U.S. Fish & Wildlife Service

HABITAT MANAGEMENT PLAN

LOGAN CAVE NATIONAL WILDLIFE REFUGE

Benton County, Arkansas

Southeast Region

Logan Cave National Wildlife Refuge

Habitat Management Plan

U.S. Department of the Interior
Fish and Wildlife Service
Southeast Region

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I. INTRODUCTION

Throughout the century of its existence, the National Wildlife Refuge System has established a reputation as premier ground for the refinement of habitat management techniques. Since the establishment of Pelican Island National Wildlife Refuge in 1903, refuge employees have taken pride in developing the latest tools for wildlife conservation with limited resources. Some of the first examples of rocket nets and airboats, equipment now considered essential for wildlife management, were developed by refuge employees. The first prescribed fire on refuge lands was conducted in 1927, at a time when the benefits of this natural process were not well recognized and most federal agencies still considered fire to have "no place in any forest" (USFS 2004).

As the discipline of wildlife management evolved, largely through the efforts of Aldo Leopold with his publication of *Game Management* in 1933, it was recognized that a greater emphasis needed to be placed on making decisions that are based on the best science of the day, while retaining some of the artful intuition that comes from years of field experience. Sound wildlife management will always involve the skillful integration of science and art in disciplines as diverse as biology and sociology.

Habitat is defined as simply "the physical and biological surroundings of an organism" (Bolen and Robinson 1995). It includes all of the natural components of an ecosystem that are essential for survival including food, cover, and water. The processes that shaped features in northwest Arkansas, including Logan Cave National Wildlife Refuge (NWR), are complex and dynamic. This Habitat Management Plan (HMP) was developed to provide a clear, science-based outline for managing Logan Cave NWR in this challenging environment. To this end, this HMP was developed as a first step in closing the gap between the needs of wildlife and the knowledge of its stewards on Logan Cave NWR.

PLANNING PROCESS

A habitat management plan is a dynamic working document that provides a refuge manager with a decision-making process; provides guidance for the management of refuge habitat; and provides long-term vision, continuity, and consistency for habitat management on refuge lands. Each plan incorporates the role of refuge habitat in international, national, regional, tribal, state, ecosystem, and refuge goals and objectives; guides analysis and selection of specific habitat management strategies to achieve those habitat goals and objectives; and utilizes key data, scientific literature, expert opinion, and staff expertise.

The statutory authority for conducting habitat management planning on national wildlife refuges is derived from the National Wildlife Refuge System Administration Act of 1966 (Administration Act), as amended by the National Wildlife Refuge System Improvement Act of 1997 (Improvement Act), 16 U.S.C. 668dd - 668ee. Section 4(a)(3) of the Improvement Act states: "With respect to the System, it is the policy of the United States that each refuge shall be managed to fulfill the mission of the System, as well as the specific purposes for which that refuge was established …" and Section 4(a)(4) states: "In administering the System, the Secretary shall monitor the status and trends of fish, wildlife, and plants in each refuge." The Improvement Act provides the Service the authority to establish policies, regulations, and guidelines governing habitat management planning within the National Wildlife Refuge System (Service Manual 620 FW 1).

A habitat management plan is a step-down management plan of the comprehensive conservation plan (CCP). A CCP describes the desired future conditions of a refuge or planning unit and provides long-range guidance and management direction to achieve the purpose(s) of each refuge; helps fulfill the mission of the National Wildlife Refuge System (Refuge System); maintains and, where appropriate, restores the biological integrity, diversity, and environmental health of each refuge and the Refuge System; helps achieve the goals of the National Wilderness Preservation System, if appropriate; and meets other mandates. The CCP for Logan Cave NWR was finalized in 2008 (USFWS 2008).

Habitat management plans comply with all applicable laws, regulations, and policies governing the management of Refuge System. The lifespan of an HMP is 15 years and parallels that of refuge CCPs. HMPs are reviewed every 5 years, utilizing peer review recommendations, as appropriate, in the HMP revision process or when initiating refuge CCPs. Annual Habitat Work Plans (AHWP) will contain management specifics and are prepared annually.

REFUGE PURPOSES

The purposes of a national wildlife refuge, as established by Congress or the Executive Branch, are the barometers by which all actions on that designated public land are measured. Habitat management, public use, and all other programs are required to fulfill the established purposes of the refuge.

Logan Cave NWR was established in 1989 under the authority of the Endangered Species Act of 1973 (16 U.S.C. 1534), with the following purpose:

> "…to conserve fish or wildlife which are listed as endangered species or threatened species."

In addition to the specific purposes that were established for each refuge, the Improvement Act provides clear guidance for the mission of the Refuge System and prioritizes wildlife-dependent public uses. The Improvement Act states that each refuge will:

- Fulfill the mission of the Refuge System;
- Fulfill the individual purposes of each refuge;
- Consider the needs of wildlife first;
- Fulfill requirements of comprehensive conservation plans that are prepared for each unit of the Refuge System
- Maintain the biological integrity, diversity, and environmental health of the Refuge System; and
- Recognize that wildlife-dependent recreation activities, including hunting, fishing, wildlife observation, wildlife photography, and environmental education and interpretation are legitimate and priority public uses; and allow refuge managers authority to determine compatible public uses.

REFUGE VISION

The refuge vision was developed for the Comprehensive Conservation Plan for Logan Cave NWR (USFWS 2008).

> *Logan Cave National Wildlife Refuge will maintain and enhance communities and habitats necessary for the continuing existence and recovery of federally listed endangered and threatened species. Through communication, cooperation, and consultation, the refuge will foster partnerships with private landowners and other interested parties for the conservation of important Ozark cave habitat.*

RELATIONSHIP TO OTHER PLANS

A CCP was finalized for Logan Cave NWR in 2008, which includes goals and objectives for refuge management over a 15-year period (USFWS 2008). The Biological Review Report was conducted in 2010 to aid in the development of this HMP. The purpose of this HMP is to provide more specific guidance that will facilitate the selection of prescriptions for implementing the goals and objectives of the CCP. In order to maintain consistent strategies for managing wildlife and habitats on the refuge, several other planning documents were used in the development of this plan.

Refuge endangered species with approved recovery plans include the following:

- Gray bat (*Myotis grisescens*), which is federally listed as endangered, uses Logan Cave NWR for a maternity site;
- The Benton Cave crayfish (*Cambarus aculabrum*), which is federally listed as endangered;
- The Ozark cavefish (*Amblyopsis rosae*), which is federally listed as threatened; and
- Indiana bat (*Myotis sodalist*), which is federally listed as endangered, historically hibernated in Logan Cave NWR.

Logan Cave NWR lies within the focus area of a variety of regional or ecosystem-based conservation plans and cooperative initiatives.

<u>Arkansas Wildlife Action Plan</u> (Anderson 2006): This plan, developed by teams of wildlife professionals representing both public agencies and private organizations, provides a comprehensive strategy for determining priorities and effectively allocating funding for state wildlife grants.

The plan presents a list of “Species of Greatest Conservation Need” (SGCNs) and uses a standardized protocol to assign a “Species Priority Score” to each SGCN. For each species on the list of SGCNs, the plan summarizes information on habitat requirements, conservation problems and threats, data gaps and research needs, monitoring strategies, and recommended conservation actions. State-wide maps of reported occurrence and potential habitat are also provided for each SGCN.

Habitat management for SGCNs is approached on the basis of U.S. Environmental Protection Agency (USEPA) Level III ecoregions. For each ecoregion, the plan lists the SGCNs likely to be present, ranks the problems threatening the SGCNs, identifies the types of habitats that occur, and makes general recommendations on appropriate conservation actions. To support more detailed analyses, the plan also provides information on evaluating the status and quality of each of the individual habitat types. Species lists for Logan Cave NWR include 67 birds and 13 mammals that are designated as SGCNs in this plan (http://www.wildlifearkansas.com/strategy.html).

Arkansas/Red Rivers Ecosystem Plan (USFWS 2000): This plan, developed by the Service with input from state fish and wildlife agency partners, is intended to guide the Service as it sets priorities, allocates resources, and conducts its activities and programs in the Arkansas/Red River Basins.

The plan presents strategies and action items for the following general objectives:

- Maintain and improve water quantity
- Maintain and improve water quality
- Conserve and restore focus species
- Conserve and restore focus habitats
- Increase public outreach efforts relative to service programs, and
- Improve outdoor recreational opportunities.

Gray Bat Recovery Plan (USFWS 1982): This plan was completed in 1982 and provides priorities for protection and management of caves, guidelines for protection of foraging habitat, public education, and monitoring procedures. Logan Cave NWR was purchased mainly to protect the maternity gray bat colony that uses the cave. Several of the recovery actions listed in the plan have been implemented at Logan Cave NWR, such as gating and fencing cave openings, providing protection and management, and monitoring population.

Indiana Bat Recovery Plan (USFWS 2007): The original plan was completed in 1983 and revised in 2007 by the Indiana Bat Recovery Team. The plan provides the current status of the Indiana bat, its habitat requirements, and limiting factors and actions needed for recovery.

Ozark Cavefish Recovery Plan (USFWS 1989): This plan was completed in 1989 and outlines distribution, status, habitat requirements, limiting factors, and causes of decline for the Ozark cavefish. Several of the recovery actions listed in the plan have been implemented at Logan Cave NWR, such as gating and fencing cave openings, providing protection and management, and monitoring population and one-year baseline water quality parameters.

Recovery Plan for the Benton Cave Crayfish: This species was listed as endangered in 1993. At that time, *C. aculabrum* was known to exist in only two caves in northwest Arkansas: Logan Cave and Bear Hollow Cave. Since then, this crayfish has been found in two additional locations. The plan outlines known habitat requirements, limiting factors, and actions needed for recovery. Several of the recovery actions listed in the plan have been implemented at Logan Cave NWR, such as gating and fencing cave openings, providing protection and management, and monitoring population and one-year baseline water quality parameters.

Ozark Ecoregional Conservation Assessment (TNC 2003): This assessment of the Ozarks ecoregion was divided into different subunits to accommodate sub-ecoregional variability bases on biophysical processes and biogeographic patterns of different functional group of biota. The team logically divided the Ozarks into various subsectional classification systems depending on the system and biota: terrestrial, karst, or surface aquatic systems. From a terrestrial perspective, the Ozarks are divided into two sections, the Boston Mountains and Ozark Highlands, each with distinct subsections. Distributional patterns of karst fauna are more related to subsurface bedrock and aquifer patterns than to surface topography. Five distinct karst subsections occur within the ecoregion. These karst subsections are not directly correlated with terrestrial subsections. The plan describes the ecological stressors that threaten biodiversity in these systems and then develops strategies to address threats. Logan Cave NWR is located in the Springfield Plateau terrestrial subsection and the Springfield karst subsection of the Ozark Highlands.

Partners for Amphibians and Reptile Conservation (PARC) Plan: This plan was founded in 1998 to address the need for conservation of herpetofauna-amphibians and reptiles-and their habitats. Its mission is to conserve amphibians, reptiles, and their habitats as integral parts of the ecosystem and culture through proactive and coordinated public/private partnerships.

II. BACKGROUND, INVENTORY, AND DESCRIPTION OF HABITAT

LOCATION

Logan Cave NWR, established in 1989, is located near the northwest corner of Benton County (Figure 1) and includes a limestone solution cave with approximately 1.5 miles of passageways. Logan Cave NWR provides habitat for the endangered Gray bat, endangered Benton Cave crayfish, and the threatened Ozark cavefish. The cave also has historically provided habitat for the endangered Indiana bat. Logan Cave NWR is located in the Gulf Coastal Plain and Ozarks Landscape Conservation Cooperative.

PHYSICAL OR GEOGRAPHIC SETTING

CLIMATE

Because of its geographic location, Northwest Arkansas' weather is characterized by sudden and dramatic changes in temperature and climate as warm, moist air from the Gulf of Mexico collides with cold air from Canada and hot, dry air from the Southwest. The average high temperature is 68 degrees Fahrenheit and the average low is 44 degrees Fahrenheit. The recorded high and low temperatures are 114 degrees Fahrenheit and -15 degrees Fahrenheit, respectively. Average rainfall is 45 inches and the average snowfall is 12 inches. The first frost of the cold season typically occurs between October 9 and October 13, and the last frost of the season typically occurs between April 8 and April 19.

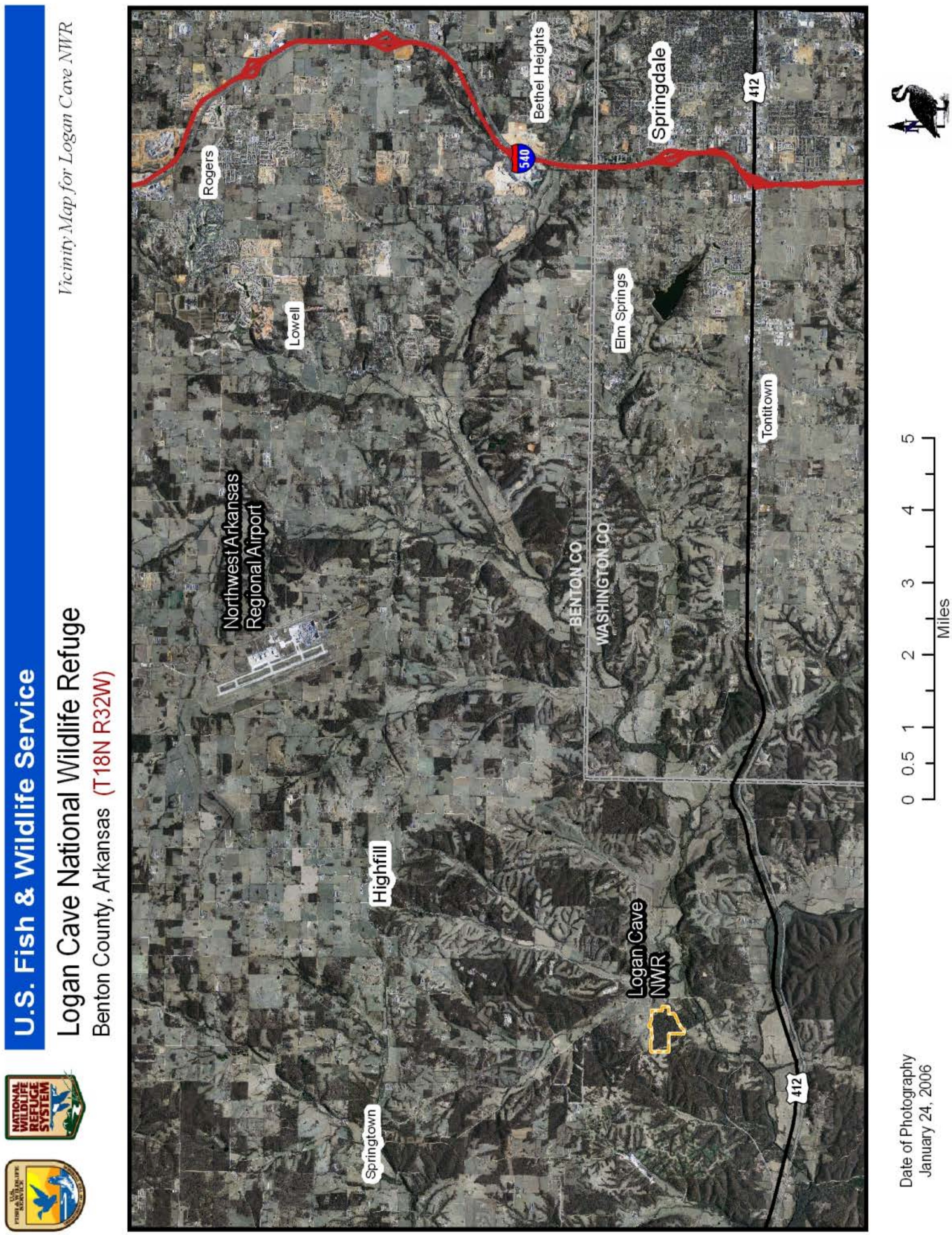
TOPOGRAPHY AND HYDROLOGY

Surface Water and Groundwater

The Boone and St. Joe Formations form the dominant groundwater aquifer in northwestern Arkansas. Chert content within the Boone Formation ranges from a few to 70 percent, and laterally extensive chert layers perch groundwater at different zones within the formation. Overall, groundwater within the Boone-St. Joe aquifer is perched upon the underlying Chattanooga Shale. Both the Boone and St. Joe formations are dissected by numerous caves and solution channels. Groundwater flow within the Boone-St. Joe aquifer occurs preferentially through solution channels, including caves, fault zones, and fractures. The widespread occurrence of solution channels also affects surface water, resulting in disappearing streams and springs throughout the area. More than 90 percent of springs in northwest Arkansas with discharge in excess of 3.4 million gallons per day are within 1,600 feet of faults, and many fault zones and fault-related fractures have associated parallel caves and solution channels that formed by preferential groundwater flow.

The recharge zone for Logan Cave is described by Aley and Aley (1987) as 3,015 hectares (7,450 acres) in area lying north and east of the cave entrance. The recharge zone is the surface and groundwater regions that contribute water to the Logan Cave Stream and spring. The surface streams are primarily discrete losing streams that flow through mostly agricultural land. In 1968,

Figure 1. Vicinity map for Logan Cave NWR



forest dominated 59 percent of the recharge zone; this decreased to 43 percent by 1987 and has steadily decreased until the only forested areas remaining are along creek bottoms or ridge tops where it is too steep for livestock or poultry operations.

SOILS

According to the 1977 Soil Survey of Benton County, Arkansas, Clarksville series soils cover the majority of the hill slopes near Logan Cave, whereas Nixa series soils cover the ridge tops. Clarksville soils form from very cherty limestone and generally consist of a cherty silt loam with high permeability and moderate strength. These soils typically are classified in accordance with the Unified Soil Classification System as silty, clayey, or poorly graded gravel. The fine-grained fraction of Clarksville soils is non-plastic to slightly plastic and has low potential for swelling and shrinking with variations in moisture content. Nixa series soils are very similar to Clarksville soils, except that the Nixa soils have very low permeability. Both soil series generally are brown to yellowish brown, although the Nixa soils grade to reddish brown near bedrock. Both soil series grade into weathered bedrock and fill fractures within the upper parts of the bedrock.

GEOMORPHOLOGY

Logan Cave NWR is located in the NW ¼ NE ¼ Section 33, T18N, R32W, Benton County, Arkansas. The elevation of Logan Spring (lower entrance) is 1,040 feet and the sinkhole entrance is at 1,100 feet. This area is typical of the Ozarks, with rocky soils, numerous caves, losing streams, springs, and underground rivers. The landscape around Logan Cave NWR is picturesque with gently rolling hills, springs, streams, pasture, and wooded hillsides giving way to the Osage Creek valley. A spring-fed stream, with an average water flow of 5 million gallons per day, extends the entire length of the cave. This stream emerges from the cave, flows into a natural oxbow lake and then into the Osage Creek, a large tributary of the Illinois River.

Geographically, Logan Cave NWR is located within the Springfield Plateau geologic province on the southwest flank of the Ozark Dome, which is a broad uplift centered in southeast Missouri. The Springfield Plateau is comprised of bedrock units formed from sediments deposited by Paleozoic seas. These bedrock units dip gently to the south, and many are cut by normal faults with downward motion on their south sides. The upper part of the Springfield Plateau is composed of cherty limestone of the Lower Mississippian Boone Formation, which is underlain by chert-free limestone of the St. Joe Formation (Schultz and McKenna 2004).

Logan Cave NWR is underlain by generally flat-lying bedrock of the St. Joe Formation. Springs often discharge from caves and conduits in the St. Joe Formation due to the impermeable nature of the underlying Chattanooga Shale. Chattanooga Shale underlies the refuge at shallow depths. The shale is exposed to the south because elevations in the area decrease to the south. A normal fault is recorded to run along the east boundary of the refuge. The regional water table, which occurs in the St. Joe-Boone aquifer, has been recorded at a depth of 75 feet near the sinkhole entrance to Logan Cave. It seems that Logan Cave may have formed because groundwater perched on chert beds or low-permeability limestone beds flowed preferentially through fractures formed by tectonic activity on the nearby fault, resulting in dissolution of surrounding limestone (Schultz and McKenna 2004).

MANAGEMENT UNIT DESCRIPTIONS

For the purpose of this HMP, the refuge is delineated into three management units, the recharge zone, the cave environment (including Logan Cave Stream), and the cave entrances. The recharge zone (Figure 2) is the surface and groundwater regions that contribute water to the Logan Cave Stream and spring.

The refuge also manages 1.5 miles of known cave passageways (Figure 3). The caves main passageway is relatively narrow with a low ceiling. In some areas, the ceiling gradually declines, leaving only a tiny crawl space. Approximately halfway through the cave is an area where gray bats congregate their maternity colony. For management and research purposes, Logan Cave Stream is delineated into three regions. The lower region extends from Logan spring to the sinkhole and contains mostly riffle habitat. The middle region extends 230 meters from the sinkhole and is characterized by a single, large pool. The upper region extends 685 meters from the end of the middle region to the upper reaches of the cave and has riffle and pool habitat.

There are two known entry points for the cave: the sinkhole and spring (Figure 4). The sinkhole consists of a steep sided funnel shaped depression about 50 feet in diameter located on a forested hillside. The spring entrance is located on a hillside under an overhang rock bluff. The cave entrances provide particularly rich habitat and consist of extensive rock overhangs with subdued lighting that maintains a higher humidity than the surrounding oak-hickory forest. The resulting environment supports a variety of plant and animal life forms.

HISTORIC HABITAT CONDITIONS

CULTURAL AND REFUGE LAND HISTORY

There has never been a comprehensive archaeological investigation within the refuge by the Service. There is evidence of an old home place close to the mouth of the cave, and in the 1940s, a cannery operated close to the mouth of the cave, using the water from the spring. The remnants of an old fish hatchery and fish ponds were located south of the refuge boundary. Water from the cave (Logan Spring) supplied the hatchery, fish ponds, and the Logan community. Today, water from the spring supplies water for a large poultry operation, several residences, and a tree/plant nursery.

Northwest Arkansas is one of the fastest growing areas in the nation and Benton County is the fastest growing county in the state (U.S. Census Bureau 2010). The related development is moving toward regions like the refuge that retain a rural atmosphere, yet remain close to cities that are bustling with economic activity.

Population change can be an indication of economic vitality, the types of economic sectors that are likely to be strong, probable development and disturbance impacts on wildlife habitat. The U.S. Census Bureau (2010) ranks Benton County second in the state for total population. First is Pulaski County, with the capital city of Little Rock. In April 2000, Benton County had a population of 153,343 and 221,339 in 2010. That's a 44.3 percent increase. The population percent change from 1990 to 2000 was 57.3 percent. Three of the top five cities in Arkansas with significant growth rates are in Benton County. Springdale, located in Washington County, was also on this list.

Figure 2. Recharge zone, Logan Cave NWR

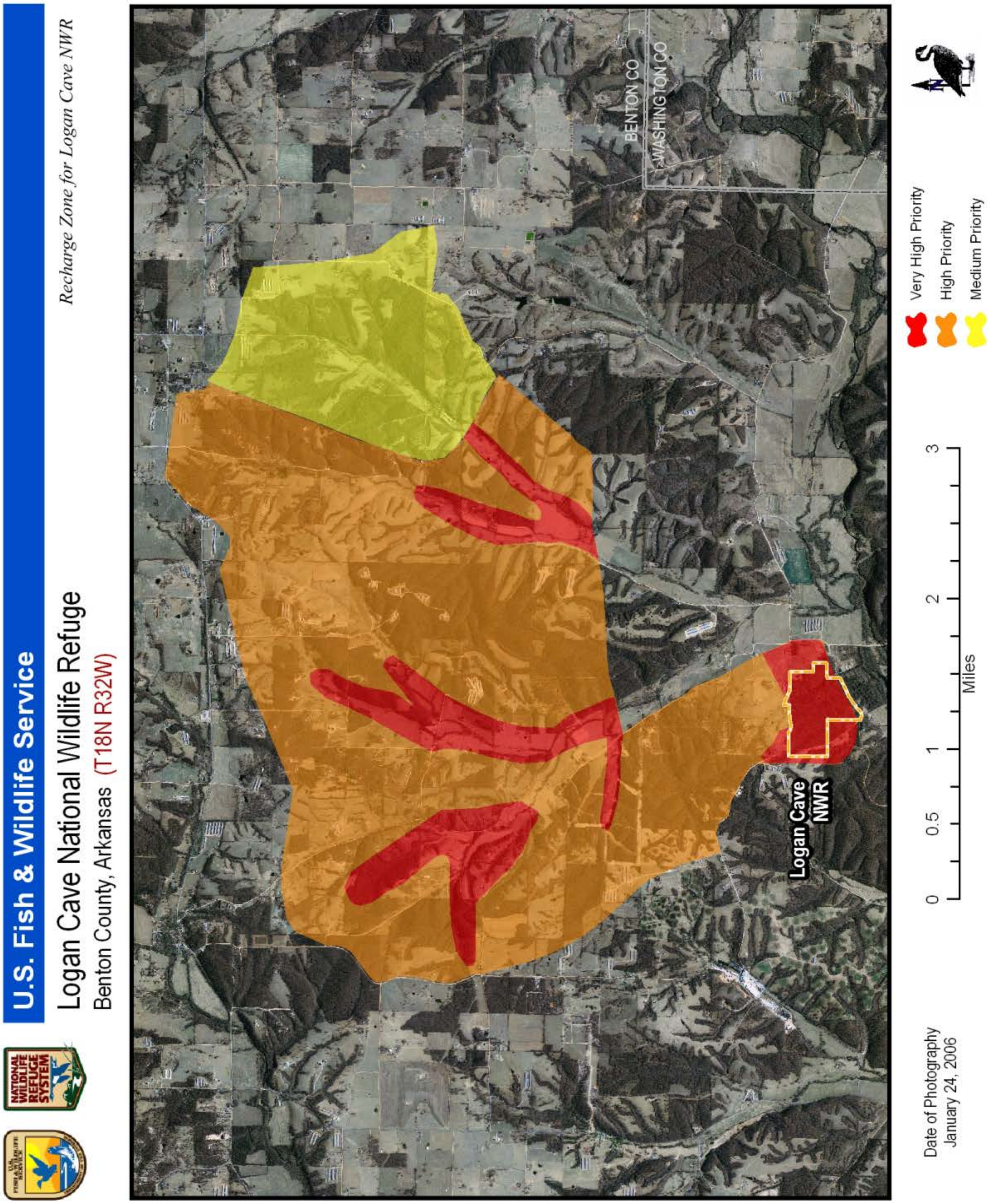


Figure 3. Logan Cave passage in relation to the surface

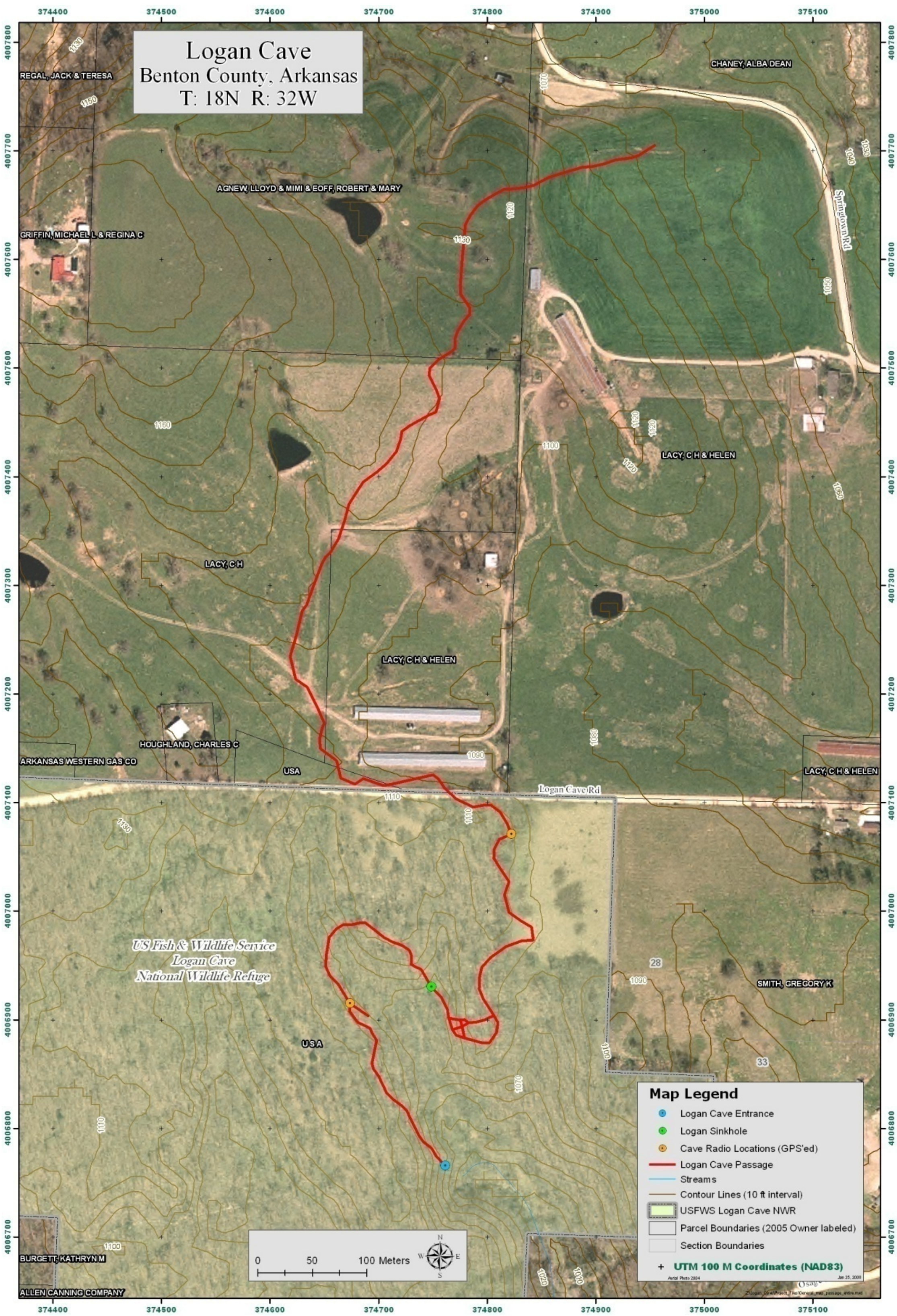
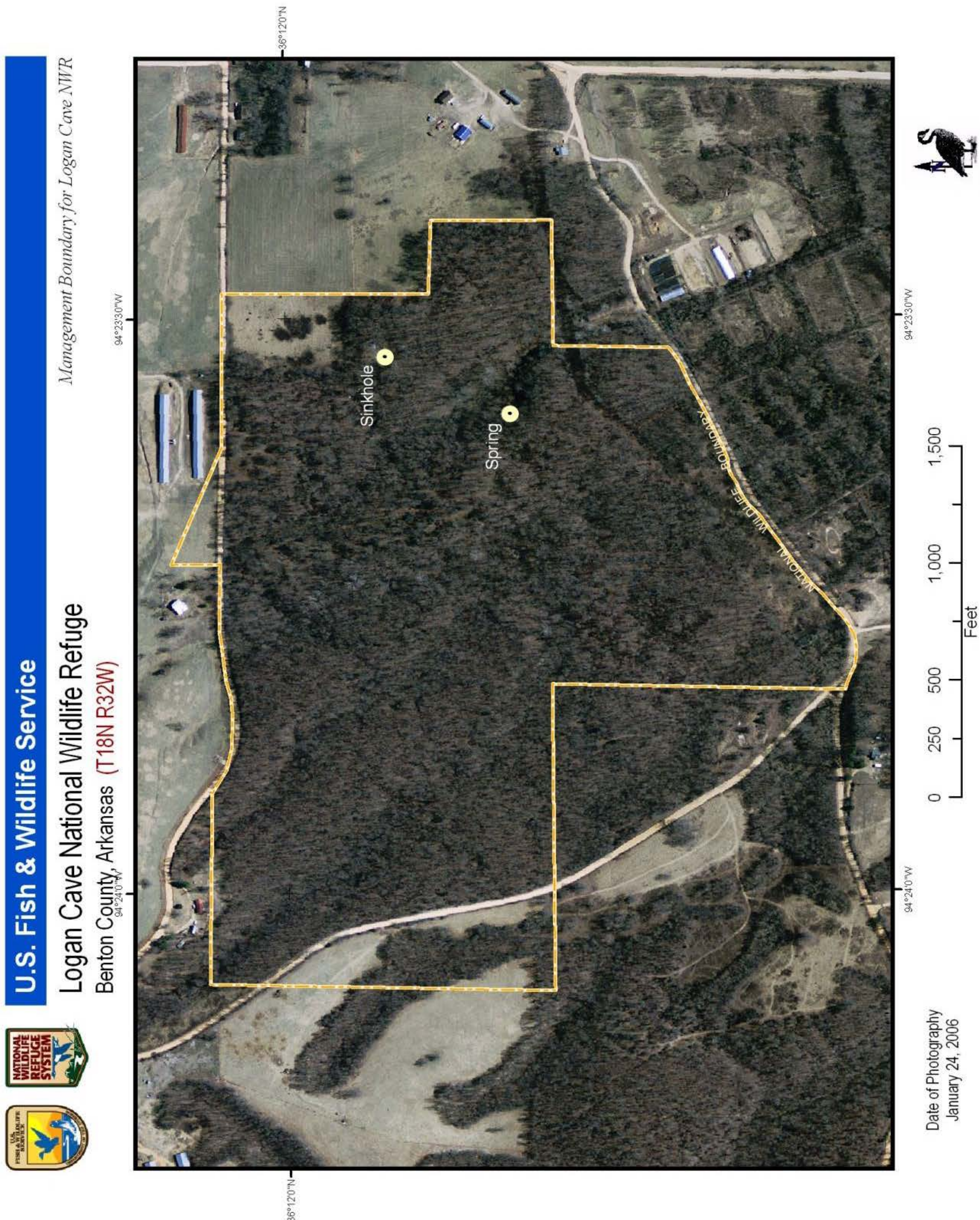


Figure 4. Logan Cave NWR boundary and cave entrance locations (spring and sinkhole)



Poultry and cattle agribusiness, light manufacturing, retail distribution, retail support, and transportation are the most important economic sectors. Important agricultural crops include hay and pasture for livestock. Benton County leads the state and is third in the nation for broiler (poultry) production. Much of Tyson's Food operation is located in Benton County and headquartered in adjacent Washington County.

There are several large manufacturing industries in Benton County, including Glad Manufacturing, Kraft Foods, Rogers Tool Works, Allen Canning, Daisy Outdoor Products, and J.B. Hunt. Wal-Mart has its headquarters in Bentonville and numerous Fortune 500 companies have regional offices in Benton County to support their accounts at Wal-Mart. The Northwest Arkansas Regional Airport is located in Highfill, only a few miles from the refuge.

With major industries located nearby and the rapidly increasing population, development in the region has skyrocketed in the past few years. Real estate values have increased significantly and the once-wooded landscape surrounding the refuge is quickly turning into houses, apartments, golf courses, and other commercial developments. The refuge is rapidly becoming a small island in a sea of development.

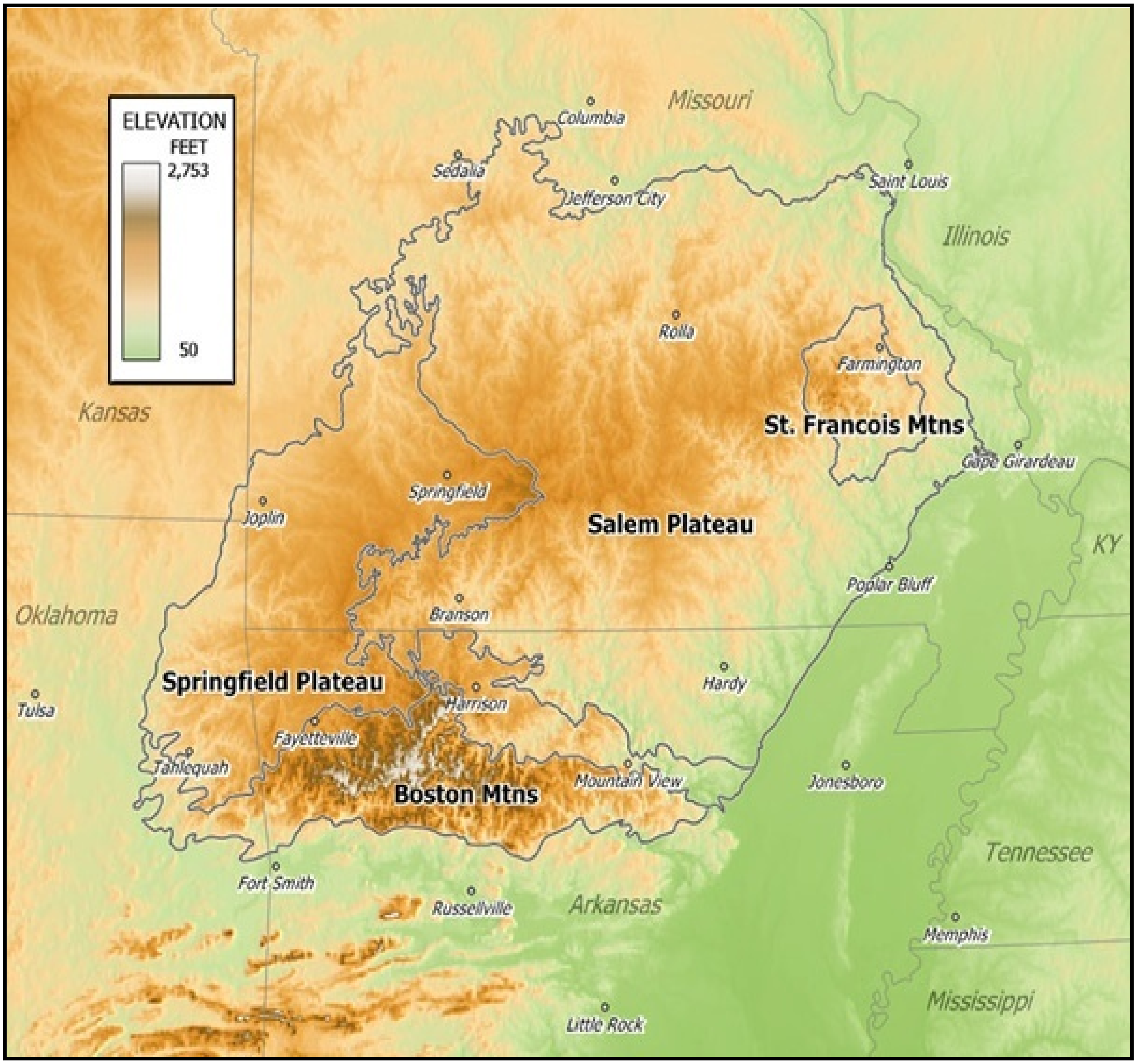
PRE-EUROPEAN SETTLEMENT CONDITIONS

Logan Cave NWR is located in the Springfield Plateau of the Ozark Highlands. This region includes southern Missouri, northern Arkansas, and portions of Oklahoma, and Kansas (Figure 5). In conjunction with the Ouachita region to the south, the Ozarks comprise the only highland in mid-continental North America, and the only significant topographic relief between the Appalachians and the Rocky Mountains.

This area was once covered in a shallow tropical sea. When ancient marine organisms died, their calcium rich shells and skeletons sank to the bottom of the sea, forming thick calcareous deposits. These deposits became today's bedrock of limestone and dolomite. Later a magma pulse pushed up the Ozarks and fractured the limestone. Fractures are enlarged with the dissolution of limestone by mildly acidic waters. These processes formed the caves, springs, and other underground passageways we see today.

Consequently, karst areas, such as northwest Arkansas, contain numerous exposed karst features and subterranean passageways. Surface water enters groundwater systems rapidly as it passes through broken bedrock under thin layers of permeable soil. Groundwater in karst areas can travel as quickly as a few thousand feet to over a mile per day. If the surface water is polluted, the groundwater will also be polluted and sensitive habitats will no longer be able to support delicate cave animals. The Logan Cave recharge zone is the perfect example of this kind of surface water/groundwater interaction. These and other characteristics of karst ecosystems make the surface/groundwater environment fragile and highly susceptible to human disturbance.

Figure 5. The Ozarks and primary physiographic regions



CURRENT HABITAT CONDITIONS

The Logan Cave area has a very diverse habitat, which includes representatives of several Ozark Mountain types: oak-hickory forest, grassland, shrubland, floodplain, marshland, and bottomland hardwood. The cave entrances provide particularly rich habitat and consist of extensive rock overhangs with subdued lighting that maintains a higher humidity than the surrounding oak-hickory forest. The resulting environment supports a variety of plant and animal life.

A spring-fed stream, with an average water flow of 5 million gallons per day, extends the entire length of the cave. This stream emanates from the cave at Logan Spring, flows into a natural oxbow lake and then into Osage Creek, a large tributary of the Illinois River.

Logan Cave is a large limestone-solution cave with approximately 1.5 miles of surveyed passageways. The three ecological classification types of limestone solution caves (e.g., tunnel, seepage, and sinkhole) are present in different sections of the cave. The cave's passageway is relatively narrow with a low ceiling. In some areas, the ceiling gradually declines, leaving only a tiny crawl space. Approximately halfway from the sinkhole to the spring entrance is an area (the bat room) with a high dome ceiling where gray bats congregate their maternity colony. This dome formed when large rock plates caved-in. The cave's internal temperature is a constant 55 degrees Fahrenheit.

SURFACE HABITAT

The terrestrial cave environment for Logan Cave is extremely stable and such stability is of primary importance to troglobitic organisms that inhabit the cave. However, the aquatic cave environment is not as stable due to the relationship with surface water entering the cave through the recharge zone.

The recharge zone (Figure 2) is described by Aley and Aley (1987) as 3,015 hectares (7,450 acres) in area, lying north and east of the cave's spring entrance. The surface streams in the recharge zone are primarily discrete sinking streams that flow through mostly agricultural pastureland. Two major classes of land-use occur in the recharge zone: (1) residential/ commercial use, and (2) agriculture. The recharge zone has numerous livestock operations, including approximately 50 hog and poultry houses from which Aley and Aley (1987) identified three potential types of impacts. First, feedlots and animal houses are normally on well-drained slopes, which lead to runoff during heavy rains. These runoff waters may contain high levels of biological or chemical pollutants that can have a negative impact on Logan Cave Stream. Second, farmers occasionally dispose of wastes on unused areas of their property. These areas may be located where runoff could reach stream sources and eventually Logan Cave Stream. Third, toxins and chemicals in animal feeds can pass through the animals and reach streams, via land application of wastes. Aley and Aley (1987) stated that two major impacts of residential/ commercial development are inappropriate sewage disposal and increased erosion or storm runoff. Recovery of the species utilizing Logan Cave is directly related to the water quality in Logan Cave Stream, which is directly affected by land uses within the recharge zone.

Aley and Aley (1987) delineated the recharge zone into hazard areas to identify those surface areas which have differing potentials for the introduction of groundwater contaminants into Logan Cave: (1) Low hazard; (2) moderate hazard; (3) high hazard; and (4) very high hazard areas; the higher the hazard, the higher in *priority* for protection of these areas (Figure 2).

LOGAN CAVE STREAM

Logan Cave Stream extends the entire length of the cave and emerges at the mouth as Logan Spring. Water clarity in Logan Cave Stream is very high, except after storm events that result in increased flow and decreased clarity. Water quality is high except for seasonal increases in coliform bacteria associated with livestock operations in the recharge zone and traces of pharmaceuticals and other organic wastewater constituents from inadequate septic systems. To ensure success of all species in Logan Cave, water quality needs to remain at a constant high level (Table 1).

Table 1. Water quality parameters for Logan Cave water quality studies

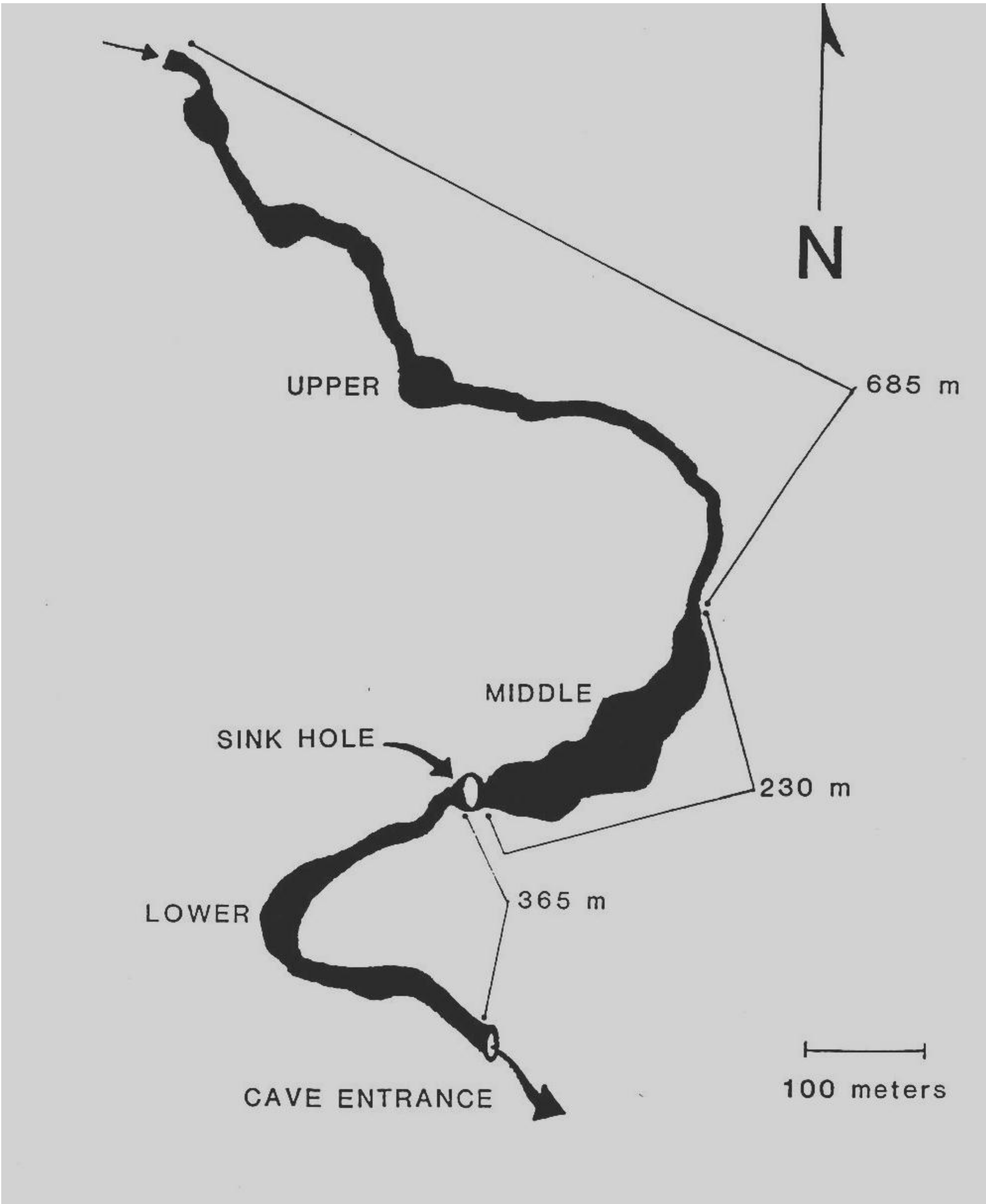
Alkalinity	Aluminum	Ammonia	Arsenic
Barium	Boron	Cadmium	Calcium
Chloride	Chromium	Cobalt	Conductivity
Copper	*E. coli* (MPN)	Fluoride	Hardness
Iron	Lead	Magnesium	Manganese
Molybdenum	Nickel	Nitrate	Ortho Phosphate
pH	Phosphorus (ICP),	Potassium	Selenium
Sodium	Sulfate	Titanium	Total Coliform (MPN)
Total Nitrogen	Total Organic Carbon	UV	Total Phosphorus
Total Suspended Solids	Turbidity (NTU)	Vanadium	Zinc

For research purposes, Logan Cave Stream is divided into three regions (Figure 6) classified by habitat types (Means 1993). The lowermost reach is 365 m long and extends from the cave mouth upstream to the sinkhole. This reach consists of runs and riffles, with the substrate being primarily rock and rubble. The middle reach consists of a 230-meter-long pool that extends from the sinkhole to the next upstream riffle. Rock and silt comprise most of the substrate, with the maximum depth being 3 meters. The third reach is 685 meters and extends upstream from the pool to a point where the cave roof meets the stream. This reach includes pools, riffles, and runs, with gravel, silt, and bedrock substrates.

CAVE ENTRANCES

The sinkhole and spring entrances are the only two known entry points. The sinkhole consists of a funnel-shaped depression about 20 hectares (50 feet in diameter on a forested hillside. The spring entrance is located on a hillside under an overhanging rock bluff. The northwestern third of the refuge consists of hillsides that support a mature community of oak and hickory. The forest growing on the slopes surrounding the cave's sinkhole entrance provides natural organic litter to the cave ecosystem for a food energy base. Leaves that fall through the sinkhole and into the stream are the base energy source for the cave's aquatic fauna. Upstream from the sinkhole, the cave area contains several large seeps, which cascade down the walls from the ceiling. These seeps introduce organic matter in the form of fine particulates and dissolved material. These organic materials supply nutrients for many inhabitants of the cave.

Figure 6. Logan Cave Stream regions



The entrances to the cave are rich ecologically. They consist of extensive rock overhangs with subdued lighting. The moisture content is higher and more stable than the surrounding forest. The cave also moderates the temperature near the openings. The resulting environment supports a nice growth of ferns, liverworts, mosses, and other plants. The spring harbors crayfish, sculpins, darters, frogs, salamanders, insects, and aquatic plants.

BAT FORAGING AREA

Summer caves, especially those used by maternity colonies, are usually located within a kilometer of rivers or reservoirs over which the bats feed. Adult gray bats feed almost exclusively over water along river and reservoir edges. Newly volant young gray bats often feed and take shelter in forests surrounding cave entrances. Whenever possible, gray bats of all ages fly in the protection of forest canopy between caves and feeding areas. Such behavior provides increased protection from predators such as screech owls. Forested areas surrounding cave entrances, between caves, and over-water feeding habitat clearly are advantageous to gray bat survival. Gray bat feeding areas have not been found along sections of rivers or reservoirs where adjacent forests have been cleared. Logan Cave NWR is mostly forested with a mature community of oak and hickory. Logan Cave bats use the forest canopy as they make their way to the wooded corridor along Osage Creek, just south of the refuge.

HABITAT CHANGES FROM HISTORIC TO CURRENT CONDITION

The land area that is now Logan Cave NWR was in private ownership by Mr. Jack Ware of Springdale, Arkansas, for about 40 years prior to 1989. In the 1940s, a small cannery operated on the property. There was unlimited and heavy use of the cave by careless spelunkers. Extensive writings on some walls of the cave record visits by people from the 1930s. Prior to Service ownership, spent small-caliber rifle and pistol cartridges littered the floor of the bat room. Remains of fireworks were scattered through the cave. Other items found in the cave include bottles, cans, flashlights, shoes, clothing, and carbide deposits from lamps. Old timbers from a wooden raft were in the long pool. A former owner used the raft to conduct guided tours. Past attempts to dam the stream that exits from the spring entrance, as well as drilling into the cave for water, were unsuccessful.

Beside the efforts to increase utilization of the water, there were several other plans for commercial use of the cave and property. One individual wanted to purchase the land and build a house at the spring entrance. Raising mushrooms, bottling the spring water for sale, and charging for tours were other commercial attempts that occurred prior to Service ownership of the land.

The original acquisition proposal for Logan Cave included the entire Ware tract, about 155 hectares (385 acres), which included what is now the refuge, plus lands east of Logan Road, and from the spring entrance south to the section line, and included the fish hatchery, ponds, oxbow lake, and riparian acreage on both sides of Osage Creek. The Service’s Ecological Services office would only support the purchase of 80-100 acres of land, but later increased that to include parts of Logan Spring for a total of about 50 hectares (124 acres).

Initial work at the cave included cleaning up as much debris as possible inside the cave and the surrounding area. Some carbide deposits may remain because some spelunkers buried their spent carbide instead of packing it out. Grazing occurred on the land until 1994.

Lands in the Ware tract, which were not purchased by the Service, have been extensively developed. Ten chicken houses operate near the refuge; a concrete dam is across the spring stream holding a pool of water at the spring entrance. The dam facilitates the withdrawal of water for private use. New houses exist on the south side of Osage Creek and most of the roads are paved. A new natural gas transmission pipeline is along the north edge of the refuge. A newly constructed 15,000-seat amphitheater is located on Logan Cave Road east of the refuge. There are plans for a golf course near the refuge.

CHANGES ASSOCIATED WITH GLOBAL CLIMATE CHANGE

Climate change and its relationship to existing problems of conserving fish and wildlife is the transformational conservation challenge of the 21st Century. The Intergovernmental Panel on Climate Change (IPCC) reported that the warming of the world's climate system is unequivocal, based on documented increases in global average air and ocean temperatures, unprecedented melting of snow and ice, and rising average sea level (IPCC 2007). While the distribution and abundance of fish and wildlife are naturally dynamic, relative to a variety of environmental factors, climate change may drastically alter and accelerate the natural cycles that we are familiar with today. Some effects may include changes in precipitation, increased frequency and intensity of extreme weather events, rising sea levels, tidal fluctuations, and invasions of new exotic species. Consequently, climate change is a challenge not only because of its direct effects, but also because of its potential to amplify the other stressors that have and will continue to be conservation issues.

The IPCC (2007) concluded that warming and sea level rise would continue for centuries even if greenhouse gas emissions are stabilized now. The Service is working to anticipate and address this challenge while protecting fish and wildlife habitats and maintaining biodiversity.

The effects of climate change and global warming will be changes in weather/rainfall patterns, decreases in snow and ice cover, rising sea levels, and stressed ecosystems. For the southeastern United States, this could mean extreme precipitation events; greater likelihood of warmer/dryer summers and wetter/reduced winter cold; and, alterations of ecosystems and habitats due to these changes in weather patterns. For Logan Cave NWR, warmer conditions would favor increased densities of vegetation and wetter conditions would favor trees and vegetation that are better adapted to these conditions. If conditions become drier, the current range and density of forests would be reduced and replaced by grasslands and the probability of wildfires would increase. A recent study of the effects of climate change on eastern United States' bird species concluded that as many as 78 bird species could decrease by at least 25 percent while as many as 33 species could increase in abundance by at least 25 percent due to climate and habitat changes (Matthews et al. 2004). In short, global warming could increase storm intensity, negatively change ecologically important plant species, alter the spread of invasive species, increase drought-induced fires, and further imperil already threatened and endangered species. Management at Logan Cave NWR will need to monitor and manage habitats for these changes.

III. RESOURCES OF CONCERN

Priorities associated with wildlife and habitat management for the Refuge System are determined through directives, policies, and legal mandates. Resources of concern include species, species groups, and/or communities that support refuge purposes as well as Service trust resource responsibilities (including threatened and endangered species and migratory birds). Resources of concern are also native species and natural, functional communities such as those found under historic conditions that are to be maintained and, where appropriate, restored on a refuge (601 FW 3.10B[1]).

Resources of concern for Logan Cave NWR were selected after taking into account the conservation needs identified within international, national, regional, or ecosystem goals/plans; state fish and wildlife conservation plans; recovery plans for threatened and endangered species; and previously approved refuge resource management plans as identified in the Comprehensive Conservation Planning Process policy [602 FW 3.4C [1][e]), as well as Chapter 1 of this HMP. The species/communities selected as resources of concern from these plans support the following Refuge System mandates:

- Support refuge purposes and the Refuge System mission;
- Conserve biological integrity, diversity, and environmental health (giving special consideration to rare, declining or unique natural communities, species, and ecological processes within the refuge boundary and the Ozark Highlands); and
- Fulfill Service trust resource responsibilities.

Resources of concern identified for Logan Cave NWR include:

- Gray bat
- Ozark cavefish
- Benton Cave crayfish
- Indiana bat
- Other karst species

GRAY BAT

SIGNIFICANCE

Gray bats are a migratory bat and most are concentrated in the cave regions of Alabama, Arkansas, Kentucky, Missouri, and Tennessee, with smaller populations found in adjacent states. The species occupies cold hibernating caves or mines in winter and warmer caves during summer. Gray bats are highly dependent on aquatic insects, especially mayflies, caddisflies, and stoneflies. The Gay bat was listed as endangered on April 28, 1976, and the recovery plan was published in 1982. Listing factors included:

- Human disturbance;
- Environmental disturbance; pesticides, chemical pollution, and siltation of waterways;
- Deforestation;

- Impoundment of waterways (and subsequent cave inundation);
- Cave commercialization and improper gating.

The Recovery Priority of the Gray bat is 8, which means the species has a moderate degree of threat and high recovery potential. Although some threats to various caves remain, overall the species has exhibited an increase in population numbers and distribution.

The Service has confirmed the presence of white-nose syndrome (WNS) at Fern Cave National Wildlife Refuge (NWR) in Jackson County, Alabama. Fern Cave NWR provides winter hibernation habitat for several bat species, and contains the largest documented wintering colony of federally listed endangered gray bats, with over one million gray bats hibernating there. The disease was confirmed in tri-colored bats that were collected at two entrances to the cave. Although no visible fungal growth was observed on hibernating gray bats during these winter surveys, laboratory testing detected the presence of fungal DNA on swabs submitted from several live gray bats. Swab samples taken by Tennessee Valley Authority biologists in 2012 of two bats in Collier Cave in Tennessee tested positive for the fungus after they were re-checked in March 2013, using more sensitive techniques. One bat was a federally endangered gray bat; the other was a tri-colored bat. The disease is not currently known to cause mortality in gray bats, and the potential impact of WNS on gray bat populations is still unknown (USFWS 2013).

IDENTIFICATION OF HABITAT REQUIREMENTS

The gray bat is, perhaps, the most restricted to cave habitats of any bat species. With rare exceptions, the gray bat uses caves year-round. Summer caves, especially those used by maternity colonies, are nearly always located within a kilometer of rivers or reservoirs over which the bats feed. Adult gray bats feed almost exclusively over water along river or reservoir edges.

Newly volant young gray bats often feed and take shelter in forest surrounding cave entrances. Gray bats of all ages fly in the protection of the forest canopy between caves and feeding areas. Such behavior provides increased protection from predators such as screech owls. Forested areas surrounding caves and between caves and over-water feeding habitat clearly are advantageous to gray bat survival. Gray bat feeding areas have not been found along sections of river or reservoir where adjacent forest has been cleared.

POTENTIAL REFUGE CONTRIBUTION TO HABITAT NEEDS

Adult female gray bats utilize Logan Cave NWR from March through August as a maternity site for raising their young. Adult females will give birth to a single young in late May or early June. Most young begin to fly within 20-25 days after birth. July emergent counts for Logan Cave NWR average around 20,000. The 2008 and 2009 summer exit surveys yielded 5,040 and 5,470 bats, respectively. Exit surveys for 2010, 2011, and 2012 yielded 20,900, 19,000, 12,300 bats, respectively. These are one-time exit surveys and results vary greatly.

OZARK CAVEFISH

SIGNIFICANCE

The Ozark cavefish is one of the most cave-adapted members of the Amblyopsidae family, and one of the most cave-adapted vertebrates known. This specialization to the cave environment may limit its ability to recover from even minor perturbations. This, combined with the shrinking of its known range, was the basis of the Ozark cavefish being officially recognized as a threatened species by the U.S. Department of the Interior, effective December 3, 1984 (49 FR:43965-43969). The listing factors are:

- The present or threatened destruction, modification, or curtailment of its habitat or range;
- Agriculture, especially confined animal feeding operations (hog and chicken farms) – waste from these farms are land applied within the recharge zone;
- Urbanization/development
    - Stormwater runoff containing numerous contaminates and septic system leachate.
    - Recreational caving and collecting;
- Disease or predation;
- The inadequacy of existing regulatory mechanisms for groundwater;
- Other natural or man-made factors affecting its continued existence
    - Human entry
    - Contaminant spill/accidents
    - Natural gas extraction
    - Increasing levels of pharmaceuticals and other organic wastewater constituents in Ozark cavefish waters.

The recovery priority of the Ozark cavefish is 5c, which means the recovery potential is low because of the increase in and limited ability to reduce existing threats from urbanization, the difficulty with which conservation actions are implemented, and the predicted increase in the Ozark human population. Furthermore, as the biology of the Ozark cavefish and its groundwater habitat are poorly understood, recovery of this species will remain problematic. "C" was added to the recovery priority number as this species is in conflict with construction, development, and other forms of economic activity.

IDENTIFICATION OF HABITAT REQUIREMENTS

The distribution of the Ozark cavefish is entirely within the Springfield Plateau of the Ozark Highlands. Logan Cave is one of 35 caves known to have a population of the Ozark cavefish; however, Logan Cave has the second largest population in Arkansas, and throughout its range. During a survey conducted in 2009, biologists observed 49 cavefish, and in 2012, 23 cavefish were counted (USFWS unpubl. data).

All of the caves with fish contain some comparatively large source of allochthonous energy, usually bat guano, or washed or blown leaf litter. Plankton is the primary food of *A. rosae*; however, they also eat isopods, amphipods, crayfish, and salamander larvae. The guano from the bats and leaf litter that washes into the stream in Logan Cave feeds the small invertebrates that in turn provide a food source to the cavefish. The bats and the forest along with stable water quality are essential elements that work together for the continued existence of the Ozark cavefish within the Logan Cave ecosystem.

POTENTIAL REFUGE CONTRIBUTION TO HABITAT NEEDS

Protecting Logan Cave against trespass helps reduce disturbance of the gray bat maternity colony and reduces foot traffic inside the cave, thereby reducing turbidity, the chance of stepping on a cavefish, and collection. The Service has gated and fenced both entrances to the cave. The recharge zone for Logan Cave lies mostly on privately owned land, so to protect this cavefish, it is essential that the Service and its partners use all tools possible to protect the recharge zone from contamination, including educating the local landowners about karst environments and how they can keep this species and their groundwater protected.

BENTON CAVE CRAYFISH

SIGNIFICANCE

The Benton cave crayfish is a small, troglobitic (i.e., obligate cave-dwelling) crayfish. The species is one of five species of troglobitic crayfish in the Ozark region. This crayfish is about 4.8 cm (1.8 inches) long, with white, un-pigmented skin and reduced eyes. Very little is known about the life history of the Benton cave crayfish. Consistent with other troglobitic species, the species has increased longevity (can live up to 75 years), low egg production, delayed reproductive maturity, and a low metabolic rate. This species feeds on organic matter that is left by bats or washed into the cave from the surface. The current known population of the Benton cave crayfish is estimated at less than 200 individuals, occupying less than four square kilometers of underground streams and pools at four sites in Benton County Arkansas: Logan Cave, Bear Hollow Cave, Old Pendergrass Cave, and in Brush Creek. The species was listed as endangered on May 27, 1993. The 1996 recovery plan listed the following reasons for the species decline:

- Destruction of habitat including water quality degradation;
- Disturbance by spelunkers or trespassers;
- Collecting;
- Low reproductive potential; and
- Competition and predation by troglophilic or epigean species.

IDENTIFICATION OF HABITAT REQUIREMENTS

The Benton cave crayfish is often found along stream edges or pools generally less than 50 cm (20 inches) deep. The crayfish is rarely found near cave openings, where it is vulnerable to predation by surface species. The crayfish can be found on variable substrates including silt, gravel, and bedrock and requires clear, clean water with high dissolved oxygen content for respiration. Water temperatures of cave streams are stable and hover around 14^{o} C (57^{o} F) for most of the year. Nutrient levels are generally low, and the cavefish relies on the transport of organic matter from the surface or bat guano for food. The most recent ocular survey for the Benton cave crayfish was conducted in February 2012, and resulted in 41 individuals (USFWS unpubl. data).

POTENTIAL REFUGE CONTRIBUTION TO HABITAT NEEDS

Habitat degradation, the primary reason for federal listing of the species, remains as the most serious threat to the Benton cave crayfish. Water quality analyses over the years have indicated that organic pollutants are present in the groundwater basin and fecal bacteria consistently equaled or exceeded those of regional surface waters monitored by the National Water Quality Assessment Program for the Springfield Plateau Aquifer (Graening 2006). A large portion (86 percent) of the Logan Cave groundwater recharge zone is rated as highly vulnerable to surface pollutants. Within the recharge zone, there are over 100 confined animal feeding operations and cattle ranching operations, as well as at least 60 residences on septic systems. Vandalism and trespass continue to be a management issue at the cave. Human traffic upon the stream substrate is known to cause inadvertent mortality by trampling. The severe penalties for unauthorized collection under the Endangered Species Act probably have discouraged collection since listing of the species in 1993. The primary conservation activity for this cave crayfish has been land protection. The Service purchased 49.6 hectares (123.9 acres) of land containing the cave entrances for Logan Cave and have since gated and fenced the openings. All Troglobitic species are protected by Arkansas Game and Fish Commission Regulation No. 1817 entitled "Wildlife Pet Restrictions." They cannot be possessed as pets and their sale is prohibited. The Nature Conservancy has implemented a voluntary program to upgrade septic systems in the recharge zone by retrofitting old concrete tank systems with a re-circulating, aerobic digestion trickle filter and fiberglass septic tank. Since the construction of the Northwest Regional Airport in Highfill, Arkansas, the recharge zone has increased, increasing pollutants from sewage, fertilizer, pesticide use, and increased runoff.

INDIANA BAT

SIGNIFICANCE

The Indiana bat is a temperate, insectivorous, migratory bat that hibernates in mines and caves in the winter and summers in wooded areas. The species was originally listed as being in danger of extinction under the Endangered Species Preservation Act of 1966 (32 FR 4001, March 11, 1967), and is currently listed as endangered under the Endangered Species Act (ESA) of 1973, as amended. Critical habitat for the Indiana bat was designated on September 24, 1976; it consisted of 11 caves and two mines in six states (41 FR 41914, September 24, 1976). The original recovery plan for the species was published in 1983 (USFWS 1983). An agency draft of a revised plan was published in 1999, but was never finalized. The five listing factors are (USFWS 2007):

- The present or threatened destruction, modification, or curtailment of its habitat or range;
- Overutilization for commercial, recreational, scientific, or educational purposes;
- Disease or predation;
- The inadequacy of existing regulatory mechanisms; and
- Other natural or man-made factors affecting its continued existence.

The Recovery Priority of the Indiana bat is 8, which means that the species has a moderate degree of threat and high recovery potential. As of October 2006, the Service had records of extant winter populations at approximately 281 hibernacula in 19 states and 269 maternity colonies in 16 states. The 2005 winter census estimate of the population was 457,000 (USFWS 2007).

Biologically intrinsic needs of this species include limiting use of fat during hibernation, obligate colonial roosting, high energy demands of pregnant and nursing females, and timely parturition and rapid development and weaning of young. Factors that may exacerbate the bat's vulnerability because of these constraints include energetic impacts of significant disruptions to roosting areas (both in hibernacula and maternity colonies), availability of hibernation habitat, and connectivity and conservation of roosting-foraging and migrating corridors. (USFWS 2007)

IDENTIFICATION OF HABITAT REQUIREMENTS

Indiana bats used to hibernate in Logan Cave; they have not been observed in the cave since 1955. Indiana bats use caves during hibernation from October to April, depending on climatic conditions of the cave. They require specific roost sites in caves or mines that attain appropriate temperatures to hibernate. In southern parts of the bat's range, hibernacula trap large volumes of cold air and the bats hibernate where resulting rock temperatures drop. The bats choose roosts with a low risk of freezing. Ideal sites are 50^0F (10^0C) or below when the bats arrive in October and November. Studies have shown that the preferred mid-winter temperature range of 37-43^0F (3-6^0C) may be ideal for the species. Only a small percentage of available caves provide for this specialized requirement. Stable low temperatures allow the bats to maintain a low rate of metabolism and conserve fat reserves through the winter, until spring.

Relative humidity at roost sites during hibernation usually is above 74 percent, but below saturation, although relative humidity as low as 54 percent has been observed. Humidity may be an important factor in successful hibernation.

Specific cave configurations determine temperature and humidity microclimates, and thus suitability for Indiana bats. Indiana bats select roosts within hibernacula that best meet their needs for cool temperatures. In many hibernacula, roosting sites are near an entrance, but may be deeper in the cave or mine if that is where cold air flows and is trapped. In Logan Cave, roosting sites would have most likely been near an entrance as these are the coldest areas of the cave.

POTENTIAL REFUGE CONTRIBUTION TO HABITAT NEEDS

In the recovery plan for the Indiana bat, Benton County is historically noted for having Priority Three hibernacula (< 500 bats). Summer maternity roosts are usually in trees along wooded streamside habitat. None have been detected in the Logan Cave area.

OTHER KARSTS SPECIES

SIGNIFICANCE

Other interesting life forms found throughout Logan Cave include pseudoscorpions, isopods, amphipods, beetles, collembolans, and other insects which are blind, without pigment, and strictly adapted to a subterranean habitat. Additionally, Logan Cave is known to support at least two species of state conservation concern: grotto salamander (*Eurycea spelaeus*) and a cave obligate millipede (*Trigenotyla parca*).

Maintaining these other species is vital for the continuing existence of Logan Cave's threatened and endangered species. Many karsts species break down the raw organic energy (e.g., leaf litter and guano) to make the microorganisms that become the base of the food chain for cavefish and cave crayfish.

IDENTIFICATION OF HABITAT REQUIREMENTS

Cave environments are resource poor (food is limited); consequently, cave crayfish, cavefish, and other troglobites rely on outside sources of organic matter for food. Nutrients are transported from the surface as particulate organic matter or dissolved organic matter. Dissolved organic matter is transported from the surface by cave streams, seeps, or percolation. Particulate organic matter, such as leaf litter, is carried in by cave streams or blown into the cave entrance or sinkhole by the wind. Animals, such as bats, also provide particulate organic matter through their feces (guano) or their bodily remains.

POTENTIAL REFUGE CONTRIBUTION TO HABITAT NEEDS

The most important conservation measure that needs to occur for the continued existence of these cave insects and the other Logan Cave obligate species is to ensure recharge area protection. Continued and long-term protection should be sought for the recharge area through conservation easements and jointly working with local landowners. The Service, The Nature Conservancy of Arkansas, Arkansas Game and Fish Commission, and other partners need to keep private landowners informed about programs and agencies that may be able to assist them with watershed management. Educating the public on the sensitivity of groundwater and fauna to pollution is also important and seldom occurs in the Logan Cave community. Public support can be very important in reducing and reversing water quality degradation. Educational efforts should be directed to three main groups of people: private landowners and farmers near Logan Cave, recreational cavers, and the local planning commission. Protection and recovery of all of Logan Cave's resources of concern will depend on voluntary efforts by private landowners and local governments.

RECONCILING CONFLICTING NEEDS

Multiple resources of concern are likely to have competing needs or other refuge programs may conflict with habitat needs of resources of concern. Recognize when and how these occur, and how they will be resolved. This may require prioritizing species needs. Prioritization should be resolved by considering refuge purpose(s), Refuge System mission, applicable laws, and plans.

In the event that the habitat needs of resources of concern compete with each other or with other refuge programs, refuge personnel will analyze when and how these occur, and how they will be resolved. Currently, Logan Cave NWR manages these conflicts using a time and space approach. This may require prioritizing species needs based on seasonal changes and habitat requirements or the timing with which other refuge activities occur. Prioritization is resolved by considering refuge purpose(s), Refuge System mission, applicable laws, and plans. Examples of utilized strategies may include, but are not limited to:

- No cave entrance during gray bat maternity colony presence: March 1 - October 31.
- No welding or other activities near cave entrances between March 1 and October 31.

- Restrict cavefish and cave crayfish ocular surveys to every other year and conduct concurrently during January or February. Guano samples/measurements, hibernating bat observations, etc., are conducted in conjunction with bi-annual surveys.
- Annual reviews to continually safeguard against conflicts.

IV. HABITAT GOALS AND OBJECTIVES

For habitats that require active management, goals and objectives were developed in the CCP for Logan Cave NWR, which are expanded upon or stepped down in this HMP to fulfill the refuge purposes. A habitat management goal is a broad, qualitative statement that is derived from the established purposes and vision for the refuge. Goals and objectives pertain to resources of concern identified in Chapter III.

GOAL 1 (CCP GOAL 2).

Conserve, restore, and manage the functions and values associated with a unique karst environment in order to achieve refuge purposes and wildlife population objectives.

Rationale: Habitat management will be used to restore the biological integrity, biological diversity, and environmental health of refuge lands, as well as lands within Logan Cave's recharge zone and bat foraging areas along Osage Creek and other forested riparian areas used by gray bats.

OBJECTIVE 1.A. CAVE ENVIRONMENT (CCP OBJECTIVE 2.1) –

Manage the aquatic and terrestrial functions associated with this unique karst environment by conducting cleanup (trash, debris, etc., during periodic site visits and bi-annual surveys), by annually monitoring ambient temperature, humidity, and water quality and quantity (Table 1) (at least one sample above sinkhole entrance and at Logan Spring), and by stabilizing sinkhole entrance (sediment traps/steps) of Logan Cave within the next 10 years.

Rationale: A karst environment is influenced by many factors including but not limited to: water quantity and quality, air flow and temperature, and ground cover. These factors have changed at Logan Cave in the past 20 years, mostly by unnatural causes. Knowing the species-specific karst environment parameters needed to be maintained in the cave will enable refuge staff to apply adaptive management strategies.

In 2005, construction was completed on a steel fence to prohibit public access to the sinkhole entrance. By limited access to the sinkhole entrance, sedimentation caused by foot traffic has been significantly reduced.

Resources of Concern: Benton Cave crayfish, Ozark cavefish, gray bat, Indiana bat, and other karst species.

Adaptive Management Monitoring Elements:

Habitat Response Variables	Probable Methods
▪ Support acquisition of property to include high-priority areas in the recharge area. ▪ Monitor temperature and humidity of the cave. ▪ Monitor water quality and quantity (Table 1). ▪ Stabilize sinkhole – sedimentation levels, sinkhole opening (4'X4' minimum), ground vegetation amount. ▪ Conduct cleanup inside cave in conjunction with survey trips.	▪ Submit major land expansion package to include this area for acquisition. ▪ Install temperature and humidity meters in the "bat room" and over the long pool. ▪ TNC grant. ▪ Partnerships with landowners in the recharge zone. ▪ Install sediment traps/steps inside sinkhole-fenced area. ▪ Continue to remove items left by trespassers
Wildlife Response Variables	**Probable Methods**
▪ Benton Cave crayfish, Ozark cavefish, Gray bat, Indiana bat, and other karst species abundance	▪ Bi-annual ocular surveys.

OBJECTIVE 1.B. CAVE ENTRANCES (CCP OBJECTIVE 2.2)

Regularly maintain two known entry points into Logan Cave after major weather events by removing debris and maintaining the fence/gate at the spring and sinkhole entrances. Any maintenance involving welding would need to take place between October 15 and March 15.

Rationale: The two known entry points into Logan Cave are on refuge land, which affords the Service the opportunity to protect and monitor these entrances. Preventing trespass into the cave is imperative to the survival of the species using Logan Cave. Disturbance, especially from inexperienced cavers, can have a devastating effect on the bats, cavefish, and crayfish.

Resources of Concern: Benton Cave crayfish, Ozark cavefish, gray bat, Indiana bat, and other karst species.

Adaptive Management Monitoring Elements:

Habitat Response Variables	Probable Methods
▪ Vegetation density inside and around sinkhole fence. ▪ Debris blocking Logan Spring gate. ▪ Prevent trespass into cave. ▪ Monitor cave gate at spring entrance and sinkhole fence.	▪ Initiate photo points monitoring for vertical and horizontal vegetative density monthly during spring and summer. ▪ Remove debris and obstructions from sinkhole fence and cave gate at spring, especially after heavy rains and storms. ▪ Maintain cave gate at spring and fence at sinkhole. Maintain security cameras. ▪ Develop and install informational kiosk.
Wildlife Response Variables	**Probable Methods**
▪ Benton Cave crayfish, Ozark cavefish, gray bat, Indiana bat, and other karst species abundance and protection.	▪ Bi-annual ocular surveys.

OBJECTIVE 1.C. LOGAN CAVE STREAM (CCP OBJECTIVE 2.3) (Logan Spring entrance south to refuge boundary) - Conduct baseline water quality and quantity (See Table 1 for parameters) taken from Logan Cave Stream using continuous monitoring methods and distinguishing between confined (poultry and hog operations) and residential contaminants in order to provide optimal habitat (water quality and quantity) for aquatic species use.

Rationale: A dam was constructed across the stream years ago to facilitate water withdrawal from Logan Cave Spring for the community water supply and adjacent fish farm. Today, the water is still being withdrawn for private and commercial uses. This unnatural pool of water has never been assessed to determine if it positively or negatively affects the aquatic species in the cave. Monitoring on Logan Cave Stream will decrease the amount of cave visits.

Resources of Concern: Benton Cave crayfish, Ozark cavefish, and other karst species.

Adaptive Management Monitoring Elements:

Habitat Response Variables	Probable Methods
▪ Identify legal standing of dam. ▪ Support acquisition of property to include the dam and lands south to Osage Creek. ▪ Monitor pool level. ▪ Monitor water quality and quantity.	▪ Adjacent landowner uses dam and pool of water for private business operations. ▪ Submit major land expansion package; prioritize this area for acquisition. ▪ Measure water levels near spring entrance at full level and several times throughout the year and especially during drought periods. ▪ Monitor for contaminants and amount withdrawn for private uses.
Wildlife Response Variables	**Probable Methods**
▪ Identify sensitive aquatic species in the pool. ▪ Remove competitors/ predators.	▪ Conduct samples of aquatic species. ▪ If needed to protect threatened and endangered species.

OBJECTIVE 1.D. BAT FORAGING HABITAT (CCP OBJECTIVE 2.4)

Within 2 years of the date of this HMP, develop karst informational and best management practices (BMPs) brochure, and contact new and existing landowners annually (by public meetings, informational letter, or brochure), to increase and protect important bat foraging habitat along the Osage Creek corridor by identifying important bat foraging habitats, utilizing and encouraging use of BMPs, and supporting acquisition or easements of properties in gray bat foraging areas.

Rational: The gray bat uses caves year-round, but when they are not hibernating, they must feed. Since gray bats forage primarily over water along rivers or lake shores, protective actions not only need to focus on the caves they utilize but also the areas where they feed.

Resources of Concern: Gray bats

Adaptive Management Monitoring Elements:

Habitat Response Variables	Probable Methods
▪ Support acquisition of properties in bat foraging areas identified by TNC. ▪ Restore and increase riparian habitat along Osage Creek.	▪ Submit major land expansion package including these areas for acquisition. ▪ Work with TNC and NRCS to prioritize easements for riparian buffer zones
Wildlife Response Variables	**Probable Methods**
▪ Gray bat use of Osage Creek.	▪ Work with TNC to conduct surveys.

OBJECTIVE 1.E. FOREST HABITAT (CCP OBJECTIVE 2.5) –

Utilize Karst BMP (refer to Appendix A) to maintain and enhance forest habitat surrounding and above Logan Cave to allow sustained use by gray bats.

Rational: Forested habitat on Logan Cave NWR is predominantly mature oak-hickory and covers most of the refuge. This is small for a forested tract, but in an area where the forest is severely fragmented, it can play a large role in the presence and reproduction of forest dwelling birds. Logan Cave NWR is located within the Partners in Flight's Central Hardwoods Bird Conservation Region. The biological review team agreed that management for forest dwelling birds is a relatively low priority for this refuge, as compared to management for cave habitat and fauna. However, the existing forest condition assesses to be in reasonably good condition for many priority bird species thanks to community, age, and recent natural disturbances (i.e., ice storms). If forest management is conducted in the future, the priority drivers for a desired condition should be the needs of bats.

Resources of Concern: Gray bats

Adaptive Management Monitoring Elements:

Habitat Response Variables	Probable Methods
▪ Identify plant species and associations. ▪ Determine desired understory for gray bat.	▪ Utilize Service I&M biologist and partners such as TNC and ANHC. ▪ Use TSI techniques if needed.
Wildlife Response Variables	**Probable Methods**
▪ Gray bat use of forest.	▪ Work with TNC to conduct surveys.

V. HABITAT MANAGEMENT STRATEGIES

CAVE ENVIRONMENT MANAGEMENT STRATEGIES

A karst environment is influenced by many factors including, but not limited to, water quantity and quality, airflow and temperature, and ground cover. These factors have changed at Logan Cave in the past 20-50 years, mostly by unnatural causes.

POTENTIAL MANAGEMENT STRATEGIES

1. Continue to remove any debris that washes or is carried in by trespassers inside the cave (in conjunction with survey trips) and keep debris removed from refuge property topside.
2. Monitor ambient temperature and humidity in various locations inside Logan Cave, including the gray bat maternity site and potential Indiana bat roosting sites, near the entrances and over the pool.
3. Monitor water quantity and quality using continuous monitoring methods and distinguish between confined and residential contaminants. Continuous water quality monitoring has been conducted through a Service Inventorying and Monitoring Program grant with TNC's office in Fayetteville, Arkansas (Table 1). Water quantity and discharge needs to be measured.
4. Perform botanical and wildlife surveys at both cave entrances, primarily to survey for invasive species.
5. Stabilize sinkhole entrance. The sinkhole fence has had a positive impact over time. Further stabilization would include physically removing sediment and installing retaining walls or steps to prevent soil movement into the sink by foot traffic and heavy rains. No heavy machinery will be used due to the naturally unstable environment. Minimum entrance needed by the bats would be approximately four feet.
6. Follow national WNS plan (http://whitenosesyndrome.org).

SELECTED MANAGEMENT STRATEGY AND UNIT PRESCRIPTIONS

Within the Cave Environment:

- Monitor ambient temperature and humidity in the gray bat maternity site area, to identify changing conditions over time (coordinate equipment placement with established entries).
- Monitor ambient temperature and humidity to establish if the cave has conditions suitable for Indiana bat hibernation.
- Continue to support TNC water quality sampling and use data to track cave water quality.
- Monitor vegetation at cave entrances for invasive species.
- Identify the rate of deposition of sediment (to be used to trigger management actions such as sediment removal).
- Carefully remove accreted sediment material, as indicated by rate of accretion.
- Install sediment traps inside sinkhole fence on walk path.
- Limit survey efforts to current bi-annual surveys.

- Follow national WNS prevention recommendations, including decontamination before and after all entries, use of local gear only, and minimize entries.
- Follow decontamination and clean caving recommendations to prevent transfer of pathogens of all types, regardless of WNS status through time.
- Post WNS warning signs to educate and discourage unauthorized entries.

CAVE ENTRANCES MANAGEMENT STRATEGIES

The two known entry points into Logan Cave are on refuge land, which affords the Service the opportunity to protect and monitor these entrances. Preventing trespass into the cave is imperative to the survival of the species using Logan Cave. Disturbance, especially from inexperienced cavers, can have a devastating effect on the bats, cavefish, and crayfish.

POTENTIAL MANAGEMENT STRATEGIES

1. Maintain bat friendly enclosures. Continue to inspect and perform necessary maintenance at least every six months
2. Maintain video surveillance of cave entrances.
3. Prior to the Service purchasing what is now Logan Cave NWR, heavy grazing occurred on the property. Gazing by cattle, horses, and goats continued on refuge land until 1995. Vegetation was low and in some places non-existent. After grazing ended, the vegetation began to rebound. Growth of vegetation was encouraged around the sinkhole to help reduce and slow the erosion and increase the understory and mid-level forest vegetation. Vegetation growth needs to be monitored, especially around the sinkhole entrance. Vegetation is needed to provide cover for gray bats, but too much could obstruct their flight paths, especially large trees that may fall into the sinkhole blocking the entrance.

SELECTED MANAGEMENT STRATEGIES AND UNIT PRESCRIPTIONS

- Any modifications/work conducted at the entrances should occur only between the hibernation period of October 15-March 15, while gray bats are not present.
- Maintenance of the gate and fence continues to be a priority. The gate at the spring entrance should be monitored for debris and obstructions, especially after heavy flooding rains.
- Monitor cave entrances via remote video cameras and utilize local, state, and federal officers to respond to violations.
- The vegetative structure (e.g., shrubs, vines) within the sinkhole fence should be monitored and compared to those areas outside of the fence. Vegetation should be monitored by photo-point for vertical and horizontal vegetative density and, if needed, initiate careful and incremental removal of aerial vegetation (e.g., vines, shrubs) within the fence and over the sinkhole.

LOGAN CAVE STREAM (LOGAN SPRING ENTRANCE SOUTH TO REFUGE BOUNDARY) MANAGEMENT STRATEGIES

Years ago, the stream was dammed to facilitate water withdrawal from Logan Spring for the Logan community water supply, a cannery, and adjacent minnow farm.

Today, water from the spring is not being used for the Logan community, but is still being withdrawn for private and commercial uses. Effects of water withdrawal on the cave aquatic species need to be evaluated. This unnatural pool of water has never been evaluated to determine if it positively or negatively affects the aquatic species or the bats in the cave. It does allow more competition/predation from epigeal crayfish and sculpin living in the pool.

POTENTIAL MANAGEMENT STRATEGIES

Ensure water taken from the pool leaves the cave stream at sufficient levels to achieve refuge purposes.

SELECTED MANAGEMENT STRATEGIES AND UNIT PRESCRIPTIONS

- Identify legal standing of dam, by having refuge boundary resurveyed with permanent markers installed in order to determine ownership.
- Monitor pool level for major shifts in depth and nearness to cave entrance.
- Monitor water quality and amount withdrawn from adjacent landowner using continuous monitoring methods.
- Identify sensitive aquatic species in the pool.
- Remove competitors/predators if needed to protect threatened or endangered species.
- Submit major land expansion package for the recharge area; prioritize this area for acquisition.

BAT FORAGING HABITAT MANAGEMENT STRATEGIES

Gray bats use caves year-round, but when they are not hibernating, they must feed. Since gray bats forage primarily over water along rivers or lakes shores, it makes sense to protect not only the caves they utilize but also the areas where they feed.

POTENTIAL MANAGEMENT STRATEGIES

The Nature Conservancy has mapped priority gray bat habitats in the area and is working to secure easements and restore riparian habitat along the Osage Creek.

1. Utilize BMPs and work with partners and landowners to protect and increase forested riparian corridors and improve water quality of Osage Creek and its tributaries.
2. Support acquisition of properties or easements in gray bat foraging areas. Discussion: A major expansion package including downstream gray bat foraging/riparian areas could be justified.

SELECTED MANAGEMENT STRATEGIES AND UNIT PRESCRIPTIONS

- Work with TNC to prioritize easements for riparian buffer zones along Osage Creek.
- Submit acquisition package including gray bat foraging areas.

FORESTED HABITAT MANAGEMENT STRATEGIES

Forested habitat at the refuge can be managed to provide different structural habitat for forest birds, and adjacent landowners can obtain assistance from federal and state agencies to enhance and increase forested habitat on their lands.

POTENTIAL MANAGEMENT STRATEGIES

1. Utilize Karst BMPs and work with partners and landowners to protect and increase forested riparian corridors and improve water quality of Osage Creek and its tributaries.
2. As needed, remove individual trees proactively to prevent their falling on/damaging the sinkhole fence and/or blocking the sinkhole entrance. Active forest management is not recommended at this time**.**
3. Perform continuous forest inventory (or similar survey) and work with partners and landowners to provide additional forested acres surrounding the refuge, especially in the recharge zone and bat foraging areas.

SELECTED MANAGEMENT STRATEGIES AND UNIT PRESCRIPTIONS

- Active forest management is not recommended at this time.
- Remove individual trees proactively to prevent their falling on/damaging the sinkhole fence and/or blocking the sinkhole entrance.

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APPENDIX A. COMMUNITY GROWTH BEST MANAGEMENT PRACTICIES FOR CONSERVATION OF THE LOGAN CAVE RECHARGE ZONE.

To minimize impacts to threatened and endangered species and water quality in the Logan Cave recharge zone, the Service recommends the following BMPs.

Erosion and Sediment Control

BMPs should be implemented for all construction projects within karst landscapes. BMPs should include the use of filter fences, straw bales, interceptor dikes and swales, sediment traps, ditch checks, and detention basins. Mulching, seeding, and/or re-vegetation should be conducted as appropriate. In some cases, matting or netting may be required on steep slopes and stream banks. Erosion and sediment control measures should be sized to handle at least the 25-year flood and 24-hour storm event. Erosion and sediment control BMP's should be implemented wherever necessary to prevent sediment and contaminants from entering groundwater and the karst landscape.

- It is important that construction planners reduce erosion and sedimentation into streams and karst features by:
- Identifying areas with potential for erosion problems prior to initiation of construction.
- Avoiding wetlands and low-lying areas.
- Restoring steep embankments by seeding, mulching, fertilizing, and implementing erosion control measures such as silt filter fabric fences, straw bales, matting, and sediment traps. It is critical that soil stabilization be completed immediately after the earth work is completed.
- Restoring steep approaches to stream crossings by seeding, mulching, fertilizing, and implementing erosion control measures such as silt filter fences, ditch checks, straw bales, matting, and sediment traps. It is critical that the restoration be implemented immediately after construction.
- On approaches to stream crossings, drainage control structures should be located at the top of the slope/bank and at the base of the slope/bank. Runoff should be routed to stable slopes on either side of the right of way, or routed via temporary conveyance structures to the base of the approach slope where it can infiltrate into the stream bank and eventually seep back to the channel.

1. Filter Fences and Straw Bales

   Filter fences, or a combination of filter fences and straw bales, should be installed to prevent or minimize sediment from steep slopes and disturbed areas leaving the construction site and/or entering streams or karst features. Sediment detention structures should be used in areas with moderate to high erosion potential. Filter fences are useful to intercept and retain small amounts of sediment under sheet flow conditions and should be placed along the borders of water bodies wherever disturbance or construction occurs near a water body. Filter fences should be a minimum of 10 feet from the ordinary high water mark of wetlands, streams, and rivers. The natural vegetation should be retained within the 10-foot buffer zone. Filter fences should be used in areas subject to erosion where the drainage area is one acre or less, but for larger areas a sediment basin should be also used. Filter fences should be used on slopes no greater than 1:1. The maximum flow path to each fence should be about 100 feet. No concentrated flows should be directed toward any fence. Filter fences should be trenched up slope from the barrier and supported by posts spaced a maximum of six feet apart.

Straw bales are one of the most commonly used sediment control methods. Straw bales should be used in areas subject to sheet flow and erosion and where the drainage area is no greater than 1/4 acre per 100-foot of barrier length and the maximum slope behind the barrier is 50 percent (2:1). In most cases, bales should be placed in single rows along contours with the ends tightly abutting one another. To ensure that there is no underflow, the bale barriers should be entrenched. Whenever possible, the back side of the bale should be an undisturbed natural area. If the area behind the barrier has been disturbed or is naturally subject to erosion, the barrier should be backfilled. All bales should be tied and staked. Filter fabric fences and straw bales should be maintained throughout the construction period and inspected daily during prolonged rainfall and immediately after each rainfall event.

2. Sediment Traps

Sediment traps are small temporary ponding areas used to detain stormwater runoff and allow sediment to settle, thereby minimizing the amount of sediment entering streams and rivers. Sizing criteria for the traps include inflow and sediment load, but traps are generally used for small drainage areas less than three acres. Because sediment traps filter out all but the finest sediments, filter fences are necessary at the outfall of the trap to retain silt and clay-size sediments.

Sediment traps should be located to intercept runoff from disturbed areas and should be located away from natural stream channels. A sufficient number of traps should be constructed to intercept runoff from the disturbed area and have sufficient capacity for potential storm events and accumulated sediment. Sediment traps should be designed for the specific disturbed area, for bare soil conditions, and typically for a 75 percent removal efficiency of sediment runoff. Sediment traps should consist of check dams located within an enlarged section of the interception ditch on stable ground. Stable ground should be identified as those areas with well-drained soils and/or where vegetation remains in place to provide sufficient root strength to prevent sliding. In areas where stable ground is not available, several small check dams should be used to prevent buildup of excess water. Traps should have both a low-flow outlet and an emergency overflow. Rock should be placed at the outlet and overflow to prevent erosion where the water enters the downstream drainage way. The outlet pipe, if needed, should be sized to pass runoff from a 25-year flood and/or 24-hour storm event. Traps should not be constructed on fill material.

3. Mulching and Re-vegetation

Mulching and prompt re-vegetation should be used to minimize erosion of exposed soils. Vegetation should be reestablished as soon as possible on all disturbed ground, including access roads and trench backfill. Vegetation (use native vegetation when possible) should be planted in the same growing season as construction or immediately following construction, or if not possible, the disturbed areas should be covered with straw, matting, or some other erosion-control material in the interim. At most locations, broadcast seeding and the replacement of saplings should be the predominant method of re-vegetation. Seed should be planted either by a hydroseed method or by covering with mulch. A grass and forbs mixture recommended by the Natural Resources Conservation Service and the Service should be used to reseed slopes and fertilized where suitable (do not over-fertilize). At locations where the terrain or other conditions would combine to cause a high risk of erosion, the re-vegetation method should be to drill plant grasses or hydro-seed over the steep slopes and then cover with straw or matting.

4. Permanent Stabilization

Material that was pushed aside to make temporary level working areas should be replaced onto the disturbed area. The original contours of the land should be restored as closely as possible. Equipment access crossings should be removed. After the contours have been reestablished, the topsoil that had been previously segregated should be redistributed across the surface of the disturbed area. Water bars should be graded horizontally across the slopes to help prevent gullies and erosion. Areas compacted by heavy construction equipment should be chiseled and disc-plowed to loosen compacted soil. Following final grading, the disturbed area should be stabilized by replanting with non-invasive plant species. Forested and shrub areas that have been impacted by construction, but are not to be maintained as part of the right-of-way access road, should be replanted with suitable native tree and shrub species. Within floodplains, ground stabilization should include only rooted or anchored features, used to slow runoff velocity, and erosion until vegetation is re-established. Steep slopes may require the use of matting or netting to help stabilize soil while new vegetation is established. Disturbed stream banks should be stabilized using appropriate vegetation (native if possible). Wetlands should be stabilized by replacing the original subsoil and topsoil, replacing vegetation, and returning the topography and hydrologic characteristics of the wetland as closely as possible to their original form. Disturbed wetland buffers should be stabilized by replanting appropriate vegetation.

Construction in Sensitive Areas (stream channels, karst)

Additional measures should be required for construction near sensitive areas which include stream channels and karst features. Care should be taken when working around streams and caves to prevent unnecessary damage to or removal of vegetation. If a cave or fracture is breeched or surface water is rerouted into a karst feature, all activities should cease and the Service should be contacted to assess the situation and provide further consultation before proceeding.

Staging areas should be placed at least 300 feet away from stream banks and wetlands whenever possible. In addition, all streams, ponds, and wetlands adjacent to disturbed areas should be protected by the use of filter fences, straw bales, or other BMPs to prevent sediment from entering the water body. At stream crossings, a number of measures may be necessary to decrease damage to waterways. In streams with large enough flow, temporary in-stream settling ponds should be used to catch sediments generated by construction. These sediments should be removed as soon as construction is completed in that area. For smaller streams or where appropriate, stream waters could be bypassed through construction areas by the use of flume pipes, pumps, or coffer dams. Stream waters can also be bypassed using directional drilling techniques, as discussed later.

Streams and karst areas should be restored and banks stabilized immediately following construction activities. Native plants, matting, netting, and other BMPs should be used to stabilize banks. In-stream deflectors and anchored logs should be used in high-velocity streams to protect vulnerable banks and allow for reestablishment of vegetation. Riprap revetment should also be used, if necessary, to help stabilize slopes in areas of high-velocity stream flows. The use of riprap should, however, be minimized. Rock typical of the local geology should be used if available. Monitoring of BMP performance in critical areas, particularly at sensitive stream crossings and stream approach slopes should be conducted and documented on a routine basis prior to and after major storms during construction and operation. Based on monitoring, additional BMPs or other improvements may be necessary to ensure minimization of impacts.

Extreme caution should be used during construction in the vicinity of the streams and karst features inhabited by sensitive and federally threatened and endangered species. Please contact the Service if you are unsure of the occurrence of species in the planned construction area.

All efforts should be made to minimize stream alterations that could affect water quality and fish and wildlife resources. Construction along streams should not take place during fish spawning seasons if possible.

The true extent of the subterranean environment is difficult to clearly delineate. Undiscovered karst features, such as cave openings, sinkholes, and underground passages, may occur on or near your project site, even in previously developed areas. Therefore, the Service recommends the following precautionary measures be taken to avoid impacts to groundwater and sensitive/ endangered species that may inhabit karst features not previously surveyed:

1. Survey existing and any new rights-of-way for karst features such as cave openings, sinkholes, losing streams, and springs.

2. Establish a buffer area of 300 feet or greater around any caves, sinkholes, losing streams, and springs found during the survey (or during any aspect of project implementation). The Service should be contacted for further evaluation to determine if the cave is used by federally listed or sensitive cave species.

3. If a cave is used by federally listed or sensitive species, the Service will likely request that the cave be mapped to determine if any additional openings or passages may be affected by the project. In addition, we may recommend modifications of the proposed project to allow additional buffer areas to be established. Incorporation of additional buffer areas may be necessary to avoid impacts to federally listed or sensitive species.

4. In the event that holes or other openings are encountered during construction activities, the Service requests that work efforts cease within 300 feet of the opening. The opening should be adequately marked and protected from work activities, and the Service should be contacted immediately. No fill materials should be placed into the opening until Service or Service-approved personnel have the opportunity to investigate the site thoroughly.

5. The Service should assess the caves located prior to or during construction for sensitive/endangered species and provide further consultation before activities proceed.

6. No blasting should be permitted in the vicinity of any known karst features without previous consultation.

Vehicle Maintenance, Petroleum, and Chemicals

To prevent petroleum products from contaminating soils and water bodies, the following BMPs should be implemented:

* Construction equipment and vehicles should be properly maintained to prevent leaking of petroleum products.

* Specific staging areas for equipment/vehicle maintenance and chemical storage should be established 100 yards or more away from wetlands, streams, or karst features.

* Drip pans and tarps or other containment systems should be used when changing oil and other vehicle and equipment fluids.

* Any contaminated soils or materials should be disposed of off-site in proper receptacles or at an approved disposal facility.

* Vehicle and equipment fueling should be attended at all times by site personnel. Spill cleanup materials should be stored on site and employees should be trained in spill control procedures.

* Wash water (including mild detergents) from the body of vehicles should be allowed to infiltrate into a permeable area such as gravel, grass, or loose soil 300 feet or more from wetlands, streams, or karst features. Vehicle engine or under-body and equipment wash water should be disposed of off-site at appropriate facilities depending on the contents of the waste water. Waste water should not be discharged directly into water bodies or karst features.

* Petroleum products and other chemicals should be properly stored in appropriately labeled containers under sheltered areas. Storage shelters should be designed with an impermeable floor area.

* Materials for cleaning up spills should be kept on site. Spills should be cleaned up immediately in accordance with state and federal regulations.

Solid Wastes

Solid wastes, such as vegetation removed during clearing, sanitary waste, food and food container waste, and metal and wood scraps, should be collected and disposed of according to applicable regulations or recycled/reused. Sanitary facilities should be well-maintained and conveniently located. Waste containers should be labeled and located in a sheltered area away from water bodies and drainage pathways. Erosion and sediment control structures should be frequently inspected for accumulations of solid waste and any waste removed immediately.

Chemical Controls

Herbicides, fertilizers, vehicle maintenance fluids, petroleum products, and drilling fluids should be discarded, stored, and/or changed in staging areas established as far away from streams as is economically and physically possible. Spill response protocols and a spill response kit should be maintained on site to address these concerns.

Areas where discharge material, overburden, fuel, and equipment are stored should be designed and established at least 300 vegetated feet from the edge of streams and cave watersheds. Further distance is recommended, but with proper barrier fences, surface design, and/or maintaining a vegetated buffer, most impacts can be avoided or significantly reduced.

Stream Crossings/Pipelines

Several methods can be used for stream crossings, including open cut channels and directional drilling. The standard BMPs for pipeline construction in trenches, construction near sensitive areas, and construction staging areas should be applicable to each of these water crossing methods. Construction at stream crossings should be according to the selected stream crossing method (e.g., wet trench, dry trench, or drilling) and specific mitigation concerns associated with the level of disturbance and stream sensitivity. General construction sequences for trenched stream crossings include the following basic steps:

1. Construct a flow by-pass structure (for dry trenching) to create a relatively dry stream bed or a backwater condition. Flow by-pass structures should cross the full width of channel (including side channels) in one span or in stages;

2. Once flow is controlled (in the case of wet trenching, step one above is not needed), route flow into the by-pass and trench across the entire channel width to the appropriate depth below maximum scour and install pipeline;

3. Backfill the trench with native bed material, and stabilize the bed and bank with armoring matched to baseline flow conditions;

4. Reintroduce flow and monitor performance.

Temporary in-stream settling ponds should be constructed without significantly dredging or altering the natural geology and channel of a stream. Settling ponds should be constructed using primarily fill rock or screens and disturbance or alteration of the channel should be kept to a minimum. Natural stream bed alteration necessary for diversions should be kept at a minimum and restored upon completion of activities. Riprap and filter screens used to create traps or diversions should be removed upon completion of the activities.

Critical slopes are characterized as steep approaches to stream crossings where the pipeline trench is parallel to the slope angle, areas where bank erosion can destabilize slopes, drainage is concentrated, and areas where sediments can directly enter receiving waters. Stringent erosion and sediment control measures, aggressive slope stabilization measures, and frequent monitoring should be implemented during and after construction in critical areas.

Use a directional drilling method for proposed pipeline crossings of sensitive losing streams, flowing streams, and wetlands. Prior to directional drilling, a geotechnical investigation using the least intrusive means possible (e.g., ground penetrating radar, minimal exploratory bore hole drilling, seismic refraction and reflections, cave radiolocation, resistivity, and magnetometry) should be conducted to determine subsurface/geologic conditions that would be encountered along the drill path to ensure that a directional drill pipeline at the location would be feasible and not result in unnecessary damage to a sensitive area, such as a karst void. Drilling fluids should be captured and accounted for during all drilling activities.

If directional drilling is not feasible, it is recommended that stream crossings be conducted during periods of low flow (July-September), and that limited amounts of riparian vegetation be removed during pipeline installation.

In general, stream channel disturbance using directional drilling is greatly reduced compared to trenching. Considerations include preventing runoff and contaminants from the staging areas on either side of the crossing from entering the stream. This should require construction of secondary containment structures (i.e., berms and filter fences) along with runoff dispersion and sediment traps to prevent any runoff generated in the staging areas from reaching the stream. Additionally, equipment should not be run through stream channels.

Where excavation involves native or established wetland/riparian vegetation, the top 6 to 12 inches or more of vegetation and topsoil, including the vegetation and root mass, should be carefully removed and stockpiled separately into a dedicated deposition area. After completion of site disturbance, this vegetated material and its associated soils should be placed as the surface material.

Wells located within the right-of-way should be evaluated for closure methodology and potential biological inventories. Wells adjacent to the right-of-way should be documented for future monitoring opportunities. If wells are located within the right-of-way which require closure, coordination with the Service should occur prior to closure.

Stormwater

Storm-water concerns occur during construction and after the landscapes are stabilized and developed. In fact, threats to groundwater shift from sediment, fuels, and oil/grease from construction sites, to lawn chemicals, oil and grease from personal vehicles, and other household contaminants. Plans should be made to address post construction storm-water contaminants.

The Arkansas Department of Environmental Quality and the USEPA oversee and permit storm-water runoff. In 2003, the Northwest Arkansas Regional Planning Commission developed the Northwest Arkansas Storm Water Quality Best Management Practices Preliminary Guide Manual for community use. The manual was developed with six control measures including public education and outreach, public participation and involvement, illicit discharge, detection and elimination, construction site runoff control, post-construction runoff control, pollution prevention, and good housekeeping. When open land is developed, the hydrology of the site completely changes. Possible contaminants associated with development include sediment, nutrients, microbes, organic matter, toxic contaminants, trash, and debris. Each of these together or separately can pollute groundwater. Once contaminants leave the site and enter drainage within a groundwater recharge zone, whatever the water was carrying is now contributing to groundwater pollution and can threaten rare karst animals.

Please contact Jeff Hawkins, Director, Northwest Regional Planning Commission, 406 N. Shiloh, Springdale, Arkansas 72764, or call him at 479-751-7125, for a copy of the Commission's storm-water BMPs. BMPs summarized above are presented in greater depth in this publication.

Storm-water Detention Basins

Storm-water runoff potentially contains sediments, fuels/oil/grease, brake dust, herbicides, pesticides, and other contaminants. In order to reduce the quantity of potential contaminants contained in storm water during and after construction activities, the following recommendations apply:

* Establish a stormwater detention basin capable of capturing sediments off the development. This detention basin can be roughly established initially then refined once construction is completed and the site stabilized

* Before construction begins, a detention basin should be designed and constructed to capture the first ½ inch of a rain/climatic event from the entire site proposed for development. These basins should be fenced and contain a 3:1 slope for safety reasons. The basin should not be constructed in stream drainage, but may be constructed adjacent to it. A spillway should be established in the detention basin to allow for rain/climatic events in excess of ½-inch, to be discharged based on state permitting. The bottom of the pond should be lined with a textile or bentonite type material to capture the rain and not allow leakage. This should then be covered by approximately 1 foot to 2 feet of gravel, so that during maintenance the impenetrable lining would not be breeched.

* A sediment monitoring station should be established in the detention basin to determine the rate of filling and to determine when excess sediment should be removed from the pond. At a minimum, at least once a year the pond should be inspected for trash and debris. Any visible trash or debris shall be removed. Every five years, at a minimum, the pond should be drained, the sediment monitoring station checked, and if necessary, the pond dredged to its original depth. Removed sediments should be discarded in an appropriate location where surface erosion potential is negated, as it possibly contains concentrated contaminants.

* An alternative to detention basins could be the installation and maintenance of an oil/grit/water separation system. An example can be found on the Internet at *baysaver.com*. Although these systems would replace detention basins, discharge would still need to run through a bio-retention treatment area, as described below.

* After capture of the first ½-inch flush, waters should then be directed to a bio-retention treatment area, which consists of a vegetated buffer strip, sand bed, organic or mulch layer, planting soil, and hydrophilic plants. This area provides temporary storage prior to infiltration.

Plants can remove contaminants while a clay layer can absorb hydrocarbons, heavy metals, nutrients, and other contaminants. Organic mulch filters contaminants and provides an environment conducive to growth of microorganisms, which degrade petroleum-based products and other organic materials. Bio-retention areas require maintenance.

In areas where sensitive karst features are identified or a stream corridor exists which are the target of storm-water discharge, a storm-water detention basin should be constructed as a permanent on-site structure, to allow for settling of contaminants. In addition, before storm-water flows out of these basins and into the stream corridor, it should run through some variation of a constructed bio-retention filter. This filter can remove and trap many of the floating contaminants that would not be trapped by a detention basin (i.e., oil/grease).

Another possible alternative for treatment of storm-water is separation systems. These systems allow for sediment, oils, and floatable debris to be collected. They do require periodic maintenance, but may provide a reasonable alternative to large detention basins. While these systems do reduce some contaminants, outflow from the systems should run through a constructed bio-retention filter to remove other contaminants.

The best alternative is to connect the development into an established community storm-water collection system which transfers and discharges the waters to an appropriate permitted location. All regulations established and required by the Arkansas Department of Environmental Quality must be followed.

Wastewater

Several alternatives for managing wastewater are either currently available or possible in the future. These include regional or municipal sewage treatment plants, decentralized wastewater treatment facilities, or septic systems. Currently, only septic systems are available for much of the Logan Cave recharge zone. Based on the density of most large scale developments, municipal or decentralized wastewater treatment facilities are probably the primary alternatives. Location of the treatment stations and the placement of the drip fields are of the most concern when it comes to groundwater conservation. Karst landscapes have limited soils and the closer one comes to a sensitive karst feature, generally fewer soils are available to assist in the wastewater treatment process. The Arkansas Department of Health (ADH) must be contacted for both decentralized wastewater treatment facilities and septic systems in order for them to characterize the soils as capable of functioning effectively as part of the treatment process or not. In the case of decentralized wastewater treatment facilities, both the ADH and Arkansas Department of Environmental Quality conduct reviews before permits are issued. Septic systems are reviewed and permitted by the ADH.

Where stream channels are located within the Logan Cave recharge zone, a setback of at least 100 feet should be the minimum for drip lines or drain fields. Soils should meet more than the minimum criteria for wastewater detention time, given the fact that karst geology lies just beneath and can transfer contaminants directly to the groundwater. Decentralized wastewater treatment is generally considered to be an extension of onsite wastewater treatment or conventional wastewater systems that includes some form of voluntary management practices. Decentralized systems employ a combination of technologies and are used to treat and dispose of wastewater from dwellings and businesses close to the source. Decentralized wastewater systems allow for flexibility in wastewater management, and different parts of the system may be combined into "treatment trains," or a series of processes to meet treatment goals, overcome site conditions, and to address environmental protection requirements. Each technology has advantages, as well as limitations, so a treatment technology must be selected specifically to meet local conditions and treatment objectives. Similarly, each community's own financial, physical, and regulatory factors must be evaluated to find the best technology for its circumstances.

Many considerations would determine how close to the source of generation it is practical to place the treatment center. One very important factor is the potential for beneficial reuse of reclaimed water. Other considerations include topography, soil conditions, development density (existing or desired), type of land use, and environmental impacts of the wastewater management function in any given locale.

Management is the key to keeping decentralized treatment systems functioning properly. Management can encompass planning, design, installation, operation, maintenance, and monitoring of onsite and cluster systems. Regular inspection and maintenance form the basis of any management program.

Procedures for Subdivisions Using On-site Sewage Disposal

According to the Arkansas Department of Health’s “Rules and Regulations Pertaining to Sewage Disposal Systems,” a subdivision is defined as “land divided or proposed to be divided by a common owner or owners for predominantly residential purposes into three or more lots or parcels, any of which contain less than three acres, or into platted or un-platted units any of which contain less than three acres, as a part of a uniform plan of development.”

1. You must contact an authorized “Designated Representative” to start the process. “Designated Representative” lists are available at the county health department.

2. The “Designated Representative” will submit the subdivision plans, in triplicate to the county health department.

3. The Arkansas Department of Health’s environmental health specialist will evaluate the site and write a letter with findings to the Arkansas Department of Health Engineering Division. Special consideration will be given to sites that may pose a potential problem for ecologically sensitive areas, areas of shallow bedrock, fractured rock formations, and/or other conditions that may adversely affect renovation of wastewater before re-entering the true water table.

4. Following a recommendation from the environmental health specialist, the Engineering Division will write a letter of approval or denial, usually in conjunction with the subdivision’s water system, to the property owner. Water supply, treatment, and distribution plans for the subdivision, other than individual wells for each lot, must be prepared by a registered professional engineer and submitted to the Division of Engineering for review and approval. If there are any questions, the county health department should be contacted.

Summary of Septic tanks from EPA website:

If properly designed, constructed, and maintained, a septic system can provide an effective treatment of household wastewater. Malfunctioning systems can contaminate groundwater that might be a drinking water source or home to rare karst-dependent animals. A typical septic system has four main components: a pipe from the home, a septic tank, a drainfield, and the soil. Microbes in the soil digest or remove contaminants from wastewater. A septic tank is buried in a watertight concrete, fiberglass, or polyethylene container. It holds wastewater long enough to allow solids to settle out and oil and grease to float to the surface. It also allows for partial decomposition of solid materials. A T-shaped outlet in the septic tank prevents sludge and scum from leaving the tank and traveling to the drain field. Screens are also recommended to keep solids from entering the drain field. Wastewater exits the septic tank and is discharged into the drain field for further treatment by the soil. Microbes in the soil provide final treatment, by removing harmful bacteria, viruses, and excess nutrients.

Procedures for Obtaining an Individual Septic System Permit

The Arkansas Department of Health requires all property owners using individual sewage disposal (i.e., septic system) for their property to follow the steps outlined below. You must contact an authorized “Designated Representative” to design the individual sewage disposal system or a repair to the individual sewage disposal system. “Designated Representative” lists are available at the county health department. The following steps are in accordance with the Arkansas Department of Health’s Rules and Regulations Pertaining to Individual Sewage Disposal Systems:

1. The “Designated Representative” will submit an application for a “Permit for Construction” for the individual sewage disposal system to the Arkansas Department of Health.

2. The Arkansas Department of Health’s environmental health specialist will evaluate the design and issue a “Permit for Construction” if the submitted application meets all current regulations and is appropriate for the site.

3. If approved, a copy of the permit will be mailed to the property owner at this time.

4. Upon receipt of the “Permit for Construction,” the approved individual sewage disposal system may be installed. A list of septic system installers licensed by the Arkansas Department of Health is available at the county health department.

5. After installation and before the system is covered the property owner and/or the licensed installer will contact the Arkansas Department of Health’s environmental health specialist to conduct a final evaluation of the system. If the system is approved the environmental health specialist will issue a “Permit for Operation.”

If there are any questions regarding onsite sewage disposal or septic systems, the county health department (i.e., environmental health specialist) should be contacted.

If there are questions regarding this BMP, please contact: Chris Davidson, Endangered Species Biologist, Fish and Wildlife Service, 110 South Amity, Suite 300, Conway, AR 72032; telephone: 501/513-4481; e-mail: *chris_davidson@fws.gov/* or Refuge Manager, Logan Cave National Wildlife Refuge, c/o Holla Bend National Wildlife Refuge, 10448 Holla Bend Road, Dardanelle, AR 72834; telephone: 479/229-4300; e-mail: *carla_mitchell@fws.gov/*.

APPENDIX B. MONITORING PROTOCOL FOR SURVEYING OZARK CAVEFISH AND BENTON CAVE CRAYFISH IN LOGAN CAVE NWR

To safely survey cavefish and cave crayfish in Logan Cave NWR, it is useful to have a team of five people. For this survey, the cave is split into two sections. Section one is the spring entrance upstream to the Sinkhole entrance, and Section two is the Sinkhole entrance upstream to the end of accessible cave passage. In order to ensure consistency in survey methods, it is necessary that at least one (preferably more) individual in each group has participated in previous aquatic surveys at Logan Cave NWR. Two surveyors using headlamps and diving lights, while proceeding slowly upstream from the spring entrance, conduct visual census of cavefish and cave crayfish in Section one. For this section of the cave, the use of a wetsuit is optional depending on personal preference. For Section two, a team of three people conduct a visual census of cavefish and cave crayfish using headlamps, diving lights, and snorkeling equipment while slowly moving upstream. Snorkeling equipment (e.g., mask, snorkel, fins) is necessary to consistently count individuals in deeper sections of the stream, and this equipment can be removed for shallower sections of the stream passage where it is not needed. In deeper sections, 1 to 2 surveyors snorkel pools using diving masks and dive lights to count individuals. In the longer or wider pools, the two surveyors swim side-by-side while conducting the census. The third surveyor can assist with data management when needed and is available as a backup for safety concerns. Wetsuits are recommended for this section of the cave. Data should be recorded on a dive slate, which allows the user to record data while in the water. In both sections of the cave, the size class of each cavefish and cave crayfish should be recorded. The length of each animal is classified as 1 of 3 possible categories: small (<1 inch), medium (1 to 2 inches), or large (>2 inches). After finishing the survey of cavefish and cave crayfish in Section 2, surveyors should count bats (individuals and species) while returning to the sinkhole entrance.

APPENDIX C. ENVIRONMENTAL ACTION STATEMENT

Within the spirit and intent of the Council on Environmental Quality's regulations for implementing the National Environmental Policy Act (NEPA), and other statutes, orders, and policies that protect fish and wildlife resources, I have established the following administrative record and determined that the following action is categorically excluded from NEPA documentation requirements consistent with 40 CFR 1508.4, 516 DM 2.3A, 516 DM 2 Appendix 1, and 516 DM 6 Appendix 1.4.

PREFERRED ACTION AND ALTERNATIVES

The preferred action is the approval and implementation of this HMP for Logan Cave NWR. This HMP is a step-down management plan providing the refuge manager with specific guidance for implementing goals, objectives, and strategies identified in the Logan Cave NWR Comprehensive Conservation Plan (CCP 2008).

The CCP action was the preferred alternative among three alternatives considered in the Environmental Assessment (EA) (Draft CCP and EA 2008). In the CCP, the preferred action "will result in management based on sound science for the conservation of a structurally diverse and species diverse karst habitat for threatened, endangered, and resident wildlife. A focused effort will be placed on properly administering, conserving, and developing the 123-acre area for protection of a unique cave ecosystem that provides essential habitat for the endangered gray bat, endangered Benton cave crayfish, threatened Ozark cavefish, and other significant cave-dwelling wildlife species, while contributing to other national, regional, and state goals to protect and restore karst habitats and species. It provides the best mix of program elements to achieve desired long-term conditions. Baseline inventorying and monitoring of management actions will be completed to gain information on a variety of species of special concern. Cooperative partnerships will be conducted with universities, Arkansas Game and Fish Commission, and other agencies and individuals, to provide biological information to be used in management decisions. When compatible, the wildlife-dependent recreational opportunities for wildlife observation, wildlife photography, and environmental education and interpretation will be provided and enhanced, while achieving the refuge purpose and remaining consistent with existing laws, Service policies, and sound biological principles" (Logan Cave NWR CCP 2008).

The CCP has defined goals, objectives, and strategies to achieve the stated action. The actions further detailed in this HMP have been identified, addressed, and authorized by the Logan Cave NWR CCP. This HMP expands upon and clarifies the intent of the objectives and strategies of the refuge's CCP. The list below provides a crosswalk between the HMP and CCP goals and objectives. These include the page numbers in the Final CCP (USFWS 2008):

Objective 1.A. Cave Environment (CCP Objective 2.1) - Manage the aquatic and terrestrial functions associated with this unique karst environment by conducting cleanup (trash, debris, etc., during periodic site visits and bi-annual surveys), annually monitor ambient temperature, humidity, water quality and quantity (Table 1) (at least one sample above sinkhole entrance and at Logan Spring), and stabilizing sinkhole entrance (sediment traps/steps) of Logan Cave within the next 10 years.

Cave Environment Management Strategies (CCP pages 28-29).

Objective 1.B. Cave Entrances (CCP Objective 2.2) - Regularly maintain two known entry points into Logan Cave after major weather events by removing debris and maintaining the fence/gate at the spring and sinkhole entrances. Any maintenance involving welding would need to take place between October 15 and March 15.

Cave Entrances Management Strategies (CCP page 29).

Objective 1.C. Logan Cave Stream (CCP Objective 2.3) (Logan Spring entrance south to refuge boundary) - Conduct baseline water quality and quantity (See Table 1 for parameters) taken from Logan Cave Stream, using continuous monitoring methods and distinguishing between confined (i.e., poultry and hog operations) and residential contaminants in order to provide optimal habitat (i.e., water quality and quantity) for aquatic species use.

Logan Cave Stream Management Strategies (CCP pages 29-30).

Objective 1.D. Bat Foraging Habitat (CCP Objective 2.4) - Within 2 years of the date of this HMP, develop karst informational and BMPs' brochure, and contact new and existing landowners annually by public meetings, informational letter, or brochure, to increase and protect important bat foraging habitat along the Osage Creek corridor by identifying important bat foraging habitats, utilizing and encouraging use of BMPs, and supporting acquisition or easements of properties in gray bat foraging areas.

Bat Foraging Management Strategies (CCP page 30).

Objective 1.E. Forest Habitat (CCP Objective 2.5) - Utilize Karst BMP (refer to Appendix A) to maintain and enhance forest habitat surrounding and above Logan Cave to allow sustained use by gray bats.

Forest Habitat Management Strategies: Maintain and enhance forest habitat according to CCP objective (CCP page 30).

CATEGORICAL EXCLUSION(S)

Consistent with Categorical Exclusion (516 DM 6, Appendix 1, Section 1.4 B (10)), this HMP is a step-down management plan which provides guidance for implementation of the general goals, objectives, and strategies established in the CCP, serving to further refine those components of the CPP specific to habitat management. This HMP does not trigger an Exception to the Categorical Exclusions listed in 516 DM 2 Appendix 2.

Minor changes or refinements to the CCP in this activity-specific management plan include:

- Habitat management objectives are further refined by providing numerical parameter values that more clearly define the originating objective statement.
- Habitat management objectives are restated so as to combine appropriate objectives or split complicated objectives to provide improved clarity in the context of this HMP.

- Specific habitat management guidance, strategies, and implementation schedules to meet the CCP goals and objectives are included (e.g., location, timing, frequency, and intensity of application).

All details are consistent with the CCP and serve to provide the further detail necessary to guide the refuge in application of the intended strategies for the purpose of meeting the habitat objectives.

PERMITS/APPROVALS.

Endangered Species Act, Intra-Service Section 7 Consultation was conducted and signed (2007) during the CCP process.

Other Items to include that should be listed and can be found in the EAS accompanying the final CCP include:

Floodplain Management and Protection of Wetlands, Executive Orders 11988/11990 - 2008
Form DI-711, Intergovernmental Notice of Proposed Action, 2008
National Historic Preservation Act, Protection of Cultural Resources, 2008

PUBLIC INVOLVEMENT/INTERAGENCY COORDINATION.

This HMP is a step-down of the approved CCP for Logan Cave NWR. The development and approval of the CCP included appropriate NEPA documentation and public involvement. An Environmental Assessment was developed (Draft CCP/EA 2008), which proposed and addressed management alternatives and environmental consequences. Public involvement was initiated with a notice of intent published on November 23, 2005, in the *Federal Register* (70 FR 70878). The Draft CCP/EA was announced in the *Federal Register* (73 FR 4615) and made available for public comment from January 25, 2008 through February 25, 2008. Copies of the Draft CCP/EA were posted at refuge headquarters and area locations and more than 120 copies of the Draft CCP/EA were distributed to local landowners; members of the public; and local, state, and federal agencies. A public meeting was also held on February 12, 2008, near Logan Cave. Refer to the Final CCP for specific comments and Service responses.

SUPPORTING DOCUMENTS.

Supporting documents for this determination include relevant office file material and the following key references:

U.S. Fish and Wildlife Service. 2008. Logan Cave National Wildlife Refuge, Comprehensive Conservation Plan.

U.S. Fish and Wildlife Service. 2008. Logan Cave National Wildlife Refuge, Draft Comprehensive Conservation Plan and Environmental Assessment.

U.S. Fish and Wildlife Service. 2010. Logan Cave National Wildlife Refuge Biological Review. Prepared by Tom Edwards, FWS, Division of Migratory Birds. 28 pp.

Carla Mitchell

Refuge Manager

7/23/2013

Date

Area Supervisor

11/05/2013

Date

Richard Warner

Regional Refuge NEPA Coordinator

10/30/2013

Date

Regional Chief, Southeast Region

11/8/13

Date

Logan Cave National Wildlife Refuge
Habitat Management Plan

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