Abandoned single-row cornstalk binder on the Edward Walper Trail, Old Woman Creek NERR (Charles E. Herdendorf).

CHAPTER 9. LAND USE

PRE-HISTORY LAND USE

Archaeologists believe the ancestors of American Indians spread into North America from Asia soon after 20,000 years ago. These First Americans moved south and east into what is now northern Ohio shortly after the ice of the last great continental glaciers retreated northward. By about 11,000 years ago people called Paleo-Indians roamed the southern Great Lakes region, most likely hunting elephant-like herbivores, the American mastodon (*Mammut americanum*) and the mammoths (*Mammuthus primigenius* and *M. columbi*), the giant beaver (*Castoroides ohioensis*) a black bear-sized rodent, the ox-sized ground sloth (*Megalonyx jeffersonii*), the caribou (*Rangifer tarandus*), the tundra muskox (*Ovibos moschatus*), the elk-moose (*Cervalces scotti*) and several other Ice Age animals (Feldmann and Hackathorn 1996).

Lake Erie was already several thousand years old by this time, and Indian people began to take advantage of the rich biological diversity among the plant and animal communities of the lakeshore and tributary streams. The lower Old Woman Creek watershed, which has been occupied off and on for the past 10,000 years, was attractive to Indian people because of its well-drained sandy soil and its strategic location between the forest and lakeshore. The site's location provided protected access down the valley and through the estuary to the lake for fishing and commerce, and immediate entry to nearby upland forests with their rich harvest of plant foods and game (Shane 1992).

Then, about three thousand years ago, the way of life of Indian people in much of eastern North America began to undergo a fundamental change, partially in response to the cultivation of certain plants for food. Cultivated plant foods supplemented a subsistence economy based on hunting, gathering, and fishing, and by about 900 A.D., Indian farmers became reliant on corn, beans, squash and sunflower for a significant portion of their food. As discussed in Chapter 8, the major village in the Reserve was occupied during the 15th century, the late Woodland Period. Although the villagers farmed corn, it is believed that farming was less important to the village economy than hunting, fishing, or gathering (Shane 1981, 1992).

For nearly 10,000 years man developed and refined methods of successfully exploiting the watershed environment for basic needs. About 5,000 years ago the estuary formed as the level of Lake Erie rose and flooded the valley, thus creating a very productive environment to sustain the Indian population. Although lifeways changed significantly from Paleo-Indians to the American Indians that made contact with the European settlers in the late 1700s, the importance of natural resources in everyday life remained constant. Clay from the soil, plants of the wetlands and forests, fish, birds, and mammals were essential to the survival of all these native cultures (Shane 1992).

HISTORICAL USE OF THE WATERSHED

In 1795, the Greenville Treaty was signed between the United States and the Ohio Indian tribes. This pact began an era that would see the Indians lose all their Ohio lands to the young American government. In 1805, Almon Ruggles came to the Old Woman Creek area to survey the land for the state of Connecticut. This territory was originally part of lands claimed by England as a result of the French and Indian War. Under a charter from the King of England, Connecticut laid claim to the territory that included all of present-day Erie County and Huron County, which includes the Old Woman Creek watershed. Following the American Revolution, colonies were requested to cede their holdings of western land to the newly formed government. Connecticut agreed to turn over their colonial holdings except for one western tract reserved for the state. During the American Revolution many residents of Connecticut had lost their property. In return for damages suffered (mainly by fire), the state agreed to give land to these citizens in lieu of monetary payment. In 1792 the westernmost 500,000 acres of the "Connecticut Western Reserve" was set aside as "The Firelands," to be divided among some 1,870 claimants.

Early Firelands pioneers found the land surrounding Old Woman Creek covered by dense forests of oak, chestnut, hickory, ash, walnut, sycamore, and whitewood (tuliptree). The generally rich, sandy soils in Berlin and Huron Townships were well suited for agriculture and the climate, moderated by the proximity of Lake Erie, was favorable for fruit farming. Fruit trees were first brought to the Old Woman Creek area from Canada in 1812, and became an important crop in the years to follow (Gordon 1966,1969).

During the 19th century, historical records indicate that saw mills, sandstone quarries (Figure 9.1), grist mills and at least one salt well were situated within the Old Woman Creek watershed. Small fruits such as strawberries, raspberries, and grapes were also commercially imported to this region throughout the next hundred years. Hardwood timber, particularly oak, was sought by the ship building industry in nearby Huron. This community was the largest steamship building site on the Great Lakes in 1830 (Herdendorf & Schuessler 1993).

By 1874, most of the land surrounding Old Woman Creek had been cleared, timber removed, and ditches opened to drain agricultural lands (Figures 9.2 to 9.4). These factors contributed to annual flooding of the creek, rendering its flood plain “worthless” to farmers (Wright 2000).

The last commercial ventures in the land that would become Old Woman Creek Reserve or estuary began about 1880 on Star Island in the middle of the creek. At this time, the island was accessible from the mainland in dry weather via a road through the cat-tail marsh. Charles Hardy is believed to have bought the 10-acre island from James Anderson and during the winters of the next five years, proceeded to remove the virgin hardwood timber. Then, in 1899, Martin Daniels purchased the island, built a house and barn, and raised his family there. The island was cultivated in strawberries. raspberries, grapes, red currants and tree fruits. The Daniels’ family business venture met quick success. Through the early 1900s, the Daniels’ expanded their business to include a retail outlet on the island where tourists could buy grapes, berries, and honey. With the approach of the “Great Depression” years, fruit prices dropped and the family was forced out of business and left their island farm (Wright 1981).

The immediate vicinity surrounding Old Woman Creek National Estuarine Reserve has remained relatively undisturbed since the island occupation in

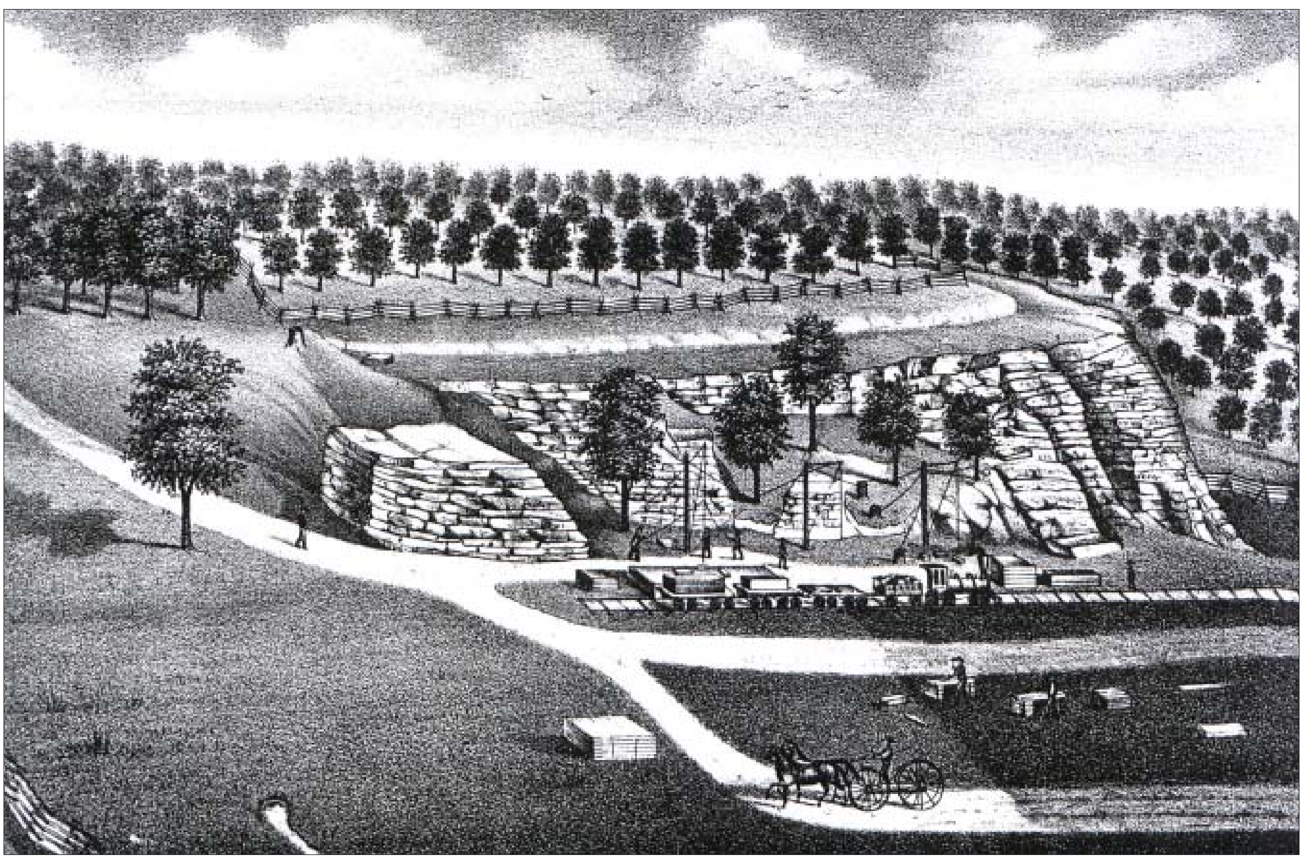

Figure 9.1. Sandstone quarry on the Berea Escarpment at Berlin Heights (Stewart & Page 1874).

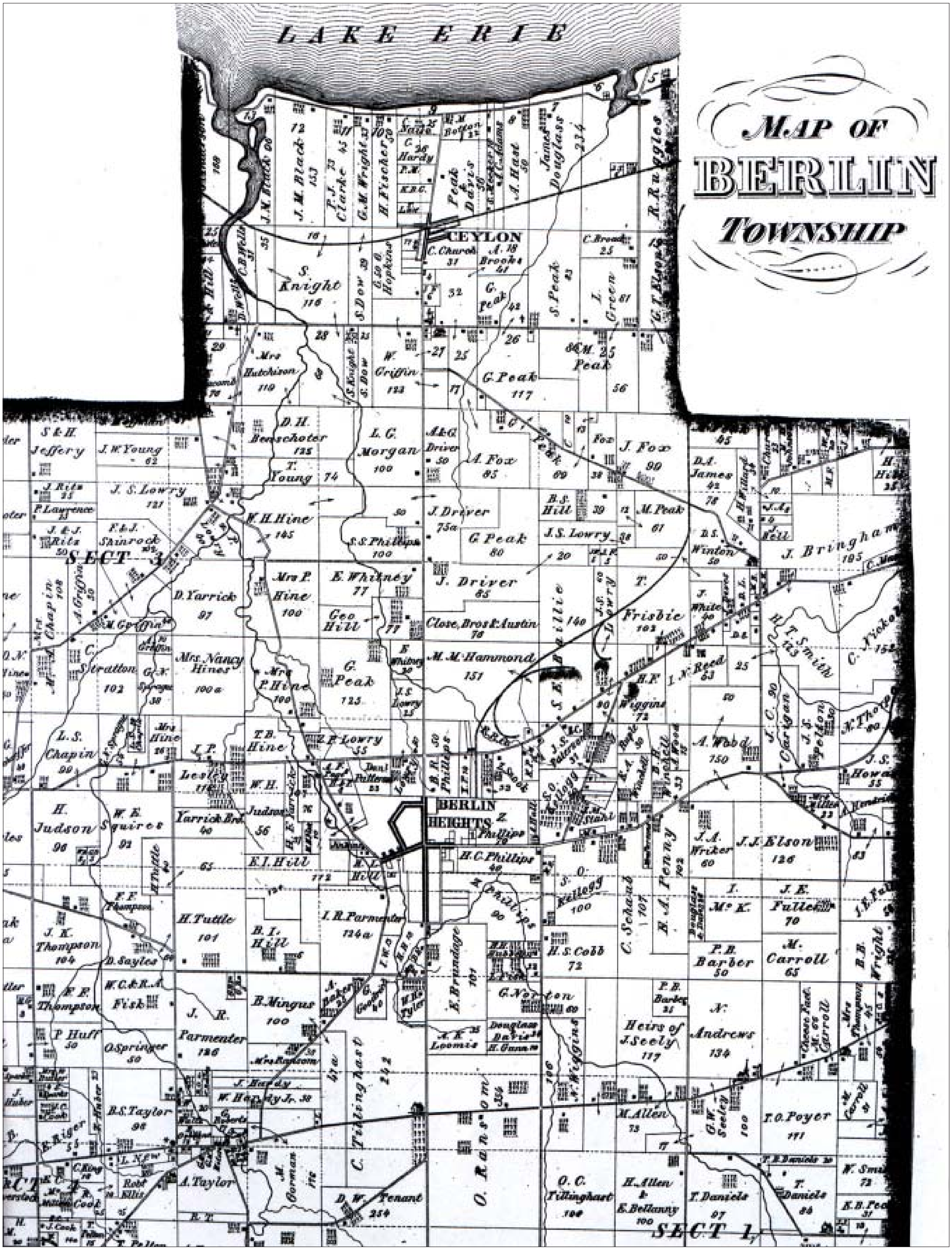

Figure 9.2. Property map of Berlin Township showing location of Old Woman Creek at upper left (Stewart & Page 1874).

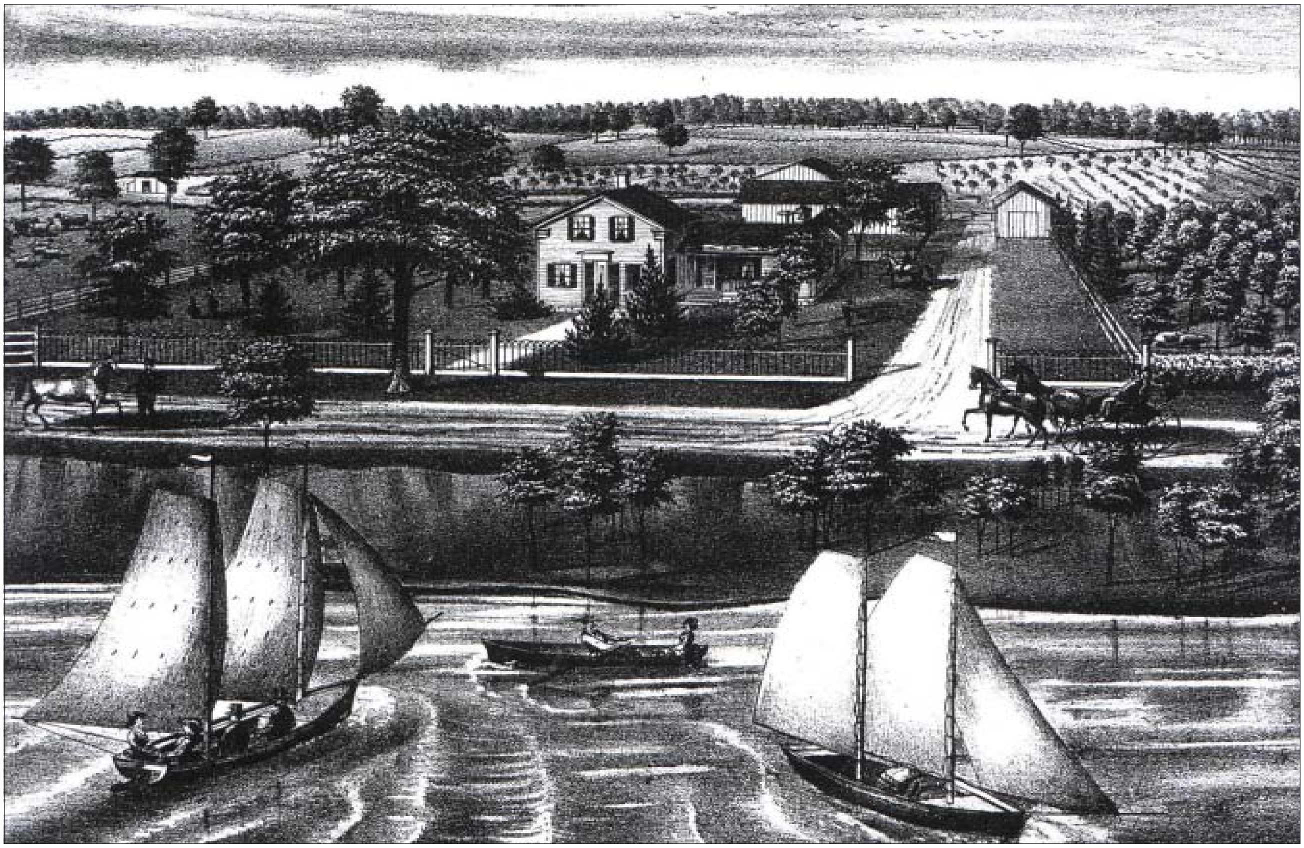

Figure 9.3. James Douglass house on lakeshore 3 km east of Old Woman Creek (Stewart & Page 1874).

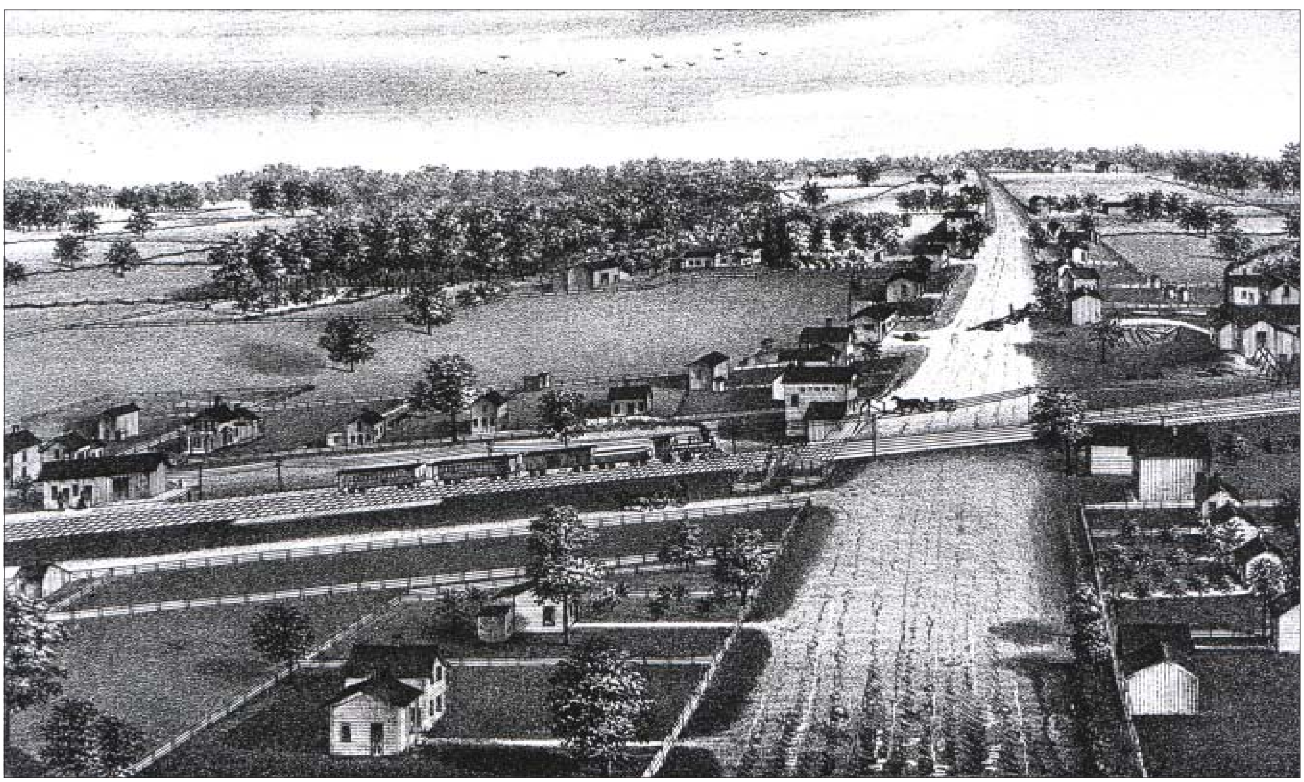

Figure 9.4. Aerial view of Ceylon showing Old Woman Creek valley at upper left (Stewart & Page 1874).

1929 for several reasons. Perhaps the most important factor has been the attitude of landowners controlling the critically located properties near the creek mouth. Three groups of people resisted the pressures from developers who would have altered the natural character of Old Woman Creek in pursuit of recreational activities and urban expansion.

The Anderson family owned the land along the estuary's western bank from 1839 until the Ohio Department of Natural Resources purchased a portion of it for the Reserve. The upland portion of this property was farmed throughout their ownership. The northernmost property on the west bank of Old Woman Creek Estuary is the Hartley homestead. This property has been in the family since the middle 1800s. Fruit and vegetable farming was the primary family vocation for two generations, and today a third generation of the Hartley family resides on the shores of the estuary. The Hartley family's strong feeling of tradition has been their incentive for maintaining the land as it is.

The third property owner instrumental in keeping Old Woman Creek in a relatively undisturbed condition was Oberlin College Beach Association. About 1917, Oberlin College trustees purchased several acres along the eastern banks of the creek. Cottages were built on the lakeshore portion of their property, but the southern portion along the estuary was preserved in its natural condition and has been managed as a private nature preserve throughout their ownership. The concern for the area's natural features by these landowners was a key in attracting ODNR to Old Woman Creek. It was through the combined efforts of local civic organizations, environmental groups, and interested citizens that Old Woman Creek National Estuarine Research Reserve became a reality.

LAND USE IN THE 20TH CENTURY

In conjunction with the Institute for Resource Information Systems of Cornell University, Old Woman Creek NERR conducted a comparative study of land use patterns within the Old Woman Creek watershed for the years 1937 and 1993 (Herdendorf 1997a). From the earliest (1937) and the most recent (1993) aerial photographs of the watershed, some 30 land use categories were discriminated and plotted for the entire 69 km^2 watershed. Once plotted, the area of each of the hundreds of individual land use polygons was determined with a polar planimeter. The results of these determinations, summarized by political subdivision (townships and counties), are presented in Tables 9.1 and 9.2. A comparison of the two time periods is presented in Table 9.3.

The most notable changes occurred in the agricultural and forest land categories. While active farm lands decreased by nearly 24% in the 56-year period, forested lands rose by over 16%. Presumably about 70% of the farm land that was vacated in the intervening years was permitted to return to woodlands. Other modest gains occurred in the residential and transportation categories, approximately 3% each. From a total area standpoint, human land use of the watershed was less intense in the early 1990s than it was in the late 1930s. However, from an ecological viewpoint, the modern application of fertilizers, pesticides, and herbicides in the 1990s may overshadow this apparent environmental improvement.

CURRENT LAND USE CONCERNS

Today, in the year 2003, the major land use in the Old Woman Creek watershed is agriculture (Figures 3.7 and 9.5). The fertile silt and sand loam soils of the area, complimented by the prolonged growing season due to the "lake effect" (see Chapter 4) are currently producing high yields of corn, soybeans, wheat, orchard fruit, and other produce associated with "truck farms." The economy of the area, however, is entering a transitional stage, as agricultural lands are being preempted by the outward growth of the city of Huron.

The area immediately surrounding the Old Woman Creek Reserve is undergoing rapid growth in planning for and construction of residential subdivisions and light industry. This development has been brought about, in large part, by recent improvements in the transportation infrastructure. With the completion of 4-lane State Route 2 in the late 1980s, with access ramps on both the east and west sides of the estuary, the lower Old Woman Creek watershed is becoming an attractive residential and commercial site. This "attractiveness" has already become a management-boundary-water quality concern for the Reserve. Maintaining the integrity of the natural estuarine community will continue to be a problem for future Reserve operations and management. Of particular concern will be: (1) surface runoff from adjacent and watershed-wide development, (2) protection of the Reserve from trespass in areas other

TABLE 9.1. OLD WOMAN CREEK WATERSHED LAND USE BY POLITICAL SUBDIVISION: 1937

Land Use (Code)	Berlin Twp.	Florence Twp.	Huron Twp.	Milan Twp.	Erie County	Townsend Twp.	Wakeman Twp.	Huron County	Watershed Total	Watershed Percent (%)
AGRICULTURE										
Cropland/crop-pasture (Ac)	2,943.3 ha	106.5 ha	100.8 ha	79.9 ha	3,230.5 ha	1,072.4 ha		1,072.4 ha	4,302.9 ha	62.7
Horticulture (Ah)										
Orchard (Ao)	321.6	8.7		1.7	332.0	9.3	0.5 ha	9.8	341.8	5.0
Permanent pasture (Ap)	939.3	40.4	3.9	7.4	991.0	216.0		216.0	1,207.0	17.6
High-intensity cropland (At)										
Vineyard (Av)	1.3				1.3				1.3	<0.1
Agriculture inactive (Ai)	152.9	3.5		8.6	165.0	20.3	4.1	24.4	189.4	2.8
COMMERCIAL										
Commercial strip (Cs)	1.6				1.6				1.6	<0.1
COMMUNICATION										
Service facilities (Tt)										
EXTRACTIVE										
Stone quarry (Es)										
Mining, underground (Eu)										
FOREST LAND										
Brush cover, <10 m (Fc)	191.8			3.1	194.9	34.6	2.1	36.7	231.6	3.4
Forest, >10 m tall (Fn)	281.6			0.8	282.4	43.7		43.7	326.1	4.8
INDUSTRIAL										
Light manufacturing (Il)	0.7				0.7				0.7	<0.1
NON-PRODUCTIVE										
Sand, beach (Ns)	0.1				0.1				0.1	<0.1
PUBLIC										
All categories (P)	8.2				8.2				8.2	0.1
RECREATION										
Outdoor (Or)										

TABLE 9.1. OLD WOMAN CREEK WATERSHED LAND USE BY POLITICAL SUBDIVISION: 1937 (cont'd)

Land Use (Code)	Berlin Twp.	Florence Twp.	Huron Twp.	Milan Twp.	Erie County	Townsend Twp.	Wakeman Twp.	Huron County	Watershed Total	Watershed Percent (%)
RESIDENTIAL										
Medium density (Rm)	36.0				36.0				36.0	0.5
Low density (Rl)				12.5				12.5	12.5	0.2
Residential strip (Rs)										
Migrant labor camp (Rc)										
TRANSPORTATION										
Railroad (Tr)	20.9		1.4		22.3	1.2		1.2	23.5	0.3
Highway, limited access (Th)										
Highway, primary (Tp)	19.3				19.3	1.4		1.4	20.7	0.3
Highway, secondary (Ts)	57.0	1.1	0.8	1.4	60.3	12.7	0.4	13.1	73.4	1.1
URBAN										
Urban inactive (Ui)										
WATER RESOURCES										
Artificial/farm pond (Wc,Fp)	0.1				0.1				0.1	<0.1
Freshwater estuary (We)	41.0				41.0				41.0	0.6
Natural (Wn)										
Streams (Ws)	8.7				8.7				8.7	0.1
WETLANDS										
Marsh/shrub wetland (Wb)	10.5				10.5	0.5		0.5	11.0	0.2
Wooded wetland (Ww)	22.2				22.2				22.2	0.3
TOTAL	5,070.6	160.2	106.9	102.9	5,440.6	1,412.1	7.1	1,419.2	6,859.8	100.0

Data Sources:

Institute for Resource Information System 1937 Old Woman Creek watershed, Huron Ohio: 1937 land use/land cover. Cornell University, Ithaca, New York. 1 map.

U.S. Geologocal Survey: 7.5 Topographic quadrangle maps for Berlin Heights, Ohio (1979); Clarksfield, Ohio (1972); Huron, Ohio (1979); Milan, Ohio (1969); Vermilion West, Ohio (1979).

Land Use Code Detail:

COMMERCIAL

Commercial strip (Cs) <33% intermixture of residential strip

RESIDENTIAL

Medium density (Rm) 15-30 m frontage

Low density (Rl) >30 m frontage

Residential strip (Rs) <33% intermixture of commercial strip

TABLE 9.2. OLD WOMAN CREEK WATERSHED LAND USE BY POLITICAL SUBDIVISION: 1993

Land Use (Code)	Berlin Twp.	Florence Twp.	Huron Twp.	Milan Twp.	Erie County	Townsend Twp.	Wakeman Twp.	Huron County	Watershed Total	Watershed Percent (%)
AGRICULTURE										
Cropland/crop-pasture (Ac)	2,381.3 ha	138.8 ha	67.6 ha	94.8 ha	2,682.5 ha	1,228.2 ha	7.1 ha	1,235.3 ha	3,917.8 ha	57.1
Horticulture (Ah)	2.9				2.9				2.9	<0.1
Orchard (Ao)	180.4				180.4				180.4	2.6
Permanent pasture (Ap)	209.0				209.0	22.0		22.0	231.0	3.4
High-intensity cropland (At)	31.5				31.5				31.5	0.5
Vineyard (Av)										
Agriculture inactive (Ai)	122.4				122.4	8.1		8.1	130.5	1.9
COMMERCIAL										
Commercial strip (Cs)	8.8				8.8	2.7		2.7	11.5	0.2
COMMUNICATION										
Service facilities (Tt)	6.6				6.6	0.5		0.5	7.1	0.1
EXTRACTIVE										
Stone quarry (Es)						10.2		10.2	10.2	0.1
Mining, underground (Eu)						0.6		0.6	0.6	<0.1
FOREST LAND										
Brush cover, <10 m (Fc)	415.4	2.7	12.5	0.5	431.1	40.0		40.0	471.1	6.9
Forest, >10 m tall (Fn)	1,116.3	20.6	1.0	4.4	1,142.3	84.0		84.0	1,226.3	17.9
INDUSTRIAL										
Light manufacturing (Il)	7.7			0.7	8.4				8.4	0.1
NON-PRODUCTIVE										
Sand, beach (Ns)	2.1				2.1				2.1	<0.1
PUBLIC										
All categories (P)	12.8		4.0		16.8				16.8	0.2
RECREATION										
Outdoor (Or)	14.8				14.8				14.8	10.2
RESIDENTIAL										
Medium density (Rm)	113.6				113.6				113.6	1.7
Low density (Rl)	119.0			3.2	122.2	1.0		1.0	123.2	1.8
Residential strip (Rs)	14.6				14.6				14.6	0.2
Migrant labor camp (Rc)	1.8				1.8				1.8	<0.1

TABLE 9.2. OLD WOMAN CREEK WATERSHED LAND USE BY POLITICAL SUBDIVISION: 1993 (cont'd)

Land Use (Code)	Berlin Twp.	Florence Twp.	Huron Twp.	Milan Twp.	Erie County	Townsend Twp.	Wakeman Twp.	Huron County	Watershed Total	Watershed Percent (%)
TRANSPORTATION										
Railroad (Tr)	15.3		1.1		16.4	1.2		1.2	17.6	0.3
Highway, limited access (Th)	67.5		11.7	2.9	82.1				82.1	1.2
Highway, primary (Tp)	19.3				19.3	1.4		1.4	20.7	0.3
Highway, secondary (Ts)	57.0	1.1	0.8	1.4	60.3	12.7	0.4	13.1	73.4	1.1
URBAN										
Urban inactive (Ui)	5.4				5.4				5.4	0.1
WATER RESOURCES										
Artificial/farm pond (Wc,Fp)	17.7				17.7	3.2		3.2	20.9	0.3
Freshwater estuary (We)	51.9				51.9				51.9	0.7
Natural (Wn)	1.3				1.3				1.3	<0.1
Streams (Ws)	12.7				12.7				12.7	0.2
WETLANDS										
Marsh/shrub wetland (Wb)	22.7	0.8			23.5	0.7		0.7	24.2	0.4
Wooded wetland (Ww)	31.3			1.7	33.0				33.0	0.5
TOTAL	5,063.1	164.0	98.7	109.6	5,435.4	1,416.5	7.5	1,424.0	6,859.4	100.0

Data Sources**:**

Institute for Resource Information System 1993 Old Woman Creek watershed, Huron Ohio: 1993 land use/land cover. Cornell University, Ithaca, New York. 1 map.

U.S. Geologocal Survey: 7.5 Topographic quadrangle maps for Berlin Heights, Ohio (1979); Clarksfield, Ohio (1972); Huron, Ohio (1979); Milan, Ohio (1969);Vermilion West, Ohio (1979).

Land Use Code Detail:

COMMERCIAL

Commercial strip (Cs)	<33% intermixture of residential strip

RESIDENTIAL

Medium density (Rm)	15-30 m frontage
Low density (Rl)	>30 m frontage
Residential strip (Rs)	<33% intermixture of commercial strip

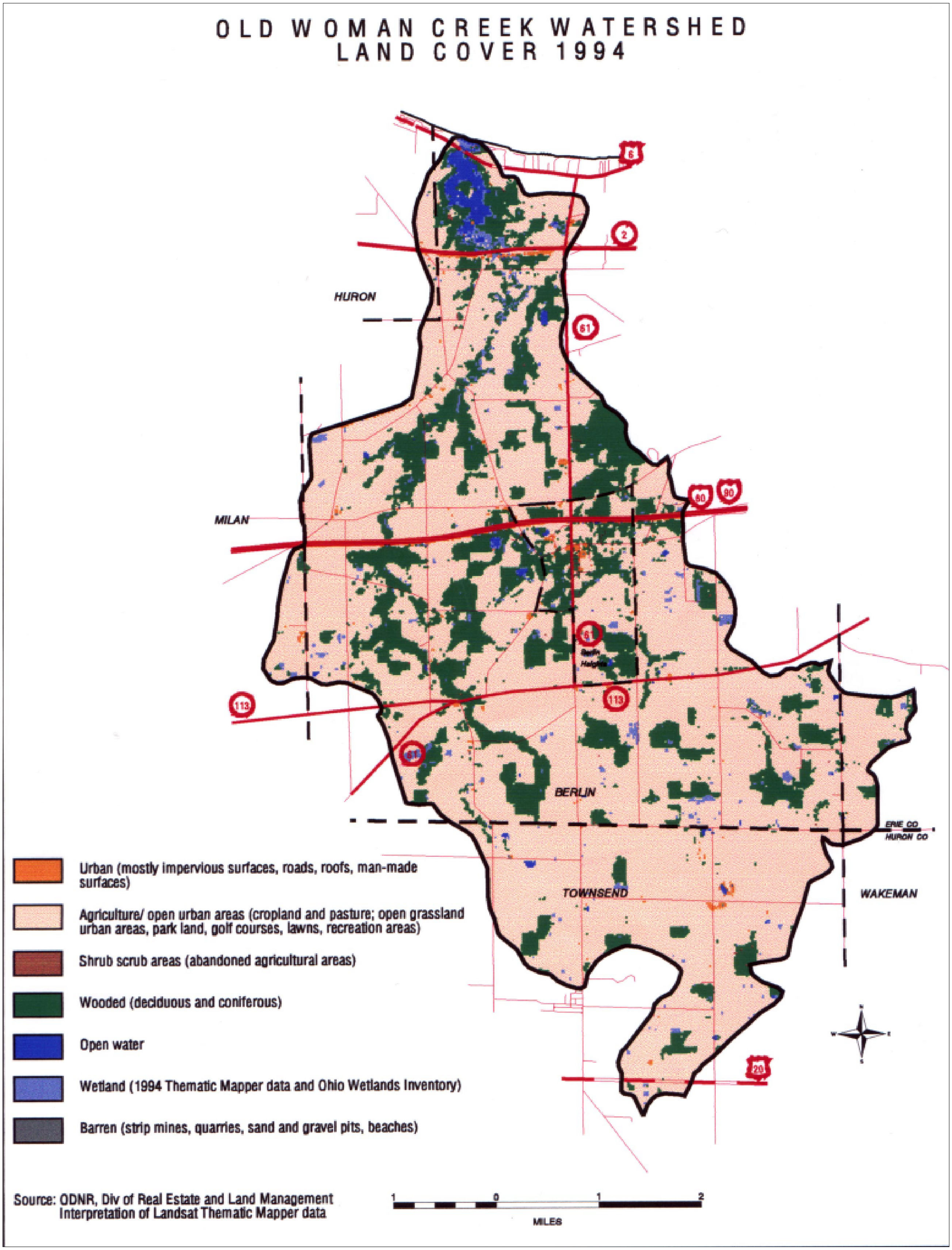

Figure 9.5. Land use patterns in Old Woman Creek watershed.

TABLE 9.3. COMPARATIVE CHANGES IN LAND USE FOR OLD WOMAN CREEK WATERSHED: 1937 AND 1993

Land Use Type	1937 Percent (%)	1993 Percent (%)	Percent Change (%)
Agriculture			
Cropland	66.3	59.5	-6.8
Orchard & Vineyard	5.1	2.6	-2.5
Pasture	17.9	3.4	-14.5
	89.3	65.5	-23.9
Commercial & Manufacturing	<0.1	0.5	+0.5
Forest	8.3	24.8	+16.5
Residential	0.8	4.2	+3.4
Water	1.2	2.1	+0.9
Transportation	0.3	2.9	+2.6
TOTAL	100.0	100.0	

than designated access points, (3) aesthetic pollution, such as visual, lights, and noise, (4) non-point source pollution from certain agricultural practices and failing domestic septic and commercial systems within the watershed, and (5) environmental risks aggravated by increased highway and rail traffic on transportation corridors through the Reserve.

HUMAN POPULATION

Old Woman Creek National Estuarine Research Reserve is located in the coastal area of central Lake Erie in eastern Erie County, Ohio (Figure 9.6). Studies conducted by Holly (1986) indicated that the Research Reserve was part of the Northeast Ohio Urban Field centered on Cleveland. He pointed out that economic and demographic trends in the 1960s and 1970s suggested that Erie County would experience a significant population expansion as a result of increased recreational and retirement use of Lake Erie coast and the dispersal of population away from cities to the east. Holly projected a 4,500-person population increase for the coastal area between Huron and Vermilion, Ohio between 1980 and 1990, and a 12,000-person increase by the year 2005. Therefore, he recommended immediate and long-term actions to preserve the Reserve's natural integrity.

Analysis of recent population data shows that the forecasted increases never materialized, and indeed, the coastal and upper watershed populations decreased from 1980 to 1990. The purpose of the following report

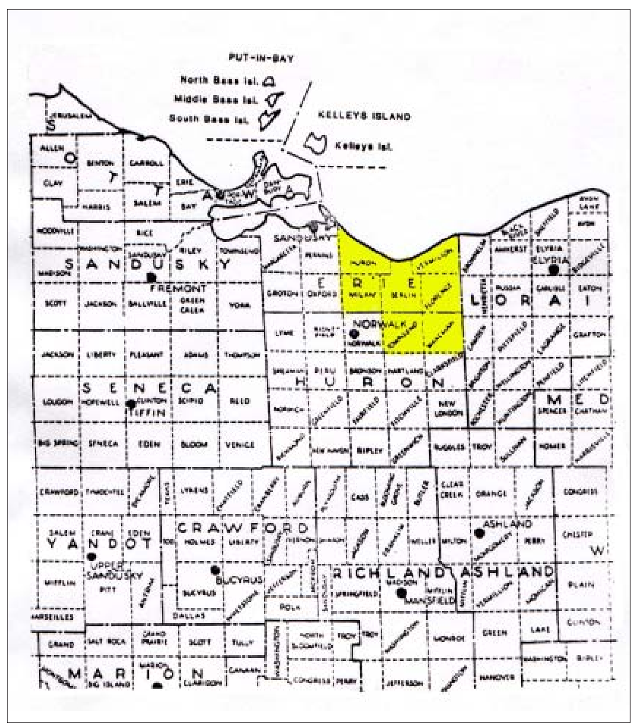

Figure 9.6. Location of political subdivisions surrounding Old Woman Creek watershed. In 1996 the watershed had a population of 33,873 in 11,502 households.

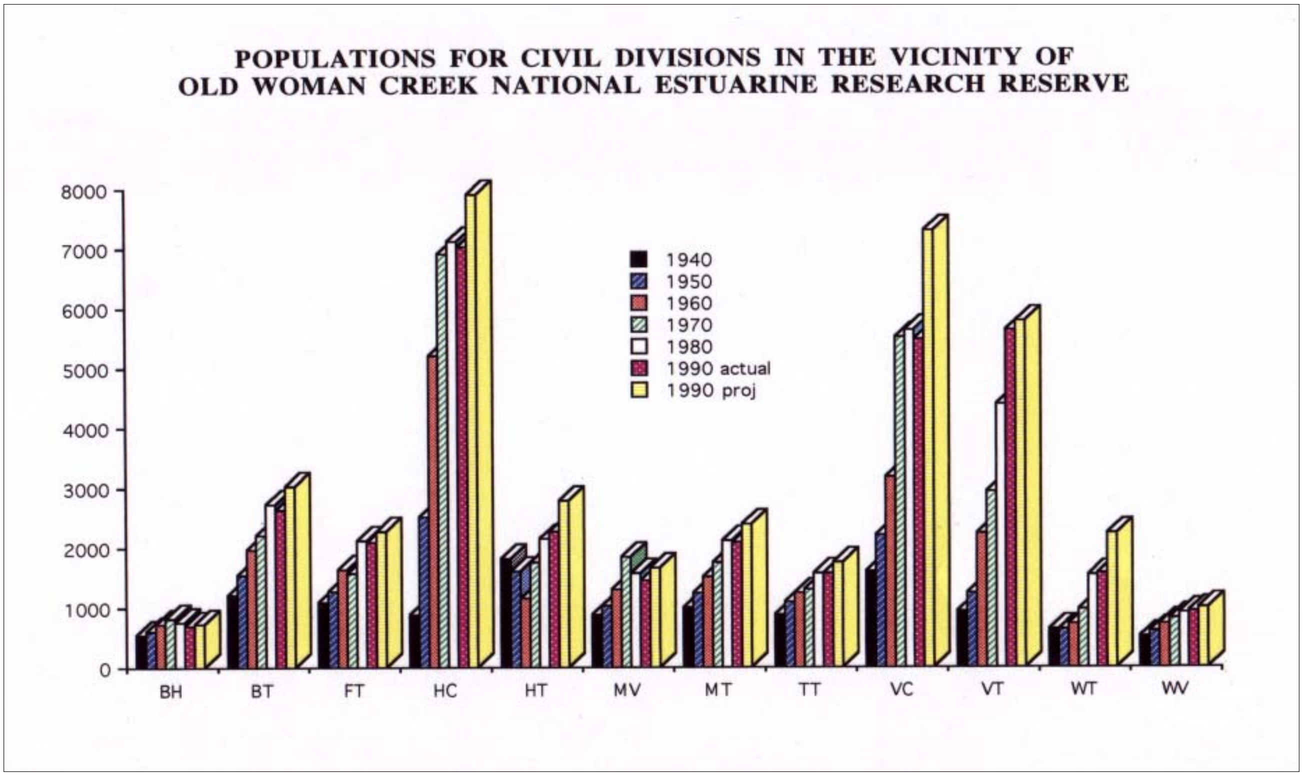

Figure 9.7. Population trends for Old Woman Creek watershed vicinity area from 1940 to 1990.

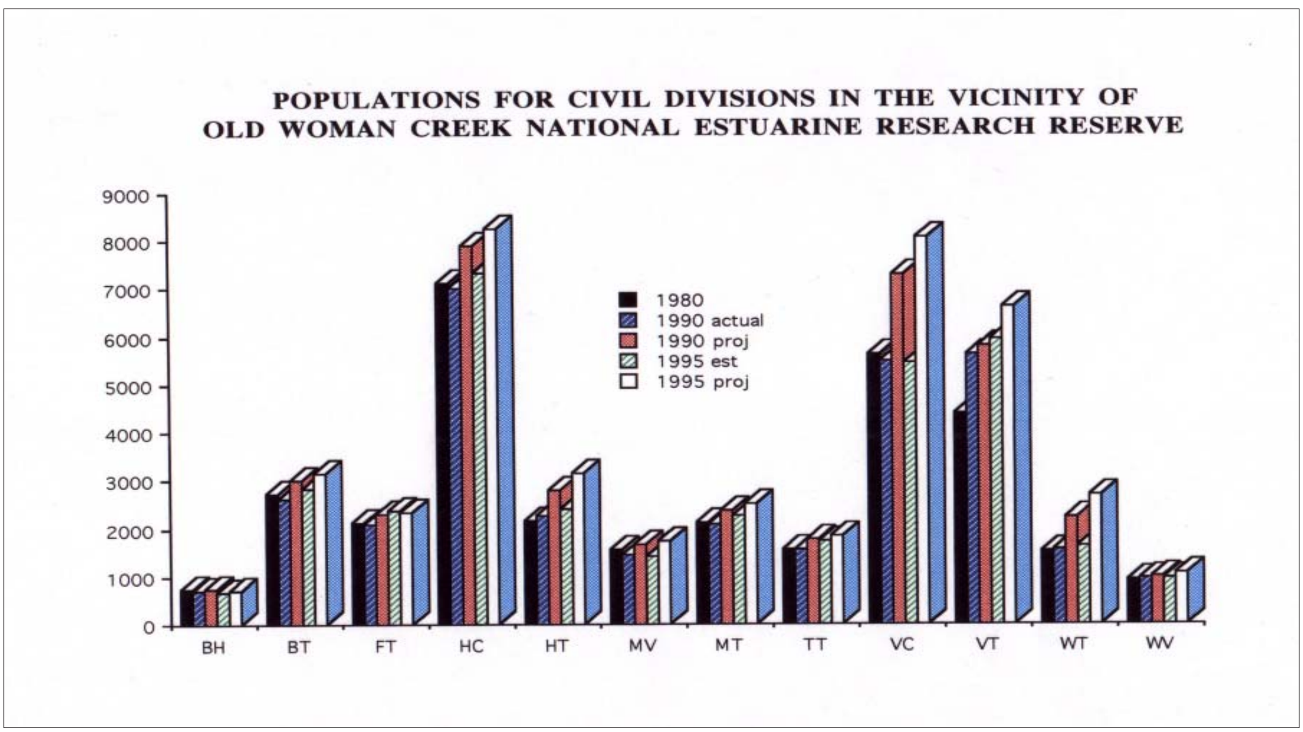

Figure 9.8. Population trends for Old Woman Creek watershed vicinity area from 1980 to 1995.

BH–Berlin Heights; BT–Berlin Township; FT–Florence Township; HC–Huron City; HT–Huron Township; MV–Milan Village; MT–Milan Township; TT–Townsend Township; VC–Vermilion City; VT–Vermilion Township; WT–Wakeman Township; WV–Wakeman Village.

TABLE 9.4. POPULATION SATISTICS FOR CIVIL DIVISIONS SURROUNDING OLD WOMAN CREEK NATIONAL ESTUARINE RESEARCH RESERVE

	1940[1]	1950[1]	1960[1]	1970[1]	1980[1]	1990[1]	1990[2] proj.	1995[3] est.	1995[2] proj.
COASTAL AREAS (ERIE COUNTY)									
Berlin Twp Annex[4]	371	456	583	657	806	777	896	838	937
Huron City	870	2,512	5,197	6,896	7,123	7,067	7,908	7,322	8,269
Huron Twp	1,827	1,605	1,161	1,745	2,156	2,093	2,782	2,393	3,137
Vermilion City	1,616	2,214	3,183	5,500	5,634	5,483	7,207	5,458	8,090
Vermilion Twp	931	1,253	2,256	2,946	4,393	4,051	5,798	4,369	6,610
	5,615	8,040	12,380	17,744	20,112	19,471	24,591	20,380	27,043
UPPER WATERSHEDS (ERIE COUNTY)									
Berlin Twp[5]	833	1,084	1,387	1,565	1,919	1,851	2,132	1,996	2,231
Berlin Heights	552	613	721	828	756	691	733	680	717
Florence Twp	1,102	1,278	1,648	1,576	2,119	2,101	2,286	2,361	2,356
Milan Twp	987	1,233	1,517	1,749	2,129	2,230	2,382	2,257	2,501
Milan Village	719	846	1,076	1,297	1,181	1,056	1,174	1,014	1,162
	4,193	5,054	6,349	7,015	8,104	7,929	8,707	8,308	8,967
UPPER WATERSHEDS (HURON COUNTY)									
Milan Village[6]	156	182	233	565	388	408	504	418	570
Townsend Twp	885	1,105	1,234	1,295	1,571	1,571	1,765	1,745	1,854
Wakeman Twp	647	646	718	964	1,540	1,567	2,248	1,618	2,692
Wakeman Village	522	620	728	822	906	951	1,005	971	1,049
	2,054	2,553	2,913	3,646	4,405	4,497	5,522	4,752	6,165

NOTES:
1. U.S. Bureau of the Census
2. Projections by Holly (1986)
3. Ohio Department of Development, Office of Strategic Research
4. Northern extension of Berlin Twp; estimated for 1940 & 1950 based on 1960 ratio
5. Berlin Twp Annex excluded
6. Estimated for 1940 & 1950 based on 1960 ratio

is to evaluate Holly's population forecasts and to provide a more recent appraisal of population trends.

POPULATION TRENDS

The human population in the vicinity of Old Woman Creek NERR (coastal area of Erie County from Huron to Vermilion) experienced a sustained high growth rate during the 1940s, 1950s, and 1960s (43%, 54%, and 43% increase per decade, respectively), moderate growth rate in the 1970s (13% increase), and a modest decline in the 1980s (3% decrease) (Figure 9.7; Table 9.4). Population estimates by the Ohio Department of Development for the first half of the 1990s indicate a projected growth rate for the decade of 9% (Figure 9.8; Table 9.4). The population in the upper reaches of the watersheds between Milan and Florence showed a similar trend with less dramatic changes. The number of residents in the townships and villages away from the coast rose in the 1960s (10% increase), continued a substantial growth in the 1970s (16% increase), and declined in the 1980s (2% loss). Likewise population forecasts for the 1990s indicate a decade growth rate of 10% (Figure 9.8, Table 9.4).

The 1996 population of the 14 civil divisions surrounding Old Woman Creek watershed was estimated by the Ohio Department of Development at 33,873 persons (Table 9.5). The average household size for these divisions ranges from 2.8 to 3.2 persons (Erie County Regional Planning Commission 1980, Holly 1986). These factors yield a total of 11,502 households in the region bounded on the northwest by Huron, northeast by Vermilion, and southwest by Milan (Figure 9.6). Concerning environmental impacts, this population has a daily water use of about 21,000 m^3

TABLE 9.5. POPULATION AND ENVIRONMENTAL IMPACTS FOR CIVIL DIVISIONS ADJACENT TO OLD WOMAN CREEK WATERSHED

	Population[1] (1996 est.)	Households[2] (no.)	Water Use[3] (m^3/day)	Sewage[4] (m^3/day)	Traffic[5] (trip/day)
ERIE COUNTY					
Berlin Heights	680	217	386	193	2,170
Berlin Twp	2,882	918	1,637	818	9,180
Florence Twp	2,431	757	1,381	690	7,570
Huron City	7,381	2,636	4,192	2,096	26,360
Huron Twp	2,295	820	1,304	652	8,200
Milan Twp	2,430	821	1,380	690	8,210
Milan Village	1,007	340	572	286	3,400
Vermilion City	5,456	1,801	3,099	1,550	18,010
Vermilion Twp	4,442	1,466	2,523	1,262	14,660
HURON COUNTY					
Milan Village	420	142	239	119	1,420
Townsend Twp	1,817	647	1,032	516	6,470
Wakeman Twp	1,637	583	930	465	5,830
Wakeman Village	995	354	565	283	3,540
TOTAL	33,873	11,502	19,240	9,620	115,020

NOTES:
1. Ohio Department of Development, Office of Strategic Research
2. Household size based on 3.14 persons for Berlin Heights and Berlin Twp; 3.21 for Florence Twp; 2.80 for Huron City and Huron Twp; 2.96 for Milan Twp and Milan Village; 3.03 for Vermilion City and Vermilion Twp; 2.81 for Townsend Twp, Wakeman Twp, and Wakeman Village (Holly 1986)
3. Water use based on per capita use of 0.568 m^3 (150 gal) per day
4. Sewage based on per capita rate of 0.284 m^3 (75 gal) per day
5. Traffic based on 10 vehicular trips per day per household

and generates 10,500 m^3 of sewage. Based on an average daily traffic generation rate of 10 vehicular trips per household (including all local trips for work, shopping, personal activities, mail delivery, trash pick-up, and commercial services), some 120,000 vehicular trips are made in the above described region.

Table 9.6 presents the areas, populations, households, and densities for the 14 civil divisions adjacent to Old Woman Creek watershed. The cities of Vermilion and Huron have the highest population densities at 1,093/km^2 and 574/km^2, respectively and Wakeman Twp. has the lowest density at 25/km^2. As expected, the housing densities are roughly proportional to the population sizes.

POPULATION FORECASTS

Holly (1986) performed a demographic and economic analysis of the region surrounding Old Woman Creek watershed and concluded that eastern Erie County lies in the path of the population expansion resulting from increased recreational and retirement use of the Lake Erie coast and the general dispersal of population away from central cities, such as Cleveland and Lorain. He predicted that Old Woman Creek National Estuarine Research Reserve will be affected by this development, necessitating intermediate and long-term forecasting and planning to preserve the Reserve as a research and interpretive natural area.

TABLE 9.6. POPULATION AND HOUSING DENSITY FOR CIVIL DIVISIONS ADJACENT TO OLD WOMAN CREEK WATERSHED

	Population[1] (1996 est.)	Households[2] (no.)	Area[3] (km^2)	Population Density[4]	Household Density[5]
ERIE COUNTY					
Berlin Heights	680	217	4.03	168.7	53.8
Berlin Twp	2,882	918	73.94	39.0	12.4
Florence Twp	2,431	757	66.52	36.5	11.4
Huron City	7,381	2,636	12.85	574.4	205.1
Huron Twp	2,295	820	47.25	48.6	17.4
Milan Twp	2,430	821	63.49	38.3	12.9
Milan Village	1,007	340	1.80	559.4	188.9
Vermilion City	5,456	1,801	4.99	1,093.4	360.9
Vermilion Twp	4,442	1,466	50.92	87.2	28.8
HURON COUNTY					
Milan Village	420	142	1.43	293.7	99.3
Townsend Twp	1,817	647	66.01	27.5	9.8
Wakeman Twp	1,637	583	64.40	25.4	9.1
Wakeman Village	995	354	1.97	505.1	179.7
TOTAL	33,873	11,502	495.60		
			MEAN	68.3	23.2

NOTES:
1. Ohio Department of Development, Office of Strategic Research
2. Household size based on 3.14 persons for Berlin Heights and Berlin Twp; 3.21 for Florence Twp; 2.80 for Huron City and Huron Twp; 2.96 for Milan Twp and Milan Village; 3.03 for Vermilion City and Vermilion Twp; 2.81 for Townsend Twp, Wakeman Twp, and Wakeman Village (Holly 1986)
3. Erie Regional Planning Commission (1970); Erie County Office of Engineer; Huron County Highway Dept.
4. Population density in number of residents per km^2
5. Household density in numbers of home sites per km^2

The forecasts made by Holly (1986) indicated steady increases in population in the townships and cities contiguous to and near the Research Reserve, with a 12,000-person increase along the coastal area from Huron to Vermilion for the 25-year period of 1980 to 2005. Rural, agricultural areas away from the coast, in the upper reaches of the watershed, were predicted to increase steadily, but more slowly than rural, non-farm areas. In both the coastal area and the upper watershed the population increases were predicted to result in a steady conversion of agricultural and vacant land to residential use, with attendant increases in water use, sewage generation, and local traffic (Table 9.5). The completion of the Ohio Route 2 Bypass linking the cities east of Vermilion to the cities west of Huron (1989) was expected to increase accessibility to the Old Woman Creek watershed, making it more desirable for residential development.

Forecasting population trends is a risky venture. The model developed by Holly (1986) forecasted a population increase of 22.3% (4,479 individuals) between 1980 and 1990 for the coastal area from Huron to Vermilion and a population increase for the upper watersheds from Milan to Florence of 7.4% (603 individuals). In actuality, the population in both sectors declined in the 10-year period between 1980 and 1990: -3.2% (-614 individuals) for the coastal area and -2.3%

(-179 individuals) for the upper watersheds based on U.S. Bureau of the Census statistics (Figure 9.5; Table 9.4). Population estimates for 1995, generated by the Ohio Department of Development, show some recovery in both sectors, but far below the projections of Holly (1986).

The present authors have attempted to determine what went wrong with the model developed by Holly (1986). The model assumptions led to a forecast of continued, and even accelerated, population growth in the region for the 1980s and beyond. The model failed to predict a leveling-off and modest decline in the population at a rate of about 0.3 % per year for the last decade. Holly considered eastern Erie County to lie within the "commuting shed" of Cleveland by virtue of highway connections. He further speculated that by the end of the century Erie County would attain sufficient metropolitan character and functional integration with urban areas to the east, through commuter traffic, that it would be incorporated into the Lorain-Elyria Statistical Metropolitan Area (SMA).

The moderate population increases in the first half of the 1990s indicate that Holly may have been a decade or two early with his expansion forecasts, but this still does not explain the population decline of the 1980s. A more plausible explanation may be that the rapid increases of the 1960s and 1970s reached a temporary saturation point in the 1980s as available infrastructure resources were being taxed to their limit and most of the prime development land been secured for residential conversion. The opening of the Ohio Route 2 Bypass at the end of the decade, improvements in water/sewage technology for remote locations, and economic prosperity appear to have stimulated a new round of development in the 1990s.

RELATIONSHIP OF LAND USE TO SOIL EROSION

Evaluating the nature and extent of soil erosion in Old Woman Creek watershed is fundamental to developing management strategies for controlling stream-borne sediment and sediment-bound nutrients. Matisoff et al (2002a) found that various portions of the Old Woman Creek watershed contribute sediment at different rates, of different size and composition, and with different associated nutrients and contaminants. These differences in rates of contribution and sediment properties result from differences in geological processes contributing sediment (e.g. surface wash, rill formation, and landslides) and differences in land usage (e.g. forested, prairie, agricultural, and urban). Standard sediment budget calculations (Dietrich and Dunne 1978) provide an initial indication of sediment production, but Matisoff et al. (2002a) used radionuclide soil tracers to achieve a more detailed discrimination of sediment sources. Characterizing soils and suspended sediment using radionuclide tracers permitted these researchers to identify sediment source areas and land uses that are problematic. This allowed for targeting of appropriate sediment management practices within the watershed.

The radionuclide profiles in agricultural no-till and tilled soils in the watershed exhibited considerable differences from undisturbed soil on Star Island located near the center of the estuary. The soils on Star Island showed a surface or near surface peak of ^{210}Pb (lead) and ^{137}Cs (cesium) while the tilled soils were largely homogeneous, due to plowing (Figure 9.9). The no-till agricultural soils were also significantly mixed by previous plowing, but rebuilding of ^{210}Pb at the surface was indicated. Radionuclide ^{210}Pb (half-life=22.3 years) is a natural decay product of ^{238}U (uranium) through a series of reactions and eventually escapes to the atmosphere; ^{7}Be (beryllium) (half-life=53.3 days) is continually produced in the upper atmosphere by cosmic rays bombarding nitrogen and oxygen. Both of these radionuclides continually reach the surface of the earth, especially during thunderstorms. Whereas, ^{137}Cs (half-life=30.2 years) in soil is mostly the result of atmospheric nuclear bomb testing during the 1960s and 1970s. Because ^{7}Be has such a short half-life and is continually being added at the land surface, its profile is relatively consistent in all land use conditions (Figure 9.9). This radionuclide has proved very useful as an indicator of sediment transport distances (Bonniwell 2001, Matisoff et al. 2002b).

Matisoff et al. (2002a) observed that sediment eroded from a soil has a specific signature corresponding to the tillage practice and the depth of erosion. Thus, radionuclide signatures in suspended sediment of Old Woman Creek and the estuary can: (1) provide a means of tracing particles eroded from the land surface, (2) identify soil sources, and (3) be used to quantify the erosion. The study showed that runoff from tilled portions of the watershed had a

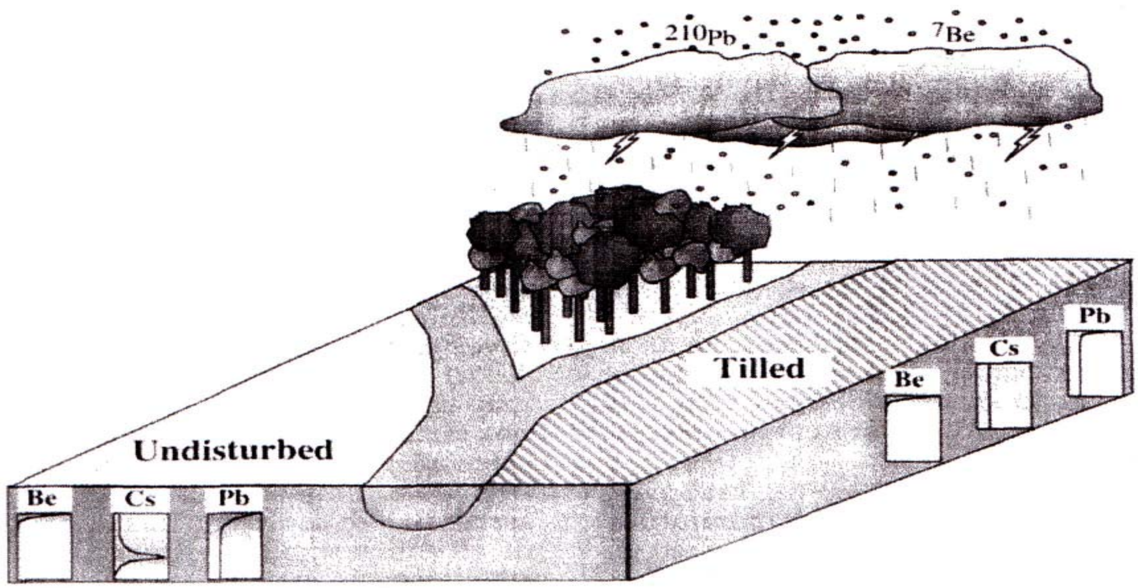

Figure 9.9. Generalized diagram illustrating the distribution of ^{7}Be, ^{210}Pb, and ^{137}Cs in soils under different tillage practices to a depth of 10 to 30 cm (Matisoff et al. 2002b).

higher sediment yield than their no-till counterparts in response to a thunderstorm, at a ratio of approximately 10:1. The tilled agricultural fields in the upper reaches of the watershed provide a disproportionate amount of suspended sediment delivered to the estuary. This investigation suggests that (1) erosion control initiatives may be most beneficial at upland locations near the head of the drainage in the watershed where erosion is the greatest and (2) improved land management practices in these areas will produce results more quickly in the receiving waters.

In addition to the identification of sediment sources, the determination of sediment transport distances is important to the understanding of sediment fluxes in the watershed. While the identification of sources allows recognition of regions or land use practices that produce large amounts of sediment (and associated nutrients and pollutants), the determination of sediment transport distances permits estimation of which areas of the watershed contribute sediment to receiving waters, i.e. Old Woman Creek estuary and Lake Erie. In addition, Matisoff et al. (2002b) used radionuclide to successfully trace particle transport within the watershed. Because of the relatively long transport distances calculated from this investigation—in relation to the length of the stream channels in the Old Woman Creek drainage basin—the majority of the fine-grained sediment that erodes from the watershed is most likely transported the entire length of the creek and delivered to the estuary and Lake Erie. These findings also show that erosion control methods implemented in the portions of the watershed where erosion is greatest will be reflected rapidly in the receiving water.

Livestock Facilities

Waste from domestic and farm animals in the watershed can be a significant source of water pollution, especially nutrients and disease-causing bacteria and viruses (Courter 1995). Old Woman Creek NERR personnel undertook a demonstration project in 1995 along the upper reaches of Old Woman Creek to determine the impact to stream water quality of various methods of handling animal wastes (Figure 9.10). The project looked at two facilities in Berlin Township where animal wastes were discharged to the west branch of Old Woman Creek (Figure 9.11). The first facility was a hog farm that contained a stabilizing lagoon into which hog wastes were placed before being discharged into the stream. The second facility was a cattle barn located about 0.5 km downstream from the holding pond at the first facility. The cattle barn had no waste control mechanisms, thus animal wastes were discharged directly to the stream by surface runoff. A series of stations was established about every 200 m along the stream at the following stations:

Station A — 100 m above (upstream) hog lagoon (control station)
Station B — 100 m below hog waste lagoon
Station C — 300 m below hog waste lagoon
Station D — 100 m above cattle barn
Station E — 100 m below cattle barn
Station F — 300 m below (downstream) cattle barn

The prime objective of the study was to measure selected water quality parameters following a major rainfall event, thereby quantifying the runoff impact of these livestock facilities on the stream. A rainstorm event occurred in May 1995 which provided the opportunity to determine the relative impact of these facilities on stream water quality. The parameters measured included coliform bacteria, streptococcus bacteria, ammonia, and total phosphorus (P). Measurements commenced at the initiation of the storm and continued at various intervals for 75 hours. Results of measurements are presented in Figures 9.12 to 9.15.

The data graphed in these figures indicates a dramatic difference in water quality downstream of the two livestock facilities. For example, the maximum coliform bacteria count at the station below the hog waste lagoon (B) was only 270 cells/cc, while at the station below the cattle barn (E) the coliform count reached 7,300 cells/cc. Similarly, streptococcus bacteria at the hog facility reached a maximum of 2,710 cells/cc for the initial measurement at hog facility while the cattle barn yielded a reading of 100,000 cells/cc. Both of the bacterial parameters show an unexpected high reading about 6 hours after the initial measurement at the control station (A), as exhibited by a coliform count of 420 cells/cc (Figure 9.16). This can be attributed to another source of animal waste upstream of the study area. Ammonia and phosphorus measurements also show a 4- to 6-hour lag at the control station for high readings, low initial measurements below the hog facility, and the highest values below the cattle barn. Clearly, this study demonstrates the effectiveness of a waste stabilization pond in lowering the discharge of enteric bacteria and nutrients to Old Woman Creek in comparison to direct discharge from a livestock facility.

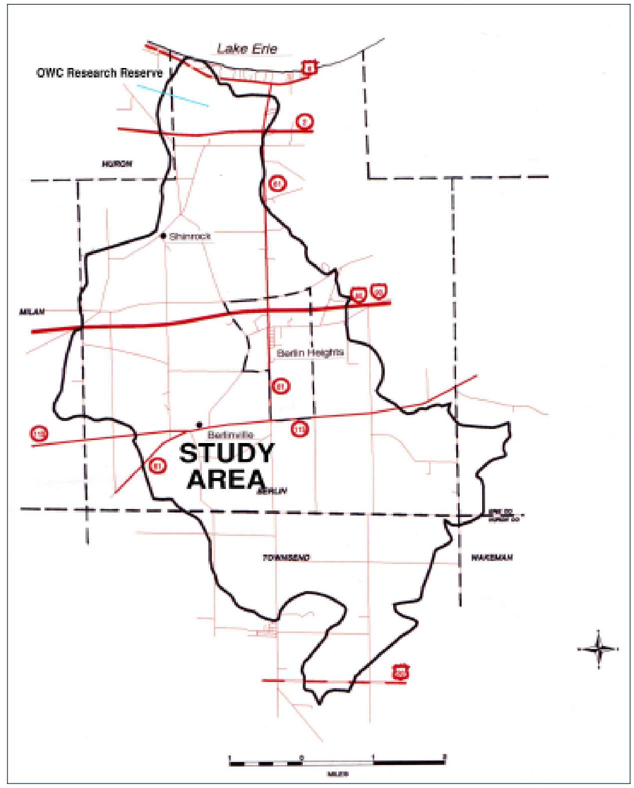

Figure 9.10. Location of livestock waste study area southwest of Berlin Heights, Ohio.

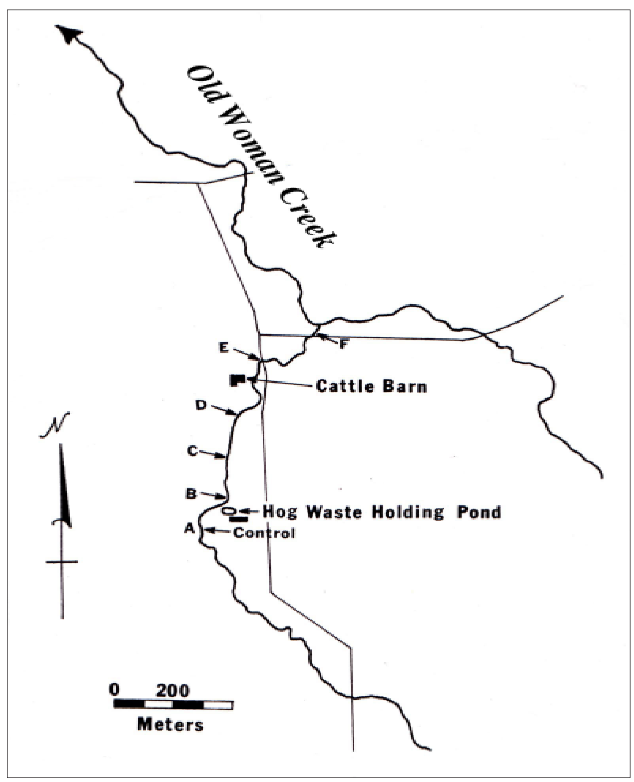

Figure 9.11. Location of water sampling stations. for livestock waste study.

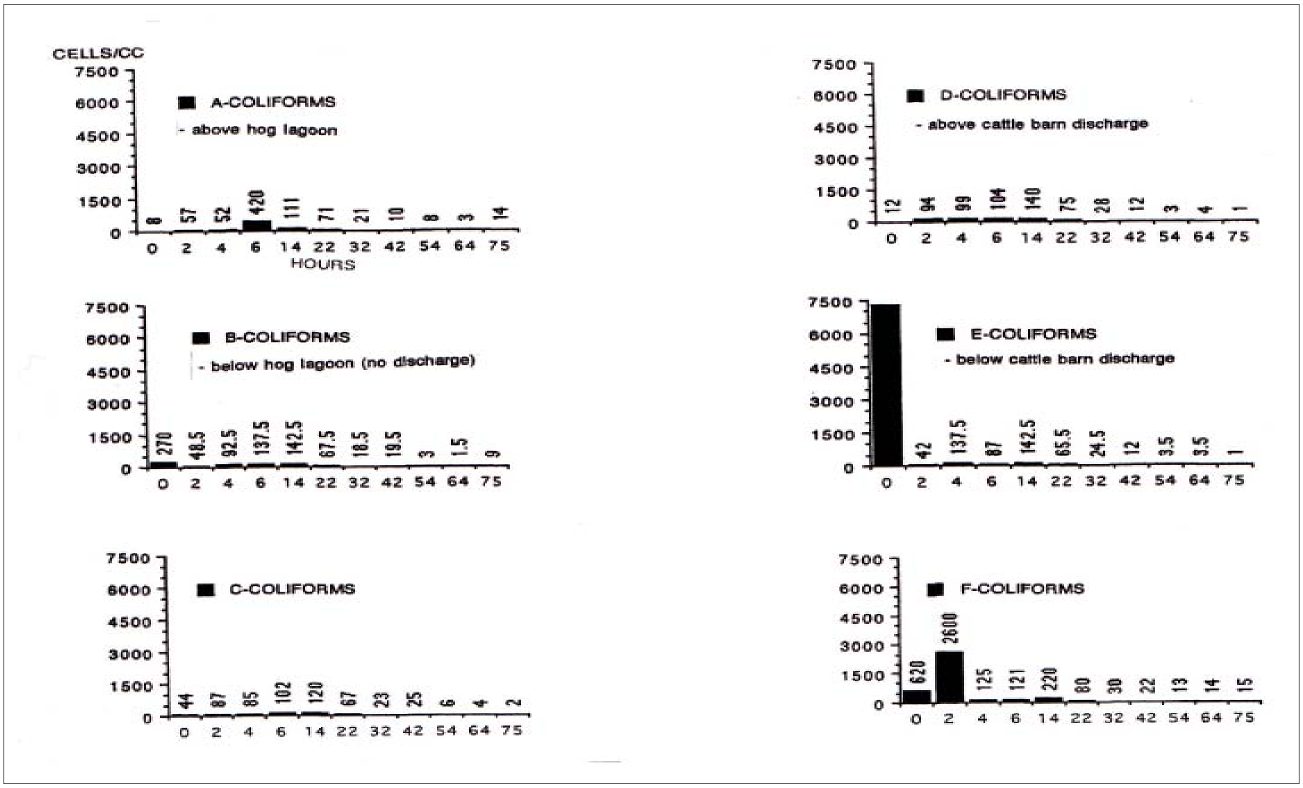

Figure 9.12. Coliform bacteria in Old Woman Creek at livestock waste study area following a rainstorm event in May 1995.

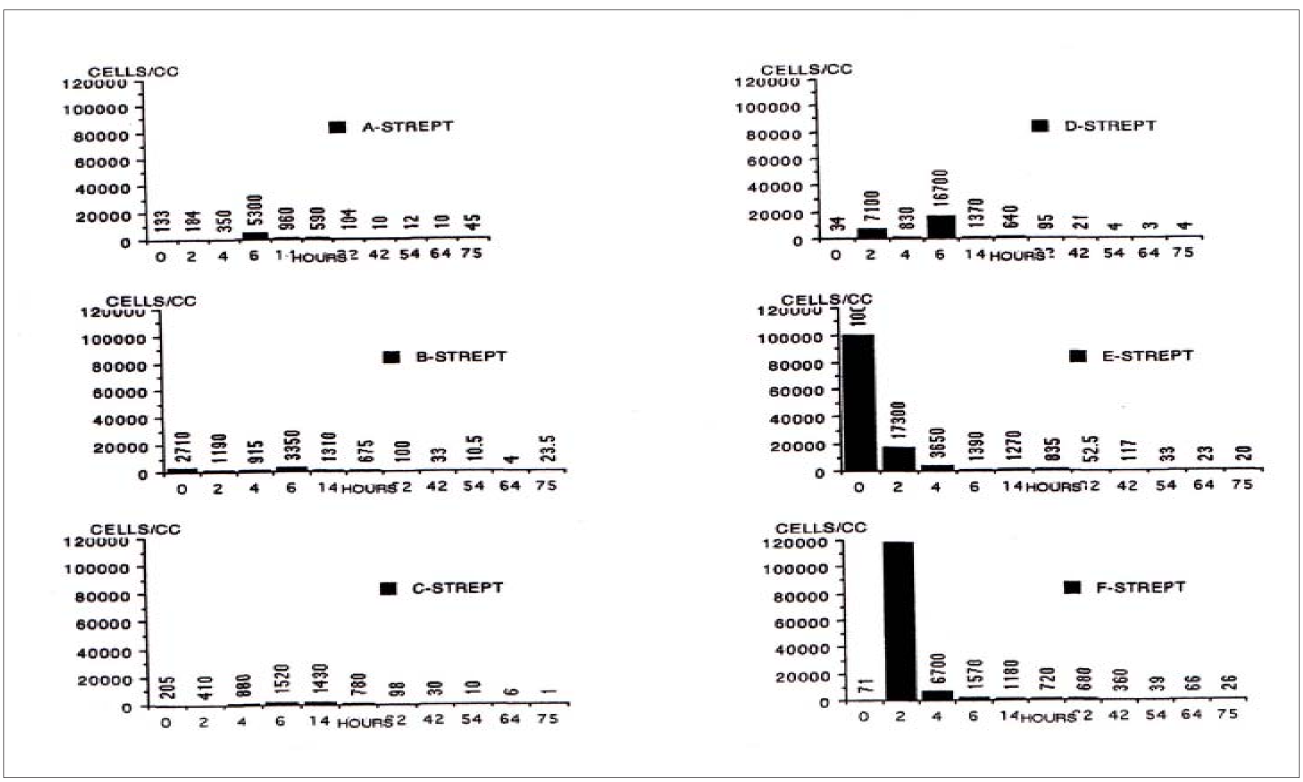

Figure 9.13. Streptococcus bacteria in Old Woman Creek at livestock waste study area following a rainstorm event in May 1995.

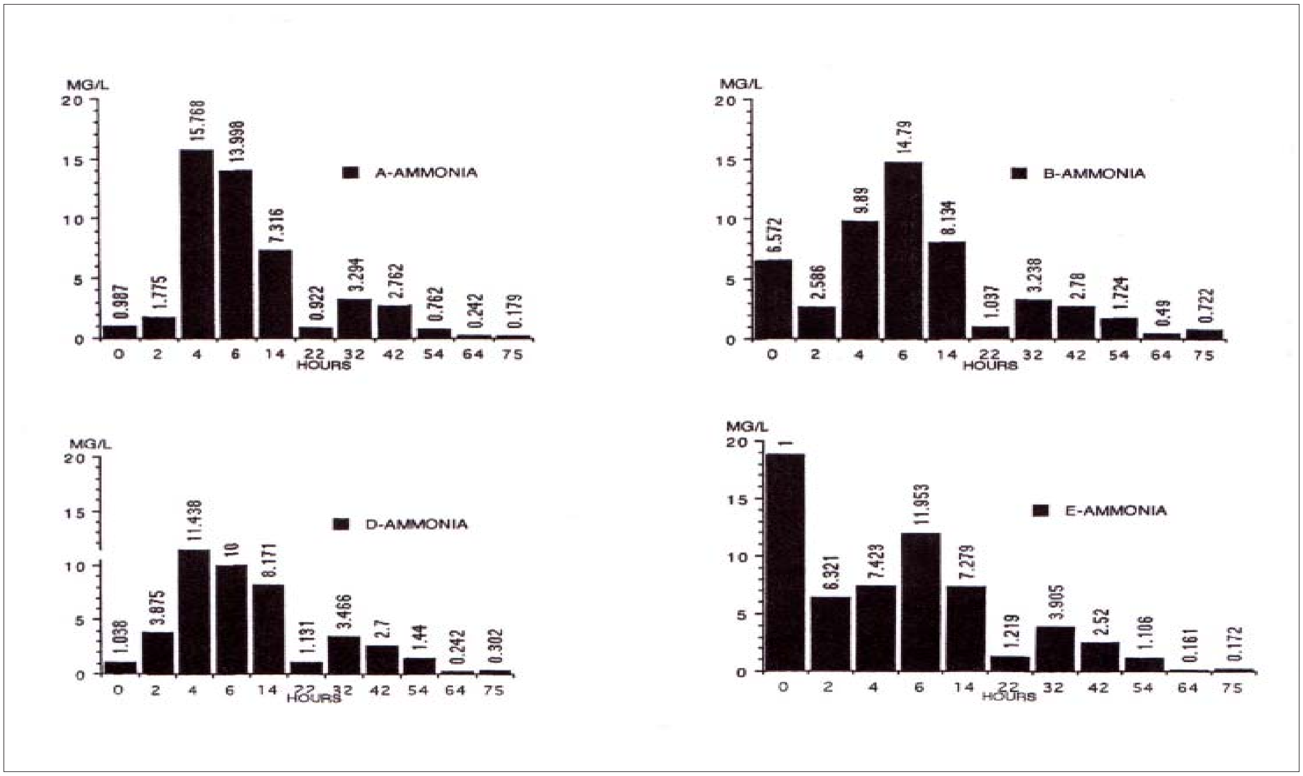

Figure 9.14. Ammonia in Old Woman Creek at livestock waste study area following a rainstorm event in May 1995.

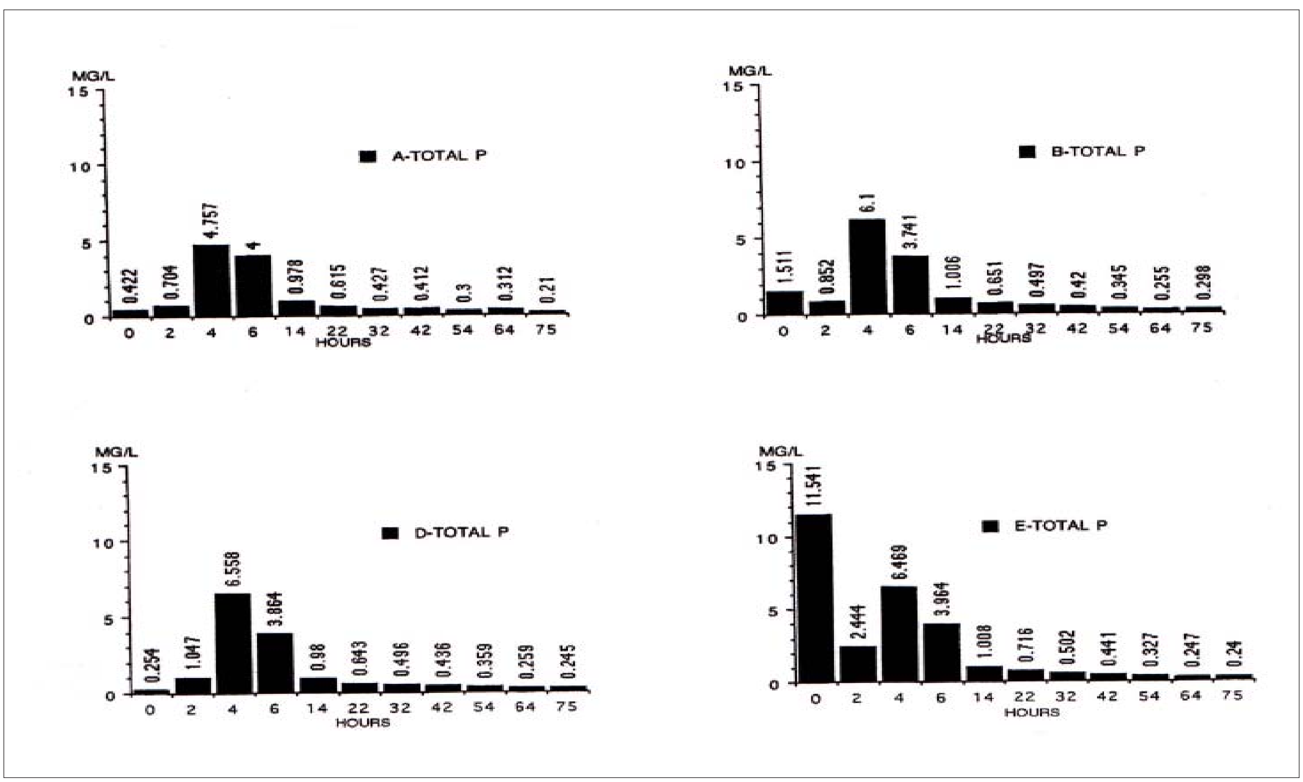

Figure 9.15. Total phosphorus (P) in Old Woman Creek at livestock waste study area following a rainstorm event in May 1995.

PRECISION FARMING

In 1996 and 1997, Old Woman Creek NERR coordinated a demonstrated project dealing with habitat management and non-point pollution reduction within the watershed and to exchange information and technology developed as a result of the project (Wright et al. 1997, 1998, 2000). Specifically, the project focused on precision farming and streambank stabilization within the Old Woman Creek watershed. The goal of the precision farming project was to protect surface and ground waters from pollution caused by excess application of agricultural chemicals. This state-of-the-art technology was made possible via a satellite-linked data sharing system. Participating farmers had each acre of their crop fields tested and soils mapped. The resultant physical and chemical parameters were entered into and analyzed by a computer software program and the outputs were made available to local suppliers of fertilizer, seed, and soil supplements. The result was a customized application plan for each farmer that would reduce pollution to the watershed streams, the estuary, and Lake Erie by using less chemicals on their soils, while achieving economic viability and sustainability.

In February 1999, local farmers who had participated in the project met at the Reserve to share results of their fall harvest yield monitoring efforts and discuss the pros and cons of the computer software, satellite-based technology, and variable applicator equipment. The project successfully demonstrated that non-point pollution reduction through precision farming generated economic benefits for farmers, the environment, and watershed community through improved water quality.

Likewise, streambank stabilization projects within the Old Woman Creek watershed have been effective in improving water quality (Echelberger 1997). In conjunction with the Erie County Water and Soil Conservation District, Old Woman Creek NERR has fostered cooperative program with several watershed farmers to protect stream banks from erosion caused by tillage and livestock facilities that are in close proximity to the water course. By adding greenbelts on the stream banks, re-channeling streams as appropriate, cleaning out ditches, and adding electrified barb wire fences to keep livestock off the stream banks, the banks are healing themselves.

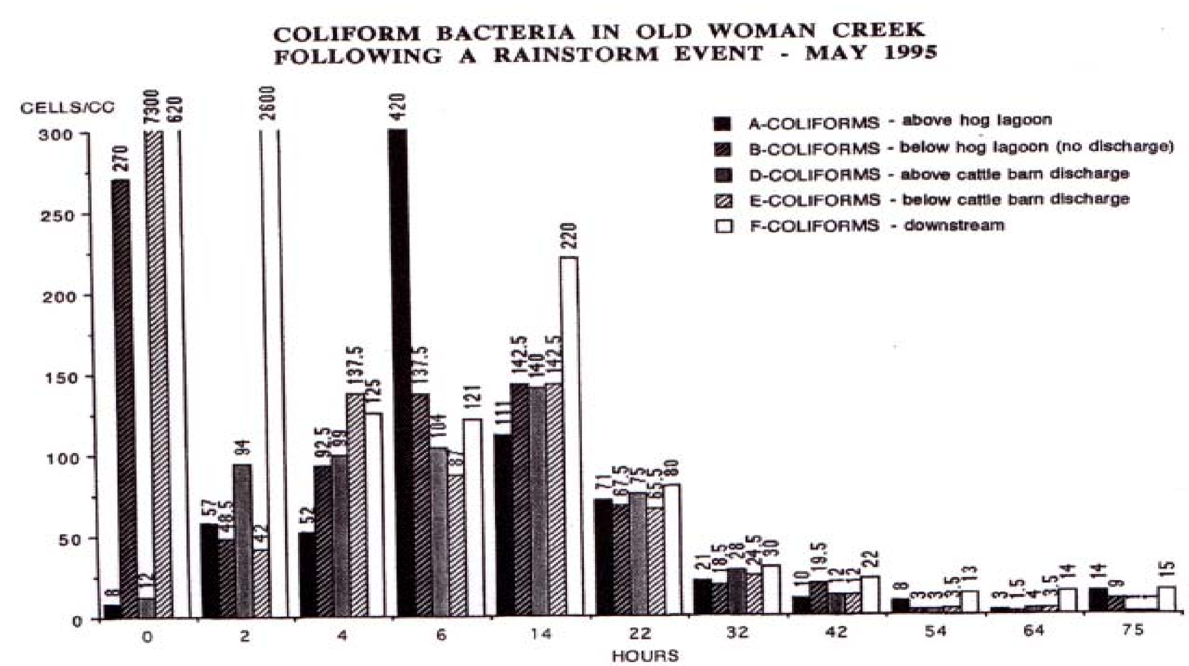

Figure 9.16. Coliform bacteria in Old Woman Creek at livestock waste study area for 72 hours following a rainstorm event in May 1995.

Hazardous Materials

As a precaution to the ever-increasing threat to ecologically sensitive coastal wetlands from catastrophic oil spill and other hazardous material releases (Figure 9.17), the Old Woman Creek NERR undertook an investigation of the potential for such accidents in the Reserve and the surrounding watershed. The result of this effort was the publication of a spill response manual that focused on the land use activities that occur within the Old Woman Creek drainage basin (Wright et. al. 1991). An inventory of potential sources and pathways for spills within the watershed yielded useful land use data. For example, two primary types of spill hazards exist within the watershed: (1) those associated with transportation corridors (Figure 9.18) and (2) those at fixed sites. These corridors or stationary sites either convey or hold hazardous materials, that if spilled within the watershed would ultimately enter the estuary, with the potential to cause severe environmental damage. Transported hazardous materials include: (1) petroleum and associated products, (2) toxic chemicals, (3) radioactive chemicals, and (4) bulk materials (e.g. ice control salts); whereas fixed sites hazardous materials consist of: (1) petroleum and associated products, (2) pesticides and herbicides, (3) liquid fertilizers, (3) industrial and commercial chemicals, (4) bacterial and viral chemicals, and (5) domestic chemicals. Statistically, the watershed contains the transportation corridors and fixed sites given in Table 9.7.

In addition to potential for spills of hazardous materials within the watershed, Old Woman Creek estuary is also vulnerable to spill which may occur in the adjacent portions of Lake Erie. Short term oscillations in Lake Erie water level, (e.g. seiches and wind tides induced by certain wind or barometric conditions) periodically cause lake water to enter the estuary from the open lake. Such oscillations between one high level and the subsequent high level have periods of generally 12 to 14 hours. Therefore, if a spill was to occur in the nearshore waters of the lake, response actions would need to be taken to potect the estuary from lake water, as well as the lake beaches.

Figure 9.17. Hazardous materials warning placards.

TABLE 9.7. TRANSPORTATION CORRIDORS AND FIXED SITES IN THE WATERSHED

Highway & Railroad	**miles**
4–lane highways (Ohio Tpk & Rt. 2)	9
2–lane highways (primary roads)	21
2–lane highways (secondary roads)	82
railroad tracks	8
	no.
4–lane x 2–lane intersections	2
2–lane x 2–lane intersections (primary)	63
4–lane x 2–lane intersections (secondary)	73
railroad x highway intersections	7
bridges & overpasses	8
Pipelines and Transmission Lines	**miles**
pipelines (petroleum & associated products)	9
pipelines (natural gas)	14
transmission lines (high voltage)	27
Buildings	**no.**
houses (total in 1991)	1,646
houses (new between 1979 & 1991)	284
barns, greenhouses, & outbuildings	452
commercial buildings	58
public & community buildings	14
industrial buildings	9
storage facilities (oil, gas, & chemicals)	11

Recent Land Cover Changes

As this Site Profile was about to go to press, new watershed land cover maps became available for the mid-1990s and 2003 (Figures 9.19 and 9.20). These maps show very little change in land cover over the past decade, illustrating that recent development has been very slow within the watershed.

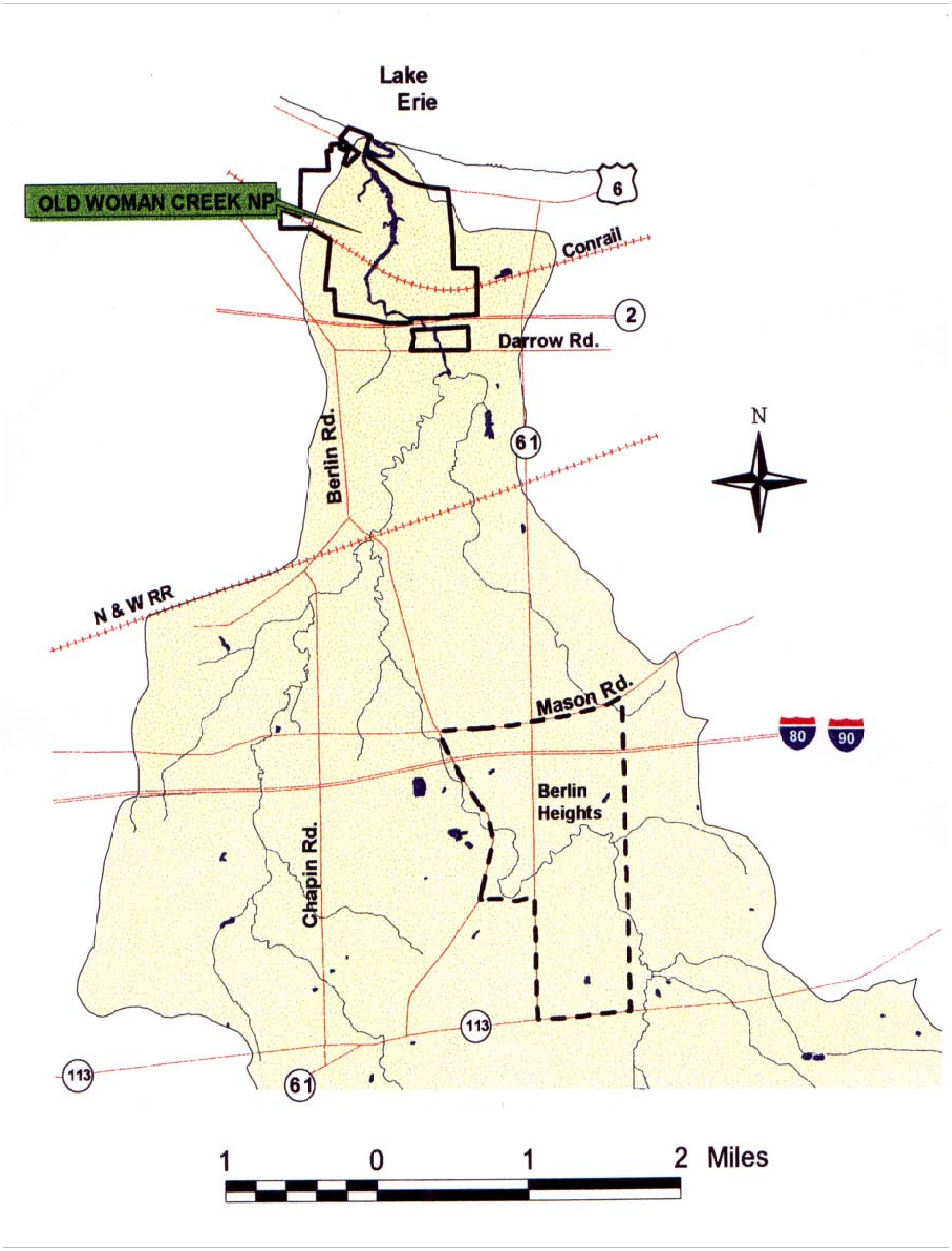

Figure 9.18. Transportation corridors in the lower Old Woman Creek watershed.

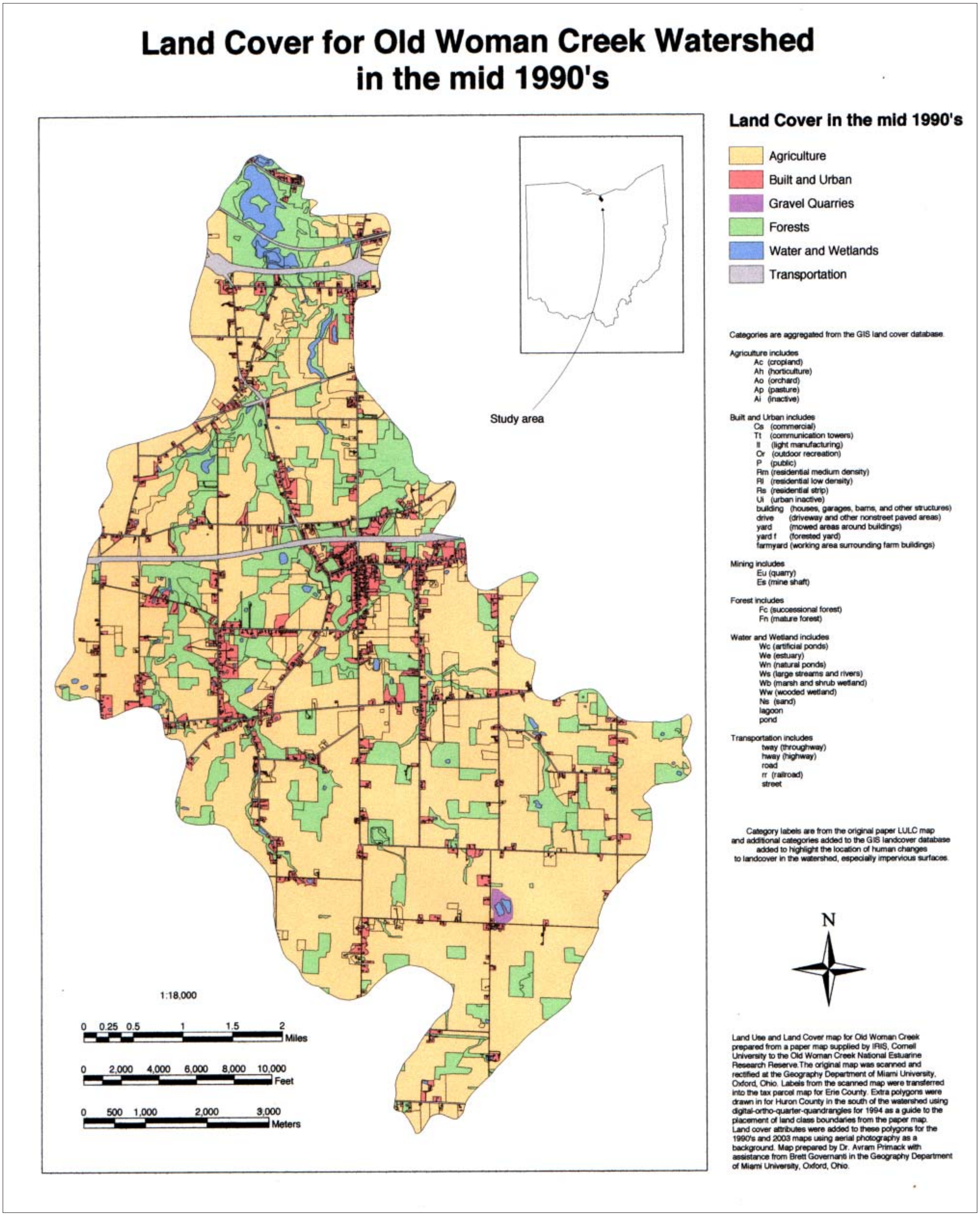

Figure 9.19. Old Woman Creek watershed land cover in the mid-1990s (Primack and Governanti 2004).

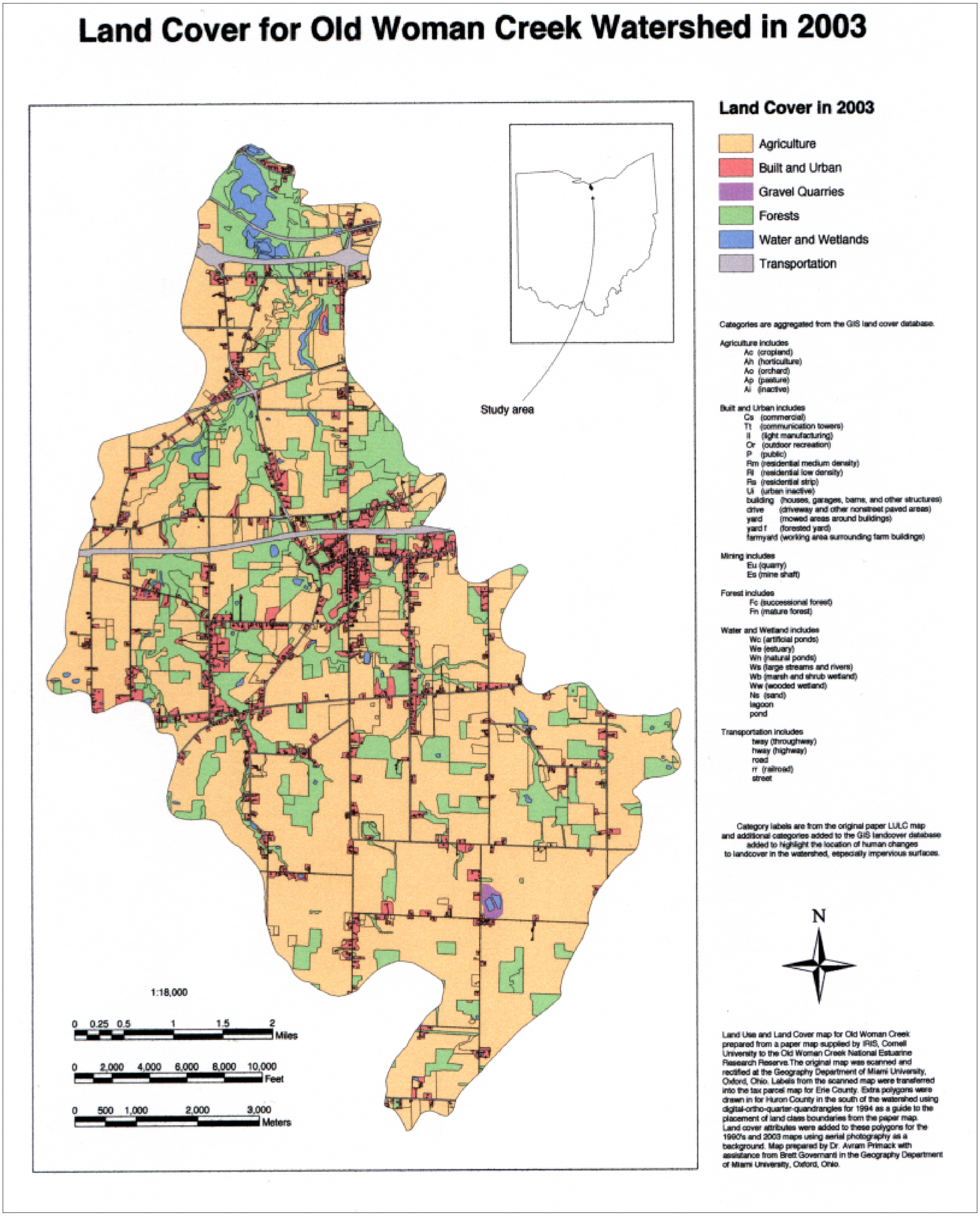

Figure 9.20. Old Woman Creek watershed land cover in 2003 (Primack and Governanti 2004).