANTS

Kingdom Monera
- Cyanobacteria (blue-green algae)

Kingdom Protista
- Rhodophytes (red algae)
- Chrysophytes (golden & yellow-green algae)
- Pyrrhophytes (fire algae)
- Cryptophytes (crytomonads)
- Euglenophytes (euglenoids)
- Chlorophytes (green algae)

Kingdom Fungi
- Myxomycetes (slime molds)
- Phycomycetes (algal fungi & water molds)
- Ascomysetes (yeasts, molds, & cup fungi)
- Basidiomycetes (mushrooms, smuts, & rusts)
- Deuteromycetes (imperfect fungi)
- Mycophycohytes (lichens)

Kingdom Plantae
- Bryophytes (mosses & liverworts)
- Lycopodiophytes (clubmosses)
- Equisetophytes (horsetails & scouring rushes)
- Filicophytes (ferns)

The algal flora and lower plants found in the vicinity of the Research Reserve embrace four of the five kingdoms of living organisms (Margulis and Schwartz 1988). As defined by Round (1969), this grouping includes the major divisions (with typical examples) listed in Table 6.1.

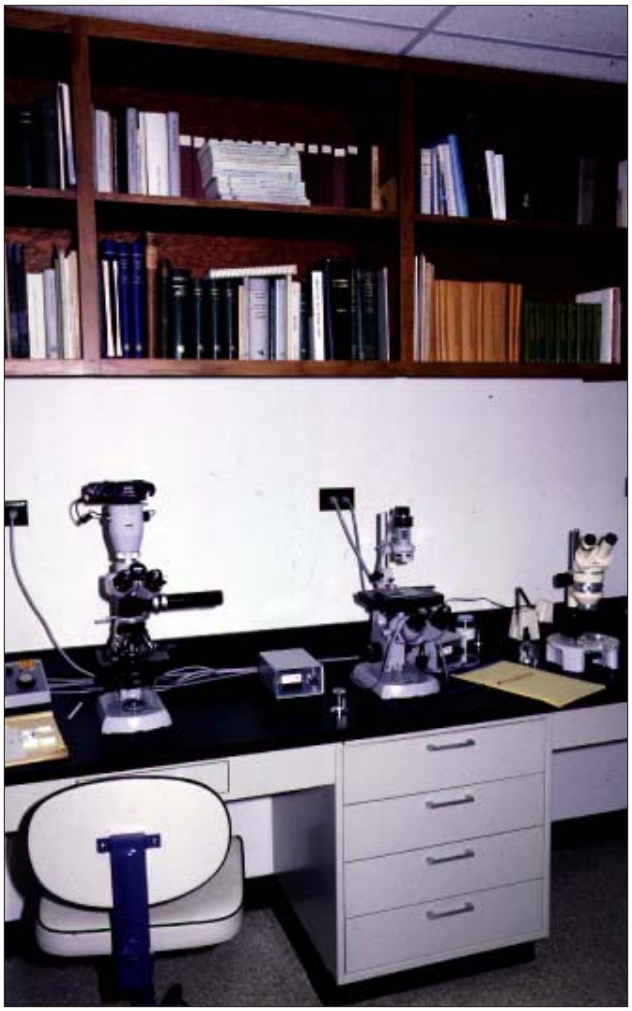


Figure 6.1. Phycology laboratory at the Ohio Center for Coastal Wetlands Study, Old Woman Creek SNP & NERR (David M. Klarer).

Research within the Old Woman Creek estuary and watershed has documented 682 algal species (Figure 6.1) and 648 lower plant species (Appendix A). A detailed treatment of these groups is contained in Old Woman Creek SNP & NERR Technical Report No. 13: *Catalogue of the Algal Flora and Lower Plants of Old Woman Creek Estuary, Watershed, and Adjacent Waters of Lake Erie* (Klarer et al. 2001).

ALGAL FLORA

The primary features used to classify algae into seven divisions include: (1) nuclear type, (2) pigmentation, (3) cell wall composition, and (4) locomotory organs (Bold and Wynne 1985). These characteristics are detailed in Table 6.2.

DIVISION CYANOPHYTA (BLUE-GREEN ALGAE)

Blue-greens, sometimes called cyanobacteria, are the most primitive photosynthetic organisms in the estuary. Like the true bacteria, they have a prokaryotic cell structure—characterized by the lack of a nuclear membrane and distinct chloroplasts (plastids containing chlorophyll). The cell walls are composed of mucopeptide, similar to that of bacteria. Blue-greens also lack flagella and the only motility results from gliding trichomes – filaments without the investing sheath (Prescott 1962). They occur in unicellular, filamentous, and colonial forms, and most are enclosed in a gelatinous sheath. Blue-greens also occur in attached benthic forms. Blue-green algae contain specialized cells, known as heterocysts (sites of nitrogen fixation) a feature unique to this group. Photosynthetic products are glycogen and glycoproteins rather than starch. There is no direct evidence of sexual reproduction such as conjugation as observed in some bacteria (Dawes 1981); vegetative reproduction by fragmentation is most common and can be more rapid than in other phytoplankton groups (Pentecost 1984).

TABLE 6.2. PRIMARY FEATURES IN THE CLASSIFICATION OF ALGAL DIVISIONS

Name & Typical Color	Nucleus	Pigment	Cell Wall	Locomotion
Cyanophyta (blue-green)	prokaryotic	chlorophyll *a* phycocyanin phycoerythrin	mucopeptide	some float & glide
Rhodophyta (red)	eukaryotic	chlorophyll *a,d* carotenoids phycoerythrin	cellulose	attached
Chrysophyta				
chrysophytes (golden-brown)	eukaryotic	chlorophyll *a,c* carotenoids xanthophylls	pectin	few flagellated
xanthophytes (yellow-green)	eukaryotic	chlorophyll *a,c* carotenoids xanthophylls	pectin	most flagellated
diatoms (golden)	eukaryotic	chlorophyll *a,c* carotenoids xanthophylls	silica	sessile; some float
Pyrrhophyta				
dinoflagellates (red-brown)	eukaryotic	chlorophyll *a,c* xanthophylls	cellulose; may be in armored plates	all flagellated
Cryptophyta (various)	eukaryotic	chlorophyll *a,c*	absent carotenoids phycoerythrin	flagellated
Euglenophyta (green)	eukaryotic	chlorophyll *a,b* xanthophylls	absent	flagellated
Chlorophyta (grass green)	eukaryotic	chlorophyll *a,b* carotenoids xanthophylls	cellulose	some flagellated

Most of the blue-greens identified in Old Woman Creek estuary are planktonic and are either spherical-shaped members of the family Chroococcacea (e.g. *Microcystis* and *Coelosphaerium*) or unbranched, filamentous forms (e.g. *Anabaena* and *Oscillatoria*) in several families. Representative species from Old Woman Creek and its estuary are: *Aphanocapsa delicatissima*, *Chroococcus dispersus*, *Gomphosphaeria lacustris*, *Anabaena spiroides*, *Oscillatoria agardhii*, and *Oscillatoria limosa* (Figures 6.2 and 6.3).

*Figure 6.2. Spherical blue-green alga (*Chroococcus*) from Old Woman Creek estuary (David M. Klarer).*

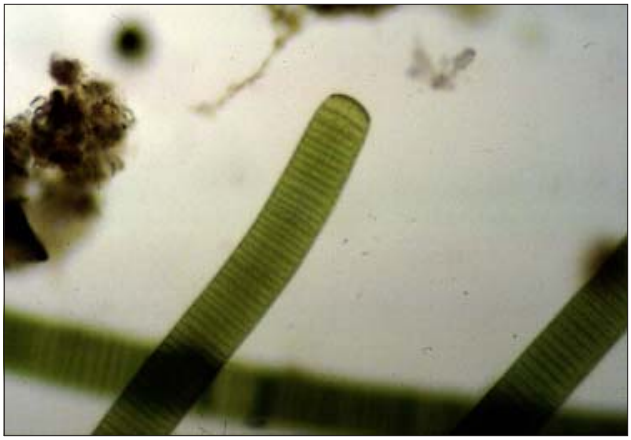


*Figure 6.3. Filamentous blue-green alga (*Oscillatoria*) from Old Woman Creek estuary (David M. Klarer).*

DIVISION RHODOPHYTA (RED ALGAE)

Red algae are sparsely represented in freshwater, including Old Woman Creek estuary where only filamentous benthic forms are present. No planktonic red algae occur in Lake Erie. The attached filaments colonize rocks and other hard substrates just below the splash zone. Because these algae contain red phycoerythrin and blue phycocyanin that mask their chlorophyll, they generally appear reddish in color. The cell wall is composed of cellulose. There is a complete lack of any flagellate stages in this group. Red algae stores polysaccharides such as floridian starch, agar, and carrageenan (Lerman 1986). Reproduction is by sexual and asexual means for the species that have invaded Lake Erie. A distinguishing characteristic of red algae is the cystocarp, a spore-forming structure that follows fertilization and the meiotic division of the zygote (Taft and Taft 1971).

The only representative of the Division Rhodophyta in the Old Woman Creek area is *Bangia atropurpurea*, which grows attached to some shore protection structures in Lake Erie off of the mouth of the creek. The attached filaments colonize the rocks and other hard substrates just below the splash zone. The simple, unbranched filaments are brownish purple in color and appear in late spring to early summer, but disappear by mid-summer.

The other major marine algal group, Phaeophyta (brown algae), is almost exclusively oceanic and benthic. There are no freshwater species that have been reported in the flora of Lake Erie or Old Woman Creek estuary.

DIVISION CHRYSOPHYTA (GOLDEN & YELLOW-GREEN ALGAE)

This division of algae consists of three important classes: Chrysophyceae (golden-brown algae), Xanthophyceae (yellow-green algae), and Bacillariophyceae (diatoms).

Class Chrysophyceae (golden-brown algae)

Chrysophytes contain chromatophores that often produce a golden-brown color because of the high content of carotenoid and xanthophyll pigments. Most chrysophytes are unicellular and most cells are unflagellated. Many species lack a cell wall; others are covered with calcareous or siliceous scales.

Vegetative reproduction by longitudinal cell division is the most common type (Wetzel 2001). Representative benthic and planktonic species from Old Woman Creek and its estuary are: *Chrysococcus* spp., *Kephryion* spp., *Pseudokephyrion* spp., *Mallomonas acaroids*, and various *Dinobyron* species including *D. bavaricum* and *D. divergens*.

Class Xanthophyceae (yellow-green algae)

Yellow-green algae are unicellular, colonial, or filamentous in form and are characterized by noticeable amounts of carotinoid pigments in comparison to chlorophyll that results in their distinct coloration. Most cells are motile, actuated by two flagella, one of which is considerably longer than the other. The cell wall, when present, contains a large amount of pectin and some species are silicified. Reproduction is largely asexual by fission. Xanthophytes are often associated with substrates, many being epiphytic on macrophytes (Wetzel 2001), but a few are planktonic. Although this group of algae is not well represented in Old Woman Creek and its estuary, *Ophiocytium capitatum* var. *longispina* is often observed in the plankton of the estuary (Figure 6.4).

*Figure 6.4. Yellow-green alga (*Ophiocytium capitatum *var.* longispina*) from Old Woman Creek estuary (David M. Klarer).*

Class Bacillariophyceae (diatoms)

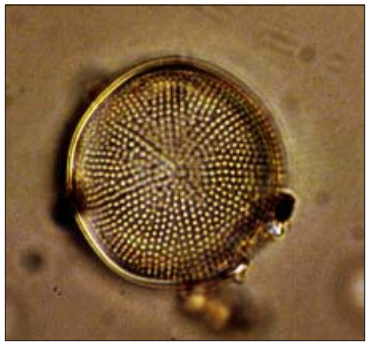
The primary characteristic of diatoms is an often ornate, siliceous cell wall (frustule). This wall consists of two lid-like halves, the epitheca (upper valve) that fits into the hypotheca (lower valve), which are connected by a girdle of cell wall material (Wetzel 2001). Both unicellular and colonial growth forms are common among the diatoms. Diatoms contain both chlorophyll *a* and *c*, carotene, and some xanthophylls. They store energy as fat and oil in large globules. This group is divided into centric diatoms (order Centrales), which have radial symmetry, and pennate diatoms (order Pennales), which are elongated with bilateral symmetry (Figure 6.5). Vegetative reproduction by cell division is the most common mode and usually takes place at night. Sexual reproduction takes place periodically when cells reach a critical minimum size through repeated asexual cell division.

Diatoms compose one of the most important algal groups in the estuary and the most important algal group in Lake Erie's nearshore waters from the standpoint of carbon fixed and oxygen produced. Over 300 species of diatoms have been identified from these habitats. Although the majority of species are sessile and associated with littoral vegetation or bottom sediments, many are important in the phytoplankton. Within Old Woman Creek, the attached species of *Gomphonema* spp., *Navicula* spp., and *Nitzschia* spp. are most common. The most important benthic diatoms in the estuary are also species of *Navicula* spp. and *Nitzschia* spp. Within the plankton in the estuary, *Aulacosieira alpigena*, smaller species of *Cyclotella* including *C. atomus* and *C. meneghiniana*, and a variety of smaller *Nitzschia* spp. are most common.

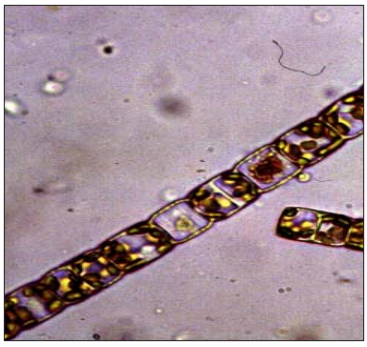
DIVISION PYRRHOPHYTA (FIRE ALGAE)

Class Dinophyceae (dinoflagellates)

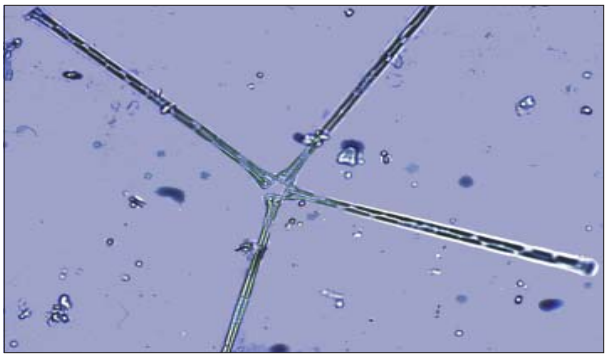
The common characteristics of this division are the preponderance of brownish pigment such as peridinin, starch and oil food reserves, and cellulose in the cell walls (Taft and Taft 1971). Dinoflagellates are unicellular flagellated algae, many of which are bizarre in shape and structure and many of which are motile. Most species have developed a conspicuous cell wall that is sculptured and bears large spines and elaborate, articulated plates. The body structure includes a transverse groove or "girdle" that encircles



Actinocyclus normanii (centric)



Stephanodiscus binderanus (centric)

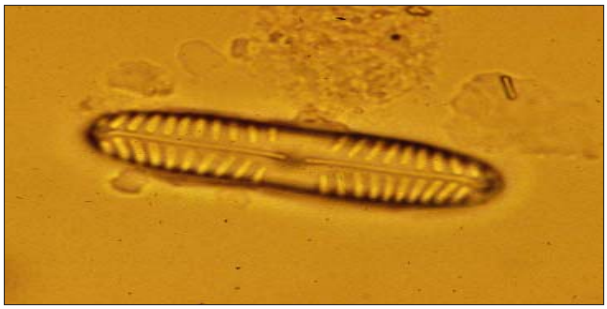


Asterionella formosa (pennate)

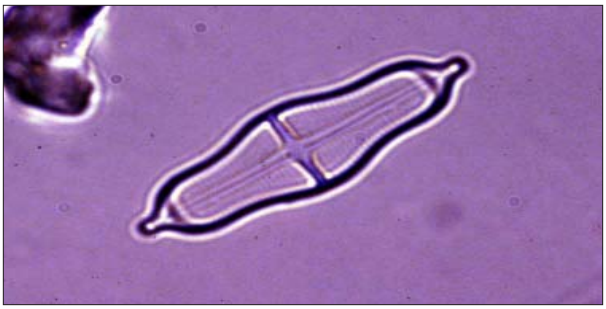
Gomphonema olivaceum (pennate)

Gomphonema sp. (pennate)

Nitzschia hungarica (pennate)



Pinnularia obscura (pennate)



Stauroneis smithii (pennate)

Figure 6.5. Centric and pennate diatoms from Old Woman Creek estuary (David M. Klarer).

the cell. Dinoflagellates differ from other bi-flagellated algae in having one of the two flagella circumscribing the body in a transverse groove while the other extends from the girdle posteriorly through a narrower groove. In most species the body is armored with thick cellulose plates ranging in color from reddish-brown to yellow, which form a case or theca. The shape and number of these plates are an important taxonomic character for species identification. The upper part of the armored cell is referred to as the epitheca and the lower part is the hypotheca. Reproduction in the motile forms is usually by vegetative cell division.

A common Lake Erie planktonic dinoflagellate is the genus *Ceratium*, which has a shape that often resembles the Eiffel Tower (Figure 6.6). The genus *Gymnodinium*, which at times reaches bloom proportions in the estuary, has green chromatophores, but lacks a distinct protective cellulose theca. Except for a brief period during 1981 when *Gymnodinium aeruginosum* reached bloom proportions, Dinoflagellates have not been a major component in the algae of Old Woman Creek estuary. Other species infrequently observed in the estuary are *Ceratium hirundinella* and *Perdiniopsis quadridens*.

*Figure 6.6. Dinoflagellate (*Ceratium*) from Old Woman Creek estuary (David M. Klarer).*

Figure 6.7. Cryptomonas *sp. (cryptomonad) a common genus found in Old Woman Creek estuary (Donald Ott).*

DIVISION CRYPTOPHYTA (CRYPTOMONADS)

Cryptomonads have ovoid to slipper-shaped cells that are rather flattened in appearance. These small, unicellular algae are motile by virtue of two anterior flagella. They are naked, in that they lack true cell walls, but possess distinct reservoir pockets and chloroplasts which contain pigments ranging from olive brown to blue to red. The one or two chromatophores in the cell contain a variety of pigments that can absorb a wide spectrum of light. Although small, these algae can have dense populations even during cold periods of the year under low light conditions (Wetzel 2001). Cryptomonads have a long longitudinal furrow and two anterior flagella. The food reserve is starch and oil.

Cryptomonads comprise a common planktonic group in the estuary and Lake Erie. They can be particularly abundant in the winter months under low light conditions. Common representatives include several species of *Crytomonas* and *Rhodomonas* (Figure 6.7). Cryptomonads are an important group in the estuary as *Cryptomonas erosa*, *C. ovata*, and *Rhodomonas minuta* var. *nannoplanctonica*, are often present in large numbers through the spring and summer.

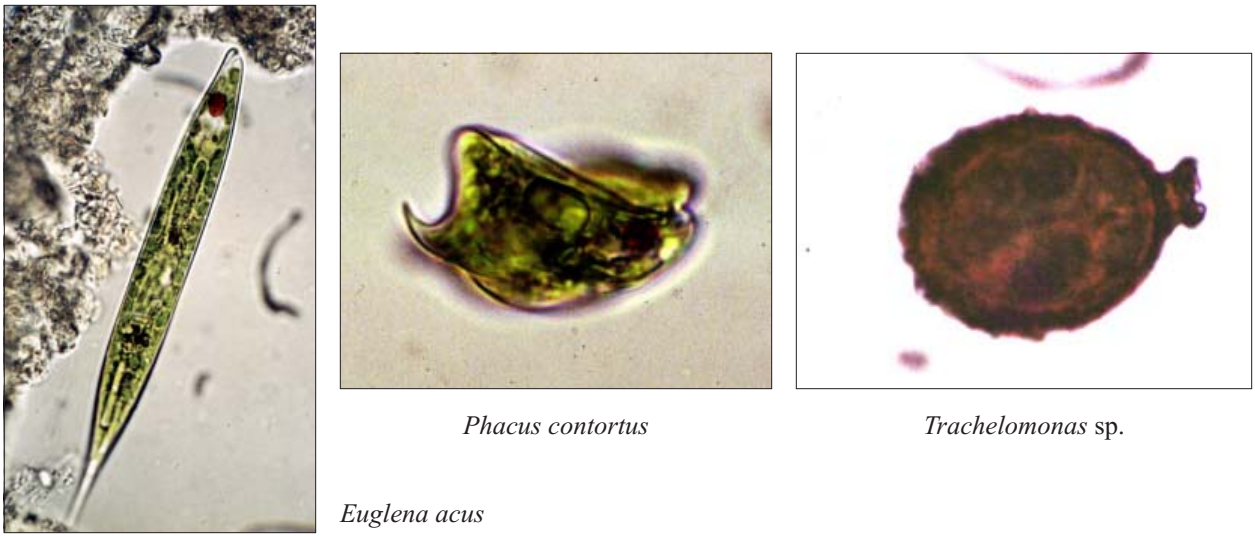


Figure 6.8. Euglenoids from Old Woman Creek estuary (David M. Klarer).

DIVISION EUGLENOPHYTA (EUGLENOIDS)

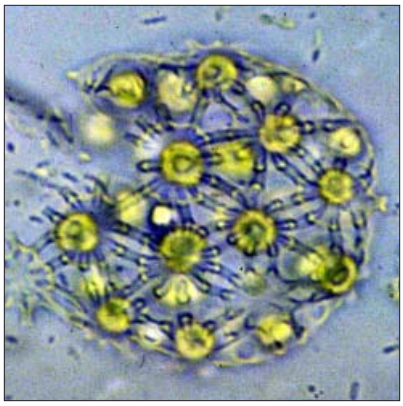
Organisms known as "euglenoids" constitute a controversial group in terms of the traditional plant verses animal debate. Most euglenoids are chlorophyll-bearing (chlorophytes), protozoa-like organisms of the Protista, and as such the chlorophytes can be considered members of the algae, division Euglenophyta (Taft and Taft 1971). Euglenoids in the order Peranemida are colorless and obtain their nutrition by absorbing dissolved food through the cell membrane (saprobic) or by the ingestion of organic material as animals must do (holozoic). Because they exhibit a distinct gullet in contrast to the indistinct gullet of the pigmented euglenoids, they are considered invertebrate protozoans and are not here included as a component of the algal flora. Appendix C and Old Woman Creek SNP & NERR Technical Report No. 12: *Catalogue of Invertebrate Fauna of Old Woman Creek Estuary, Watershed, and Adjacent Waters of Lake Erie* (Herdendorf et al. 2001d) contain information on protozoan euglenoids reported for the Research Reserve.

Euglenoid algae are unicellular flagellates that typically have grassy-green chloroplasts and a reddish stigma (eyespot). Haematochrome is often present along with chlorophyll and may give a blood-red coloration to the cell (Taft and Taft 1971). Almost all euglenoids are unicellular and free-swimming, but some are attached by stalks to various invertebrates (epizooic). They lack a distinct cell wall, but some possess a smooth outer membrane while others may have an ornamented lorica. Euglenoids have one to three flagella that arise from a canal in the cell membrane. Certain species possess a prominent orange-red eyespot which receives light stimuli. Such species have been found to be positively phototactic to low light intensity and negatively phototactic with respect to bright light and darkness (Bold and Wynne 1985). Body shapes are cylindrical, pyriform, fusiform, or ovoid. They store carbohydrates as granules in specialized reservoirs. Reproduction is asexual by longitudinal division of a motile cell.

Although few euglenoid species are truly benthic, most are planktonic in the estuary. Members of the genus *Trachelomonas* are housed in a self-secreted lorica which varies in shape depending on the species and environmental conditions. Representative species from Old Woman Creek and its estuary are: *Euglena acus*, *E. oxyuris*, *Phacus caudatus*, *Strombomonas longicauda*, *Trachelomonas volvocina*, *T. oblonga*, and *Lepocinclis ovum* (Figure 6.8).

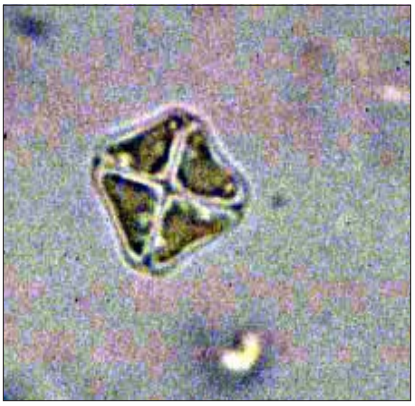
DIVISION CHLOROPHYTA (GREEN ALGAE)

Green algae are characterized by grass-green chloroplasts (pigment packets), one to many in each cell, and a firm cell wall composed of an inner layer cellulose and an outer layer of pectinaceous compounds (Figure 6.9). Green algae is the major phytoplankton

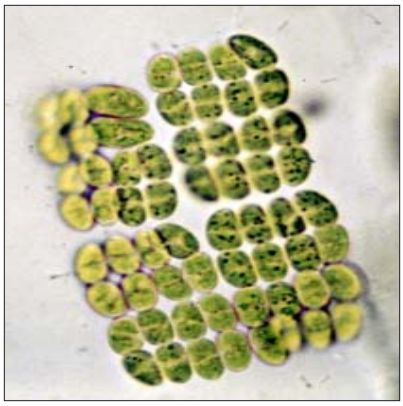


Coelastrum cambricum

Cosmarium formosulum

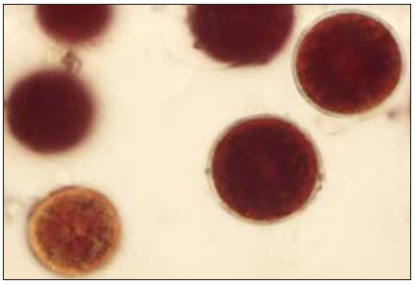


Crucigenia tetrapedia

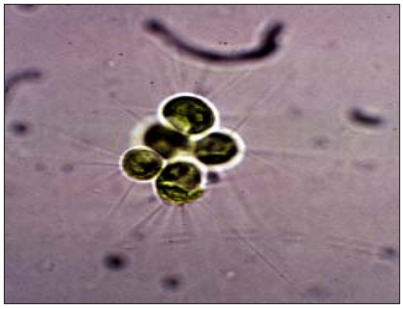


Crucigeniella rectangularis

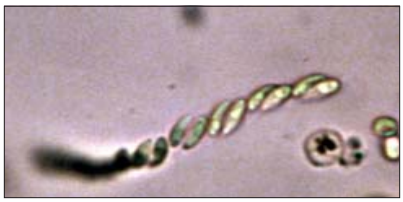
Dictyosphaerium puchellum



Haematococcus pluvialis

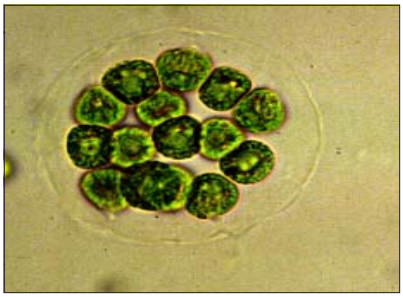


Micractinium pusillum

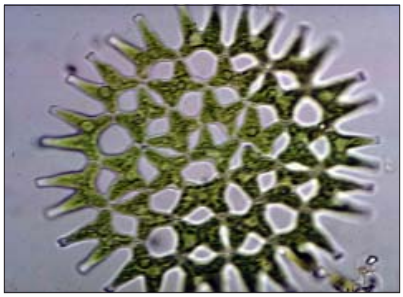


Neodesmus danubialis

Ooystis sp.



Pandorina sp.



Pediastrum boryanum

Scenedesmus opoliensis

Figure 6.9. Representative planktonic green algae from Old Woman Creek estuary (David M. Klarer).

group to contain chlorophyll *b* (a constituent of vascular plants) and is thought to be a precursor of higher plants. Some species have a stigma or red eyespot that is thought to be the site of light perception (Bold and Wynne 1985). Starch is the primary food product which is stored in structures known as pyrenoids.The body plan of greens shows a great range of cellular organization, including unicellular, colonial, filamentous (simple or branched), membranous (sheetlike), and tubular types. Green algae also occur as filamentous benthic forms, usually attached to hard substrates such as rocks or submerged logs. Green algae frequently have a unicellular stage of their life cycle which is flagellated and motile (Goldman and Horne 1983). This enables filamentous forms to colonize suitable, but discontinuous, substrates. Reproduction in green algae is asexual by vegetative division and cell division (particularly for colony enlargement), and sexual by the production of various styles of gametes.

Chlorophytes represent a large and diverse group of algae in the estuary and include both benthic and planktonic forms. Green algae are a major component of the phytoplankton and includes such common genera as *Ankistrodesmus*, *Chlamydomonas*, *Closterium*, *Scenedesmus*, and *Pediastrum* (Figure 6.9). Filamentous, benthic forms of green algae include *Cladophora* and *Ulothrix*. Representative species from Old Woman Creek and its estuary are: *Chlamydomonas globosa*, *Ankyra judayi*, *Pediastrum simplex* var. *simplex*, *Lagerheimia genevensis*, *Oocystis lacustris*, *Scenedesmus opoliensis*, *Cladophora glomerata*, and *Spirogyra* sp.

LOWER PLANTS

Although most groups of lower plants are active in carbon fixation and the building of more complex organic molecules through the process of photosynthesis, bacteria and fungi also perform the equally vital breakdown of organic matter. Without these recycling organisms, the land and waters of the Reserve would rapidly become choked with debris that could only be decomposed slowly by chemical processes. Many of the environmental processes that we think of as purely chemical are mediated by microorganisms, such as the formation of rust (iron oxidation) which can be facilitated by the bacteria *Leptothrix*—a common form in freshwater marshes. While bacteria tend to invade any organism as soon as it dies or is damaged, fungi are often secondary invaders because they are larger and slower growing (Round 1969). Saprophytic fungi, those growing on dead material, are thus the most numerous. Fundamentally, fungi are plant-like organisms that lack chlorophyll, cilia, or flagella (except some chytrids and oomycetes) and that form spores. Many construct a complex interweaving mass of fungal hyphae (filamentous threads that make up the body of a fungus) in upland habitats, while unicellular species occur in the sediments of the estuary and surrounding soil, releasing fungal spores or fragments into the water and air.

DIVISION MYXOMYCOTA (MUCUS MOLDS)

Class Myxomycetes (true slime molds)

Slime molds are "animal–like plants" found in freshwater, in damp soil, and on rotting vegetation, particularly in woodlands on fallen logs. In the course of their life cycle, independently feeding amoeboid forms aggregate into a slimy mass or wet scum (plasmodium) that eventually dries and transforms itself into a spore-forming reproductive body. Once released, the spores are dispersed by air currents. Typically the plasmodia are pigmented orange or yellow, but none photosynthesize. They feed by engulfing decaying vegetation. As the mass dries the plasmodial protoplasm becomes concentrated into a mound, from which stalked fruit (sporangia) grow. Some 50 species of Myxomycetes have been reported in the region surrounding the Reserve.

DIVISION PHYCOMYCOTA (ALGAL FUNGI & WATER MOLDS)

Members of this division of fungi are believed to be derived from algal progenitors which had lost their chlorophyll. As a result, phycomycetes have assumed a parasitic or saprophytic mode of life. Most species have nonseptate mycelium, in that they do not have cross walls in the mass of hyphae constituting the body of the fungus. This division contains the water molds which are frequently parasitic on algae or inhabit organic sediments. Over 40 species of both parasitic and saprophytic water molds have been reported in the Lake Erie islands to the west of the Reserve, while several species of *Achlya* have been reported in Old Woman Creek.

Class Chytridiomycetes (chytrids or cooking pot fungi)

These tiny fungi are the only ones which possess motile cells with a single posterior flagellum. Chytrids have a simple, sac-like thallus (undifferentiated body). Many species are aquatic and parasitize algae to such an extent that they can alter the balance of populations (Round 1969). Others are saprophytic on plants and animals in water and soil. Like other fungi, they feed and grow by extending threadlike hyphae (sometimes called rhizoids) into living hosts or dead organic debris, where they secrete digestive enzymes and absorb the resulting nutrients.

Class Oomycetes (egg fungi)

Oomycetes include fungi known as water molds, white rusts, and downy mildews. They also feed by extending hyphae into their hosts tissue and appear most commonly as a gray fuzz on dead animals. *Saprolegnia* causes diseases in fish and fish eggs and may do significant damage in a fish hatchery. Members of this genus invade the skin of fish, consume scales and flesh, and finally kill the fish. Oomycetes produce zoospores that swim by means of two flagella (undulipodia) of unequal length. After transformation, zoospores germinate and grow a new thallus, the cell walls of which are composed of cellulose.

Class Zygomycetes (pair fungi)

This class of fungi lacks cross walls (septa) and reproduces by means of spores and by conjunction (transmission of genetic material from a donor to a recipient cell). No flagellated cells have been found in this class. Many of them live on decaying vegetation. Representatives of two orders have been reported in the region surrounding the Reserve. Members of the order Mucorales are mostly saprobic, in that they excrete extracellular digestive enzymes and adsorb dead organic matter, whereas those in the order Entomophthorales are parasitic on animals, mainly insects.

DIVISION ASCOMYCOTA (ASCOMYCETES OR BLADDER FUNGI)

This division contains many familiar forms of fungi, such as yeast, fruit molds, morels (Figure 6.10), and truffles, as well as most of the fungal partners in lichens and other diverse parasitic and pathogenic forms. Members are known by one distinguishing feature, the ascu—from which the name of this division is derived—a saclike structure containing the spores (ascospores). Some of the spore-producing fruiting bodies are large and edible, such as the morel or sponge mushroom, *Morchella*.

*Figure 6.10. The common morel (*Morchella esculenta*) is found on wooded soils of the watershed (from Keizer 1997).*

Class Hemiascomycetes (yeasts)

This class includes many yeasts and other simple asconomycetes, such as fungi which cause peach leaf curl (*Taphrina deformans*) and plum pockets (*Taphrina communis*). The asci of this group is not enclosed in an ascocarp (a spherical or cup-shaped fruiting body). Many species are parasitic on ferns and higher plants, causing spots and galls on leaves, stems, and fruit.

Class Loculoascomycetes (scab molds)

This class contains many species which are parasitic on economically important food plants. Some attack the leaves of many plants while others cause apple and pear scab. Members of this class have a characteristic bitunicate asci—the inner wall of the spore sac is elastic and expands greatly beyond the outer wall when spores are released.

Class Plectomycetes (fruit molds)

Aspergillus and *Penicillum* are well known genera in this class. These fungi form green and blue colonies on fruit and produce organic acids that attack natural fibers. The fruiting bodies (ascocarps) are formed by a loose interwoven mass of hyphae, while the asci are usually unitunicate—the inner and outer ascus wall are more or less ridged and do not separate when spores are ejected. The spores are dispersed by air currents.

Class Pyrenomycetes (flask fungi)

This class contains the powdery mildews (order Erysiphales) and several orders of flask-shaped fungi. The "powdery" nature of the mildew is the result of chains of spores (conidia) budding off the spore sacs (conidiophores) at the tips of the hyphae. These fungi are mostly superficial, creating a coating of mycelium on stems, leaves, buds, and fruits of the host plants. The flask fungi, usually dark or brightly colored, often infest grasses and grains, producing a hardened hyphal mass (sclerotium) that resembles the grain in shape.

Class Discomycretes (disc fungi)

This class includes cup fungi, earth tongues, and rots. Brown rot of stone and pome fruits (e.g. peaches and apples) is caused by members of the genus *Sclerotinia*. This fungus spreads rapidly by means of oval conidia budding off in chains. As the growing season progresses, the hyphae which have spread throughout the fruits causes them to shrivel and mummify—they can often be seen attached to the fruit trees in winter. Those which fall to the ground and become buried will, in later years, grow long-stalked fruiting bodies (apothecia) of cup fungus from the mummified fruits (Round 1969).

DIVISION BASIDIOMYCOTA (BASIDIOMYCETES OR SMALL BASE FUNGI)

Basidomycetes are the most advanced division of fungi and can be distinguished from all others by the basidium—a microscopic clublike reproductive structure (spore producer) from which their name is derived. This division contains all of the woody fungi and nearly all of the large fleshy forms, including all but a few of the edible and poisonous mushrooms. Most basidomycetes go through three stages of development, involving the production of basidiospores which upon germination give rise to septate (cross-walled) mycelia with uninucleated cell. When two compatible hyphae from mycelia meet, nuclei pass from one to another and a binucleated mycelium is formed, from which the plant body (thallus) is produced. With forest trees and shrubs, certain basidomycetes form symbiotic associations called mycorrhizae. Mycorrhizal fungi are important mediators in the transfer of phosphorous and nitrogen to the host plants.

Class Teliomycetes (rust & smut fungi)

Two important groups of plant parasites—smuts and rusts—form this class. The smuts form sootlike masses (teliospores) in the ovaries of grasses, in the anthers of the pink family (Caryophyllacea), and on the leaves of the buckwheat family (Polygonaceae). The parasitic mycelium tends to concentrate in the meristematic regions of the plant (sites of active cell division) without causing much damage to vegetative growth. The rusts are much more complex and are mostly obligate parasites producing colored (often red) spore bodies (sori) which burst through the leaf or stem of the host. Some rusts have up to five stages in their complex life history. The most infamous of the rusts is *Puccinia graminis*, which causes black stem rust of wheat. According to the Erie County office of the Ohio Agricultural Extension Service, *P. graminis* occurs in the watershed, but has not been a major problem.

Class Phragmobasidiomycetes (jelly & waxy fungi)

The bodies (basidocarps) of these fungi are gelatinous to waxy. Many have brilliant yellow, orange, or reddish pigments. In the order Eutremellales, the basdia are borne in capsules extended above the surface of the gelatinous fruit body. *Tremella* (found regionally) forms a large, pigmented, foliose body that obtains nutrition saprophytically. Called trembling fungus, it looks like soft, clammy, yielding folds of jellylike material up to 10 cm high and wide that has a glistening appearance. Some species are edible.

Class Hymenomycetes (exposed hymenium fungi)

All of the species in this class have a fruiting body with an exposed fertile surface (hymenium), such as gills, lined with basidia. Most of the mushroom-like fungi are included in the large order Agaricales, within this class. Over 80 species in the order have been reported for the region surrounding the Reserve. In this group, the cap (pilus) bears flat "gills" radiating from the stalk. The development process begins underground as small button-like swellings appear on mycelial strands that gradually swell to form short stalks and hemispherical caps. Between the cap and the stalk a chamber appears where the gills form. Rapid expansion of the fruit body tears the connection between the cap's rim and the stalk leaving the torn tissue as a skirt-like annulus around the base of the base of the stalk. In the death cap, genus *Amanita*, a further layer of tissue covers the whole developing body (basidiocarp), but also eventually tears leaving a cup-like structure (volva) at the base of the stalk.

Class Gasteromycetes (stomach fungi)

Puff-balls are among the most common types of the Gasteromycetes and are found on the ground or on decaying wood in the vicinity of the Reserve; members of the genus *Lycoperdon* are typical of this group. The spores are formed in cavities which gradually enlarge producing basidia on their internal surfaces. At maturity the whole inside of the bulbous thallus is full of spores and the outer surface (peridium) becomes papery. Holes eventually appear, from which the spores are "puffed" out whenever the fruit body is disturbed. Other genera have more complex peridia which split into layers and expand as in the earth stars (*Geaster*).

DIVISION DEUTEROMYCOTA (DEUTEROMYCETES OR IMPERFECT FUNGI)

The imperfect fungi is an artificial division characterized by the absence of a sexual state, in which both Ascomycota-like mycelium and Basidiomycota-like mycelium are represented, but species can not be placed in either of these divisions because their sexual state is not known. Most of the fungi that are pathogenic for humans are deuteromycetes. They form asexual spores, often several varieties in the same species. Many of them have a yeast-like parasitic phase as well as a mycelial saprophytic phase. Two classes are recognized by Parker (1982): the Hypomycetes, a group in which the propagation unit (conidium) is not formed within an enclosed structure and the Coelomycetes, a group in which spore formation is initiated within a closed fruiting body.

DIVISION MYCOPHYCOPHYTA (LICHENS OR FUNGUS ALGAE)

Lichens constitute a special group of thallophytes (plant body not differentiated into roots, stems, and leaves), in that they are a symbiotic association of a fungus and an alga. The algal member is usually a blue-green or green alga and the associated fungus is most commonly an ascomycete, although a few lichens have a basidiomycete component. Lichens typically grow on tree trunks, rocks, and moist soil. They occur as dry crusty patched (crustose), leaflike scales (foliose), or erect, branched tuffs (fruticose), and their colors range from gray-green, yellow-orange, brown, and white to black. Like the Deuteromycetes, Margulis and Schwartz (1988) consider lichen to constitute a separate "form division" and that classification is used for the purposes of this Site Profile. Wolfe (1940) presented a grouping of lichen genera into orders and families in his pioneering work, *A Catalog of the Lichens of Ohio*. Virtually all records of lichens are from regional studies, as no study has been undertaken in the watershed since the inception of the Research Reserve.

The lichen partners are quite different from their free-living partners. The symbiots consist of algal cells embedded in the fungal mycelia, thus symbiosis is a crucial mechanism in the morphology, development, and evolution of lichens. Working together, the symbiots can synthesize organic acids and pigments that are lacking in individual algae and fungi growing alone. They are slow growing, as evidenced by studies

of lichens on gravestone, indicating a growth of only a few millimeters in a century. The dotted twig lichen, *Ramalina farinacea*, which has been reported for Erie County, is listed as an Ohio endangered plant species.

LOWER VASCULAR PLANTS

DIVISION BRYOPHYTA (MOSSES & LIVERWORTS)

The remaining "lower plants" are all true plants in that they develop from an embryo and thus, are multicellular. Within the plant kingdom there are two basic groups: the bryophytes (nonvascular plants) and the tracheophytes (vascular plants). Bryophytes are intermediate between algae and the higher plants. They have hair-like rhizoids that function as roots, but lack true vascular tissue. Most are rather inconspicuous plants growing in moist environments. They are not fully adapted to life on land in that their sperm must swim thorough water to reach their eggs (Margulis and Schwartz 1988). Because bryophytes lack the fluid-conducting tissues of the vascular plants (xylem and phloem), they also rely on surrounding water to conduct necessary fluids and salts during times of growth, but many are able to survive periods of desiccation. Although no detailed study of the bryophytes has been undertaken in the Old Woman Creek watershed, 156 different species have been reported from the region, including *Barbula indica* var. *indica* (twisted teeth moss), a listed rare plant in Ohio. Both Phillips (1997) and Whyte (1996) have reported bryophyte species from the Old Woman Creek watershed.

Class Hepaticopsida (liverworts)

Liverworts have a vegetative body (thallus) that is a somewhat fleshy, leaflike mass growing flat on moist soil or floating on the surface of a water body. The thallus carries out the main functions that in a flowering plant would be done by the roots and leaves. Distinct male and female organs are visible during the growing season. A few species of aquatic liverworts have been identified in the estuary, where they float free in the water or grow on the mud flats along the shore. *Ricciocarpus natans* has a leafy, lobed thallus that floats at the surface like duckweed, while *Riccia fluitans* normally occurs just below the surface, spreading slender branches to form a bright green network.

Class Sphagnopsida (peat mosses)

This class contains only the genus *Sphagnum*, which has been divided into over 100 species. Several species have been identified in the region surrounding the estuary, but not within the Reserve. Peat mosses are boreal plants of lowland habitats and Ohio lies near the southern limit of their range. Biologically, these plants are important because of their ability to retard decomposition, acidify their surroundings, and hold large quantities of water. All peat mosses have two types of leaf cells: small, green ones for photosynthesis and large, dead ones for water storage. *Sphagnum palustre* forms compact mats that can extent over large areas of quiet waters, at times forming floating islands that can support the weight of a person.

Class Bryopsida (true mosses)

Mosses frequently cover large areas of stream banks, grow on rocks and trees, and a few live submerged in flowing water. They grow crowded together like liverworts and lichens, with which they are commonly associated. However, their flat green leaves distinguish them from these two associates, neither of which bear leaves. Many mosses anchor their cushiony stems to the soil by a branched rootlike system of rhizoids. They are not true absorbing roots and they have no special conducting tissue in their leaves and stems. Although some mosses can survive drought conditions, all require moisture for active growth and reproduction. The hair–cap moss, *Polytrichum commune*, often forms pure stands that are several meters across with stems up to 30 cm long. Male and female organs are borne on separate plants. Sperm cells swim to the egg cells, which, when fertilized, form spores within a capsule. When the spore are released, if they land in an area with sufficient moisture, they will germinate and produce vegetative filaments (protonema). The twisted teeth moss, *Barbula indica* var. *indica*, which has been reported for Erie County, is listed on the rare plant inventory for the State of Ohio.

DIVISION LYCOPODIOPHYTA (CLUBMOSSES)

Class Lycopodiopsida

The clubmosses are relicts of the ancient scale trees that once dominated the landscape during the latter part of the Paleozoic era and eventually became fossilized into the coal measures of southeastern Ohio. Modern lycopods are relatively inconspicuous and represented by a single genera, *Lycopodium*, in the vicinity of the Old Woman Creek watershed. This common clubmoss remains green all winter and has the appearance of a miniature pine tree. They are typically found in cool, moist woodlands, under maples, pines or oaks. The plant body consists of branching horizontal rhizomes (underground stems) and an upright part bearing branches and small leaves (microphylls) which are arranged in tight whorls on the aerial branches. Clubmosses bear no seeds, but produce spores which germinate into either male or female gametophytes. The majority of the records date back to Moseley (1899) and Easterly (1950). Phillips (1997) and Jones (1997) have added additional records.

DIVISION EQUISETOPHYTA (HORSETAILS)

Class Equisetopsida

Horsetails are easily recognized by their jointed, hollow stems and rough, ribbed texture. The roughness is caused by mineral silica concentrated in the epidermal cell of the green photosynthetic stems. The abrasive nature imparted by the silica accounts for another common name for these plants, scouring rush. The division is made up of a single herbaceous genus, *Equisetum*. They thrive on mud flats, along the banks of streams, in moist low wooded areas. In the Reserve, horsetails grow along the barrier beach and in the prairie remnant located southwest of the estuary's main basin. Like many other of the lower plants, horsetails produce spores which are borne by the wind.

DIVISION FILOPHYTA (FERNS)

Class Filicopsida

Ferns are familiar vascular plants of the woodlands that, like the bryophytes, lycopods, and equisetophytes, reproduce by means of spores, rather than seeds. Spores do not carry a food store for nourishment during germination as found in the seeds of higher plants. Unlike the other lower plants, ferns do have leaves, called megaphylls or fronds, that develop directly from the main photosynthetic stem (Figure 6.11). Because their fertilization also requires the swimming of the sperm cell, ferns are limited to habitats that are at least occasionally moist. Fern fronds unroll from curled structures known as "fiddleheads." The fronds are usually compound, being divided into leaflets called pinnae that may be subdivided further into pinnules. The margins or edges may be entire (not toothed or cut), toothed, or lobed. When the clefts are deep and the lobes are long and narrow, the frond margin is termed pinnatifid. A total of 18 species of ferns in 6 families occur within the Old Woman Creek watershed (Phillips 1997, Whyte 1996, Windus 1995, and Feix and Wright 1992).

*Figure 6.11. Spinulose wood ferns (*Dryopteris carthusiana*) and mosses abound on the sandstone outcrops of the Berea escarpment, north of Berlin Heights, Ohio (Charles E. Herdendorf).*

HIGHER VASCULAR PLANTS

The higher vascular plants possess a well-developed conductive system, structural differentiation (typically roots, stems, and leaves), and seeds. Higher plants are grouped into two divisions based on seed characteristics. Within the Research Reserve and the Old Woman Creek watershed 8 species of conifers (gymnosperms) and 829 species of flowering plants (angiosperms) have been reported (Appendix B). A detailed treatment of the vascular plants from the Old Woman Creek estuary and watershed is presented in Old Woman Creek SNP & NERR Technical Report No. 10: *Catalogue of the Vascular Plants in Old Woman Creek Estuary and Watershed* (Herdendorf et al. 1999a,2001c).

DIVISIONS

DIVISION PINOPHYTA (GYMNOSPERMS OR CONIFERS)

A trait common to all gymnosperms is the absence of a protective case (ovary wall) around their seeds. This division is represented by several native and alien pines (e.g. *Pinus strobus* and *Pinus nigra*) in the Reserve and eastern hemlock (*Tsuga canadensis*) in the ravine at Berlin Heights. In pines and other cone-bearers, seeds are borne on the surface of scales that comprise the cone, and although well-protected by the scales, they are not surrounded by floral part.

DIVISION MAGNOLIOPHYTA (ANGIOSPERMS OR FLOWERING PLANTS)

The majority of visual terrestrial plants in the watershed are angiosperms, many of which produce attractive flowers. The seeds of these plants are borne within a closed structure (ovary), which eventually develops into the fruit. The flowering plants are subdivided into two classes based on the embryo's seed leaves (called cotyledons). In the monocots (class Liliopsida), a single narrow leaf first pierces the soil and stands erect (e.g. grasses, lilies, and orchids). In the dicots (class Magnoliopsida), which is the more common class, two broad leaves fall open as soon as they reach the soil surface with a seedling emerging from between them (e.g. most annuals, bushes, and trees). A total of 837 terrestrial and aquatic taxa have been identified in the watershed, two-thirds of which are found within the boundaries of the Reserve. About 78% are native and 22% are aliens (Marshall 1977).

HABITATS

As a transition zone between land and water, Old Woman Creek estuary and its immediate environs contain several distinct habitats, including upland woodlands, prairie remnants, creek valley, swamp forest, marshes, wooded coves, open waters of the estuary, an island, barrier beach, and nearshore Lake Erie (Figure 1.4). The estuary is the drowned mouth of a relatively small tributary to Lake Erie. The estuarine wetlands consists of 60 hectares that extend 2 km south of the Lake Erie shore. As the result of wave action and littoral drift, a barrier beach has formed at the mouth which bars off the estuary for extended periods. The barrier is periodically broken by storm flow from the watershed, but occasionally Lake Erie storm surges and seiches spill over the bar and into the estuary.

Moseley (1899) was the first botanist to document the vascular vegetation of Old Woman Creek watershed and his classic work, *Sandusky Flora*, forms the only comprehensive assessment of the flora in the study area. The vascular plants of the Reserve, particularly those associated with the estuary, were studied by Marshall and Stuckey (1974), Marshall (1977), Jones (1978), Francko and Whyte (1995a,b), Whyte (1996) and Trexel-Kroll (2002). Bernhardt (1996) and Phillips (1997) documented the flowering plants of certain holdings of the Erie County Metropolitan Park system within the Old Woman Creek watershed. Collectively, these botanists have provided us with an extensive understanding of the flora represented in the various habitats of the watershed. These will be discussed separately in this section and will include: (1) barrier beach, (2) estuary, (3) hardwood forests, (4) prairie, (5) ravines, and (6) old fields and rights-of-way margins (see Figure 1.4, p. 1-6).

BARRIER BEACH

A sandy barrier beach fronts the entire Lake Erie shore of the Research Reserve, a reach approximately 0.5 km long lying on the lakeward side of U.S. Route 6. The eastern section of the beach is backed by a small lagoon that is periodically connected to the lake via an inlet channel. The western section of the beach is backed by a lakeshore woodland and a small isolated pond that drains to the lake across the beach face.

Figure 6.12. Barrier beach at the mouth of Old Woman Creek estuary (Charles E. Herdendorf).

The exposed beach front is relatively free of vegetation, colonization being limited by wave action which constantly reshapes the foreshore (Figure 6.12). The xeric environment of the more protected upper beach and low dunes supports only sparse populations of mostly herbaceous species, including:

Abutilon theophrasti (velvet-leaf)
Acalypha rhomboidea (3-seed red mercury)
Astragalus canadensis (Canada milkvetch)
Ambrosia artemisiifolia (ragweed)
Amaranthus albus (tumbleweed)
Amaranthus retroflexus (pigweed)
Barbarea vulgaris (common winter-cress)
Bidens cernua (nodding beggarticks)
Bidens connata (beggarticks)
Bidens frondosa (beggarticks)
Sinapsia alba (white mustard)
Cakile edentula (inland sea-rocket)
Chenopodium album (lamb's-quarters)
Cyperus esculentus (yellow nut-grass)
Cyperus odoratus (rusty cyperus)
Cyperus rivularis (riverbank cyperus)
Digitaria sanguinalis (crab grass)
Echinochloa crus-galli (barnyard grass)
Eclipta prostrata (yerba-de-tajo)
Equisetum arvense (common horsetail)
Eragrostis pectinacea (purple lovegrass)
Euphorbia polygonifolia (seaside spurge)
Galinsoga parvifloria (galinsoga)
Hibiscus trionum (flower-of-the-hour)
Lindernia dubia (false pimpernel)
Ludwigia palustris (water-purslane)
Mirabilis nyctaginea (four-o'clock)
Oenothera biennis (evening primrose)
Panicum capillare (old witch grass)
Pilea pumila (richweed)
Plantago major (common plantain)
Polanisia dodecandra (clammy-weed)
Polygonum pensylvanicum (pinkweed)
Portulaca oleracea (common purslane)
Salsola kali (saltwort, Russian thistle)
Setaria faberi (Faber's foxtail)
Strophostyles helvula (wooly bean)
Xanthium strumarium (cocklebur)

Populus deltoides (cottonwood) and *Salix exigua* (sandbar willow) seedlings are scattered along the shore, particularly on the western section of the barrier

beach. *Rhus typhina* (staghorn sumac) and *Vitis riparia* (riverbank grape) stretch the length of the west beach, occupying a transition zone between open sand and a bordering woodland that extends south to U.S. Route 6.

The backshore of the barrier beach, where it forms the shore of the lake lagoon, exhibits a plant community that is more dependent on wetland conditions. *Phragmites australis* (common reed) forms large monotypic stands along the east and west banks of the inlet channel and extends the entire length of the lake lagoon's north shore. *Scirpus americanus* (three-square bulrush), *Scirpus fluviatilis* (river bulrush), *Impatiens capensis* (jewelweed), *Scutellaria laterflora* (mad-dog skullcap), and *Lycopus americanus* (American water horehound) are locally scattered along the backshore. *Triplasis purpurea* (purple sand-grass) and *Panicum virgatum* (switchgrass) are more common and occupy more open areas higher on the backshore.

ESTUARY

Old Woman Creek estuary is comprised of three major sub-habitats, including: (1) the open waters of the basins, (2) embayments, mudflats, and low shorelines, and (3) swamp forests. These estuarine habitats in turn contain distinct zones of vegetation. These zones contain plants of similar form and degree of adaptation to aquatic life but not necessarily phylogenetic affinity (Arber 1920). The relative proportion of the open water versus mudflat habitats is largely regulated by annual water levels in Lake Erie (when the mouth is open) and in the estuary proper (when the mouth is closed).

Open Waters

The open waters of the estuary are characterized by dense, monotypic beds of *Nelumbo lutea* (American water lotus) which extend south from the U.S. Route 6 bridge, through the main basin of the estuary, and into the south basin (Figure 6.13). In mid-1990s, *Nelumbo* beds covered up to 40% of the estuary surface

*Figure 6.13. Cove enbayment on Old Woman Creek estuary leading to the open water of the main basin. A massive bed of American water lotus (*Nelumbo lutea*) can be seen at right center (Gene Wright).*

during the peak growing season (Whyte 1996), whereas in the mid-1970s, lotus beds occupied only 10% of the estuary (Marshall 1977). Record high water levels in Lake Erie in the mid-1970s (approximately 0.5 m above mid-1990s levels) appear to be the cause of the sparse development of lotus beds during that period.

Other aquatic plants that are occasionally associated with the *Nelumbo* beds or occur in patches scattered throughout the open waters of the estuary include:

Ceratophyllum demersum (coontail)
Elodea canadensis (common water-weed)
Lemna minor (lesser duckweed)
Myriophyllum spicatum (water milfoil)
Nuphar advena (yellow water-lily)
Nymphaea odorata (white water-lily)
Peltandra virginica (arrow-arum)
Potamogeton crispus (curly pondweed)
Potamogeton foliosus (leafy pondweed)
Potamogeton nodosus (knotty pondweed)
Potamogeton pectinatus (sago pondweed)
Riccia fluitans (crystalwort)
Ricciocarpus natans (aquatic liverwort)
Spirodela polyrrhiza (greater duckweed)

During high lake level periods, beds of water smartweed (*Polygonum amphibium* var. *emersum*) develop on the submerged natural levies of the south basin (Figure 6.14). An isolated population of *Myriophyllum spicatum* was first documented in the estuary in 1992 and scattered patches were found in 1995 immediately north of Star Island on the perimeter of Nelumbo beds and along the main channel of the creek through the estuary (Whyte 1996).

Embayments and Mudflats

The Old Woman Creek shoreline is characterized by steep banks that support dense growths of woody riparian vegetation (Figure 6.13). Common species, such as *Quercus alba* (white oak), *Quercus palustrus* (pin oak), *Salix exigua* (sandbar willow), *Cornus florida* (flowering dogwood), *Cornus drummondii* (rough-leafed dogwood) *Cephalanthus occidentalis* (buttonbush), *Populus deltoides* (cottonwood), and *Vitis riparia* (river-bank grape), form a closed canopy which limits sunlight available to understory and shoreline emergent vegetation (Whyte 1996). The combination of a closed canopy and steep bluffs reduces the amount of habitat for the growth of emergent wetland vegetation to a narrow zone along the shoreline. Typical plants of this zone include: *Hibiscus moscheutos* (swamp rosemallow, Figure 6.15), *Impatiens capensis* (jewel-weed), *Iris versicolor* (blue-flag), *Leersia orzyoides* (rice cut-grass), *Phalaris arundinacea* (reed canary-grass), *Pilea pumila*

*Figure 6.14. Water smartweed (*Polygonum amphibium *var.* emersum*) on flooded natural levies of the south estuary basin (John Marshall).*

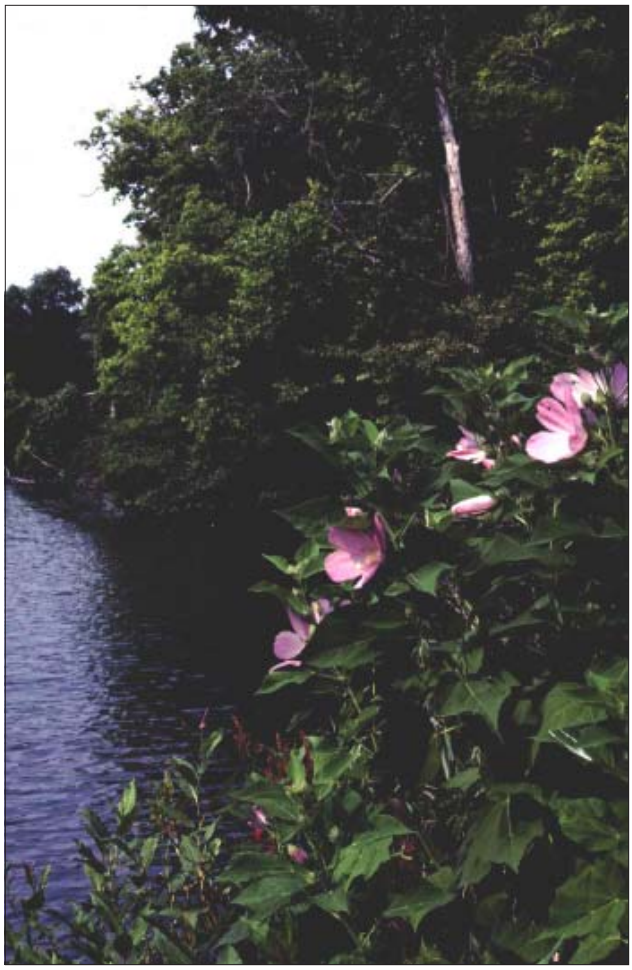


*Figure 6.15. Swamp rosemallow (*Hibiscus moscheutos*) fringing the shore of Old Woman Creek estuary (Charles E. Herdendorf).*

(clearweed), *Lobelia inflata* (Indian tobacco), *Ranunculus hispidus* (hispid buttercup), *Scutellaria lateriflora* (skullcap), *Solanum nigrum* (black nightshade), and *Carex* spp. (sedges). Along the base of the estuary bluffs and extending out into the open water, numerous fallen trees have accumulated debris to form micro-habitats with suitable substrate for herbaceous species such as *Setaria faberi* (foxtail-grass), *Carex comosa* (sedge), *Eclipta prostrata* (yerba-de-tajo), *Polygonum persicaria* (lady's thumb), and *Rorippa palustris* (common yellow cress).

From the inception of the Research Reserve through 1999, the emergent flora was confined to the very shallow embayments in the estuary. However, the lower Lake Erie water levels from 1999 to date have resulted in extensive mudflat areas in the estuary, where there was open water a few years before.

In 1977, Marshall reported that the embayment areas had a high diversity, with many areas not having a distinct dominant species. Among the common species were: *Peltandra virginica*, *Leersia oryzoides*, *Phalaris arundinaceae*, *Calamagrostis canadensis*, *Typha latifolia*, *Sparganium eurycarpus*, and various *Scirpus* and *Carex* species. Whyte (1996) examined many of these embayments 20 years later and reported many of the same species. However, Whyte noted that *Phragmites australis* was frequently found in this habitat, a species not reported by Marshall. By 2000 with falling lake water levels, these shallow mudflat embayment areas accounted for a large portion of the estuary. Trexel-Kroll (2002) also found some similarity in species composition with these earlier studies with a few exceptions. *Peltandra virginica*, although present, was uncommon. The grasses *Leersia oryzoides* and *Echinochloa* spp. increased in importance from 2000 through 2001. *Phragmites australis* was also expanding its coverage during these two years. By 2002 *Phragmites australis* and *Typha angustafolia* had assumed dominance over much of the estuary.

Along some reaches of the estuary shore (e.g. west bank north or Star Island), steep bluffs give way to open areas of low relief with associated mudflats and seasonally inundated floodplains. These aquatic areas currently (2004) support extensive monotypic colonies of *Phragmites australis* (common reed). With the exception of the climbing vines of wild cucumber (*Echinocystis lobata*), few other plants are associated with *Phragmites* stands. This reed is a recent invader, first appearing on the shores of the estuary in the mid-1980s (Whyte 1996).

Swamp Forest

Areas of wet woods are found in two embayments along the east shore where seasonally flowing streams enter the estuary. A much larger lowland or swamp forest borders the southern reaches of the estuary (Figure 6.16). Common woody species in these areas are *Cephalanthus occidentalis* (buttonbush), *Fraxinus americana* (white ash), *Fraxinus pennsylvanica* (green ash), *Quercus rubra* (red oak), *Crataegus mollis* (downy hawthorn), *Cornus florida* (flowering dogwood), and *Viburnum acerifolium* (arrowwood). Numerous herbaceous plants appear early in the growing season, including *Phalaris arundinacea* (reed canary grass) on, *Caltha palustris* (marsh marigold), *Ranunculus flabellaris* (yellow water buttercup), and

*Figure 6.16. Swamp forest in south estuary basin. Emergent beds of spatterdock (*Nuphar lutea*) in foreground (Gene Wright).*

Anemonella thalictroides (rue anemone). In total, 102 species of woody and herbacious species have been reported for these wet woodlands (Windus 1995).

Windus (2002) monitored the species composition and relative abundance in the swamp forest from 1987 through 2000. By 2000 the most common woody plants were *Fraxinus pennsylvanica*, *Cephalanthus occidentalis*, and then *Viburnum recognitum*. Through the duration of the sampling period, both *Fraxinus* and *Viburnum* declined in relative abundance while *Cephalanthus* remained about the same. The most common herbaceous plants included *Phalaris arundinacea*, *Polygonum* spp., *Sagittaria latifolia*, and less frequently *Typha* spp., *Scirpus fluviatilis*, and *Boehmeria cylindrical*. Many of the native species reported in the early years of this study have declined including the woody plants *Salix*, *Populus deltoides*, *Cornus sericea* and *Lindera benzoin*. These declines were believed related to declining water levels in the estuary. Windus (2002) expressed concern about the impact and fate of invasive species, particularly *Phalaris arundinacea* and *Phragmites australis*, which have entered the swamp forest during the study and have increased abundance through the end of this study.

HARDWOOD FORESTS

The majority of the terrestrial (upland) habitats within the Research Reserve are covered with mixed hardwood forest. Three forest associations are present on the upland portions of the Reserve and other wooded areas of the Old Woman Creek watershed: (1) oak-hickory, (2) maple, and (3) sassafras-oak-hickory (Marshall 1977). The oak-hickory association occupies the steep banks on the eastern and western sides of the Reserve. This association is dominated by *Quercus alba* (white oak) and *Carya ovata* (shagbark hickory), with several accompanying woody species, including *Q. palustris* (pin oak), *Q. borealis* (red oak), *Fraxinus americana* (white ash), *Viburnum prunifolium* (black haw), and *Sassafras albidum* (white sassafras). *Trillium grandiflorum* (large-flowered trilium), *Arisaema atrorubas* (Jack-in-the-pulpit), *Erythronium americanaum* (yellow trout-lily), and *Viola* spp. (violets) are conspicuous herbaceous associates in the spring (Figures 6.17 and 6.18), while *Cimicifuga*

*Figure 6.17. Large-flowered trillium (*Trillium grandiflorum*) in a hardwood forest of the Research Reserve (Charles E. Herdendorf).*

*Figure 6.18. Freckled blue violet (*Viola sororia*) in the upland woods west of estuary (Charles E. Herdendorf).*

racemosa (black cohosh) and *Lobelia cardinalis* (cardinal flower) bloom in July, particularly in forest openings along the east bank of the estuary (Figure 6.19). South of the northern railroad bridge, the eastern upland forest merges with a swamp forest on the inundated Old Woman Creek floodplain. On the western uplands, south of the railroad, a small plantation of *Pinus strobus* (white pine) thrives within the oak-hickory forest.

The maple forest association occupies a small area on the eastern bluff at the mouth of the estuary. This is a lakefront woodland that lies on the north side of U.S. Route 6. Dominant trees at this site are *Acer saccharinum* (silver maple) and *Acer rubrum* (red maple). Associated woody species include *Populus deltoides* (cottonwood), *Hamamelis virginiana* (witch hazel), *Rhus glabra* (smooth sumac), and *Cornus florida* (flowering dogwood).

The sassafras-oak-hickory association exists on Star Island near the center of the main basin of the estuary. This woodland is dominated by *Sassafras albidum* (white sassafras), with *Quercus alba* (white oak) and *Carya ovata* (shagbark hickory) comprising

*Figure 6.19. Cardinal flower (*Lobelia cardinalis*) in a cove depression along the Edward Walper Trail east of Old Woman Creek estuary (Gene Wright).*

the major woody associates. Individuals of these three taxa are generally younger than those found in the woodlands on the eastern and western uplands adjacent to the estuary, indicating more recent clearing on the island. Herbaceous dominants of the spring flora are *Trillium grandiflorum* (large-flowered trilium) and

Podophyllum peltatum (may–apple). These taxa are significantly more abundant on Star Island than in any other woodland in the Reserve (Marshall 1977).

PRAIRIE

While most of the upland areas of the Research Reserve are either woodlands or old farm fields, a small grassland prairie occurs along the railroad right-of-way at the western side of the Reserve. This 2-hectare site is unlike the old fields on the Reserve, in that its species composition includes many plants commonly associated with prairie habitats found in western Ohio and northeastern Illinois (Jones 1944, Vestal 1914). Conditions in the Reserve support nearly 50 herbaceous species that comprise an upland prairie community (Figure 6.20):

Andropogon gerardii (big bluestem)*
Anemone virginiana (thimbleweed)*
Apocynum sibiricum (clasping-leaf dogbane)
Asclepias syriaca (common milkweed)*
Asclepias tuberosa (butterfly-weed)*
Aster dumosus (bushy aster)
Aster novae-angliae (New England aster)
Aster undulatus (aster)
Cacalia atriplicifolia (pale Indian-plantain)
Carex cephalophora (sedge)
Carex lasiocarpa (slender sedge)
Carex pensylvanica (sedge)
Carex retroflexa (reflexed sedge)
Ceanothus americanus (New Jersey tea)
Celastrus scandens (American bittersweet)
Cirsium vulgare (bull thistle)
Clematis virginiana (virgin's bower)
Conyza canadensis (horseweed)
Coreopsis tripteris (tall tickseed)
Epipactis helleborine (helleborine)
Equisetum arvense (common horsetail)
Euphorbia corollata (flowering spurge)*
Euphorbia dentata (toothed spurge)
Helianthus divaricatus (sunflower)
Helianthus tuberosus (Jerusalem artichoke)
Heliopsis helianthoides (Sweet ox-eye)
Hydrangea arborescens (wild hydrangea)
Lactuca canadensis (wild lettuce)
Lespedeza capitata (bush clover)*
Lespedeza virginica (bush clover)*
Lilium michiganense (Michigan lily)
Melilotus officinalis (yellow sweet clover)
Panicum virgatum (switchgrass)*
Pycnanthemum virginianum (mountain mint)
Rhus glabra (smooth sumac)
Rudbeckia hirta (black-eyed Susan)
Silphium trifoliatum (rosinweed)*
Sisyrinchium albidum (blue-eyed grass)
Sisyrinchium mucronatum (blue-eyed grass)
Solidago juncea (early goldenrod)
Sorghastrum nutans (Indian grass)*
Spiranthes cernua ((nodding ladies'-tresses)*
Spiranthes magnicamporum (ladies'-tresses)
Symphytum officinale (common comfrey)
Veronicastrum virginicum (Culver's-root)

* most common prairie species in Old Woman Creek estuary

*Figure 6.20. Prairie habitat in the Research Reserve. American bittersweet (*Celastrus scandens*) in the foreground and tall prairie grasses in the background (Charles E. Herdendorf).*

occuring at the Old Woman Creek site with species reported for Castalia Prairie in western Erie County, Ohio (Hurst 1971), prairie remnants in northwestern Ohio (Anderson 1971, Jones 1944) and black-soil prairies of northeastern Illinois (Vestal 1914). Of eleven major prairie-related taxa identified at Old Woman Creek (* in above list), Marshall found that all occured in at least three of the four prairie areas surveyed. He also found that *Andropogon gerardii* (big bluestem) and *Sorghastrum nutans* (Indian grass) were the dominant plants at the Old Woman Creek site—two of the four species that Vestal (1914) considered to be dominant among Ohio's prairie flora.

The soils underlying the prairie site are classified as Sission loamy fine sand and silt loam (Redman et al. 1971). Sission soils are well-drained, granular, and friable, often occurring on the top and sides of knolls. The prairie site is situated at the crest of a bluff that is exposed to the dominant southwesterly winds. These conditions are favorable for the development of prairie plant communities, particularly exposure to sun and wind along the railroad right-of-way. Vestal (1914) pointed out that disturbances, such as burning and mowing, associated with rights-of-way are beneficial to the maintenance of prairies in Ohio. Marshall (1977) reported the occurrence of charred material in the soil at the site, indicating that fire initiated by sparks from passing rail cars was a likely disturbance which periodically rejuvenated the prairie.

OLD FIELDS AND RIGHT-OF-WAY MARGINS

Old fields in the vicinity of the Reserve are in various stages of succession depending on the period of time that has elapsed since the field was last tilled, mowed, or burned (Figure 6.21). The most recently abandoned fields are characterized by *Ambrosia artemisiifolia* (common ragweed), *Ambrosia trifida* (giant ragweed), *Polygonum pensylvanicum* (pinkweed), *Rhus glabra* (smooth sumac), *R. typina* (staghorn sumac), *Stachys tenuifolia* (hedge-nettle), *Aster* spp., and *Solidago* spp. (goldenrods). At a later successional stage, shrub plants become more prevalent, including *Cornus* spp. (dogwoods), *Crataegus* spp. (hawthorns), and *Salix* spp. (willows), then saplings of *Carya ovata* (hichory), *Sassafras albidum* (white sassafras), and *Quercus* spp. (oaks).

The margins of U.S. Route 6, the Conrail embankment, and other transportation rights-of-way in the vicinity of the Research Reserve represent another type of disturbed terrestrial habitat that is dominated by herbaceous, pioneer species. In these continually disturbed areas, many of the species are non-native "weedy" plants such as, *Chaenorrhinum minus* (dwarf snapdragon), *Epipactis helleborine* (helleborine), *Hemerocallis fulva* (orange day-lily), *Linaria vulgaris* (butter-and-eggs), *Melilotus albus* (white sweet clover), *Melilotus officinalis* (yellow sweet clover), *Sedum telephium* (garden orpine), and *Saponaria officinalis* (soapwort). These "weedy" species are capable of surviving severe chemical and physical disturbances and frequently displace native vegetation (Marshall 1977).

RAVINES

At Berlin Heights, Old Woman Creek has cut a picturesque ravine through the Berea Sandstone and into the Ohio Shale (Figures 2.22 and 2.28). Here, Moseley (1899) found several unusual plants not found farther west in Erie and Ottawa counties. The walls of the deep ravines of Old Woman Creek, Chappel Creek, and the Vermilion River, like the wall of a cellar, are warmed slowly in the summer so that the north sides of the steep, wooded slopes are some of the coolest places in the region; hence they support many plants which are more common farther to the north and east, including:

Asplenium rhizophyllum (walking fern)
Cacalia atriplicifolia (Indian plantain)
Cardamine diphylla (two-leaved toothwort)
Carex pedunculata (sedge)
Cypripedium reginae (showy lady-slipper)
Dichanthelium depauperatum (panic-grass)
Dryopteris marginalis (marginal wood-fern)
Gaultheria procumbens (wintergreen)
Gentianopsis detonsa (fringed gentian)
Hieracium paniculatum (hawkweed)
Hydrophyllum canadense (waterleaf)
Isopyrum biternatum (false rue-anemone)
Jeffersonia diphylla (twinleaf)
Maianthemum canadense (false lily-of-valley)
Mitchella repens (partridge-berry)
Polypodium virginianum (common polypody)
Polystichum acrostichoides (Christmas fern)
Rubus odoratus (flowering raspberry)
Scutellaria nervosa (skullcap)
Thelypteris hexagonoptera (beech-fern)
Tsuga canadensis (hemlock)
Vaccinium pallidum (hillside blueberry)

Figure 6.21. Old field habitat found along the Edward Walper Trail in the Research Reserve (Charles E. Herdendorf).

INVERTEBRATE FAUNA

Invertebrate is the name given to any of the animals or animal-like organisms without backbones as contrasted with the vertebrates (e.g. fish, amphibians, reptiles, birds, and mammals), all of which have a vertebral column. Taxonomically, invertebrates are grouped into some 37 phyla in two kingdoms: Protista and Animalia. Representatives of 13 of the invertebrate phyla have been identified in Old Woman Creek estuary and watershed, and the adjacent waters and tributaries of Lake Erie. Altogether, a total of 1,373 taxa of aquatic and terrestrial invertebrates have been documented from the study area: 318 protozoan, 4 sponge and hydroid, 7 flatworm and gastrotrich, 34 rotifer, 3 nematode, 33 mollusk, 46 annelid worm and leech, 77 spider and water mite, 87 crustacean, 758 insect, and 6 tardigrade and bryozoan species. Nearly 60% of these taxa are found within the boundaries of the Research Reserve (Appendix C). A detailed treatment of the invertebrates is contained in Old Woman Creek SNP & NERR Technical report No. 12: *Catalogue of the Invertebrate Fauna of Old Woman Creek Estuary, Watershed, and Adjacent Waters of Lake Erie* (Herdendorf et al. 2000b,2001b).

PROTISTA: PROTOZOAN INVERTEBRATES

Protozoans consist of a large group of unicellular animals that have adapted their cell to serve as their entire body. Classified as a subkingdom of the Kingdom Protista, protozoans are not simple organisms. Within a single cell they must perform all of the body functions for which higher animals have multiple organ systems. Protozoans live under almost all natural conditions where moisture is found (Jahn et al. 1979). Within Old Woman Creek estuary and watershed researchers have identified 318 taxa of these microscopic creatures (Figure 6.22).

The locomotor organelles of Protozoa are used to separate them into major taxonomic groups. These organelles include: (1) undulipodia, which possess cilia or flagella and (2) pseudopodia, which are elongated extensions of the body formed by protoplasmic flows. To propel the cell, undulipodia produce rotary, undulatory, and helical wave motions, whereas pseudopodia create flowing motions (Pearse et al. 1987). The protozoan taxa reported for Old Woman Creek estuary are listed in Table 6.3.

PHYLUM SARCOMASTIGOPHORA

The sarcomastigophorans include both flagellated and amoeboid protozoans, thus the phylum is divided into two subphyla based on the type of locomotion organelles. The mastigophorans possess flagella, whereas the sarcodines utilize pseudopodia.

Subphylum Mastigophora

Mastigophorans are protozoans that have one or more flagella. Some are plant-like and contain green chloroplasts (chromatophores), such as the dinoflagellates, phytomastigophores, and euglenoids. Thus, many of the species in this subphylum can also be classified as algae. Others are more animal-like and lack chloroplasts, such as the zoomastigophores.

Class Dinoflagellata. Dinoflagellates differ from other mastigophores in having a transverse groove or "girdle" holding a circumferential flagella. The groove typically has a posterior extension which has a second (longitudinal) flagellum. The body is commonly armored with thick cellulose plates ranging in color from reddish-brown to yellow. The anterior part of an armored cell is referred to as the epitheca and the posterior part is the hypotheca. Dinoflagellates are a major food source for aquatic organisms. The genus *Gymnodinium*, which is a benthic inhabitant of the estuary, has green chloroplasts but lacks a protective cellulose case (theca).

Class Phytomastigophora. Three orders of this class comprise common benthic groups in the estuary: cryptomonads, chrysomonads, and volvoceans. Cryptomonads are very small, flattened protozoans with distinct reservoir pockets and yellow to brownish-green chloroplasts. Chrysomonads are also very small protozoans that possess a variety of features including spines, pallmella (group of cells in a gelatinous matrix), lorica (loose fitting sheath), branched stalk, and colonial arrangements. Volvoceans are larger solitary or colonial protozoans with cellulose walls through which 2 to 8 flagella extend from each cell.

Class Euglenea. Euglenoids are flagellates that typically have grassy green chloroplasts and reddish sigma (eyespot with photoreceptive function). They store carbohydrates as granules in an anterior reservoir

TABLE 6.3. CLASSIFICATION OF PROTOZOANS REPORTED FOR OLD WOMAN CREEK ESTUARY

	Taxa Reported	Undulipodia		Pseudopodia
		Cilia	Flagella	
SUBKINGDOM PROTOZOA				
Phylum Sarcomastigophora	198			
Subphylum Mastigophora	145		•	
Class Dinoflagellata	2		•	
Class Phytomastigophora	48		•	
Class Euglenea	60		•	
Class Zoomastigophora	35		•	
Subphylum Sarcodina	53		•	
Class Lobosa	33			•
Class Filosa	4			•
Class Granuloreticulosa	2			•
Class Heliozoa	14			•
Phylum Ciliophora	120	•		
Class Kinetofragminophora	53	•		
Class Oligohymenophora	28	•		
Class Polyhymenophora	39	•		

(Ruppert and Barnes 1994). The family Trachelomonadidae consists of euglenoids that are each housed in a self-secreted lorica of various shapes. The order Peranemida are colorless euglenoids that obtain their nutrition by absorbing dissolved food through the cell membrane (saprobic) or by the ingestion of organic material as animals must do (holozoic). They exhibit a distinct gullet in contrast to the indistinct gullet of the pigmented euglenoids.

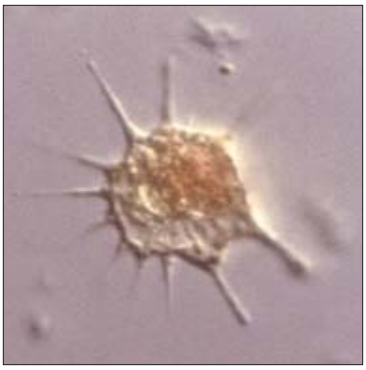
The organisms known as "euglenoids" constitute a controversial group in terms of the traditional plant versus animal debate. Most euglenoids are chlorophyll-bearing (chlorophytes), protozoa-like organisms of the Protista, and as such the chlorophytes can be considered members of the algal Division Euglenophyta (Taft and Taft 1971).

Class Zoomastigophora. These mastigophorans lack chloroplasts and stigma. Members of the family Codonosigidae typically have a transparent, ovoid body with a protruding collar that encircles a flagellum. Some individuals resemble collared cells lining the incurrent channels of sponges, suggesting an evolutionary relationship. Codonosigids are solitary or colonial, some loricate, and some stalked. The other common family in Old Woman Creek, Bodonidae, has two flagella and kinetoplasts (a replicating structure located near the base of the flagella). Nutrition is holozoic or coprozoic (ingestion fecal pellets that have been enriched by microbial activity).

Subphylum Sarcodina

Sarcodina are distinguished by their movement, which is by induced protoplasmic flow, and by their pseudopodia, which are temporary cytoplasmic extensions. Pseudopodia can be long and thin (axopodia), tapered and branched (filopodia), granular and interweaving in an anastomosing fashion (granuloreticulopodia), large and finger-like (lobopodia), or polytubular (myxopodia). Pseudopodia are used to capture food as well as aid in locomotion. Four classes of these protozoans have been identified in Old Woman Creek estuary.

Class Lobosa. This large class contains protozoans that more commonly known as "amoebas" as well as their close relatives which form tests (or shells). Amoebas typically form lobopodia of various



Amoeba sp.

Bodo saltans (SEM)

Codonella cratera

Cyclidium sp.

Halteria grandiniella

Rimsotrombidium lacustris

Stylonychia sp.

Urotricha farcta

Figure 6.22. Representative protozoans found in Old Woman Creek estuary (Peter J. Lavrentyev).

types which facilitate locomotion. The family Difflugiidae, represented in the estuary by several benthic species, form shells composed of mineral particles that are ingested by these protozoans and embedded in the shell in a secreted matrix (Ruppert and Barnes 1994).

Class Filosa. Members of this class found in Old Woman Creek feed on algae. *Vampyrella lateritia* has a round bright orange body, the color imparted by carotinoid granules derived from algal food. Using filopodia that resemble suctorial tentacles, these protozoans enter algal cells by digesting a hole in the cellulose wall of the alga, insert pseudopodia and digest the internal protoplasm, and then move to the next cell to repeat the process (Jahn et al. 1979). In this manner *Vampyrella* destroys many filamentous algae, including the green alga *Mougeotia*.

Class Granuloreticulosa. Most of the protozoans in this group form a calcareous test from which, through small pores, the granuloreticulopodia are extended in bundles that branch to form interweaving networks around the body (Jahn et al. 1979). In Old Woman Creek estuary this class is represented by *Biomyxa vagans* in the order Athalamida and *Diplophrys archeri* in the order Foraminiferida.

Class Heliozoa. These delicate protozoans have spherical bodies with many radiating axopodia; hence their common name, "sun animalcule." *Actinophrys sol*, found in Old Woman Creek, is a typical freshwater form of this group. Some members, such as the genus *Heterophrys*, have skeletons composed of silica secreted by the organism and embedded in an outer gelatinous covering.

PHYLUM CILIOPHORA

The ciliates propel their bodies and feed with short cilia (undulipodia) or a group of cilia (cirri). Many species have two types of nuclei, large ones (macronuclei) and small ones (micronuclei). Many ciliates have cilia in rows on the body or in tufts, but no specialized cilia around the mouth. In other ciliates, cilia are grouped in or around the mouth, as well as in rows along the body (Figure 6.23).

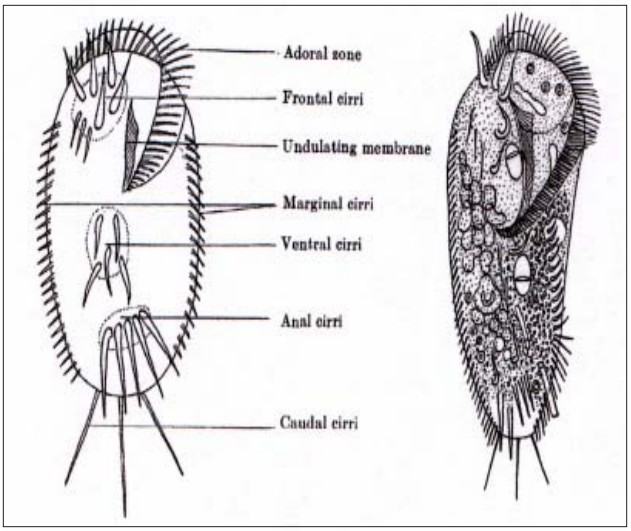


*Figure 6.23. Example of a ciliated protozoan (*Stylonychia mytilus*) found in Old Woman Creek estuary (from Kudo 1939).*

Class Kinetofragminophora. Members of this class lack cilia as special organelles around or in the mouth. However, some members of the order Prostomatida have club-shaped tactile cilia around the mouth. *Coleps octospina,* representative of this class in the estuary, has a barrel-shaped body with eight posterior spines. Ciliates in the order Haptorida found in the estuary are rapacious carnivores, such as *Didinium nasutum* which preys on *Paramecium*. Members of the order Suctorida have cilia only as larvae; adults are sessile with sucking and piercing tentacles used to catch prey and extract the cytoplasm. The suctorean *Acineta*, has a short stalk which is commonly attached to algae on the carapaces of turtles.

Class Oligohymenophora. These ciliates have either a series of cilia or an undulating membrane that curves counter-clockwise along the rim of the mouth cavity. The common, and extensively studied, aquatic genera *Paramecium* and *Tetrahymena* are members of this class and are residents of the estuary. These ciliates possess water expelling vesicles that eliminate excess water engulfed during the feeding process. Members of the suborder Sessilina of the order Peritrichida, such as *Vorticella campanula*, are often attached by a self-produced stalk to a variety of substrates in aquatic habitats, but large peritrichs have been reported in western Lake Erie plankton (Herdendorf and Monaco 1983). Planktonic *Vorticella* are often associated with blooms of blue-green alga *Anabaena flos-aqua*.

Class Polyhymenophora. These ciliates all have a band of membranelles (fused rows of cilia) arranged clockwise around or leading to the mouth. Members of the order Hypotrichida scuttle about on their ventral cirri (tufts of cilia fused together to form stiff, motile structures) as if they had tiny legs. In the estuary, *Stylonychia* is typical of this order with distinct frontal, ventral, anal, and caudal cirri (Kudo 1939). In the family Tininnidae of the order Oligotrichida, the transparent body of *Tinntinnidium fluviatile* is attached inside a trumpet-shaped lorica. The lorica is commonly impregnated with an agglomeration of sediment particles and is attached to submerged vegetation in the estuary.

ANIMALIA INVERTEBRATES

All animalia invertebrates are heterotrophs, in that they must obtain energy in the form of organic food produced by other organisms. Most of the distinctive characteristics of animals are associated with the requirements of finding, engulfing, and digesting food (Parker 1982). Animalia invertebrates from 11 phyla have been identified in the Old Woman Creek study area, altogether yielding 1,055 species (Table 6.4 and Appendix C).

PHYLUM PORIFERA

This phylum includes small freshwater sponges that are occasionally found in freshwater wetlands. They live in colonies, forming finger-like lobes, cushion-shaped masses, or encrusting patches. Because sponges do not require sunlight, they often live on the underside of submerged logs and other objects, commonly in association with bryozoan colonies and zebra mussels. Sponges of the estuary, Family Spongillidae, do not have specialized organs and are made up of a loose network of cells supported by siliceous spicules embedded in a collagen binder known as spongin (Thorp and Covich 1991). The chief food sources for sponges are very fine particulate matter and planktonic organisms suspended in the water column. As sedentary animals, they obtain their food by filtering the water that surrounds them through a series of pores located on the outer surface of their body.

PHYLUM CNIDARIA

This phylum, also known as Coelenterata, is primarily composed of marine members and has been relatively unsuccessful in adapting to freshwater except for the class Hydrozoa. In Old Woman Creek watershed two species of this class have been identified, the brown hydra (*Hydra americana*) from the estuary and a freshwater jellyfish (*Craspedacusta sowerbyi*) from an abandoned sandstone quarry pit (Baillie Quarry) 3.4 km northeast of Berlin Heights. The polyps of hydras are common on many hard, submerged surfaces, while the medusoid jellyfish are rare and seemingly absent for a number of years. The body wall of cniderians is characterized by three layers, a thin acellular gel (mesoglea) sandwiched between two thicker cellular layers (ectoderm and endoderm) that surround a central body cavity. These animals capture most of their invertebrate prey with ectodermal batteries of stinging or sticky nematocysts.

PHYLUM PLATYHELMINTHES

In Old Woman Creek estuary this phyla is represented by 5 species in three orders of the class Turbellaria. Two of the orders (Catenulida and Neorhabdocoela) are considered micoturbellarians and members are typically less than 1 mm in length, whereas individuals of the other order (Tricladida) can reach up to 20 mm and are considered macroturbellarians. Triclads, also known as planarians, have been the subject of more study that the smaller orders. Turbellarians are unsegmented flatworms that live in benthic and epiphytic environments. Most flatworms scavenge bacteria, algae, and protozoans; however, triclads are predatory on other invertebrates. These animals have not been found in great numbers in the estuary, but they were reported as widespread in the sediment and on plants.

PHYLUM GASTROTRICHA

Gastrotrichs are microscopic, elongated animals that colonize sediments and submerged plant stems and leaves. One genus, *Chaetonotus*, has been identified in Old Woman Creek estuary. *Chaetonotus* feeds on organic debris, algae, protozoans, and bacteria which are swept into its terminal mouth by the beat of four ciliated tufts which are arranged in pairs on either side of the head (Kershaw 1983). The body wall is covered by a cuticle secreted by the epidermis and the dorsal

TABLE 6.4. CLASSIFICATION OF ANIMALIA INVERTEBRATES REPORTED FOR OLD WOMAN CREEK

	Taxa		
PHYLUM PORIFERA Class Demospongiae (horny sponges)	2		
PHYLUM CNIDARIA Class Hydrozoa (hydras)	2		
PHYLUM PLATYHELMINTHES Class Turbellaria (flatworms)	5		
PHYLUM GASTROTRICHA Class Chaetonotida (gastrotrichs)	2		
PHYLUM ROTIFERA (rotifers)	34		
Class Bdelloidea		3	
Class Monogononta		31	
PHYLUM NEMATODA Class Adenophorea (roundworms)	3		
PHYLUM MOLLUSCA	33		
Class Gastropoda (snails)		11	
Class Bivalvia (clams)		22	
PHYLUM ANNELIDA	46		
Class Hirudinea (leeches)		4	
Class Oligochaeta (segmented worms)		42	
PHYLUM ARTHROPODA	922		
Class Arachnida		77	
Order Araneae (spiders)			74
Order Acriformes (water mites)			3
Class Crustacea		87	
Subclass Branchiopoda		39	
Order Cladocera (water fleas)			39
Subclass Ostracoda (seed shrimps)		9	
Subclass Copepoda (water-hoppers)		25	
Order Calanoida			9
Order Harpacticoida			4
Order Cyclopoida			12
Subclass Branchiura: Order Arguloida (fish lice)		1	
Subclass Malacostraca		13	
Order Isopoda (sow bugs)			2
Order Amphipoda (scuds)			4
Order Decapoda (crayfishes & shrimps)			7
Class Insecta	758		
Subclass Entognatha		4	
Orders Collembola & Diplura (springtails & diplurans)			4
Subclass Ectognatha		754	
Order Thysanura (bristletails)			1
Order Ephemeroptera (mayflies)			21
Order Odonata (damselflies & dragonflies)			51
Orders Blattaria & Mantodea (cockroaches & mantids)			4
Order Isoptera (termites)			1
Order Orthoptera (grasshoppers & crickets)			15
Order Dermaptera (earwigs)			4
Order Plecoptera (stoneflies)			4
Order Thysanoptera (thrips)			3
Order Hemiptera (true bugs)			78
Order Homoptera (cicadas, leafhoppers & aphids)			32
Order Neuroptera (nerve-wing insects)			12
Order Coleoptera (beetles)			179
Orders Mecoptera & Siphonaptera (scorpionflies & fleas)			3
Order Diptera (true flies)			127
Order Trichoptera (caddisflies)			74
Order Lepidoptera (butterflies & moths)			83
Order Hymenoptera (ants, bees & wasps)			52
PHYLUM TARDIGRADA: Class Eutardigada (water bears)	1		
PHYLUM BRYOZOA: Class Phylactoaemata (bryozoans)	5		

surface bears a series of spines and scales. Gastrotrichs have a relatively short life span—usually between 3 to 21 days.

PHYLUM ROTIFERA

Rotifers are small (<1 mm long) but active members of the aquatic community. The head characterized by a crown of feeding cilia (corona) that gives the appearance of revolving wheels—hence the group's scientific name "Rotifera" and the common name "wheel animalcules"—and a muscular pharynx with a set of hard jaws, the mastax. The cilia of the head region are also used for locomotion. Most species are transparent and many have a thickened, sometimes armored, body wall (lorica) that tapers to a tail-like projection called a foot. The foot contains glands that can secrete an adhesive material used to anchor the rotifer during feeding (Pearse et al. 1987). Thus these animals can be either planktonic or sessile. Some 34 taxa of rotifers have been identified for Old Woman Creek estuary and the adjacent waters of Lake Erie, in 2 classes, 3 orders, and 10 families (Figure 6.24). Rotifers occur in a variety of aquatic habitats, both benthic and planktonic. As a group, rotifers are considered generalist suspension feeders, consuming a wide variety of small animal prey and plants. However, certain species have highly specific food habits. Most rotifers are females—the male being diminutive and short-lived.

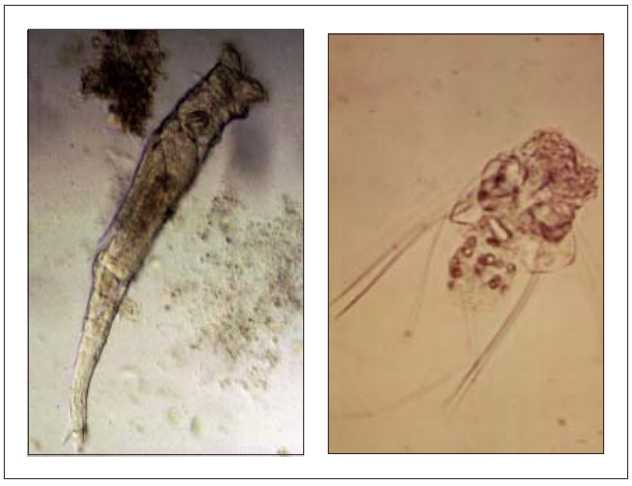


*Figure 6.24. Planktonic rotifers (*Philodina *sp., left;* Polyarthra *sp., right) found in Old Woman Creek estuary (David M. Klarer).*

PHYLUM NEMATODA

Nematodes, commonly known as roundworms because of their circular cross-section, are a diverse group of animals that can occur in great numbers within a small area. Three genera (*Tobrilus*, *Dorylaimus*, and *Criconemoides*) in 3 orders and in 3 families of the class Adenophorea have been identified in Old Woman Creek estuary. Nematodes are small invertebrates (generally less than 1 cm long) that occur in most benthic and epiphytic habitats in the estuary and at times they are very abundant. Roundworms totally lack cilia and flagella. They move by undulatory propulsion in which sinusoidal waves pass backwards along the body length. This strategy is particularly suitable for movement in a fluid medium. The genus *Tobrilus* feeds on small microfauna, including other nematodes; *Dorylaimus* is adapted for harvesting algae and other microflora; and *Criconemoides* is an ectoparasite that commonly attacks plant roots which in turn form galls that become feeding sites for others of their kind (Parker 1982).

PHYLUM MOLLUSCA

These soft-bodied animals, often with hard calcareous shells, include two familiar freshwater classes: Gastropoda (snails) and Bivalvia (clams). Their fleshy mantle secretes a shell which consists of a protein matrix reinforced by crystalline calcium carbonate in the form of either calcite or aragonite. Respiratory gills (ctenidia) are located in a posterior cavity formed by folds in the mantle.

Class Gastropoda. Snails possess a single shell (or valve) that is either flatly coiled or spiraled into a cone-like shape. In the estuary, the shells are typically drab-colored and range in size from a few millimeters for the small physids to over 50 mm for the Japanese mystery snail (*Cipangopaludina japonicus*). Part of the soft body protrudes from the shell aperture and bears a distinctive head with a pair of tentacles, often containing photosensitive eyes. Ten species of aquatic snails, in 2 orders and 5 families, have been identified in Old Woman Creek estuary, as well as one terrestrial species in the watershed. Most of the snails are benthic organisms that move slowly over the sediments of the estuary. Many feed on encrusted growths of algae, while others are detritivores or omnivores. Some burrow into the soft muds or detritus during dry periods

or when habitats become frozen solid in winter. The land snail, *Mesodon thyroidus* in the family Polygyridae, prefers the humid woodlands surrounding the estuary. Members of this family live under dead wood, leaves, and stones. They mainly are active nocturnally or during rain, and feed primarily on mold and fungi (Parker 1982).

Class Bivalvia. Clams and mussels possess a two-piece shell, made up of 2 valves, thus the name "bivalve." The two opposing valves are connected by a hinge and are opened and closed with powerful muscles. Clam shells are commonly oval shaped, range in color from yellow to brown or green, and possess concentric, annular growth lines. Zebra and quagga mussels (*Dreissena polymorpha* and *Dreissena bugensis*), recent invaders of Lake Erie, have distinctive strips and litter the barrier beach at the estuary mouth. Unlike the snails, the protruding soft body parts of the bivalves lack head, eyes, and tentacles. Bivalves generally feed by filtering planktonic microorganisms out of the water, but some burrowing forms feed on organic matter strained from the substrate. Seven species of bivalves, in 2 orders and 3 families, have been found in Old Woman Creek estuary and an additional 15 species are in the adjacent nearshore waters and tributaries of Lake Erie. Four of the bivalves reported for the nearshore waters of Lake Erie in the vicinity of the Reserve are listed by the Ohio Division of Wildlife (1992) as threatened (T) or of special interest (S); no other invertebrates found within the study area appear on the State list:

Black sandshell (*Ligumia recta*) (T)
Fawnsfoot (*Truncilla donaciformis*) (T)
Deertoe (*Truncilla truncata*) (S)
Purple wartyback (*Cyclonaias tuberculata*) (S)

PHYLUM ANNELIDA

The most obvious trait of annelids is their body plan which consists of an elongated and segmented tube. Each segment is essentially the same and divided from the next segment by a ring-like marking. Two classes are found in the estuary, the leeches (Hirudinea) and aquatic and terrestrial earthworms (Oligochaeta).

Class Hirudinea. Leeches are flattened, segmented worms—often patterned and brightly colored. They possess both anterior (front) and posterior (rear) suckers, which are variously used for attachment, feeding, or locomotion. The leeches found in the estuary are either predators of other macroinvertebrates or temporary ectoparasites of fishes, amphibians, turtles, or water birds. Of the 4 species of leeches documented for the estuary, *Batracobdella phalera*, a fish parasite, is most common.

Class Oligochaeta. Aquatic earthworms are generally elongated, cylindrical worms that bear a few short bristles or hairs (chaeta) on each body segment. The silty bottom sediments and algal mats of the estuary have yielded 42 species of oligochaets in 2 orders and 4 families. Many are deposit feeders on the soft sediments of the estuary, utilizing the organic components for their nutrient source (Figure 6.25). Others feed primarily on periphyton or detritus, and a few are carnivorous, such as *Chaetogaster* spp.

*Figure 6.25. Oligochate worm (*Branchiura sowerbyi*) found in Old Woman Creek estuary sediments (Center for Lake Erie Area Research).*

PHYLUM ARTHROPODA

This phylum is the most successful in terms of numbers and diversity of terrestrial invertebrate animals and one of the most prominent freshwater taxa. Three of the classes are diverse and important components of the Old Woman Creek estuary and watershed: Arachnida (spiders and water mites); Crustacea (cladocerans, copepods, amphipods, and crayfishes); and Insecta (flies, bugs, and beetles). As a group, most members are characterized by a chitinous exoskeleton and ridged, jointed appendages which have been modified as legs, mouthparts, and antennae.

Class Arachnida

This class includes spiders, scorpions, ticks, and mites. In general, they are terrestrial arthropods that have their body divided into two main regions: (1) a cephalothorax (fused head and thorax) bearing 6 pair of appendages, of which 4 pairs are walking legs, and (2) an abdomen that bears no locomotive appendages. The 4 pair of walking legs and the absence of antennas serve as a simple way to distinguish arachnids from insects which have 3 pairs of walking legs and prominent antennas. The two arachnid orders that contain spiders and mites are represented in the watershed.

Order Araneae. In spiders the cephalothorax is covered by a carapace shield which usually contains 8 simple eyes. The abdomen generally has 3 pair of silk spinnerets. The proteinaceous fluid silk, which issues from these appendages, polymerizes under tension forming a hardened thread (Pearse et al. 1987). The tips of the spinnerets have a battery of minute spinning tubes that connect with several kinds of silk glands. The glands produce different types of silk for constructing various parts of a web, producing adhesive threads, making a protective cocoon, and binding the prey. All spiders spin silk, but relatively few species weave the spiraling orb webs (family Araneidae) found in the uplands surrounding the estuary. Within the Old Woman Creek watershed, 74 species of spiders, in 16 families, have been identified (Phillips 1998).

Order Acriformes. Mites differ from spiders in having their cephalothorax and abdomen fused into an unsegmented, ovoid body. Only members of the suborder Hydrachnida have become adapted to aquatic environments. Most water mites are brightly colored—commonly dark red, scarlet, or orange (Figure 6.26). They breathe air, but spend extended periods in the estuary on the mud bottoms and submerged plants searching for prey. Like spiders, water mites are carnivorous feeders, clutching their prey and sucking the body juice. Three genera of water mites have been identified in Old Woman Creek estuary.

Class Crustacea

Crustaceans have segmented bodies that are divided into head, thorax, and abdomen. They possess paired, joined appendages; and have an exoskeleton—a hard, durable, and protective body covering. The sclerotization of the covering (stiffening facilitated by chitinous plates) is interrupted at the joints which insures mobility. The exoskeleton is molted at intervals to permit growth of the individual. Nine orders of crustaceans are found in the Old Woman Creek study area, including cladocerans, ostracods, copepods (calanoids, harpacticoids, and cyclopoids), arguloids, isopods, amphipods, and decapods.

*Figure 6.26. Water mite (*Limnesia *sp.) found in Old Woman Creek estuary (Center for Lake Erie Area Research).*

Subclass Branchiopoda. Order Cladocera (water fleas) consist of small crustaceans, 0.2 to 3.0 mm in length, that swim in rapid jerks caused by the beating of branched second antennae. Cladocerans are the preferred food of many young and adult estuary fishes. They have a distinct head with vision organs, usually consisting of a compound eye and a smaller light sensitive eye or ocellus (Ruppert and Barnes 1994). The body is covered by a protective bivalve carapace. Complex movements of thoracic legs produce a constant current of water between the valves which facilitates the filtering of food particles, such as bacteria, algae, protozoans, and organic detritus from the water. In Old Woman Creek, its estuary, and the adjacent nearshore waters of Lake Erie, a total of 39 species, in 8 families, have been identified (Figure 6.27). Bur et al. (1986) reported the spiny water flea (*Bythotrephes cederstroemi*) as a recent invader to the Great Lakes (Figure 6.28).

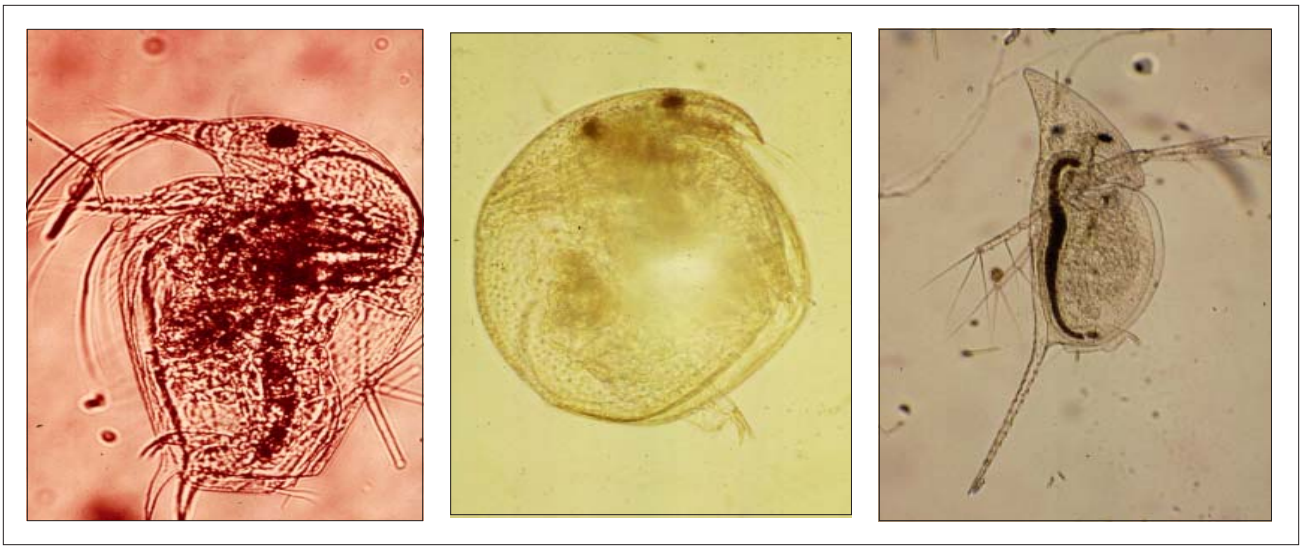


*Figure 6.27. Planktonic cladocerans (*Bosmina longirostris*, left;* Chydorus sphaericus*, center;* Daphnia retrocurva*, right) found in Old Woman Creek estuary (David M. Klarer).*

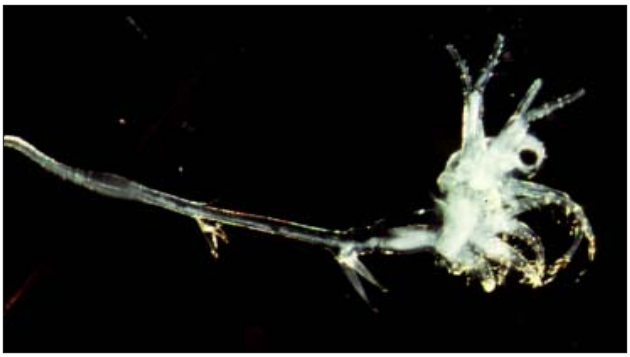


*Figure 6.28. Spiny water flea (*Bythotrephes cedarstroemi*) found in the nearshore waters of Lake Erie (Kenneth Krieger).*

Subclass Ostracoda. Commonly known as seed shrimp, these small crustaceans are distinguished by a bivalved carapace which envelops their soft body. They are typically herbivores or detritivores that live in benthic habitats. Nine species of ostracods, in 5 separate families, have been found in the estuary.

Subclass Copepoda. Copepods are another group of small crustaceans—subdivided into three orders: Calanoida, Harpacticoida, and Cyclopoida. Copepods have been estimated as the most numerous multicellular animal in the world (Pearse et al. 1987). They are voracious consumers of phytoplankton and small invertebrates and are in turn fed on by a variety of larger invertebrates and fishes. The copepod body is shrimp-like and ranges from 0.3 to 3.0 mm in length. They appear to glide rapidly and smoothly through the water by using thoracic appendages (calanoids) or the second antennae (cyclopoids). Harpacticoids tend to crawl over the bottom. Identification of the three orders is based mainly on morphological details of appendages and feeding habits. Calanoid copepods feed on plankton by filtration. Their second antennae are used as screws to produce a current from which phytoplankton is either filtered or seized by the mouth. Cyclopoid copepods (so named for a single eye spot in the front of the head) do not filter feed but use mandibles to capture a variety of small animals, including mosquito larvae (Figure 6.29). Harpacticoid copepods inhabit macrophytes and sediments, and feed by scraping organic matter from submerged surfaces. A total of 25 copepod species, in 4 families, have been reported from the estuary.

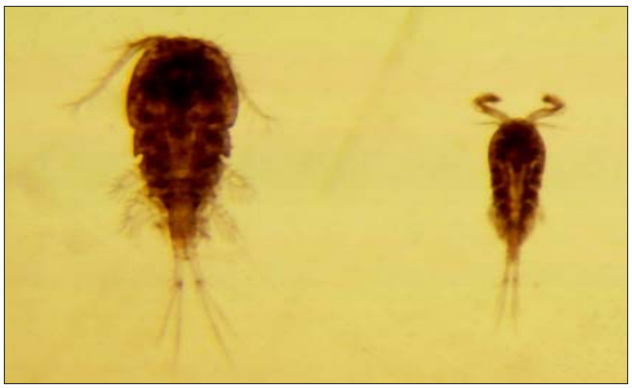


*Figure 6.29. Planktonic copepod (*Cyclops *sp.) from Old Woman Creek estuary (Kenneth Krieger).*

Subclass Branchiura. In the estuary, this subclass is represented by one genus, *Argulus*, in the order Arguloida. As the common name "fish lice" suggests, these small crustaceans are ectoparasites and attach themselves to the gills of fish. Their mandibles have been modified to form a pair of hooks and their maxillules have become large suckers. In *Argulus* the mandibles are incorporated into a specialized proboscis —a sheathed, hollow spine is used to pierce the skin of the host fish and extract body fluids (Thorp and Covich 1991).

Subclass Malacostraca. This subclass contains three important orders which are represented in Old Woman Creek estuary: Isopoda (aquatic sow bugs), Amphipoda (scuds), and Decapoda (crayfishes and shrimps). Isopods are dorsoventrally flattened and well adapted for crawling. As the name of the order implies, all their walking-leg appendages are similar in design. Most isopods are detritus feeders, such as *Caecidotea racovitzai*. Of the three orders, amphipods are more compressed laterally and tend to swim on their sides. Their first three pleopods (abdominal appendages) are modified as swimmerets. The two common amphipods in the estuary are *Gammarus fasciatus* and *Hyalella azteca*. Decapods are the largest arthropods in the estuary and are represented by two crayfishes (*Cambarus diogones* and *Orconectes rusticus*) and a glass shrimp (*Palaemonetes kadiakensis*).

Class Insecta

Insects, the largest class of invertebrates found in the Old Woman Creek watershed, consist of two subclasses: Entognatha (primitive insects represented by springtails and diplurans) and Ectognatha (true insects represented by 22 orders). Altogether, 758 taxa of insects have been identified from the study area.

Orders Collembola & Diplura. These two orders include the springtails and diplurans. As primitive insects, they are small, wingless, and usually blind. Springtails have an abdominal jumping organ and well-developed legs. Diplurans have a v-shaped tail formed by two caudal filaments at the end of their abdomen. These insects live in damp leaf humus, decomposing wood, and in soil beneath stones and fallen trees in the upland woodlots surrounding the estuary and throughout the watershed.

Order Thysanura. This order includes the silverfish. These fast-running insects have three narrow, elongated appendages at the end of the abdomen. Unlike the more primitive entognathan insects which occupy similar natural habitats, silverfish have compound eyes. These silver-gray insects can be domestic pests, feeding on the starch in books and textiles.

Order Ephemeroptera. This order includes the mayflies. These winged insects have medium-sized, elongated soft bodies with usually three long threadlike tails. Mayflies are unique insects in that a fully winged terrestrial life stage (subimago) precedes the sexually mature adult stage. The adult mouthparts are reduced and useless, thus they are short-lived as their "ephemeral" order name implies. Mayflies spend nearly all of their lives as nymphs in the waters of the creek, estuary, and lake. Aquatic nymphs of some 18 species have been found in the estuary, Old Woman Creek, and adjacent tributaries. The burrowing mayfly, *Hexagenia limbata*, has only two tails and is noteworthy because it emerges in enormous numbers from Lake Erie, piling up along the shore and in the streets of lakeside towns (Figure 6.30). Until the middle 1950s, this was a frequent happening along the shores of the lake, but environmental degradation in Lake Erie dramatically reduced the numbers of these insects for four decades. With improved Lake Erie water quality in the 1990s, mayflies have experienced a resurgence.

*Figure 6.30. Adult mayfly (*Hexagenia limbata*) after emerging from estuary sediments (Gene Wright).*

Order Odonata. This order includes the damselflies and dragonflies. Within the Old Woman Creek study area, 25 species of damselflies and 24 species of dragonflies have been identified. These relatively large, beautifully colored insects spend most of their time in flight. Their immature stages are aquatic (breathing by means of gills); the adults are most often found near water. Both nymphs and adults are predaceous on various other insects and invertebrates, but they are harmless to humans in that they neither bite nor sting. The gills of damselfly nymphs take the form of three leaflike structures at the end of the abdomen, while in dragonfly gills are internal within the rectum. Dragonfly nymphs draw in water through the anus, extract dissolved oxygen, and expel it through the same organ (Figure 6.31). To escape predation, they can expel water rapidly yielding a type of jet propulsion. Adults of both groups have four elongated, many-veined, and membranous wings and can be differentiated by the position of their wings while at rest—damselflies fold their wings close together vertically over their backs, while dragonflies hold their wings straight out horizontally from the body.

*Figure 6.31. Nymph darner dragonfly (*Aeshna *sp.) on aquatic vegetation (ODNR).*

Orders Blattaria and Mantodea. These orders include the cockroaches and mantids. Cockroaches are relatively large, flattened, oval-shaped, and fast-running insects with long hair-like antennae and numerous leg spines. Their head is concealed under a triangular shield (pronotum). They have an unpleasant odor and feed at night, hiding in crevices during the day. The Oriental cockroach (*Blatta orientalis*) and the American cockroach (*Periplaneta americana*) commonly invade houses within the watershed, while the small, wood cockroach (*Parcoblatta*) is more often found in woodlots under dead logs and stones.

Mantids are large, elongated, and slow-moving insects that are striking in appearance because their front legs are bent in an upraised or "praying" position. They are predaceous on a variety of insects, usually laying in wait for their prey in this attitude. They are colored a protective green and brown that makes them difficult to see in foliage. Although strong fliers, they are rarely observed on the wing. The Chinese mantid or praying mantis (*Tenodera aridifolia sinensis*), now relatively common in the watershed, was introduced to the United States near Philadelphia about 100 years ago (Borror and DeLong 1971).

Order Isoptera. This order includes the termites. These social insects, sometimes called white ants, live in colonies having a caste system which includes reproductive males and females, sterile workers, and sterile soldiers. Termites are destructive, feeding entirely on wood. The wood particles are then digested by protozoan living in the termite's gut. The eastern subterranean termite (*Reticulitermes flavipes*) is found in the watershed. This termite eats the soft spring growth of wood, hollowing out the sapwood along the length of the grain and leaving only brown specks of excrement behind. As they consume living trees or wood buildings, they maintain contact with the ground by means of earthen tubes that connect the feeding galleries with the ground (Swan and Papp 1972).

Order Orthoptera. This order includes the grasshoppers, katydids, and crickets. These insects are noted for their powerful hind legs, which are adapted for jumping by greatly enlarged third segments (femora). They usually have two pair of long, narrow, many-veined wings. Crickets and katydids produce a characteristic sound, or song, by rubbing specialized parts of their forewings together, in contrast to band-winged grasshoppers which snap hind wings in flight. Males generally do the singing; songs mainly function to attract females for mating. Most members of this order are plant feeders; some are very destructive to cultivated plants. Within the watershed, 6 grasshopper, 2 katydid, and 7 cricket species have been identified.

Order Dermaptera. This order is represented by at least 3 species of earwigs in the watershed. These are medium-sized insects, typically brown in color, with short leathery forewings and long membranous hindwings that fold straight back under the front pair. Some species are wingless, such as the ring-legged earwig (*Euborellia annulipes*) which occasionally invades dwellings feeding on foodstuffs and house plants. A distinctive feature of earwigs is a pair of curved, pincer-like cerci at the hind end of insect that are used in defense, such as grasping an attacking ant. The wings of the European earwig (*Forficula auricularia*) are not strong enough for this insect to take off from the ground or for sustained flight— they can only fly by taking off from a high place.

Order Plecoptera. This order includes the stoneflies. The common name of these insects reflects the fact that they spend most of their life as nymphs (2-3 years) crawling among stones in streams, and as adults (15-20 days) resting on rocks near the water. They are poor fliers and are seldom found far from water. Stonefly nymphs are similar in appearance to mayfly nymphs, except that they only have two tail filaments. Because stonefly nymphs lack extensive gills, in many species obtaining oxygen by diffusion through the body cuticle, they occur only in oxygen-rich water. Thus, the presence of stonefly nymphs in a stream is an indicator of good water quality conditions. The green-winged stonefly (*Isoperla duplicata*) feeds on the pollen of foliage along the banks of Old Woman Creek. Most of the 14 stonefly species identified for the study are were found in Old Woman Creek upstream of the estuary or in nearby Mill Hollow on the Vermilion River.

Order Thysanoptera. This order includes the thrips. They are mostly small, inconspicuous insects with two pairs of wings fringed with eyelash-like hairs. Although small, their bodies are well armored (sclerotized) and solid brown, black, or yellow in color. They can be found in most blossoms and feed by sucking juices from plants. A common thrips (family Thripidae), a three-tailed thrips (family Phlaeothripidae), and a banded thrips (family Aeolothripidae) have been observed in the watershed.

Order Hemiptera. This order includes the true bugs. These insects have widely differing sizes, shapes and habits. Their wings are usually thickened at the base and membranous at the tip. The main unifying characteristic of this order is the structure of the piercing-sucking beak (rostrum) and mouthparts, common to all members. During piercing, the rostrum, richly supplied with organs of smell and touch, does not enter the tissue of the food organism, but guides a bundle of hollow, barbed stylets to a favorable spot for the bite. Juices are most often sucked from the sieve tubes in the vascular bundles of plants. The order contains aquatic bugs such as water scorpions (*Nepa* and *Ranata*), giant water bugs (*Belostoma*), water boatmen (*Trichocorixa*), backswimmers (*Notonecta*), and water striders (*Gerris*), as well as diverse terrestrial bugs including lace bugs (*Corythuca*), plant bugs (*Lygus*), assassin bugs (*Sinea*), seed bugs (*Lygaeus*), and stink bugs (family Pentatomidae)—all of which have representatives in the study area. Unlike their land-based, plant eating counterparts, many water bugs attack any animal they can manage, large or small, including small fish. Altogether, 78 species of bugs in 27 families have been identified in the vicinity of Old Woman Creek.

Order Homoptera. This order includes the cicadas, leafhoppers, and aphids. These insects are closely related to the true bugs, except the wings of homopterans are similar along their length and not divided into a thick strong base and a fragile tip, as they are in the order Hemiptera. All homopterans are terrestrial and vegetarians; most of them suck the juices from vascular plants. Many members of this order are serious pests of cultivated plants, causing damage by feeding and by serving as vectors of plant diseases. Common representatives in the study area include spittlebugs (*Philaenus*), cicadas (*Tibicen*), leafhoppers (*Graphocephala*), and aphids (*Aphis*). A total of 32 species of homopterans in 10 families have been found in the watershed.

Order Neuroptera. This order includes the nerve-wing insects, such as dobsonflies, alderflies, and lacewings. Members of this order have many veins in their delicate wings. The nymphs of dobsonflies (*Corydalus*) are aquatic; known as hellgrammites, they are extremely predacious and cannibalistic during this 2-to-3-year phase in steams such as Old Woman Creek.

The larvae of the spongillafly (*Climacia*) are parasitic on and live in the cavities of freshwater sponges. The larvae move onto land in summer where they weave a cocoon, covered with hexagonal meshed net, on vertical objects near the shore. Here transformation to a pupa takes place before they emerge as flying adults. The green lacewing known as golden eye (*Chrysopa oculata*) appears in autumn in the watershed as a greenish shimmering insect with sparkling gold eyes and transparent wings that look as fragile as glass. Within the watershed, 11 species of neuropterans in 6 families have been identified.

Order Coleoptera. This order includes the beetles and weevils. The extraordinary variety in their forms has made the beetles the insect order with by far the greatest number of species. In Old Woman Creek watershed 179 species of beetles in 39 families have been reported. This is a small number, however, compared with the nearly 350,000 species of beetles that have been described world wide. The name of the order means sheathed wings, referring to the hardened forewings that cover the membranous hindwings. Most beetles are herbivorous, but some families that live in Old Woman Creek and the estuary are hunters, such as the predaceous diving beetles (*Dytiscus* and *Laccophilus*), while other water beetles are scavengers (*Berosus* and *Hydrophilus*). Whirligig beetles (*Dineutes*) often form large aggregations in protected open waters of the estuary (Figure 6.32). Most of the beetle families are terrestrial and have the ability to fly, but most often only to reach low vegetation. Land beetles eat leaves, bark, dung, and some textiles. The larvae, called grubs, can be either predacious or vegetarian. Although some species attack plants and food stores, others eat plant pests and pollinate flowers.

Orders Mecoptera and Siphonaptera. These orders include the scorpionflies and fleas. The slender bodies of scorpionflies are amber-colored with dark spots or bands on their four membranous wings. The common name for these insects is derived from the male genitalia which looks like the upward curved sting organ of a scorpion. The common scorpionfly, *Panorpa helena*, occurs in the watershed and inhabits woods and ravines with dense vegetation. They feed chiefly on dead or injured insects.

*Figure 6.32. Gyrating mass of whirligig beetles (*Dineutus *sp.) in an embayment of Old Woman Creek estuary (Charles E. Herdendorf).*

Fleas are small wingless insects that feed on the blood of mammals and to a lesser extent that of birds. The genus *Ctenocephalides* includes the cat flea (*C. felis*) and the dog flea (*C. canis*)—common pests of cats and dogs in the watershed and in buildings where these domestic animals are kept. The dog flea serves as the intermediate host of the dog tapeworm (*Dipylidium caninum*).

Order Diptera. This order includes the true flies. Common in all habitats, flies are easily distinguished from other insects because they have only one pair of complete wings. Most flies have large compound eyes and mouthparts that are modified for piercing, lapping, or sucking. The larvae (maggots) of many species are soft, legless, headless, and often white. The aquatic larvae of mosquitoes (*Aedes* and *Culex*), midges (*Chironomus* and *Procladius*), and crane flies (*Tipula*), all found in the estuary, are slender and have distinct heads. Many of the chironomid larvae are blood red in color (Figure 6.33). These "bloodworms" have hemoglobin in their circulatory system that allows them to store oxygen and survive at near anoxic conditions. A total of 127 species of flies, in 38 families, have been identified within the study area, 54 species of which are in the midge family (Chironomidae).

*Figure 6.33. Chironomid larvae (*Chironomus *sp.), a major component of the Old Woman Creek benthos (ODNR).*

Order Trichoptera. This order includes the caddisflies. Trichopterans are an advanced order of insects, closely related to the order Lepidoptera (butterflies and moths), but adapted for aquatic life in the immature stages. Adult caddisflies are similar to moths except their wings usually possess hairs rather than the scales typical of moth wings. Caddisflies are usually brownish, inconspicuous, small, and moth-like; they are most active at night. Like mayflies, the adults have reduced mouthparts and seldom, if ever, eat. The head and thorax of the aquatic larvae are sclerotized and pigmented; the abdomen is soft and colored light brown to brilliant green. Their 3 pair of legs are prominent and directed forward. Many larvae construct portable cases of various natural objects, such as grains of sand and gravel, leaves, or twigs, which are fastened together with a glue-like substance or with silk. Larval cases vary considerably, both in shape and materials employed, but each species makes a characteristic type of case, such as tube-makers (*Polycentropus*), log-cabin makers (*Limnephilus*), and sailcase makers (*Helicopsyche*). Larvae of some species construct silken nets (*Hydropsyche*) and feed on material caught in the nets. Most larvae feed on plant material, but a few non-case makers (*Rhyacophila* and *Phryganea*) are predaceous. Within the estuary and adjacent streams tributary to Lake Erie, a total of 74 species of caddisflies, in 9 families, have been identified.

Order Lepidoptera. This order includes the butterflies and moths. As noted earlier, these insects have 4 large membranous wings that are covered with scales. When handled some of these scales easily rub off. Moths and butterflies are separated on the basis of certain head structures; individual families are further divided on the basis of wing venation. Moths have threadlike or plumose antennae and a bristle (frenulum) at the front base of the hind wing, whereas butterflies have knobbed antennae and lack a frenulum. Lepidopterans feed principally on nectar and other liquid foods, and are commonly associated with flowers. Their flight is somewhat erratic, but relatively fast. A few butterflies, such as the monarch (*Danaus plexippus*), migrate great distances. The larvae of this particular species feeds on milkweed. Lepidopteran larvae, commonly called caterpillars, are cylindrical in shape with well-developed heads, 3 pair of thorax legs, and 5 pair of abdominal prolegs. Many larvae pupate in silken cocoons. A total of 83 moth and

butterfly taxa, including one aquatic taxa, have been reported in the watershed.

Order Hymenoptera. This order includes the ants, bees, and wasps. From a human standpoint, this order is regarded as the most beneficial of all the insects, for it contains food producers (honeybees), plant pollinators, and parasites or predators of various insect pests. The insects in this order also exhibit a great diversity of habits and complexity of behavior culminating in elaborate social organizations. The winged members have four membranous wings, with the hindwing smaller than the forewing. In flight, a tiny set of hooks are employed to attach the two sets of wings together. Ants, bees, and wasps have a constricted "waist" or pedicel between the thorax and the abdomen, whereas sawflies and horntails (*Tremex*) do not. Larvae have well-developed heads and mouthparts, but are legless except for sawflies. Most species are solitary, but ants and some bees and wasps have a complex social organization with sterile workers. Investigators have identified 52 species of hymenopterans, in 21 families, within the Old Woman Creek watershed.

PHYLUM TARDIGRADA

Tartigrades, or water bears, are near microscopic animals that live in the film of water surrounding mosses, algae, and rooted aquatic plants. The body has a somewhat bear-like appearance and consists of a distinct head and trunk with four pairs of leg-like projections, each bearing four claws. They crawl over vegetation, using their claws to grasp, while they feed on algal filaments and plant leaflets by sucking out cellular fluids. The tardigrades collected in the estuary belong to the family Macrobiotidae.

PHYLUM BRYOZOA

Bryozoans are aquatic animals that occur in colonies. The individual animals (zooids) grow in a non-living case. They have a unique tentacular food-collecting organ called the lophophore. In the estuary, *Pectinatella magnifica* creates massive gelatinous colonies (Figure 6.34), *Plumatella casmiana* forms more honeycomb masses, *Lophopodella carteri* is found in small sac-like masses, and *Plumatella repens* occurs in branching and threadlike colonies. Called "moss animals," bryozoan colonies often look like mossy masses on lily pads or encrustation on floating twigs and branches. When the colonies disintegrate in the fall, most species produce a large number of oval winter buds (statoblasts). Similar to the gemmules of a sponge, individuals produced from these buds form new colonies in the spring.

*Figure 6.34. Bryozoan colony (*Pectinatella magnifica*) on an American lotus (*Nelumbo lutea*) leaf pad in the main basin in Old Woman Creek estuary (Gene Wright).*

VERTEBRATE FAUNA

Vertebrates are all members of the animal phylum Chordata, subphylum Vertebrata. Of the seven classes in this subphylum, six are found in Old Woman Creek watershed and the adjacent region of Lake Erie: Agnatha (jawless fish), Osteichthyes (bony fish), Amphibia, Reptilia, Aves (birds), and Mammalia; only the class Chondrichthyes (cartilaginous fish – sharks and relatives) is absent. Members of this phylum possess the following characteristic features, at least during some stage of development: (1) a notochord (whence the name of the phylum is derived), a stout yet flexible rod-like structure running down the back of the trunk in the position occupied by the backbone in typical adult vertebrates, (2) a hollow dorsal nerve cord lying above the notochord, and (3) numerous gill slits, which open outward from the pharynx to the exterior (Gray 1970). The notochord is prominent in the embryo in every vertebrate, but in the adult it is supplanted by the backbone—vertebral column to which the group owes its name.

The diversity of habitats present within the Reserve and Old Woman Creek watershed contribute to a variety of plant and animal communities, each comprised of a distinctive fauna. A total of 121 fish, 27 amphibian, 25 reptilian, 52 mammalian, and 370 avian species have been identified in the Reserve, watershed, and adjacent tributaries and waters of Lake Erie; over half of these taxa are found within the boundaries of the Research Reserve (Appendixes D, E, and F). A detailed treatment of the vertebrate animals reported from the Old Woman Creek watershed is presented in Old Woman Creek SNP & NERR Technical Report No. 11, *Catalogue of the Vertebrate Fauna in Old Woman Creek Estuary, Watershed, and Environs* (Herdendorf et al. 1999b,2001d).

FISH

Within the Old Woman Creek estuary and watershed, 51 different fish species, in 2 classes, have been identified by Ohio Division of Wildlife (1974, 1980), Thibault (1984,1985), Hoffman (1985), Rotenberry et al. (1987,1989), Thoma (1999), Johnson (1994), and Jude (1996). Of the 51 species, 49 are reported from the estuary and 11 from the creek proper (Appendix D). None of the 23 fish species considered endangered, threatened, or of special concern found in north central Ohio have been reported from the waters of Old Woman Creek (Ohio Division of Wildlife, 1992; amended 1996). An additional 70 fish species in the adjacent tributaries and waters of Lake Erie (Trautman 1957,1981b; Tomelleri 1997).

Class Agnatha

This class includes the lampreys, the most lowly of vertebrates. These serpentiform fishes resemble eels superficially, but eels are highly developed bony fishes. In contrast, lampreys have no bones, no trace of paired fins, nor the biting jaw which is one of the most significant structural features of all other vertebrates. Two species of lamprey have been collected by Trautman (1981b) in Lake Erie off the mouth of the estuary (see Appendix D). To prey on other fish, lampreys, have developed an adhesive disk on a round mouth to attach to the prey and a protrusible rasping tongue-like organ.

Class Osteichthyes

This class consists of the bony fishes—an ancient group appearing in the Devonian Period (350 million YBP) which rapidly assumed a dominant position in freshwaters. Diagnostic characteristics include: (1) jaws, (2) bony vertebrae, (3) paired fins, (4) paired nostrils, (5) commonly scaled body, and (6) usually a swim bladder. A total 119 species of bony fishes have been reported for the Old Woman Creek, adjoining watersheds, and the adjacent waters of Lake Erie (Figures 6.35 to 6.37 and Appendix D).

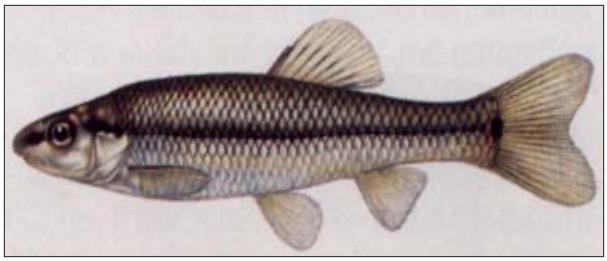
AMPHIBIANS AND REPTILES

Class Amphibia

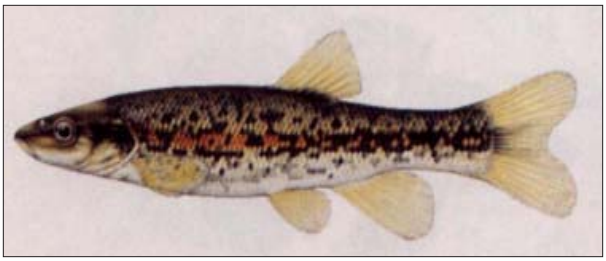
Amphibians constitute a class of vertebrate animals that include salamanders, toads, and frogs. These animals are characterized by: (1) moist glandular skin without scales, (2) toes that are devoid of claws, and (3) a larval stage that is usually aquatic. Most amphibians have four limbs that have evolved from ancestral lobe-fined fishes. All amphibians have gills during their early development stage, and while some retain them in adulthood, many others evolve lungs. Amphibians were the first vertebrates to cope with the rigors of life on land. Limbs and lungs are adaptations for a terrestrial existence, but amphibians remain vulnerable to dehydration and are still strongly linked to aquatic environments.

Rainbow [Steelhead] trout (*Oncorhynchus mykiss*)

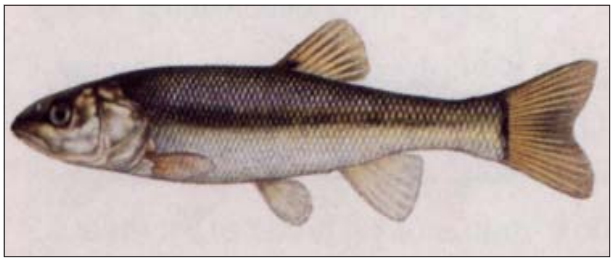
Stoneroller minnow (*Campostoma anomalum*)



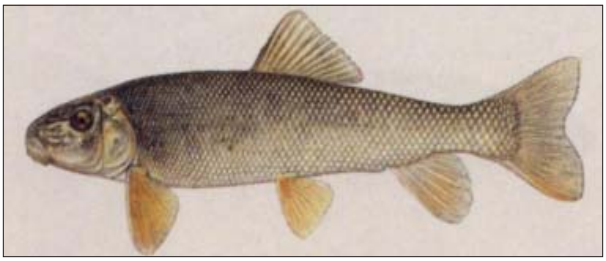
Bluntnose minnow (*Pimehales notatus*)



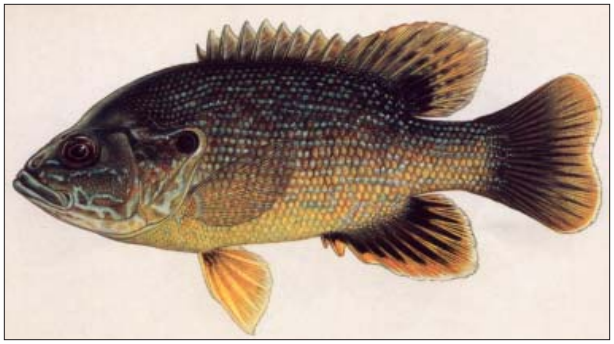
Blacknose dace (*Rhinichthys atratulus*)



Northern creek chub (*Semotilus atromaculatus*)



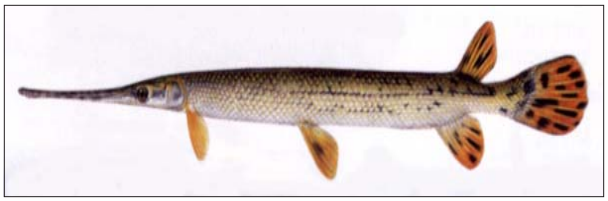
White sucker (*Catostomus commersoni*)



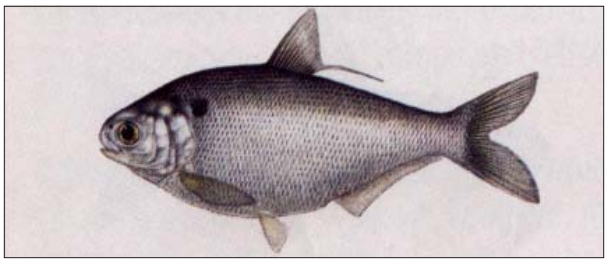
Green sunfish (*Lepomis cyanellus*)

Rainbow darter (*Etheostoma caeruleum*)

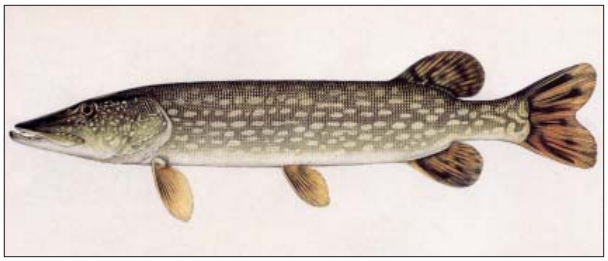
Figure 6.35. Representative fishes of Old Woman Creek (ODNR, artist: Joseph Tomelleri).



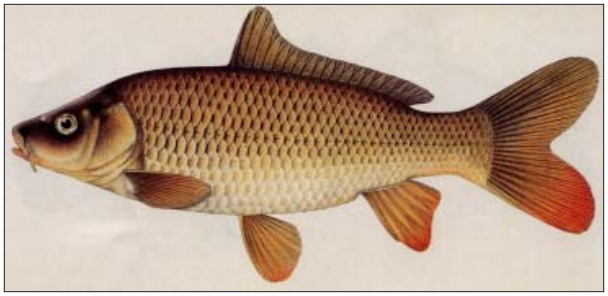
Longnose gar (*Lepisosteus osseus*)



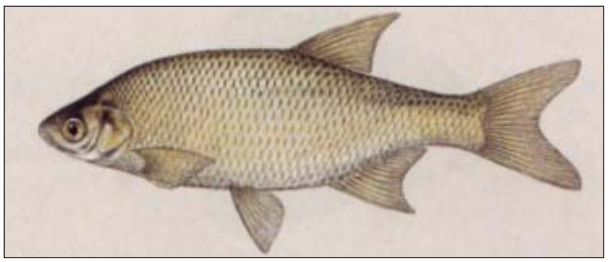
Gizzard shad (*Dorosoma cepedianum*)



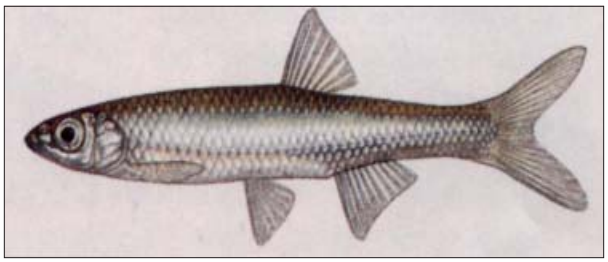
Northern pike (*Esox lucius)*



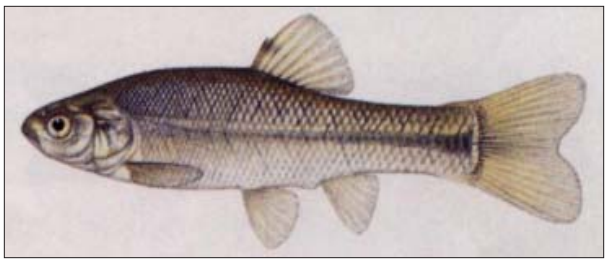
Common carp (*Cyprinus carpio*)



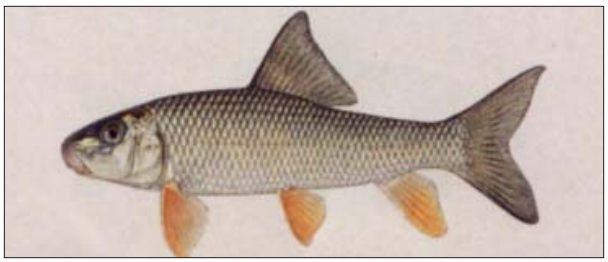
Golden shiner (*Notemigonus crysoleucas*)



Emerald shiner (*Notropis atherinoides*)



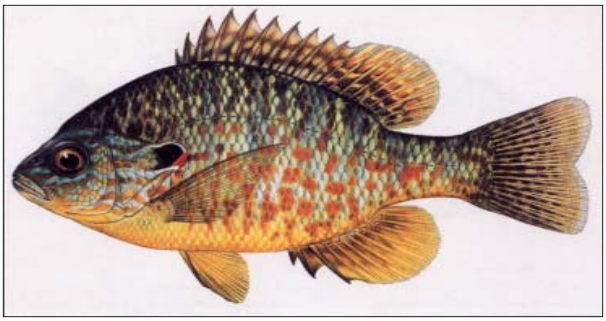
Fathead minnow (*Pimephales promelas*)



Golden redhorse (*Moxostoma erythrurum*)

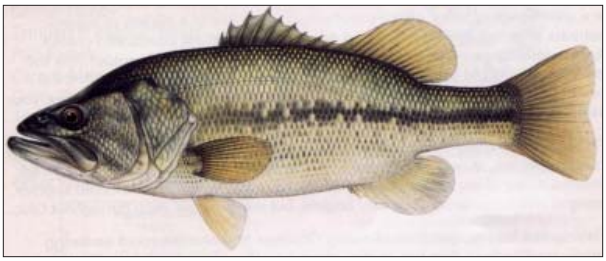
Figure 6.36. Representative fishes of Old Woman Creek estuary (ODNR, artist: Joseph Tomelleri).

Brown Bullhead (*Ameiurus nebulosus*)



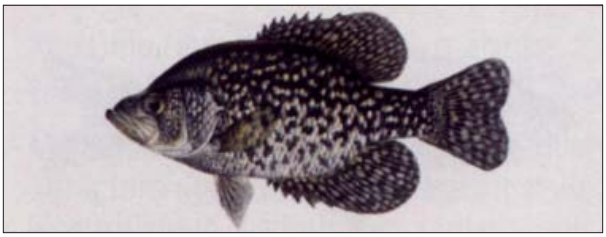
Pumpkinseed (*Lepomis gibbosus*)

Bluegill sunfish (*Lepomis macrochirus*)

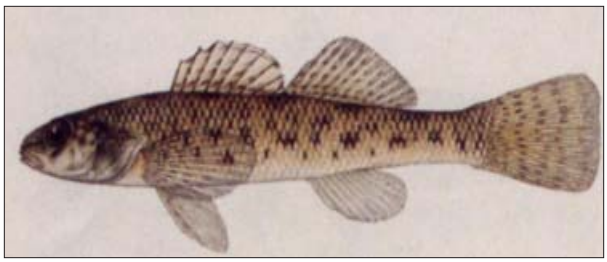


Largemouth bass (*Micropterus salmoides*)

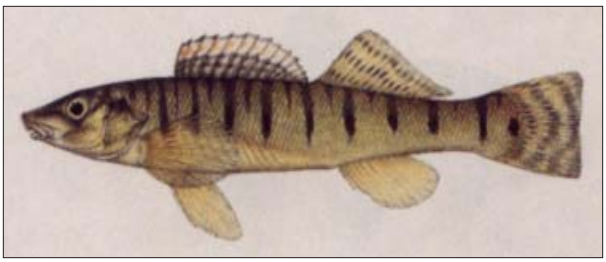
White crappie (*Pomoxis annularis*)



Black crappie (*Pomoxis nigromaculatus*)

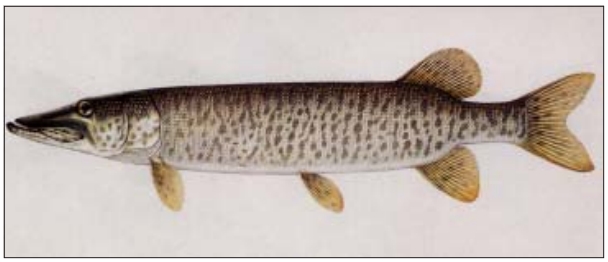


Johnny darter (*Etheostoma nigrum)*

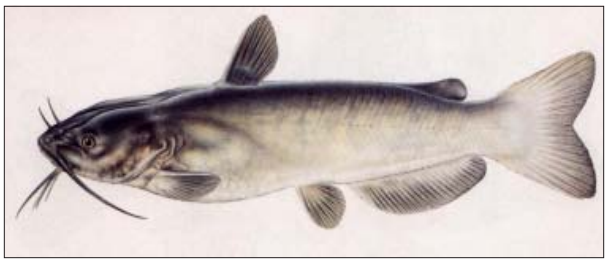


Logperch darter (*Percina caprodes*)

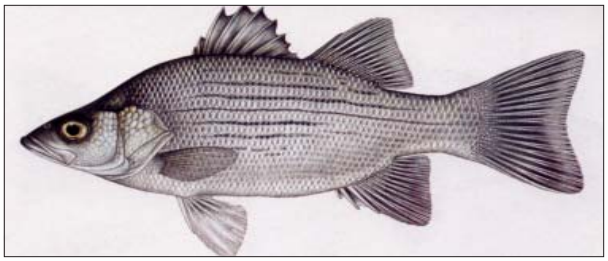
Figure 6.36 (cont'd). Representative fishes of Old Woman Creek estuary (ODNR, artist: Joseph Tomelleri).



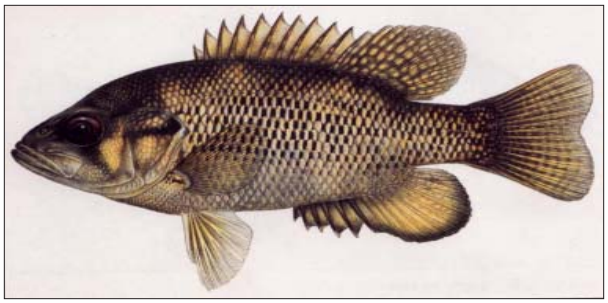
Muskellunge (*Esox masquinongy*)



Channel catfish (*Ictalurus punctatus*)

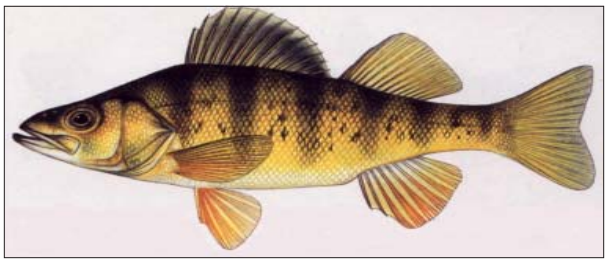


White bass (*Morone chrysops*)

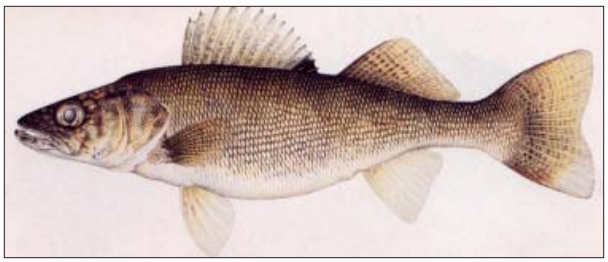


Rock bass (*Lepomis macrochirus*)

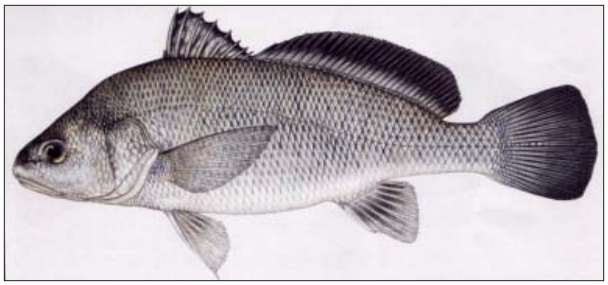
Smallmouth bass (*Lepomis macrochirus*)



Yellow perch (*Perca flavescens*)



Walleye (*Sander vitreus vitreus*)



Freshwater drum (*Aplodinotus grunniens*)

Figure 6.37. Representative fishes of nearshore Lake Erie (ODNR, artist: Joseph Tomelleri).

Most amphibians lay their eggs in water; the fish-shaped larvae have gills and tail-fins (Morgan 1930). Amphibian eggs which are deposited in sites exposed to sunlight have a dark pigment (melanin) over the upper hemisphere; whereas eggs deposited in concealed sites out of the light, lack the pigment. The occurrence of melanin may function to protect the embryo from ultraviolet radiation and to increase the temperature of the egg, through the greater heat absorption of a black or dark brown surface (Duellman and Trueb 1994, Stebbins and Cohen 1995). The black upper surface and the white lower surface may provide countershading, as found in many fish species, which makes floating eggs less detectable to predators when viewed from above the surface or from the bottom of the pool.

This class is represented by 16 species of salamanders, toads, and frogs in the Old Woman Creek watershed and adjacent waters of Lake Erie (Bernhardt 1985); an additional 11 species have been reported in nearby watersheds (Appendix F). The salamanders found in the study area are of three types [families]: (1) giant salamanders of which the aquatic and continually-larval mudpuppy is a member, (2) mole salamanders of which both the underground spotted salamander and a hybrid form (Figure 6.38) are resident, and (3) the lungless salamanders of which four subtypes [genera] are present: (a) dusky, (b) brook [two-lined], (c) woodland [redback, slimy, and ravine], and (d) red salamanders. The toads and frogs in the study area are also of three types [families]: (1) dry, warty skinned toads of which American and Fowler's toads are members, (2) chorus frogs of which the spring peeper and western chorus frog are abundant, and (3) true frogs of which the bullfrog, green frog, and leopard frog (Figure 6.39) are present.

*Figure 6.38. Silvery salamamder (*Ambystoma platineum*), a hybrid species common in the watershed (Glen Bernhardt).*

*Figure 6.39. Leopard frog (*Rana pipens*), one of the most abundant frogs in Lake Erie coastal wetlands (Glen Bernhardt).*

The Family Ambystomatidae (mole salamanders) is the only poorly represented family in the fauna of Old Woman Creek with only 2 of 7 regional species reported. The only amphibian listed as a species of special concern by the Ohio Division of Wildlife (1992; amended 1996), *Hemidactylium scutatum* (4-toed salamander) has not yet been found in the Old Woman Creek watershed.

Class Reptilia

Reptiles form a class of vertebrates that (1) are clad in scales or plates, (2) possess toes with claws, and (3) produce young that are miniature replicas of the parents. This class is represented by 19 species of turtles and snakes in the Old Woman Creek watershed and adjacent waters of Lake Erie; an additional 6 species have been reported in nearby watersheds (Appendix F). The turtles found in the study area are of four types [families]: (1) musk turtles, (2) snapping turtles, (3) box/water turtles, of which five subtypes [genera] (painted, spotted, Blanding's, map, and box turtles) are present, and 4) softshell turtles (Figures 6.40 and 6.41).

The snakes in the study area all belong to the colubrid family or harmless snakes, the largest snake family in the world. They vary in form and size from 2-m black rat and blue racer snakes to tiny brown snakes. Colubrid heads are as wide or wider than the neck with large and regularly arranged scales. Most members of this family have solid teeth on both jaws and well-developed eyes. Subtypes [genera] found in Old Woman Creek watershed include: racers, ringneck, rat (black rat and fox), milk, water (Figure 6.42), queen,

*Figure 6.40. Eastern box turtle (*Terrapene carolina*), a terrestrial turtle shown here on the Berea Escarpment (Charles E. Herdendorf).*

*Figure 6.41. Young spiny softshell turtle (*Apalone spiniferus*), a predominately aquatic turtle of the creek and estuary (Glen Bernhardt).*

brown (northern and midland), and garter (Butler's and eastern) snakes. The eastern fox snake (Figure 6.43) has been observed in trees overhanging the estuary.

The reptiles of the watershed are primarily known through the work of Bernhardt (1985). The algal species *Haematococcus pluvialis* has been reported by the authors only from the shell of the *Chelydra serpentina* (snapping turtle). Four of the six reptiles listed as species of concern by the Ohio Division of Wildlife (1992; amended 1996) have been reported from the Old Woman Creek watershed.

*Figure 6.42. Northern water snake (*Nerodia sipedon sipedon*), resting on a fallen tree at the edge of the estuary (Glen Bernhardt).*

*Figure 6.43. Eastern fox snake (*Elapha vulpina gloydi*), a resident of the estuary shore and uplands (Glen Bernhardt).*

BIRDS AND MAMMALS

Class Aves

This class forms a very distinct vertebrate group, characterized by a series of special features, most of which are adapted for flight and life in the air. Birds are bipedal for terrestrial locomotion, the front limbs being transformed into wings containing the rudiments of three fingers. The body is compact with an oversized breastbone (sternum) for the attachment of wing muscles. The skull, and the remainder of the skeleton, is lightly built, teeth are absent, and the tail bone is reduced. A high body temperature is maintained (38 to 44˚ C), commensurate with the need for continuous activity during flight. Feathers, the most prominent avian feature, are believed to be derived from horny reptilian scales (Gray 1970); these insulate the body and form lift-producing surfaces over the wings and tail. Birds have highly varied plumage and habits but, except for the Ratitae (birds with only rudimentary wings and no keel to the breastbone—such as the ostrich or kiwi), are built on a uniform structural pattern. The skin of birds differs from that of mammals in being thin, loose, and dry; there are no sweat glands—the only skin gland is the preen (uropygial) gland at the base of the tail (Young 1962). Feathers are cleaned with the beak, using oil obtained from this gland which is especially well developed in aquatic birds.

A total of 370 bird species have been reported in the region surrounding Old Woman Creek (Appendix E). Of this number all but 45 have been observed within the watershed. Virtually all of the 45 species not in the watershed were sightings of birds that were well away from their home range, such as the *Gavia pacifica* (Pacific loon) or the *Plegadis chihi* (white-faced ibis). Of the 44 species that are listed as species of concern by the Ohio Division of Wildlife, all but one species, *Chondestes grammacus* (lark sparrow), have been sighted in the Old Woman Creek watershed. One hundred and twenty five of the species are considered to be migratory and are passing through the region only to travel to and from their breeding and/or wintering grounds. Members of the local Audubon Society, Firelands Chapter assisted in compiling the list of birds in the Old Woman Creek watershed. Waterfowl (Figure 6.44), wading birds (6.45), and kingfishers (Figure 6.46) are the most common avian groups utilizing the estuary.

Bald Eagles. The bald eagle (*Haliaeetus leucocephalus*) is the national symbol of the United States and is listed as an endangered species by the State of Ohio (Ohio Division of Wildlife 1996). Two hundred years ago, when the first settlers arrived in northern Ohio, bald eagles were common along Lake Erie and in the coastal marshes and estuaries. As natural areas were converted to farms, harbors, and cities, the number of eagles declined. By 1975, only 4 active eagle nests remained in Ohio, all were along the shore of western Lake Erie. With the decreased use of many pesticides and the establishment of coastal preserves in recent decades, eagle numbers have increased to over 100 nests in 2004. In the past decade the bald eagle has become a relatively common raptor at the Reserve. During the winter months, as many as 14 individuals have been observed at one time roosting at the southern edge of the estuary and fishing in the nearshore waters of Lake Erie (Wright et al. 1997). Bald eagles are daytime feeders that primarily eat fish, but also consume waterfowl, small mammals, and carrion.

Mature bald eagles are easily identified by their large size, dark brown body, and conspicuous white head and tail (Figure 6.47). Immature eagles are a mottled brownish-gray color and acquire their white feathers at 3 to 5 years of age. Life expectancy in eagles is 15 to 20 years. The sexes are alike in appearance—females with an average weight of 5.4 kg are slightly larger than the males at 4.5 kg. An adult bird is about 80 cm long and has a wingspread of nearly 200 cm. Bald eagles are monogamous; the pair starts building a nest in December or January and nesting begins in February or March. The nest (sometimes called an eyrie) is usually located high in the fork of a large tree, often near a body of water. Many times the pair will simply add new branches, twigs, and grass to an existing nest (or even take over a great blue heron's nest) rather than build a new nest each year. In this way huge nests can be constructed, such as the "Great Nest" once located several kilometers to the east of the Reserve at Vermilion. This nest, the largest recorded in North America (Peterjohn 1989), was used from the 1891 to 1925 by several pairs of eagles until it fell 25 m to the ground during a storm. The nest measured nearly 4 m across by 2.5 m high, and weighed almost 2 tons.

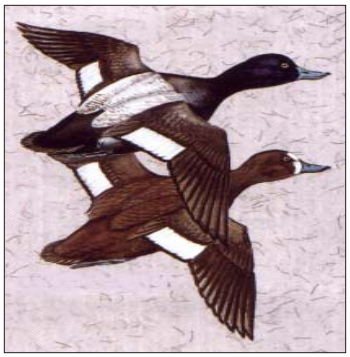
A clutch usually consists of 2 dull white eggs, sometimes 1, and rarely 3. The incubation period is about 35 days, with both the female and male taking

American black duck (*Anas rubripes*)

Blue-winged teal (*Anas discors*)

Bufflehead (*Bucephala albeola*)

Goldeneye (*Bucephala clangula)*



Lesser scaup (*Aythya affinis*)

Mallard (*Anas platyrhynchos*)

Ruddy duck (*Oxyura jamaicensis*)

Wood duck (*Aiix sponsa*)

Figure 6.44. Representative waterfowl of Old Woman Creek estuary (Ducks Unlimited Canada).

*Figure 6.45. Great blue heron (*Ardea herodias*), a common wading bird of the estuary (Cornell Laboratory of Ornithology).*

turns incubating the eggs and feeding the eaglets after they hatch. Young eagles normally leave the nest 10 to 13 weeks after hatching. The first documented nesting by a pair of bald eagles at the Reserve took place during the winter of 1994-1995. They constructed a nest in a large white oak tree between the prairie and the estuary shore, not far from the railroad bridge. One egg was laid, but soon after the male deserted the nest. Remarkably, the female carried on alone, successfully incubating, hatching, and feeding the eaglet and eventually fledging a young eagle. This may be the only recorded incident of single-parent rearing by a bald eagle. The next winter the pair returned to the same nest (at least the same female, but perhaps with a different male partner). Two eggs were laid, but failed to hatch; later tests indicated the eggs were viable until day 27, about a week short of the necessary incubation time for a successful hatch. In 1997, two young eagles were fledged from the nest, but one was later found dead on the railroad tracks. The next winter the pair moved the nest to a location on the east side of the estuary, not far from the U.S. Route 6 bridge, again in a high white oak tree. Two young eagles were successfully fledged from this nest in 1998. The following year was the most successful to date, when 3 eagles were fledged in July 1999. Again in 2000, two eaglets were fledged.

*Figure 6.46. Belted kingfishers (*Ceryle alcyon*), male at top and female at bottom, painted on Lake Erie driftwood (artist: B. Hamler).*

*Figure 6.47. Bald eagle (*Haliaeetus leucocephalus*) soars over Old Woman Creek estuary (Gene Wright).*

Class Mammalia

As the name of this class implies, mammals nurse their young and in most cases bear them alive at an advanced stage of development—the young being nourished within the mother's uterus. As in birds, a high body temperature is maintained, permitting continuous activity in a wide range of climatic conditions, especially terrestrial environments (Young 1962). The presence of hair or fur in many members aids in temperature maintenance. The brain is highly developed, particularly in regard to learning ability.

A total of 52 species of mammals have been reported from the region surrounding Old Woman Creek (Appendix F). Of this number 27 species have been reported from studies within the Old Woman Creek watershed (Figure 6.48). Eleven of the mammalian species were extirpated from the region in the 1800s (Mayfield 1962). Of the various families of mammals, only the Family Vespertilionidae (bats) is poorly represented in the Old Woman Creek watershed (1 species out of 8 species reported in the region). Patrick (1981) and Bernhardt (1985) have recorded most of the initial sightings from the Old Woman Creek watershed.

Young red fox (*Vulpes vulpes*)

Raccoon (*Procyon lotor*)

Groundhog (*Marmota monax*) in live trap

White-footed mouse (*Peromyscus leucopus*)

White-tailed deer fawn (*Odocoileus virginianus*)

Bison (*Bison bison*) in domesticated herd

Figure 6.48. Representative mammals of Old Woman Creek estuary and watershed (Glen Bernhardt, Charles E. Herdendorf, Gene Wright).