Chapter 3: Refuge Resources & Current Management

This chapter provides a detailed description of the Refuge and its resources including its habitat, the species that occur there, how these habitat and species are managed, and the recreational opportunities it offers. The chapter is divided into six major sections: 3.1 Landscape Setting; 3.2 Physical Environment; 3.3 Biological Environment; 3.4 Socioeconomic Environment; 3.5 Archeological, Cultural, and Historical Resources; and 3.6 Current Management and Administration.

Overlooking the Sally Bull Hollow Unit. (Credit: Steve Hensley, 1992)

3.1 Landscape Setting

Ozark Plateau National Wildlife Refuge (NWR) is located in eastern Oklahoma along the southwest edge of the Ozark Plateau and Boston Mountains near the Arkansas, Kansas, and Missouri borders. The Refuge is in a region of karst topography, eroded to form steep hills, incised valleys, and prominent bluffs. Much of the drainage is underground resulting in a number of caves and springs. In addition, the clear rocky bottom streams, ground water aquifers and recharge areas, wetlands, and large stands of oak-hickory and oak-hickory-pine forest support a diverse array of plant and animal life that not only are endemic to the Ozark Plateau, but are sometimes unique to each cave or spring because of their isolation from one another. Ozark Plateau NWR is a prime example of the need to implement Strategic Habitat Conservation on a landscape level in order to achieve the Refuge's purpose(s) of:

- Preventing extinction and aiding in recovery of federally-listed endangered and threatened Ozark cave species;
- Reducing the need for future listing of species of concern in the Ozarks;
- Protecting large continuous stands of Ozark forest essential to interior forest nesting migratory birds; and

- Providing important environmental educational opportunities identifying the need for protecting fish and wildlife and other karst resources of the Ozarks.

Ozark Plateau NWR presently consists of nine management units, totaling 4,093 acres, in four counties in the Ozarks of eastern Oklahoma near the borders of four states (Arkansas, Kansas, Missouri, and Oklahoma) and four Fish and Wildlife Service regions (2, 3, 4, and 6). Political boundaries mean little to the trust fish and wildlife resources Ozark Plateau NWR was established to protect and manage, so it is extremely important that the Refuge operate on a landscape-level across state and regional boundaries (see Chapter 2, Figure 2-2 for a landscape-level map of the area).

3.1.1 Strategic Habitat Conservation and Landscape Conservation Cooperative

Strategic Habitat Conservation (SHC) is a way of thinking and doing business that requires the Service to set biological goals for priority species. It allows for making strategic decisions, and encourages constant reassessment and improvement of actions. These are critical steps in dealing with a range of landscape-scale resource threats such as urban development, invasive species, and water scarcity--all magnified by accelerating climate change.

SHC incorporates five key principles in an ongoing process that changes and evolves:

- Biological Planning (setting targets)
- Conservation Design (developing a plan to meet the goals)
- Conservation Delivery (implementing the plan)
- Monitoring and Adaptive Management (measuring success and improving results)
- Research (increasing our understanding)

To ensure that science entities are strategically placed, the Service and U.S. Geological Survey (USGS) have developed a national geographic framework for implementing SHC at landscape scales. The framework provides a platform upon which the Service can work with partners to connect project- and site-specific efforts to larger biological goals and outcomes across the continent.

The framework serves as a base geography for Landscape Conservation Cooperatives (LCCs), which are management-science partnerships between the Service, other federal agencies, states, tribes, NGOs, universities, and other entities. These partnerships inform and assist integrated resource management actions by addressing climate change and other stressors within and across landscapes. LCCs are fundamental units of planning and science capable of carrying carry out the functional elements of SHC. The framework for a landscape level planning approach is described in Chapter 4: Goal 1.

GCPO
Gulf Coastal Plains & Ozarks
Landscape Conservation Cooperative

http://gcpolcc.org/

Ozark Plateau NWR is located within the Interior Highlands subunit of the Gulf Coast Plain and Ozarks Landscape Conservation Cooperative (GCPOLCC), which will facilitate conservation planning and design across a highly diverse region in southeastern North America that extends for 180 million acres from the mountain tops of the Ozark, Boston and Ouachita ranges, to the pine savanna and prairies of the West and East Coastal Plains, and down into the swamps, bayous and alluvial bottomlands of the Mississippi Alluvial Valley. This area consists mainly of the Lower Mississippi River Valley Joint Venture. The Mississippi River bisects the region. The Ozark Plateau NWR takes an active role in the Ozark Partnership (http://ozarks.cr.usgs.gov/) that more specifically focuses on the Ozarks to help sustain the biologically rich, nationally-significant natural resources of the Ozarks. The Ozark Partnership's aim is to improve effectiveness and efficiency of science and management through the cooperative work of state, tribal, federal and NGOs that conduct natural resource research and management in the Ozarks. It also welcomes private citizens and landowners. Some of the steps being taken include:

- working cooperatively in geographic locations on topics of mutual interest
- sharing research methods and monitoring protocols
- expanding applicability of results
- sharing products, tools, and information

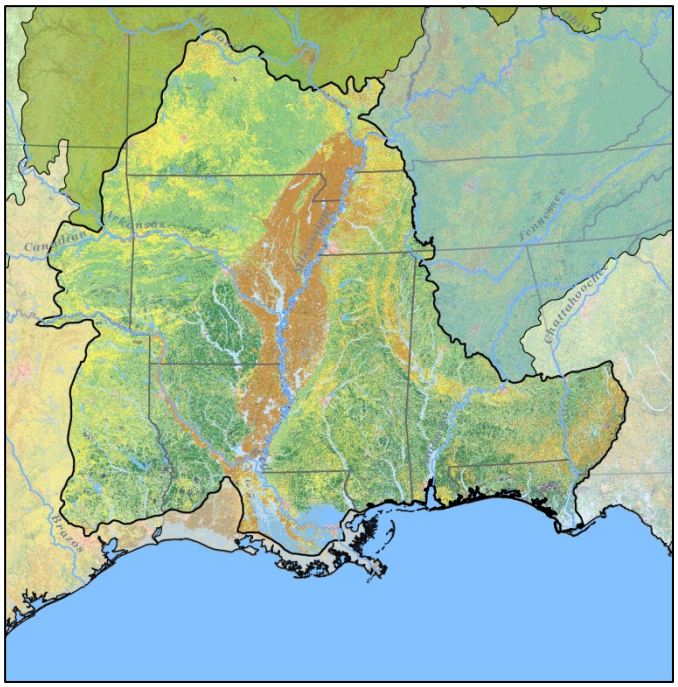


Figure 3-1. Gulf Coastal Plains & Ozarks LCC

The Ozark Partnership and GCPOLCC will be working closely with the USGS's Climate Response Centers. There will be conservation science partnerships among the Service, federal agencies, states, tribes, NGOs, universities and other entities. What's more, they will be fundamental units of planning and science capacity that will help us carry out the functional elements of SHC (i.e. biological planning, conservation design, conservation delivery, monitoring and research), filling existing gaps in our science capacity, and ultimately informing our response to accelerating climate change and other stresses.

3.1.2 Ecoregion Setting

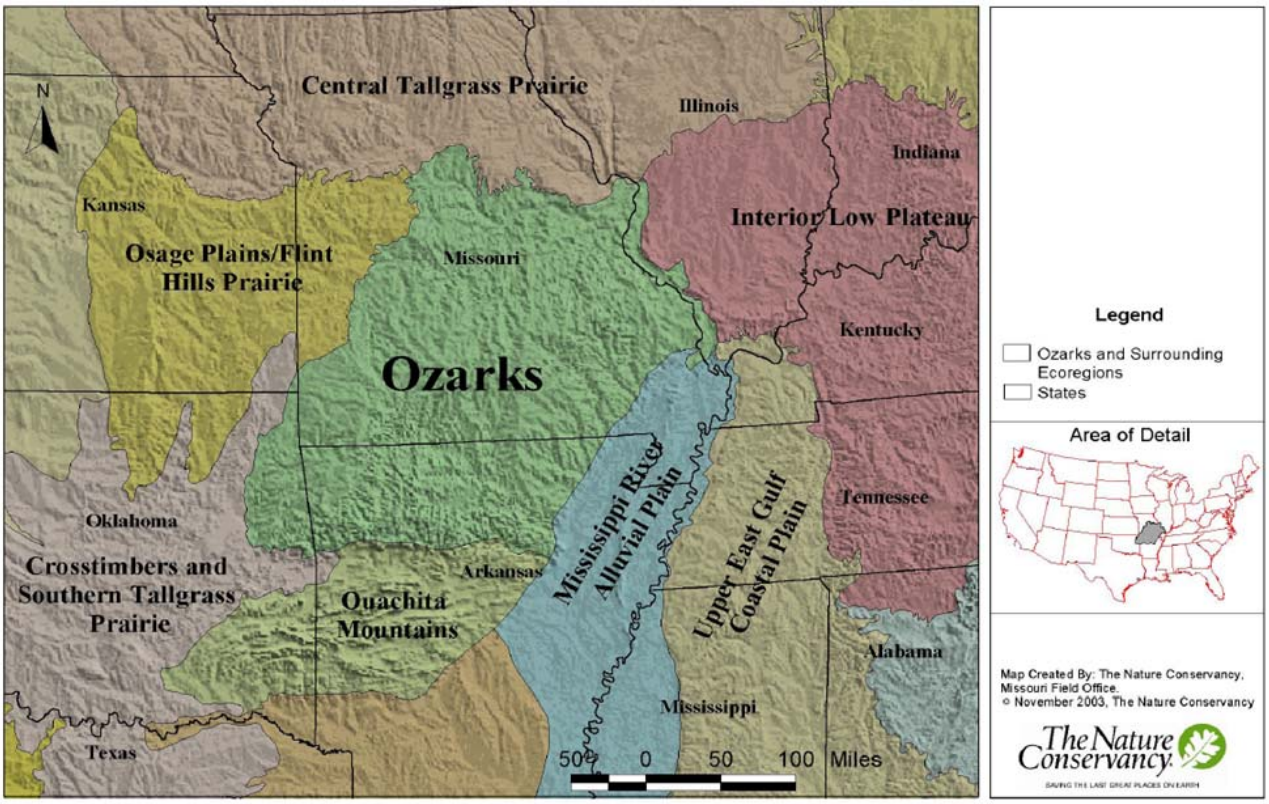
Ecoregions denote areas of general similarity in ecosystems and in type, quality, and quantity of environmental resources. They are designed to serve as a spatial framework for research, assessment, management, and monitoring of ecosystems and ecosystem components. By recognizing the spatial differences in the capacities and potentials of ecosystems, ecoregions stratify the environment by its probable response to disturbance. These general purpose regions are critical for structuring and implementing ecosystem management strategies across federal agencies, state agencies, tribes, and nongovernment organizations that are responsible for different types of resources within the same geographical areas (EPA, 2010).

The Nature Conservancy's (TNC) ecoregion planning approach divides the nation into natural areas as the foundation for identifying and protecting unique natural areas and features. TNC ecoregions were based on original work by Robert Bailey which are similar to Omernik's ecoregions and were modified by TNC in cooperation with the network of Natural Heritage Programs (Omernik 1987; Bailey, 1989).

Ozark Plateau NWR is located within TNC's, Bailey's, and Omernik's "Ozarks ecoregion", an area encompassing nearly 34 million acres in parts of Missouri, Arkansas, Oklahoma, Illinois, and a small corner of Kansas (see Figure 3-2). Oklahoma's portion of the Ozarks ecoregion constitutes approximately 5.8 million acres, or roughly 17% of the total ecoregion acreage. Along with the Ouachita region to the south, the Ozarks form the only significant highland region in mid-continental North America. Parts of this region have been continually exposed for at least 225 million years. Because of high habitat diversity and antiquity of the landscape, Ozark biota is characterized by an unusually high level of species disjunctions and endemism, with more than 160 endemic species documented from the ecoregion. (TNC, 2003).

High levels of topographic, geologic, edaphic and hydrologic diversity exist throughout the Ozarks, resulting in a wide variety of habitat types. This is a region of rugged uplands with abundant exposed rocks and variable soil depths. The landscape in various terrestrial subsections of the Ozarks ranges from extensive areas of karst terrain on irregular plains, to highly dissected regions with steep hills and deeply entrenched valleys, as well as limited areas of ancient low mountains with elevations up to 3000 feet. There are also smaller, linear areas of alluvial terrain and major riparian features. (TNC, 2003).

Figure 3-2. Ozarks Ecoregion (The Nature Conservancy, 2003).



3.1.2.1 Terrestrial Description

The Ozark Plateaus support a mosaic of forest, prairies, glades, barrens, and savannas depending on such factors as topography, bedrock, soils, fire, and native herbivores. These plant communities vary widely in their composition and size, and they appear to have changed significantly since settlement by Europeans. Open, grassy communities, such as savannas, barrens, and glades, were more common in the northern and particularly the northwestern sections of the Ozark Plateau than in the southern Boston Mountains region, which was more densely forested (Heikens, 1999). Historically, most of this habitat occurred in a more open woodland condition. However, the combination of large-scale harvesting and decades of fire suppression have resulted in much of this habitat currently being densely stocked, relatively even-aged second-growth forest.

Presently mesic forests have a relatively high diversity of tree species and a diverse vegetative structure. In the Ozarks region, these forests are typically dominated by white oak (*Quercus alba*), northern red oak (*Quercus rubra*), mockernut hickory (*Carya tomentosa*), bitternut hickory (*Carya cordiformis*), sugar maple (*Acer saccharum*), and white ash (*Fraxinus americana*). The moist soil conditions often allow the development of abundant understory vegetation including dominant small trees such as flowering dogwood (*Cornus florida*), rusty blackhaw (*Viburnum rufidulum*), northern spicebush (*Lindera benzoin*), strawberry bush

(*Euonymous atropurpureus*) and pawpaw (*Asimina triloba*). Other common forest trees include shumard oak (*Quercus shumardi*), chinquapin oak (*Quercus muehlenbergii*) and American basswood (*Tilia americana*). This habitat type is found throughout the Region and in both the Boston Mountains and Springfield Plateau sections. Sugar maples are often associated with the most mesic sites and those that experience infrequent fire. The more mesic sites often have greater understory development/ structure. (ODWC, 2005).

3.1.2.2 Aquatic Description

The Ozark Plateau NWR is located atop the Ozark aquifer, which is part of a larger system called the Ozark Plateau aquifer system. This system includes the Springfield Plateau, Ozark, and the St. Francois aquifers. The age of rocks that comprise this system range from Cambrian to Mississippian. The rocks consist of dolomite, sandstone, shale, and chert which tend to dip southward. The aquifer system reaches into southern Missouri and small portions of southeastern Kansas and eastern Oklahoma. The Ozark aquifer is by far the thickest aquifer in the northern aquifer system. The Ozark aquifer is comprised of limestone and dolomite with some areas containing chert, shale, and sandstone. These rocks date back to Late Cambrian to Middle Devonian. Most of the water that comes from the Ozark is used for agricultural purposes, although some of the water is used for industrial and municipal reasons. The aquifer is more than 3,000 feet thick in most places, but in central Arkansas it extends to 5,000 feet (USGS 1992-95) (Renken, 1998).

Figure 3-3. Ozark Aquifer (Credit: Unknown)

There is a study unit that involves most of the aquifer which includes all four states. It has an area of 48,000 square miles. There are major water quality concerns in the study area that include elevated concentrations of nutrients, elevated concentrations of bacteria, trace elements, dissolved solids, and radionuclides in ground water. The area has a temperate climate with average annual precipitation around 38-48 inches per year. The study area has an average annual temperature of 56-60 degrees F, and evapotranspiration rates of 30-35 inches per year. The land surface area ranges from 200 feet to around 2,300 feet. There is mining in all four states and the greatest amount occurring in the northwestern portion. Lead-zinc mining has been economically important in the past and coal is still being mined. The

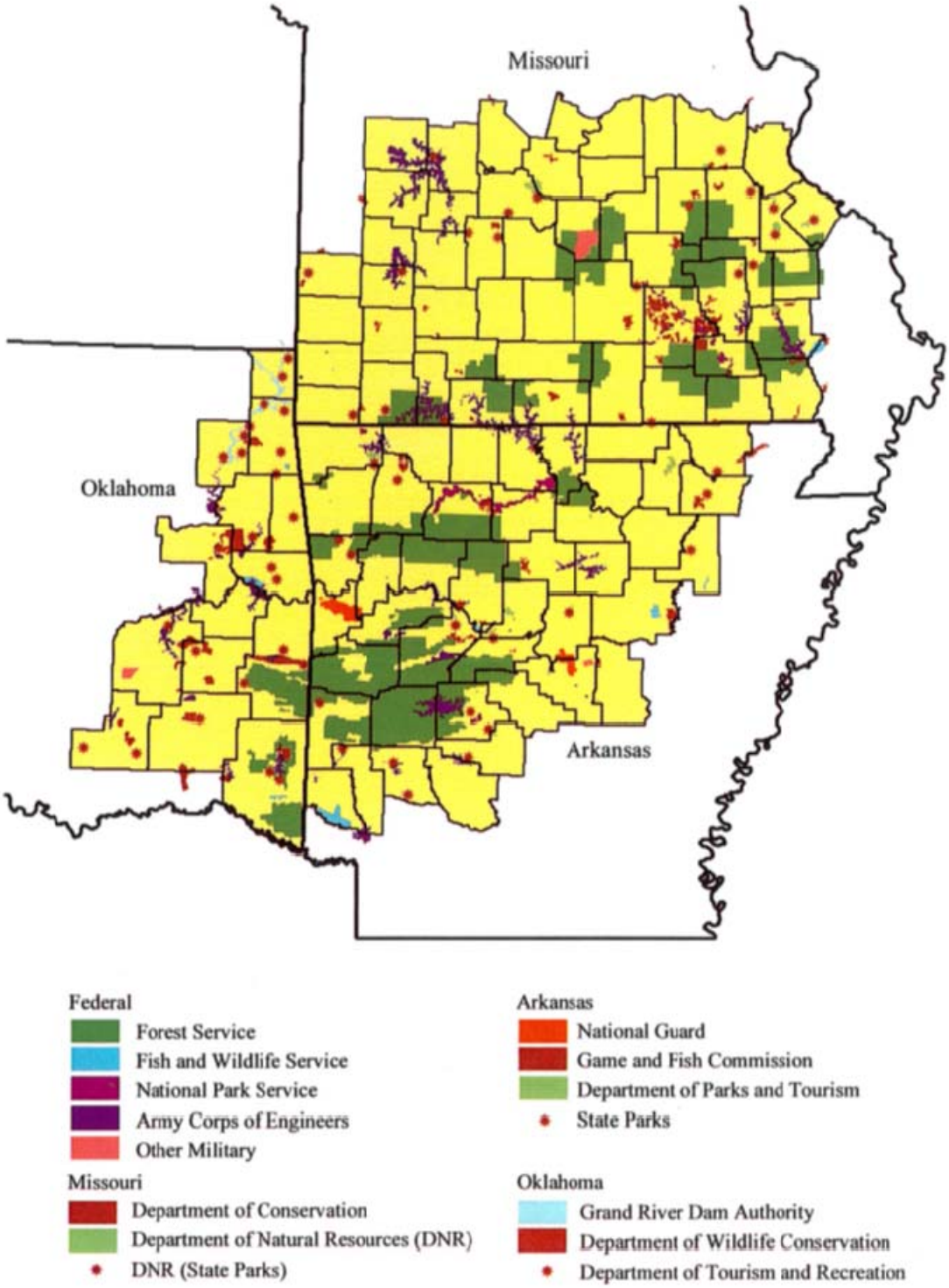
average annual runoff is about 14 to 20 inches per year in the Boston Mountains (Petersen et.al, 2005).

3.1.3 Protected Areas in the Ozarks Ecoregion

The International Union for Conservation of Nature (IUCN) defines a protected area as "a clearly defined geographical space, recognized, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values" (Dudley, 2008). Protected areas serve a variety of purposes for society. They are an expression of our community's goals to maintain the value of biodiversity and to ensure these values are passed on to future generations. They represent the diversity of the earth's history and the current natural processes, and provide many environmental services such as clean air, water, and nutrients. They are treasured landscapes reflecting the inherited cultures of many generations and they hold spiritual values for many societies (IUCN 2005).

Protected areas cover over 13% of the earth's land surface (IUCN 2005). In the United States, over 10,480 protected areas, including state level protected areas, account for 27% of the land area (1,006,619 sq. mi) (UNEP 2008). Protected areas in the Ozarks total about 6.5 million acres and are shown in Figures 3-4 and 3-5.

Figure 3-4. Protected Areas in the Ozarks. (U.S. Forest Service, 1999).

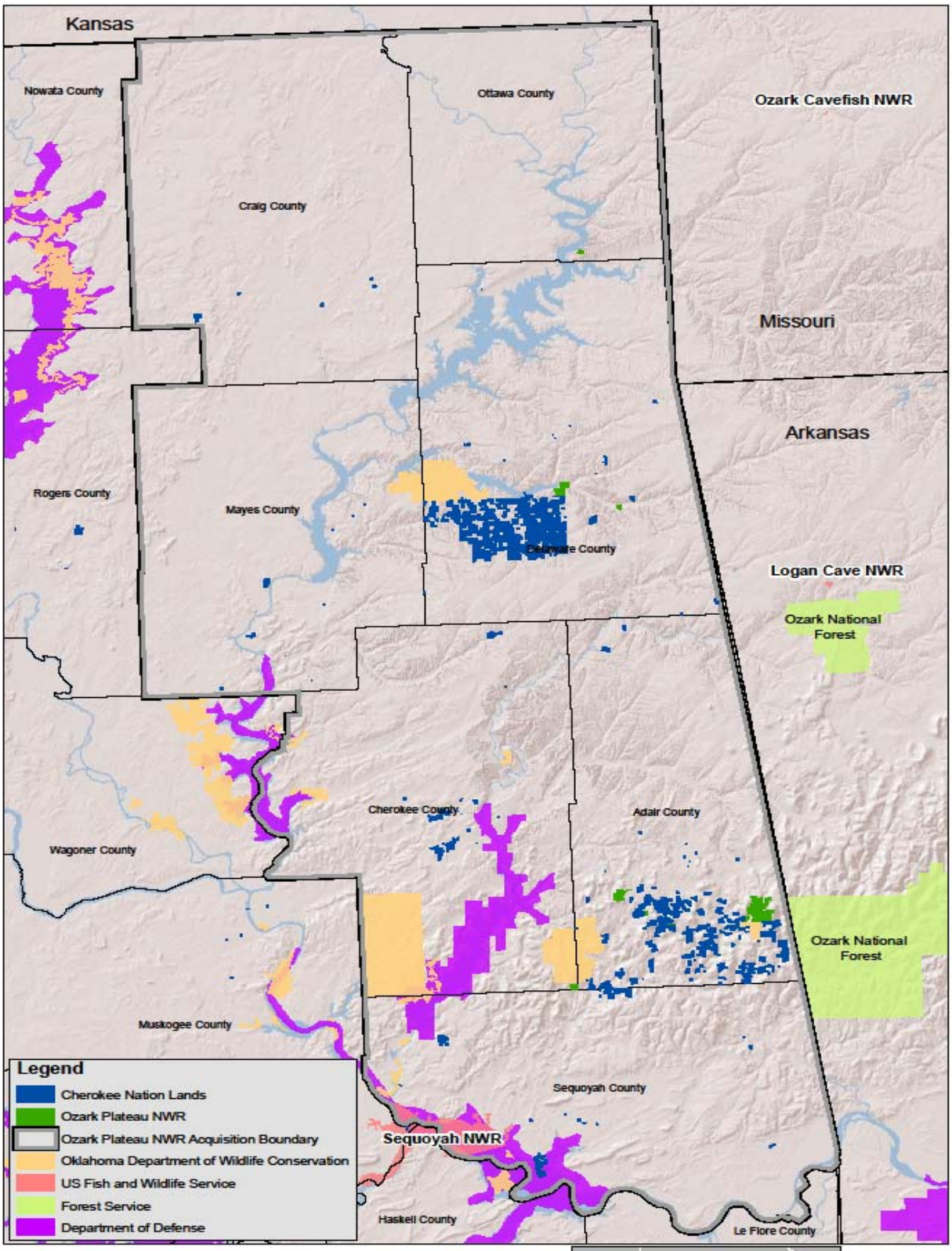


U.S. Fish & Wildlife Service

Ozark Plateau National Wildlife Refuge

Ottawa, Delaware, Adair and Sequoyah Counties, Oklahoma

Acquisition Boundary Map



PRODUCED IN THE DIVISION OF REFUGE PLANNING
ALBUQUERQUE, NEW MEXICO
LAND STATUS CURRENT TO: 5/31/09
MAP DATE: December, 2010
BASEMAP: N/A
MERIDIAN: N/A
FILE: obc_acquisition_bound_12.6.10_sh1

0 4 8 16 Miles

0 4 8 16 Kilometers

UTM ZONE 14
NAD 83

3.1.4 Migration Corridors

Conservation corridors are physical connections between disconnected fragments of plant and animal habitat. Without such connections some species would be unable to reach necessary resources like food, water, mates and shelter. Working with partners to identify key conservation corridors and crucial habitats is needed to conserve the habitat and wildlife species that depend on it.

Aerial of autumn foliage in the rolling hills of the Ozark Plateau. (Credit: Bruce Dale/National Geographic Stock)

Seasonal bat migration and the timing and corridors used are important factors taken into consideration in establishing and managing Ozark Plateau NWR. Gray bats are one of the few species of bats in North America that inhabit caves year-round, migrating each year between winter and summer caves. Gray bats have been documented to regularly migrate from 17 to 437 km between summer maternity caves and winter hibernacula (Tuttle 1976b; Hall and Wilson 1966). Gray bats exhibit strong philopatry to both summering and wintering sites (Tuttle, 1976a; Tuttle, 1979; Kennedy and Tuttle, 2005; Martin, 2007).

The most important migration corridors for the federally listed endangered and threatened Ozark cave species that Ozark Plateau NWR was established to protect and recover are those used by gray bats migrating between their summer maternity caves in eastern Oklahoma and where they hibernate during the winter in large caves in northern Arkansas and southern Missouri. These migration corridors have not been specifically identified. However, with increasing threat of energy development projects, including wind power, and the extreme rate of development in the Ozarks of northwest Arkansas and southwest Missouri, it is important that these be identified and protected. Also, because Ozark Plateau NWR was established to provide habitat for interior nesting Neotropical migratory songbirds, cooperation and work with a number of partners within the Central Flyway, especially including the Central Hardwood Bird Conservation Region, is extremely important.

Migrating gray bat. (Credit: Bat Conservation International)

It is essential to protect large continuous stands of Ozark forest essential both for feeding areas, movement and migration corridors for bats and birds and nesting areas for migratory birds that need unbroken expanses of high quality oak-hickory and oak-hickory-pine Ozark forest. The expanses of unfragmented Ozark oak-hickory forests that are still present in much of the seven-

county acquisition area are recognized for their importance to the thousands of migratory birds that inhabit the forests for breeding, feeding and migration to and from breeding and wintering areas. Many of the cave sites are within or adjacent to these forested sites.

3.1.5 Refuge Location

The Ozark Plateau NWR consists of 4,093 acres in nine management units presently located in four counties (Adair, Cherokee, Delaware, and Ottawa) in Baily's Oak-Hickory Forest Ecoregion along the southwest edge of the Ozark Plateau and Boston Mountains in northeastern Oklahoma near the borders of Arkansas, Missouri, and Kansas and Fish and Wildlife Service Regions 2, 3, 4, and 6. It is approximately 90 miles east of Tulsa, Oklahoma, and 40 miles west of the Fayetteville, Arkansas metropolitan area. Ozark Plateau NWR has been authorized to expand up to 15,000 acres in a seven-county area in northeastern Oklahoma including the existing counties plus Craig, Mayes, and Sequoyah Counties. (See Chapter 1, Figure 1-1 for a map of current Refuge units and acquisition area).

3.1.6 Surrounding Land Uses

The conservation land status of Ozark Plateau NWR is just one of a variety of land uses found across the larger landscape. Urban, suburban, rural and industrial developments in northeast Oklahoma, northwest Arkansas, and southwest Missouri, as well as intensive agricultural and livestock land uses, present an array of threats to fish, wildlife, and their habitats, including invasive plants, feral animals, habitat fragmentation, pathogens, and pollutants. Tulsa County, Oklahoma, just 70 miles west of the Refuge area, has over 590,000 people and is the most densely populated county in the State of Oklahoma (Data Place, 2007). Northwest Arkansas and southwest Missouri together constitute one of the nation's fastest growing areas in population and commercial activity, due in part to the continued growth of Wal-Mart, Tyson Foods, and supporting industries (CensusScope, 1990-2000).

Ozark Plateau NWR is found within a matrix of surrounding land uses including rural residential and agricultural land uses; Cherokee Nation commercial and managed lands; the City of Tulsa; State Wildlife Management Areas; Oklahoma State Parks; National Forest; and U.S. Army Corps of Engineers-managed lands and waterways.

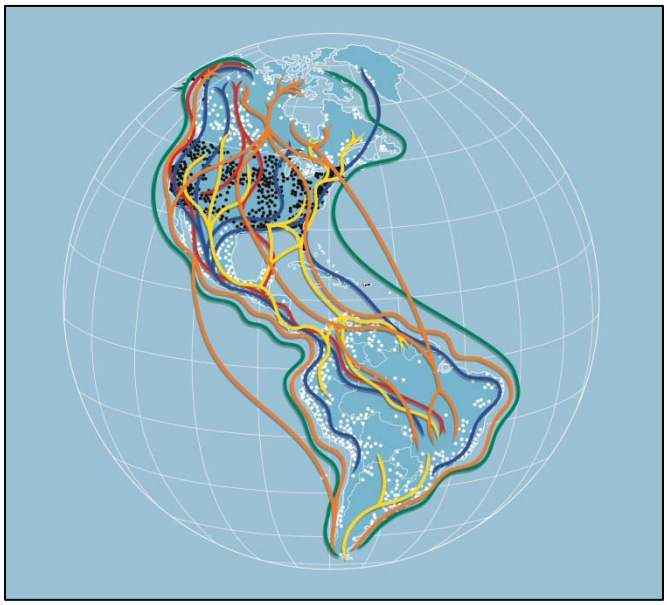
Rural land uses still predominate in the seven-county Ozark Plateau project area. Livestock grazing, growing sorghum, wheat, soybeans, and hay/alfalfa, and confined animal feeding operations for poultry and hogs, are typical agricultural activities throughout the area. Forest products from timber operations are a source of income for some landowners.

Tourism, including hunting and fishing, stimulate recreational developments including resorts, campgrounds, lake marinas, vacation homes, and associated support services. A newer trend in

the Ozarks is residential retirement development. Retirees are attracted by the relatively inexpensive land prices and the desirable aesthetics of the rural, rolling wooded hills, and small town atmospheres. The increasing population growth in the region is also stimulating changes in land use from agricultural to urban development uses, such as residential, commercial, and industrial development, primarily near the larger towns and cities.

3.1.7 Flyway

Because Ozark Plateau NWR was established to provide habitat for both federally listed threatened and endangered cave species and Neotropical migratory forest songbirds, it is important to protect large continuous stands of Ozark forest essential for feeding and nesting areas as well as movement and migration corridors in the Central Flyway. These migratory birds using the flyway need unbroken expanses of high quality oak/hickory and oak/hickory/pine Ozark forest. This requires cooperation among a number of partners throughout the Central Flyway.



Hemispheric flyways. (Credit: National Audubon Society)

3.2 Physical Environment

This section describes the physical environment in which the Ozark Plateau NWR is found. It includes a description of the climate, geology and soils, aquifers and groundwater, oil and gas occurrences and potential, environmental contaminants, and water and air quality found at the Refuge.

3.2.1 Climate

Adair, Delaware, Ottawa, Cherokee, Craig, Mayes, and Sequoyah Counties in northeastern Oklahoma lie in a belt of warm, humid, subtropical to continental-type climate. Mild weather prevails during the autumn and spring months. Clear skies and dry atmosphere prevail during the summer months with hot days and relatively cool nights. Winters are generally mild, with spells of cold alternating with periods of mild weather.

Mean annual temperature for the Stilwell, Oklahoma area is 60 degrees F. Monthly average temperatures range from 38 degrees F. in January to 82 degrees F. in July (see Figure 3-6). The first killing frost in the area occurs in late October, and the last killing frost in the spring can occur mid to late April. Relative humidity, on average, ranges from 42% to 95% during the day.

Major weather changes occur in the area when cool dry air from the Pacific Ocean or the Arctic meets warm, moisture-laden the Gulf of Mexico. Winters are short and mild. Average dates for the first frost in the fall are in October. Summers are long, hot, and humid. An average year has 180 clear days, 95 partly cloudy days and 140 cloudy days. Prevailing southeasterly winds average 10 miles per hour (National Weather Service, Stillwell, Oklahoma Station).

The area receives 35 to 55 inches of precipitation with an average rainfall is 43.68 inches (see Figure 3-7). Most of the rainfall occurs during the warmer months. May and June are the rainiest months, on average, whereas February is usually the driest month. Snow is usually light and remains on the ground for only a few days at a time. Nearly every winter has at least one inch of snow, with one year in two having ten or more inches.

Figure 3-6. Ozark Plateau NWR Average Monthly Temperatures (Fahrenheit)

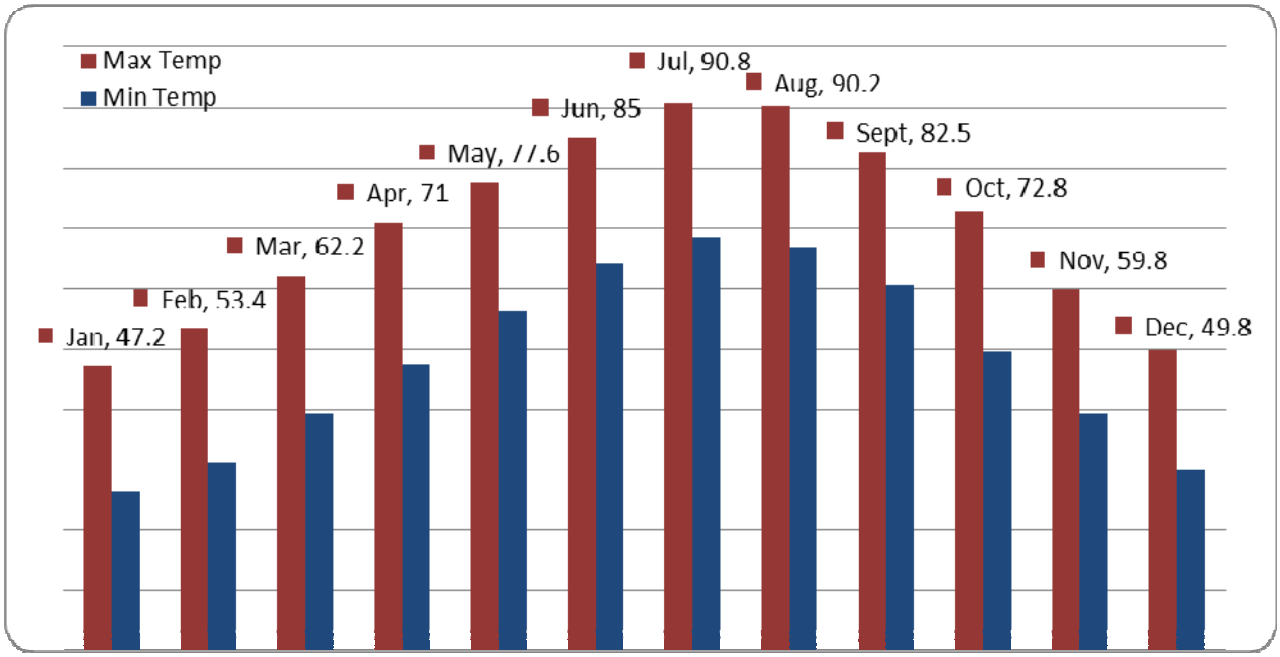
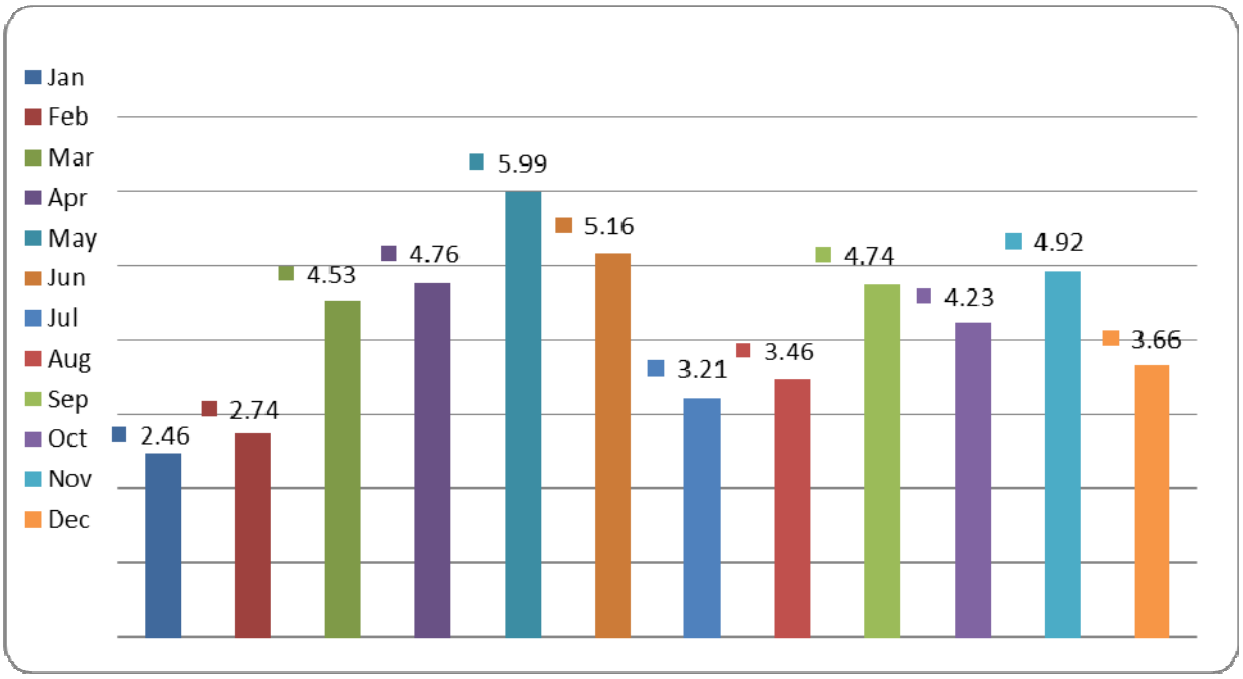


Figure 3-7. Ozark Plateau NWR 30-year Average Monthly Precipitation (inches)



(Oklahoma Climatological Survey)

3.2.2 Air Quality

Pursuant to the Clean Air Act, as amended in 1977, the Service has an affirmative responsibility to protect air quality related values on national wildlife refuges. Polluted air injures wildlife and vegetation, causes acidification of water, degrades habitats, accelerates weathering of buildings and other facilities, and impairs visibility.

Under the Clean Air Act, the U.S. Environmental Protection Agency (EPA) has established primary air quality standards to protect public health. The EPA has also set secondary standards to protect public welfare. Secondary standards relate to protecting ecosystems, including plants and animals, from harm, as well as protecting against decreased visibility and damage to crops, vegetation, and buildings.

The EPA has developed National Ambient Air Quality Standards (NAAQS) for six principal air pollutants (also called "criteria pollutants"). They are ground-level ozone (O_3), particulate matter (PM), nitrogen dioxide (NO_2), sulfur dioxide (SO_2), carbon monoxide (CO), and lead (Pb).

The Oklahoma Department of Environmental Quality maintains air quality monitors throughout the State. The nearest monitors to the Ozark Plateau NWR are in Pryor and Muskogee. All seven counties in the Ozark Plateau NWR acquisition area meet the NAAQS for the six principal air pollutants (www.deq.state.ok.us; www.epa.gov/, 2012). There may be scattered sites having

lesser quality air due to local industries and urban concentrations of vehicles, but to date there have been no violations of criteria pollutant standards.

3.2.3 Water Resources

Aquifers and Groundwater

The Ozarks are known for their clean springs, clear cold streams, deep reservoirs, and important underground aquifers. A major aquifer in the region is the Roubidoux, a deep aquifer located predominantly in Delaware and Ottawa Counties. One of Tulsa's principal water sources is an aquifer in Delaware County underlying some existing and proposed Refuge lands. Karst regions are particularly vulnerable to underground water contamination because karst formations can easily catch surface runoff, transfer it to underground water bodies, and transfer it back to other surface water bodies. Typical practices such as septic systems, confined animal feeding operations, and dumping trash and debris "out of sight" in sinkholes all jeopardize groundwater quality in the Ozarks.

OT4 Cave Stream. (Credit: Steve Hensley)

Significant water courses in the approved land acquisition area are the Spring River, Neosho (Grand) River, Spavinaw Creek, and Sallisaw Creek, plus designated state scenic rivers

including the Illinois River, Barren Fork, Flint Creek, Lee Creek, and Little Lee Creek administered by the Oklahoma Scenic Rivers Commission. The Refuge protects portions of the Spavinaw Creek, Neosho River, Sallisaw Creek, Lee Creek, and Little Lee Creek watersheds. Grand Lake, Lake Hudson, Fort Gibson Lake, Tenkiller Lake, Robert Kerr Lake, Webber's Falls Lake, Lake Eucha, Spavinaw Lake, and Green Leaf Lake are known throughout the project area, for their aesthetic, recreational, and water supply qualities. Their existence drives much of the area's recreation-related development and economic sectors.

Water Rights

Currently, the Refuge does not own any water rights. In 1957, the Oklahoma Legislature created the Oklahoma Water Resources Board (OWRB) to manage the State's water resources (Focht, et. al., 2007). Stream water is considered to be water that is owned by the public and is subject to appropriation (i.e., a right to use water). If there is not enough water to satisfy all uses of a river, creek, lake or pond, the permit filing date determines who gets the water. "First in time, first in right." (Focht, et. al., 2007). The allocation system ties ownership of groundwater to surface land ownership so that the amount of water allocated to each landowner is determined by the number of acres of land overlying the basin he or she owns. The OWRB regulates the use of groundwater, even though the groundwater is considered private property like oil, gas, coal and other minerals. A permit is required for non-domestic use of water, but even domestic users are prohibited from wasting groundwater pumped from a well (Focht, et. al., 2007). In eastern Oklahoma, there remains much controversy and issues regarding water rights, especially tribal water rights, such as in the cases of Atlantic & P.R. Co. v. Mingus, 165 U.S. 413 (1897), U.S. v. GRDA, 63 U.S. 229 (1960), Choctaw v. U.S., 397 U.S. 620 (1970), Oklahoma v. Tyson, 258 F.R.D. 472 (N.D. Ok. 2009), and Choctaw and Chickasaw Nations vs. Oklahoma City and the Oklahoma Water Resources Board, CIV-11-927-C (2011) (Greetham; Ellis, 2011).

High flow season (spring) on the Refuge. (Credit: Steve Hensley, 2011)

Water Quality

Water quality is a measure of the suitability of water for a particular use based on physical, chemical, and biological characteristics. Natural water quality varies from place to place, with the seasons, with climate, and with the types of soils and rocks through which water moves.

Water quality is also affected by human activities including, but not limited to, urban and industrial development, farming, mining, combustion of fossil fuels, and stream-channel alteration. (USGS, 2001).

The Clean Water Act of 1977 (CWA) requires states to identify and prioritize waters that do not currently support designated uses. Water bodies that do not meet one or more applicable water quality standards and those that are threatened for a designated use by one or more pollutants are listed on each state's 303(d) list. The 303(d) list includes waters impaired by both point and non-point source pollution. Point source pollution occurs when contaminants enter the water body from a distinct localized source, such as a chemical plant or equipment exhaust. Non-point source pollution occurs when contaminants enter the water body from indirect sources, such as residential development or agricultural practices.

Ozark Plateau NWR does not contain any impaired water bodies that are currently listed on the State of Oklahoma Department of Environmental Quality's 303(d) list (U.S. Geological Survey, 2001, and Oklahoma Department of Environmental Quality, 2010).

The Refuge and several partners conducted a water quality study in May and June of 2006 at four caves and one surface location to measure water quality and detect any groundwater contaminants. In karstic areas, surface contaminants may be transported to groundwater and ultimately cave ecosystems where they may impact resident biota. In the 2006 study, polar organic chemical integrative samplers (POCIS) and semi-permeable membrane devices (SPMD) were deployed to detect potential chemical contaminants in these systems. All caves sampled were known to contain populations of the federally listed threatened Ozark cavefish, *Amblyopsis rosae*. The surfacewater site was directly downstream from the outfall of a municipal wastewater treatment plant and a previous study indicated a hydrologic link between this stream and one of the caves. A total of 83 chemicals were detected in the POCIS and SPMD extracts from the surfacewater and cave sites. Of these, 55 chemicals were detected in the caves. The organic wastewater chemicals with the greatest mass measured in the sampler extracts included sterols, plasticizers, the herbicide bromacil, and the fragrance indole. Sampler extracts from most of the cave sites did not contain many wastewater contaminants, although extracts from samplers in the surfacewater site and the cave hydrologically-linked to it, had similar levels of diethylhexyphthalate and common detections of carbamazapine, sulfamethoxazole, benzophenone, N-diethyl-3-methylbenzamide (DEET), and octophenol monoethoxylate. Further evaluation of this system is warranted due to potential on-going transport of wastewater-associated chemicals into the cave. Halogenated organics found in caves and surface-water sites included brominated flame retardants, organochlorine pesticides and polychlorinated biphenyls. The placement of samplers in the caves (i.e., distance from cave mouth, etc.) may have influenced the number of halogenated organics detected due to possible aerial transport of residues. Guano from cave-dwelling bats also may have been a source of some of these

chlorinated organics. Seven-day survival and growth bioassays with fathead minnows (*Pimephales promelas*) exposed to samples of cave water indicated initial toxicity in water from two of the caves, but these effects were transient with no toxicity observed in follow-up tests (Bidwell, et. al., 2006).

Ridgewalking along unique geologic formations in the Ozark Plateau in search of caves. (Credit: Shea Hammond)

3.2.4 Geology and Soils

Geology

The Ozarks have been a continuous land mass since the end of the Paleozoic Era and are one of the oldest geological regions in North America (Heikens, 1999). They were uplifted at least twice; however, after the Cretaceous uplift, the region was eroded to a relatively flat plain, which existed until the second uplift in the late Tertiary (Heikens, 1999). The Ozarks are also known for their hilly topography, which resulted from uplifting during and since the Pennsylvanian Period (330-315 million years ago), all of which are unglaciated. Northwestern Arkansas and southwestern Missouri also share the Ozark Mountains' distinctive geology and topography.

The key geologic feature common throughout the Ozark Plateau is the presence of karst geological formations. Karst formations are bedrock of limestone and chert that were deposited in the shallow inland seas during the Mississippian Period (365-330 million years ago). Since limestone can be dissolved by acidic runoff, underground caverns and streams, sinkholes, and other formations typical of karst areas have formed during the millions of years that have passed. Geologic formations of karst caves and sinkholes are found throughout the area and are the reason for the distinctive cave environments that support diverse and unique animal communities. In the northern portion of the area (Ottawa and Delaware Counties) cave forming formations are the St. Joe and Boone formations with some possibly found in the Cotter formation. Further south (in Adair County), caves are more likely to be found in the Pitkin limestone and Hale formation. Even further south (in southern Adair County and Sequoyah County), cave habitat can be found in large talus cracks in areas of Atoka sandstone. On the west side (Cherokee, Craig, and Mayes Counties), the St. Joe, Pitkin, and Hale formations are where caves are most likely to occur.

Economic mineral resources in the area include limestone, shale, cement, tripoli, sand and gravel. Oil and gas are also produced, but not in the major quantities as other parts of Oklahoma are known for. Mining is one of the lowest, or the lowest, industry in all seven counties, in terms of annual earnings (Government Information Sharing Project).

In Ottawa County the Tri-State lead and zinc mining area near Miami and Picher often produced the nation's records for zinc production between 1918 and 1945. No mining has occurred there since 1974, and now the tailing piles (mine waste) and groundwater contamination have led to the site's designation as an Environmental Protection Agency Superfund Site. It is one of the first and largest Superfund sites in the nation. (See also FWS Partial Restoration Plan and EA http://www.fws.gov/contaminants/restorationplans/tarcreek/rpTar_Creek_partial6_00_toc.cfm).

Soils

Soils in the Ozarks of Oklahoma have been influenced by the karst and sandstone geology and hilly topography, and range from sandy loams to heavy clays to rock outcrops, with various loams predominating. Loam is a soil textural class that is influenced to varying degrees by silt, sand, and clay. Loams are considered the best soil texture for agriculture. Soil associations that dominate the project area include the Enders-Conway-Hector and the Hector-Pottsville associations (Oklahoma Comprehensive Water Plan, 2012). For a detailed description of soil series, see the U.S. Department of Agriculture, Natural Resources Conservation Service's Soil Survey publication for the desired county.

Throughout the Ozark regions, erosion has resulted in thin, rocky soils. Soil depth ranges from areas of exposed bedrock and no soil, to areas with soil 10-40 cm deep, to pockets of relatively deep soil (>1 m). Most of the soils within the action area are Alfisols or Ultisols. They formed in material weathered from cherty limestone. Physical and chemical weathering has caused the cherty limestone to disintegrate into its least soluble components, which are chert and clay. The chert remains in the form of angular fragments or wavy horizon beds interstratified with layers of clay. Down slope movement by gravitational creep and overland water flow has altered the cherty material in the upper part of some soils. In general, the soils are shallow to very deep, moderately well-drained to excessively drained, and medium textured to fine textured. The soil temperature regime is mesic bordering on thermic, the soil moisture regime is udic, and mineralogy is mixed or siliceous.

Many of the soils on nearly level to moderately sloping upland divides are Fragiudults (Captina, and Tonti series). Many of the soils on moderately sloping to steep side slopes in the uplands are Paleudults (Clarksville series). Many of the soils on terraces and the adjacent flood plains are Hapludalfs (Razort and Waben series) and Paleudalfs (Britwater series) (USFWS et al. [BABO HFRP], 2010).

3.2.5 Oil and Gas Occurrences and Potential

Other than limestone, there is few known oil, gas, or mineral deposits in the area. Limestone and dolomite deposits and gravel do occur in Adair, Cherokee, Craig, Delaware, Mayes, southeast Ottawa, and extreme northern Sequoyah Counties. There has been some coal mining in western Craig, extreme western Mayes, and extreme southern Sequoyah Counties. Also, in the past lead and zinc has been mined in extreme northern Ottawa County. There are no oil or gas production sites or facilities on or near current Refuge property. However, if oil or gas is discovered near the Refuge in the future, development could contaminate groundwater aquifers, springs, and streams and, along with limestone quarries, directly destroy cave, aquifer, streams, and forest habitat.

The Refuge owns mineral rights on all Units. There are no mineral extraction operations on any Refuge lands.

3.3 Biological Environment

This section describes the biological environment in which the Ozark Plateau NWR is found. It includes a description of the present, historical, and potential future condition of terrestrial and aquatic habitat types found on and surrounding the Refuge, as well as the natural processes that influence them. It identifies priority wildlife species and representative species used for monitoring purposes, and includes a discussion of various wildlife types that benefit from the Refuge.

3.3.1 Habitat Types

The Ozark region encompasses all or portions of the Refuge's seven-county acquisition area of Adair, Cherokee, Craig, Delaware, Mayes, Ottawa, and Sequoyah counties. It is equivalent to the combination of the Ozark Highlands and the Boston Mountains in both Bailey's and Omernik's ecological classification systems. The Oklahoma Comprehensive Wildlife Conservation Strategy (Strategy) describes terrestrial habitats or "conservation landscapes" in the Ozark Region and prioritizes them as "very high, high, and/or moderate" in terms of conservation landscapes and issues (ODWC, 2005).

3.3.1.1 Terrestrial Classes

Northeastern Oklahoma is part of the Ozark Plateau geographic area containing hilly, deciduous forests in Bailey's Oak-Hickory Forest Ecoregion and supports an oak-dominated deciduous forest community. The principal oak species are blackjack, post oak, black oak, southern red oak, Shumard oak, pin oak, bur oak, and white oak. Hickory species include black hickory, shagbark hickory, and mockernut hickory. Typical understory vegetation includes flowering dogwood, eastern redbud, green brier, poison ivy, May apple, white sassafras, and coralberry.

Valleys in floodplains contain silver maple, river birch, American elm, eastern cottonwood, American sycamore, American linden, and various oaks. The Ozark chinquapin tree (*Castanea pumila var. ozarkensis*), a state species of concern, is scattered throughout the forested areas (ODWC, 2005).

Table 3-1. Terrestrial Conservation Landscapes on Ozark Plateau NWR Units (ODWC, 2005)

Conservation Landscape	Ozark Plateau NWR Units
Very High Priority Conservation Landscapes	
Limestone caves	All Units
White Oak/Hickory Mesic Forest	Sally Bull Hollow, Liver, Gittin Down Mountain, Varmint
High Priority Conservation Landscapes	
Shortleaf Pine-Oak-Hickory Woodlands	Potter, Beck, Mary and Murray Looney, Eucha, Boy Scout
Herbaceous Wetlands	Mary and Murray Looney, Sally Bull Hollow, Varmint, Boy Scout, Eucha
Oak-Hickory Bottomland Hardwood Forest	Mary and Murray Looney, Eucha, Sally Bull Hollow, Varmint, Boy Scout
Moderate Priority Conservation Landscapes	
Post Oak/Blackjack Oak-Hickory Woodland and Forest	Sally Bull Hollow, Liver, Gittin Down Mountain, Varmint
Tallgrass Prairie	Beck, Mary and Murray Looney

Limestone Cave

Much of the Ozark Plateau NWR is underlain by the Springfield Plateau, a formation of porous limestone with deep fissures that is often referred to as karst. Slightly acidic groundwater moves through the fissures and cracks in the limestone dissolving and/or eroding subterranean stream channels, and caves. Because of its geology, the Ozark Plateau contains many complex systems of interconnected aquifers, caves, sinkholes and springs, and these systems in turn support diverse subterranean communities of salamanders, bats, Ozark cavefish, cave crayfish and other cave and/or aquifer dwelling invertebrates. Caves are openings into the karst formation that connect the above ground community with the subterranean community. In contrast to the Springfield Plateau, the Boston Mountains section of the ODWC Ozark Region is a sandstone formation in which very few caves exist. Despite the widespread nature of the Springfield Plateau, cave systems are uncommon and locally-occurring. The distribution and biological composition of caves is poorly known and in need of further investigation (ODWC, 2005).

White Oak/Hickory Mesic Forest

The relative condition of White Oak/Hickory Mesic Forest habitat is currently poor with a declining trend. This forest type occurs as small patches of mesic forest in ravines and hollows within drier upland oak forest, or as long bands of habitat found on the lower slopes around small valleys, or the more protected northern and eastern slopes of hills and valleys. This habitat is found on the Refuge but restricted to certain physical features of the landscape and sites with favorable moisture and soil conditions. As a result this habitat type can only be managed or restored in specific areas and it rarely occurs as large contiguous landscapes (ODWC, 2005).

Autumn colors in the Ozark oak-hickory forest. (Credit: Shea Hammond)

Shortleaf Pine-Oak-Hickory Woodlands

Shortleaf Pine-Oak-Hickory Woodlands habitat occurs locally in portions of the Springfield Plateau in Cherokee and Delaware Counties. This habitat type is comprised of a mosaic of woodlands and forests dominated by Shortleaf Pine (*Pinus echinata*), and several species of oaks and hickories. These woodlands and forests are found on ridge tops, and on dry, rocky upper portions of east, south, and west-facing slopes. This habitat type is shaped by the combination of dry soils and periodic fire (ODWC, 2005).

Post Oak/Blackjack Oak-Hickory Woodlands and Forests

The relative condition of Post Oak/Blackjack Oak-Hickory Woodlands and Forests habitat is currently poor with a declining trend. Dry to mesic, oak-dominated woodlands, and forests are widespread on Refuge lands and typically occur on upper slopes, ridges, bluff escarpments, and slopes with a southern or western aspect. This plant community is structured by topographic position and naturally occurring fire and represents the majority of upland woodland and forest in the Ozark Region. This habitat type usually develops on sites with shallow or well-drained soils, and is dominated by only a few species of trees but is a structurally diverse mosaic of oak-hickory woodlands and oak-hickory forests that vary geographically depending upon soil conditions, aspect, and fire history (ODWC, 2005).

Herbaceous Wetlands

Herbaceous wetlands are small, uncommon and locally-occurring plant communities on the Refuge, usually found embedded within larger habitats or fire-maintained plant communities such as Tallgrass Prairies. The distribution, abundance and biological composition of herbaceous wetlands is poorly known in this Region and is in need of further study. Wetlands most frequently develop within or near the floodplains of streams and rivers. However in the Ozark Region, many floodplains are forested and are not conducive to the maintenance of herbaceous wetlands. Herbaceous wetlands are often seasonally flooded depressions within prairies and floodplains where periodic disturbances such as fire and flooding limit the encroachment of woody plant species. As a result of fire suppression and habitat loss, it is likely that much of the current herbaceous wetland habitat within the landscape exists in human-maintained areas such as pastures in both uplands and floodplains (ODWC, 2005).

Tallgrass Prairie

Tallgrass Prairie habitat remains where the shallow rocky soils are unsuitable for conversion to crop agriculture and ranching is the most common land use. Where prairie habitat remains, decades of continuous grazing, fire suppression and encroachment of native and non-native plants has resulted in changes in the plant community composition and structure. These changes include greater woody plant cover, increased proportions of exotic grasses and decreased abundance of native forbs. Tallgrass Prairies are herbaceous plant communities dominated by four common, tall grass species: big bluestem (*Andropogon gerardi*), Indian grass (*Sorghastrum nutans*), switchgrass (*Panicum virgatum*) and little bluestem (*Schizachyrium scoparium*). There are few sites currently on the Refuge of this habitat type. The structure of this habitat type is maintained by the occurrence of natural fires that limit the growth of woody plant species and favor grasses and some forbs. All four of the dominant grass species are present in most Tallgrass Prairie sites; however big bluestem and Indian grass tend to be most prevalent in mesic sites, while big bluestem and little bluestem are most common on drier sites. In mesic loamy soils such as those found in floodplains and bottomlands, switchgrass and big bluestem are often the dominant grasses (ODWC, 2005).

3.3.1.2 Aquatic Classes

The Ozark landscape is deeply dissected by clear-flowing, often spring-fed, moderate- to high-gradient streams.

Table 3-2. Aquatic Conservation Landscapes on Ozark Plateau NWR Units (ODWC, 2005)

Conservation Landscape	Ozark Plateau NWR Units
Very High Priority Conservation Landscapes	
Springs	All Units
Gravel Bottom Streams	Sally Bull Hollow, Varmint, Mary and Murray Looney, Potter, Boy Scout
Moderate Priority Conservation Landscapes	
Large Rivers	Boy Scout

Springs

The relative condition of Spring habitat is currently poor with a declining trend. Springs and seeps are widespread on Ozark Plateau NWR lands, but are extremely small habitats that are typically found in association with wetlands or the headwaters of streams. These springs are also associated with many caves. As a result of the limestone karst geology of the region, groundwater aquifers, subterranean streams, and springs are numerous in this area. The Springfield Plateau supports many species of conservation need that inhabit groundwater aquifers and these species may be encountered at springs or within caves (e.g., amphipods, isopods, and Grotto salamander). Despite the number of springs in the region, the distribution and biological composition of springs and seeps is poorly known in large part because these habitats are small and difficult to locate or access (ODWC, 2005).

Fast-flowing stream on Ozark Plateau NWR. (Credit: Shea Hammond)

Gravel-bottom Streams and Associated Riparian Forests

The relative condition of Gravel-bottom Stream and Associated Riparian Forests habitat is currently poor with a declining trend, according to the Oklahoma Comprehensive Wildlife Conservation Strategy. All or nearly all of the streams on the Refuge have cobble or gravel substrates. Because of the karst geology of the Springfield Plateau, many surface streams have a strong groundwater connection. Most streams receive a substantial amount of their flow from springs and seeps. Many streams have sections in which the stream loses flow to or gains flow from shallow groundwater aquifers. Streams in areas of low elevation gradient have well developed series of pools and riffles. These streams are typically slightly too moderately entrenched, are much wider than they are deep, and have well-developed floodplains. Streams in areas with higher elevation gradients are typically wider than they are deep but are moderately entrenched, have few meanders, narrow floodplains, and are structured as a series of pools and steps (ODWC, 2005).

Small River

Small River habitat in the Ozark Region of Oklahoma is limited to the Spring and Illinois Rivers, each of which is a tributary of the Grand/Neosho River, which flow within the Refuge approved acquisition area. The lower portions of both rivers have been affected by impoundments that have reduced their effective lengths. The Spring River flows for approximately 15 miles in Oklahoma before reaching Grand Lake of the Cherokees. The lower part of the Illinois River has been impounded by the construction of Tenkiller Reservoir, which has reduced its length to approximately 40 miles of flowing water. Both the Spring River and the Illinois River are clear swiftly-flowing rivers with gravel to cobble substrates. Flow rates are typically greater during the winter and spring months and lower during the summer and fall. These small rivers contain gravel bars and sloughs but not the dynamic mosaic of sandbars, mudflats and sloughs that are found within the larger rivers. Sloughs along these rivers are typically rocky and surrounded by woody vegetation including river birch (*Betula nigra*), sycamore (*Platanus occidentalis*), and red maple (*Acer rubra*) (ODWC, 2005).

Large River (Grand-Neosho River)

The relative condition of Large River habitat is currently poor with a declining trend. The only large river within the Ozark Region is the Grand-Neosho River that forms its western boundary. The Grand-Neosho River is dammed, forming Grand Lake, which has a cove that borders the Refuge's Boy Scout Unit. Historically, the Grand-Neosho was a deep, swift moving river but has been modified by the construction of three reservoirs that have inundated most of the river's length. The ODWC considers the large river habitat to be the three impoundments, the remaining river channel that connects these and the seasonally flooded areas along the river and reservoirs (ODWC, 2005).

3.3.1.3 Natural Disturbance Processes

The Refuge experiences frequent, small-scale wildfires that normally range from a few acres to approximately 1,000 acres. Because of the remote locations of most Refuge units, there is little or no damage to structures or other property from the wildfires. Wildfires on the Refuge tend to benefit native species and are therefore beneficial to the natural biodiversity of the habitats.

Tornadoes and ice storms occur infrequently on Refuge lands. They damage trees by breaking limbs and occasionally uproot trees, resulting in localized areas of dense, tangled ground debris and clutter.

Ice storm in the Ozarks.
(Credit: Marvin Smith, Jan. 2009)

Seasonal floods occur on the Refuge's gravel bottomed streams. The naturally occurring floods benefit the bottomland forests and riparian areas by replenishing nutrients and maintaining the native vegetation. These flood events do not cause damage to any structures or other Refuge resources. Most caves in the Ozarks are part of the groundwater aquifer and were formed by water flowing through them due to frequent flooding during rain events. These caves provide substantial habitat for subterranean aquatic organisms adapted to these events. However, at times, flooding has caused problems for bats using caves that are inundated by water and also by repositioning sediments that either open or close cave passages.

The majority of earthquakes in eastern Oklahoma take place in both Oklahoma and Lincoln Counties, which are approximately 200 miles west of the Refuge (Oklahoma Geological Survey, 2010), however minor earthquakes, similar to the one occurring in Sally Bull Hollow during the summer of 2011, do infrequently occur in the seven-county acquisition area. These earthquakes may contribute to rocks falling within the caves.

3.3.1.4 Historical Habitat Description

The extent of pre-settlement savanna that occurred in the Ozark region is unknown. Some botanists have proposed that savanna was extensive in pre-settlement times, but others believe the area primarily was forest of varying tree densities. Most ecologists believe that before European settlement, the Ozark region consisted of plant communities with scattered, open-grown trees, primarily xeric oak (*Quercus*) species, intermixed with prairie. The Ozarks were described as beautifully picturesque; having an open grass area, with park-like groves, and where scattering oak trees interspersed did not inhibit the growth of grasses. In the late 1800's, tree

density had increased to an improved forest condition, as a result of the fence law enactment, which prevented livestock from grazing in woodlands. Despite the fact that the fence law was not enacted in portions of eastern Oklahoma until the mid-1900's, this increase in woody cover has been attributed to several factors, including soil erosion, prairie deterioration, gully formation and most commonly, fire suppression (Heikens, 1999).

Upland oak-hickory forests had a historic fire regime that played a significant role in their composition and structure (Lorimer, 2001; Abrams, 2005; Hutchinson et al., 2008). Most ecologists believe that, prior to European settlement, the Ozarks supported a lower-density forest, and that tree density generally has increased while the cover of herbaceous understory vegetation has been reduced due to fire suppression (Sauer, 1920; Howell and Kucera, 1956; Heikens, 1999).

3.3.1.5 Estimated Future Habitat Conditions due to Climate Change

Habitat within the Ozark ecoregion will respond to climate change in different ways and to varying extents, due in part to the heterogeneous impacts of climate change factors themselves and in part to other factors, such as the amount of stress an ecosystem may already be under and the adaptability of the species within it. The rate of potential adaptation may or may not be sufficient to keep pace with current and future rates of climate change (Bedoya et al., 2008).

According to TNC's climate wizard models, the northeastern Oklahoma region will have a 2-degree increase in annual temperatures and a 5% decrease in annual precipitation, (climatewizard.org, 2007). On the Refuge, changes in climate in and around caves may affect their habitat suitability for different bat species (Newson et al., 2009; page 109). Changes in temperature and rainfall patterns may affect both the timing and the availability of insect prey for bats (Newson et al., 2009, page 109). Warmer drier conditions may shift hardwood forests north and produce more woodland savannah conditions within the Refuge acquisition area. The Refuge would like to have more information on the effects of climate change on habitat and wildlife.

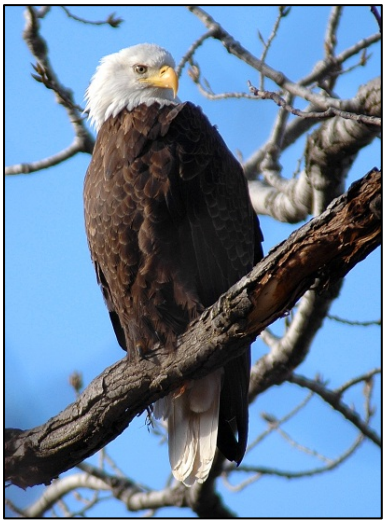
3.3.2 Wildlife and Plants

Wildlife

The area has a wildlife complement that represents Ozark oak-hickory and oak-hickory-pine forest, streams, springs, caves, aquifers, and other karst features on a landscape or ecoregion level. In addition to popular game and non-game species, it supports a diverse array of vertebrate and invertebrate species that not only are endemic to the Ozark Plateau, or Oklahoma, but are sometimes unique to each cave because of their isolation from one another. Because cave and aquifer ecosystem often develop their own endemic species complements, it is possible that numerous un-described and un-catalogued fauna may exist in the recently discovered, or yet

undiscovered, caves. Three new species of insects have been identified from one Refuge cave. The area encompasses the known distribution of the federally-listed endangered Ozark big-eared bat (*Corynorhinus townsendii ingens*), gray bat (*Myotis grisescens*), threatened Ozark cavefish (*Amblyopsis rosae*) and a portion of the endangered Indiana bat (*Myotis sodalis*) range in eastern Oklahoma and the Service's Southwest Region (Region 2). Also, two species of concern Oklahoma cave crayfish (*Cambarus tartarus*) and Delaware County cave crayfish (*Cambarus subterraneus*), use caves in the area. The forested areas surrounding the caves and overlying the aquifers not only protect groundwater quality in recharge areas but are also important for providing habitat for migratory bird and bat foraging, breeding, and nesting/roosting for wildlife species that need un-fragmented tracts of forest. Essential caves, movement corridors, and foraging habitat for the bats and ground water recharge areas supplying water to the aquifers used by the cavefish and cave crayfish may be found in the Refuge's seven-county approved acquisition area as well as across nearby state and Service Regional boundaries. This reflects in Ozark Plateau NWR's management goals of implementing a landscape approach for protection of habitats for a number of Service trust resources and the natural biological diversity in the Ozarks.

Ozark big-eared bats in AD125 Cave. (Credit: Steve Hensley)



Bald eagle near Fort Gibson. (Credit: Richard Stark, 2009)

Bald eagles (*Haliaeetus leucocephalus*) now have been delisted from federally endangered due to recovery and are found on the Refuge in northeastern Oklahoma because of the abundant rivers and reservoirs. The longnose darter (*Percina nasuta*), a federal species of concern, is found in one stream in the area (Lee Creek). Other federal species of concern found in the area include the eastern small-footed bat (*Myotis leibii*), the southeastern big-eared bat (*Corynorhinus rafinesquii*), the southeastern bat (*Myotis austroriparius*), the bat cave isopod (*Caecidotea macropoda*), the Bowman's cave amphipod (*Stygobromus bowmani*), the Ozark cave amphipod (*Stygobromus ozarkensis*), and Ozark chinquapin (*Castanea pumila var. ozarkensis*). In addition, the federally-listed endangered American burying beetle (*Nicrophorus americanus*) is also found within the acquisition area.

Plants

Prior to the 19th century, uplands were dominated by open stands of mature oak–hickory forest. Savannas consisting of scattered trees and tall grass prairies were also common throughout the project area. The open forest conditions and savannahs were maintained by periodic wild fires that resulted naturally from lightning strikes or were intentionally set by indigenous native tribes as a land management tool. Through decades of fire suppression, the forest stands are now much denser with a closed canopy and a greatly reduced herbaceous understory. Areas once dominated by savannahs have also evolved into dense stands of oak and hickory forest with shaded conditions that no longer support extensive areas of native grasses.

Spring leaves begin to green the Sally Bull Hollow Unit.(Credit: Steve Hensley)

Tree species found on upper drier ridges, include post oak (*Quercus stellata*), blackjack oak (*Quercus marilandica*), and black hickory (*Carya texana*). Shallow eroded soils consist primarily of post oak and blackjack oak. In the more fertile valleys, burr oak (*Quercus macrocarpa*), white oak (Quercus alba), yellow oak (Quercus muehlenbergii), bitternut hickory (*Carya cordiformis*), and pecan (*Carya illinoensis*) are most common. Black oak (*Quercus velutina*) and mockernut hickory (*Carya tomentosa*) occur on moderately deep soils with intermediate moisture conditions. Riparian zones, swales and wetlands support species such as water oak (*Quercus nigra*), sycamore (*Platanus occidentalis),* sweetgum (*Liquidambar styraciflua*), American elm (*Ulmus Americana*), red elm (Ulmus rubra), and green ash (*Fraxinus pennsylanica*). Persimmon (*Diospyros virginiana*) and sassafras (*Sasssafras albidum*) are found in the open areas where competition for sunlight and space is less intense. On steep north or northeast facing slopes, sugar maple (*Acer saccharum*), white oak (*Quercus alba*), and Shumard oak (*Quercus shumardii*) are common with a scattered occurrence of shagbark hickory (*Carya ovata*). Eastern redcedar (*Juniperus virginiana*), a highly invasive species is rapidly increasing over the entire project area as the result of continued fire suppression. Large areas of forestland throughout the project area have been cleared and planted with bermuda grass (*Cynodon dactylon*) and tall fescue (*Festuca arundinacea*) for pasture and hay production. A list of plants occurring on Ozark Plateau National Wildlife Refuge (surveyed by Dr. Ron Tyrl of OSU) is shown in Appendix D.

3.3.2.1 Priority Species

Priority species are identified based on federally listed threatened and endangered species, species of concern identified in the State's Oklahoma Comprehensive Wildlife Conservation Strategy, and representative species developed from the State Strategy and Refuge assessment.

Threatened and Endangered Species

Ozark big-eared bat. (Credit: Merlin D. Tuttle of BCI)

Ozark Big-Eared Bat

The Ozark big-eared bat was federally listed as endangered on November 30, 1979 (44 FR 69208). Critical habitat has not been designated. The final recovery plan was signed on March 28, 1995 (USFWS, 1995). A five-year review on the current status of the Ozark big-eared bat was completed by the Service on May 22, 2008, wherein the Service determined that the existing listing classification of endangered remains valid (USFWS, 2008). The Ozark big-eared bat was federally-listed as endangered in 1979 due to its small population size, reduced and limited distribution, and vulnerability to human disturbance. Disturbance of hibernating bats causes the loss of critical fat stores and increases the probability of starvation during the winter, while disturbance at maternity roosts can result in loss of young. The bat also is listed as endangered by the States of Oklahoma, Arkansas, and Missouri (although the species is believed to have been extirpated from Missouri).

Refuge Units that occur in Adair and Cherokee Counties provide important cave and foraging habitat for this species. There are twelve known “essential caves”, defined as a cave used by a maternity colony or as a hibernaculum, in Oklahoma, six of which occur on the Ozark Plateau National NWR (USFWS et al. [BABO HFRP], 2010). Five of the six are used as maternity caves and three as hibernacula. Approximately one-third of the known Oklahoma maternity colonies roost in caves that occur on the Refuge, while over 50% of the entire known population of Ozark big-eared bats hibernate in caves that occur on the Refuge.

The Ozark big-eared bat is an insectivorous bat that specializes on moths and uses caves year-round. Colonies typically begin to form at hibernacula in October and November (Clark et al., 1996 and 2002). Both sexes hibernate together in clusters that typically range from two to 135 individuals (Clark et al., 1993, 1997 and 2002). The Ozark big-eared bat is known to exhibit winter activity (Kunz and Martin, 1982; Clark et al., 2002). Hibernating colonies gradually begin to break up in spring from April through May (Clark et al., 2002). Females also begin to congregate at warm maternity caves to give birth and rear their young over the summer (Clark et al., 1993, 1996, and 2002). Distances between hibernacula and summer caves are known to range from 6.5 to 65 km (4 to 40 miles). The exact timing of the formation of maternity colonies varies between years, but usually occurs between late April and early June (Clark et al., 2002; USFWS, 1995). Like other temperate bats, the species exhibits strong roost fidelity, returning to

the same maternity sites and hibernacula year after year (Kunz and Martin, 1982; Clark et al., 1996; Weyandt et al., 2005).

Lepidoptera moth. (Credit: Sean Mack)

Ozark big-eared bats typically emerge from their caves to forage shortly after sunset (Clark et al., 1993 and 2002). Forested habitats are an important source of food for the Ozark big-eared bat. A recent study on the diet of the Ozark big-eared bat and prey abundance in Arkansas found that the bats prey on a wide diversity of moth species, and that most of the species are dependent upon woody forest plants as a host (Dodd, 2006). The study also found a positive correlation between woody species richness and moth occurrence. Conservation of the Ozark big-eared bat, therefore, requires not only protection of important caves but also forested habitat that supports abundant and diverse moth populations (Leslie and Clark, 2002; Dodd, 2006; Dodd and Lacki, 2007). Conservation practices that encourage a diversity of woody forest plant species (e.g., prescribed fire, selective thinning) to provide a rich prey base of moths benefit Ozark big-eared bat colonies. The Ozark big-eared bat has been shown to selectively forage in both edge and forested habitats and also to use habitats in proportion to prey availability.

A recent genetics study provides further insight into the need to protect each maternity colony. Weyandt et al. (2005) examined population genetic variability and found that maternally inherited markers differed among sites, indicating very strong site fidelity and limited dispersal by females and high natal philopatry.

Disease, including white-nose syndrome (*Geomyces destructans*) (WNS), which was not present at time of listing, and predation were not considered major factors for the endangered status of the Ozark big-eared bat. There was little information available on the disease, however this may affect their populations drastically in the future (see also Chapter 2: Sections 2.3.1. and 2.3.3 for more information on WNS).

The Service recently completed a 5-year review for the Ozark big-eared bat (USFWS, 2008). At the time of listing, the Ozark big-eared bat was known from only a few caves in northwestern Arkansas, southwestern Missouri, and northeastern Oklahoma. The entire population was estimated to consist of about 100-200 individuals. Since listing, additional caves used by

maternity colonies in the summer and as hibernacula have been discovered in Oklahoma and Arkansas. The population is estimated to currently consist of about 1,800 individual bats (Figure 3-8) with about 400 in Arkansas and 1,400 in Oklahoma.

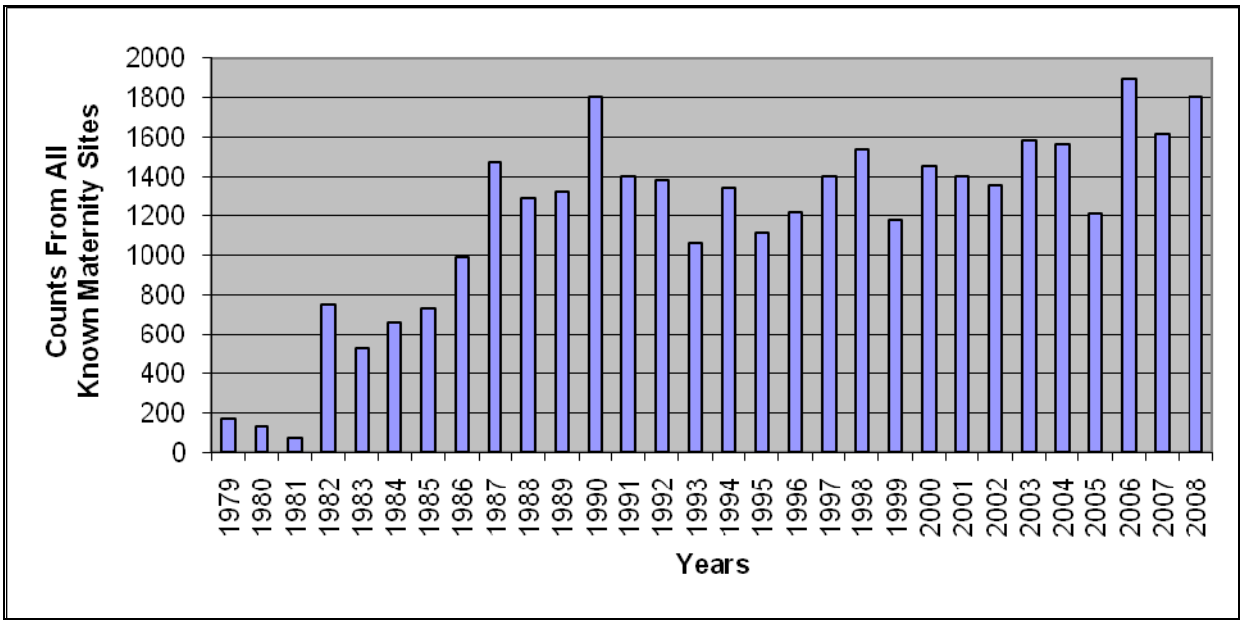


Figure 3-8. Population estimates of the Ozark big-eared bat by year since listing as endangered in 1979.

Census counts indicate that the overall population has experienced a slightly increasing trend since 1997 (Figure 3-9), when the last discovered essential maternity site from which we have several years of population data (a maternity cave in Arkansas) was added to the annual counts. The overall population estimate has averaged about 1,500 bats between 1997 and 2008. An increasing population trend is observed over this time period when the data from Arkansas is considered alone. In contrast, estimates from exit count data for Oklahoma indicate that the population size in Oklahoma has experienced an overall slightly declining trend since 1987, the first year in which annual monitoring efforts included all known essential maternity sites from the state. The apparent declining trend in Oklahoma may be attributable to movement among caves, including sites not known to us, and not an actual decrease in bat numbers, and due to the difficulty in monitoring bats at certain caves.

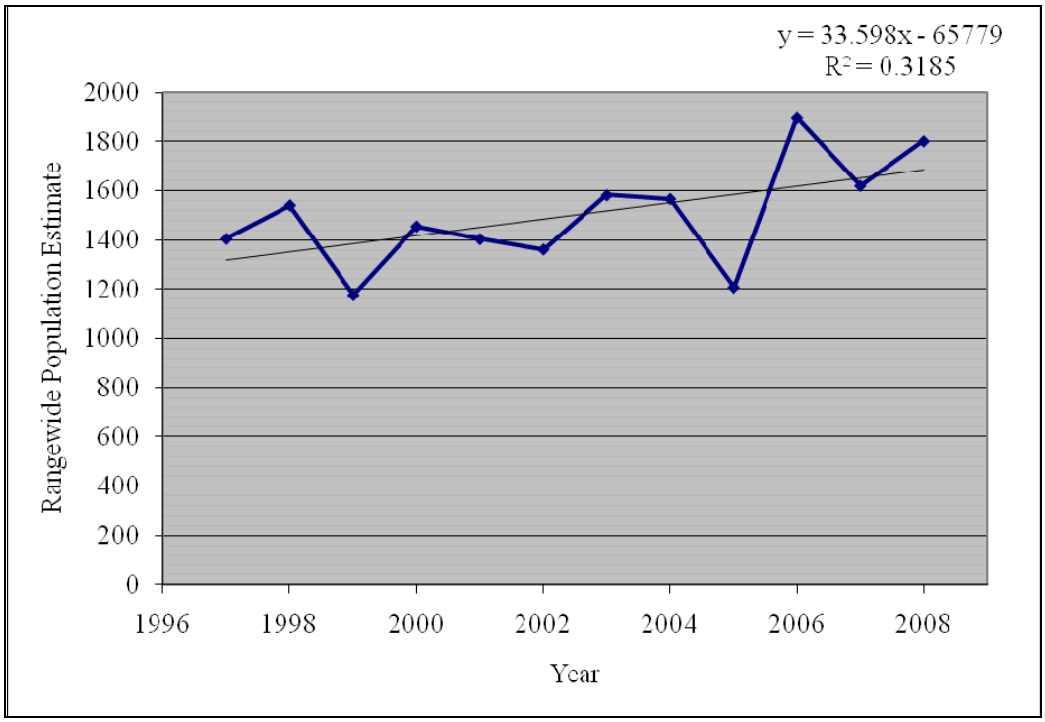


Figure 3-9. Overall Ozark big-eared bat population estimates based on summer counts from known maternity sites

Gray Bat

The gray bat was federally listed as endangered on April 28, 1976 (41 FR 17740). Critical habitat has not been designated. The final recovery plan was signed on July 8, 1982 (USFWS, 1982). The Service completed a five-review on the status of the gray bat on September 30, 2009 (USFWS, 2009). The Service determined that the existing listing classification of endangered remains valid primarily due to the potential threat of WNS.

Hibernating gray bat. (Credit: Richard Stark)

The gray bat is a medium-sized bat with gray fur. The species belongs to the plain-nosed bat family, *Vespertilionidae*, and is one of the largest species within the genus *Myotis* in eastern North America (Decher and Choate, 1995).

The gray bat can be distinguished from other species in the genus *Myotis* by the uniform color of its dorsal fur in which hair shafts are gray from base to tip. The dorsal hairs of other bats within its range are bi- or tri-colored. Additionally, the wing membrane attaches at the ankle of the foot instead of at the base of the toes as in other members of the genus (Barbour and Davis, 1969; Harvey et al., 1981; Decher and Choate, 1995; Tuttle and Kennedy, 2005). The calcar on gray bats is not keeled and the skull has a distinct sagittal crest (Harvey et al., 1981; Mitchell, 1998).

Gray bats are one of the few species of bats in North America that inhabit caves year-round, migrating each year between winter and summer caves. Gray bats have been documented to regularly migrate from 17 to 437 km between summer maternity caves and winter hibernacula (Tuttle 1976b; Hall and Wilson 1966). Gray bats exhibit strong philopatry to both summering and wintering sites (Tuttle, 1976a; Tuttle, 1979; Kennedy and Tuttle, 2005; Martin, 2007).

Winter hibernation sites are typically deep vertical caves that trap large volumes of cold air (Tuttle, 1976a; Harvey et al., 1981; Harvey, 1994; Martin, 2007). Hibernation sites also often have multiple entrances where there is good air flow (Martin, 2007). During hibernation, the species typically forms large clusters with some aggregations numbering in the hundreds of thousands of individuals (Harvey, 1994; Tuttle and Kennedy, 2005). It is estimated that 95% of the species range-wide population hibernates in only nine caves (Tuttle, 1979).

Gray bats feed on flying insects over bodies of water including rivers, streams, lakes and reservoirs. Mayflies, caddisflies, and stoneflies make up the major part of their diet, but beetles and moths also are consumed (Harvey, 1994; Tuttle and Kennedy, 2005). Gray bats are known to travel up to 35 kilometers from caves to prime feeding areas (La Val et al., 1977; Tuttle and Kennedy, 2005). However, most caves are within 1-4 km (0.6 – 2.5 miles) of foraging areas (Tuttle, 1976b).

Stoneflies, a delicious food source for the gray bat. (Credit: Gilbert Rowley; flytying123.com)

Likely predators include wildlife known to prey on bat species such as snakes, owls, hawks, raccoons, bobcats, and feral house cats. Predation and WNS were not considered significant threats at the time of listing.

The fungus associated with WNS (*G. destructans*) was documented recently on gray bats in Missouri during the spring of 2010. Mortality events attributable to WNS have not occurred in any gray bat populations to date. Research is ongoing to determine whether all bats that come into contact with the fungus will develop WNS. However, the discovery of the fungus on gray bats is cause for concern. WNS appears to kill only hibernating bats. Conservation biologists, therefore, are concerned that gray bat populations may be impacted during future hibernation seasons. Because a large percentage of the gray gat population hibernates in a limited number of caves, disease transmission could occur rapidly and the resulting impacts could be severe.

In the 1982 approved Gray Bat Recovery Plan, populations at 13 sites (45%) have been stable or increasing (USFWS, 2009). Populations of many gray bat priority caves also have been

monitored, and roughly 33% of priority caves across the species' range have stable or increasing populations (USFWS, 2009).

Sasse et al. (2007) analyzed data from 48 gray bat maternity sites involving three subpopulations in the Ozark Highlands of Missouri, Arkansas, and Oklahoma between 1978 and 2002. The authors report that 79% of these colonies were stable or increasing. However, Elliott (2008) estimated that despite an overall increase in gray bat numbers in Missouri, the overall state population of this species was still only about 46% of what the maximum past population historically was.

Ozark Cavefish

The Ozark cavefish (*Amblyopsis rosae*) was listed as threatened on November 1, 1984 (49 FR 43965). Critical habitat has not been designated. The final recovery plan was signed on December 17, 1986 and revised in 1989 (USFWS, 1989). A five-year review of the listing status is currently being conducted by the Service.

Ozark Cavefish (Credit: Dante Fenolio)

Ozark cavefish are small fish reaching a maximum total length of about 5.0 cm (about two inches). The fish are true troglobites (i.e., obligatory cave or aquifer inhabitants). They lack pigment, but appear pinkish-white because their translucent skin reveals blood and organs. The Ozark cavefish has only rudimentary eyes and no optic nerve since their lives are spent in the darkness of caves. The Ozark cavefish is difficult to distinguish from other cavefish species in the field. Differentiation is based on degrees of cave adaptation.

Knowledge of cavefish life history is limited. The species is believed to have low reproductive capacity and to be slow to reproductive maturity (Robinson and Buchanan, 1988). Infrequent reproduction may be an adaptation to a limited food supply.

The Ozark cavefish primarily feeds on small crustaceans such as copepods, isopods, and amphipods. Cavefish also prey upon small crayfish, small cavefish, oligochaetes (e.g., segmented worms), small salamanders and salamander larvae (Poulson, 1963).

The Ozark cavefish is considered the most adapted of all the cavefish for cave life due to well-developed sensory papillae. They tend to occur in caves with groundwater recharge (as opposed to caves that rely on surface water sources), and generally are acknowledged to be a groundwater obligate. Ozark cavefish occur in flowing cave streams with chert rubble substrate and pool areas. They also have been found in wells and sinkholes.

Ozark cavefish have no known documented predators. Predation likely occurs at times by species known to use caves such as raccoons and surface fish species that may enter caves. Similarly, disease currently is not considered to be a factor in population viability.

The Ozark cavefish has not been observed for over six years in 19 of the 35 sites that currently are considered occupied. Of the remaining 16 sites, the Service currently considers six populations to be in decline while 10 are considered stable (David Kampwerth, USWFS Recovery Lead, pers. comm.). However, Graening et al. (2009) recently conducted population trend analyses for seven currently occupied caves, and found two to have increasing population trends. Trends were not detected from the other five caves examined due to high variance and limited data. Cave Springs and Logan Caves represent approximately 80% of all countable Ozark cavefish. The other 12 occupied sites are represented by counts of 1-2 individuals typically, although higher counts have occurred.

A range wide estimate of countable cavefish using recent population monitoring numbers suggests about 220 individuals (Graening et al., 2009; David Kampwerth, USWFS Recovery Lead, pers. comm.). However, it must be noted that the population size of the Ozark cavefish is difficult to estimate. Biologists can only enter those "portals" (i.e., caves with streams, sink holes, wells) large enough to accommodate our size. Because we are unable to access groundwater conduits that the fish are distributed throughout, we can only count fish in accessible reaches of caves and wells.

Table 3-3. Oklahoma State Species of Concern occurring on the Refuge

Common Name	Scientific Name	Global/State Conservtion Status
Eastern small-footed bat	Myotis leibii	
Southeastern bat	Myotis austroriparius	
Rafinesque's big-eared bat	Corynorhinus rafinesquii	
Longnose darter	Percina nasuta	
Grotto Salamander	Eurycea speleae	G4 / S3
Oklahoma cave crayfish	Cambarus tartarus	G1 / S1
Bowman's cave amphipod	Stygobromus bowmani	
Ozark cave amphipod	Stygobromus ozarkensis	
Bat cave isopod	Caecidotea macropoda	
A cave amphipod	Stygobromus alabamensis	
Onondaga cave amphipod	Stygobromus onondagaensis	
A cave isopod	Caecidotea ancyla	
A cave springtail	Pseudosinella sp. nov.	N/A
Ozark chinquapin	Castanea pumila var. ozarkensis	

Migratory Birds

The Refuge is located where the Central and Mississippi Flyways indiscernibly merge. This area also is located within the Central Hardwoods Bird Conservation Region (BCR), which is one of 67 BCRs identified by the four major bird initiatives operating under the auspices of the North American Bird Conservation Initiative (NABCI). BCRs are the regional ecological units through which the NABCI hopes to ensure the long-term health of North America's native bird populations.

Cerulean Warbler (Credit: Anonymous)

A wide variety of bird species occur in this area. One of the purposes of Ozark Plateau NWR's establishment is to protect large continuous stands of mature Ozark forest essential to interior forest nesting migratory birds such as tanagers, warblers, and flycatchers that require nesting some distance from an edge (see Table 3-4). Because the Ozark Highlands contain some of the more extensive forests remaining in the central United States, the area likely serves as habitat for populations of interior forest bird species of conservation concern such as the Cerulean warbler (*cerulean Dendroica cerulean*) and worm-eating warbler (*Helmitheros vermivorus*). The habitats associated with the floodplains of the area's rivers and streams, such as wooded riparian zones, and emergent wetlands, and the reservoirs that occur within the Ozark Highlands provide habitat for numerous species of migratory waterfowl, water birds, and shorebirds. Waterfowl species common during spring and fall migrations include the mallard (*Anas platyrhynchos*), gadwall (*A. strepera*), canvasback (*Aythya valisineria*), and lesser scaup (*A. affinis*), while wood ducks (*Aix sponsa*) are the primary breeding species of waterfowl in the area.

Table 3-4. Central Hardwoods Bird Conservation Region Priority Bird Species (2012)

Forest-Woodland Priority Species	Continental Concern	Regional Concern
Red cockaded woodpecker	Y	Y
Brown-headed nuthatch	Y	Y
Cerulean warbler	Y	Y
Swainson's warbler	Y	Y
Bachman's sparrow	Y	Y
American woodcock	Y	Y
Wood thrush	Y	Y
Worm-eating warbler	Y	Y
Kentucky warbler	Y	Y

Ruffed grouse		Y
Yellow-billed cuckoo		Y
Whip-poor-will		Y
Northern flicker		Y
Eastern wood-pewee		Y
Blue-gray gnatcatcher		Y

3.3.2.2 Representative/Focal Species

Ozark Plateau NWR was established to prevent the extinction and help in recovery of federally listed threatened and endangered Ozark cave species, and prevent the need for listing additional species of concern. For that reason, the Refuge will focus monitoring those species as their "representative species". "Representative species" are defined by the Service as species that represent larger guilds of species that use habitats similarly. Therefore, if the sustainability of a representative species is dwindling due to, for example, habitat fragmentation or poor habitat management, then it is assumed that many other wildlife species also interconnected within this habitat will be affected similarly. Monitoring both the habitat conditions concurrently with the health and population sustainability of the following threatened and endangered species and species of concern (see Table 3-5) will reflect the overall effectiveness of Refuge habitat management actions and guide future adaptive management strategies.

Table 3-5. Representative Species of Ozark Plateau NWR and respective federal and state status.

Ozark big-eared bat (*Corynorhinus townsendii ingens*)	Endangered
Gray bats (*Myotis grisescens*)	Endangered
Indiana bat (*Myotis sodalis*)	Endangered
Ozark crayfish (*Cambarus aculabrum*)	Endangered
Ozark cavefish (*Amblyopsis rosae*)	Threatened
Neosho madtom (*Noturus placidus*)	Threatened
Bald eagle (*Haliaeetus leucocephalus*)	Recovered
Eastern small-footed bat (*Myotis leibii*)	Species of Concern
Southeastern bat (*Myotis austroriparius*)	Species of Concern
Southeastern big-eared bat(*Plecotus rafinesquii*)	Species of Concern
Longnose darter (*Percina nasuta*)	Species of Concern
Ozark cave crayfish (*Cambarus tartarus*)	Species of Concern
Bowman's cave amphipod(*Stygobromus bowmani*)	Species of Concern
Ozark cave amphipod(*Stygobromus ozarkensis*)	Species of Concern
Bat cave isopod (*Caecidotea macropoda*)	Species of Concern
Ozark chinquapin(*Castanea pumila var. ozarkensis*)	Species of Concern

The area encompasses the existing known range of the federally endangered Ozark big-eared bat (*Corynorhinus townsendii ingens*) in Oklahoma. The Ozark big-eared bat is generally associated with caves, cliffs, and rock ledges in well drained, mature oak-hickory Ozark forests. Maternity caves and hibernacula occur in a number of different surroundings, from large continuous blocks of forest, to smaller forest tracts interspersed with open areas for agile maneuvering while foraging. All bat species on the Refuge play a major role in affecting both terrestrial species (controlling the local insect and pest populations) and subterranean species. Federally endangered gray bats (*Myotis grisescens*), federally endangered Indiana bats (*Myotis sodalis*), federally threatened Ozark cavefish (*Amblyopsis rosae*), and species of concern, cave crayfish (*Cambarus tartarus*) also use caves in the area, and frequently the same caves. Each of these species is directly or indirectly connected with one another in a complex cave food web. For instance, the bats feed on terrestrial insects (outside the cave) and deposit guano inside the cave. Guano is a highly nutritious protein-rich substance because bats don't completely digest their food (Bat Conservation International, 2005). Bat droppings in turn support an unusual and healthy subterranean ecosystem (Bat Conservation International, 2005). Within the caves, fungus and microscopic decomposers break down organic material such as guano, feeding a slew of other species including the Ozark cave amphipod and cave isopods. These creatures in turn feed the cave crayfish and Ozark cavefish. To conclude, bat guano supports a unique mycological community within Ozark caves (Graening, et al, 2011).

Other federal species of concern found in the area include the eastern small-footed bat (*Myotis leibii*), the southeastern big-eared bat (*Corynorhinus rafinesquii*), the southeastern bat (*Myotis austroriparius*), the bat cave isopod (*Caecidotea macropoda*), the Bowman's cave amphipod (*Stygobromus bowmani*), and the Ozark cave amphipod (*Stygobromus ozarkensis*). Isopods and amphipods, which feed on algae, diatoms, dead animals and/or plants, and bacteria, also play an important role in purifying cave or stream water.

Ozark cave amphipod (Stygobromus ozarkensis)
(Credit: Dante Fenolio, 2011)

Bald eagles (*Haliaeetus leucocephalus*) are no longer listed but are still protected and are found on the Refuge and in northeastern Oklahoma because of the abundant reservoirs and rivers. Bald eagles play an important role as a bird of prey controlling populations of small mammals and fish species occurring on and off the Refuge. The sustainability of bald eagles will indicate the quality and quantity of water resources on the landscape scale as well as reflect the abundance of prey. Lastly, the longnose darter (*Percina nasuta*), a federal species of concern, is found in one

stream in the area (Lee Creek) and feeds on small aquatic invertebrates. The fish will be another indicator of the health of the local aquatic resources that support many other fish and wildlife species.

3.4 Socioeconomic Environment

This section describes the socioeconomic environment of Ozark Plateau NWR. It includes a discussion of nearby human populations and economies; the archeological, cultural, and historical resources associated with the Refuge; public use opportunities and access; and public use and Service administrative facilities.

3.4.1 Population

The socioeconomic region contains Adair, Cherokee, Craig, Delaware, Mayes, Ottawa, and Sequoyah Counties- basically the northeast corner of Oklahoma. All the counties are not far east of Tulsa, Oklahoma, which has a population of approximately 916,000 (2008). However, the eastern counties adjacent to Arkansas also are not far west of Fayetteville and Fort Smith, Arkansas, with a 2008 population estimate of approximately 421,000. They are the largest and closest cities to provide certain services and amenities that are unattainable within the counties. Western Arkansas is one of the fastest growing areas in the nation and the related development is moving toward eastern Oklahoma. Such growth will probably result in substantial increases in Oklahoma land values in the future. The 2008 population estimate range for all seven Oklahoma counties in the project area was between 15,132 and 45,733, with all but 2 counties in the 30,000+ range. The region retains a rural flavor, even though some individual cities and towns are bustling with economic activity.

Suburban sprawl in Bentonville, AR. (Credit: treehugger.com, 2008).

Population change can be an indicator of economic vitality, the types of economic sectors that are likely to be strong, probable development, disturbance impacts on wildlife habitat, and trends in real estate markets. The following table shows population changes in the seven counties between the 2000 census and 2008 population estimates.

Table 3-6. Ozark Plateau NWR Acquisition Area Population, 2000-2008. (Bureau of the Census)

County	2000 Census Population	2008 Population Estimates	Number Increase, 2000-2008	Percent Increase, 2000-2008
Adair	21,038	21,811	773	3.7%
Cherokee	42,521	45,733	3,212	7.6%
Craig	14,950	15,132	182	1.3%
Delaware	37,077	40,425	3,348	9.0%
Mayes	38,369	39,912	1,543	4.0%
Ottawa	33,194	31,849	-1,345	-4.0%
Sequoyah	38,972	41,034	2,062	5.3%
Area Total	**226,121**	**235,896**	**9,775**	**4.3%**

3.4.2 Economy

3.4.2.1 Regional Economic Profile

The primary economic sectors (categories of economic activities) in the region include manufacturing, government, services, agriculture (including timber), and retail trade (Government Information Sharing Project). Although, not listed as a specific economic sector, tourism is an increasing contribution to local economies, especially through the sectors of services and retail trade. Other economic sectors in the project area include construction; finance, insurance, and real estate; transportation/utilities; wholesale trade; agricultural services; and a small amount of mining.

3.4.2.2 Economic Significance of the Refuge

Land acquired from willing sellers in fee by the Service is removed from the county tax rolls. However, to offset lost tax revenues, the county receives an annual payment in lieu of taxes, as provided by the Refuge Revenue Sharing Act of 1935 (16 U.S.C. 7145:49 Stat. 383, as amended). Funding is provided for these payments from net income from the sale of products or privileges on Service lands and appropriated funds from Congress. Some examples of receipts are oil and gas royalties, grazing fees, timber sales, etc. These funds are distributed based on one of the three following formulas that provide the highest return to the county:

- Seventy-five cents per acre,
- 25% of the net revenue received from the operation of the Refuge, or
- 3/4 of 1% of the appraised value of the property, which must be reappraised by the Service every five years (this formula is the most commonly applied).

If not enough revenues are available in the fund to make full payments, the Service distributes the funds proportionately nationwide. Congress is authorized to make up the difference. For Fiscal Year 2009, the Fish and Wildlife Service paid Adair County $3,018, Delaware County $1,059, and Ottawa County $303.

Refuge Revenue Sharing payments usually exceed the property taxes paid by the previous private landowners in cases where agricultural exemptions exist. The payment figure varies due to local land price trends and at what level Congress appropriates additional funds to make up the shortfall. The Service is required to reappraise its refuge lands every 5 years to allow for adjustments in the payments to account for local land price trends. Private landowners continue to pay property taxes on lands on which the Service holds conservation easements.

3.5 Archeological, Paleontological, Cultural, and Historical Resources

3.5.1 Archeological and Paleontological Resources

The Refuge has partnered with the State Historic Preservation Office and the Sam Noble Museum of Natural History concerning archeological and paleontological sites for a number of years. Short-faced bear, tapir, peccary, and dire wolf remains have been discovered in caves on and near the Refuge. In addition, arrowheads, spear points, and grinding stones used by Native Americans during pre-settlement times, possibly by the Caddo and Osage Tribes, have been found on and near the Refuge. There is a possibility for unknown historical, archeological, and/or paleontological sites to be discovered in the future on or near the Refuge. With the help of the Refuge's partners, valuable information can be identified and preserved.

3.5.2 Cultural Resources

The Service, as are all other federal agencies, is required to protect cultural resources on all acquired lands under Section 106 of the National Historic Preservation Act of 1966, the Archeological Resources Protection Act of 1979 and the Antiquities Act of 1906 by consulting with the State Historic Preservation Officer or the Oklahoma Archeological Survey regarding the protection of any potential cultural resource sites on specific properties proposed for acquisition. If any archaeological or historical resources are acquired in the expanded area, Refuge management activities are supposed to protect or minimize impact on such resources. If cultural resources are found during construction of any Refuge facility, the Service is required to salvage or protect those resources. For those lands remaining in private ownership, it is a voluntary consideration by the private landowner to ensure protection of these resources.

The Ozarks are the home of a number of Native American Nations both here aboriginally and those forced to relocate here. Now these Nations have a significant influence on the past and present culture of the area and many of the people are of Native American ancestry. Native

American Nations in the seven-county area include the Cherokee, Creeks, Delaware, Eastern Shawnee, Miami, Modoc, Muskogee, Osage, Ottawa, Peoria, Quapaw, Seneca-Cayuga, and Wyandotte. Archeological sites may be extent throughout the region (http://www.travelok.com/).

3.5.3 Historical Resources

The Ozarks are significant for their history involving their use by early Native Americans as well as Native American tribes later forced to relocate from the east and west, and the westward expansion of European-American settlers and freed African-Americans after the Civil War. Numerous historic sites occur in the region such as homes, buildings, cemeteries, farmsteads, and settlements. Significant sites within the project area include original tribal government locations, Sequoyah's home, Tsa La Gi Cherokee Village, Fort Gibson Stockade, the Tri-State Mining area in Ottawa County, and a number of local museums associated with early settlement and timber industry. (Oklahoma Department of Tourism website, http://www.travelok.com).

There are several historical sites on Ozark Plateau NWR. For example, there are the remains of an old wagon trail that ran between Sallisaw and Tahlequah, Oklahoma on the Potter Unit, as evidenced by old bridge abutments. This trail was the main thoroughfare for local travelers, prior to the development of roads and highways. Crystal Cave on the Potter Unit was a commercial cave used for local dances in the 1920s and 30s. There is an old rock dam on the Potter Unit that was constructed to provide swimming opportunities dating back to pre-1916. Cabins and infrastructure on the Mary & Murray Looney Unit have historical significance to the caving community in the Ozarks because they were used by many caving experts as a base station to explore caves in eastern Oklahoma and western

Historical cabin used by Oklahoma caving community for decades. Currently, the "Mary & Murray Looney Education & Research Center" (MMLERC) of Ozark Plateau NWR. (Credit: Steve Hensley)

Arkansas, including January-Stansbury Cave, which was later donated by Mary and Murray Looney to the Refuge (Graening, 2011).

3.6 Current Management & Administration

This final section describes how the Refuge currently administers and manages its resources including: funding and staffing, facilities and infrastructure, landscape level resources/issues, Refuge habitats and wildlife, public uses, and cultural resources.

3.6.1 Administration

Currently, there are three full-time Refuge staff members, one Wounded Warrior, one Student Conservation Association (SCA) intern, and one part-time Student Career Experience Program (SCEP) student. Refuge Headquarters is currently located at the Mary & Murray Looney Education & Research Center (MMLERC), which provides only one office. Due to limitations on office space at these Headquarters, each of these staff members described above works out of either the Oklahoma Ecological Services (ES) Field Office in Tulsa, the MMLERC (Refuge), and/or Sequoyah NWR.

Refuge Manager, Wildlife Refuge Specialist, and Maintenance Worker. (Credit: Brian Fuller, 2010)

3.6.1.1 Funding & Staffing

The Refuge receives funding and staffing for operations, infrastructure and maintenance, through the Department of the Interior budget approved by Congress, and allocated to refuges by the U.S. Fish and Wildlife Service Southwest Regional Office. Refuge staff continues to seek additional funding elsewhere, such as applying for grants and working with NGOs, in order to implement all current management activities and educational programs.

As mentioned above, Refuge staff currently consists of three permanent full-time exempt (FTE) employees. These include:

- Refuge Manager/Wildlife Biologist (GS-12)
- Deputy Refuge Manager/Wildlife Refuge Specialist (GS-07/09)
- Maintenance Worker (WG-07/08)

Additional staff and work volunteers include:

- Wounded Warrior
- SCA intern
- SCEP student
- Youth Conservation Corps member (shared with Sequoyah NWR)
- Volunteers: 10 to 20 volunteers per year from the local chapter of the National Speleological Society (Tulsa Regional Oklahoma Grotto, Central Oklahoma Grotto, Arbuckle Mountain Grotto) and other organizations that provide 300 to 1,000 hours of volunteer labor per year
    - Volunteers help with a number of projects including cave mapping, cave gates construction/repair/maintenance, environmental education, invasive plant removal, trail maintenance, litter and trash cleanup, cabin renovation and maintenance, chimney repair, 2010 Ozark Summit administration and support, research and citizen science, and wildlife inventorying and monitoring
- At present there is no formal Friends Group
    - However, the Tulsa Regional Oklahoma Grotto (local chapter of the National Speleological Society) has served as an informal friends group for over 20 years. Being a 501(c) non-profit, they have assisted with numerous projects and have held donated land for the Refuge while going through the long realty process.

3.6.1.2 Administrative Facilities and Infrastructure

Mary & Murray Looney Education & Research Center (MMLERC)
The Refuge currently operates and maintains the Mary & Murray Looney Education & Research Center (MMLERC), a 1,200 square feet, semi-renovated cabin with one meeting room, one office, two bathrooms, one sleeping room, and a kitchen. The MMLERC is ADA-accessible from the parking lot into the cabin. Adjacent to the MMLERC, there is an un-renovated and un-used outdoor pavilion consisting of 300 square feet enclosed studio space and a 200 square feet outdoor patio.

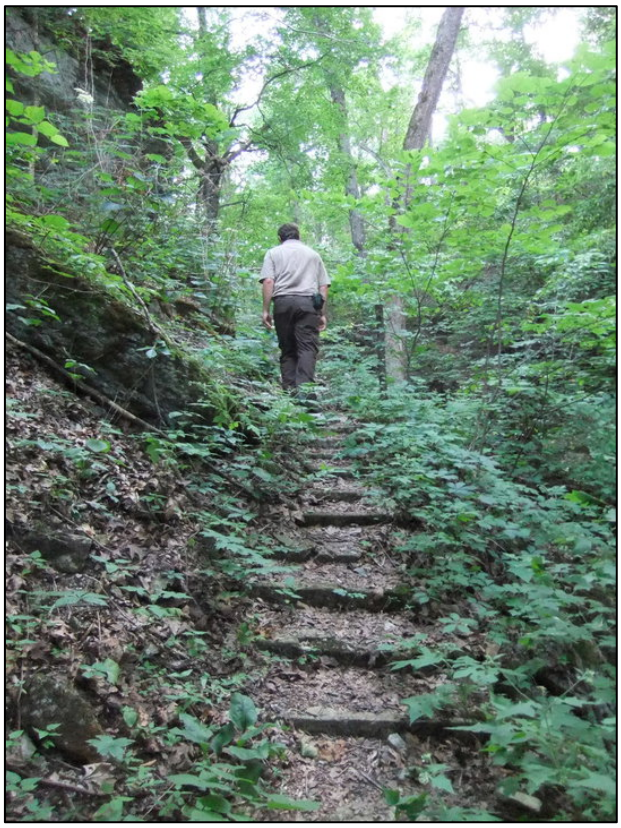
Refuge Headquarters Site
The Refuge operates Refuge Headquarters at the MMLERC cabin, which provides only one office and is primarily used for hosting environmental education (EE) and interpretation programs. Refuge staff currently works from various office locations (non-centralized) including the Oklahoma Ecological Services Field Office in Tulsa, the MMLERC (Refuge), and/or Sequoyah NWR.

Access Roads
The Refuge uses and maintains a 0.25-mile, unpaved and unimproved (dirt/rock) access road to the MMLERC, with a gate. There is an unpaved parking area (power cut easement), between the entry gate and MMLERC, for approximately 10 vehicles near the MMLERC. Excess parking is

available near the maintenance shop, next to the Guess House (150 yards). Refuge staff utilizes a very narrow access road to the Beck Unit maintenance shop which currently does not have a turn-around area.

Nature Trails and Overlooks

Currently, the Refuge utilizes and maintains a few trails around the Refuge including a deteriorating path from the MMLERC to the pavilion, a small path from the parking area to the MMLERC, one 1/4-mile trail from MMLERC to Spavinaw Creek, 1/8-mile trail from MMLERC to the old garden area at top of hill, 150-yard trail from Guess House to the MMLERC, and 1/4-mile of trails near the Guess House on the Looney Unit. Currently, there are no established overlook areas.



Walking the lush nature trails of the Looney Unit. (Credit: Sarah Catchot)

Public Use Signs and Interpretive Displays

Currently, the Refuge neither posts public use signs for any Refuge units, except for at the entrance of caves stating that they are closed to the public, nor posts interpretive displays at the MMLERC or on the Looney Unit. The signs in the cave entrances are designed and placed so as not to draw attention to the cave.

Boundaries

There are 60 miles of unit boundaries with a total of over 4 miles of fencing and 11 gates that are maintained and repaired by Refuge staff. Only two of the Refuge units have been completely surveyed and marked (see Chapter 2, Table 2-3).

Maintenance Shops and Service Buildings

The Refuge utilizes and maintains two maintenance shops and one storage building including: Beck Unit Shop: 50’ x 30’ metal building on concrete pad for cave gate construction and storage; Looney Unit Shop: 50 x 30 metal building on concrete pad for all other maintenance and contains a WNS decontamination site; and Guess House metal storage building: 30' x 20'.

Refuge Housing

Ozark Plateau NWR provides Refuge housing for Refuge staff at the Guess House, located on the Looney Unit and one bedroom at the MMLERC cabin for volunteers, researchers, interns,

educators, Refuge staff, and other guests. In addition, the Refuge would currently maintain a life use agreement with Leslie Krause, in which, after he resides and maintains Krause House on the Beck Unit, the house reverts to the Refuge (via donation) at termination of agreement.

Utilities/Right-of-ways

The only utility right-of-ways on the Refuge are two Public Service of Oklahoma electric utility and telephone right-of-ways on the Looney Unit and Beck Unit. On the Looney Unit, a 1,400 ft. right-of-way runs from the county road on the west side east to the MMLERC cabin and a 1,100 ft. right-of-way runs from the east side west to the Guess House. On the Beck Unit, a 200 ft. right-of-way runs from Highway 10/59 south to the Krause House.

3.6.1.3 Oil and Gas Operations/Management

The Refuge owns mineral rights on all units. Currently, there are no mineral extraction operations on any Refuge lands and none are anticipated in the future.

3.6.1.4 Partnerships

Since Ozark Plateau NWR (originally the Oklahoma Bat Caves National Wildlife Refuge) was established in 1985, the Service staff has continually kept local, municipal, county, state, tribal, and Congressional officials and agencies apprised of its activities.. Cooperative partnerships with landowners to protect and manage caves and surrounding habitat on private property have been successful. Numerous collaborative research, monitoring, protection, mapping, and management ventures have helped protect the Ozark big-eared bat, gray bat, and Ozark cavefish populations and helped prevent extinction of other federally listed species as well as reduce the need for future listing of species of concern.

Caving partners and volunteers. (Credit: Steve Hensley)

In addition to acquiring fee title and conservation easements from willing sellers, the Service has also purchased management easements from TNC. It has also developed management agreements with the City of Tulsa and the Cherokee Nation for certain tracts of land and established an inter-agency agreement with the Ozark National Forest in Arkansas to coordinate cave and karst management. In addition, the Service worked with the Oklahoma Department of Wildlife Conservation (ODWC) to develop a project to protect caves and foraging habitat on private land that is funded through Section 6 of the Endangered Species Act. The Service's

Partners for Fish and Wildlife Program has also been used to assist private landowners in protecting caves and foraging habitat on their lands. In addition, the Service is helping to implement the Natural Resource Conservation Service's (NRCS) Healthy Forest Reserve Program to protect federally listed cave species in eastern Oklahoma on private land surrounding the Refuge.

Partnerships continue to be an important part of the Refuge's actions to acquire, manage, and conserve lands, inventory and monitor, conduct research, assist in protecting and restoring habitat, share information about resources, conduct environmental education, and reduce Ozark habitat loss and fragmentation. The Refuge continues to build and maintain relationships with landowners adjacent to and near the Refuge, private businesses, citizen science groups/projects, NGOs, local, state, tribal, and federal agencies (for a full list of partners, see Chapter 5, Table 5-1).

3.6.1.5 Memorandums of Understanding & Agreements

The Refuge maintains partnerships with private landowners, conservation organizations, state, tribal, and federal agencies through conservation agreements, memoranda of understanding (MOU), the Partners for Fish and Wildlife Program, Section 6 of the Endangered Species Act, and provides technical assistance. Currently, the Refuge has a conservation agreement (in need of updating) adjoining the Liver Unit in Adair County with the Cherokee Nation to protect and provide cave access across 120 acres. Also the 130 acre-Eucha Unit is managed through a conservation agreement with the City of Tulsa on Spavinaw Creek and adjoins the Beck Unit in Delaware County. It protects a historic federally listed endangered Ozark big-eared bat cave and groundwater recharge areas to an aquifer used by federally listed threatened Ozark cavefish. Also, the Refuge has entered into a memorandum of agreement (MOA) with Ozark National Forest just across the state line in Arkansas and Region 4 of the Fish and Wildlife Service to cooperate on cave management and cave species monitoring. In addition, the Refuge works with the National Speleological Society (NSS) through a national memorandum of understanding between the Service and NSS to assist with implementation of the Federal Cave Resource Protection Act to help with cave management, exploration, mapping, inventorying, resource monitoring, cave gate construction, clean up, and search for important undiscovered caves and other karst resources. The Refuge also works with Bat Conservation International (BCI) through a national memorandum of understanding between the Service and BCI to protect, study, and manage bats and their habitat.

3.6.1.6 Law Enforcement and Resource Protection

The Refuge currently shares a Law Enforcement (LE) Officer with Sequoyah NWR and works with the Service's Zone LE Officer from Salt Plains NWR and Division of Law Enforcement out of Edmond, OK. In addition, it relies on assistance from ODWC Game Wardens, County Sheriff

Deputies, Oklahoma Highway Patrol, and Cherokee Nation Marshals. The Refuge has also worked with other state, tribe, and/or federal LE agencies to ensure legal compliance, safety, and protection of Refuge resources.

3.6.1.7 Safety

The Refuge currently follows their (draft) Ozark Plateau NWR Station Safety Plan, Cave Safety Plan, and utilizes a cave-specific "job hazard analysis", which identifies risks and recommended protective measures for caving activities.

3.6.2 Current Landscape-level Management

3.6.2.1 Ozark Habitat Loss & Fragmentation

Land and Conservation Easements Acquisition from Willing Sellers and Conservation Agreements
The Refuge addresses habitat loss and fragmentation by acquiring land and conservation easements from willing sellers (up to 15,000 acres) and entering into conservation agreements with private landowners, conservation organizations, state, Tribal Nations, and other federal agencies. The Refuge does not build or permit the construction of any new roads or infrastructure on Refuge lands except for Refuge operation purposes and would continue its practices of maintaining and restoring forested habitat as resources allow. Conservation Agreements with Cherokee Nation, City of Tulsa, and private landowners continue to preserve forested and/or cave habitats.

Restoration
The Refuge restores 70 acres of agricultural land to forested habitat at the Beck Unit. Additionally, the Refuge maintains approximately 4,000 existing acres as forested habitat.

3.6.2.2 Climate Change

Monitoring
The Refuge staff and university partners monitor baseline cave microclimates with temperature and humidity loggers, which record data every fifteen minutes or every hour everyday year-round. The loggers are located in one Refuge cave and one cave managed jointly with TNC.

Service staff and university partners monitor known maternity colonies and hibernacula annually. Two techniques are used to estimate colony size at these caves. 1) Conduct an exit count as the bats emerge from the cave at night to forage using night vision optics, thermal videography, and infrared videography. 2) For most gray bat maternity sites, guano pile measurements are taken in the fall or winter to estimate colony size. Acoustic monitoring is also used to gain insight on use of Refuge tracts and caves by bat species.

The technique used at the hibernacula consists of entering the cave and counting the bats. Monitoring bat population sizes on private, State, Tribal, and Refuge lands provides baseline information for understanding how climate change is affecting populations.

Using night vision optics to count bats emerging from summer maternity cave. (Credit: Sarah Catchot, 2010)

The Refuge conducts surveys by contracting with universities, nongovernmental organizations, and working with volunteers to monitor mammals, birds, herps, fish, cave invertebrates, terrestrial insects, and vegetation. Table 3-7 shows surveys that have been completed on the Refuge Units.

Table 3-7. Species Surveys Completed on Ozark Plateau NWR until 2012.

Species Survey	*Management Unit Surveyed*
Mammals	• Sally Bull Hollow
Birds	• Sally Bull Hollow • Mary & Murray Looney • Eucha • Beck • Potter
Herpetofauna	• Sally Bull Hollow
Fish	• Sally Bull Hollow
Cave invertebrates	• Sally Bull Hollow • Eucha • Beck • Gittin Down Mountain • Liver • Varmint • Mary & Murray Looney • Potter • Boy Scout
Terrestrial insects	• Sally Bull Hollow • Mary & Murray Looney
Vegetation	• Sally Bull Hollow • Gittin Down Mountain • Liver • Mary & Murray Looney

Green Infrastructure
The Refuge installs and maintains energy-efficient appliances and a heating and cooling system (stove, refrigerator, dishwasher, hot water heater, washer and dryer) at the MMLERC. Water filtration systems are also maintained at the MMLERC and Guess House, thereby reducing the need to bring bottled water onto the Refuge.

Carbon Sequestration
There is no current monitoring of this.

3.6.2.3 Surface and Ground Water Quality & Quantity

Land and Conservation Easements Acquisition from Willing Sellers
The Refuge acquires land and conservation easements from willing sellers to protect the land from development. In the past 25 years, the Refuge has purchased 3,572.35 acres in fee, 162 acres of conservation easements, manages 359 acre of conservation agreements, anticipates purchasing about 400 acres in the next few years, and is approved to acquire up to 15,000 acres from willing sellers in the future. Once acquired, the Refuge implements appropriate forest management practices to control water run-off such as burning to control fuel loads and invasive species, planting native species, thinning, controlling unauthorized grazing, and monitoring the health of the forest and effects of management practices. The Refuge uses adaptive forest management practices on its existing 4,093.35 acres of oak-hickory forest, grasslands, and riparian areas within recharge areas.

Steve Hensley gets wet as he emerges from cave. (Credit: Shea Hammond)

Groundwater Mapping
The Service works with private landowners, NGOs, universities, Tribal Nations, USGS, and Regional Service Hydrologist, I&M, and Contaminants personnel to map groundwater recharge areas within the acquisition area, in and around all Refuge units, including private lands, specifically used for locations where Ozark cavefish, cave crayfish, and other important aquatic cave organisms are present. The Refuge identifies all landowners in determined and potential recharge zones and seeks permission to perform delineation process, which consists of using fluorescent-dye tracing to determine recharge areas, general directions of groundwater flow, and minimum and maximum groundwater travel times in days and miles from losing streams as a result of dye tracing.

Monitoring
The Refuge partners with universities, USGS, EPA, Oklahoma Department of Environmental Quality, and OWRB to monitor surface and groundwater quality (amount of pesticides, nitrates, phosphates, pharmaceuticals, and heavy metals) on and around all units on the Refuge. Water sampling has taken place on the Mary & Murray Looney Unit and other Refuge units.

The Refuge also partners with local municipalities and water authorities to share information about water levels affecting the Refuge. The Refuge coordinates surface water quality monitoring in Spavinaw Creek with the City of Tulsa and the State of Oklahoma. Spavinaw Creek is a water supply source for the City of Tulsa. The Refuge and the City share this monitoring data.

Partnerships
The Refuge works with adjacent and nearby landowners (private, NGOs, state, Tribal Nations and federal agencies) to implement conservation agreements, assist with wildlife management through the Partners for Fish and Wildlife program and Section 6 of the Endangered Species Act, and provide technical assistance.

3.6.2.4 White-nose Syndrome (WNS)

WNS National Plan
The Refuge would implement the actions and standards in the current White-nose Syndrome National Plan (http://www.fws.gov/whitenosesyndrome/pdf/WNSnationalplanMay2011.pdf), as it is updated. At this time, the actions include controlling access to caves for only WNS research and monitoring needs, decontaminating cave gear, and monitoring T&E and non-T&E bats to establish baseline data on Refuge and neighboring private-land caves.

Monitoring
The Refuge partners with universities, caving organizations and other NGOs, state, Tribal Nations, USGS, and other federal agencies to monitor for WNS on- and off- the Refuge.

Public Outreach
The Refuge performs public outreach regarding WNS by visiting schools and leading educational or interpretive discussions about the issue, discussing it with local landowners and organizations, and producing exhibits/booths on the topic.

Cave Access Control
The Refuge posts signs prohibiting public entry in all Refuge caves, constructs and maintains cave gates to control access to caves, and receives on-call LE support from Sequoyah NWR.

3.6.2.5 Migration Corridors

The Refuge monitors baseline bird and bat populations in caves and on bat routes using mobile acoustic monitoring to identify high risk areas and locate areas that would minimize impacts of wind energy farms and other development projects.

3.6.3 Current Habitat Management

3.6.3.1 Degradation of Cave, Stream, and Forest Habitat

Protective grill over Ozark big-eared bat cave on Liver Unit. (Credit: Steve Hensley)

Cave Protection
The Refuge continues its current activities with caving organizations and other volunteers to build, maintain, and repair approximately 50 cave gates on- and off-Refuge. The Refuge posts signs prohibiting entry at cave locations, continues a policy of maintaining confidentiality of cave locations, and implements the Federal Cave Resource Protection Act. LE officers stationed at Sequoyah NWR and a Zone Officer at Washita NWR provide "on-call" response to investigate cave gate vandalism and consult on effective monitoring actions. The Refuge partners with local residents, TNC, Grand River Dam, and State/Tribal Game Wardens to monitor for unauthorized entry to caves and report any sightings or violations to the Refuge Staff. The Refuge staff also removes trash and some graffiti from caves, when necessary.

Fire Management
See Fire Management category below.

Boundaries
The Refuge surveys and marks Refuge boundaries, as funding becomes available.

Partnerships
The Refuge consults with adjacent landowners about any illegal grazing issues and removes any illegal dump materials.

3.6.3.2 Lack of Detailed, Scientific Cave Habitat Data

Research and Monitoring

The Refuge contributes research efforts on the Ozark Subterranean Biodiversity Project, similar projects, and other cave fauna bio-inventories in collaboration with the USFS, NPS, Tribal Nations, state agencies, universities, TNC and other NGOs, on all Refuge units and surrounding private lands. Additionally, the Refuge conducts annual monitoring surveys of bat hibernacula and maternity sites, as well as cavefish and cave crayfish surveys. The technique used at the maternity sites consists of conducting an exit count as the bats emerge from the cave at night to forage using night vision optics, thermal videography, and infrared videography. For most gray bat maternity sites, guano pile measurements are taken in the fall or winter to estimate colony size. Acoustic monitoring is used to gain insight on use of Refuge tracts and caves by bat species. The technique used at the hibernacula consists of entering the cave and counting the bats. The Refuge also searches for additional cave locations and cave mapping efforts on known caves with Refuge staff, cavers, NSS and other partners. Cave mapping informs the Refuge staff of overlying landowners and help to identify outreach efforts.

Refuge Manager and Biologist return to the "light of the sun" after a hard day's work monitoring in the caves. (Credit: Shannon Wallace)

3.6.3.3 Invasive Flora

Fire Management

See 3.6.3.4 Fire Management category below.

Herbicide Treatment

The Refuge does not currently use chemical treatments for invasive flora.

Mechanical Treatment

The Refuge removes invasive plants with hand tools, chainsaws, and uses a tractor to mow approximately 10 acres total one time per year on the Krause, Looney, Sally Bull Hollow, and Eucha Units.

Partnerships
The Refuge continues to work in partnership with the City of Tulsa and Land Legacy for challenge cost-share for invasive plant control using hand tools or mechanical treatment, plantings, and prescribed burning (see 3.6.3.4 Fire Management below). The Refuge also continues partnerships through agreements with private landowners for prescribed burns by Service personnel on approximately 400 acres every 3-5 years. The Refuge also inventories vegetation in partnership with Oklahoma State University to monitor native and invasive plants.

Prescribed burn on the Looney Unit. (Credit: Shea Hammond)

3.6.3.4 Fire Management

Ozark Plateau NWR enhances its Fire Management Program through assistance provided by Service personnel of the Oklahoma/North-Texas Fire Management District (remotely located at Wichita Mountains Wildlife Refuge).

Wildfire Management
The Refuge typically experiences frequent, small-scale wildfires that normally range from a few acres to approximately 500 acres per year. Management responds to a wildland fire on Refuge lands based on objectives established in the applicable Habitat Management Plan (HMP) and Fire Management Plans (FMP). A wildfire may be concurrently managed for more than one objective. Response to wildland fire is based on ecological, social, and legal consequences of the fire. Responses to wildland fire are coordinated with all affected agencies/tribes/cooperators regardless of the jurisdiction at the ignition point. The appropriate response to wildland fire is dictated by:

- the circumstances under which a fire occurs;
- the likely consequences to firefighter/public safety and welfare; and
- the natural/cultural resource values to be protected

Initial response is the immediate decisions and actions taken to react to an ignition. These decisions and actions may include a management or initial decision to postpone taking action on the ground based on conditions, safety, and/or competing priorities. Initial response to human-caused wildfires will be to suppress the fire at the lowest cost with the fewest negative consequences with respect to firefighter and public safety. Unplanned natural ignitions may be managed to achieve HMP and FMP objectives when risk is within acceptable limits. Wildland Fire Decision Support System has tools available to assist in these decision processes, 1)

organizational needs assessment, 2) complexity analysis. Objectives established in applicable HMP and FMPs direct strategy/tactics selected in response to wildland fires on federal land.

The Refuge receives wildfire suppression assistance from local fire departments, the Oklahoma Department of Agriculture, Food and Forestry – Oklahoma Forestry Services, Tribal Nations, and Service personnel and other federal agency personnel. The Refuge pursues funding to implement 1) FireWise activities 2) coordination/training with adjacent volunteer fire departments and 3) community wildfire protection plan (CWPP-e) actions and fuel treatments.

Prescribed Fire Management

The Refuge implements their FMPs on the Looney and Sally Bull Hollow Units. Treatment goals for forest management are to maintain open understory, reduce fuel loads, and foster mature oak-hickory or oak-hickory-pine overstory, while increasing understory diversity through prescribed fire. Prescribed fire is planned on a 3 to 5 year rotation. Although actual acres treated per year vary due to units selected for treatment and treatment boundaries, an annual average of approximately 400 acres per year is treated during the rotation cycle. Currently, the Refuge does not have a FMP to perform prescribed fire management on other Refuge units.

Monitoring

All projects are monitored to determine if treatment objectives were met and to document weather, fire behavior, fuels information, and smoke dispersion. Evaluation reports are to be completed and maintained in the project file and accomplishment reports (namely, FMIS and NFPORS), as per agency requirements.

3.6.4 Current Wildlife Management

3.6.4.1 Threatened and Endangered (T&E) Species and Species of Concern

Monitoring and Research

The Refuge contributes scientific research efforts on the Ozark Subterranean Biodiversity Project, similar projects, and other cave fauna bio-inventories in collaboration with the USFS, NPS, Tribal Nations, state agencies, universities, TNC and other NGOs, on all Refuge units and some surrounding private lands.

FWS biologist handling an Ozark big-eared bat. (Credit: Shea Hammond, 2011)

Additionally, the Refuge conducts annual monitoring surveys of bat hibernacula and maternity sites, as well as cavefish and cave crayfish surveys. The technique used at the maternity sites

consists of conducting an exit count as the bats emerge from the cave at night using night vision optics, thermal videography, and infrared videography. For most gray bat maternity sites, guano pile measurements are taken in the fall or winter to estimate colony size. The technique used at the hibernacula consists of entering the cave and counting the bats. Radio telemetry and acoustic monitoring surveys are done to gain insight on migration and movement corridors bat species utilize.

Partnerships

The Refuge partners with private landowners, the NSS, TNC, the City of Tulsa, universities, the Grand River Dam Authority, ODWC, Tribal Nations, and USGS to conduct monitoring and surveys of T&E species on- and off- Refuge. The Refuge also partners with Oklahoma State University and University of Central Oklahoma to perform genetic research on bat species to identify genetic diversity and gather information related to WNS.

Surveying cave crayfish. (Credit: S. Hensley)

Fire Management

See 3.6.3.4 Fire Management above.

3.6.4.2 Migratory and Resident Bird Species

The Refuge conducts bird point counts during the spring and other migration seasons to monitor bird populations and establish data trends over time. The Refuge uses prescribed fire to promote ideal nesting/foraging habitat in Ozark forests for bird species (see 3.6.3.4 Fire Management). The Refuge enforces the policies of limited public use activities and maintains continuous forest habitats to favor interior forest bird species.

"Yellow-throated warbler feeds its fledgling". (Credit: Phil W./"it'slaterthanyouthink" of flickr.com, 2004)

3.6.4.3 Resident Non-T&E Species

Monitoring

The Refuge conducts mobile acoustic monitoring once or twice a month from the spring through fall from roadways and videography of cave entrances during the spring and summer to determine non-T&E bat population counts and habitat preferences. Collecting this information allows the Refuge to continue assessing population declines due to WNS and habitat loss, focus

conservation efforts on specific habitat types, and fulfill the Refuge's mission of preventing the listing of species.

Bioinventories
The Refuge performs approximately one bio-inventory in 2 or 3 caves every 5 years by volunteers and other partners to monitor other cave species.

3.6.4.4 Invasive Fauna Species and Pest Management

The Refuge does not currently manage for invasive fauna species or pests.

3.6.5 Current Public Use Opportunities

3.6.5.1 Hunting

The Refuge does not currently allow hunting.

3.6.5.2 Environmental Education

The Refuge manages high-quality, environmental education (EE) programs on the Looney Unit and at the Mary & Murray Looney Education & Research Center (MMLERC), by permit only. These programs are limited to 10-20 people, 2 or 3 times per week in the spring and fall, 1 or 2 times per week in the summer, and approximately once per month in the winter. These EE programs are primarily "place-based" on Refuge resources- including on-site, field-based classes and experiential education in Ozark forests, streams, riparian areas, and karst environments on the Looney Unit and/or on nearby private lands in cooperation with local residents.

EE programs are hosted, sponsored, and lead in cooperation with multiple partners. The Refuge works with Ozark Tracker Society to provide placed-based EE programs to teach tracking, survival, bird language, and mentoring skills as while fostering opportunities for people to develop a meaningful relationship with nature. Ozark Plateau NWR also coordinates Refuge-based collegiate-level classes and field trips, with the following universities: Oklahoma State University (OSU), University of Oklahoma (OU), Rogers State University (RSU), Northeastern State University (NSU), University of Arkansas (UA), University of Southern Mississippi, University of Missouri, Missouri State University, and John Brown University. As part of overnight EE programs, NGOs and university groups (of approximately 30 people maximum) camp "primitively" overnight in the designated area, by permit only, approximately 12 weekends per year. Local K-12 school classes conduct site visits to the Looney Unit and MMLERC for resource education programs. The Refuge coordinates with tribal entities to provide tribal-hosted EE programs from a Native American cultural perspective in their Native language and English to share information regarding cultural and natural resources, local ethno-botanical knowledge, and healthy living and cooking using native/natural edible plants. The Refuge works

Coyote mentoring program at the MMLERC. (Credit: Shea Hammond, 2010)

with many other partners including: BCI, Blue Thumb, Boy Scouts of America, Campfire USA, Land Legacy, NSS, Tulsa Audubon Society, TNC, and approximately 1,000 hours from dedicated volunteers.

3.6.5.3 Interpretation

The Refuge manages interpretive programs regarding cave and karst resources for approximately 25 people per month on-site at the Looney Unit and MMLERC, and five to several hundred people per month off-site at schools and events. On-site interpretation programs are conducted in coordination with local residents, BCI, Blue Thumb, Boy Scouts of America, Campfire USA, Land Legacy, NSS, Ozark Tracker Society, Tulsa Audubon Society, TNC, universities including OSU, OU, RSU, NSU, UA, and John Brown University. On-site programs (aside from introductory interpretive discussions for most EE groups that visit the Refuge) are primarily for school and youth groups, civic organizations, naturalists/scientists, university faculty and students, Tribal groups, Service staff, and other agency staff. Interpretation may include short interpretive hikes on primitive trails and discussions that interpret natural and cultural information regarding the Ozark ecoregion, karst ecosystem, geology, water resources, Native American cultural resources and paleo resources, federally listed T&E species, especially about bats and other cave species, species of concern, game and nongame species, migratory birds, and cave technology

Hidden shelter. (Credit: Shea Hammond)

demonstrations (anabat acoustic detectors, real-time infrared and thermal videography, night vision, etc). Refuge staff conducts visits to local K-12 schools, especially in October to make interpretive presentations on bats, usually during the Halloween season.

3.6.5.4 Wildlife Observation & Photography

The Refuge provides wildlife observation and photography opportunities by permit only on the Looney Unit, in conjunction with interpretive and/or EE programs, to view and/or photograph Ozark Plateau NWR's diverse habitats including Refuge forests, streams, and cave exteriors as well as wildlife including resident and migrating birds, mammals, fish, insects and butterflies, etc. There are currently no opportunities for unescorted, unpermitted wildlife observation and photography.

3.6.5.5 Wood Harvesting

The Refuge does not currently permit wood harvesting by the public.

3.6.5.6 Public Outreach

Refuge staff performs public outreach by hosting information booths and making presentations at public shows, such as the Illinois River Festival and the Wildlife Expo in central Oklahoma. The Refuge maintains a Fish and Wildlife Service website with limited information. Confidentiality is maintained to protect sensitive cave and karst resources. As is currently, no pamphlets or fliers about the Refuge are available.

3.6.6 Current Cultural Resource Management

3.6.6.1 Historical Sites

The Refuge protects historical sites by keeping those areas confidential and limiting public access. The Refuge partners with SHPO and Tribal Nations to preserve these sites.

3.6.6.2 Archeological and Paleontological Sites

There are currently four known archeological sites on Sally Bull Hollow, Potter, and Looney Units and short-faced bear and tapir remains on one Refuge Unit. All these sites are kept confidential with limited public access. The Refuge partners with Sam Noble Museum archeologists and paleontologists (from University of Oklahoma), SHPO, and Tribal Nations to preserve all archeological and paleontological sites.