

Chapter 3: Refuge Environment and Management

Introduction

Established in 1994, the Patoka River National Wildlife Refuge and Management Area is located in Pike and Gibson counties in southwestern Indiana. It was created under authority of the Emergency Wetlands Resources Act in part to protect one of two remaining intact floodplain forest systems within Indiana. The river corridor project encompasses 30 miles of the Patoka River and 19 miles of oxbows with a total of 12,700 acres of existing wetlands.

Presently, the acquisition boundary for the NWR & MA includes 23,743 acres. This differs from the 22,083 acres included in the Record of Decision for the 1994 Environmental Impact Statement (EIS) that established the Refuge & MA. There are two reasons for this difference. The first is that past methods of calculating acres (e.g. summing acres found in tax records or plat books) have given way to computerized Geographic Information Systems (GIS) that rely on standardized data which provide greater uniformity of acreage values. It is important to note that for legal transactions deed acres remain the legal standard, but habitat acreage figures throughout this document are based on GIS generated values. In the EIS the area within the acquisition boundary was stated at 22,083 acres. The same boundary is calculated to contain 22,817 acres using GIS protocols. The second reason for the acreage difference is that an additional 926 acres have been authorized for acquisition since the original boundary was established, bringing the total area authorized for acquisition to the present figure of 23,743 acres. The Refuge also administers a 219-acre parcel transferred to the Service from the Farm Ser-

Great Horned Owl nest, Patoka River NWR & MA. Photo credit: USFWS

vices Agency now known as White River Bottoms. Although managed by Refuge staff, and part of the National Wildlife Refuge System it is not included as part of the Patoka River NWR & MA and does not figure in the total acreage. See Figure 3 and Table 1.

Most of the information in this chapter comes from the Environmental Impact Statement (EIS) prepared in conjunction with the establishment of the Patoka River National Wetlands Project (USFWS, 1994). The wetlands project led to the creation of Patoka River National Wildlife Refuge and Management Area.

Wetland Loss in Indiana

The 20th century witnessed a dramatic decline in the acreage of America's wetland habitat that is so critical to maintaining migratory bird and other

Figure 3: Acquisition Authority, Patoka River NWR & MA

Table 1: Status of Land Acquisition, Patoka River NWR & MA

Description	Acres Cited in 1994 EIS	Current GIS Acres
Establishment acquisition boundary	22,083	22,817
Additional lands approved for acquisition	--	926
Total acres authorized for acquisition	--	23,743
FSA Lands (White River Bottoms)	--	219

wildlife populations. By the close of the century and the dawn of the new millennium, the U.S. Fish and Wildlife Service estimated that nationally, only 103 million acres (less than half) remained of the estimated 221 million acres of wetlands that existed in the lower 48 states at the time of Euro-American settlement.

In the State of Indiana, long-term wetland loss has been even more dramatic. Of the estimated 5.5 million acres of wetlands that existed in Indiana at the time of settlement, only 813,000 acres (15 percent) remained by the 1990s (Rolley, 1991), according to the most recent and complete analysis of the state's wetland resources (Indiana WETlands, 2004). Historically, about 85 percent of this wetland loss has been for agricultural purposes with the remainder attributable to urban and industrial development (IDNR, 1988). In the mid-1990s, the Indiana Division of Fish and Wildlife and the USFWS estimated an annual loss of 5 percent of remaining wetlands. However, wildlife biologists and conservationists held hope that compliance with the "Swampbuster" provisions of the 1985 and 1990 farm bills, alongside with increasing awareness by farmers of the importance of wetlands, could moderate future wetland losses due to agricultural conversion.

Of the wetlands remaining in Indiana, only a small percentage remains as they existed 200 years ago. Few of the state's natural wetlands now support their original complement of plants and animals. This biological diversity has been degraded as a result of impacts to water quality, alterations of water levels and upstream watersheds and other surface disturbances. The seriousness of this loss is best recognized by the fact that over 120 different plants that occur naturally in wetlands and over 60 species of wetland-dependent animals are listed as either endangered, threatened or of special concern by the Indiana Department of Natural Resources (IDNR). Of all wetland types, the palustrine forested wetlands (bottomland hardwoods) have been identified in Indiana as the "state wetland priority

type." This means priority for protection is based on the historical pattern of loss and alterations occurring in Indiana and the multiple values they have to fish, wildlife and plant resources (IDNR, 1988).

The Ohio River Valley Ecosystem

The U.S. Fish and Wildlife Service has adopted an ecosystem approach to conservation because we cannot look just at an individual animal, species, or fragment of land in isolation from all that surrounds it. The Service has recognized some 53 ecosystems in the conterminous 48 states. We recognize that we are not going to achieve conservation within the boundaries of a National Wildlife Refuge, or restore aquatic resources with a National Fish Hatchery, and that listing an endangered species is not going to conserve the system on which it depends. The ecosystem approach thus strives to be comprehensive. It is based on all of the biological resources within a watershed (the total land area from which water drains into a single stream, lake, or ocean) and it considers the economic health of communities within that watershed landscape. An ecosystem approach to fish and wildlife conservation means protecting or restoring the function, structure, and species composition of an ecosystem while providing for its sustainable socioeconomic use.

Patoka River NWR & MA is located within the Ohio River Valley Ecosystem (ORVE) as currently defined by the U.S. Fish and Wildlife Service. This ecosystem drains a total area of approximately 141,000 square miles and includes portions of 10 states. The Ohio River, which is the backbone of this ecosystem, is formed by the confluence of the Allegheny and Monongahela Rivers at Pittsburgh, Pennsylvania and flows 981 miles in a southwesterly direction to its confluence with the Mississippi River at Cairo, Illinois (ORVET, no date).

Figure 4: Ohio River Valley Ecosystem

The Ohio River ecosystem bisects three regions of the Deciduous Forest Formation of eastern North America: the Mixed Mesophytic Forest Region (upper basin, roughly upstream of Portsmouth, Ohio), the Western Mesophytic Forest Region (lower basin from Portsmouth, Ohio, to Paducah, Kentucky), and the Mississippi Alluvial Plain Section of the Southeastern Evergreen Forest Region (lowermost portion of the basin from Paducah, Kentucky, to Cairo, Illinois (USFWS, 1999). (See Figure 4)

The mixed mesophytic and western mesophytic forests have been classified broadly as a tulip poplar-oak region. The dense, mixed mesophytic forest contains a fair abundance of two indicator species, white basswood and yellow buckeye, in a total group of 15 to 20 dominant species. The western mesophytic forest is marked by a transition from extensive mixed mesophytic communities in the east to extensive oak and oak-hickory communities in the

west. The western mesophytic forest is less dense, has few dominants, and usually lacks the two indicator species of the mixed mesophytic forest.

In the lower, downstream portion of the ecosystem, near Paducah, Kentucky, the Ohio River enters the northernmost extension of the Mississippi Alluvial Plain. In this alluvial region, three subdivisions of "bottomland forest" (i.e., palustrine forested wetland) are recognized: swamp forest, hardwood bottoms, and ridge bottoms. The swamp forest, consisting principally of cypress and tupelo gum, occupies land on which water stands throughout the year except during periods of extreme drought. The hardwood bottoms contain a large number of species, frequently flood, and generally remain covered with water through the late winter and spring. Ridge bottoms contain some of the tree species of hardwood bottoms, but have a larger number of oaks and hickories; occurring at slightly higher elevations than hardwood bottoms, these areas are covered by water only during floods (USFWS, 1999).

The rich flora and fauna of the ORVE reflect its diverse physiography and unique geologic past. Numerous Service trust resources occur in the ecosystem, including many federally listed endangered/threatened plants, mussels, fishes, birds and mammals; waterfowl and other migratory water birds; and neotropical migratory land birds.

The unusually rich and diverse fauna found in the ecosystem is the product of a multitude of biotic and abiotic factors which have evolved over time. Throughout geologic time, changes in such factors as topography, climate, and geomorphology have formed, modified, and eliminated habitats and consequently have had a profound effect upon the distribution of the faunal assemblages in the ecosystem. Due to the ecosystem's central geographical location in the eastern United States, some species with northern affinities and others with southern affinities occur in the ecosystem in addition to those common to the central region of the country (USFWS, 1999).

Over the past few centuries of Euro-American settlement and industrialization, the Ohio River Valley ecosystem has been subjected to many environmental stresses which have diminished the bounty of its living resources. Much of the region's economic activity – agriculture, lumbering, mining, energy production, manufacturing, and recreation – is based on the watershed's natural resources. Sustaining most of these activities requires maintenance of a healthy ecosystem. Stress from human activities has adversely affected the ecological integrity of the ORVE, and there are indications that this stress is increasing.

Environmental alteration and degradation are continuing challenges to the maintenance of a productive and healthy ORVE. Resources of the area are threatened by land conversion, poor land-use practices, direct and indirect physical alteration of the area's rivers and streams, acid mine drainage and acid precipitation, destruction of wetland habitats, and both point- and nonpoint-source discharges of pollutants. Herbicides, insecticides, nutrients, and sediment are significant components of the agricultural runoff that adversely affect aquatic systems throughout the area. Acid precipitation from sulfur dioxide and nitrous oxides from power plants and other airborne pollutants are having dramatic effects on aquatic and terrestrial communities, particularly at high elevations (USFWS, 1999).

Restoring habitat through partnerships Patoka River NWR & MA. Photo credit: USFWS

Natural resources are further threatened by an expanding human population and its increased demand for renewable and nonrenewable resources. Contamination of both aquatic and terrestrial systems through acid mine drainage and the accidental release of toxic chemicals is a continuing threat. Operation and maintenance of the inland navigation system and the recent invasion of the non-native zebra mussel are having significant adverse impacts on native flora and fauna of the area's rivers and streams. Other non-native species are threatening native components of aquatic and terrestrial systems throughout the area. The expansion of urban and suburban areas within the ecosystem and the concurrent loss of forest, wetlands, agricultural lands, and other types of open space associated with this expansion have reduced the quantity and quality of natural habitats available to fish and wildlife.

The Service published a strategic plan on conserving the trust resources of the ORVE in 1999 (USFWS, 1999). The plan set forth four goals:

1. Protect, restore and enhance habitats and essential processes necessary to maintain healthy native animal and plant populations.
2. Protect, restore and enhance diversity of native flora and fauna.
3. Promote and support compatible and sustainable uses of the ecosystem's resources and utilize existing laws, regulations, and influence to control incompatible and unsustainable uses of these resources.
4. Develop public awareness and support for ecosystem resource issues.

The strategic plan also identified seven resource priorities:

Resource Priority 1: In cooperation with partners, reverse the decline of native aquatic mollusks within the Ohio River Valley Ecosystem with emphasis on endangered, threatened and candidate species and species of concern.

Resource Priority #2: In cooperation with partners, reverse the decline and achieve stable, viable populations of migratory landbirds and other bird species of concern.

Resource Priority 3: In cooperation with partners, reverse the decline of native fishes with emphasis on interjurisdictional listed and candidate species and species of concern.

Resource Priority 4: In cooperation with partners, protect and restore karst/cave habitat supporting listed and candidate species and species of concern.

Resource Priority 5: In cooperation with partners, protect and restore wetland, riverine and riparian habitat in the Ohio River watershed for the protection and enhancement of migratory waterbirds and other wetland dependant species of concern.

Resource Priority 6: In cooperation with partners, reduce the decline and promote the recovery of rare resources identified as listed/proposed threatened and endangered species, candidate species and species of concern not otherwise addressed in Resource Priorities 1- 5 (e.g. plants, reptiles, amphibians, etc.).

Resource Priority 7: In cooperation with partners, achieve the necessary level of protection for those high priority areas within the Ohio River Valley Ecosystem that would help meet the goals of the ORVE Team. In particular, emphasis will be placed on the objectives of Resource Priorities 1 through 6 and Public Use Priority 1.

A number of action strategies accompanied these resource priorities in the strategic plan. In addition, the plan contained one public use priority:

Public Use Priority 1: In cooperation with partners, promote and support sustainable fish and wildlife-oriented recreational uses while maintaining the long-term health of the ecosystem and the Service's trust resources.

The Service's ORVE Team has several important roles. Primary among them is serving as an advocate at the field level for federal trust fish and wildlife resources within the Ohio River watershed. This includes reviewing the Team's resource priorities and charting a direction for the Team to ensure it addresses the highest priority resource needs. To facilitate accomplishment of the Team's on-the-ground efforts, the Team actively seeks funding, explores expansion of existing partnerships and establishment of new ones, and seeks ways to involve all interested stakeholders (USFWS, 1999).

The ORVE Team is comprised of representatives of each of the Service's field offices located within the Region 3 (Midwest), 4 (Southeast), and 5 (Northeast) portions of the Ohio River Valley watershed. In addition, representatives from the respective Service regional offices, as well as several state fish and wildlife agencies, participate as Team members. Typically, the Team meets three times per year at various locations within the ecosystem.

Snowy Egret. Photo credit: USFWS

The Team's seven Sub-groups are the primary mechanisms for conducting activities on the ground. The Sub-groups correspond to the Team's resource priorities, i.e., fish and wildlife and associated habitats, and its public use priority. They are, in no priority order: native aquatic mollusks; migratory land birds and other bird species of concern; native fishes; karst/cave habitat; wetland, riverine, and riparian habitat; declining and rare species; and fish and wildlife-oriented recreational use. In addition to the Sub-groups, the Team has established four Standing Committees to conduct activities that generally cut across all priority resources. The Standing Committees address GIS needs and activities, outreach, acid mine drainage and valley fills, and land protection (USFWS, 1999).

Other Units Administered

The staff of Patoka River NWR & MA administers two units apart from the main body of the Refuge: Cane Ridge and White River Bottoms. Both units are part of the National Wildlife Refuge System, but White River Bottoms is not officially included as part of the total acreage comprising the Patoka River Refuge & MA.

The 488-acre Cane Ridge Wildlife Management Area lies 24 miles west of the Refuge headquarters near the confluence of the White, Patoka, and Wabash Rivers, a traditional waterfowl migration and wintering area. Acquired by a coalition of conservation partners, the property became part of Patoka River NWR & MA in 1999. The area includes 193 acres of moist soil wetlands in four management units, 180 acres of reforested bottomland hardwoods, and a 59-acre deep water impoundment with nesting islands that provide habitat for the federally endangered Least Tern. Cane Ridge WMA is a Globally Important Bird Area.

The 219-acre White River Bottoms Wildlife Management Area lies 9 miles to the north of Oakland City. This WMA lies just to the northwest of Petersburg on the south side of the White River. Although not officially included as part of Patoka River NWR & MA, White River Bottoms became part of the National Wildlife Refuge System when control of the land was transferred to the Service in 1994 from the Farm Services Agency. It has been restored from agricultural fields by being planted to bottomland hardwood trees.

Migratory Bird Conservation Initiatives

Over the last decade, bird conservation planning has become increasingly exciting as it has evolved from a largely local, site-based focus to a more regional, landscape-oriented perspective. Significant challenges include locating areas of high-quality habitat for the conservation of particular guilds and priority bird species, making sure no species are inadvertently left out of the regional planning process, avoiding unnecessary duplication of effort, and identifying unique landscape and habitat elements of particular tracts targeted for protection, management and restoration. Several migratory bird conservation initiatives have emerged to help guide the planning and implementation process. Collectively, they comprise a tremendous resource as Patoka River National Wildlife Refuge and Management Area engages in comprehensive conservation planning and its translation into effective on-the-ground management.

North American Waterfowl Management Plan

Signed in 1986, the North American Waterfowl Management Plan (NAWMP) outlines a broad framework for waterfowl management strategies and conservation efforts in the United States, Canada, and Mexico. The goal of the NAWMP is to restore waterfowl populations to historic levels throughout the continent. The NAWMP is designed to reach its objectives through key joint venture areas, species joint ventures, and state implementation plans within these joint ventures.

Patoka River NWR & MA is in the Upper Mississippi River-Great Lakes Joint Venture. The boundaries of this joint venture extend across Minnesota, Iowa, Missouri, Wisconsin, Illinois, Indiana, and Michigan. They include important migration and staging areas that were converted to agriculture. The purpose of the Upper Mississippi River-Great Lakes Joint Venture is to increase populations of waterfowl and other wetland wildlife by protecting, restoring, creating, and enhancing wetlands and associated upland habitats. Joint venture partners include private landowners, the National Fish and Wildlife Foundation, state agencies, and the U.S. Fish and Wildlife Service. Partners are endeavoring

Nesting Interior Least Tern. Photo credit: USFWS

to increase public awareness through information and education and are providing incentives to private landowners (Graziano and Cross, 1993).

The 1998 NAWMP Update established a habitat objective for the Upper Mississippi – Great Lakes Joint Venture of protecting 1,329,000 acres of waterfowl and wetland habitat and restoring or enhancing another 605,200 acres (NAWMP, 1998).

A 2004 update to the NAWMP set a target of conserving 758,572 additional acres of waterfowl and wetland habitat in the Upper Mississippi – Great Lakes Joint Venture through a combination of securement, protection, restoration, enhancement, and management (NAWMP, 2004).

Partners In Flight

Formed in 1990, Partners in Flight (PIF) is concerned primarily with landbirds and has developed Bird Conservation Plans for numerous *Physiographic Areas* across the U. S. (see <http://www.partnersinflight.org>). These plans include priority species lists, associated habitats, and management strategies. Patoka River NWR lies within PIF Physiographic Area 14, the Interior Low Plateaus Area.

The Interior Low Plateaus form a diverse landscape consisting of six distinct subregions that extends from north Alabama across central Tennessee and Kentucky into southern Illinois, Indiana, and Ohio. Its hilly topography sets it apart from the Coastal Plain to the south and Prairie Peninsula to the north. To the west, the Mississippi River valley separates the Interior Low Plateaus from the Ozark Highlands. Western mesophytic, oak-hickory, and beech-maple forests were historically the most abundant cover types. There were also tallgrass

prairie elements in the north and northwest, oak savannahs in the Bluegrass and other northern sections, barrens and glades in central regions, and forested wetlands along major waterways (PIF, no date).

Habitat loss through conversion to agriculture and other uses and the fragmentation and reduced quality of what remains are the biggest conservation challenges in this area. Grasslands and savannahs have been converted to cool season pasture. Many glades and barrens have become urban areas, and others have been overtaken by woody vegetation due to fire suppression. Floodplain forests have largely been either inundated by reservoirs or converted to row crops. Conservation objectives vary by subregion, but in general, in order to perpetuate existing high priority species and to create an opportunity to re-establish two extirpated species (Greater Prairie-Chicken and Swallow-tailed Kite), the following actions should be implemented:

- Sustain existing forested acreage, with about 80 percent in hardwoods and the remainder in short-rotation pine management;
- Manage about 400,000 ha of that hardwood forest in long rotation patches of about 4,000 ha each;
- Consolidate an additional 90,000 ha of forested wetland;
- Additionally, restore 40,000 ha of native warm season grass and oak savannah habitat; and
- Incorporate bird conservation into ongoing barren and glade conservation projects.

U.S. Shorebird Conservation Plan

Partners from state and federal agencies and NGOs from across the country combined their resources and expertise to develop a conservation strategy for migratory shorebirds and their habitats. The plan provides a scientific framework to determine species, sites, and habitats that most urgently need conservation action. Main goals of the U.S. Shorebird Conservation Plan, which was completed in 2000, are to ensure that adequate quantity and quality of shorebird habitat is maintained at the local level and to maintain or restore shorebird populations at the continental and hemispheric levels. Separate technical reports were developed for a conservation assessment, research needs, a comprehensive monitoring strategy, and education and outreach. These national assessments were used to step down goals and objectives into 11 regional conserva-

tion plans. Although some outreach, education, research, monitoring, and habitat conservation programs are being implemented, accomplishment of conservation objectives for all shorebird species will require a coordinated effort among traditional and new partners. The U. S. Shorebird Conservation Plan Council serves as the steering committee for the U. S. Shorebird Conservation Plan and oversees the implementation of the regional, national, and international goals of the Plan. Meetings of the Council are held twice a year (USFWS, no date).

Under the Shorebird Conservation Plan, Patoka River NWR is located in the Upper Mississippi Valley/Great Lakes Region (UMVGL), which is covered by a regional plan prepared in 2000 and updated in 2006 (de Szalay et al., 2006). The UMVGL region is a diverse area that includes five Bird Conservation Regions and provides important habitat for shorebirds, especially migrants. Thirty-two shorebird species occur in the region, with 25 being common or abundant. Twenty-three species are of moderate or higher concern in the region. High-priority species include: greater yellowlegs, whimbrel, buff-breasted sandpiper, short-billed dowitcher, marbled godwit, Wilson's phalarope, upland sandpiper, American woodcock, and the Federally-listed piping plover; the latter five species breed in the region.

Various habitats within the region, including natural and managed wetlands, river floodplains, lake shoreline, sand and gravel bars, reservoirs, and flooded agricultural fields, provide the shallow water and sparsely-vegetated conditions required by foraging shorebirds. However, like other interior areas, the UMVGL region experiences dynamic climatic conditions, making habitat conditions for shorebirds unpredictable. Moreover, loss of wetlands from urban development, river dredging and diking, and agriculture has reduced the amount of habitat in the region. A primary goal of this UMVGL regional shorebird plan is to ensure the availability of shorebird foraging and nesting sites over a range of climatic conditions by protecting, restoring, and managing a variety of habitat types throughout the UMVGL region.

Waterbird Conservation for the Americas

Formerly known as the North American Waterbird Conservation Plan, Waterbird Conservation for the Americas (WCA) is an independent, international, broad-based, and voluntary partnership created to link the work of individuals and institutions

having interest and responsibility for conservation of waterbirds and their habitats in the Americas (WCA, 2005a). WCA's vision is that the distribution, diversity, and abundance of populations and habitats of breeding, migratory, and nonbreeding waterbirds are sustained or restored throughout the lands and waters of North America, Central America, and the Caribbean. The geographic extent of the WCA initiative includes North America, Central America, the islands and waters of the Caribbean, the Pacific Ocean including the U.S.-associated Pacific Islands, and the western Atlantic Ocean including Bermuda. The WCA includes the interests of 29 nations.

The term "waterbird" refers to bird species dependent on aquatic habitats to complete portions of their life cycles. It includes seabirds, coastal waterbirds, wading birds, and marsh birds. The WCA focuses these groups. Shorebirds and waterfowl, while indeed waterbirds, are the subject of their own initiatives (discussed above).

Under WCA, planning regions were created to allow planning at a scale that is practical yet provides landscape-level perspective. Regional boundaries are based on a combination of both political and ecological considerations. Patoka River NWR is situated in the Upper Mississippi Valley/Great Lakes (UMVGL) Region, within a subregion known as Bird Conservation Region (BCR) 24, the Central Hardwoods. Like the NAWMP, WCA has also established joint ventures, and that of BCR 24 is called the Central Hardwoods Joint Venture (CHJV).

The UMVGL Region provides a wide variety of waterbird nesting, roosting and foraging habitats, including marshes, ponds, creeks, streams, sloughs, lake shorelines, islands (especially in the Great Lakes), shoals, river floodplains (especially along the Mississippi, Illinois, Missouri, and Ohio Rivers), and reservoirs. Forty-six waterbird species regularly occur in the region during at least one portion of the year, including loons, grebes, pelicans, cormorants, herons, night-herons, egrets, bitterns, rails, moorhens, coots, cranes, gulls and terns, and 19 of these species are of high conservation, stewardship or management concern. In the context of the continental, the region is extremely important for many of these waterbird species. Though the UMVGL Region has experienced major declines in wetland habitat over the last 200 years, the northern portion of the UMVGL Region still contains large amounts of wetlands and the Great Lakes are a stronghold for island breeders (WCA, 2005b).

Figure 5: Bird Conservation Region in Which Patoka River NWR & MA is Located

A Regional Plan for waterbird management and conservation is currently being prepared and Patoka River National Wildlife Refuge figures in that plan, which described the Refuge as, “one of the most significant bottomland hardwood forests remaining in the Midwest.”

North American Bird Conservation Initiative

In a continental effort, the North American Waterfowl Management Plan, Partners in Flight, U.S. Shorebird Conservation Plan, and Waterbird Conservation for the Americas planning efforts are being integrated under the umbrella of the North American Bird Conservation Initiative (NABCI). The goal of NABCI is to facilitate the delivery of the full spectrum of bird conservation through regionally-based, biologically-driven, landscape-oriented partnerships (see <http://www.dodpif.org/nabci/index.htm>). The NABCI strives to integrate the conservation objectives for all birds in order to optimize the effectiveness of management strategies.

NABCI also uses BCRs as its planning units. BCRs are becoming increasingly common as the unit of choice for regional bird conservation efforts; as it does for the WCA initiative, Patoka River NWR lies within BCR 24, the Central Hardwoods for the purposes of the NABCI (see Figure 5).

Each of the above four bird conservation initiatives has a process for designating conservation priority species, modeled to a large extent on the PIF method of calculating scores based on independent assessments of global relative abundance, breeding and wintering distribution, vulnerability to threats, area importance (at a particular scale, e.g. PA or BCR), and population trend. These scores are often used by agencies in developing lists of bird species of concern; e.g., the U. S. Fish and Wildlife Service based its assessments for its 2001 list of nongame Birds of Conservation Concern primarily on the PIF, shorebird, and waterbird status assessment scores.

Region 3 Fish and Wildlife Conservation Priorities

Every species is important. But 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. 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 includes 116 Resource Conservation Priority species within the Ohio River Valley Ecosystem and notes those known to occur on the Refuge.

Indiana Comprehensive Wildlife Strategy

The Indiana Comprehensive Wildlife Strategy completed in 2006 identifies conservation priorities within Indiana. Patoka River NWR & MA staff contributed to the plan and the Refuge provides habitat for more than 50 of the birds, mammals, reptiles, and amphibians listed in the Strategy as conservation priorities (see Appendix C: Species Lists).

Other Recreation and Conservation Lands in the Area

Sugar Ridge Fish & Wildlife Area

Sugar Ridge Fish & Wildlife Area, owned and managed by the Indiana Department of Natural Resources (IDNR), is unique in that much of the land has been strip-mined for coal and since reclaimed. Sugar Ridge (Figure 6) is made up of six separate areas, totaling approximately 8,100 acres, interspersed with the USFWS's Patoka River NWR holdings. The strip-mined land now features about

100 pits and lakes, along with rows of overburden from the mining operation. The land that has not been mined is mostly rough and rolling. A large part of the land which is now Sugar Ridge Fish and Wildlife Area (Areas I, II and III) was once leased from Amax Coal Company. Leasing began in 1964 and continued until 1980 when most of the land was donated to the Division of Fish and Wildlife (IDNR, no date-a).

Sugar Ridge is open to various forms of outdoor recreation by the public, including hunting (deer, squirrel, and wild turkey are common); fishing on 145 acres in 24 major fishing pits for such sport fish as bluegill, redear, channel catfish, and largemouth bass; trapping (by drawing only); and wildlife watching on upland game habitat, wooded reclaimed mine areas and stripper pits which attract a wide variety of song birds, woodpeckers, hawks, and waterfowl. In addition, mushrooms, berries and nuts may be gathered. A written permit is required to remove plants, animals, rocks and fossils (IDNR, no date-a).

Glendale Fish & Wildlife Area

The Indiana DNR's Glendale Fish & Wildlife Area maintains 8,060 acres of land and over 1,400 acres of lakes and impoundments about 12 miles north of Patoka River NWR. These lands and waters provide quality hunting and fishing opportunities for the public, as well as wildlife watching and camping in designated areas. Wetland trapping is available by drawing only (IDNR, no date-b).

Acquisition began in 1956, and land purchases were made through the 1960s. Several minor purchases were made in the 1970s. The construction of the dam that formed Dogwood Lake began in 1963 and was completed in 1965. The lake, with an average depth of eight feet, was renovated in 1978 and restocked with fish in 1979 (IDNR, no date-b).

Pike State Forest

Pike State Forest, owned and operated by Indiana DNR's Division of Forestry, sits astride the Patoka River adjacent to Patoka River NWR toward its eastern side. The State Forest (SF) consists of 3,889 acres which vary from hilly uplands to the low bottomlands of the river. Due to its diverse habitats, a wide variety of plant and animal life make their homes at Pike SF. Several recreational opportunities are available on the SF, including hunting, horseback riding, picnicking, bird watching

Figure 6: Other Conservation Lands in the Area of Patoka River NWR & MA

and hiking. Visitors can also camp for a fee, with sites available on a first come, first serve basis (IDNR, 2005a).

Acquisition of the land that makes up Pike State Forest began in the 1930s, and continues through the present day. Most of the historic buildings on the property were constructed by the Works Progress Administration (WPA) during the Great Depression, using material cut from local timber stands.

Ferdinand State Forest

Ferdinand State Forest is located about 20 miles southeast of Patoka River NWR. This State Forest consists of 7,700-acres with limited acquisition still occurring. In 1933, the 900 acres that became the SF were purchased by a local conservation club to build a lake and establish an area to hunt and fish. The club offered management of the project to the Indiana Department of Conservation the following year, marking the establishment of Ferdinand State Forest (IDNR, 2005b). In 1934, the Civilian Conservation Corps (CCC) built a camp there, as well as roads, service buildings, and one of the most beautiful forest lakes in the state. Ferdinand SF has excellent deer and squirrel hunting and the surrounding area is rich in German heritage.

The state forest offers primitive camping, fishing, boating, swimming, picnicking, mountain biking, and hunting for whitetail deer, turkey, squirrel, fox and raccoon.

Other Recreation and Conservation Lands

Within an hour or two's drive from Patoka River NWR in southwestern Indiana are a number of other federal and state parks, forests, and fish and wildlife areas offering outdoor recreation and heritage tourism. These include New Harmony State Historic Site, Harmonie State Park (west of Patoka Refuge, along the Wabash River separating Indiana from Illinois), Hovey Lake Fish & Wildlife Area, Lincoln State Park, Jackson Recreation Area, Hoosier National Forest, and Patoka Lake, an 8,800-acre flood control lake 60 miles upstream of the refuge and cooperatively managed by the Army Corps of Engineers and the Indiana Department of Natural Resources.

*Grey wood/beaver flooding, Patoka River NWR & MA.
Photo credit: USFWS*

Socioeconomic Setting

Patoka River National Wildlife Refuge and Management Area is located in Pike and Gibson Counties, Indiana, and is in close proximity to Daviess, Dubois, Knox, Spencer, and Warrick Counties. Compared to the State of Indiana as a whole this seven-county area has a smaller population growth rate and is less racially and ethnically diverse. On average, the area's population has a lower median income, and less high school and college education than the state's population.

Population

The total population of the seven counties was 226,861 in the 2000 Census (USCB, 2006). The population increased 6.9 percent during the 1990s while the state's population increased 9.7 percent. Warrick County grew the most at 16.6 percent, and Knox the least at minus 1.6 percent. The seven-county population was 97.3 percent white in 2000; the State population was 87.5 percent white. In Indiana, 6.4 percent of the people 5 years and older speak a language other than English at home; in the seven-county area the figure is 4.6 percent.

Employment

In 2000 there were a total of 21,744 full- and part-time jobs in Pike and Gibson counties. Farm/forestry/fishing employment accounted for about five percent of the jobs across the area. The manufacturing and education/health/social services industries

were and are the largest economic and employment sectors in these counties (USCB, 2000a; USCB, 2000b).

Income and Education

Average per-capita income in the seven-county area was \$18,619 in 1999; in Indiana it was \$20,397. The median household income in the seven-county area was \$40,057 in 1999; in the state it was \$41,567 (USCB, 2006).

In the seven-county area, 14.8 percent of persons over 25 years of age hold a bachelor's degree or higher. The comparable figure in the state is 19.4 percent. This discrepancy is typical of the difference between largely rural areas like these seven counties and entire state populations which include large numbers of more urban residents who are professionals and have higher educational attainment on average (USCB, 2006).

Potential Refuge Visitors

In order to estimate the potential market for visitors to the Refuge, we looked at 1998 consumer behavior data for an area within an approximate 60 mile radius. The data were organized by zip code areas. We used a 60 mile radius because we thought this was an approximation of a reasonable drive to the Refuge for an outing.

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, photography, freshwater fishing, hunting, and hiking. In order to estimate the general environmental orientation of the population we also looked at the number of people who potentially might hold a membership in an environmental organization.

Winter scenery, Patoka River NWR & MA. Photo credit: USFWS

The consumer behavior data apply to persons greater than 18 years old. For the area that we included in our analysis, out of a total population of 1,233,654 the population of persons greater than 18 years old was 925,980. The estimated maximum participants in the 60 mile radius for each activity are: birdwatching (72,351), photography (99,570), hunting (82,727), freshwater fishing (146,610), and hiking (86,325). The number of persons who might hold a membership in an environmental organization is estimated at about 19,941. The projections represent the core audience for repeated trips to the Refuge. On days with special events or major attractions such as when large numbers of birds are at the Refuge, visitors can be expected to travel longer distances.

Climate

The Refuge lies in the path of moisture-bearing low pressure formations that move from the western Gulf region, northeastward over the Mississippi and Ohio Valleys to the Great Lakes and northern Atlantic Coast. Much of the area's precipitation results from these storm systems, especially in the cooler part of the year. The average annual precipitation totals 44.2 inches. Of this total, about 23 inches, or nearly 52 percent, falls during the growing season of April to September. The highest and lowest annual precipitation totals for the period of record are 64.8 inches in 1945 and 28.0 inches in 1887, respectively. Maximum monthly precipitation is 15.1 inches while the minimum is 0.05 inches. The average seasonal snowfall is about 13.5 inches. On the average, 3 days out of the year have at least 1 inch of snow on the ground (NOAA, 1991).

Convective thunderstorms developing in the maritime tropical air from the Gulf of Mexico and squall line activity seem to be the factors which combine to supply summer rainfall. Severe storms are rather infrequent, but high winds and hail often accompany these storms and can cause isolated property damage. The area is in “tornado alley,” with the potential for tornados highest in early spring and late fall. The tornado frequency is probably less than one every 10 years.

In winter the average temperature is 34 degrees Fahrenheit, with an average daily minimum of 25 degrees. The lowest temperature on record (January 17, 1977) is minus 18 degrees. In summer the average temperature is 76 degrees, and the average daily maximum is 87 degrees. The highest recorded temperature (September 2, 1953) is 104 degrees (NOAA, 1991). Based on the average dates the first and last killing frosts, the area normally has 180 to 190 frost free days per year (SCS, 1989).

Prevailing wind direction is from the south-southwest. Strong and cold north to northwest winds occur from late autumn to early spring as large domes of arctic high pressure move into the Midwest. The strongest winds occur during a deep winter storm passage through the Lower Ohio Valley.

The average relative humidity is mid-afternoon is roughly 60 percent. Humidity is higher at night and the average at dawn is about 85 percent.

Climate Change

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 (CO₂) 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 CO₂. 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. The actions proposed in this CCP would conserve or restore land and habitat, and would thus retain existing carbon sequestration on the Refuge. This in turn contributes positively to efforts to mitigate human-induced global climate change.

One Service activity in particular – prescribed burning – releases CO₂ 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 Patoka NWR 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 on the Refuge 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 Refuge. Adjustments in refuge 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°F (2°C), while the southern portion, along the Ohio River valley, has cooled by about 1°F (0.5°C). Annual precipitation has increased, with many of the changes quite substantial, including as much as 10 to 20% 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 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 degrees to 6 degrees Celsius). The average minimum temperature is likely to increase as much as 1 degree 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

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.

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 CO₂ 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.

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

Wood Duck pair, Patoka River NWR & MA. Photo credit: USFWS

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 CO₂), 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 popu-

lations 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.

Air Quality

The U. S. Environmental Protection agency has established National Ambient Air Quality Standards (NAAQS) to protect public health and welfare from the detrimental effects of air pollution. Acquired lands of the Refuge and MA are located in areas designated as Nonattainment for Fine Particulate Matter PM-2.5. These areas include Cane Ridge WMA in Montgomery Township, Gibson County and the White River Bottoms WMA in Washington Township, Pike County. Air pollution concentrations for fine particulate matter is above the NAAQS levels for this "criteria pollutant" regulated by the Clean Air Act.

Southwest Indiana is in the Illinois Coal Basin and is blessed with rivers and large quantities of coal. These natural resources have resulted in the concentration of many coal-fired power plants. In fact, southwest Indiana has the highest concentration of coal-fired power plants per given area of anywhere on earth. As such, air pollution associated with these power plants is at a high level which explains why six of the seven counties in southwest Indiana are all or partially in Nonattainment for Fine Particulate Matter (PM- 2.5).

The "criteria pollutants" identified by the EPA as part of the Clean Air Act include carbon monoxide(CO), ozone(O3), nitrogen oxides(NOx), sulfur dioxide(SO2), lead(Pb) and particulate matter(PM). The Clean Air Act's Prevention of Significant Deterioration(PSD) program sets strict standards to limit the amount of additional pollutants(SO2), nitrogen dioxide(NO2) and total suspended particulate concentrations) that can be released into the air within designated Attainment Areas. Under this program, Attainment Areas are divided into three classes, each allowing different levels of additional pollutants. The Refuge and MA as well as most of Indiana, is currently a Class II Attainment Area. A Class II designation allows moderate additional deterioration of air quality unless the area comes under Nonattainment status. Nonattainment status means any new source or proposed modifications to existing sources of air pollutants must provide for offset reductions in existing pollution so that the air quality does not deteriorate even further.

Primary pollutants affecting the area's air quality are fine particulate matter, SO₂ and NO₂, all of which are associated with coal-burning power plants. Nitrogen oxide is a major component of ozone smog and fine particulate matter. these pollutants are known to cause premature mortality and aggravate respiratory and cardiovascular disease, lung disease and asthma. Most vulnerable to these air pollutants are older adults, people with heart and lung disease, children and pregnant women.

Of the many coal-fired power plants in southwest Indiana, several contribute more concentrated pollutants to the air shed of the Refuge and MA based on their closer proximity and location considering prevailing winds. To the west is Duke Energy's Gibson Generating Station (third largest in world based on 3,250 megawatts), to the north is Indianapolis Power and Light and the Frank E. Ratts Generating Station of Hoosier Energy Division and to the south is the Alcoa Generating Plant in Warrick County and the American Electric Power - Indiana Michigan Power Plant at Rockport.

These and other coal -fired plants are all making major investments in pollution control devices to reduce emissions. However, their emissions are still increasing due to an increase in the amount of coal being burned to produce more power and changes in the blends of coal being burned. Atmospheric concentrations of these EPA "criteria pollutants" can only improve with offset reductions of existing pollution sources.

At the beginning of this 21st century, private industry is being spurred on to construct new ethanol refineries and biofuel power plants with offers of Federal subsidies, relaxation of air pollution standards for ethanol refineries and new regulations requiring energy production from renewable fuel sources. In recognition of the increasing demand for more electric power sources and the Federal mandate to increase the use of fuels made from renewable resources, the Indiana Department of Environmental Management (IDEM) is preparing a new Air Monitoring Station Plan to increase the number of air monitoring stations across the State. The location of these new Air Monitoring Stations will better document existing air pollution Nonattainment locations and serve as a guide for locating new sources of pollution away from existing Nonattainment Areas.

Construction of the new-terrain I-69 Interstate highway crossing through the Refuge and MA will make this a high growth potential area. For the long

Wintering waterfowl, Patoka River NWR & MA. Photo credit: USFWS

term protection and management of the biological resources of the Refuge and MA and enjoyment of these resources by the visiting public, a cooperative effort between the Service and IDEM is being made to establish an Air Monitoring Station on or near the refuge. This is the best way to allow for wise decision making related to permitting new-source industrial developments with inherent pollution outputs.

Geology and Soils

This section of Chapter 3 draws heavily on the Patoka River National Wetlands Project EIS, pages 75-88 (USFWS, 1994).

Geology

The Refuge is located on the eastern shelf of the Illinois River Basin, a prominent regional down-warp (bowl) centered in southeastern Illinois. During the Paleozoic Era this basin underwent repeated cycles of subsidence and uplift with accompanying sedimentation and erosion. The cycles stopped in late Pennsylvanian time when the basin was uplifted and subjected to a final episode of degradation (IDGNR, 1898). The remaining thickness of Pennsylvanian rocks in the area is about 1,200 to 1,900 feet. These rocks are composed of cyclical sequences of shale, siltstone and sandstone intermixed with thin, widespread beds of coal, clay, limestone and black shale. In general, these intermixed layers are dipping 1 to 2 degrees west towards the center of the basin.

Within the Pennsylvanian-age rocks, five distinct formations are exposed within the Refuge & MA boundaries:

- *Staunton Formation:* Composed primarily of sandstone and sandy shale, this 75 to 100 feet thick layer is the oldest (deepest) formation and crops out near the eastern boundary of the Refuge & MA.
- *Linton Formation:* Above the Staunton is the 80-foot thick Linton formation. Composed primarily of sandstone, and shale, this formation is found in the eastern and central areas of the Refuge & MA.
- *Petersburg Formation:* This formation lies above the Linton and crops out in the east and central portions of the Refuge & MA. Approximately 100 feet thick, the formation is a sequence of shale, limestone and sandstone.
- *Dugger Formation:* Above the Petersburg lies a 70 to 100-foot thick sequence of sandstone, siltstone, limestone, shale, coal, and underclay comprising the Dugger formation. This formation occurs in the higher elevations of the western portion of the Refuge & MA.
- *Shelburn Formation:* Composed primarily of sandstone and shale, this formation caps the highest sites in the western part of the Refuge & MA.

In addition to these rock formations, most of the area is covered by a mantle of unconsolidated material. During the Pleistocene period, till, outwash and loess was deposited during successive cycles of continental glaciation, ending about 8,000 years ago with the withdrawal of the Wisconsinian glaciers from Indiana. These deposits range from only several feet to nearly 100 feet thick, with the deepest deposits occurring in the western portion of the Refuge & MA (IDNR, 1990).

Minerals

Oil

Small oil production wells are common within and adjacent to the Refuge & MA with the majority on the western end near Oatsville.

Gas

In the past, any natural gas produced incidental to oil production was vented or burned off at the wellhead. In the past two years, interest has been building in producing natural gas from a deeper geological seam known as the New Albany Shale. This is a complex unconventional reservoir with low volume but low decline production found at about 4,000 feet deep in Gibson County. To date, only a few of these wells have been drilled in southwest Indi-

ana. Coalbed methane gas (CBM) is also being explored as a possible new source of energy especially if coal production continues to decline because of the high sulfur content of most Illinois Basin coals. Methane gas is also being produced from old underground mine voids with one mine gas well in Gibson County.

Coal

The Refuge & MA lies on the eastern edge of the Illinois Coal Basin and is in the heart of Indiana's coal producing region. Most of the coal is of moderate to high sulfur content, which means the coal has to be cleaned and the sulfur scrubbed out of emissions when used in steam electric power plants. Although coal mining has been continuous in and near the Refuge & MA for nearly a century, substantial deposits of coal remain unmined. Recent coal industry statistics indicate that approximately 3,670 million tons of recoverable coal (surface and underground minable) remain in Pike and Gibson counties (ICC, 1992). The Office of Surface Mining (OSM) estimated a total coal reserve base of 105 million tons within the Refuge & MA alone, of which 40.5 million tons are accessible by underground mining and 65.5 million tons accessible by surface mining methods.

Over 20,000 acres of Pike County were surface mined for coal prior to the passage of the Surface Mining Control and Reclamation Act of 1977 (SMCRA). Many of the remaining ungraded spoil ridges and final-cut lakes provide excellent wildlife habitat. Nevertheless, some old overburden spoil ridges and abandoned coal preparation sites contain low grade coal, shale and sandstone laced with natural pyrites. Rainfall leaches out high levels of acid-forming substances such as sulfates and metals such as magnesium, iron, aluminum and manganese. As these metals dissolve in the acid water, the total acid salts reach toxic concentration levels. Toxic runoff from such areas impairs water quality in streams and lakes, devastating aquatic life.

Today, all water from mining sites must pass through sediment ponds to improve water quality; mined areas are graded back to approximate original contours and covered with topsoil; pyritic bearing rock is buried deep in the mine pit out of contact with surface water flows and the site is revegetated according to approved reclamation plans. The array of problems long associated with the area's surface mining activities are not a result of today's mining methods, but rather from strip mining prior to SMCRA. Within the Refuge & MA boundaries there

Impacts of strip mining on adjacent lands, Patoka River NWR & MA. Photo credit: USFWS

are approximately 150 acres of old strip mines. Most of the acid producing abandoned mine lands are located outside the Refuge but within the watershed. Most of these have been or are being reclaimed by Indiana Department of Natural Resources' Abandoned Mine Land Program.

Soils

Lying in the valley's floor and subject to periodic flooding, bottomland soil associations make up the majority of Refuge soils. Upland soil associations are located above the flood-zone on valley side-slopes and ridges.

Bottomland Soil Associations

Found on the floodplains of the Patoka River and its major tributaries, these soils were formed in the sand, silt and clay deposited during flood events. Soils within these associations are nearly level, deep, and poorly drained. Soils can also be classified based on hydric (wetness) characteristics, which in turn influence the type of plants that will grow there. Hydric soils are soils that are wet long enough to periodically produce anaerobic conditions. Hydric soils or soils with hydric inclusions comprise the majority of the soil types found in the bottomland.

Nearly 75 percent (16,970 acres) of the Refuge & MA is composed of three such soil associations:

- *Belknap-Bonnie-Wakeland Association*: While it makes up only 13 percent of Pike County, this association represents 46 percent of the Refuge & MA. With adequate drainage, these soils are used mainly for cultivated crops. Some areas are used for hay and pasture while other areas

South Fork Patoka River, Patoka River NWR & MA.
Photo credit: USFWS

are wooded. Flooding and wetness are the principle problems.

- *Stendal-Bonnie-Birds Association:* This soil association represents about 7 percent of Gibson County and 12 percent of the Refuge. The soils are used mainly as cropland, but flooding, wetness, and ponding are problems. They are well-suited for woodland, and used as such along stream channels and in undrained areas.
- *Petrolia Association:* Approximately 3 percent of Gibson County and 17 percent of the Refuge & MA is comprised of this soil association. Flooding and wetness can hinder crop production, but the soils are well-suited for woodland.

Upland Soil Associations

These associations are found on ridge tops and side slopes adjacent to the above floodplain soils. Having formed in loess, material weathered from sandstone, siltstone, shale, and regolith in surface-mined areas, these soils are generally formed on gently to severely sloping sites and are well-drained.

About 25 percent of the Refuge & MA is composed of five upland soil associations:

- *Zanesville-Hosmer Association:* This soil association represents nearly 17 percent of Pike County and seven percent of the Refuge & MA. These soils are fairly well suited for cultivated crops, woodland and recreational uses. Erosion is a hazard, and Hosmer soil's fragipan restricts rooting depth and permeability. Wetness is a problem associated with perched water tables.
- *Zanesville-Gilpin Association:* Soils in this association make up 14 percent of Pike County and five percent of the Refuge & MA. The hazard of erosion, the slope, a fragipan in the Zanesville soils and the moderate depth to bedrock in the Gilpin soils make the association better suited to woodlands, hay and pasture than to cultivated crops.
- *Hosmer Association:* This soil association comprises 16 percent of Pike and Gibson counties and five percent of the Refuge & MA. These soils are used mainly for cultivated crops, hay, and pasture. Some areas are wooded. Erosion is the primary hazard. Hosmer's fragipan restricts rooting depth and can create localized wetness due to perched water tables.
- *Fairpoint-Bethesda Association:* Soils in this association make up about 16 percent of Pike County and nearly four percent of the Refuge & MA. These soils are found in very steep areas where overburden was cast during surface mining, and in nearly level to strongly sloping areas where overburden was smoothed and shaped. This soil association is mainly suited for woodland, hay and pasture because of the slope, erosion hazard, low available water capacity and scattered rock fragments.
- *Alford-Sylvan Association:* This soil association accounts for approximately 19 percent of Pike and Gibson counties and roughly four percent of the Refuge & MA. These soils are well suited to woodland. The steeper areas of this association are used for hay and pasture while the flatter sites are generally suited to cropland. Slope and the hazard of erosion are the primary problems.

Although there are 73 recognized soil types within the 23,743-acre Refuge & MA, over 70 percent of the Refuge is comprised of soils from just six soil series. These include:

- Belknap series (4,144 acres)
- Bonnie series (3,744 acres)

- Petrolia series (3,230 acres)
- Hosmer series (1,835 acres)
- Zanesville series (1,441 acres)
- Steff series (1386 acres).

The majority of these soil series represent soils that are either hydric or contain hydric inclusions, and are located in the Patoka River floodplain. Fifteen soil types are considered hydric and an additional 15 soil types contain pockets of hydric soil. Combined, these 30 soil types account for over 15,000 acres, or 68 percent of the Refuge. Of the remaining 7,000-plus Refuge acres, approximately 5,300 acres are prone to erosion and are classified highly erodible.

Water and Hydrology

This section was reproduced or modified from the Patoka River National Wetlands Project EIS, pages 88 to 101 (USFWS, 1994).

The drainage area of the Patoka River watershed includes 862 square miles in eight counties. At the upper eastern end of the watershed, the Patoka flows rapidly within a relatively narrow floodplain through deeply incised uplands, dropping at the rate of 12 feet per mile. Much of the uplands in this segment of the watershed are forested, with relatively small farms interspersed throughout. As the river enters the flat land created by Glacial Lake Patoka near Jasper, flow slows dramatically as the river's gradient decreases to 1 foot per mile. The predominant land use in the uplands changes from forestland to farmland.

The Refuge is located within this slow, meandering stretch of river with its wide floodplain, numerous oxbows and low rolling uplands. A total of 30 miles of river channel, 16 miles of natural meanders plus 14 miles on the western end that were channelized in the 1920s, are included in the Refuge & MA boundaries. In addition there are 19 miles of oxbow lakes and three miles of the South Fork, a major tributary entering the Patoka River just north of Oakland City (Figure 7).

Two notable events influence the present water regime of the Patoka River. The first was an attempt to drain nearly 100,000 acres of forested wetlands for farming in the 1920s. Known as Houchin's Ditch and beginning at the town of Winslow, the project replaced 36 miles of natural, meandering river with about 17 miles of dredged, straight ditch. The assumption was that by straightening and deepening

the channel, high water would flush through the area more quickly and adjoining lands could be more easily drained. Although some subsequent drainage and clearing of adjacent forested wetlands occurred, overall the project was a failure because of the bowl-shaped topography of this section of the floodplain, the river's low gradient, and the hydrologic relationship between the Patoka and Wabash Rivers.

Nearly 19 miles of natural river meanders were cut off and isolated from the main channel. Water exchange within these man-made oxbows is now limited to periods of high water. Unfortunately, heavy sediment loads are carried during these periods and results in increased deposition in the oxbows. Consequently, these important ecological units are becoming shallower and hold water for a shorter duration. Although this process occurs in all natural riverine systems, new oxbows are continually being created as river meanders are severed from the main channel. In the case of Houchin's Ditch, these oxbows are not being replaced and the associated wetland habitat is being lost.

The second major event affecting the river's flow regime was the Corps of Engineers' construction in the late 1970s of Patoka Lake. Located approximately 63 miles above the Refuge, this 8,000-acre impoundment was designed to provide flood control as well as recreation and water supply. Since the lake was built, flow regulation by it has reduced flood stages in the lower segment of the river usually several times a year.

During the initial start-up of Patoka Lake in 1979, the month of July received an all time high record one month rainfall. The lake behind the dam rose rapidly forcing summer releases of stored water. This resulted in flooding of much of the floodplain crop fields, particularly within the present Refuge and MA boundaries. Farmers blamed the new dam for creating the problem and demanded that something be done. Subsequently, in an effort to lessen the possibilities of summer flooding, a special federal appropriation of \$1.3 million was provided to the Corps to remove all channel obstructions and most leaning trees on both sides of the river from the Patoka Lake Dam to the Wabash River, a length of 121 miles. This was completed in 1981. It reduced localized flooding immediately upstream of drift piles, but largely eliminated in-stream cover and the overhead tree canopy, negatively affecting the river's fish and wildlife resources. The project also

Figure 7: Hydrology at Patoka River NWR & MA

increased the rate and extent of streambank erosion by removing many of the tree roots which had stabilized the river bank.

Agriculture (and associated land clearing, ditching and drain tiles), surface coal mining, and to a lesser extent urban development affect the Patoka River and its watershed. These activities contribute to rapid runoff of precipitation, increased soil erosion, and heavy sediment loads in streams. After any substantial rain event, the Patoka River and its tributaries are characterized by turbid, sediment-laden water.

Ditching, damming, and channelization efforts dating back to the early 1900s are largely responsible for the loss of wetlands throughout the area. Oil well developments, over 20,000 acres of abandoned coal mine lands, intensive agricultural and logging operations as well as runoff or discharges of industrial, community, and farming effluents degrade water quality within the watershed.

Refuge Resources

The sections under this heading draw heavily upon the Patoka River National Wetlands Project EIS (USFWS, 1994).

Plant Communities

Wetlands

Within the Refuge & MA are 12,700 acres of forested wetlands, emergent wetlands, scrub-shrub wetlands, agriculturally modified wetlands, and open water habitat.

American lotus, Snakey Point Marsh, Patoka River NWR & MA. Photo credit: USFWS

Forested Wetland

The majority (55 percent) of wetlands within the Refuge & MA fall in this category. Characterized by woody vegetation that is 20 feet or taller, forested wetlands are found within the floodplain of the Patoka River and its tributaries where the terrain is relatively flat and soils are poorly drained. Soils may remain saturated for most of the growing season on some sites and only a week or two during the growing season on other sites. Most areas of forested wetland experience some degree of annual flooding. Tree species composition often reflects the hydrology of the site. On the wettest areas, the mature forested wetland supports black willow, sweetgum and river birch. Areas frequently or seasonally flooded are dominated by silver maple, cottonwood, sycamore, pin oak, Shumard oak, swamp chestnut oak, overcup oak, swamp white oak, green ash, and red maple. On drier bottomland sites that are infrequently flooded for short durations, the dominant canopy trees include American beech, pecan, black walnut, American elm, and cherrybark and other oaks. For a more complete list of plants common to the Refuge's bottomland forested wetlands see Appendix C.

Forested wetlands transformed by flooding as a result of beaver activity cover hundreds of acres within the Refuge. Depending on when they were created, these areas may contain stumps as well as dead and/or dying trees. They are typically covered by a growth of duckweed, with coontail and bladderwort under the surface. Buttonbush, whitegrass, common arrowhead, and knotweed commonly dominate the borders.

Scrub-shrub Wetland

These freshwater, vegetated wetlands are dominated by woody vegetation less than 20 feet tall. Scrub-shrub wetlands may represent a successional stage leading to forested wetland, or they may be relatively self-maintaining, stable communities. They are more or less permanently inundated. Plant species found in shrub-shrub wetlands include true shrubs such as buttonbush, red-osier dogwood and swamp privet, as well as young trees, or trees and shrubs that are small or stunted because of environmental conditions. Some of these include pumpkin ash, red maple, and willows.

Within the Refuge, scrub-shrub wetlands are found exclusively around the fringes of beaver flooded areas and in many of the numerous river oxbows created either through natural river meandering or as a result of river channelization in the

American Coot, Patoka River NWR & MA. Photo credit: USFWS

1920s. A total of 1,053 acres (4.7 percent) of Refuge lands are scrub-shrub wetlands, which represents eight percent of the Refuge's total wetland acreage.

Emergent Wetland

Emergent wetlands, commonly referred to as marshes and sloughs, are characterized by erect, rooted water plants that are present for most of the growing season in most years. These wetlands normally contain standing water, though at times they will dry up. Common perennial plants found in emergent wetlands include cattail, bulrushes, sedges, dock, and smartweeds. For a more complete list of plants found in this wetland type within the Refuge see Appendix C.

The Refuge contains about a thousand acres of emergent wetlands. This represents about 4.5 percent of the Refuge and 8 percent of the Refuge's total wetland acreage.

Agriculturally Modified Wetland

Lands in this category, although disturbed annually by agricultural activities, still possess the hydrologic characteristics and hydric soils necessary to perform many of the natural functions of undisturbed wetlands. These functions include absorbing rain and flood waters and recharging local groundwater and aquifers. Because of their location in the floodplain, winter flooding makes waste grain as well as natural foods available to migrating and wintering waterfowl. The majority of waterfowl use within the Refuge is currently associated with these agricultural lands. Approximately 22 percent of the Refuge wetlands fall into this category, and nearly all are located at the western end of the Refuge & MA.

Open Water

The 837 acres of Refuge in this category include upland lakes and ponds, oxbows associated with the Patoka River and the waters of the Patoka River and its various tributaries.

Uplands

The principal natural community found in the Refuge is classified upland forest. As with the bottomland forests, upland forest resources have been heavily utilized by the area's timber industry. Mature upland forests are extremely limited in the Refuge; they occur at higher elevations where terrain is steeper and soils are well-drained. On southwest-facing slopes, these forests would typically contain both white and black oaks, hickory, and blackgum. On more mesic (wetter) sites, such as northeast aspects and valleys, the tree species composition would include red oaks, yellow poplar, beech, sugar maple, walnut, hickory, and cherry. Some pines are present in upland forest, but they are not indigenous to this part of Indiana. Although upland forest can be found in most areas of the Refuge, the majority is located in Pike County. This natural community type represents 15 percent of the total Refuge & MA.

Invasive Plant Species

Some exotic (also known as non-native or alien) plants greatly alter the plant communities of natural areas while others more commonly affect already disturbed or agricultural areas. Left unchecked, noxious plant species can seriously degrade the productivity and wildlife value of invaded habitats.

Fortunately, most of the Refuge & MA's wetlands are relatively free of noxious plants. Those in the area possessing the greatest potential for serious impacts include common reed grass, reed canary grass, and moneywort. The first two are a greater threat in open wetland sites, whereas moneywort can carpet large areas of floodplain forests (as well as open areas). Purple loosestrife was found in the Refuge in 2006 and eliminated. Both purple loosestrife and common reed grass have been observed to form monocultures, completely overrunning wetlands to the exclusion of almost all other plant species. Monitoring will be necessary to assure prompt action is taken to control these plants before they become a problem in the future.

On upland sites and agricultural communities, the most troublesome noxious plant is Johnson grass. Owing to its hardiness, growth and reproductive mechanisms, and its close relationship to domestic corn, this introduced species is widespread and difficult to control in both Pike and Gibson counties. As a result of seed dispersal during flood events, bottomland agricultural fields are particularly prone to infestation making it common to see this plant in those areas.

Other plants classified as noxious weeds in the area include Canadian thistle, bur cucumber and shatter cane. Although locally significant, these species do not represent as pervasive a problem as Johnson grass.

Threatened and Endangered Plants

The Indiana Natural Heritage Data Center is a continuously updated data management system which contains locations of all rare plant species in Indiana. Based on this information, which includes both historical collections and recent discoveries, the Indiana Division of Nature Preserves (IDNP) compiled a list of 55 potential rare plants which could occur within the Refuge & MA. IDNP personnel then conducted field investigations to confirm the presence of any of these rare plant species. In 1991, 17 individual areas within the Refuge & MA were inventoried. A total of 20 state-listed plant species were verified during the survey (Homoya, et al., 1992). No federally-listed threatened or endangered plants are known to occur within the Patoka River NWR/NWA.

Two of the 20 state-listed plant species are particularly noteworthy. The discovery of sickle pod (*Cassia obtusifolia*) represents the first documented occurrence of this species in the state. Also, three populations of buttonweed (*Diodia virginiana*) were found in the Project area. These finds represent the second, third and fourth occurrences of this species documented in Indiana. The vast majority of rare plants found during IDNP'S survey are associated with forested and emergent wetlands. Although a few species were found in disturbed habitat, most were growing in relatively stable wetland communities, and were scattered rather evenly throughout the inventoried area of the Patoka River floodplain.

Fish and Wildlife Communities

Birds

The Patoka River and surrounding wetland and upland areas provide an array of habitat types which fulfill the necessary breeding, feeding, migration and wintering requirements for a variety of avian species. Scientific surveys, organized bird counts and casual observations have recorded over 231 species of waterfowl, wading and shore birds, songbirds, game birds and others within the Refuge & MA.

Waterfowl

The Patoka River bottoms, particularly during periods of high water in late fall and early spring, is an important waterfowl migration stop-over in the eastern portion of the Mississippi flyway, and one of the more important sites in the state. Average fall/winter duck populations in the Refuge & MA are conservatively estimated at 5,000-8,000 birds during years with good available water, i.e., sufficient rainfall to provide lowland flooding. Data available for waterfowl use during spring migration shows a minimum of 15,000 ducks, utilizing the area on their journey north. Most of this use occurs in the Oatsville, Wirth and Wheeling Bottoms, historically high-use areas, although birds are also found on the other numerous wetlands throughout the Refuge & MA. Cane Ridge Wildlife Management Area, west of the main body of the Refuge and along the Wabash River, seasonally attracts waterfowl populations estimated at 10,000 ducks and 8,000 Snow Geese annually.

The Patoka River valley contains some of the best Wood Duck nesting and brood rearing habitat in the State. Beaver activity is largely responsible, although other factors such as rising water tables

Drake Wood Duck. Photo credit: USFWS

and erosion-related sedimentation of area ditches also have contributed to the increase in wetlands. Although Wood Duck is the major species breeding on the Refuge & MA, adjacent lands, particularly strip-mined areas reclaimed since 1977, also support nesting by several other waterfowl species, including Mallards, Blue-wing Teal and Northern Shoveler. Local nesting by Giant Canada Geese has been documented since the early 1980s. Most nesting is found on reclaimed strip mine lands.

Shorebirds and Wading Birds

The Patoka River NWR & MA provides an abundant source of food and high quality nesting and roosting sites for resident and migrating shorebirds and wading birds. Although approximately 40 species have been observed in the Refuge & MA, the majority are transitory, utilizing the emergent wetlands, shallow flood waters and temporary mudflats for resting and to obtain protein (in the form of invertebrates) essential for continued migration and successful reproduction.

The Refuge & MA hosts numerous species of plovers, sandpipers, dowitchers, and rails, among others. One notable migrant is the Sandhill Crane. Each fall, thousands of cranes stage at the Jasper-Pulaski Fish and Wildlife area in northern Indiana. Their journey to wintering grounds in Florida takes them over the Patoka River bottomlands. When habitat conditions are suitable, flocks of 50 to 100 birds have been observed resting and feeding before continuing south.

Several species of wading birds, notably the Great Blue Heron, Black-Crowned Night-Heron and Yellow-Crowned Night-Heron, are known to nest within the Refuge & MA. Several other species, including the American and Least Bitterns, Green-Backed Heron, Piping Plover, Killdeer, and Common Snipe have breeding ranges which encompass the Refuge & MA, and it is reasonable to assume that many or most of these species nest here. Wilson's Phalarope and Black-necked Stilt are documented nesters at Cane Ridge Wildlife Management Area, located west of the main body of the Refuge along the Wabash River.

Raptors

The Refuge area supports permanent or seasonal populations of at least 14 species of birds of prey. Open fields and emergent wetlands provide essential habitat for Northern Harriers, American Kestrels, Short-eared Owls, Barn Owls, and Broad-Winged, Rough-Legged, and Red-Tailed Hawks. Forested wetlands and upland forests support

per's and Sharp-Shinned Hawks, Great Horned Owls, Barred Owls and Eastern Screech Owls. In addition, the state-listed Red-Shouldered Hawk currently nests within the Refuge & MA. The Patoka River area probably has the largest expanse of nesting habitat for this species remaining in the state.

The Osprey, a state-listed endangered species, as well as a species of management concern to the Service, has been observed utilizing Patoka River wetlands during migration. The Mississippi Kite, extremely rare in Indiana, has also been observed on the Refuge.

Upland Game Birds

Resident populations of Bobwhite Quail, Ruffed Grouse and eastern Wild Turkey occur within Patoka River NWR & MA. Resident and migrant populations of Mourning Dove and American Woodcock also occur locally.

In general, quail require a diversity of habitats, including forests, brush, grass and cultivated lands. Successional zones between forest and field (edge or ecotone) is particularly important.

Few quail inhabit the interior of large tracts of bottomland or upland forests. Quail populations in the area are considered fair, with annual recruitment determined generally by winter and spring weather and the availability of suitable nesting/brood habitat.

Ruffed Grouse is a woodland species that generally prefers early stages of forest succession. Hardwood thickets characterized by dense stands of young saplings and vine tangles, old fields reverting to trees and young pine plantations are important habitat components. Historically, Ruffed Grouse populations in Indiana were declining in the early 1960s and their distribution was restricted to a small area in the south-central part of the state. An intense trapping and transplanting effort by the Indiana DNR was undertaken to reverse this trend. As Indiana forests have matured, the amount of young forest preferred by Ruffed Grouse has declined, resulting in lower grouse numbers in recent years.

Generally speaking, the Wild Turkey is a forest dweller, favoring mature mast-producing hardwoods (mainly oaks) with a mixture of understory plants like dogwood, sassafras, and greenbriar. Turkeys also make use of green plants (clover, wheat) and seeds (grasses, wheat, agricultural crops) found in pastures, crop fields, roadsides and disturbed or

Opossum and young, Patoka River NWR & MA. Photo credit: USFWS

abandoned areas. These more open areas provide the insects needed by poult for the protein necessary for rapid growth and development, and the forest/field interface is often preferred by nesting hens. The Refuge & MA contains these essential habitat components, and consequently the area supports a good turkey population.

Although migratory, Mourning Doves are present on the Refuge year round. Winter birds are principally migrants from northern areas utilizing the area after the local breeding population has migrated south. Heaviest concentrations of Mourning Doves occur in late summer as breeding birds and young of the year stage in large flocks prior to moving south. Most local birds are gone by early November. Because of their adaptability and high reproductive capacity, Mourning Doves are the most abundant upland game bird in the area as well as in the state. Strictly ground-feeding seed eaters, doves find abundant foods at Patoka River NWR & MA. Principal foods include waste grain in winter wheat, corn, milo and silage fields, annual weeds (foxtail, spurge, crabgrass, ragweed) in abandoned or disturbed area, and both planted and volunteer vegetation in large areas of newly-reclaimed strip mining lands.

Although limited nesting is known to occur, American Woodcock primarily utilize the area during spring and fall migrations. During these seasons they occur in fairly dense coverts of regenerating woodlands in the early stages of succession. Because the woodcock relies almost exclusively on earthworms as a food source, favored sites are in rich, moist bottomlands or upland riparian areas. Although never abundant on the Refuge, large flights during migration, particularly in the fall, can

result in temporarily high populations in small, isolated areas offering good habitat with plenty of worms.

Passerines (Perching Birds)

Detailed information on the abundance of some non-game bird species is not available, but it is known that well over 100 species of passerines and other species utilize the Refuge & MA at some time each year. Prior to settlement, the larger, unbroken tracts of bottomland forest were undoubtedly important habitat for many neotropical migrants, that is, species that summer and breed in North America and winter in Latin America. Neotropical migrants include most of our forest and grassland songbirds. Subsequent forest fragmentation, both in southern Indiana and nationally for agricultural expansion, roadways, urbanization, utility (pipeline and transmission line) corridors, and timber production has had serious impacts on many of these birds and population declines have been noted for many species. However, counts of singing male Cerulean Warblers noted while canoeing the Patoka River in the eastern third of the Refuge, showed some of the highest count totals recorded in Indiana. The large number of Prothonotary Warbler pairs recorded in the bottoms during a 1997-98 Breeding Bird Research Study by Hurley was significant enough to justify listing the Patoka River NWR as an Important Bird Area by the National Audubon Society.

At the time of the NWR/MA's establishment in the early 1990s, forestland within the area, both upland and bottomland, had been reduced in extent and quality. Yet it still offered the best habitat in the area and has been utilized for nesting and migration by a variety of warblers, thrushes, vireos, woodpeckers, flycatchers and sparrows. The Refuge's reforestation efforts over the past decade have been beneficial to shrub-scrub and forest-dwelling passerines.

Mammals

Indiana is home to 54 species of mammals, of which 41 species occur on the Patoka River NWR & MA. These include an array of game, non-game and furbearing mammals.

Game Mammals

The Refuge provides excellent habitat for Indiana's only big game species, the white-tailed deer. Interspersed bottomland forest, agricultural fields, idle/scrub lands, wetlands and upland forest pro-

vides the habitat diversity necessary for abundant food, protective cover, and reproductive activities. Population density estimates in the 1990s by the Indiana DNR indicate 33 deer per square mile of suitable habitat in Pike County and 22 deer per square mile of deer habitat in Gibson County. In terms of county-wide averages for all types of land and habitat types, Pike County supports 15 deer per square mile while Gibson County is estimated at six per square mile. With the exception of open water and some emergent wetlands, the Refuge & MA is considered to be suitable deer habitat, and supports approximately 25 to 30 deer per square mile. Deer are present in sufficient abundance to cause agricultural depredation in isolated locations. Because of the area's deer abundance, deer hunting is an extremely popular activity for local and visiting sportsmen.

Patoka River woodlands and adjacent uplands provide habitat for both fox and gray squirrels, the most sought after small game mammals in the state. Productive squirrel habitat contains adequate den trees for escape, protection and reproduction, and dependable food sources in all seasons. Squirrel reproduction and survival fluctuates with changing yields of heavy-seeded mast, particularly acorns. Other fruits and berries, floral parts, buds, bark, roots, fungi and animal matter provide foods when heavy mast is unavailable. A variety of hardwood tree species is essential to a balanced habitat, but the stocking of heavy-seeded species – oak, hickory, beech, walnut – determines carrying capacity.

Much of the bottomland forest within the proposed Project area has been continually harvested for the heavy-seeded tree species, i.e., oak and hickory. Subsequently, these woodlands do not contain optimum stands of these important squirrel foods, and populations are considered fair. Upland forests, particularly those managed by the Indiana DNR, are characterized by more tree species diversity; their squirrel populations are generally considered good.

The other major small game mammal within the Refuge & MA is the eastern cottontail rabbit. They require early successional vegetation, and rabbits are found in good numbers in and around abandoned fields, fence rows, pasture borders and reclaimed strip mine lands. As strict herbivores, the cottontail favors new growth grasses, succulent forbs and some agricultural grains. During severe winter weather, the bark of young woody growth can sustain rabbits for short periods.

Furbearers

Furbearers generally include those animals harvested by hunting or trapping primarily for the commercial value of their pelts. Because most of these animals are closely associated with wetland/aquatic sites, Patoka River NWR & MA provides excellent habitat for furbearers such as muskrats, beaver, coyotes, foxes, and others.

Marshes are the preferred habitats of muskrats, but the species also occurs along streams and ditches as well as in lakes and ponds. Areas such as Snakey Point provide excellent muskrat habitat. Although somewhat cyclical, muskrat populations in area marshes, ponds, oxbows, and the Patoka River itself are considered good.

Beaver are thought to have been extirpated in Indiana by 1900. Natural range expansion by way of the extensive river systems and relocating some beavers to wild areas away from human habitations have resulted in a nearly state-wide distribution today. Within the Refuge & MA, nearly all suitable habitat is currently occupied by beaver. Beaver activity is responsible for the shallow water and standing dead timber in several large areas, most notably west of Line Road and north of Snakey Point. Beavers impound areas adjacent to water courses to provide access to food and other essential habitat needs; these areas are later abandoned when food supplies are depleted and the animals move to new territory. Although significant in short-term impacts, these activities are a natural phenomenon in the Patoka's bottomland forests and increase the diversity of wetland types and the wildlife that utilize them. This cycle (bottomland timber beaver impoundment emergent marsh scrub-shrub wetland bottomland timber) has occurred historically in the Patoka bottoms.

Unfortunately, the beaver's habit of impounding waters frequently brings it in direct conflict with man. Beaver activity results in plugged road culverts and flooded roadways, water encroachment on railroad grades, reduced drainage and flooding of agricultural lands, and loss of timber resources. Beaver can be trapped and dams can be removed, but as long as suitable habitat is available these remedies are at best temporary because beaver will quickly re-colonize the site. Refuge management policy is to remove nuisance beavers whenever their works on the refuge are impacting private lands off the refuge.

Coyotes and red and gray foxes are relatively common on the Refuge & MA. Over the last few

decades, the coyote population has gradually increased in areas of suitable habitat, primarily upland brushy, grassy and abandoned fields. Abandoned strip-mined lands as well as newly reclaimed areas provide ideal habitat for coyotes. Red foxes occur in similar habitat and it is believed that the coyote often displaces some red fox from these areas, thus depressing red fox populations. Gray foxes are found more commonly in bushy and wooded habitats both in uplands and bottomlands. Food habits of coyotes and foxes are similar and include primarily small rodents and occasional birds. When present in sufficient numbers coyotes are known to prey heavily on white-tailed deer fawns. Occasionally, coyotes impact livestock producers (sheep and pigs).

Mink, otters, weasels, skunks, opossum, and raccoons are also relatively abundant in the area. Food habits range from the carnivorous behavior of minks, otters, and weasels to the omnivorous habits of raccoons, opossum, and skunks. Mink, otters, weasels and raccoon are closely associated with wetland habitats, streams and ponds; opossum and skunks are more often found in the uplands. Because they are all considered predators, they occasionally cause damage to domestic animals, i.e., prey on poultry and other tended animals. Otters were reintroduced into the Patoka River by the Indiana Department of Natural Resources over a period of several years in the late 1990s. This popular reintroduction effort has resulted in otters dispersing throughout the Patoka River Watershed and beyond.

Nongame mammals

Numerous small nongame mammals find suitable habitat on the Refuge & MA. Included in this group are shrews, moles, bats, chipmunks, mice and voles. Although there are little specific data regarding population sizes, the interspersed woodlands, wetlands, abandoned fields, agricultural lands, creeks, ponds and river make it reasonable to assume that these species are faring well. Although rarely observed, and frequently underappreciated, nongame mammals are critically important as a food source for the larger, predatory mammals as well as most of the area's hawks and owls.

Amphibians and Reptiles

The Patoka River valley is within the range of at least 60 species of herptiles, that is, snakes, turtles, lizards, skinks, salamanders, newts, sirens, toads and frogs (Conant, 1958). A diverse assortment of reptiles and amphibians occur on the Refuge and fill

Five-lined skink, Patoka River NWR & MA. Photo credit: USFWS

many important niches in the ecosystem's natural food chain. Patoka's herpefauna include the northern copperbelly water snake, a species of concern which has been found to inhabit the buttonbush swamps of the bottoms in large numbers, and spring's tiny harbinger, the spring peeper, a small frog whose persistent, shrill mating call pierces March nights in an ancient rite of spring.

Because the majority of these species require moist woodlands, ponds, streams, marshes, swamps or quiet backwaters, Patoka River NWR & MA provides excellent herpetilian habitat. Many species of reptiles and amphibians are nocturnal or secretive in nature which makes it difficult to adequately determine population status. And although there are no current data on population levels, it is assumed that numbers are adequate to maintain existing herpetile communities. However, it is reasonable to assume that, as has been noted with other aquatic organisms, populations of reptiles and amphibians have been negatively impacted by the long-term degradation of water quality in the Patoka River watershed. As the acid mine water drainage is eliminated in the watershed and refuge bottomland fields are purchased and restored to hardwood forests, water quality is constantly improving. The South Fork Patoka River is an outstanding example of watershed restoration efforts leading to the reestablishment of a stream fishery which now supports nesting Bald Eagles and public fishing opportunities where none existed for 50 years prior to Refuge establishment.

Fish

Most of the Refuge's fishery resources are associated with the Patoka River and its wetlands. Two fisheries surveys of the Patoka River and many of its tributaries in the late 1980s and early 1990s revealed that fish populations were surprisingly diverse and abundant, especially considering the environmental abuses this river has endured over the past 70 years (Stefanavage, 1993; U.S. Fish and Wildlife Service, 1989). A total of 66 species of fish representing 15 families were found to inhabit these waters. Although not usually considered prime fish habitat, overall species diversity in the Patoka River in 1991 compared favorably with other southwest Indiana streams (Stefanavage, 1993).

Considering the Patoka River's low dissolved oxygen levels, muddy brown/green water, and limited in-stream structure (habitat), it is not surprising that common carp was found to be the most abundant species. Gizzard shad, an important food source for more desirable predatory fish, was the second most abundant. Third in number was smallmouth buffalo, an edible species frequently sought by anglers. It is interesting to note that the smallmouth buffalo population appears large enough to support commercial fishing. Of the more popular game fish, channel and flathead catfish probably provide the best sport fishing opportunities in this section of the river. Largemouth bass, bluegill and crappie, while present, do not have populations large enough, or do not grow at a sufficient rate, to offer substantial fishing opportunities.

As a result of the U.S. Army Corps of Engineers channel clearing project in the early 1980s, and ongoing, similar activities by the Upper and Lower Conservancy Districts, fish habitat in terms of in-stream cover ranges from none to very little. Few log jams, brush piles and root-wads are found in the river within the proposed Project area. Consequently, species requiring in-stream cover (largemouth bass, bluegill, crappie) are limited by available habitat. Riffle/pool habitat is also scarce. In general, the stretch of river within the proposed Project is classified glide/run, and is characterized by a mud and silt bottom. Species diversity in the channelized portion of the river (downstream from Winslow) is lower than in the natural, meandering channel. Diversity at sampling sites averaged 14 species in the channelized river while the natural river supported an average of 19 species. Fish of interest to commercial and sport fishermen (buffalo, drum, channel and flathead catfish and spotted bass) were more abundant in the unchannelized section.

In addition to inadequate in-stream habitat, non-point source pollution, particularly acidic waters from abandoned coal mines and illegal releases of salt brine produced from oil wells, has been a limiting factor for the Patoka River fisheries. Decreases in fish numbers and species diversity immediately below Mill Creek and the South Fork Patoka River, both of which have carried high levels of acid mine waters, attest to the deleterious impacts associated with this pollutant. Fish kills associated with acid drainage were not uncommon in the South Fork at the time of the Refuge's establishment. One of these occurred on September 1, 1991, when heavy rain fell after two months of dry weather. Dead bluegill, bowfin, common carp, gar, and largemouth bass were observed. It appears that fish species from the Patoka River would recolonize the lower portion of the South Fork during drought periods. Then, as described above, fish populations in the South Fork would be wiped out when major storm events occurred which flushed acidic water into the stream from abandoned mine areas. This acid water flush-out problem of the South Fork has been largely eliminated in the past 10 years due to the efforts of the Indiana Division of Reclamation's Abandoned Mine Land Reclamation Program and local citizen efforts associated with the Appalachian Clean Stream Initiative of the U.S. Office of Surface Mining. Illegal releases of salt brine from oil wells while documented as being common practice in the 1960s,

Patoka River, Patoka River NWR & MA. Photo credit: USFWS

Pied-billed Grebe, Patoka River NWR & MA. Photo credit: USFWS

1970's and 1980's has largely been eliminated thanks to enforcement efforts by the Indiana Division of Oil and Gas.

One clear sign that water quality in the main stream Patoka River is improving as a result of improved enforcement actions and millions of dollars of reclamation efforts in the watershed are the increasing reports of paddlefish. (*Polyodon spathula*) since the late 1990s. Known to spawn in the Wabash River, part of the life cycle needs for these gill feeders includes rich feeding grounds found in flooded bottomland hardwoods. As the water quality of the Patoka River has improved, paddlefish have returned to this ancestral feeding area during spring floods to build up their body fats for successful egg production. Fishermen now report seeing paddlefish on a regular basis in the Patoka River and associated tributaries, oxbows and marshes. Recent contaminant surveys by Bloomington Ecological Services in the early 2000s also saw the return of harlequin darters which hadn't been found in the Patoka River since the late 1800s.

Invertebrates

The wetlands associated with the riparian ecosystem along the Patoka River support good invertebrate populations in their nutrient-rich waters. Nesting waterfowl, waterfowl broods and shorebirds are highly dependent on these protein-rich food sources for successful reproduction and healthy growth. Invertebrates associated with wetlands in the area include protozoa, crustaceans, mol-

lusks, snails and insects. Contaminant studies to evaluate the impact of salt brines on freshwater shrimp and crayfish were conducted on the Patoka River between 2000-2002 by Tom Simon of the Bloomington Ecological Services Office. One result of this study was the discovery of a new species of burrower crayfish identified now as the painted-hand mudbug (*Cambarus nov.sp.diogenes*) named because of the red tips on its claws. It turns out that this new crayfish species is the most common species on the Patoka River NWR.

Insects

By far the most obvious (and obnoxious) insects in the area are mosquitoes. Of the 51 species known to occur in Indiana, 30 could be expected to inhabit the southwestern portion of the state (Siverly, 1972). The majority of these species are considered pests whose biting activities often thwart otherwise enjoyable outdoor living and recreational activities, but do not pose any substantial human health risk. The most common nuisance mosquitoes found in local floodplains are *Psorophora ciliata* and *Aedes vexans*, the latter being perhaps the number one pest species in the area. These floodwater species are not significant vectors(carriers) of human diseases in southern Indiana.

Molluscs

Historically, the Patoka River supported a rich diversity of freshwater mussels that were utilized by Native Americans and wildlife alike. One early survey documented 21 species occurring in the river with other historical records showing an additional 12 species. Most of these mussels are relatively common in Indiana's larger creeks. The ring pink and hickory nut are big river species and probably lived near the confluence with the Wabash River. The ring pink is on the federal list of endangered species, but is believed to be extirpated from Indiana. The club-shell, and fat pocketbook, both federally endangered species, are reported in historical records. A more recent survey of the Patoka River found no live specimens of these species, but did turn up a weathered fat pocketbook shell, although not within the portion of the river flowing through the Refuge.

A survey of freshwater mussels conducted in 2000 along the entire length of the Patoka River and portions of its tributaries found 28 mussel species (Ecological Specialists, Inc. 2001). This is fewer than the 33 species reported in historic records. The segment of the Patoka River flowing through the Refuge contained 17 mussel species. No species were

found in the channelized portion of the river probably because the habitat in this stretch has been altered so as to render it unsuitable.

The diversity of freshwater mussels within the Patoka River has declined from historic levels, a trend that is similar for freshwater mussels across North America. Human activities during the past 90 years have greatly reduced the river's capability to support the once large assortment of bottom-dwelling mollusks. River channelization, erosion-related sedimentation, pesticide and fertilizer runoff, pollutants from oil and coal extraction, improperly treated sewage, and toxic industrial discharges have combined to degrade bottom substrates, water quality, and the riverine ecosystem in general. The diversity and numbers of mussels present in a river serves as an excellent barometer of river water quality. The more species and the higher the number of mussels found indicate the higher the water quality and stream bottom health. Future mussel surveys will be used to compare back to the initial surveys conducted when the Patoka River NWR was established to verify improvements resulting from management practices.

Threatened and Endangered Species

Threatened and Endangered Flora

The Indiana Natural Heritage Data Center is a continuously updated data management system which contains locations of all rare plant species in Indiana. Based on this information, which includes both historical collections and recent discoveries, the Indiana Division of Nature Preserves (IDNP) compiled a list of 55 potential rare plants that could occur within the proposed Wetlands Project. IDNP personnel then conducted field investigations to confirm the presence of any of these rare plant species. In 1991, 17 individual areas within the Project area were inventoried. A total of 20 state-listed plant species were verified during the survey (Homoya, et al., 1992). No federally-listed threatened or endangered plants are known to occur within the NWR/MA. The vast majority of rare plants found during IDNP'S survey are associated with forested and emergent wetlands.

Two of the 20 state-listed plant species are particularly noteworthy. The discovery of sickle pod (*Cassia obtusifolia*) was the first documented occurrence of this species in the state. Also, three populations of

buttonweed (*Diodia virginiana*) were found in what is now the Refuge & MA. These finds were the second, third and fourth occurrences of this species documented in Indiana.

More current data on endangered, threatened and rare plants in Gibson and Pike counties are available from the Indiana Department of Nature Preserves (IDNP) within Indiana DNR (IDNP, 2005a; IDNP, 2005b). Table 2 shows those vascular plants listed by IDNP expected to occur in either Gibson or Pike counties, or both, as of 2005. (Table 2)

In addition to these species and subspecies/varieties of wild plants, IDNP lists four "high quality natural communities" found in Gibson and/or Pike counties, including Forest – floodplain wet-mesic, Forest – upland dry-mesic, Forest – upland mesic, and Wetland – swamp shrub. Each of these communities occurs on the Refuge & MA.

Threatened and Endangered Fauna

Whooping Crane (*Grus Americana*)

In 2001, the U.S. Fish and Wildlife Service initiated a reintroduction of a Nonessential Experimental Population of Whooping Cranes in the Eastern United States. The intent was to establish a migratory flock that would summer and breed in Wisconsin and winter in west-central Florida which was historical habitat. Since the migration route is a learned rather than an innate behavior, captive-reared Whooping Cranes released in Wisconsin were led by ultralight aircraft to establish their historical flight path to suitable wintering areas in Florida. Five Whooping Crane yearlings were led over 1,200-miles in 2001, followed by 16 in 2002, 15 in 2003, 17 in 2004, 21 in 2005 and 18 in 2006. The first record of these introduced Whooping Cranes visiting the Patoka River NWR was on November 17, 2003, when a pair (2-02-F and 13-02-M) spent several days in the Patoka River bottoms near the Francisco Mine within the Refuge acquisition area. On March 27, 28 and 29, 2005, No. 2-01-F and No. 8-02-M spent their time in corn field stubble at Patoka River NWR in Pike County near Line Road. Annual stop overs on the Refuge are expected to occur every spring and fall once a viable flock is established.

Bald Eagle (*Haliaeetus leucocephalus*)

An increase in abundance and distribution of the Bald Eagle across the United States led to its reclassification from endangered to threatened in

Table 2: Endangered, Threatened, or Rare Vascular Plants in Gibson and Pike Counties, Indiana, as of 2005

Scientific Name	Common Name	Gibson County	Pike County	FED	STATE	GRANK	SRANK
<i>Acalypha deamii</i>	Mercury	✓			SR	G4?	S2
<i>Armoracia aquatica</i>	Lake Cress	✓			SE	G4?	S1
<i>Azolla caroliniana</i>	Carolina Mosquito-fern	✓			ST	G5	S2
<i>Calyocarpum lyonii</i>	Cup-seed	✓			ST	G5	S2
<i>Carex socialis</i>	Social Sedge	✓			SR	G4	S2
<i>Carex straminea</i>	Straw Sedge	✓			ST	G5	S2
<i>Catalpa speciosa</i>	Northern Catalpa	✓			SR	G4?	S2
<i>Chelone obliqua var. speciosa</i>	Rose Turtlehead	✓	✓		WL	G4T3	S3
<i>Clematis pitcheri</i>	Pitcher Leather-flower	✓			SR	G4G5	S2
<i>Crataegus grandis</i>	Grand Hawthorn	✓			SE	G3G5Q	S1
<i>Crataegus viridis</i>	Green Hawthorn	✓			ST	G5	S2
<i>Cyperus pseudovegetus</i>	Green Flatsedge	✓	✓		SR	G5	S2
<i>Didiplis diandra</i>	Water-purslane	✓	✓		SE	G5	S2
<i>Diodia virginiana</i>	Buttonweed	✓	✓		WL	G5	S2
<i>Gleditsia aquatica</i>	Water-locust	✓			SE	G5	S1
<i>Hibiscus moscheutos ssp. lasiocarpus</i>	Hairy-fruited Hibiscus	✓			SE	G5T4	S1
<i>Hottonia inflata</i>	Featherfoil		✓		ST	G4	S2
<i>Iresine rhizomatosa</i>	Eastern Bloodleaf	✓			SR	G5	S2
<i>Itea virginica</i>	Virginia Willow		✓		SE	G4	S1
<i>Juglans cinerea</i>	Butternut	✓			WL	G3G4	S3
<i>Linum striatum</i>	Ridged Yellow Flax	✓			WL	G5	S3
<i>Ludwigia decurrens</i>	Primrose Willow	✓	✓		WL	G5	S2
<i>Mikania scandens</i>	Climbing Hempweed		✓		SE	G5	S1
<i>Orobanche ludoviciana</i>	Louisiana Broomrape	✓			SE	G5	S2
<i>Phacelia ranunculacea</i>	Blue Scorpion-weed		✓		SE	G4	S1
<i>Platanthera flava var. flava</i>	Southern Rein Orchid	✓			SE	G4T4?Q	S1
<i>Potamogeton pusillus</i>	Slender Pondweed	✓	✓		WL	G5	S2
<i>Rhexia mariana var. mariana</i>	Maryland Meadow Beauty		✓		ST	G5T5	S1
<i>Sagittaria australis</i>	Longbeak Arrowhead		✓		SR	G5	S2
<i>Selaginella apoda</i>	Meadow Spike-moss		✓		WL	G5	S1
<i>Senna obtusifolia</i>	Blunt-leaf Senna		✓		SR	G5	S2
<i>Sparganium androcladum</i>	Branching Bur-reed	✓			ST	G4G5	S2

Table 2: Endangered, Threatened, or Rare Vascular Plants in Gibson and Pike Counties, Indiana, as of 2005 (Continued)

Scientific Name	Common Name	Gibson County	Pike County	FED	STATE	GRANK	SRANK
<i>Styrax americanus</i>	American Snowbell	✓	✓		WL	G5	S3
<i>Taxodium distichum</i>	Bald Cypress	✓			ST	G5	S2
<i>Trachelospermum difforme</i>	Climbing Dogbane	✓	✓		SR	G4G5	S2
<i>Vitis palmata</i>	Catbird Grape	✓	✓		SR	G4	S2
<i>Wisteria macrostachya</i>	Kentucky Wisteria		✓		SR	G5	S2

Sources: IDNP, 2005a and IDNP, 2005b
 FED: LE = Endangered; LT = Threatened; C = candidate; PDL = proposed for delisting
 STATE: SE = state endangered; ST = state threatened; SR = state rare; SSC = state species of special concern; SX = state extirpated; SG = state significant; WL = watch list
 GRANK: Global Heritage Rank: G1 = critically imperiled globally; G2 = imperiled globally; G3 = rare or uncommon globally; G4 = widespread and abundant globally but with long term concerns; G5 = widespread and abundant globally; G? = unranked; GX = extinct; Q = uncertain rank; T = taxonomic subunit rank
 SRANK: State Heritage Rank: S1 = critically imperiled in state; S2 = imperiled in state; S3 = rare or uncommon in state; G4 = widespread and abundant in state but with long term concern; SG = state significant; SH = historical in state; SX = state extirpated; B = breeding status; S? = unranked; SNR = unranked; SNA = nonbreeding status unranked

1995. It also led to a 1999 proposal to remove the Bald Eagle from the endangered species list. The Bald Eagle was removed from the list of threatened and endangered species in July 2007. The species became endangered because of habitat loss and reproductive failure brought on by the accumulation of the pesticide DDT and other organochlorine insecticides. Today, the DDT threat is largely gone. Efforts focus on maintaining sites eagles depend on for nesting, feeding, migration, and wintering. On the Refuge, the Bald Eagle occurs as a winter migrant and a summer breeder. Absent as a nesting species for many years, a chick was produced in spring 2002. A pair of Bald Eagles began nesting near the Snakey Point Marsh adjacent to the South Fork Patoka River in 2001. Unsuccessful that first year, one eaglet was raised in 2002, one in 2003, two out of three in 2004, one killed by falling tree in 2005, two lost from wind storm in 2006, and two fledged in 2007.

Least Tern (*Sterna antillarum*) (Interior Population)

The historic breeding range of the federally listed endangered Least Tern extended from Texas to Montana and from eastern Colorado and New Mexico to southern Indiana. It included large rivers of the Red, Missouri, Arkansas, Mississippi, Ohio, and Rio Grande River systems. It nests on sand and gravel bars and protected beach areas of large rivers, and winters in coastal Central and South Amer-

ica. The species is endangered because human disturbance and alteration of river systems have rendered much of its nesting habitat unusable.

The 488-acre Cane Ridge Wildlife Management Area lies 24 miles west of the Refuge headquarters includes 193 acres of moist soil wetlands in four management units, 180 acres of reforested bottomland hardwoods, and a 59-acre deep water impoundment with nesting islands that provide habitat for the Least Tern. The terns have used the nesting islands for that purpose fledging 52 young in 2005 and 42 young in 2006.

Fat Pocketbook (*Potamilus capax*)

Designated as federally endangered in 1976, this mussel is found in slow flowing waters of large rivers with mud or sand bottoms. The primary contributors to its decline are activities related to navigation and flood control such as impounded waters or dredging. The fat pocketbook has been found in the Wabash and White Rivers in Indiana. Its specific occurrence and distribution within the Refuge/MA is unknown at this time.

Indiana Bat (*Myotis sodalist*)

The Indiana bat was listed as federally endangered in 1967 under the Endangered Species Conservation Act, a precursor to the Endangered Species Act of 1973. Primarily the bats declined in number because of loss or disturbance of caves or other hibernacula. The bats hibernate communally

in large numbers. Disruption or destruction of a single site can dramatically affect the population. It occurs in several locations across Indiana. A maternity colony containing more than 100 adults in a large dead tree was first documented on the Refuge in 2005.

Copperbelly Water Snake (*Nerodia erythrogaster neglecta*)

The copperbelly water snake was proposed for listing as a threatened species in 1993 because of habitat loss and fragmentation largely associated with coal mining. The listing was never finalized. Instead, the Service entered into conservation agreements with mining regulatory agencies and coal industry representatives in Indiana, Kentucky, and Illinois. The agreements greatly reduced existing threats to the species, especially those posed by mining operations, precluding the need to list the southern population of the snake under the Endangered Species Act. Research conducted on the Patoka River NWR in 1994, 1995 and 1996 showed the Refuge area contained a significant viable population of copperbelly water snakes in suitable habitat which centered around buttonbush swamps associated closely with beaver impoundments. A large area of the Refuge bottomlands were designated Core Conservation Habitat in the Copperbelly Conservation Agreement with coal companies. This designation placed those lands off limits to any future surface coal mining efforts to protect some the highest quality copperbelly habitat remaining in its national range.

In addition to these federally listed species, a number of animal species are listed by the Indiana Department of Nature Preserves on their database of endangered, threatened and rare wildlife in the state (IDNP, 2005a; IDNP, 2005b). Table 3 shows those wild animal species and subspecies listed by IDNP expected to occur in either Gibson or Pike Counties, or both, as of 2005.

Threats to Resources

There are two main kinds of threats to environmental quality and plant and animal communities at Patoka River National Wildlife Refuge and Management Area: invasive species and contaminants. These are now considered in turn.

Current coal mine reclamation, Patoka River NWR & MA. Photo credit: USFWS

Invasive Species

Invasive species are plants or animals that are often (but not always) non-native or exotic to a given habitat. They are capable of spreading, sometimes quickly, to the detriment of native flora and fauna, which may be displaced, reduced in population, or even extirpated. In pursuing its mission to conserve America's native biodiversity, the Service contributes to nationwide efforts to control the unchecked expansion of invasive plant and animal species.

Some exotic (non-native) plants may substantially alter the plant communities of more natural, undisturbed areas while others more commonly affect disturbed or agricultural areas. Left unchecked, these invasive plant species can seriously degrade the productivity and natural value of invaded sites.

Most of the Refuge's wetlands are relatively free of noxious plants. Those in the area possessing the greatest potential for serious impacts include common reed grass (*Phragmites communis*), reed canary grass (*Phalaris arundinacea*) and moneywort (*Lysimachia nummularia*). The first two are a greater threat in open wetland sites, whereas money wart can carpet large areas of floodplain forests (as well as open areas). A plant not yet noted, but certainly expanding its range toward the area, is purple loosestrife (*Lythrum salicaria*). This species and common reed grass have been observed to completely overrun wetlands to the exclusion of almost all other plant species.

In uplands the most troublesome invasive is Johnson grass (*Sorghum halepense*). Due to its hardiness, growth and reproductive mechanisms, and its close relationship to domestic corn, this introduced species is widespread and difficult to control in both Pike and Gibson counties. As a result of seed

Table 3: Endangered, Threatened, or Rare Fauna in Gibson and Pike Counties, Indiana, as of 2005

Scientific Name	Common Name	Gibson County	Pike County	FED	STATE	GRANK	SRANK
Crustacean: Malacostraca							
<i>Orconectes indianensis</i>	Indiana Crayfish	✓			SR	G2G3	S2
Mollusk: Bivalvia (Mussels)							
<i>Cumberlandia monodonta</i>	Spectaclecase	✓		C	SX	G2G3	SX
<i>Cyprogenia stegaria</i>	Eastern Fanshell Pearlymussel	✓	✓	LE	SE	G1	S1
<i>Epioblasma flexuosa</i>	Leafshell	✓			SX	GX	SX
<i>Epioblasma propinqua</i>	Tennessee Riffleshell	✓			SX	GX	SX
<i>Epioblasma torulosa torulosa</i>	Tubercled Blossom	✓	✓	LE	SE	G2TX	SH
<i>Fusconaia subrotunda</i>	Longsolid	✓	✓		SE	G3	S1
<i>Lampsilis ovata</i>	Pocketbook	✓				G5	S2
<i>Lampsilis teres</i>	Yellow Sandshell	✓	✓			G5	S2
<i>Ligumia recta</i>	Black Sandshell	✓				G5	S2
<i>Obovaria retusa</i>	Ring Pink	✓		LE	SX	G1	SX
<i>Obovaria subrotunda</i>	Round Hickorynut	✓	✓		SSC	G4	S2
<i>Plethobasus cooperianus</i>	Orangefoot Pimpleback	✓		LE	SE	G1	S1
<i>Plethobasus cyphus</i>	Sheepnose	✓		C	SE	G3	S1
<i>Pleurobema clava</i>	Clubshell	✓	✓	LE	SE	G2	S1
<i>Pleurobema cordatum</i>	Ohio Pigtoe	✓	✓		SSC	G3	S2
<i>Pleurobema pyramidatum</i>	Pyramid Pigtoe	✓	✓		SE	G2	S1
<i>Potamilus capax</i>	Fat Pocketbook	✓	✓	LE	SE	G1	S1
<i>Ptychobranchus fasciolaris</i>	Kidneyshell		✓		SSC	G4G5	S2
<i>Quadrula cylindrica cylindrica</i>	Rabbitsfoot	✓	✓		SE	G3T3	S1
<i>Simpsonaias ambigua</i>	Salamander Mussel		✓		SSC	G3	S2
Insect: Ephemeroptera (Mayflies)							
<i>Homoeoneuria ammophila</i>	A Sand-filtering Mayfly	✓			SE	G4	S1
<i>Pseudiron centralis</i>	A Mayfly	✓	✓		SE	G5	S1
Insect: Lepidoptera (Butterflies & Moths)							
<i>Euphyes dukesi</i>	Scarce Swamp Skipper	✓			ST	G3	S1S2
Fish							
<i>Ammocrypta clara</i>	Western Sand Darter		✓		SSC	G3	S3
<i>Ammocrypta pellucida</i>	Eastern Sand Darter		✓			G3	S2
<i>Cycleptus elongatus</i>	Blue Sucker	✓	✓		G3	G4	S2
<i>Etheostoma camurum</i>	Bluebreast Darter		✓			G4	S1

Table 3: Endangered, Threatened, or Rare Fauna in Gibson and Pike Counties, Indiana, as of 2005

Scientific Name	Common Name	Gibson County	Pike County	FED	STATE	GRANK	SRANK
<i>Etheostoma histrio</i>	Harlequin Darter	✓	✓			G5	S1
<i>Etheostoma squamiceps</i>	Spottail Darter	✓			G4	G5	S1
<i>Etheostoma tippecanoe</i>	Tippecanoe Darter		✓		SSC	G3G4	S1
Amphibian							
<i>Rana areolata circulose</i>	Northern Crawfish Frog		✓		SE	G4T4	S2
Reptile							
<i>Kinosternon subrubrum</i>	Eastern Mud Turtle	✓			SE	G5	S2
<i>Nerodia erythrogaster neglecta</i>	Copperbelly Water Snake	✓	✓	PS:LT	SE	G5T2T3	S2
<i>Opheodrys aestivus</i>	Rough Green Snake	✓			SSC	G5	S3
<i>Pseudemys concinna hieroglyphica</i>	Hieroglyphic River Cooter	✓			SE	G5T4	S1
Bird							
<i>Ammodramus henslowii</i>	Henslow's Sparrow	✓			SE	G4	S3B
<i>Ardea herodias</i>	Great Blue Heron	✓	✓			G5	S4B
<i>Asio flammeus</i>	Short-eared Owl		✓		SE	G5	S2
<i>Botaurus lentiginosus</i>	American Bittern	✓			SE	G4	S2B
<i>Buteo lineatus</i>	Red-shouldered Hawk	✓	✓		SSC	G5	S3
<i>Buteo platypterus</i>	Broad-winged Hawk		✓	No Status	SSC	G5	S3B
<i>Circus cyaneus</i>	Northern Harrier	✓	✓		SE	G5	S2
<i>Cistothorus platensis</i>	Sedge Wren	✓			SE	G5	S3B
<i>Falco peregrinus</i>	Peregrine Falcon	✓		No Status	SE	G4	S2B
<i>Haliaeetus leucocephalus</i>	Bald Eagle	✓		Delisted 2007	SE	G5	S2
<i>Ixobrychus exilis</i>	Least Bittern	✓			SE	G5	S3B
<i>Lanius ludovicianus</i>	Loggerhead Shrike		✓	No Status	SE	G4	S3B
<i>Nyctanassa violacea</i>	Yellow-crowned Night-heron	✓	✓		SE	G5	S2B
<i>Nycticorax nycticorax</i>	Black-crowned Night-heron		✓		SE G5 S1B	G5	S1B
<i>Phalaropus tricolor</i>	Wilson's Phalarope	✓			SX	G5	SHB
<i>Rallus elegans</i>	King Rail	✓	✓		SE	G4	S1B
<i>Sterna antillarum athalassos</i>	Interior Least Tern		✓	LE	SE	G4T2Q	S1B
<i>Thryomanes bewickii</i>	Bewick's Wren	✓				G5	S1B
<i>Tyto alba</i>	Barn Owl	✓	✓		SE	G5	S2
Mammal							
<i>Lutra canadensis</i>	Northern River Otter	✓	✓			G5	S2
<i>Lynx rufus</i>	Bobcat		✓	No Status		G5	S1
<i>Mustela nivalis</i>	Least Weasel	✓			SSC	G5	S2?

Table 3: Endangered, Threatened, or Rare Fauna in Gibson and Pike Counties, Indiana, as of 2005

Scientific Name	Common Name	Gibson County	Pike County	FED	STATE	GRANK	SRANK
<i>Myotis sodalis</i>	Indiana Bat or Social Myotis	✓	✓	LE	SE	G2	S1
<i>Sylvilagus aquaticus</i>	Swamp Rabbit	✓			SE	G5	S1
<i>Taxidea taxus</i>	American Badger	✓	✓			G5	S2

Sources: IDNP, 2005a and IDNP, 2005b
 FED: LE = Endangered; LT = Threatened; C = candidate; PDL = proposed for delisting
 STATE: SE = state endangered; ST = state threatened; SR = state rare; SSC = state species of special concern; SX = state extirpated; SG = state significant; WL = watch list
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 SRANK: State Heritage Rank: S1 = critically imperiled in state; S2 = imperiled in state; S3 = rare or uncommon in state; G4 = widespread and abundant in state but with long term concern; SG = state significant; SH = historical in state; SX = state extirpated; B = breeding status; S? = unranked; SNR = unranked; SNA = nonbreeding status unranked

dispersal during flood events, bottomland agricultural fields are particularly prone to infestation, making it common to see this plant in those areas.

Other plants classified as noxious weeds in the Refuge & MA include Canadian thistle, bur cucumber and shatter cane. Although locally significant, these species do not represent as pervasive a problem as Johnson grass.

Aquatic resources at Patoka River National Wildlife Refuge are also at risk from non-native invasive animals, such as zebra mussels, common carp, grass carp, bighead carp, and silver carp. Although most of these species have not been documented in the Patoka River, all have been documented in the Ohio and Wabash Rivers, many have been documented in other tributaries to the Wabash River in Indiana, and all have the potential to expand their range into the Patoka River. These nuisance aquatic animals may substantially alter habitats and food web dynamics that native aquatic communities are dependant upon for sustainability.

Common carp are established within waters of the Patoka River National Wildlife Refuge and are troublesome in rivers, streams, and wetlands due to their ability to alter aquatic habitats by uprooting vegetation, reducing water transparency, and reducing aquatic plant growth. Grass carp, which are established in the Ohio and Wabash Rivers, consume aquatic vegetation and also have the potential to alter aquatic habitats and their native communities. Bighead and silver carps are established in the Ohio and Wabash Rivers and are rapidly dispersing throughout many interior smaller order streams throughout the Midwest. It is likely that these fish

will disperse into the Patoka River. Bighead and silver carp feed on plankton and have the potential to alter aquatic food webs. Zebra mussels primarily consume phytoplankton, but also filter other suspended materials from the water column and can substantially alter ecosystems that they invade. Zebra mussels have extirpated native unionid mussels after colonizing new waters.

Table 4 lists key invasive species at Patoka River NWR & MA.

Contaminants

The principal contaminants present in the Patoka River area are those associated with surface coal mining and crude oil extraction. Present-day surface mining (post-1977 and SMCRA) is tightly regulated and closely monitored to assure water quality in downstream areas is not substantially impacted by mining refuse or erosion-related sediments. Although occasional accidental discharges of deleterious materials such as slurry from wash plants or equipment-related petroleum products adversely affect aquatic resources in portions of the watershed, for the most part current surface mining contributes little contamination to the Patoka River.

Before SMCRA, however, coal mining, both underground and surface, produced coal refuse piles and slurry ponds containing waste material such as pyrite, shale and clay, which were separated from the usable coal during cleaning operations. In Pike County, at the time of the Refuge's establishment in the early 1990s, there were at least 186 acres of refuse piles, 129 acres of slurry ponds, and 3,113 acres of mined land with less than 75 percent vege-

Table 4: Invasive Plants and Animals at Patoka NWR/MA

Species Name	Summary
Common Carp	Originating in Asia, common carp were introduced to North America in 1877, first in Maryland and subsequently throughout the United States. They spread rapidly and became naturalized in all waters into which they were introduced. They are adapted to relatively low-oxygen, polluted, turbid waters. Due to their habit of grubbing through bottom sediments for food and alteration of their environment, they destroy, uproot and disturb submerged vegetation, causing serious damage to native duck and fish populations.
Phragmites or Common Reed Grass	<i>Phragmites</i> or common reed is a widely distributed, highly aggressive wetland plant whose origin is unclear, although both native and non-native genotypes or lineages have been documented. It can grow up to 6 meters high in dense stands and is long-lived. <i>Phragmites</i> is capable of reproduction by seeds, but primarily does so asexually by means of rhizomes.
Johnson Grass	Originally native to the Mediterranean, this tall, coarse grass with stout rhizomes now occurs in all warm-temperate regions of the world. Johnson grass invades riverbanks and disturbed sites crowding out native species and slowing succession. Rhizome cuttings commonly form new plants, making it very difficult to eradicate. It spreads rapidly and is not affected by many of the agricultural herbicides.
Moneywort or Creeping Jenny	Originally from Europe, this attractive but weedy herb, a member of the Primrose family, has escaped from lawns and gardens and now occurs in many states in the East and West. Moneywort is reported from many counties in Indiana, where it can be found growing in a variety of different habitat types. Preferring moist, rich, shaded soils, it flourishes best and poses the biggest threat in wetter areas such as wet meadows, swamps, floodplain forests, stream banks, bottoms, ditches, roadsides and along the banks of small water bodies.
Japanese Knotweed	Introduced from Asia in the late 1800s as an ornamental and for erosion control, this weed can tolerate a variety of adverse conditions, including deep shade, high temperatures, high salinity and drought. Knotweed is commonly found near water sources, such as streams and rivers, in low-lying areas, waste places and utility rights-of-way and around old home sites. It spreads quickly to form dense thickets that exclude native vegetation and greatly alter natural ecosystems. Japanese knotweed poses a significant threat to riparian areas, where it can survive severe floods and rapidly colonize scoured shores and islands. Once established, populations are extremely persistent.
Reed Canary Grass	This grass is native to lowland areas of the Midwest and has escaped from cultivation in other regions. Various strains of reed canary grass are found throughout the world except Antarctica and Greenland. It is a major threat to marshes and natural wetlands because its hardiness, aggressive nature, and rapid growth allow it to displace native wetland plant species. This species occurs in wetlands, including marshes, wet prairies, wet meadows, fens, stream banks, and swales. It has been planted widely for forage and for erosion control.
Autumn Olive	This deciduous shrub is native to China and Japan and can range from 3 to 20 feet in height. It is easily recognized by the silvery, dotted underside of the leaves. Small, yellowish flowers or red, juicy fruits are abundant and occur on clusters near the stems. Autumn olive invades old fields, woodland edges, and other disturbed areas. It can form a dense shrub layer which displaces native species and closes open areas. Since its introduction in 1830, it has been widely planted for wildlife habitat, mine reclamation, and shelterbelts.

Table 4: Invasive Plants and Animals at Patoka NWR/MA (Continued)

Species Name	Summary
Japanese Honeysuckle	This species is native to eastern Asia and was first introduced into America in 1806 at Long Island, NY. It is an evergreen to semi-evergreen vine that can be found either trailing or climbing to heights of over 80 feet. It has opposite, oval shaped leaves that are 1 to 2.5 inches long and showy, fragrant, tubular flowers that are whitish-pink to yellow in color. Japanese honeysuckle invades a variety of habitats, including forest floors and canopies, roadsides, wetlands, and disturbed areas. It can girdle small saplings by twining around them and can form dense mats in the canopies of trees, shading everything below. Japanese honeysuckle has been planted widely throughout the United States as an ornamental, for erosion control, and for wildlife habitat.
Bush Honeysuckle	The four species of bush honeysuckle that cause most invasive problems (Amur, Morrow's, Tartarian, and Belle) are all referred to as "bush honeysuckle." Native to Asia and western Europe, these shrubs were introduced to North America in the 1700s and 1800s and are frequently used for landscaping and to improve wildlife habitats; they have become naturalized in many areas of the Northeast and Midwest. The bush honeysuckles are tolerant of a variety of edaphic (soil) and environmental conditions. Typical habitats include disturbed successional communities, wetlands, prairie, woodland edges, and partially closed forests.

tation cover (haul roads, railroad grades, etc.) (Allen et al., 1978). Most of these areas were located off the refuge but contributing to runoff in the watershed.

Surface mining also created pyrite-laced cast overburden ridges which act as unconsolidated aquifers easily transporting water through the spoils. Pyrite is the most common sulfide mineral, and its oxidation is one of the most acidic of all weathering actions. In the presence of oxygen and water, sulfuric acid is formed, and results in what is commonly called acid mine drainage (Kolankiewicz, 1982). This runoff water contains high concentrations of acid, calcium, magnesium, iron, aluminum, manganese, sulfate and coal fines, and contributes to the degradation of many of the area's streams and lakes. In some instances, such as Augusta Lake on Sugar Ridge Fish and Wildlife Area 4, acid concentrations are so high that most aquatic organisms, including fish, cannot survive. Although little of this land is within the Refuge, drainage from off-site adversely impacts aquatic resources in several tributaries to the Patoka River as well as the river itself. Mill Creek, Stone Coe Creek, Barren Creek and the South Fork Patoka River have carried heavy loads of acidic water into the Patoka, particularly following heavy rains.

The Abandoned Mine Land Reclamation program, funded by a tax on current coal production, has been active in the watershed starting in the late 1980's remediating barren, acid-producing spoil and refuse sites. Initial efforts of this reclamation pro-

gram focused on revegetating numerous barren sites, de-watering low-pH lakes and eliminating safety hazards including steep highwalls. Efforts to control acid mine drainage seeps and to minimize downstream flowage to mingle with higher quality fresh waters, increased as a result of the Appalachian Clean Stream Initiative began in 1994. This special program made water quality improvement to enhance the general welfare of local communities an equal priority with safety considerations for the Abandoned Mine Land Program. Since then, much headway has been made in reducing the volume of acid mine drainage. Water quality studies completed by the Service in 1992 indicated that acidity levels in affected waterways were as high then as they were in a comprehensive study completed in 1968 (Corbett, 1969). Where there were few if any fish or invertebrates in the South Fork Patoka River in 1992, there are now sufficient quantities to attract nesting Bald Eagles and sport fishermen.

Oil production operations in the area have also affected water quality in the Patoka River and its tributaries. Inadequate storage tank containment, open pits of oil, and irresponsible spills or overflows of crude oil from some of the 82 operating wells/storage tanks within or adjacent to the Refuge have contaminated surface waters and adversely impacted the area's plant and wildlife resources in the past. While not a continuous phenomenon, spills of one sort or another have occurred regularly enough to be of concern. For example, during 1992, at least three spill events were documented to have

directly impacted the South Fork Patoka River. The last spill involving approximately 4,000 gallons of crude oil resulted when a storage tank was struck by lightning. Inadequate earthen berms failed to contain the spill which flowed into the South Fork and had to be contained and removed with soaker booms and pumps. Abandoned orphan oil wells resulting from bankrupt or dead operators remain in place until the Indiana Division of Oil and Gas has funds to clean them up. Cooperative efforts and cost sharing between the refuge and the Division of Oil and Gas have resulted in the removal of at least 10 abandoned oil wells within the refuge area. Presently, there are no abandoned oil wells within the refuge acquisition area.

An additional, and perhaps more insidious, oil production-related pollutant is the salt water often discharged at oil wells. A 1969 study found that at some sites on the Patoka, chlorides from oil well brine waste was a greater threat to water quality than acid mine drainage (Corbett, 1969). Salt water not only impairs water quality, but also sterilizes upland spill areas to the point of eliminating plant life. Stricter regulations, improved enforcement efforts and the increased use of salt water injection wells have reduced the magnitude of this problem in the last decade. Occasional accidents, and, in some cases, deliberate discharges continue to pose the threat of contamination in the watershed.

Being located in a watershed with a substantial amount of agriculture, the Refuge & MA's resources may be exposed to an assortment of agriculture-related contaminants. Erosion of farmland soils as well as direct rainfall runoff can introduce fertilizers and a variety of pesticides, mainly organochlorine or

organophosphate products, into the bottomland ecosystem. These substances may be toxic both through direct exposure as well as through bioaccumulation in the food chain with secondary effects on reproduction and behavior. In a 1989 Indiana Department of Environmental Management (IDEM) monitoring study, tissue analysis of fish from Patoka River confirmed the presence of numerous metals, including mercury, and several pesticides, most notably chlordane, nonachlor and dieldrin. Similar findings have been documented in other bottomland systems in this region of the country (U.S. Fish and Wildlife Service, 1992).

According to files maintained by the IDEM Office of Solid and Hazardous Waste, there are 41 sites in Pike and Gibson counties that are identified under the Comprehensive Environmental Response and Compensation Liability Inventory System (CERCLIS, 1991). Of the total sites, 10 are located within or close to Patoka River NWR & MA. Nine of these were placed on the CERCLIS list because Surface Impoundment Assessments (SIA) had been completed for these sites. These small surface impoundments were created and used to store and dispose of brine and oil well drilling wastes before this practice was banned. The conclusion of "no further remedial action planned" was made regarding these sites. The remaining site on the CERCLIS list is a railroad tie treatment plant located southwest of Winslow. The site was reviewed under authority of the Resource Conservation and Recovery Act (RCRA) by IDEM and EPA for past improper waste disposal in surface impoundments. Subsequent upgrading of the facility corrected those problems.

Interstate 69

In 1999 the Indiana Department of Transportation (INDOT) initiated an Environmental Impact Statement (USDOT and INDOT 2003) for the Federal Highway Administration (FHWA) that considered a range of possible highway corridors to link Evansville and Indianapolis, including one that would cross an area within the Refuge acquisition boundary. In March 2004, after extensive public involvement and analysis, the FHWA issued a Record of Decision (USDOT 2004) that selected an alternative that included the Refuge crossing (Figure 8).

After the Record of Decision (ROD) was issued, INDOT began secondary analyses for each of six sections of the highway corridor. These secondary

Refuge entrance sign, Patoka River NWR & MA. Photo credit: USFWS

Figure 8: Projected Route of Interstate 69

analyses, which include additional public involvement, help determine the final alignment of the 350-foot wide highway within the 2,000-foot wide approved corridor. The impacts of the highway crossing on Refuge resources will be considered in the secondary analysis. Each of the six secondary analyses will culminate with a Record of Decision by the FHWA. Once the ROD is issued for a section, final design, land acquisition, and construction can commence. The Refuge Manager continues to work closely with INDOT officials concerning the design and placement of the highway. Although the highway would cross an area within the Refuge acquisition boundary, none of the lands within the highway corridor are presently part of the Refuge and there are no plans to acquire lands within the highway corridor.

As part of a concerted effort to minimize impacts to the fish and wildlife resources of the Refuge, the highway planners agreed to bridge the entire floodplain crossing of the Patoka River NWR & MA. The bridge, approximately one mile long, will be as high as 30 feet above the floodplain floor to allow safe wildlife passage and minimize construction and placement of fill in this wetland environment. This

would greatly reduce the hydrologic impacts in the watershed by minimizing upstream flooding and, thereby, reducing the need for additional mitigation action.

Administrative Facilities

The Refuge utilizes GSA leased space in Oakland City for its headquarters. The office building was newly constructed in 1993. Renovation and expansion occurred in 2003 when the GSA lease was renewed. Currently the office has nine rooms (offices and storage) which encompass approximately 1,900 square feet. The Refuge will continue to pursue opportunities to acquire facilities and move out of leased space.

Through the same GSA lease, the Refuge has access to a 30-foot by 50-foot heated pole barn (1,500 square feet) that is utilized for equipment storage and minor maintenance needs.

Through its land acquisition program, the Refuge owns another pole barn which measures approximately 50 feet by 100 feet (5,000 square feet), and is used to store supplies and equipment.

Archeological and Cultural Values

Responding to the requirement that these plans include “the archaeological and cultural values of the planning unit,” the Service contracted for a cultural resources overview and management direction study. This short section of the CCP derives in part from this source as well as others.

The earliest generally accepted human culture in North America is termed PaleoIndian, commencing approximately 13,000 years ago in Indiana. Evidence of these people is relatively extensive in southern Indiana, and at least 16 PaleoIndian sites are reported in Gibson County. The Refuge, however, is outside the known geological concentrations of PaleoIndian sites.

The next cultural group is termed Archaic, and its origins dated to 10,000 years ago. The Archaic culture is quite evident in southern Indiana. The warm and dry period known as the Hypsithermal (or Altithermal) occurred during the Middle Archaic period when many sources of water disappeared. Archaic period sites occur on the Refuge.

Pottery, constructed burial and other mounds, gardening, and eventually the bow and arrow are among the distinguishing characteristics of the Woodland period that commenced about 2,600 years ago. A variety of sites from the Woodland period are found and more are anticipated within the Refuge.

The Middle Mississippian culture commenced about 950 years ago and continued into the early historic people. Sites from this period are found within the Refuge boundaries and more, especially in buried contexts, can be anticipated in the Refuge area.

The connection between prehistoric cultures and recognized Indian tribes in southwest Indiana has not been established. Treaties at Vincennes included the Shawnee, Potawatomi, Eel River, Kickapoo, Kaskaskia (later Peoria), Delaware, Piankashaw, Wea, and Miami; only the last four plus the Fox having an apparent connection to the Refuge area.

The French moved into southern Indiana, especially Vincennes, in the late 17th century. They were replaced by the British in 1763. In turn, British claims gave way to the United States whose possession was confirmed in 1794. The Refuge area was settled by farmers from the upland South (Appalachia) whose cultural patterns continue into the 21st century; also by Germans and Irish who came to build the Wabash and Erie Canal and stayed as farmers; and by southern and eastern Europeans and African-Americans.

Early transportation routes included the mid-19th century Wabash and Erie Canal.

Following the Civil War, coal mining became the major industry in the area and continues into the 21st century. At least 10 per cent of Pike County has been strip mined.

Current Management

Habitat Management

Forested Wetlands (Bottomland Forest)

Wetland management at Patoka River NWR & MA consists primarily of restoring forested wetlands, that is bottomland forests (Figure 10 and Figure 9). In 2007, the total acreage of forested wetlands on the Refuge & MA was 8,647 acres, of which 3,056 acres were owned by the Service. With the aim of maximizing species diversity within the restored wetland, we are trying to reintroduce the most component of the forested wetland communities, plant-

Bald Eagle pair, Patoka River NWR & MA. Photo credit: USFWS

ing seedlings at 500 per acre. Trees are planted with a mechanical planter, in rows, and the priority sites are those that will complement our objective to restore a forested border along the river.

We are also engaged in restoration on prior converted wetland, areas that were in agricultural production when they are purchased. Typically we obtain a field that is planted right up to the edge of the River. We then plant seedlings a couple of hundred feet wide parallel to the River. The management of these, once planted, is passive. We just “walk away,” allow competition to encroach, and permit these sites to remain brushy and thick. It does not affect seedling survival, but the thick habitat benefits wildlife. Patoka River wetlands are flooded annually naturally.

Under current management, over the long term (100-200 years), we would like to achieve approximately 12,000 to 13,000 acres of bottomland hardwood stands with a mosaic of age and structural classes distributed across a narrow elevation gradient. Lower elevations would be dominated by black willow, sweetgum, silver maple, and river birch. Pin oak, Shumard oak, swamp chestnut oak, swamp white oak, red maple, green ash, sycamore, and cottonwood would dominate mid-elevations, while upper elevations would be dominated by cherry bark oak, other oaks, hickory, and pecan. Over the coming 10-15 years, the Refuge will maintain existing bottomland forest area of 3,056 acres. We will

Figure 9: Current Landcover (West), Patoka River NWR & MA

Figure 10: Current Landcover (East), Patoka River NWR & MA

also reforest to bottomland hardwoods future land acquisitions that have suitable soils and that are outside of areas managed as non-forested habitat.

Emergent Wetlands

In 2006, the total acreage of emergent wetlands on the Refuge & MA was 775 acres, of which 465 acres were owned by the Service. Our current objective is to maintain presently owned emergent wetlands (465 acres) in a mixture of vegetation such as cattail, bulrush, sedges, spatterdock, water lily and smartweeds. We will allow the amount and species composition of emergent wetlands across the remainder of the Refuge (both currently owned and future acquisitions) to fluctuate through natural succession.

Lakes and Ponds

In 2006, the total acreage of lakes and ponds on the Refuge & MA was 885 acres, of which 345 acres were owned by the Service. Our objective over the medium term future is to maintain the number and total surface area of lakes and ponds at or above the current amount.

Patoka River, Oxbows, and Patoka Tributaries

In 2006, the total acreage of the Patoka River, its oxbows and tributaries on the Refuge & MA was 534 acres, of which 200 acres were owned by the Service.

Water Quality

The Refuge's current objective is to improve water quality within the Patoka River and its tributaries to move towards compliance with Indiana Department of Environmental Management standards. The long-term goal is removal of the streams from the list of impaired waters.

Moist Soil Units

In 2006, the total area of moist soil units on the Refuge & MA was 265 acres, all owned by the Service.

The Refuge has restored nine small wetlands covering approximately 19 acres that were built between 2000 and 2006. Two were built with low earthen dikes with water control structures, providing the capability to manipulate water levels. These units are managed as moist soil, seasonal wetlands. One depends on flooding for a water source and the other is on a small drainage swale. Water is stored in shallow pools to encourage waterfowl, shorebird and marsh/waterbird use. Seven other wetlands are referred to as macrotopography wetlands which are

shallow scrapes no deeper than two feet in floodplain cropfield locations dependent on annual flooding for water supply. Bottomland hardwood trees have been planted all around these wetlands. They are set up for passive management to resemble old river oxbows.

At Cane Ridge we have four moist soil units that total 193 acres. These are managed to achieve shallow fall flooding, and are slowly drained in the spring. They are intended to benefit waterfowl and shorebirds and are allowed to revegetate and grow in the summer with moist soil plants. The four units can be managed independently with occasional needs of manipulating the vegetation to ensure the control of woody intrusion. The units are fed from the Least Tern unit and they are all gravity flow, so there are no costs associated with this low-intensity type of management. The Refuge maintains 6 miles of dikes at Cane Ridge.

At Dillin Bottoms, Ducks Unlimited designed and supervised construction of two moist soil units covering 62 acres. These units are designed to be flooded by reverse flow flap gates during high water or with a permanent station auger pump operated by a portable diesel engine and PTO shaft.

Over the medium term future, we intend to maintain existing moist soil areas (265 acres) and convert up to a total of 700 acres of bottomland farmland to moist soil management that provides a diversity of native herbaceous plant foods such as wild millet (*Echinochloa* spp.), panic grass (*Panicum* spp.), sedges (*Cyperus* spp. and *Carex* spp.), and beggarticks (*Bidens* spp.).

Grasslands

In cooperation with Quail Unlimited we have planted 25 acres of warm season grasses on the Refuge using commercially available seeds. At the present time, maintenance is limited to mowing or mechanical disturbance. The seed mix is Indian grass, big blue, little blue, side oats, and switch grass.

Upland Forests

In 2006, the total acreage of the upland forest on the Refuge & MA was 2,704 acres, of which 183 acres were owned by the Service. We currently manage 40 acres of upland forest, which was reseeded cropland. The remainder of the upland forest is not actively managed. Over the long term (100-200 years), we hope to achieve a mosaic of hardwood stands of different age and structural classes distributed on upland areas. These forests

*Wabash and Erie Canal (left), Patoka River NWR & MA.
Photo credit: USFWS*

would be dominated by white oaks, black oaks, hickory, and blackgum on drier sites, and by red oaks, yellow poplar, beech, sugar maple, walnut, hickory, and cherry on wetter sites. In the coming years, we intend to maintain upland forest on presently owned areas (183 acres) and for future acquisitions maintain existing upland forest and restore upland forest on non-forested upland sites with suitable soils.

Cropland

In 2006, the total acreage of bottomland farmland on the Refuge & MA was 4,507 acres, of which 1,059 acres were owned by the Service. For the most part, land acquired as cropland is being maintained as cropland until we have the money and ability to convert them to moist soil units or bottomland forests. The continued farming is being done by the original farmer, or a tenant farmer, through an annual cooperative farming agreement. One-quarter of the crop is left standing in the field as our share. Frequently these fields are not planted at all due to flooding. In those cases, the farmer will plant a mix of wildlife friendly plants (millet, buckwheat, milo) for waterfowl on our fourth of the acreage. Over time, we intend to convert bottomland cropland areas into bottomland forest and moist soil units.

Upland Openings

In 2006, the total acreage of upland openings on the Refuge & MA was 2,139 acres, of which 98 acres were owned by the Service. Over the coming 10-15 years, our objective is to maintain existing owned upland openings and those existing upland openings on future acquisitions of reclaimed minelands.

Invasive Plant Species

Our aim now and over the medium-term future (10-15 years) is to slow the spread of invasive plant species (of present interest are Japanese honeysuckle, reed canary grass, autumn olive, Johnson grass, and Japanese knotweed) through monitoring and control measures.

Interior Least Tern Nesting Habitat

The Refuge provides six acres of nesting habitat for Interior Least Terns at Cane Ridge Wildlife Management Area. This area is kept free of vegetation and is fenced to prevent predation by mammals.

Private Lands and Watershed Management

Patoka River staff work with surrounding private landowners on conservation projects that benefit us jointly. Over the coming 10-15 years, our aim is to increase wildlife habitat and reduce sedimentation on 150 acres of private lands within the Patoka River and surrounding watersheds.

Farm Services Administration Conservation Easements

The Farm Services Agency, formerly known as the Farm Services Administration, is an agency within the U. S. Department of Agriculture. FSA makes loans to farmers and ranchers temporarily unable to obtain credit from commercial lending institutions. FSA sometimes obtains title to real property when a borrower defaults on a loan secured by the property. FSA holds such properties in inventory until sale or other disposal.

The Service is involved in the inventory disposal program because some FSA inventory properties contain or support significant fish and wildlife resources or have healthy restorable wetlands or other unique habitats. Some qualifying properties are transferred to the Service and become part of the National Wildlife Refuge System. Others are sold, with restrictions known as conservation easements that protect wetlands or other habitats. In most cases, the Service is responsible for the management and administration of properties with conservation easements.

Since the late 1980s and early 1990s, the Refuge has managed habitat on six Farm Services Administration Conservation Easements in five different Indiana counties:

- 90 acres with 24.5 acres of riparian habitat in Vermillion County;
- 40 acres of forested wetland in Gibson County;

- 35.8 acres of forested wetland and riparian area in Vermillion County;
- 55 acres of riparian and forested wetlands in Sullivan County;
- 14 acres of riparian habitat in Fountain County;
- 365 acres with eight easements in Martin County.

Land Acquisition

We continue to acquire lands from willing sellers within the acquisition boundary as a means of managing and conserving a diversity of habitats.

Wildlife Management

Threatened and Endangered Species

At present, the only threatened and endangered species on the Refuge that is actively managed is the Interior Least Tern. As noted elsewhere, at the Cane Ridge Wildlife Management Area 24 miles west of the Refuge, the Service is providing a protected nesting area, where a bare sandy substrate on two 3-acre islands is maintained for nesting and fencing provides some protection from disturbance). While other T & E species like the Indiana bat occur at Patoka River NWR & MA, no active measures are underway at this time to conserve their populations. In the near term we intend to implement a monitoring program to track abundance, population trends, and/or habitat associations of listed species.

Migratory and Resident Birds

Currently, there is active management of 62-acres in Dillin Bottoms for migratory and resident birds at Patoka River NWR & MA and 193 acres of moist soil management units at Cane Ridge WMA. Over the next 5 years, we intend to implement a monitoring program to track abundance, population trends, and/or habitat associations of selected migratory and resident bird species or groups of species (e.g. waterfowl, migrating land birds, shorebirds, marsh birds).

Native Resident Wildlife

Currently, there is no active management of native resident wildlife at Patoka River NWR & MA. It is our intent to implement a monitoring program to track abundance, population trends, and/or habitat associations of selected native resident wildlife species in the coming years.

Fish and Other Aquatic Species

At present, Patoka River NWR & MA does not have an active fisheries management program. Management's aim over the next decade and a half is to create or maintain diverse, self-sustaining fisheries in Refuge lakes, ponds, and streams.

Interior Least Terns

We actively manage a nesting population of Interior Least Terns at Cane Ridge Wildlife Management Area. Our objective is to support 100 nesting adult terns producing 75 fledglings annually.

Pest Management

On occasion it is necessary for us to remove beaver dams when their activities impact a neighbor's property or structures.

Fish and Wildlife Monitoring

Except for waterfowl, at present, Patoka River management conducts no standardized monitoring or surveying that results in weekly entries into a database. Instead, we make opportunistic observations. For waterfowl, there are weekly surveys at the Cane Ridge Area. When the Refuge grounds are flooded, we make a circuit to those areas that are accessible to conduct waterfowl counts.

River otter were released on the Refuge in 1996. In the winter when there is snow, the Refuge wildlife biologist walks and drives transects on the Refuge looking for otter sign and thus gauge trends in their activity. Activity that is decreasing, constant, or increasing from one year to the next is a good indication of whether the area's otter population is decreasing, stable, or increasing.

*South Fork birding trail, Patoka River NWR & MA.
Photo credit: USFWS*

Visitor Services

As a relatively new refuge with a small staff and an initial priority on land acquisition, habitat restoration, and environmental remediation (reduction of contaminants), Patoka River has had a smaller visitor services program than other more established national wildlife refuges. Nevertheless, each of the “Big Six” public uses emphasized in the National Wildlife Refuge System Improvement Act of 1997 – hunting, fishing, wildlife observation, wildlife photography, environmental education and interpretation – those uses traditionally supported and encouraged on the National Wildlife Refuge System, occurs at Patoka River National Wildlife Refuge and Management Area.

Visitation has grown since the Refuge’s establishment in 1994, increasing to 21,221 visits in 2005. Visitor services have increased commensurately. There are multiple access points to the Refuge and with approximately 75 percent of the land within the Refuge acquisition boundary not yet acquired, Refuge lands are intermingled with private holdings. This intermingling requires clear signing and visitor information. Refuge management plans on placing new entrance signs and kiosks at existing boat ramps, Snakey Point, and along Highway 57 over the next 5 years.

There is not currently a visitor center on the Refuge and there are no plans for one in the foreseeable future. The Refuge headquarters on SR 64 (West Morton) in Oakland City is an administrative site that offers visitor information.

Hunting

There were 8,873 hunting visits (waterfowl 4,093, other migratory birds 466, upland game 1,399, big game 2,915) in 2006. This use is likely to increase over the life of the CCP because of the impending closure of mine company lands and the loss of public hunting opportunities on lands elsewhere in the area. Hunting on the Refuge is in accordance with applicable State regulations.

Migratory birds hunted at Patoka River NWR include ducks, geese, coots, Sora Rails, Common Snipes, Woodcocks, and Mourning Doves. Game birds sought by hunters on the Refuge include Quail and Wild Turkey. Small game at Patoka River NWR & MA includes cottontail rabbits, gray and fox squirrels. Furbearers pursued include red and gray fox, coyote, raccoon, and opossum. The only big game hunting on the Refuge is for white-tailed deer.

Shotgun hunters using scattershot may possess and use only approved non-toxic shot. Use or possession of lead shot is prohibited while hunting all species except Wild Turkey on the Refuge. Firearms, archery equipment and crossbows meeting State requirements are permitted on the Refuge only during the designated hunting season.

All motor vehicles must remain on maintained roads and be parked so as not to interfere with other traffic. Off-road vehicles are not permitted on Refuge lands. Hunters with disabilities must possess the required State permit; State regulations and access conditions apply.

Dogs are allowed for hunting according to State regulations during designated seasons only. Dog training or running in the off-season is prohibited.

For waterfowl hunting, pits or permanent blinds may not be constructed on the Refuge. Only portable blinds or structures constructed of native plant materials are permitted and blinds must be removed or dismantled at the end of each day’s hunt. Decoys must also be removed at the end of each day’s hunt. Likewise, permanent turkey or deer stands may not be erected or used on the Refuge. Portable tree stands may be used for turkey or deer hunting following the same guidelines established for State-owned lands.

Fishing

There were 7,346 fishing visits to Patoka River NWR in 2006. The Refuge provides both bank and boat fishing opportunities on the Patoka River, its oxbows and tributaries, and at Snakey Point Marsh, in accordance with State seasons and regulations and the Refuge fishing plan. Access to some reaches of the river is limited. Refuge staff works cooperatively with the Indiana Department of Natural Resources on fisheries management.

Of the more popular game fish, channel and flat-head catfish probably provide the best sport fishing opportunities in the section of the river running through the Refuge. Largemouth bass, bluegill and crappie, offer outstanding fishing opportunities at Snakey Point Marsh.

As a result of channel clearing along the Patoka River, fish habitat structure is poor; there is little in-stream cover, that is, few log jams, brush piles and root-wads. Thus, those species requiring in-stream cover (largemouth bass, bluegill, crappie) are limited by available habitat. Riffle/pool habitat is also scarce. Species diversity in the channelized portion of the river (downstream from Winslow) is lower

Figure 11: Current Visitor Facilities, Patoka River NWR & MA

than in the natural, meandering channel. Fish of interest to recreational anglers, including buffalo, drum, channel and flathead catfish and spotted bass, are more abundant in the unchannelized section of the Patoka River.

Wildlife Observation and Photography

There were 6,063 wildlife observation visits and 106 photography visits in 2006. Photography and observation visits are projected to increase to 500 in 2007 because of the new observation platform at Cane Ridge. The Refuge provides opportunities for wildlife observation and photography throughout, but Cane Ridge and Snakey Point in particular have facilities such as trails, docks or observation platforms that facilitate these two activities. The Refuge intends to enhance opportunities for observation and photography by building an observation platform at Cane Ridge and trails at Snakey Point and South Fork.

Interpretation

The Refuge Manager and Assistant Refuge Manager provide guided tours and programs upon request and maintain a monument on the McClure Tract. In the near term, they plan to provide interpretive elements in proposed kiosks and other selected sites as well as increase opportunities for interpreted trails, walks, and programs.

Environmental Education

The Refuge Manager and Assistant Refuge Manager provide environmental education upon request typically less than five times annually. In the near future, their intent is to develop capacity to provide Environmental Education materials and programs to teachers and others upon request.

Friends and Volunteers

Volunteers donated 403 hours of their time to the Refuge in 2006. Staff hopes to help convert this enthusiasm into a more formal Friends group in the coming years.

Outreach

Refuge staff speaks to local civic and sportsmen's groups upon request approximately 12-15 times per year. We also provide information and interviews for local news media and outdoors writers as well as distribute news releases 2-3 times annually. In the coming years, we will be exploring how to establish off-site facilities and opportunities.

Archeological and Cultural Values

Cultural resources are important parts 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.

Cultural resources management in the USFWS is the responsibility of the Regional Director and is not delegated for the Section 106 process when historic properties could be affected by Service undertakings, for issuing archeological permits, and for Indian tribal involvement. The Regional Historic Preservation Officer (RHPO) advises the Regional Director about procedures, compliance, and implementation of the several cultural resources laws. The Refuge Manager assists the RHPO by early and timely notification of the RHPO about USFWS undertakings, by protecting archeological sites and historic properties on USFWS managed and administered lands, by monitoring archeological investigations by contractors and permittees, and by reporting violations.

Special Management Areas

There are no designated Special Management Areas on the Refuge.

Wilderness Review

As part of the CCP process, lands within the acquisition boundary of Patoka River National Wildlife Refuge and Management Area were reviewed for wilderness suitability. No lands were considered suitable at this time for Congressional designation as wilderness as defined by the Wilderness Act of 1964. Patoka River NMR/MA does not contain 5,000 contiguous acres of roadless, natural lands. Nor does the Refuge possess any units of sufficient size to make their preservation practicable as wilderness. Refuge lands and waters have been substantially altered by humans, especially by agriculture, river channelization, road-building, and coal mining. As a result of both extensive modification of natural habitats and ongoing manipulation of natural processes, adopting a "hands-off" approach to management at the Refuge would not facilitate the restoration of a pristine or pre-settlement condition, which is the goal of wilderness designation.