Chapter 3: Refuge Environment and Management

Introduction

Muscatatuck National Wildlife Refuge

Muscatatuck NWR manages lands in Jackson, Jennings, and Monroe Counties in south-central Indiana. Management responsibilities also include a 30-county Wildlife Management District, which involves management of U.S. Department of Agriculture's (USDA) Farm Service Agency Conservation Easements and team membership in the Wetland Reserve Program Wetland Evaluation Team with USDA – Natural Resource Conservation Service (NRCS) for the 22-county southeast Indiana area. Although formal management responsibility for the 30-county Partners for Fish and Wildlife private lands district was transferred by agreement to the Indiana State Private Lands Coordinator in 2004, Muscatatuck NWR still assists with past projects completed with Muscatatuck NWR partners, provides coordination and support in six counties, and makes referrals from other counties to the State Private Lands Coordinator.

Ecological Context

Historic Vegetation

Historically, the Refuge was a part of the expansive, contiguous deciduous hardwood forest that covered most of the central and southern part of the state. Lindsey (1997) listed oak-hickory and beech-maple as the dominant pre-settlement forest types. Prior to European settlement of the area, the Muscatatuck River Basin was an old lake basin. The forest community has been defined as "Bluegrass Till Plain Flatwoods" by the Indiana Invasive Plant Species Assessment Work Group (Jacquart et al. 2002) and "Southeastern Till Plain Beech-Maple Division" by IDNR Division of Nature Preserves (2005). This area is generally wet or moist most of the year.

River otter. Photo credit: Dan Kaiser

Information gleaned from the General Land Office (GLO) survey notes from November 1806 is summarized in the following paragraphs. Names in bold are the names as found in the original survey notes and those within parentheses are current interpretations of the species represented (Homoya 2007).

> In the Jennings County portion of the Refuge the area is mostly upland flats and moist slopes. The tree species mentioned the greatest number of times is **beech** (American beech; *Fagus grandifolia*). As with today, this species is characteristic of these communities. Three other species mentioned are sugar (sugar maple; *Acer saccharum*), **W. ash** (White ash; *Fraxinus americana*), and **cherry** (black cherry; *Prunus serotina*).
>
> In the western portion of the Refuge (Jackson Co.) most of the same species listed above are mentioned; additional types occur, especially in the floodplains. The list includes: "**Ash;** (green ash; *Fraxinus pennsylvanica*), **maple** (red maple; *Acer rubrum* and/or silver maple; *Acer*

saccharinum), **elm** (American elm; *Ulmus americana*) in the bottoms, **beech** (American beech; *Fagus grandifolia*) and **poplar** (tulip tree; *Liriodendron tulipifera*) on the Highland." These notes were describing a survey line between sections 25 and 26 T. 6 N. R. 6 E. Also mentioned for the floodplain in this region was **ironwood** (probably blue beech; *Carpinus caroliniana*, and not hop hornbeam; *Ostrya virginiana*).

W. oak (white oak; *Quercus alba*) and/or **swamp chestnut oak** (*Quercus michauxii*) and/or **swamp white oak** (*Quercus bicolor*), and **gum** (sweet gum; *Liquidambar styraciflua*) were mentioned in a floodplain just north of the Vernon Fork Muscatatuck River along the section line between sections 35 and 36, T. 6 N. R. 6 E. White oak is not a normal component of wet floodplain forests in Indiana, but does occur in slightly elevated portions of floodplains, (Homoya 2007). There are no references to any open areas or grasslands. There are references to a few swamps in the floodplain; they were forested and probably only ephemerally wet.

In addition to written descriptions of historic vegetation conditions, soil information can be used to understand the vegetation capacity of a landscape. The soils in any given locality are a result of the parent rock material, organisms, climate, and relief. These factors and the resulting soils limit what overlying native vegetation can inhabit an area. Soil survey data collected over the past century by the USDA's Natural Resource Conservation Service have included written descriptions of native vegetation, which can be tied to the soil unit and mapped. Figure 2 uses data from the Soil Survey Geographic (SSURGO) Database to display the potential natural vegetation found at Muscatatuck NWR. The dominance of a mixed deciduous forest covertype is consistent with other accounts of the region's native vegetation status.

Female Wood Duck and brood. Photo Credit: Mark Trabue

The land of the future Refuge was cleared for farms in the mid 1800s as the state was settled by Europeans. When the Service purchased the land there were 116 private land ownerships, 4,100 acres being farmed, and most of the area had been altered from its original forest cover type. Since the Service has managed the land the cover has changed away from agriculture to managed wetlands and trees. Fire was likely a part of the forces shaping the forest prior to European settlement as indigenous populations used fire as a management tool in forested areas. Fire has been suppressed in the Muscatatuck NWR area for much of the last century, except for some areas of the Refuge that were treated with fire as a management tool in the 1990s.

Today the more common species in the bottomland hardwood forest are pin oak, swamp white oak, swamp chestnut oak, sweet gum, green ash, river birch, silver and red maple and shellbark hickory.

Land Use/Cover

The Refuge lies in a predominantly agricultural landscape. Farm land constitutes 63.5 percent of the land area in Jackson County and 59.1 percent in Jennings County (FedStats 2002). Within this predominantly agricultural landscape, the developed area of Seymour to the west of the Refuge is a notable exception (Figure 3). Forested lands and woodlots are scattered among the agricultural lands. Based on 2001 national land cover data developed by the Multi-Resolution Land Characteristics Consortium, the area within a 6-mile distance of the Refuge is 61.8 percent agricultural, 10.8 percent developed, and 26.4 percent forested (U.S. Geological Survey 2001).

Figure 2: Potential Natural Vegetation, Muscatatuck NWR

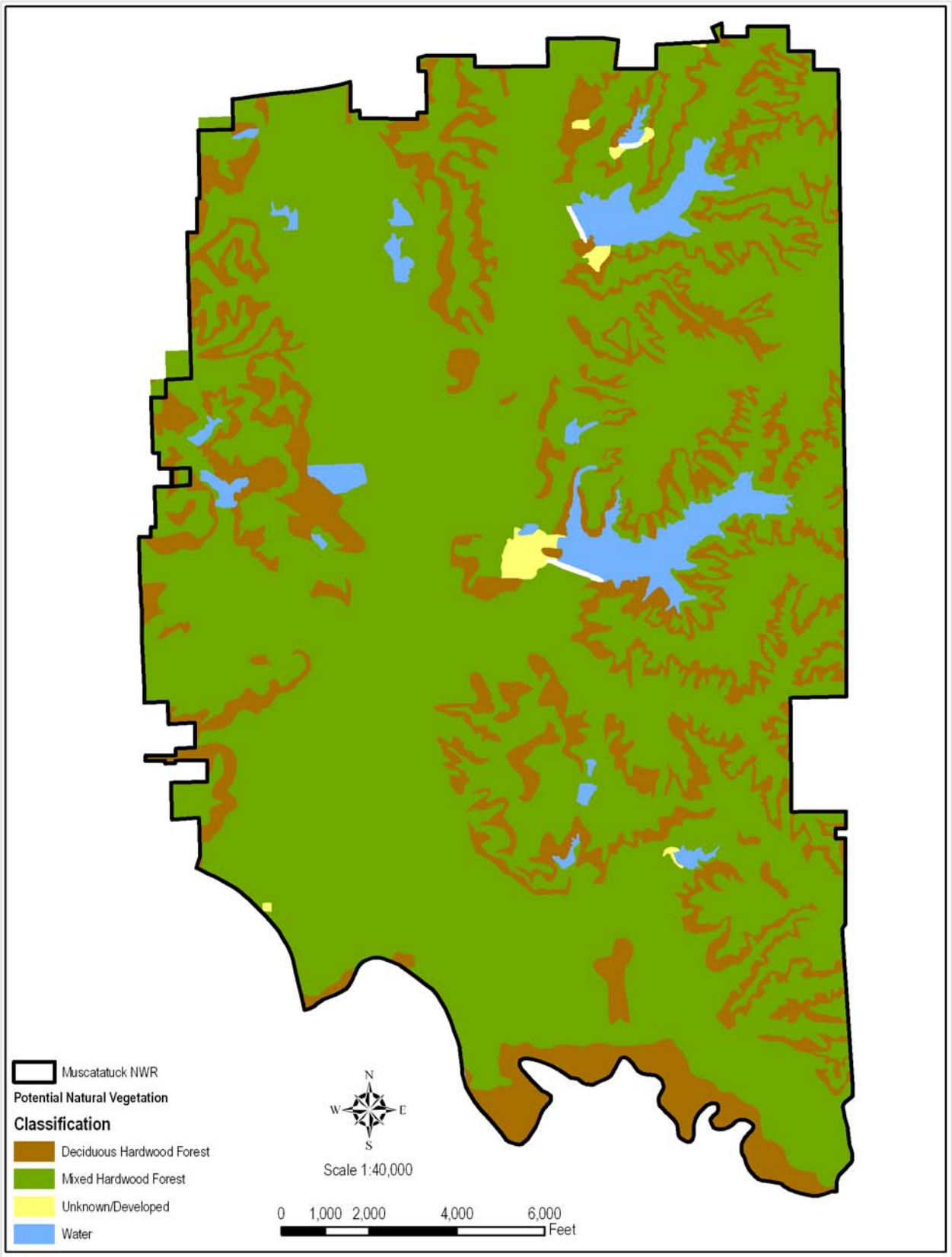
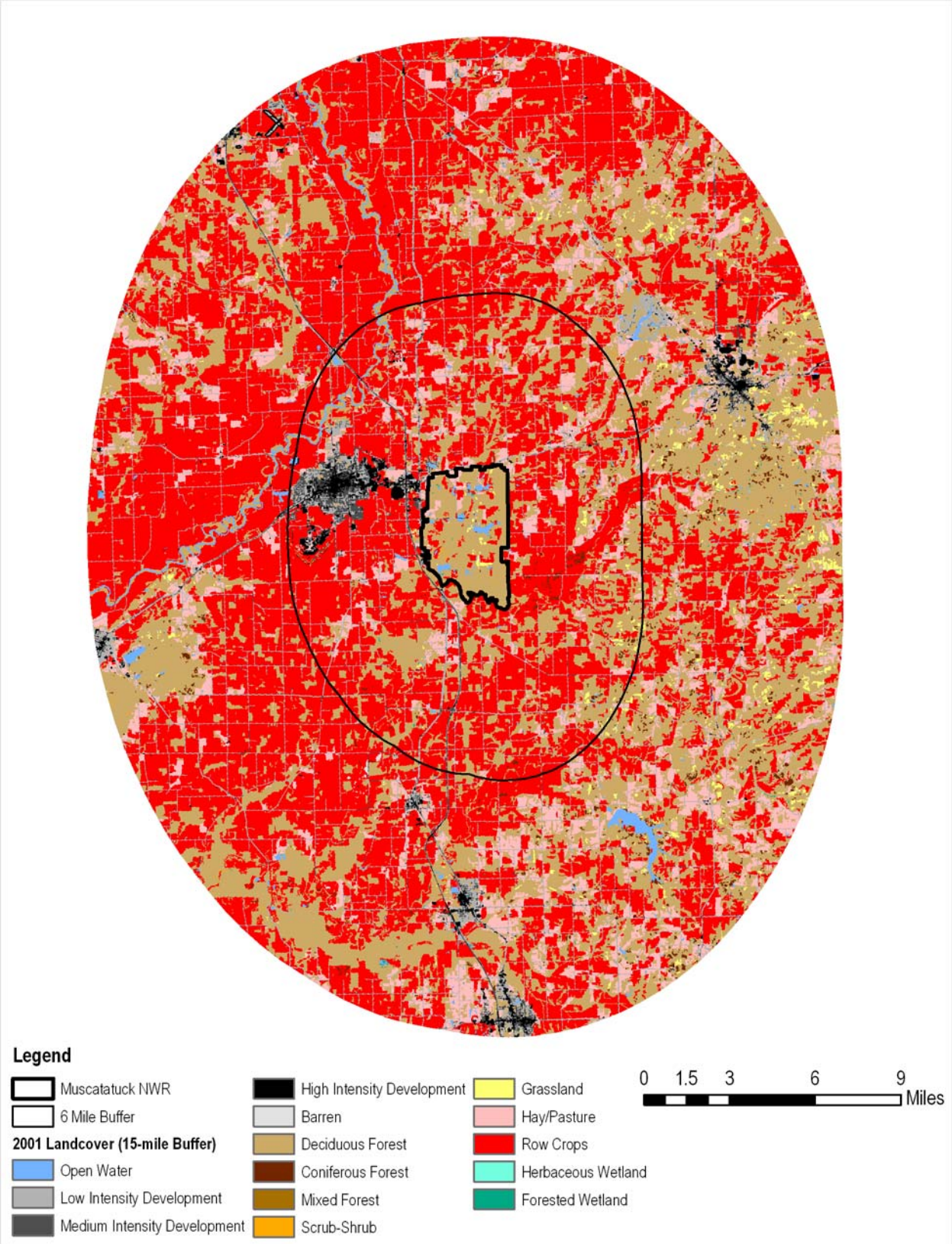


Figure 3: Land Use / Land Cover in the Vicinity of Muscatatuck NWR



Migratory Bird Conservation Initiatives

Several migratory bird conservation plans have been published over the last decade that can be used to help guide management decisions on refuges. Bird conservation planning efforts have evolved from a largely local, site-based orientation to a more regional, even inter-continental, landscape-oriented perspective. Several transnational migratory bird conservation initiatives have emerged to help guide the planning and implementation process. The regional plans relevant to Muscatatuck NWR are:

- The Central Hardwoods Joint Venture Concept Plan
- Upper Mississippi River and Great Lakes Region Joint Venture of the North American Waterfowl Management Plan
- The Upper Mississippi Valley/Great Lakes Regional Shorebird Conservation Plan
- The Upper Mississippi Valley/Great Lakes Regional Waterbird Conservation Plan

Each of the bird conservation initiatives has a process for designating priority species, modeled to a large extent on the Partners in Flight method of computing scores based on independent assessments of global relative abundance, breeding and wintering distribution, and vulnerability to threats, area importance, and population trends. These scores are often used by agencies in developing lists of priority bird species. The Service based its 2001 list of Non-game Birds of Conservation Concern primarily on the Partners in Flight shorebird and waterbird status assessment scores.

Region 3 Fish and Wildlife Conservation Priorities

Every species is important; however the number of species in need of attention exceeds the resources of the Service. To focus effort effectively, Region 3 of the Fish and Wildlife Service compiled a list of Resource Conservation Priorities (U.S. Fish & Wildlife Service 1999). The list includes:

- All federally listed threatened and endangered species and proposed and candidate species that occur in the Region.
- Migratory bird species derived from Service wide and international conservation planning efforts.
- Rare and declining terrestrial and aquatic plants and animals that represent an abbreviation of the Endangered Species program's preliminary draft "Species of Concern" list for the Region.

Appendix D lists 72 Regional Resource Conservation Priority species relevant to the Refuge.

Other Conservation and Recreation Lands in the Area

The state of Indiana, other federal agencies, and non-governmental conservation organizations own and manage lands and recreation access sites within a 50-mile radius of the Refuge (see Figure 4). The state areas include public access sites, fish and wildlife areas, recreation areas, forests, and nature preserves. The federal areas include Big Oaks National Wildlife Refuge, Hoosier National Forest, and Department of Defense lands. Among non-governmental organizations, The Nature Conservancy is a major land owner and manager. Local governments also own and manage community parks in the area. Conservation easements and other partners also own and manage a significant amount of land in the surrounding area.

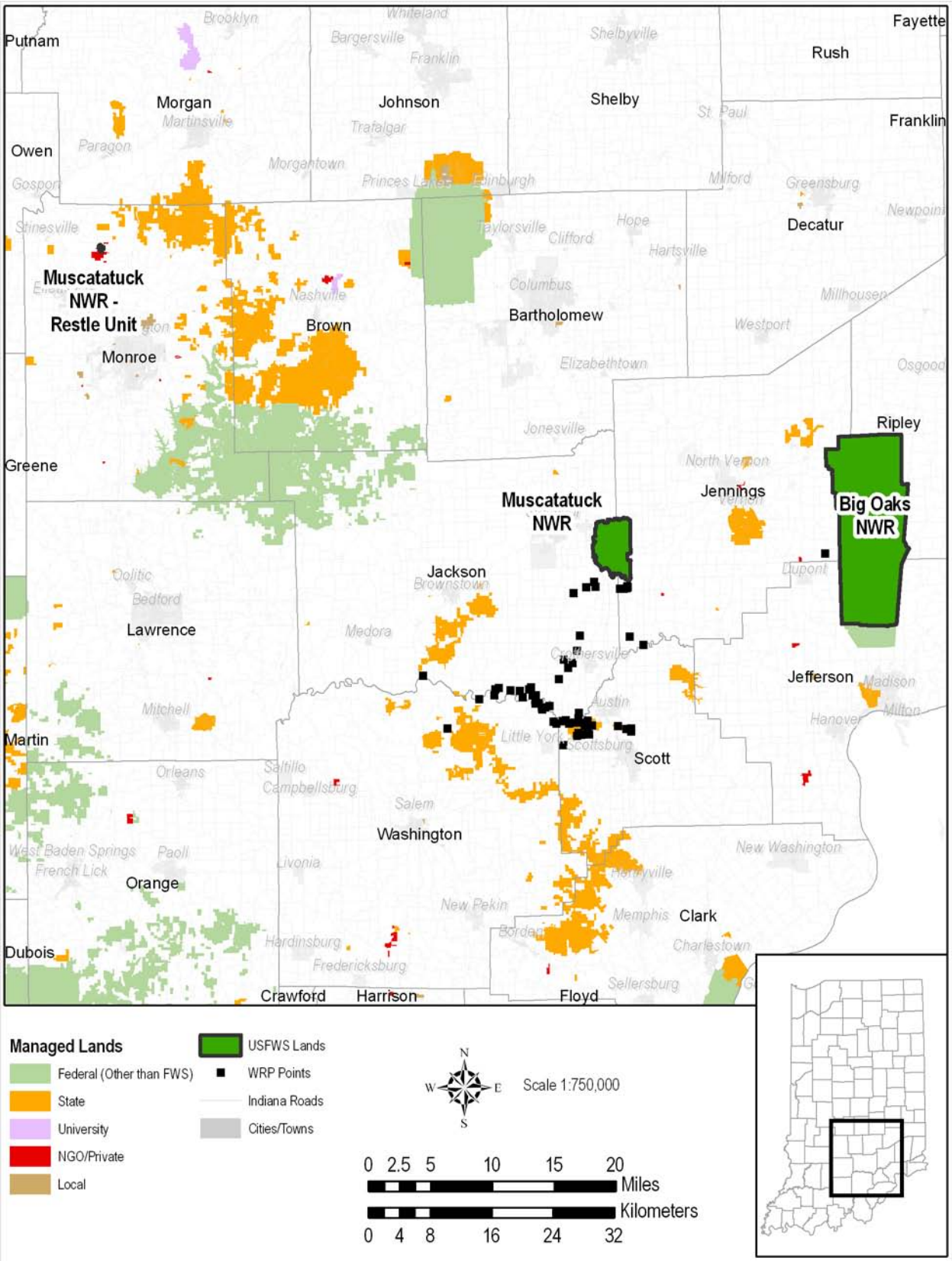
Conservation Corridors

Increasing urbanization and widespread land use changes are greatly affecting natural landscapes and healthy ecological systems by fragmenting and degrading habitats. Traditional approaches to land conservation are often opportunistic, piecemeal, site specific, and narrowly focused.

However, increasing attention is being given to collaborative landscape conservation efforts that are proactive, strategic, comprehensive, and integrative. Regional analyses that consider larger geographic extents are helping to focus conservation efforts among a growing consortium of stakeholders and partners. Creating a series of ecological hubs and linkage corridors increases the connectivity, effectiveness, and resiliency of the biological systems that preserve biodiversity and essential ecological services.

Efforts are under way in Midwest Region of the U.S. Fish and Wildlife Service to create models that outline a basic conservation network throughout the Midwest. Recent emphasis on Strategic Habitat Conservation and the effects of global climate

Figure 4: Other Conservation and Recreation Lands in the Vicinity of Muscatatuck NWR



White-tailed deer. Photo credit: U.S. Fish and Wildlife Service

change have catalyzed these efforts in the Service. Using land cover (Figure 3 on page 11) and the existing conservation estate (Figure 4), it is possible to visualize the beginnings of a land conservation network with Muscatatuck NWR, Big Oaks NWR, and other major state and federal landholdings as major ecological hubs linked through private and public conservation efforts. The Refuge System is positioned well to play an integral role in the design and implementation of a regional conservation network.

The growing emphasis on landscape-level issues has demanded a shift in the scale at which environmental problems are approached. To continue providing the ecological services that sustain wildlife and human populations alike, the Service is looking outside Refuge boundaries and engaging in conversations with other members of the conservation community. It is only through collaborative efforts and partnerships – both public and private – that issues of this magnitude and scale can be effectively addressed.

Socioeconomic Context

Muscatatuck NWR is located in Jackson and Jennings Counties with a small satellite unit in Monroe County. Jackson and Jennings Counties are less racially and ethnically diverse than the state of Indiana as a whole. The population in the counties has a lower average income and a lower percentage of high school and college graduates than the state's population as a whole (U.S. Census Bureau 2008).

Population and Demographics

The population estimate for the two counties was 70,664 in 2005. The population increased 12.2 percent during the 1990s while the state's population increased 9.7 percent. Jennings County grew more at 16.5 percent, and Jackson County grew 9.6 percent. The two-county population was 98 percent white in 2005; the state population was 88.6 percent white. In Indiana, 6.4 percent of the people 5 years and older speak a language other than English at home; in Jackson County it is 4.3 percent; in Jennings County it is 2.5 percent. The population for Jackson County is projected to be 43,654 in 2025, a 3.4 percent increase from 2005; for Jennings County the projected population is 33,695 for 2025, an 18.5 percent increase from 2005. The largest community in Jackson County is Seymour with a 2005 population of 18,890. The largest community in Jennings County is North Vernon with a 2005 population of 6,433 (STATS Indiana, 2007).

Employment

In 2004 there were a total of 38,327 full- and part-time jobs in the two-county area. Manufacturing was the largest of the major economic sectors in both counties accounting for 25.8 percent of the jobs in Jackson County and 19.3 percent of the jobs in Jennings County. Retail trade, transportation, and warehousing were also notable sectors. Farm jobs made up 5 percent of employment (U.S. Census Bureau 2008).

Income and Education

Average per-capita income in the two counties was $25,885 in 2004; in Indiana it was $30,204. The median household income in 2003 for Jackson County was $41,502; for Jennings County $39,514; for Indiana and $43.323. In Jackson County, 11.5 percent of persons over 25 years of age hold a bachelor's degree or higher; in Jennings County 8.4 percent; in Indiana 19.4 percent of persons over 25 years hold a bachelor's degree or higher (U.S. Census Bureau 2008).

Table 1: Maximum Adult Audiences Within 30, 60, and 90 Miles of Muscatatuck NWR for Four Activities

Approximate Driving Distance to Refuge	Total Population	Birdwatching	Fishing	Hunting With Shotgun	Contribute to Environmental Organization
30 miles	285,584	15,674	44,988	14,619	3,095
60 miles	1,743,239	82,886	235,698	67,640	15,589
90 miles	5,164,171	235,928	657,836	181,566	41,891

Demand and Supply for Wildlife-Dependent Recreation

In order to estimate the potential market for visitors to the Refuge, we looked at 2007 consumer behavior data within approximately 30, 60, and 90-mile drives of the Refuge. The data were organized by zip areas. We used the three driving distances because we thought this was an approximation of reasonable maximum drives to the Refuge for an outing by different groups. From experience we know, for example, that visitors come from the nearby local area to view wildlife in the evening. We also know that people seeking interesting varieties of bird species drive from Cincinnati, Ohio to visit the Refuge. The 30-mile area extended beyond the communities of Bedford, Columbus, Greensburg, Madison, North Vernon, Salem, Scottsburg, and Seymour. The 60-mile area extended from the southern portion of the Indianapolis metropolitan area to the northern portion of the Louisville metropolitan area. The 90-mile area included the Cincinnati metropolitan area.

The consumer behavior data that we used in the analysis is derived from Mediamark Research Inc. data. The company collects and analyzes data on consumer demographics, product and brand usage, and exposure to all forms of advertising media. The consumer behavior data were projected by Tetrad Computer Applications Inc. to new populations using Mosaic data. Mosaic is a methodology that classifies neighborhoods into segments based on their demographic and socioeconomic composition. The basic assumption in the analysis is that people in demographically similar neighborhoods will tend to have similar consumption, ownership, and lifestyle preferences. Because of the assumptions made in the analysis, the data should be considered as relative indicators of potential, not actual participation.

We looked at potential participants in birdwatching, fishing, and hunting with shotgun. In order to estimate the general environmental orientation of the population, we also looked at the number of people who might contribute to an environmental organization.

The consumer behavior data apply to persons greater than 18 years old. Table 1 displays the consumer behavior numbers for each of the three distances to the Refuge. The projections represent the maximum audience that we might expect to make a trip to the Refuge for approximate drives of half-hour, hour, and one and a half hours. Actual visitors will be fewer because the estimate is a maximum, and we expect only a fraction of these people will travel to the Refuge.

We also considered the maximum number of students that might potentially participate in environmental education offered by the Refuge by looking at the school populations in Jackson and Jennings Counties. For Jackson County the school enrollment in preschool through grade 12 was 8,142 according to the 2000 census. For Jennings County the equivalent enrollment was 5,828. The projected school age (5-19) population for the two counties for 2025 is 14,843.

Additional perspective on wildlife-dependent recreation was gained from Indiana's Statewide Comprehensive Outdoor Recreation Plan (SCORP) 2000-2004. In a survey of the population, recreation planners found that in the planning regions that contain the Refuge approximately 58 percent of the respondents participated in fishing regularly in the last year. Fishing was exceeded in participation only by the walking/hiking/jogging category. The approximate percentages of respondents for other

activities were: nature observation/photography (36 percent), hunting (33 percent), and trapping (6 percent) (Indiana Department of Natural Resources 2000). Within the nature observation/photography category respondents reported participation in wildlife viewing, gathering (mushroom, berry etc.), viewing fall foliage, nature photography, and bird watching.

The SCORP identified the counties and regions that contain the Refuge as meeting or exceeding the regional recreation land standard of 35 acres per thousand population. The Indiana State Trails Plan (Indiana DNR 2006) reported 76 miles of trails in Jackson County and 17 miles of trails in Jennings County. The Refuge trails are included in these totals.

Climate

The Refuge experiences a continental climate of warm, humid summers and moderately cold winters. The area receives moisture from the Gulf of Mexico as air masses move up the Mississippi and Ohio River Valleys. January is the coldest month with a mean temperature of 28 degrees Fahrenheit. July is the warmest month with a mean temperature of 74.5 degrees Fahrenheit. April 20 and October 12 are the frost and freeze dates for 32 degrees Fahrenheit with a 50 percent probability. The average annual precipitation is about 46 total inches. Precipitation is distributed relatively evenly across the months of the year with a low average of 2.84 inches in February and a high average of 5.01 inches in May (Source: National Climatic Data Center).

Muscatatuck NWR. Photo Credit: U.S. Fish & Wildlife Service

Geology and Soils

The Refuge lies within the Scottsburg lowland physiographic division of Indiana. The lowland has resulted from a greater erosion of shales compared to the underlying limestones and siltstones of adjacent uplands. Thick glacial deposits that are older than Wisconsin glacial deposits cover the area with little variation in topography (Wayne 1956). More specifically, Muscatatuck NWR's geology includes the combination of underlying bedrock strata and the unconsolidated soils material deposited by glacial action.

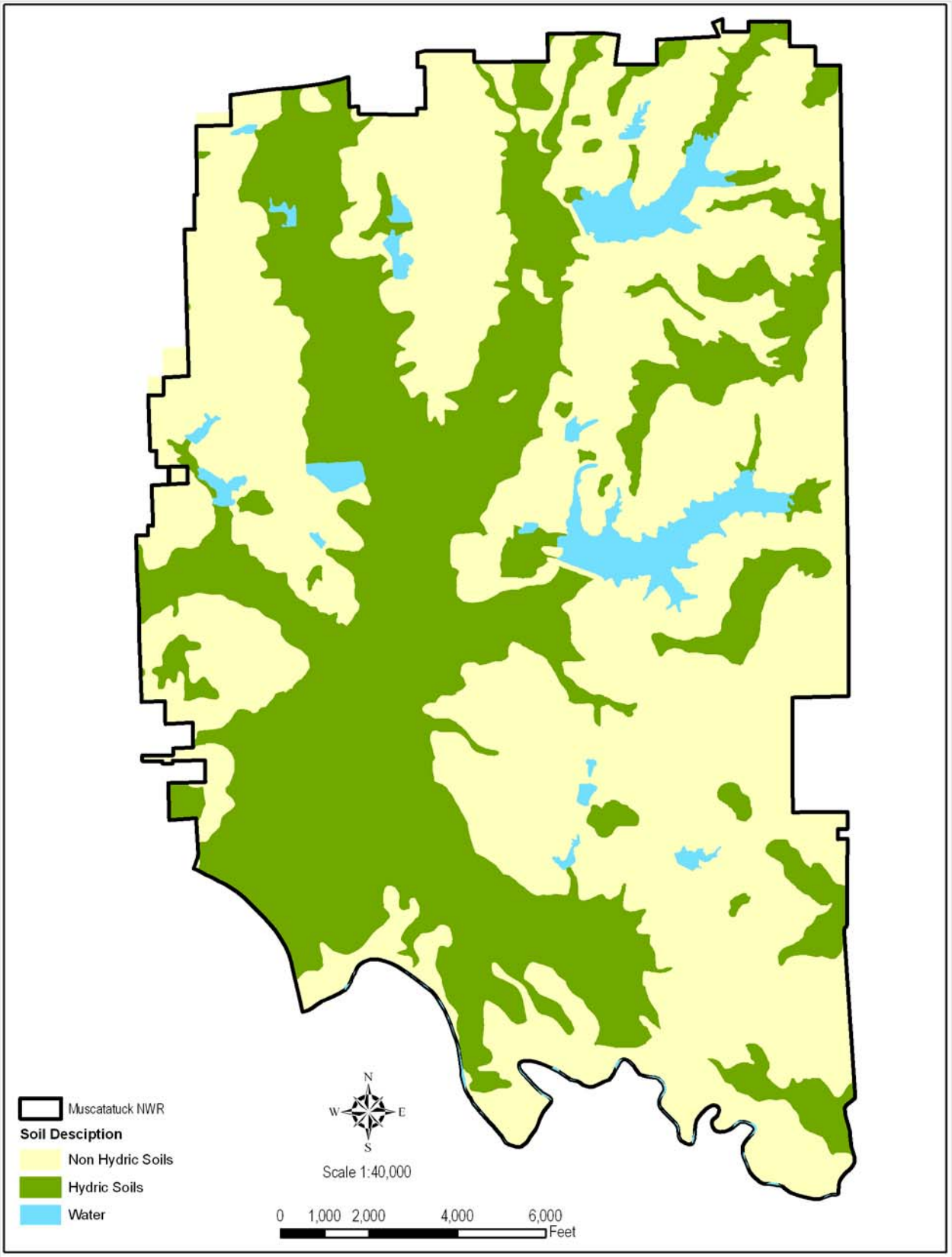
The Refuge has upland and river valley areas, causing variations in depth of the unconsolidated soil material to bedrock. A well drilled in the northeast part of the Refuge encountered bedrock at a depth of 40 feet. The bedrock depths can vary quite widely depending on the amount of material deposited and subsequently removed by erosion. The glacial material is dominantly stratified sands and clays that have been blanketed with a mantle of wind blown silt (loess).

In the floodplain area, bedrock is typically less than 10 feet below the surface. (Marshall et al. 2007)

Hydric soils (Figure 5) cover 2,962 acres of the Refuge. Non-hydric soils cover the remaining 4,797 acres. Soils on the Refuge are grouped into five soil associations: Dubois-Peoga-Haubstadt, Stendal-Birds-Piopolis, Haymond-Wakeland-Wilbur, Bloomfield-Alvin, and a small amount of Ayrshire-Lyles (Marshall et al. 2007; Nagel et al. 1990; Nickell et al. 1976).

The Dubois-Peoga-Haubstadt association of soils are very deep, nearly level to strongly sloping, moderately well to poorly drained, medium textured soils that have formed in loess and the underlying stratified lacustrine sediments on terraces. The somewhat poorly drained Dubois soils are nearly level to gently sloping on narrow flats and upper side slopes. The moderately well drained Haubstadt soils are gently to strongly sloping on side slopes. Both Dubois and Haubstadt soils have very slowly permeable fragipans present in the soil profile. Peoga soils are nearly level, poorly drained, and are on broad flats. The moderately well-drained Otwell soils actually have a higher number of acres within the Refuge area, and are often intermixed with the Haubstadt soils. The minor soil in this association is the well-drained Negley soils on steep side slopes. Also included with this association is a small amount

Figure 5: Hydric Soils, Muscatatuck NWR



Muscatatuck NWR. Photo credit: U.S. Fish & Wildlife Service

of Illinoian till soils in the very eastern boundary of the Refuge. These soils are the somewhat poorly drained Avonburg, moderately well-drained Nabb and Cincinnati, which all have fragipans. The soils of this association comprise approximately 4,172 acres, or about 54 percent of the Refuge area.

The Stendal-Birds-Piopolis association of soils are very deep, nearly level, somewhat poorly to poorly drained, medium and moderately fine textured soils formed in fine-silty acid alluvium on floodplains. Within the Refuge area, Birds soil is the more dominant component of the association, with slightly more that 2,000 acres. Birds soils are poorly drained and are formed in non-acid silty alluvium over alluvium with a higher clay content, in slow backwater areas of floodplains. Stendal soils are somewhat poorly drained, are formed in silty acid alluvium and tend to occur on slightly elevated areas, which are called steps, of the floodplain. Piopolis soils are poorly and very poorly drained and are formed in clay alluvium on floodplains. There is currently no Piopolis mapped within the Refuge area. Minor soils in this association are the poorly drained Bonnie and moderately well-drained Steff soils. Bonnie soils are formed in silty acid alluvium and are found in similar positions as Birds soils. Steff soils are formed in silty acid alluvium and are found in positions similar to Stendal. These soils are found mainly in the watersheds of Mutton Creek Ditch, Storm Creek Ditch, and Sandy Branch. The soils of this association comprise approximately 2,367 acres, or about 30 percent of the Refuge area.

The Haymond-Wakeland-Wilbur association of soils are very deep, well to somewhat poorly drained, nearly level, formed in coarse-silty non-acid alluvium on floodplains. Within the Refuge area, Wakeland soils are the more dominant component of the association, with slightly over 400 acres. Wakeland soils are somewhat poorly drained and are formed in silty non-acid alluvium on floodplains. Haymond soils are well-drained and are formed in silty non-acid alluvium on floodplains. Minor soil in this association is the well-drained, coarse loamy Wirt soils on natural levees of the floodplain adjacent to streams. These soils are found mainly in the Vernon Fork of the Muscatatuck River watershed. The soils of this association comprise approximately 600 acres, or about 7 percent of the Refuge area.

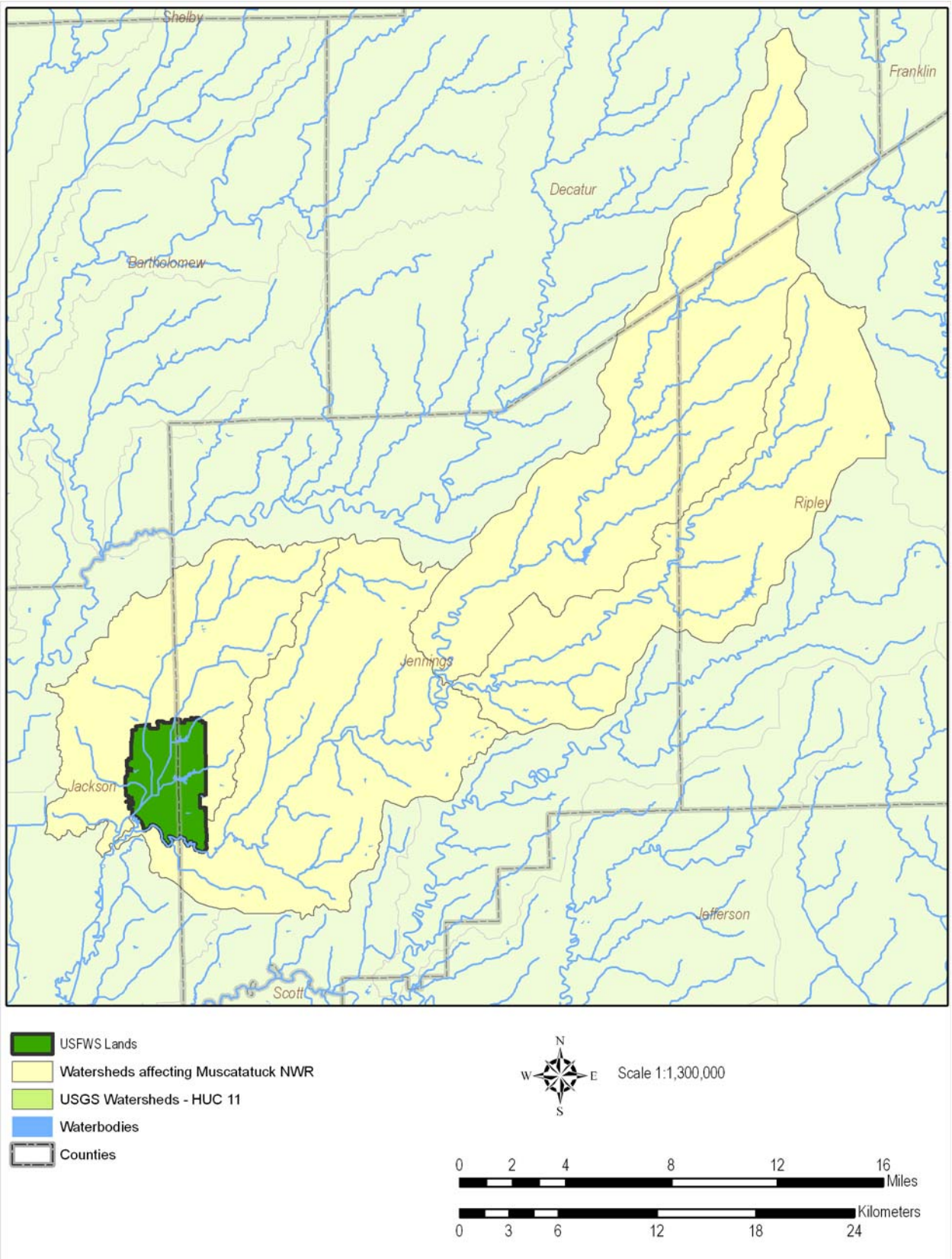
The Bloomfield-Alvin association of soils are very deep, nearly level to strongly sloping somewhat excessively to well-drained, coarse textured soils formed in eolian (windblown) sand deposits (dunes) on uplands. Bloomfield soils are nearly level to strongly sloping somewhat excessively drained on ridges and narrow side slopes of dunes. Alvin soils are well-drained and are intermixed with the Bloomfield soils on similar landforms. Minor soils in this association are the Bobtown and Medora soils. Bobtown soils are moderately well-drained and formed in moderately coarse textured eolian (windblown) sand deposits. Medora soils are moderately well-drained and are formed in loess and the underlying sandy outwash material, and have a fragipan. These soils are located mainly in the northwestern corner of the Refuge and comprise approximately 200 acres, or 3 percent of the Refuge area.

The Ayrshire-Lyles association of soils is very deep, nearly level, somewhat poorly and very poorly drained, moderately coarse textured coarse textured soils, formed in eolian (windblown) sand deposits (dunes) on uplands. Ayrshire soils are somewhat poorly drained and are on flats of uplands. Lyles soils are poorly drained, have very dark colored surface layers and are in slight depressions of uplands. These soils comprise about 43 total acres and are located mainly in the northwestern corner of the Refuge area.

Hydrology

The Refuge lies within a flat, relatively well drained portion of the Wabash River Basin (Figure 6). Water flows away from the Refuge down the Vernon Fork of the Muscatatuck River, into the Muscatatuck River, the White River, and on to the Wabash River. Three small streams, Sandy Branch, Mutton Creek, and Storm Creek, flow through the

Figure 6: Muscatatuck NWR and the Wabash River Basin Watershed



Refuge and enter the Vernon Fork soon after leaving the Refuge. The subwatersheds of Upper- and Lower- Mutton Creek and Upper- and Lower-Storm Creek, which cover 30,100 acres above the Refuge, flow into the Refuge. Approximately 8,525 acres of the Mutton Creek-Sandy Branch subwatershed, which includes the eastern portion of Seymour, also flows into the Refuge. The annual floodplain of the Vernon Fork extends 2,000 to 3,500 feet into the Refuge along its southern border. Annual floods inundate approximately 2,700 acres of the Refuge.

Mini Marsh, Muscatatuck NWR. Photo credit: U.S. Fish & Wildlife Service

Refuge Habitats and Wildlife

Acreages used to describe Refuge habitat in this section include the Restle Unit.

Wetlands

Wetlands cover roughly 70 percent of the Refuge and much of this land floods annually. (See Figure 7 for current Refuge land cover.)

The majority of wetland habitat is bottomland hardwood forest (4,180 acres), and managed water units that include moist soil units, brood marshes, greentree impoundments, and Stanfield, Moss and Richart Lakes (approximately 1,260 acres), which were built 1979-1982 with Bicentennial Land Heritage Program (BHLP) funds. The Refuge also has more than 70 other small ponds and wetland areas included in the 1,260 acres referenced above; these were constructed by former land owners to be stock ponds or ponds near residences and are utilized by migratory birds and wildlife. Several seeps exist on the Refuge, one of which is the Muscatatuck Seep Springs Research Natural Area. This wetland type is an acid seep spring that has only been documented in seven other locations in Indiana, one of which was destroyed, making it extremely rare in the state. Examples of wildlife that use these wetlands include Wood Ducks and Hooded Mergansers, which nest in the bottomland hardwoods, American Bald Eagle, copperbelly watersnake, river otter and many other species from all faunal assemblages.

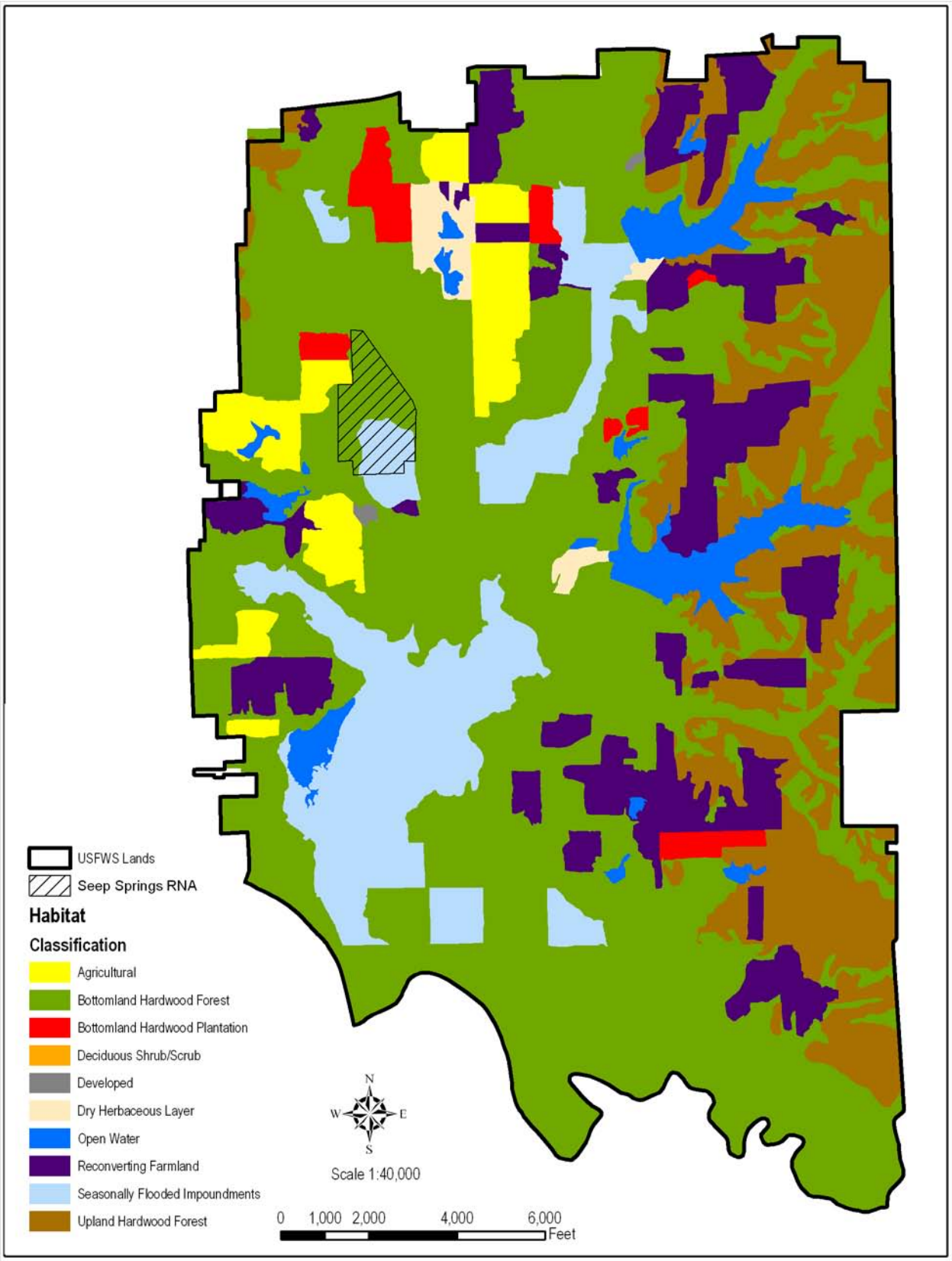
Forests

Approximately 69 percent (about 5,400 acres) of the Refuge is covered by forests. Of this, about half of the Refuge, or approximately 78 percent of the forested area (about 4,180 acres), is classified as one of several types of bottomland hardwood forest. Bottomland hardwood forests are a type of cold-deciduous forest that are temporarily or seasonally flooded and occur on wet soils and in floodplains. American beech and a variety of maple and oak species dominate bottomland forests and ash, sweetgum, river birch and sycamore are also present. The remaining 15 percent of the forested area (approximately 1,210 acres) of the Refuge is classified as upland hardwood forest. Upland hardwood forest is also classified as a cold-deciduous forest type that primarily occurs in lowland or submontane habitats on soils that are unaffected by seasonal flooding. Varieties of oaks and maples dominate, and these forests can also include American beech and eastern red cedar along with other species (Sieracki et al. 2002).

Examples of trees commonly found on the Refuge include:

- pin oak
- swamp white oak
- swamp chestnut oak
- sweet gum
- green ash
- river birch
- silver maple
- red maple
- shellbark hickory
- white oak
- red oak
- white ash
- tuliptree

Figure 7: Current Land Cover, Muscatatuck NWR



- American beech

Examples of wildlife that use the forests include white-tailed deer, eastern gray squirrel, eastern fox squirrel, southern flying squirrel, woodchuck, Indiana bat and forest birds such as:

- Wood Duck
- Hooded Merganser
- Red-shouldered Hawk
- Red-headed Woodpecker
- Northern Flicker
- Acadian Flycatcher
- Cerulean Warbler
- Prothonotary Warbler
- Worm-eating Warbler
- American Redstart
- Louisiana Waterthrush
- Kentucky Warbler
- Rusty Blackbird
- Yellow-billed Cuckoo
- Wood Thrush

Grasslands

Areas of grasslands totaling approximately 80 acres, including road edges, dam spillways and dikes, are mowed for maintenance purposes and, secondarily, for wildlife viewing along the auto tour route. The majority of these fields contain non-indigenous species such as fescue, timothy and orchard grass, and clover and the remaining dominant grassland vegetation includes native broadleaves, bluegrass, bluegrass-fescue, alfalfa-brome, and panic grass. Fescue is the dominant species over much of the non-cultivated open area.

A wide variety of wildlife utilize the grasslands including an abundance of small mammals, especially various mice and vole species, eastern cottontail rabbit, and larger mammals such as white-tailed deer and coyote, several snake species including black king snake, black rat snake, eastern garter snake, many raptor species including Red-tailed Hawk, and Northern Harrier, and a plethora of grassland birds such as:

- Sedge Wren
- Grasshopper Sparrow
- Henslow's Sparrow

Yellow Warbler, Muscatatuck NWR. Photo credit: Mark Trabue

- Song Sparrow
- Indigo Bunting
- Dickcissel
- Red-winged Blackbird
- Eastern Meadowlark
- Bobolink

Birds

More than 279 bird species have been reported on the Refuge and 120 of those are considered nesting species. A rich diversity of waterfowl, raptors, and songbirds are commonly observed on the Refuge. Wood Duck broods are common sightings in the spring and summer months. Waterfowl use days during the winter and spring migrations number in the hundred of thousands. A Bald Eagle nest has been active since 2002 and winter migrants are commonly seen. Muscatatuck NWR is also known for the spring and summer migration of songbirds, especially warblers, in May.

The Refuge was designated a Continentally Important Bird Area in June 1998. The designation was based on Christmas bird count data and the Refuge's wintering numbers of Canada Geese from the James Bay population. Between 2001 and 2007, the Refuge was a stopover site for the Whooping Crane Eastern Partnership (WCEP) ultra-light-led Whooping Crane migration every fall. A complete list of bird species and a general guide to their seasonal occurrence and status on the Refuge can be found in Appendix C.

Mammals

Thirty-seven species of mammals are known to occur on the Refuge. The mammals include the federally listed endangered Indiana bat and state-listed endangered evening bat, and the white-tailed deer, a species popular for hunting and wildlife viewing. Occurrence of the Indiana bat, including lactating females, on the Refuge was confirmed in 1995 and reaffirmed in 2007 by telemetry studies that found that the Indiana bat is a summer resident on the Refuge (Whitaker 1995; Carter 2007), and it may be more abundant than was generally thought. These bats are also known to form maternity colonies on the Refuge; one maternity roost was studied and its coordinates recorded in 2007, (Carter 2007).

Another notable mammal is the river otter, once extirpated from the state of Indiana. Reintroduction efforts for the state of Indiana were begun in January 1995 with 25 otters released at Muscatatuck NWR. This has resulted in numerous otters using the Refuge. Three confirmed otter litters were produced in 1996, and Refuge staff believe that they have produced litters annually ever since 1996. The reintroduction in Indiana has been successful and river otters are no longer considered endangered in the state (Johnson et al. 2007). A complete list of mammal species that occur on the Refuge can be found in Appendix C.

Amphibians and Reptiles

The wide diversity of habitats found on the Refuge makes it suitable for a broad range of amphibians and reptiles; 44 species of herpetofauna are known on the Refuge. They include three state-listed endangered species – the four-toed salamander, the copperbelly watersnake, and the Kirtland's snake – and the rough green snake, an Indiana Species of Special Concern.

As of November 1996, under the provisions of the Copperbelly Watersnake Conservation Agreement and Strategy, scientific investigation began to better understand the life history patterns of the copperbelly watersnake. The Refuge has been a stronghold for the species, allowing for intimate study (Kingsbury 1997). While many in the scientific community have commented on the ecology of the species, few have detailed aspects of its life history (Conant et al. 1991). Telemetry work at the Refuge has proven valuable in clarifying the ecological requirements of this species and observational data collected since 1992 and tracking/locating data collected in 1997 through 2000 revealed this species' dependence on both the palustrine emergent habitat, as well as the floodplain forest habitat provided by the Refuge.

Indiana University Professor Dr. Meretsky discovered the state-listed endangered four-toed salamander during her work with the seep spring study. The salamander is associated with mature forests with wetlands with mossy edges and the young spend several months in the water before they come out on land. Records from central and southern Indiana appear to be based upon very small isolated colonies, some of which may no longer exist, making the Refuge population a significant find. A complete list of the amphibians and reptiles that occur on the Refuge is provided in Appendix C.

Fish

Fish species were collected and inventoried during a 2007 survey of waterbodies within the Refuge including tributary streams outside the Refuge. A total of 54 species were collected from within the Refuge, and more than 75 fish species are known to occur on the Refuge (Appendix C). The most diverse families represented were the minnow and darter families, which each included 11 species on the Refuge. Fishing for largemouth bass, bluegill, redear sunfish, crappie, and channel catfish is popular and draws an estimated 15,000 fishing visits per year at the Refuge.

In addition to the sites surveyed on the Refuge, 50 more sites were surveyed in the area surrounding the Refuge. New records for the Refuge included the finding of the eastern sand and harlequin darters in the Vernon Fork Muscatatuck

Red-eared Sliders. Photo credit: U.S. Fish & Wildlife Service

River. In addition, the flier was collected from Moss Lake and Mutton Creek, while the redspotted sunfish was collected from Mutton Creek. These records probably represent the northern and eastern records for these species.

Invertebrates

An intensive survey of aquatic macroinvertebrates was conducted concurrently with the fish survey during the spring of 2007. Fifty samples were collected from a variety of creeks, streams, and lake outlets. The results of this survey are still pending; however, five species of crayfish were collected including the paintedhand mudbug, Great Plains mudbug, northern crayfish, Sloan's crayfish, and rusty crayfish (Simon 2008).

Thirty three dragonfly species have been recorded on the Refuge including the beaverpond baskettail, eastern pondhawk, and shadow darner. The Refuge is known as a good location to observe dragonflies in the area (Curry 2001). With accompanying photographs taken at Muscatatuck NWR, many of these dragonfly species are highlighted in the book *Dragonflies of Indiana* (Curry 2001). The beaverpond baskettail dragonfly occurs on the Refuge and is considered a rare species in the state of Indiana. Butterfly surveys have been conducted since 2002 by volunteers using a protocol established by the North American Butterfly Association, and 60 species have been identified to date including the cabbage white, an exotic species. A complete listing of dragonfly and butterfly species documented on the Refuge can be found in Appendix C.

At least 24 species of mollusks have been documented as occurring on the Refuge (Harmon 1996, Fisher 2007) A follow-up investigation of several of the mussel survey sites used by Harmon (1996) was conducted in 2007 (Fisher 2007). A total of eight sites were sampled in 2007 for live, fresh dead, and weathered dead shells. Harmon's (1996) study documented 20 species present on the Refuge; the 2007 inquiry yielded three new species from the Vernon Fork that had never been documented on the Refuge, including elephantear, flutedshell, and deertoe. The little spectaclecase was found in both the 1996 and the 2007 surveys; however, only fresh dead specimens were encountered (Fisher 2007). This species is a species of special concern in Indiana and is listed as imperiled (S2) within the state. The Asiatic clam, a non-native invasive species, is markedly abundant on the Refuge, especially within the Vernon Fork of the Muscatatuck River. A complete listing of mollusk species documented on the Refuge can be found in Appendix C.

Blue gill. Photo credit: U.S. Fish & Wildlife Service

Threatened and Endangered Species

State-listed/Candidate Species

A total of 61 state-listed endangered and special concern species have been documented on the Refuge with five more suspected to occur on the property. Examples of state-listed endangered species include:

- Indiana bat
- evening bat
- southern tubercled orchid
- climbing milkweed
- copperbelly water snake
- four-toed salamander
- Kirtland's snake
- Kirtland's Warbler
- Interior Least Tern
- Peregrine Falcon
- Bald Eagle
- Bewick's Wren
- Yellow-crowned Night-Heron
- Black-crowned Night-Heron
- Virginia Rail

- Common Moorhen
- King Rail
- Least Bittern
- Loggerhead Shrike
- Osprey
- Short-eared Owl
- Trumpeter Swan
- Northern Harrier
- American Bittern
- Upland Sandpiper
- Least Tern
- Black Tern
- Barn Owl
- Short-eared Owl
- Sedge Wren
- Golden-winged Warbler
- Marsh Wren
- Henslow's Sparrow
- Cerulean Warbler
- Black-and-white Warbler

State species of special concern on the Refuge include:

- least weasel
- little spectaclecase mussel
- Sharp-shinned Hawk
- Red-shouldered Hawk
- Great Egret
- Greater Yellowlegs
- Solitary Sandpiper
- Ruddy Turnstone
- Short-billed Dowitcher
- Wilson's Palarope
- Chuck-will's-widow
- Whip-poor-will
- Sandhill Crane
- Broad-winged Hawk
- Worm-eating Warbler
- Hooded Warbler
- rough green snake

Several other plant species are included on a state watch list. Those species are: American ginseng, bog bluegrass, Walter's St. John's-wort, smooth white violet, club spur orchid (also called small green woodland orchid), Loesel's twayblade and American lotus.

The Refuge species lists in Appendix C include each species' state and federal status.

Threatened/Endangered/Candidate Species (Fed Listed)

Least Tern, Whooping Crane, Indiana bat, and copperbelly watersnake use the Refuge.

Whooping Cranes from the "Operation Migration" project have used the Refuge as a stopover on their annual trip down to Florida. Free ranging/direct release cranes are routinely seen within 20 miles of the Refuge and one was spotted on the Refuge in 2008.

There is substantial documentation of the copperbelly watersnake's use of the Refuge. The copperbelly watersnake primarily inhabits shallow wetland systems consisting of sloughs, oxbows, river floodplains and buttonbush swamps, much of which have been lost or heavily fragmented (Pruitt and Szymanski 1997). In addition, the copperbelly watersnake is known to rely extensively on terrestrial habitat to traverse between spatially and temporally unpredictable wetland resources (Roe et al. 2003), offering an ideal system to investigate the role of terrestrial habitat on wetland connectivity. Presently, the copperbelly watersnake exists mainly as isolated, often small, populations separated by as much as 300 kilometers. Moreover, northern populations were listed as threatened by the Service and endangered by the states of Indiana, Michigan, and Ohio (Pruitt and Szymanski 1997). Genetic testing was done on the Muscatatuck NWR population in 2005 as part of a study that represented seven sampling sites located in Ohio/ Michigan, Indiana, and Kentucky. The Indiana regional sampling site was conducted in a disjunct population along the Muscatatuck River, in the Muscatatuck NWR in Jackson County, Indiana, and at a wetland 29 river kilometers south of Muscatatuck NWR in Washington County, outside of Austin, Indiana. The two Indiana sites are as different from each other as they are from any of the other sampling sites, despite their geographic proximity. (Marshall et al. In Press)

Kudzu. Photo credit: U.S. Fish & Wildlife Service

The federally-listed endangered Indiana bat was confirmed on the Refuge in 1995 and reaffirmed in 2007 by telemetry studies that found that the Indiana bat is a summer breeding resident on the Refuge (Whitaker 1995; Carter 2007). These bats are also known to form maternity colonies on the Refuge; one maternity roost was studied and its coordinates recorded in 2007 (Carter 2007).

Several species that were previously considered candidate species occur at times on the Refuge. These include the Loggerhead Shrike and Cerulean Warbler, bog bluegrass, American ginseng, and the southern tubercled orchid.

Threats to Resources

Invasive Species

Invasive, exotic, and noxious weeds are common throughout most of the Refuge's habitat types. Although research on quality, distribution, and abundance estimates are lacking, it is evident to anyone passing through on Refuge roads that autumn olive, garlic mustard, reed canary grass, multiflora rose, crown vetch and many other species dominate certain portions of the landscape. Japanese stiltgrass, multiflora rose, tree-of-heaven, autumn olive and kudzu threaten the diversity and health of the bottomland and upland hardwoods while other species, such as reed canary grass, attempt to out-compete native vegetation along riparian corridors, in moist soil units and in other wetland types. Many of the invasive species encountered have the capability over time of producing solid monocultures that shade out native vegetation and reduce overall plant diversity and, consequently, overall animal diversity (Pimentel 2005).

Examples of invasives found on the Refuge include:

- purple loosestrife
- autumn olive
- Canada thistle
- Johnson grass
- multiflora rose
- moneywort
- common carp
- Asian clams
- Japanese stiltgrass
- oriental bittersweet
- garlic mustard
- kudzu
- reed canary grass
- Asian ambrosia beetle
- Asian ladybugs
- European Starling
- Brown-headed Cowbird
- House Sparrow
- mosquito fish
- gypsy moth

There has only been one account of a gypsy moth (1995) and subsequent traps have not revealed any moths. It is not considered a major problem.

Water Contamination

Water contamination affecting the Refuge includes surface runoff and National Pollutant Discharge Elimination System (NPDES) discharge from populated areas, crop and livestock runoff, septic system failures, accidental spills, as well as pollutants from power substations, petroleum refineries, and industrial parks in the area. Contaminants may be entering the Refuge via a number of surface and groundwater sources, including:

- Vernon Fork of the Muscatatuck River (VFMR) and its tributaries
- Mutton and Storm Creeks
- Sandy Branch Creek

- Numerous unnamed drainages that enter the system during flooding periods
- City of Seymour
- Adjacent highways, roads, and railroads including discharge from accidents
- Underground storage tanks

Agriculture is the primary land use in the watershed. Run-off from crop fields, pastureland, and feedlots contributes to non-point source pollution. Erosion, sedimentation, eutrophication, and contamination from application of pesticides, herbicides, and fertilizers all introduce contaminants into the watershed and Refuge system. Many of these substances, such as organochlorines and organo-phophates, are known to be toxic to fish and wildlife via direct exposure, bioaccumulation, and bio-magnification (Cox 1991). In addition to fluvial and riparian deposition, flooding occurs during high rainfall periods of the year in many areas of the Refuge. These flood waters carry debris, chemicals, and other contaminants to large otherwise terrestrial areas of the Refuge.

In addition to agriculture, rapid residential and transportation development in the areas surrounding the Refuge have had detrimental impacts on the watershed. As more land is cleared and paved, there are decreases in sediment interception, increased throughfall, and changes in roughness coefficients and slope, all of which contribute to increases in flow rates, erosion, and amount of particles, sediment, and other substances reaching the Refuge (Tang et al. 2005). The Refuge is within a mile or less of three major highways, all of which cross at least one of the three primary tributaries that enter the Refuge. This creates sources of run-off containing salts, fuel, and other petroleum products.

The construction of homes and businesses has put a strain on waste water treatment facilities and septic systems that could result in nutrient and bacterial problems within the watershed. There is also potential for accidental spills to occur. The Refuge is bordered on two sides by major highways (U.S. 31, U.S. 50 and I-65) and by a well-traveled county road (Jennings CR900W) on a third side. Two of the three roads encompassing the Refuge are hard surface roads. In addition, the CSX Railroad runs approximately three-quarters of a mile north of the Refuge, crossing both Mutton and Storm Creek ditches. Another railroad, the Madison Railroad, crosses the VFMR upstream in North Vernon. In 1980, a derailed train spilled between 8,000 and 10,000 gallons of chlorobenzene directly into Storm Creek Ditch (McWilliams-Munson 1996).

Atmospheric deposition of heavy metals is a concern worldwide and the Refuge falls under the same general fish advisory as most of the waters in the state of Indiana. This advisory establishes recommendations for fish consumption based on elevated mercury levels in the fish in Indiana (Indiana Department of Natural Resources 2008). The problems associated with heavy metal contamination may be compounded at Muscatatuck NWR due to the impoundment of water and trapping of sediment, collection, and concentration of runoff from a large watershed, and the wetting and drying cycles that contribute to the methylation of mercury.

Urban Development

The city of Seymour is located just west of the Refuge, with Interstate 65 between the two as depicted in Figure 3 on page 11. U.S. Highway 50 passes across the northern boundary of the Refuge and continues west into downtown Seymour. Because of this crossroads, the development of businesses along the U.S. 50 corridor west of the Refuge has increased steadily, and the northern and western sides of the Refuge have seen an increase in residential development.

According to the U.S. Census, the population and number of housing units in both Jackson and Jennings Counties increased between 2000 and 2007. Both Jackson and Jennings Counties populations increased by just under 1,000 people, but the number of housing units in each increased by over 1,200 units in that same time period. These population and development increases bring additional concerns regarding impervious surfaces, increased traffic on roadways, additional water management needs, habitat loss and fragmentation, and increased visitation at the Refuge.

Military Activity

Areas adjacent to the Refuge have seen an increase in military activity in recent years. In addition to activity associated with Camp Atterbury and Jefferson Proving Grounds, in 2005 the Muscatatuck Urban Training Center (MUTC) was created in South Central Jennings County. The Indiana National Guard converted this 1,000-acre

Coyote. U.S. Fish and Wildlife Service photo.

site into an urban training center with 70 buildings and a mile of tunnels. Air traffic related to combat maneuvering and refueling, as well as training exercises and convoys, have increased the potential for wildlife disturbance and accidental discharges.

Atmospheric Concerns

In addition to the atmospheric deposition of heavy metals discussed in the water contamination section, ozone levels are a factor for the Refuge.

Ozone exposures in Indiana are the highest in the nation's north central region and are relatively high when compared with many states nationwide. The portion of Indiana that contains the Refuge, in particular, exhibits elevated ozone levels. The ozone exposure adversely affects trees and other plants. Ozone stress is expected to be less severe on some oaks and maples because they are relatively tolerant of ozone. Nevertheless, given the current ozone exposures and evidence of foliar injury, the potential exists for reduced tree growth and reduced forest health on the Refuge. (Woodall et al. 2005)

Climate Change Impacts

The U.S. Department of the Interior issued an order in January 2001 requiring federal agencies under its direction that have land management responsibilities to consider potential climate change impacts as part of long range planning endeavors.

The increase of carbon dioxide (CO_2) within the earth's atmosphere has been linked to the gradual rise in surface temperature commonly referred to as global warming. In relation to comprehensive conservation planning for national wildlife refuges, carbon sequestration constitutes the primary climate-related impact that refuges can affect in a small way. The U.S. Department of Energy's "Carbon Sequestration Research and Development" defines carbon sequestration as "...the capture and secure storage of carbon that would otherwise be emitted to or remain in the atmosphere."

Vegetated land is a tremendous factor in carbon sequestration. Terrestrial biomes of all sorts – grasslands, forests, wetlands, tundra, and desert – are effective both in preventing carbon emission and acting as a biological "scrubber" of atmospheric CO_2. The Department of Energy report's conclusions noted that ecosystem protection is important to carbon sequestration and may reduce or prevent loss of carbon currently stored in the terrestrial biosphere.

Conserving natural habitat for wildlife is the heart of any long-range plan for national wildlife refuges and management areas. The actions proposed in this CCP would conserve or restore land and habitat, and would thus retain existing carbon sequestration on the WMA. This in turn contributes positively to efforts to mitigate human-induced global climate change.

One Service activity in particular – prescribed burning – releases CO_2 directly to the atmosphere from the biomass consumed during combustion. However, there is actually no net loss of carbon, since new vegetation quickly germinates and sprouts to replace the burned-up biomass and sequesters or assimilates an approximately equal amount of carbon as was lost to the air (Boutton et al. 2006). Overall, there should be little or no net change in the amount of carbon sequestered at Kirtland's Warbler WMA from any of the proposed management alternatives.

Several impacts of climate change have been identified that may need to be considered and addressed in the future:

- Habitat available for cold water fish such as trout and salmon in lakes and streams could be reduced.

- Forests may change, with some species shifting their range northward or dying out, and other trees moving in to take their place.
- Ducks and other waterfowl could lose breeding habitat due to stronger and more frequent droughts.
- Changes in the timing of migration and nesting could put some birds out of sync with the life cycles of their prey species.
- Animal and insect species historically found farther south may colonize new areas to the north as winter climatic conditions moderate.

The managers and resource specialists responsible for the WMA need to be aware of the possibility of change due to global warming. When feasible, documenting long-term vegetation, species, and hydrologic changes should become a part of research and monitoring programs on the WMA. Adjustments in land management direction may be necessary over the course of time to adapt to a changing climate.

The following paragraphs are excerpts from the 2000 report: *Climate Change Impacts on the United States: The Potential Consequences of Climate Variability and Change*, produced by the National Assessment Synthesis Team, an advisory committee chartered under the Federal Advisory Committee Act to help the US Global Change Research Program fulfill its mandate under the Global Change Research Act of 1990. These excerpts are from the section of the report focused upon the eight-state Midwest Region.

Observed Climate Trends

Over the 20th century, the northern portion of the Midwest, including the upper Great Lakes, has warmed by almost 4 degrees Fahrenheit (2 degrees Celsius), while the southern portion, along the Ohio River valley, has cooled by about 1 degree Fahrenheit (0.5 degrees Celsius). Annual precipitation has increased, with many of the changes quite substantial, including as much as 10 to 20 percent increases over the 20th century. Much of the precipitation has resulted from an increased rise in the number of days with heavy and very heavy precipitation events. There have been moderate to very large increases in the number of days with excessive moisture in the eastern portion of the Great Lakes basin.

Scenarios of Future Climate

During the 21st century, models project that temperatures will increase throughout the Midwest, and at a greater rate than has been observed in the 20th century. Even over the northern portion of the region, where warming has been the largest, an accelerated warming trend is projected for the 21st century, with temperatures increasing by 5 to 10 degrees Fahrenheit (3 to 6 degrees Celsius). The average minimum temperature is likely to increase as much as 1 to 2 degrees Fahrenheit (0.5 to 1 degree Celsius) more than the maximum temperature. Precipitation is likely to continue its upward trend, at a slightly accelerated rate; 10 to 30 percent increases are projected across much of the region. Despite the increases in precipitation, increases in temperature and other meteorological factors are likely to lead to a substantial increase in evaporation, causing a soil moisture deficit, reduction in lake and river levels, and more drought-like conditions in much of the region. In addition, increases in the proportion of precipitation coming from heavy and extreme precipitation are very likely.

Midwest Key Issues:

1. Reduction in Lake and River Levels

Water levels, supply, quality, and water-based transportation and recreation are all climate-sensitive issues affecting the region. Despite the projected increase in precipitation, increased evaporation due to higher summer air temperatures is likely to lead to reduced levels in the Great Lakes. Of 12 models used to assess this question, 11 suggest significant decreases in lake levels while one suggests a small increase. The total range of the 11 models' projections is less than a 1-foot increase to more than a 5-foot decrease. A 5-foot (1.5- meter) reduction would lead to a 20 to 40 percent reduction in outflow to the St. Lawrence Seaway. Lower lake levels cause reduced hydropower generation downstream, with reductions of up to 15 percent by 2050. An increase in demand for water across the region at the same time as net flows decrease is of particular concern. There is a possibility of increased national and international tension related to increased pressure for water diversions from the Lakes as demands for water increase. For smaller lakes and rivers, reduced

flows are likely to cause water quality issues to become more acute. In addition, the projected increase in very heavy precipitation events will likely lead to increased flash flooding and worsen agricultural and other non-point source pollution as more frequent heavy rains wash pollutants into rivers and lakes. Lower water levels are likely to make water-based transportation more difficult with increases in the costs of navigation of 5 to 40 percent. Some of this increase will likely be offset as reduced ice cover extends the navigation season. Shoreline damage due to high lake levels is likely to decrease 40 to 80 percent due to reduced water levels.

Adaptations: A reduction in lake and river levels would require adaptations such as re-engineering of ship docks and locks for transportation and recreation. If flows decrease while demand increases, international commissions focusing on Great Lakes water issues are likely to become even more important in the future. Improved forecasts and warnings of extreme precipitation events could help reduce some related impacts.

2. Agricultural Shifts

Agriculture is of vital importance to this region, the nation, and the world. It has exhibited a capacity to adapt to moderate differences in growing season climate, and it is likely that agriculture would be able to continue to adapt. With an increase in the length of the growing season, double cropping, the practice of planting a second crop after the first is harvested, is likely to become more prevalent. The CO_2 fertilization effect is likely to enhance plant growth and contribute to generally higher yields. The largest increases are projected to occur in the northern areas of the region, where crop yields are currently temperature limited. However, yields are not likely to increase in all parts of the region. For example, in the southern portions of Indiana and Illinois, corn yields are likely to decline, with 10-20 percent decreases projected in some locations. Consumers are likely to pay lower prices due to generally increased yields, while most producers are likely to suffer reduced profits due to declining prices. Increased use of pesticides and herbicides are very likely to be required and to present new challenges.

Adaptations: Plant breeding programs can use skilled climate predictions to aid in breeding new varieties for the new growing conditions. Farmers can then choose varieties that are better attuned to the expected climate. It is likely that plant breeders will need to use all the tools of plant breeding, including genetic engineering, in adapting to climate change. Changing planting and harvest dates and planting densities, and using integrated pest management, conservation tillage, and new farm technologies are additional options. There is also the potential for shifting or expanding the area where certain crops are grown if climate conditions become more favorable. Weather conditions during the growing season are the primary factor in year-to-year differences in corn and soybean yields. Droughts and floods result in large yield reductions; severe droughts, like the drought of 1988, cause yield reductions of over 30 percent. Reliable seasonal forecasts are likely to help farmers adjust their practices from year to year to respond to such events.

3. Changes in Semi-natural and Natural Ecosystems

The Upper Midwest has a unique combination of soil and climate that allows for abundant coniferous tree growth. Higher temperatures and increased evaporation will likely reduce boreal forest acreage, and make current forestlands more susceptible to pests and diseases. It is likely that the southern transition zone of the boreal forest will be susceptible to expansion of temperate forests, which in turn will have to compete with other land use pressures. However, warmer weather (coupled with beneficial effects of increased CO_2), are likely to lead to an increase in tree growth rates on marginal forestlands that are currently temperature-limited. Most climate models indicate that higher air temperatures will cause greater evaporation and hence reduced soil moisture, a situation conducive to forest fires. As the 21st century progresses, there will be an increased likelihood of greater environmental stress on both deciduous and coniferous trees, making them susceptible to disease and pest infestation, likely resulting in increased tree mortality.

As water temperatures in lakes increase, major changes in freshwater ecosystems will very likely occur, such as a shift from cold water fish species, such as trout, to warmer water species,

such as bass and catfish. Warmer water is also likely to create an environment more susceptible to invasions by non-native species. Runoff of excess nutrients (such as nitrogen and phosphorus from fertilizer) into lakes and rivers is likely to increase due to the increase in heavy precipitation events. This, coupled with warmer lake temperatures, is likely to stimulate the growth of algae, depleting the water of oxygen to the detriment of other living things. Declining lake levels are likely to cause large impacts to the current distribution of wetlands. There is some chance that some wetlands could gradually migrate, but in areas where their migration is limited by the topography, they would disappear. Changes in bird populations and other native wildlife have already been linked to increasing temperatures and more changes are likely in the future. Wildlife populations are particularly susceptible to climate extremes due to the effects of drought on their food sources.

Administrative Facilities

The original portion of the Visitor Center (with restrooms) was constructed in the mid-1970s and featured a small office, lobby exhibit area, storage area, projection room, and auditorium/AV room separated by a breezeway from public restrooms. In 1989 the office was converted to a bookstore. Approximately 10 feet was added to the back of the original building in the early 1990s to create a bird viewing room, expanded bookstore, and additional storage areas. In 2003 a new wing, the Conservation Learning Center, was constructed using private funding obtained by one of the Refuge Friends groups, the Muscatatuck Wildlife Society Foundation. The new Conservation Learning center featured a large auditorium, exhibit area, and storage room. Numerous exhibits are located in the new wing. The two wings are connected by a breezeway with large glass windows. The Refuge office is situated in a remodeled ranch-style house across from the Visitor Center. Workshops, garages, storage buildings, and additional offices are located in the west-central area of the Refuge off of County Road 400 North.

The Muscatatuck Wildlife Society, our primary Friend's Group, operates a bookstore in our Visitor Center that is staffed by volunteers every afternoon and many mornings, and the building is closed when not staffed. Volunteers greet visitors, answer questions, and provide literature and information on Refuge hunting, fishing, and wildlife viewing opportunities. The Visitor Center has a paved, 16-car parking lot in front of the building, and a paved 33-car lot located across from the building off the loop road. A gravel overflow parking lot that can accommodate approximately 50 vehicles is located about 100 yards south of the Office, east of County Line Road.

Muscatatuck NWR Visitor Center. Photo credit: U.S. Fish & Wildlife Service

Cultural Resources and Historic Preservation

The earliest generally accepted human culture in Indiana is known as the PaleoIndian, a small population of nomadic peoples who moved into the state about 14,000 years ago upon the retreat of the glaciers. Sites are rare, usually disturbed, and important. A PaleoIndian point has been found in Jackson County but none have been found on the Refuge.

The Service has conducted several archeological investigations on the Refuge, which have identified numerous Archaic culture sites in the period 10,500 to 3,000 years ago. During this period the people engaged in extensive trade of far distant exotic materials. They also adapted to major temperature and resulting environmental changes as the Pleistocene ended and the associated megafauna became extinct following the retreat of the glaciers. This was followed by the hot and dry altithermal, which ended during a climatic period much like the 20th century. The primary subsistence pattern of

the Archaic period was hunting and gathering of a large range of animal and plant resources: "The ecotone between the swamp and the adjacent uplands [in the Refuge area] would have provided a unique blend of ecological resources for exploitation." (Myers 1979:11). Two cemeteries, the Barkman and Myers cemeteries, are also located on the Refuge.

Pottery, gardening, mounds (usually burial), and later the bow and arrow are indicative of the Woodland culture commencing about 3,000 years ago. Sites from this culture have been located on the Refuge. The Woodland culture was partially but not entirely displaced by the final prehistoric culture, the Mississippian, in the period 1,100 to 400 years ago. But by the time Western culture (Euro-American) arrived the area had been de-populated.

In the Refuge area neither the archeological nor the early documentary record provides any connection between prehistoric cultures and historic Indian tribes. The earliest written records indicate the Miami, Illinois, and Shawnee lived in the area, but the Iroquois from New York drove out those tribes in the early 1600s. Nevertheless, the Miami and Shawnee along with the Delaware were in Jackson and Jennings Counties until being displaced entirely by 1818.

Between the 1830s and the 1870s farmers settled on what is now the Refuge. Originally subsistence-based hog and corn farmers, the early settlers relied heavily on the abundant wildlife and plant resources. Later a network of rural graveled roads led to the introduction of manufactured goods, which improved rural life during the early 20th century. But concurrently, erosion caused by extensive deforestation from expanding farms stripped away the topsoil and some farmers abandoned the land. To create additional fertile farmland, Mutton and Storm Creeks were ditched for drainage between 1880 and 1900. "By 1870 most of the present refuge area was utilized for farming and this pattern of small farms continued essentially uninterrupted in the area until the creation of the Refuge in 1966." (Myers 1979:23)

Cultural resources are all an important part of the Nation's heritage. The Service is committed to protecting valuable evidence of human interactions with each other and the landscape. Protection is accomplished in conjunction with the Service's mandate to protect fish, wildlife, and plant resources.

As of March 1, 2008, the National Register of Historic Places listed 11 historic properties in Jackson County and five in Jennings County. This small number is surely not representative of the number of potential historic properties in the counties. Two of the National Register properties are archaeological sites that are are located on the Refuge, the listings resulting from Service-funded research: sites 12-J-62 and 12-J-87. Also as of March 1, the Refuge inventory of identified known and potential cultural resources based on Service-sponsored archeological investigations and maps resulted in a list of 140 sites of which 94 are on the National Register, have been determined eligible, or are considered eligible until determined otherwise. Archeological surveys have covered just 1,920 acres of the Refuge so many more sites are likely to occur on the Refuge. Of special note of the known sites is the Carl Myers farm (including log cabin, log barn, and persimmon orchard remnant) which should be nominated to the National Register.

The Refuge has a small number of Native American artifacts on exhibit in the Visitors Center. These artifacts were found on the Refuge and are on loan from the Glenn Black Museum of Indiana University in Bloomington. The display has several artifacts including lithic points, tools, and a pot. The Refuge is included in the Region-wide scope of collections statement dated October 31, 1994.

Muscatatuck NWR. Photo credit: U.S. Fish & Wildlife Service

Muscatatuck NWR. Photo credit: U.S. Fish & Wildlife Service

Visitation

Muscatatuck NWR is open from sunrise to sunset 365 days a year. There are two entrances to the Refuge and both have automatic gates that open at sunrise and close at sunset. Special extended hours are set during hunting seasons. The Conservation Learning Center is also regularly used for meetings and presentations by groups that have a wildlife conservation or management purpose or program, including evening hours by arrangement.

The Refuge annual visitation was estimated at approximately 174,000 in 2006. The number of visitors per year is obtained through estimates derived in large part from traffic counters at both entrances. Undetected malfunctions in the counters are believed to have led to reports of lower numbers of visitors in some recent years.

The Visitor Center is located on a loop off County Line Road (across from the Office) and is usually by-passed by repeat visitors. A counter at the main point of entry indicated approximately 13,000 visitors to the Visitor Center during the last year.

We do not have an accurate breakdown of visitor numbers per activity but we believe the largest segment of our visitors come for wildlife observation including bird watching, followed by fishing, interpretation/education, and hunting.

Current Management

Habitat Management

Acreages used to describe Refuge habitat in this section include the Restle Unit.

Wetland Management

A total of approximately 1,260 acres on the Refuge have water control structures, including moist soil units, greentree reservoirs, managed wetlands, and open water units (Figure 8). Annual water management plans have been followed since 1984 and these plans give management strategies for each unit that include specific water levels needed to create and maintain various habitat or to make food available and attractive to wildlife, particularly for Wood Duck production. Water management techniques include:

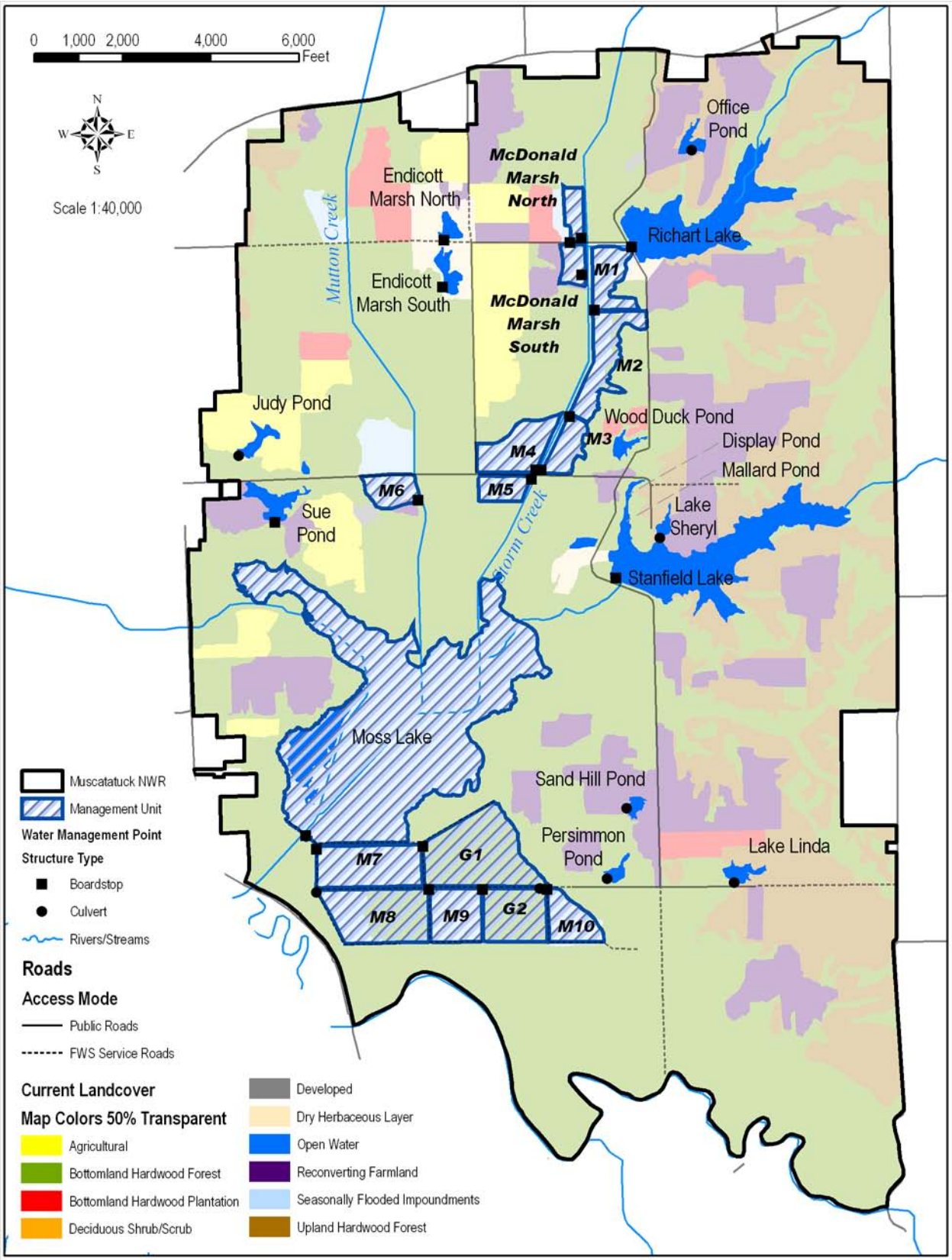
- Removing water to expose mudflats for shorebird use.
- Allowing seed germination of desirable moist soil plants.
- Allowing natural or mechanical rejuvenation of a permanent marsh or moist soil unit.
- Discouraging use of an area by muskrats.
- Adding water and maintaining different depths to stimulate invertebrate production.
- Creating and maintaining brood habitat and waterfowl migratory feeding areas (Smith and Kadlec 1983).

The primary goals of water management are to provide optimum conditions for food and cover for migrating birds, especially waterfowl, nesting and brood habitat for Wood Ducks and Hooded Mergansers, and habitat for other species that use wetland areas.

Moist Soil Units

Muscatatuck NWR actively manages 296 acres in 10 moist soil units through water and vegetation manipulation. Moist soil management on Muscatatuck NWR has been focused primarily on producing dense stands of perennial emergent vegetation on eight units to provide foraging and resting habitat for spring migrating waterfowl. Another objective on these eight units has been to provide brood habitat for resident Wood Ducks, Hooded Mergansers and Canada Geese. These objectives were achieved through water level

Figure 8: Water Management Infrastructure, Muscatatuck NWR



manipulations timed to coincide with providing optimum habitat conditions for germinating smartweed while also maintaining pool levels throughout the summer months for the broods. Seasonal flooding of these units has generally been planned to occur from September through April. However, proper hydrological manipulation in these units has proven difficult to achieve due to excessive flooding and/or beaver activity combined with a lack of personnel. The remaining two units have been managed to provide sparse perennial emergent vegetation combined with drawdowns timed to coincide with southward migrating shorebird arrival to provide optimum mudflat habitat, a critical need for this avifaunal group (Smith and Kadlec 1983). Water manipulations are generally conducted so that flooding occurs between September and March, although these units have been subjected to the same limitations outlined above.

Regular maintenance of moist soil units is a necessary phase in any management scheme due to the eventual invasion of these areas by more persistent or woody vegetation, i.e. buttonbush, willows, and Eastern cottonwood. The preferred means of maintaining a particular unit generally involves methods of mechanical disturbance, mowing or disking, to set back succession (Gray et al. 1999). Most units are scheduled to undergo treatment approximately once every 3 to 5 years. However, due to a shortage of staff and impediments to drawdown such as beaver activity and inclement weather, the achievement of many desired management activities are not realized as scheduled. In a normal year, plans call for the maintenance of one to three of the moist soil units. During this process, drawdown may begin earlier than "normal" to facilitate entry into the units with the necessary equipment. Following vegetation manipulation the units are reflooded and enter back into the "normal" cycle of drawdown and floodup until another maintenance cycle is necessary.

Grasslands

Grassland management is extremely limited, with only 80 acres currently in this kind of habitat. Active management of grasslands in the past entailed mowing, burning, and haying; however, these activities have been abandoned largely due to lack of staff and funds, increasing costs of active management, and changes in objectives. The current objective for many areas that were previously farmed (approximately 870 acres) is to allow them to revert to hardwood forest to reduce forest fragmentation. Once that process begins, those areas are considered in the context of forest management.

Muscatatuck NWR. Photo credit: Jon Kauffeld

Control of invasive species is at the forefront of management goals at the Refuge, and exotic species found in grassland areas are addressed on a case-by-case basis. It is currently considered desirable to control invasives throughout all habitat types because of their threat to the biological integrity and diversity of every habitat as native species are out-competed for space and resources. Often these shifts in the floral community structure and composition are followed by shifts in the faunal community, which in some instances could be detrimental to rare or endangered species and reduce overall diversity.

Forests

With approximately 4,180 acres in bottomland hardwood forest (including 48 acres on the Restle Unit) and approximately 1,210 acres in upland hardwood forest, these areas comprise the dominant cover type on the Refuge. Forest restoration is primarily accomplished through natural succession. Currently, approximately 870 acres of Refuge land are in the process of reverting back to upland and bottomland forest from previous agricultural use. Most fields are small and are surrounded by excellent seed sources for deciduous trees, although some tree planting of oaks (mast producing trees) has occurred and will continue to occur and increase as funding permits. The U.S. Forest Service has seven permanent inventory points located on Muscatatuck NWR as part of its national Forest Inventory and Analysis (FIA) Program. The FIA is a national program of the USDA Forest Service that conducts and maintains comprehensive inventories

of the forest resources in the United States (Forest Service 2007). This provides forest/landscape level assessments.

Tree planting has occurred sporadically since the Refuge was established. From establishment in 1966 to 2000, approximately 82 acres were planted in selected fields that had been retired from farming (Sieracki et al. 2002). The fields selected were chosen because of their location near existing forested tracts and to help repair forest fragmentation. Since 2000, 30 additional acres were planted in 2004, 15 acres in 2007, and 19 acres in 2008. The Refuge plans to plant 28 acres in 2009. The Refuge requests planting plans from the local area IDNR Forester prior to undertaking any new planting projects. The plans include native species of a diversity of tree species (mostly oaks) at a rate of 500 trees per acre. Planting has been done by a consulting forester. The Refuge Friends Group, the Muscatatuck Wildlife Society, and the National Wild Turkey Federation have helped fund projects.

Cropland

Food crops of corn and soybeans with wheat as a cover are planted annually on 267 acres of cropland under a cooperative farm agreement with a local farmer. According to the 2007 vegetation map, the Refuge retains approximately 330 acres of land associated with agriculture. The Refuge's share of the crops is left in the field for wildlife. This maintains open habitat and adds diversity to a mostly forested Refuge (Donalty et al. 2003). Canada Geese, waterfowl, Sandhill Cranes, and resident species forage on the Refuge's share of the crop. Wintering raptors prey upon small mammals feeding in these fields. Farmed acres also create good wildlife viewing along Refuge roads and the auto tour route.

Monitoring

A number of surveys, censuses, studies, and investigations are conducted on the Refuge that help to monitor the status of its wildlife and plant populations (see Table 2). Birds, mammals, herptofauna, and habitat are monitored on regular schedules. The surveys are conducted by Refuge staff, volunteers and in partnership with IDNR. Weekly waterfowl surveys, mid-winter waterfowl and Bald Eagle counts, and a few other surveys are requested by the state on an annual basis and the survey data upon completion is sent to IDNR. Staff with IDNR summarize and analyze the information and provide the Refuge copies of the analyses. The purpose of monitoring is, in general, to determine the presence or absence and estimate the numbers of fish and wildlife present and to aid in making management decisions, and to respond to information requests from state agencies, the public and other partners.

Public Use

The National Wildlife Refuge System Improvement Act of 1997 established six priority uses of the Refuge System. These priority uses all depend on the presence of wildlife or expectation of the presence of wildlife, and are thus called wildlife-dependent uses. These uses are:

- hunting
- fishing
- wildlife observation
- photography
- environmental education
- environmental interpretation

Muscatatuck NWR provides opportunities for all six priority uses of the Refuge System.

Hunting

Hunting is permitted for white-tailed deer, rabbit, squirrel, turkey, and quail in certain locations on the Refuge during most of the established state seasons. Hunting leaflets are updated annually and hunters are required to sign the front of the leaflet and carry it with them while hunting. The Refuge also keeps the state of Indiana Hunting and Trapping Guide with all state rules and regulations in stock as a service to hunters. Deer and turkey hunting are allowed on a large portion of the Refuge during their respective seasons, while squirrel, rabbit, and quail hunting are only allowed in a small portion of the deer and turkey hunting area. No hunting is allowed in the Refuge closed area, in a large section in the northeast corner of the Refuge where the Visitor Center and most of the hiking trails are located, or within 100 yards of any building (Figure 9 on page 38).

Special deer hunts are held for archery and muzzleloading gun hunters during certain periods and approximately 3,000 hunters participate annually. The deer hunt drawings are done by the state. Bowhunters hunt in a different time period from the muzzleloading hunters. A late "open" archery season, open to all hunters with a valid state

Table 2: Monitoring History, Muscatatuck NWR

Study/Survey	Priority (10 high, 1 low)	Scales	FWS R3 RCP	No. Runs	No. Routes
Water Level Monitoring, MSU Hydrology	10	Refuge		26+	1
Invasive Species Mapping and Monitoring	10	Refuge, State, National		N/A	N/A
MSU Vegetation Cover Survey	9	Refuge		1	N/A
Water Quality Monitoring	8	Refuge, State		4	5
Waterfowl Brood Survey	8	Refuge	✓	10	1
Species Lists	7	Refuge	✓	N/A	N/A
Tubercled Orchid Survey	7	Refuge, State		1	2
Migratory Waterfowl Surveys	6	Refuge, State, National	✓	52	1
Fish Survey	6	Refuge, State	✓	N/A	N/A
FWS Eastern Greater Sandhill Crane Survey	5	Refuge, Region	✓	1	1
Audubon Christmas Bird Count	4	Refuge, State, National	✓	1	?
Audubon May Day Count	4	Refuge, State, National	✓	1	?
Bald Eagle Count	3	Refuge, State		1	1
NoAm Amphibian Monitoring Program	3	Refuge, State, National		3	1
Great Blue Heron Rookery Count	3	Refuge, State		1	1
Aquatic Invertebrate Survey	3	Refuge, State	✓	N/A	N/A
Abnormal Amphibian Monitoring	3	Refuge, Region, National		N/A	N/A
Butterfly Abundance and Diversity	2	Refuge		1	?

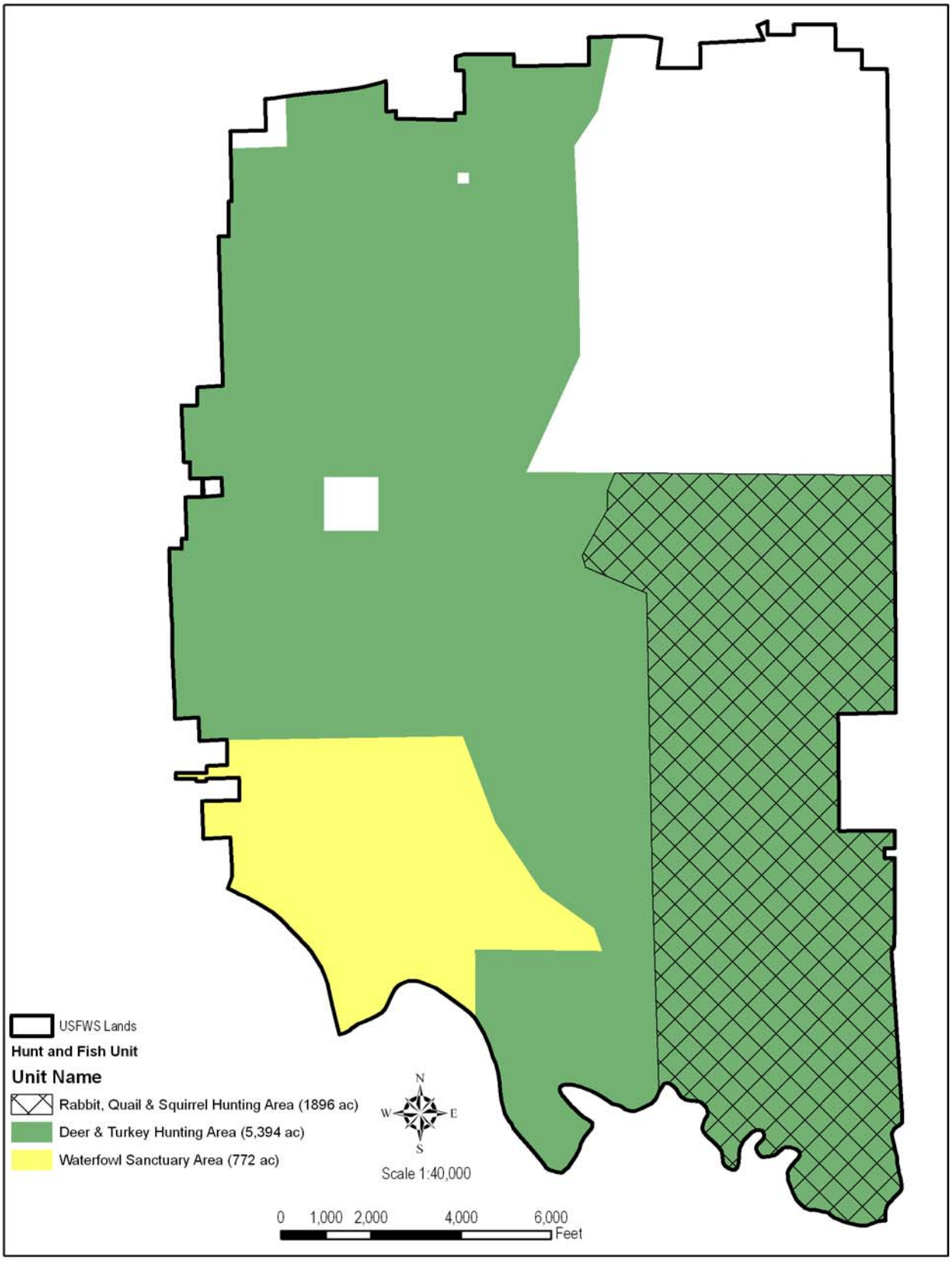
hunting license and available tag, is held on the Refuge after the muzzleloader season is over. Only handicapped hunters are permitted to use crossbows during Refuge deer hunts. The deer hunting area is the same as the turkey area – approximately three-quarters of the land area of the Refuge.

The turkey hunt requires a special permit during the spring season and involves 10-15 hunters per day over approximately three-fourths of the land area of the Refuge. Special permit drawings are done by the state. Rabbit hunting is open to members of the public with a valid state hunting license and involves a small percentage of Refuge visitors. Rabbit and quail hunting are the only hunting activities on the Refuge where dogs may be used and be off-leash. Squirrel hunting is a new, small, but growing activity. The rabbit, quail, and squirrel hunting area covers the southeast quarter of the Refuge and is the area east of County Line Road and south of Barn Road. Very few visitors hunt quail here as the quail population is marginal and most of the hunting area is reverting to brush.

The Refuge remains open to non-hunting activities throughout the hunting season. Refuge visitors and hunters scouting for a future hunt day may enter hunting areas for any otherwise allowed purpose. All Refuge public use roads also remain open during all hunts as do all public fishing sites.

Hunters park on the Refuge only in designated hunting areas to access all parts of the Refuge that are open to hunting. Additionally, many hunters park on adjacent public roads, including CR 900 W.,

Figure 9: Public Use, Hunting, at Muscatatuck NWR



Turkey hunting on Muscatatuck NWR. Photo credit: U.S. Fish & Wildlife Service

Hwy. 31, and CR 500 N., outside the Refuge and walk in to their hunting areas, but most park along the Refuge roads. Refuge staff have little contact with hunters aside from answering questions prior to and during the hunt. Self-service deer registration boxes are located at each entrance gate where hunters are required to register their kill before taking it to a state-authorized check station. Turkey hunters are asked to report the location of their takes, and successful deer hunters are asked to fill out a harvest card.

Fishing

Fishing is provided year-round at two large lakes, Stanfield and Richart, two small lakes, Linda and Sheryl, and at Display, Mallard, Sand Hill, and Persimmon Ponds. A fishing leaflet is available and is updated annually as needed. The Refuge also keeps the state of Indiana Fishing Guide with all state rules and regulations in stock as a service to anglers. Fishing structures and paved paths provide accessibility to handicapped anglers at three sites – Stanfield Lake and Lake Linda, which have accessible floating ramps and platforms, and Sand Hill Pond, which has a paved walkway. Stanfield Lake has a concrete boat ramp and non-motorized boats may be launched and used on this lake. Parking lots and single-panel kiosks with regulations and leaflets are located at each fishing area except for Richart Lake, Display Pond, Mallard Pond, and Lake Sheryl. Concrete outhouse facilities are located at the Stanfield Lake and Persimmon Pond parking lots for the convenience of all visitors. Regular bathroom facilities with running water are located at the Visitors Center. A map of all Refuge fishing areas is provided in the fishing leaflet.

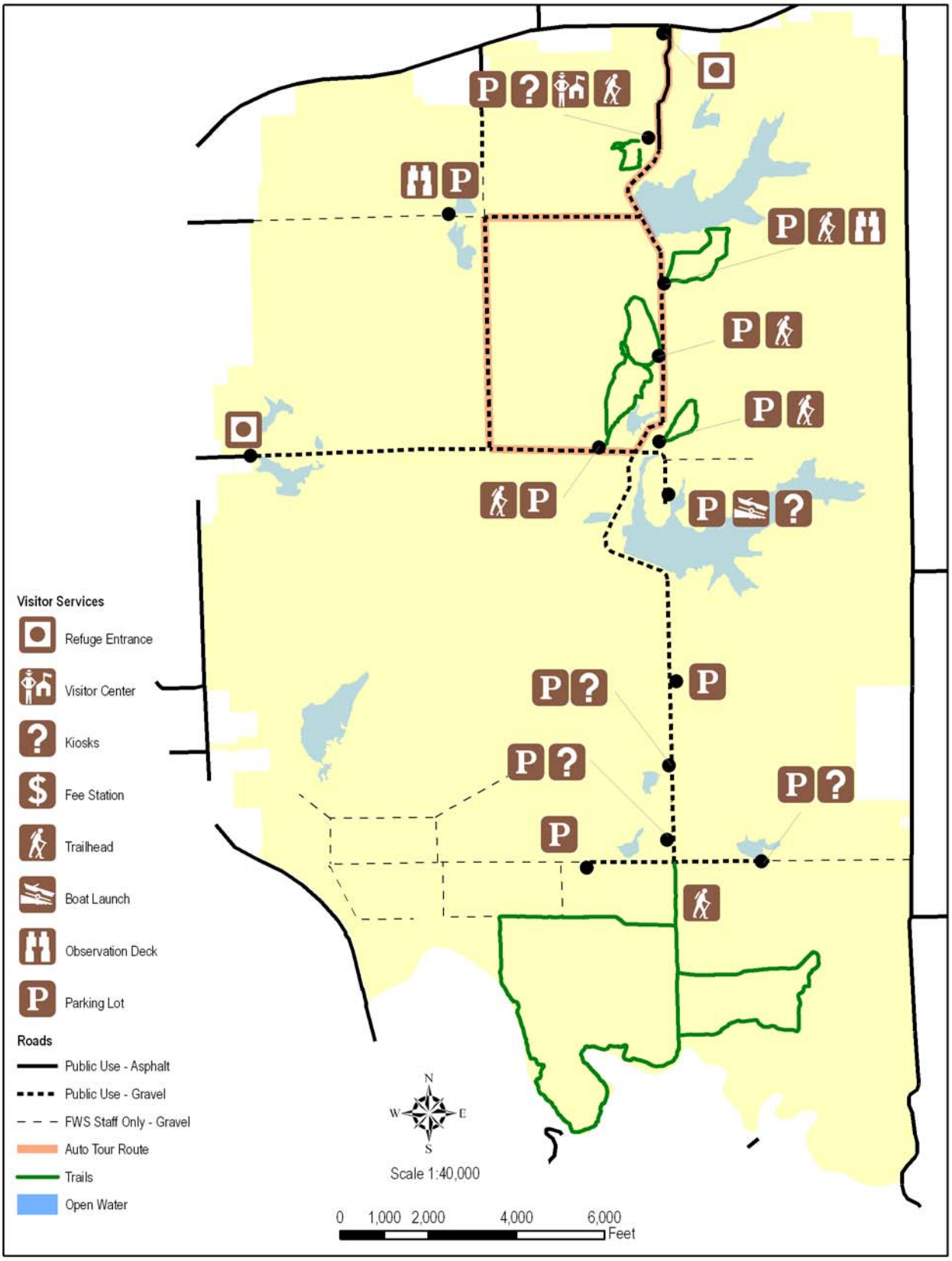
Fishing in the creeks and the seasonal drainages that enter and cross the Refuge is not allowed in an effort to provide relatively undisturbed habitat to Wood Ducks and their broods, which make extensive use of these habitats. Fishing is also not allowed in any of the Refuge's constructed moist soil units or marshes. Fishing is permitted from the banks of the Muscatatuck River except from the shoreline in the waterfowl sanctuary closed area.

Refuge fishing areas are generally shallow. Aquatic weed growth makes bank fishing difficult in the warm months and some Refuge visitors use "float tubes" or "belly-boats" – inner-tube type aides for wading (or floating) across the water. Fishing is permitted by hook and line only, and generally state regulations apply. Sought-after fish species include largemouth bass, bluegill, crappie, and channel catfish.

Interpretation, Observation, and Photography

Nine miles of roads are open for wildlife observation from autos, buses, motorcycles, or bicycles, plus an approximately 4-mile auto tour route with numbered posts and an interpretive leaflet. There are two observation structures, the Hackman Overlook on Richart Lake and the Endicott Observation Deck on the Auto Tour Route. The Hackman Overlook is located approximately one-half mile from the Richart Trail parking lot and overlooks Richart Lake. Recently, this structure has attracted vandals who have been marking it with graffiti and carvings, and the structure has been identified by staff as a maintenance problem. The Endicott Viewing Platform is an accessible raised wooden structure that overlooks both the North and South Endicott Marshes, has two fixed public use spotting scopes, and provides good opportunities to view marsh, wading, and waterbirds (Figure 10).

Figure 10: Visitor Services Facilities, Muscatatuck NWR



There are seven hiking trails of various lengths on the Refuge including the 0.4-mile (paved) Chestnut Ridge Interpretive Trail near the Visitor Center that features numbered posts with a leaflet. Most hiking trails are about a mile long except for the East and West River trails in the floodplain of the Muscatatuck River, which between them provide a 7-mile route for wildlife observation and hunter access along the river.

A self-service audiovisual program that presents an overview of the Refuge is available at the Conservation Learning Center. There are interpretive exhibits in both wings of the building and the Indiana Junior Duck Stamp Contest entries are on display in the CLC auditorium. New exhibits were recently built and installed in the old wing of the Visitor Center by a contractor and were opened to the public in the summer of 2008. A two-panel kiosk is located in the Visitor Center parking lot.

Large Refuge special events include a migratory bird festival in May, kids fishing event in June, and a friends' group Refuge Week "Log Cabin Day" festival in October. The "Wings Over Muscatatuck" bird festival held on International Migratory Bird Day is the Refuge's major annual event and attracts a growing audience of approximately 1,000 visitors when the weather is good. The Jackson County Visitor Bureau and the Muscatatuck Wildlife Society are major sponsors of this event, which features day-long guided birding tours of the Refuge, bird walks, bird banding demonstrations, bird and wildlife interpretive programs, live birds of prey/Bald Eagle programs, exhibits by conservation groups, vendors, and kids' birding activities.

The "Take a Kid Fishing" event at Muscatatuck NWR has been funded by the Muscatatuck Wildlife Society for many years. The 1-day event features special fishing for "kids and friends" in a pond normally closed to fishing, fishing and casting contests, fish art contests, loaner fishing poles, free bait, fishing lessons on request, and lots of door prizes. Trophies are awarded to event winners. Attendance varies between 400-600 people.

With the help of the Service's National Conservation Training Center, Muscatatuck NWR staff operate two booths at the National Future Farmers of America (FFA) Convention in Indianapolis for 3 days each October. The focus of the outreach effort is on providing career and background information on the Fish and Wildlife Service and wildlife conservation issues. Between 40,000-50,000 young people and several thousand teachers attend the convention annually, and this event is considered the largest gathering of students anywhere in the United States.

Visitors at Muscatatuck NWR. Photo credit: U.S. Fish & Wildlife Service

The "Log Cabin Day" festival in October celebrates the end of National Wildlife Refuge Week and is a project of the Muscatatuck Wildlife Society. The friends group provides a free ham and bean lunch at Myers Cabin during the event and there are old-time crafts, music, blacksmiths, a storyteller, horse-drawn wagon rides into the adjacent closed area (which is open that week), wildlife exhibits and information, and a volunteer set-up with a spotting scope on the Refuge Bald Eagle nest. "Wetland Day" programs have been held in mid-March for several years and feature guided waterfowl tours.

Wildlife photographers visit the Refuge on a regular basis but exact numbers are unknown. Annual wildlife photography contests are held in conjunction with bird festival and Refuge Week events and the Refuge hosts the monthly meetings of the Muscatatuck Photography Club.

Environmental Education

Many school groups visit the Refuge during the spring and fall, and primarily use the Refuge for self-directed activities. Unfortunately, with transportation funding cuts to public schools,

numbers have been decreasing over the last few years. Refuge staff assist teachers prior to their visits whenever possible but do not usually work with students directly. Staff work with Girl Scouts on badge-work and "linking girls to the land" activities.

Four "Conservation Field Day" programs are held for third-graders from Jackson and Jennings Counties in May and October with about 300 youngsters involved each day, and as such provides Refuge contact with most of the third-graders in each of these counties each year. The interagency effort features programs on wildlife, forestry, soils, wetlands, and recycling. Instructors usually include educators from the Indiana Department of Natural Resources, local Soil and Water Conservation Districts, Purdue Extension, Indiana Department of Environmental Management, Solid Waste Management Districts and the Refuge. The programs feature hands-on activities for the youngsters and are well received by area teachers.

Muscatatuck NWR manages the Indiana Junior Duck Stamp art contest with over 450 entries each year. Refuge volunteers do much of the work in administering the program and the Muscatatuck Wildlife Society provides a substantial amount of the award funding. Other partners in the program include the Indiana Department of Natural Resources, Ducks Unlimited, and Bass Pro Shops. An awards ceremony is held at the Refuge during the May migratory bird festival. The original art of the Junior Duck Stamp Contest winners is kept on display in the Visitor Center Auditorium for one year before being returned to the students.

A "Junior Birder" kids program is administered during the summer months and is being expanded with volunteers. An "Invasive Species" patch program is available and has been used by Scouts and other youth groups. Master Naturalist classes and teacher workshops are held on the Refuge periodically. Songbird, Prairie, and Wetland Trunks are available on loan from the Refuge as are other educational materials. Kids' activities are an important part of the migratory bird festival held annually in May, and "skins and bones" are featured at the Refuge Week festival.

The "Refuge Rangers," an elementary school group of about 30 students from Hayden School, has spent considerable time learning about the Refuge and helping with projects under the leadership of their teacher, a Refuge volunteer. This group has recently published a field guide to Muscatatuck NWR written by and for children, and with the assistance of the National Fish and Wildlife Foundation and the Muscatatuck Wildlife Society, this guide is being made available to all students who visit the Refuge as part of a school-based field trip.

Non-wildlife Dependent Recreation

Collecting mushrooms, nuts, and berries is permitted along with collecting shed deer antlers. Large numbers of people collect mushroom species at the Refuge in the spring.

Some jogging and bicycling occurs on the Refuge. Jennings County High School regularly brings their physical education and cross-country teams out for practice runs on Refuge trails.

Predator, Pest, and Invasive Species Management

Animal Species

Currently two mammalian aquatic nuisance species exist at the Refuge, the North American beaver and muskrat. Beaver create serious problems on the Refuge by constructing dams that impede water flow and cause flooding, which has proven to be detrimental to bottomland hardwood stands and has resulted in less than desirable conditions in moist soil units and green tree units. This also creates an enormous workload for Refuge staff who spend countless hours removing mud and debris from water control structures and tearing out dams from waterways. These animals also damage stands of timber by girdling trees, causing either mortality or stunting growth due to the loss of cambium tissue.

Beaver and muskrat will both burrow into dike banks, reducing overall structural integrity. These burrows reduce functionality of the dikes in two ways, both of which are costly to repair. First, over time these burrows cave in, causing surface damage that may encumber travel of vehicles or equipment, thus slowing down or preventing maintenance efforts. Second, these burrows can either directly cause seepage or leaks in dikes or do so indirectly by creating open sites that erode, leading to leaks and seepage. Refuge staff have begun to address these issues by removing problematic animals.

Three other species are targeted for control on the Refuge: feral dogs, feral cats, and Mute Swans. Feral dogs and cats are hand trapped or live trapped when evidence of their presence is detected. These animals are then turned over to a county animal control officer. Mute Swans are an invasive species targeted for control because their aggressive territorial behavior discourages use of wetlands by other waterfowl.

Plant Species

Invasive plant species management requires a multi-faceted approach that involves inventory, control, and monitoring. Preliminary mapping surveys of invasive plant species began in 2003 and are an ongoing project. Japanese stiltgrass, kudzu, garlic mustard, Japanese knotweed, oriental bittersweet, tree-of-heaven, and purple loosestrife have all been mapped, at least partially, with only kudzu and the loosestrife believed to have been fully mapped. A final report from a Challenge Cost Share research grant was submitted in November of 2007 and included information on many of these species and their distributions.

Invasive plant control is a species-specific and site-specific endeavor, and a list of all control methods for every species occurring on the Refuge is beyond the scope of this plan. However, most of the control efforts at Muscatatuck NWR involve chemical application, usually a glyphosate based product, although this is not always the case. Chemical applications may be foliar, basal bark, or cut stump treatments and may be used in combination with mechanical treatments. Mechanical means are employed when such methods are feasible and judicious. These methods may include hand-pulling, cutting (with weedeaters, brush cutters, or mowers), and disking (Blossey 2004). Fire, although not currently used on the Refuge, is also a viable option for the control of many species and may be considered for use in the future. Currently biological and mechanical control methods are in use at the Refuge. Recently, the Refuge has focused on attacking stiltgrass, loosestrife, knotweed, kudzu, garlic mustard, and tree-of-heaven as part of an early detection rapid response approach. Work has begun to create "weed free" areas starting with an area surrounding the Visitor Center. Creating an Integrated Pest Management Plan (IPM) is a high priority for the Refuge and will be essential in establishing long-term objectives, strategies, and priorities for invasive plant management.

Myers Cabin, Muscatatuck NWR. Photo credit: U.S. Fish & Wildlife Service

Treatments are often conducted by volunteers and interns, or through partnerships with local groups and organizations. With a limited staff, these associations help the Refuge to accomplish an otherwise impossible task. Partnering and sharing resources is an integral part of the management of invasives at Muscatatuck NWR and will continue to be into the future. Currently, a multi-agency/partner project is under way to establish a Southern Indiana Cooperative Weed Management Area (CWMA). The Refuge has taken a role in the project and expects to work closely with partners as establishment progresses.

Archaeological and Cultural Resources

The Myers Cabin is a restored family log cabin at the south end of the Refuge that was built between 1870-1890 by Louis Myers. The barn behind the cabin was built in 1900 and is an excellent example of "hand-pegged" construction. Carl Myers, a son of Louis, was in the plant nursery business and developed (or found) some seedless persimmon trees, which he sold commercially from his house adjacent to Myers Cabin. A small grove of the seedless persimmon trees still remains close to the cabin. The cabin was continuously occupied by the Myers family and the barn was in use until it was purchased by the Fish and Wildlife Service around 1966. Both structures are in very good condition and have been restored and maintained by the Muscatatuck Wildlife Society.

The Barkman Cemetery is located along County Line Road and was in use at the time of the Refuge establishment. A path to the cemetery is maintained for ease of access from a small parking lot. There

are more than 30 headstones, and many have been repaired by volunteers. The cemetery is maintained by Refuge and volunteer staff and is regularly visited by family members.

The Myers Cemetery is a small site located along the East River Hiking Trail, and has only about seven headstones. It is in the woods and does not require mowing. A marker for an unknown civil war soldier was apparently stolen from the cemetery in the early 1980s.

The Refuge has two national register archaeological sites, the Low Spur site and the Sand Hill site. The Sand Hill site and most of the Refuge area was scoured by collectors long-before the Refuge was purchased. Over 73 archaeological sites have been documented on the Refuge by professional archaeologists. Recovered artifacts indicate the Refuge area was intensively occupied in the Archaic (10,000-1,000 B.C.) and Woodland (1,000 B.C.-A.D. 1200) time periods with Late Archaic and Woodland components particularly well represented. Early Archaic sites were found on upland ridge and bluff tops and both Early and Late Archaic sites were found on ridge spurs and lowland terraces. Large multi-component sites were located on a variety of landforms. Many of the sites have been interpreted as short-term, temporary campsites, perhaps seasonal extractive camps (like hickory-nut processing) or sites occupied for part of the year. Fire-cracked rock, chert flakes, projectile points, and pieces of pottery were commonly found during excavations and are curated at the Glenn Black Museum at the University of Indiana in Bloomington, Indiana.

Law Enforcement

Until 2003, the Muscatatuck NWR law enforcement staff consisted of one or more collateral duty officers assisted by state conservation officers and State Police when needed and as available. From 2003 to 2006 no station staff did law enforcement work and collateral duty officers from Big Oaks NWR worked during deer hunts on a limited basis. In 2006, a full-time Refuge Officer assigned to Big Oaks NWR was responsible for all of the law enforcement work at both Big Oaks NWR and Muscatatuck NWR. That position was vacated in 2007. The full-time law enforcement position at Big Oaks NWR was tranferred to Muscatatuck NWR in late 2007 and the Refuge has filled the position. This position continues to be a shared position between both Refuges, and also provides limited assistance to Patoka River NWR in southwestern Indiana. Law enforcement support is also provided by our zone officer, state conservation officers, and the State Police.

Historically, the Refuge had a reputation as a "trophy" deer hunting area and was known to local Conservation Officers as an active deer poaching area. In the past, while operating on a part-time basis as a collateral duty, Refuge officers focused on resource-oriented violations: fishing in areas closed to fishing, deer poaching, marijuana growing, and ginseng collecting. More recent efforts undertaken by full-time officers have expanded to include a larger number of violations associated with public use including: after-hours trespass, illegal vehicle operation, driving without a license, and illegal substance possession offenses, in addition to wildlife resource based violations.

The Refuge receives excellent but limited support from state conservation officers from two counties. The Seymour State Police Post is within 4 miles of Muscatatuck NWR and responds when called for serious problems. County Sheriff deputies are sometimes seen on the Refuge, and have been helpful. The State Police frequently have been called to let locked-in visitors out of the Refuge at night. This is a burden for the post and an issue that requires attention. Law Enforcement personnel from Crab Orchard NWR and Cypress Creek NWR provide assistance by working on larger operations.

Existing Partnerships

The Refuge has partnerships with local, state, and national organizations. These partnerships benefit the Refuge in many ways, including fostering good community relations and enhancing habitats and wildlife populations. Examples of partnerships include the following:

- The Refuge is a host agency for Experience Works (formerly Green Thumb), a senior work training program that supplies enrollees that work on the Refuge an average of 20 hours per week.
- A curatorial cooperative agreement between the Service and the Glenn A. Black Laboratory of Archaeology, University of Indiana, provides for the curation and storage of the 10 Refuge archeological collections containing a total of 23,635 artifacts. Artifacts are owned by the Federal Government and can be recalled by the

Regional Historic Preservation Officer for exhibits and other Refuge and Service purposes.

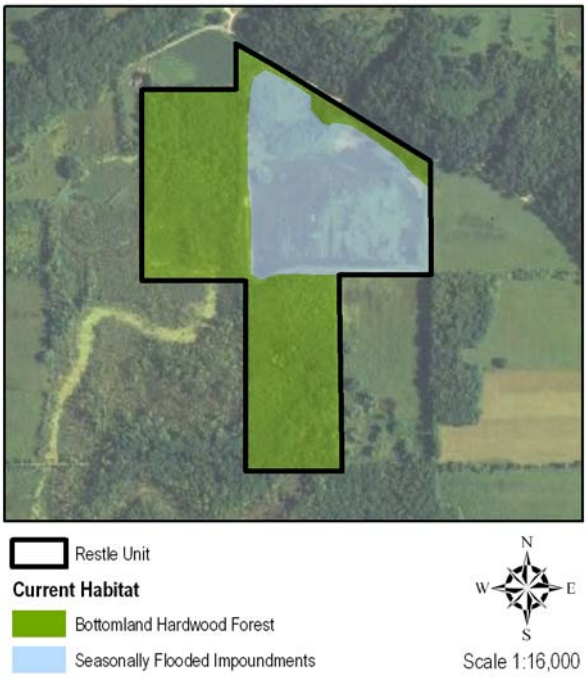
- Muscatatuck NWR has been fortunate to have many partners in the local area, including:
  - Muscatatuck Wildlife Society
  - local Soil and Water Conservation Districts
  - Natural Resource Conservation Service
  - Purdue Extension
  - local Ducks Unlimited Chapters
  - local Wild Turkey Federation
  - Indiana Department of Natural Resources
  - local Resource Conservation and Development Councils
  - area conservation and birding clubs
  - sporting good stores
  - scouting and civic groups
  - local Visitor Bureaus
  - U.S. Forest Service
  - Hayden School Refuge Rangers
  - local universities

Other Management Areas

Research Natural Area

The Muscatatuck Seep Springs Research Natural Area (MSS-RNA) occupies a 97-acre portion of the Refuge (Figure 13 on page 50). It is one of only seven acid seep springs documented in Indiana. The cold, acidic groundwater yields a unique assemblage of plant species. Many of the plants that occur here are restricted to these exact environmental conditions. These conditions are extremely uncommon in the landscape, especially in southern Indiana. This community is also ranked G3 (Globally Rare) in the Natural Heritage system, an international database of biological and conservation sites coordinated by the Nature Conservancy. State-listed plant species found here are: American ginseng, club spur orchid, southern tubercled orchid, bog bluegrass, Walter's St. Johnswort, and smooth white violet. Also found here are the state-listed endangered four-toed salamander and the state-listed endangered copperbelly watersnake.

Figure 11: The Restle Unit of Muscatatuck NWR



Restle Unit

The Restle Unit of Muscatatuck NWR is a 78-acre parcel in Monroe County, northwest of Bloomington, Indiana, that was donated to the National Wildlife Refuge System in 1990 (see Figure 11). It has a 30-acre emergent wetland that was repaired by a Maintenance Action Team in September 2005. The rest of the remaining acreage is bottomland hardwoods. It is a palustrine floodplain forest with swamp white oak, pin oak, swamp cottonwood, sycamore and silver maple.

Historically the area was a part of a large forested area called the Central Hardwood Region. The GLO original survey notes of 1811 and 1815 refer to forests comprised of beech, burr oak, maple, water oak, poplar, hickory, elm, and ash (Slusher and Welch 2001). The land was cleared for agriculture in the mid-1800s as the state was settled and tile drainage began in the late 1800s. An extensive system of ditches was put in place in order to control the hydrology for farming.

The Restle Unit lies within the outer margin of the floodplain on the north side of Bean Blossom Creek. Steep uplands with intermittent streams form a border north of the property. The Unit is

relatively flat, has a low gradient, and is seasonally flooded. It is located in the south central part of the state, in a region known as the Mitchell Karst Plain Section of the Highland Rim Natural Region, as classified by the Indiana Natural Heritage program. The major soil types are Zipp, silty clay loam that is frequently flooded, and Burnside silt loam, which is occasionally flooded (Thomas 1981).

The Restle Unit provides habitat for a diversity of wildlife including Wood Ducks, Canada Geese, Hooded Mergansers, Mallards, and other waterfowl. At least 80 bird species have been identified using the unit including Bald Eagle, Osprey, Northern Harrier, Black-crowned Night-Heron, Great Egret, and Great Blue Heron. Beaver, muskrats, white-tailed deer, eastern fox squirrel, raccoon, red fox, opossum, and eastern mole are mammals that have been seen on the Unit. Some of the amphibians and reptiles seen in the Unit include cricket frog, green frog, spring peeper, southern leopard frog, painted turtle, snapping turtle, northern banded water snake, and ribbon snake. The federally-listed endangered Indiana bat has not been confirmed on the Unit, but is suspected to be present because the habitat provided matches its requirements. No studies have been conducted to find them. An IDNR radio collared bobcat was tracked using the Restle Unit in June and July 2002.

The Restle Unit is surrounded by a complex of protected land called the Bean Blossom Bottoms that includes acreage owned by Sycamore Land Trust and Wetland Reserve Program land. A total of 708 acres are protected. At least 109 bird species, including Prothonotary Warbler, Wood Thrush, Cerulean Warbler, Red-headed Woodpecker, American Woodcock, Willow Flycatcher, Prairie Warbler, Henslow's Sparrow, Virginia Rail, and King Rail, all have been reported from the Bean Blossom Bottoms area and the area is recognized as an Indiana Important Bird Area (IBA) by the Audubon Society. These lands support a Bald Eagle nest, a Great Blue Heron rookery, the state-listed endangered Kirtland's snake and northern crayfish frog (last confirmed in 1998).

The Unit is included in the Audubon designated Beanblossom Bottoms Important Bird Area (IBA). State-listed species seen include the Bald Eagle, Northern Harrier, Barn Owl, Osprey, Black-crowned Night-Heron, and Black Tern. State species of concern include the Great Egret, Red-shouldered Hawk, and Sandhill Crane. Twenty-three bird species of Conservation Concern were listed on the IBA nomination form (Cole 2007).

Invasive, exotic species and noxious weeds seen at the Unit include reed canary grass, Asian bush honeysuckle and European starling. Thorough inventory work has not yet been done.

Management of the Unit as stated in the Restle donation document is: "grantee shall perpetually manage the real estate as a wetland habitat for native wildlife and plant enhancement and protection." Deed restrictions to the management of the property include the prohibition of timbering, burning, hunting, trapping, fishing, use of herbicides or insecticides, construction of buildings, general public access, and commercial sale of any resources. The restrictions have exceptions for the protection of wetlands, protection of native plant and animal habitat, and construction of observation blinds.

The 30-acre wetland area will be managed for migrant and nesting waterfowl and, when appropriate, mudflats may be exposed for shorebird use. The bottomland hardwood forest will continue to grow without active management.

The Restle Unit was donated with the restriction that "no general access of the public to the area shall be permitted." An observation deck overlooking the unit with a parking area on Bottom Road was constructed in 1998 and is available for the public to use.

Farm Service Agency Conservation Easements

The Refuge manages nine conservation easement areas totaling 130.5 acres located within the Wildlife Management District, a 30-county area in Indiana (Figure 12). On these Farm Service Agency (FSA) easements, the FWS is authorized to protect and manage important natural resource interests including wetlands, floodplains, riparian corridors, and endangered species habitat. Ownership of the easement land is retained by private individuals, but with restrictions related to conservation management. Service employees are responsible for habitat management and are granted access for maintenance, monitoring, enforcement, and other management activities.

Most FSA conservation easements are visually checked for boundary signs, trespass, and various other infractions every 2 years.

Figure 12: FSA Easements Administrated by Muscatatuck NWR

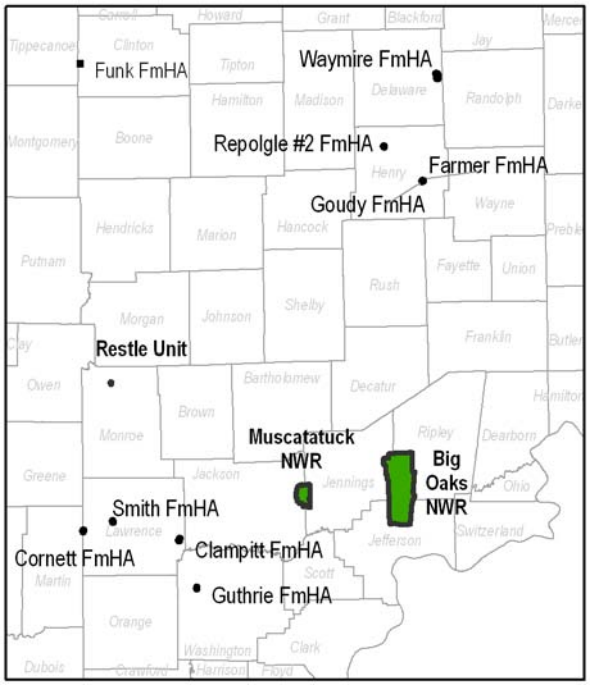


Table 3: Six-year Operating and Maintenance Budget

FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007
$1,339,425	$805,000	$570,343	$682,920	$662,410	$546,139

Current Staff and Budget

Staff

The Refuge's staffing, as of September 2007, includes eight full-time equivalent positions:

- Refuge Manager
- Wildlife Refuge Specialist
- Wildlife Biologist
- Maintenance Mechanic
- Tractor Operator (vacant)
- Park Ranger (law enforcement)
- Outdoor Recreation Planner
- Administrative Technician

Budget

A 6-year history of the operating and maintenance budget for the Refuge is shown in Table 3.