Appendix A

Species Accounts

Gray Bat
(Myotis grisescens)

Status

State: Endangered under Missouri Code of State Regulations (State of Missouri 2017). NatureServe Rank[1] S3**:** Vulnerable.

Federal: Endangered, final listing April 28, 1976 (USFWS 1976).

Critical Habitat: Critical Habitat has not been designated for the gray bat.

Other: A national recovery plan for the species was completed on July 1, 1982.

The gray bat was federally listed as endangered by the U.S. Fish and Wildlife Service (USFWS) in 1976 primarily because of disturbance and vandalism at hibernacula and maternity caves (USFWS 1982). At the time of listing, there were an estimated 128,000 individuals, but more recent efforts provided an estimate of more than 3,000,000 bats—an increase linked both to the discovery of new populations and population increases (USFS 2005). In 2017, FWS developed a minimum population estimate of 4,486,263 gray bats (Marquardt, 2018). Approximately 800,000 gray bats hibernate in four caves in southern Missouri (Missouri Department of Conservation 2000; 2016, Colatskie 2017). USFWS has not designated critical habitat for the gray bat.

Description

The gray bat is one of the largest members of the genus *Myotis* weighing approximately 0.35 ounces (10 g) at maturity, with a forearm length between 1.6 to 1.8 inches (40.5 to 45.5 mm) (USFWS 1976, Decher and Choate 1995). While the gray bat is similar to three other *Myotis* species covered by this Plan (the Indiana bat [*Myotis sodalis*], the northern long-eared bat [*Myotis septentrionalis*], and the little brown bat [*Myotis lucifugus*]), it can be distinguished by its large size, uniformly gray fur, wing membranes that attach at the ankles of the feet, notched claws, and its unkeeled calcar (Decher and Choate 1995).

Range

The geographic range of the gray bat is primarily the limestone karst areas of the southeastern United States (Figure 1), with the majority of populations occurring in Alabama, Arkansas, Kentucky, Missouri, and Tennessee (Barbour and Davis 1969). This range extends as far north as southern Indiana (Brack et al. 1984), as far west as southeastern Kansas (Choate and Decher 1996), and as far east as western North Carolina and Virginia (Decher and Choate 1995). The species is also a well-known migrant and occasionally occurs many miles outside its normal range (Stihler and Brack 1992, Tuttle et al. 2005).

[1]A standardized ranking system for species and community types that is compiled by partner agencies (such as MDC) and reported to NatureServe.

Known Range in Missouri and Occurrence on MDC Lands

Gray bats are known from 66 counties in Missouri (Figure 2). Lands owned and managed by the Missouri Department of Conservation (MDC) are present in all 66 of these counties. MDC has actively managed the gray bat since before the species was federally listed. This has included the purchase and management of many of the most important gray bat sites in the state. There are 27 areas in 18 counties that are owned and managed by MDC and include approximately 64 caves used by gray bats. These include several well-established hibernacula; most notably Coffin Cave (approximately 500,000 bats—the largest concentration in the state) and Bat Cave (11,000 – 61,000 bats). Important maternity and transient season caves on MDC lands include Saloon Cave, Blackwell Cave, and Shop Hollow Cave, each of which contain several thousand gray bats each year.

Gray bats have been recorded in 55 counties during the active months (April-October). These counties include 688,0494acres (278,444 Ha) of MDC lands.

Modeled Distribution in Plan Area

Gray bats are abundant in the karst areas of Missouri, which occur from the southwestern portion of the state, through the Ozarks, and into the northeastern area of the state along the Mississippi River (Missouri Department of Conservation 2016). There are fewer karst areas in the northern portion of Missouri, but gray bats are known to occur at the several that are present (LaVal and LaVal 1980).

The modeled distribution map is intended to provide insight into areas where gray bats may be encountered while foraging and migrating (Figure 3), because unlike other covered species, the primary roosting habitats are well known. The Ozark Highlands and Interior River Lowlands are considered areas of high potential occupancy. The species is unlikely to occur in the extreme northwest part of the state (Western Loess Hills, Rolling Loess Prairies, and Loess Hills and Rolling Prairies), with areas of low probability of occurrence (i.e., low occupancy) characterized by the rest of the northwest quarter of the state, the extreme southeast (the boot heel/Mississippi Aluvian Plains), and Metropolitan St. Louis. The species is moderately likely to occur throughout the rest of the state. These areas are described as medium occupancy in Figure 3.

Ecology

The annual life cycle of the gray bat is similar to the other covered species, but is often described in different terms due to its year-round reliance on underground habitat. For gray bats, seasonal ecology is often discussed in terms of the caves being used at a given time. Gray bats move annually between hibernacula and summer caves (which are divided into maternity and bachelor roosts). During the migration between winter and summer caves, gray bats stop at well-defined sites known as transient caves.

Gray bats are true "cave bats", meaning they require caves for both winter hibernation and summer roosting, although some gray bats are also known to use storm sewers (Harvey and McDaniel 1988, Decher and Choate 1995), bridges (Johnson et al. 2002, Cervone and Yeager 2016), quarries, mines (Brack et al. 1984), and other man-made buildings and tunnels (Elder and Gunier 1978, Evans and Drilling 1992, Missouri Department of Conservation 2016). Gray bats use separate caves for hibernation and summer roosting, and may migrate hundreds of kilometers between summer roosts and hibernacula (Tuttle 1976b). Gray bats are philopatric to their summer and winter sites, and are found in large numbers in caves year-round (Missouri Department of Conservation 2016). The same individual gray bats will often return to the same hibernacula, summer caves, and even migratory stop-over sites each year (LaVal and LaVal 1980).

Winter Hibernation

Migration to winter hibernacula from summer roosts begins in August and lasts through early November (Figure 4) (Missouri Department of Conservation 2000). Gray bat hibernacula are often vertical caves with domed rooms where cold air enters and then gets trapped. Temperatures within these areas typically range between 43 to 52 degrees Fahrenheit (° F) (6 to 11.6 degrees Celsius [° C]) (Tuttle 1976a; 1979). Gray bats have a distinctive, loose-armed posture while roosting and form large, irregular clusters that make it difficult to count individuals.

Staging, Swarming, and Migration

Movement patterns of gray bats in Missouri have been the subject of multiple studies (Myers 1964, Elder and Gunier 1978, LaVal and LaVal 1980, Elder and Gunier 1981, Gerdes 2016), and the following comments are drawn from these studies. During the migration between winter and summer caves, gray bats stop at well-defined sites known as transient caves.

Male gray bats are active beginning in early March and female gray bats begin to migrate from the hibernacula to the summer range by late March. Males are typically active earlier in the spring and migrate to the summer range earlier. A few males may stay near summer caves throughout the year. In other species, this would be considered the start of spring staging. Transient caves are used by both sexes in April. By mid-May females have moved to maternity caves and males to bachelor roosts. Gray bats of all ages and sexes can be found at both the maternity and transient caves in July and August. This is likely the initiation of what would be termed swarming in other bats, and activity follows the bats south toward the hibernacula. Mating occurs soon after adults arrive at the hibernaculum, and females begin hibernation immediately after. Males and juveniles will remain active for several weeks after females begin hibernation, but all individuals are usually hibernating by the beginning of November. Females store sperm over the winter, and become pregnant after emerging from hibernation in April (USFWS 1982).

By early November, most gray bats have reached hibernacula and activity decreases prior to torpor. Acoustic data indicates that some bats make the move between winter and summer habitats in a matter of days (Gerdes 2016).

Gray bats from Missouri frequently migrate between hibernacula in Missouri and summer sites in Missouri and surrounding states. These sites may be separated by hundreds of miles. Elder and Gunier (1978) indicated that the typical distance between summer and winter ranges for a gray bat captured in Missouri is 124 miles (200 km), although one bat migrated 398 miles (640 km). Gray bats are known to move between Missouri and adjacent states including Illinois, Kansas, Arkansas, and Oklahoma (Myers 1964, Elder and Gunier 1978, LaVal and LaVal 1980, Elder and Gunier 1981, Gerdes 2016).

Summer Roosting Habitat

Male gray bats emerge in spring (late March to mid-May) to form bachelor colonies, though many do not roost separately until females give birth to a single pup in late May or early June (USFWS 1982). Females and pups form maternity colonies in caves with subterranean water sources and domed ceilings capable of trapping warm air with temperatures between 57-79° F (14-26° C) (Tuttle 1976a). Maternity colonies are also often within 0.6-2.5 miles (1-4 km) of above-ground water sources (Tuttle 1976b, USFWS 1997).

Males and first-year females will disperse to multiple, smaller caves, or within separate sections of maternity caves, during the reproductive season (USFWS 1982, Missouri Department of Conservation 2000). Adult males will roost with females following volancy of pups (USFWS 1982).

Diet, Nightly Behavior, and Foraging

Brack and LaVal (2006) completed a detailed analysis of the diet based on bats captured at five maternity and two transient caves in Missouri. The most commonly encountered food items were caddisflies (Trichoptera), beetles (Coleoptera), and moths (Lepidoptera) which were abundant in both the diet and in samples collected near the caves. Other important food items were stone flies (Plecoptera), may flies (Ephemeropta), and true flies (Diptera). Diet tracked patterns in landscape-level abundance but also provided clear evidence of selection by different ages and reproductive classes. Juvenile bats fed extensively on beetles, which provide a greater energy reward per unit of capture effort (Brack and LaVal 2006), and are abundant near the caves. Adult females focused more extensively on aquatic insects (Brack and LaVal 2006), which required substantial travel to capture. This suggests adult females travel to distant foraging grounds in part to avoid competing with the juveniles.

Foraging habitat for the gray bat typically includes streams, lakes, or wetland features, where gray bats can forage for aquatic and terrestrial flying insects (Tuttle 1976b, LaVal et al. 1977, USFWS 1982, Clawson and Titus 1992, Best and Hudson 1996, Missouri Department of Conservation 2000). Laval et al. (1977) observed that gray bats in Missouri foraged more often over waterways adjacent to wooded areas than over waterways adjacent to pasture land. However, specific macro-habitat characteristics of waterways and adjacent areas may vary in importance among different gray bat colonies (Moore et al. 2017). Forest areas surrounding caves, and flyways are also important foraging habitat for gray bats (Tuttle 1979), particularly juveniles (Brack and LaVal 2006).

Individual gray bats may travel 12-21 miles (19-34 km) to forage, depending on available habitat and colony size (LaVal and LaVal 1980). In Missouri, gray bats are known to travel up to 12.4 miles (20 km) away from their roost to forage (Missouri Department of Conservation 2000). Increased distances to foraging areas may lead to a decreased rate of growth by the pups (Tuttle 1976a).

Ecological Relationships

During summer, many species of bats (especially males) make use of caves, and thus may overlap with gray bats. Bats of all species regularly overlap with each other during nightly foraging behavior, but the level of these interactions is poorly characterized. Several authors have suggested that the high densities of gray and other bats in the major karst regions is the cause of the long-distance migrations undertaken by other species, especially the Indiana bat (Murray and Kurta 2002). Because gray bats make long-distance migrations, occupy caves throughout the year, and are not severely affected by WNS they may be an important vector in moving the disease between far-flung cave systems (Gerdes 2016) .

Gray bats share hibernacula with a variety of other cave-hibernating species. Occasional bats of other species (especially Indiana bats) are found within clusters of gray bats. Similarly, it is not unusual for individual gray bats to be found within clusters of other species, especially Indiana bats.

Survivorship

Like most bats, gray bats are long-lived once they reach maturity with longevity likely exceeding 14 to 17 years (Harvey et al. 2011). Based on gray bats banded in Missouri, Elder and Gunier (1981) documented an annual survival rate of approximately 70 percent per year of unknown-age bats with females having a slightly higher rate than males. Juvenile mortality can be substantial especially during the period when bats are just learning to fly (Tuttle 1976a).

Population Trends

Populations of gray bats in Missouri have dramatically increased since the species was listed in 1976, and the population appears to have remained stable after the arrival of WNS (Colatskie 2017). This marked, long-term population growth is largely the result of efforts by MDC and USFWS to protect important gray bat sites (Boyles et al. 2008). Range-wide population trends are similar, with the most recent population analysis by USFWS indicting a 104 percent increase in population between 1982 and 2007 (USFWS 2009). In fact, the most recent five-year review (USFWS 2009) indicated that the threat posed by WNS is the primary reason the species was not down-listed to threatened.

Threats

As part of the five-year status review, USFWS completed a review of threats for the species (USFWS 2009). As noted above, WNS was considered the primary threat at the time of the review. While gray bats are known to be infected with WNS, no large-scale population declines have been noted in Missouri (Cryan et al. 2013, Colatskie 2017). Other important factors included adverse modification of caves, disturbance of bats in the caves, impoundment of waterways, chemical contamination, and climate change (USFWS 2009). Marvel Cave, Missouri was once an important gray bat site, but has been a commercial cave since 1960 (USFWS 2009). The fact that this site is the only high priority site that has avoided protection (USFWS 2009) is demonstrative of the success of conservation efforts targeted at this species. Gray bats were initially listed because of their sensitivity to disturbance which may lead them to abandon caves or move to areas that provide protection but also lower quality microhabitats (Tuttle 1975; 1979). Burning of trash and debris at Marvel Cave, Missouri was responsible for the deaths of more than 3,000 gray bats (Elder and Gunier 1978) in February 1971. Further, disturbance may result in spontaneous abortions or dislodgement of young (Gunier 1971).

Deforestation may decrease the amount of terrestrial insect prey available to gray bats foraging in woodlands. Impoundments of water sources may both change the waterways that adult gray bats depend on for foraging and change aquatic insect prey base available to foraging gray bats (USFWS 1982). Historically, some gray bat caves were likely flooded by impoundments (USFWS 1982). Gray bats in Missouri are known to have been negatively affected by organochloride pesticides (Geluso et al. 1976, Clark et al. 1978), and it is likely that newer pesticides also have negative effects on bats (Eidels et al. 2016). As noted in Chapter 3 (Section 3.3.2, Wind Development) gray bats have never been found under wind turbines, but this is likely a result of the limited amount of wind energy development within the range of the species. The impact of global climate change on gray bats has not been analyzed, but it is noteworthy that gray bats are highly selective about the types of caves used and occupy a range sandwiched between the Coastal Plain and glacially-derived Till Plains—a distribution that leaves little room for the species to shift ranges in response to climate change.

Potential Sources of Take

Among the covered activities, the one with the greatest potential impact is prescribed fire. Prehistoric tribes camping or living in caves used by gray bats likely disturbed individuals through smoke from campfires, potentially causing suffocation (Tuttle 1986). Fatalities of numerous gray bats was recorded following the burning of debris from a construction site outside of Marvel Cave in Missouri (Mohr 1972). Fire from prescribed burns may alter vegetation surrounding the entrance of caves used by gray bats and subsequently alter airflow. Smoke and noxious gases may enter caves depending on weather and airflow around the cave entrance (Tuttle and Stevenson 1977, Carter et al. 2002, Perry 2012) which may cause arousal if bats are hibernating at the time (Dickinson et al. 2009).

A second covered activity with the potential to impact gray bats is vehicular collisions. There are no records of gray bats being killed by vehicles, but mortality among similar species has been documented (Sparks and Choate 2000, Russell et al. 2009).

Deforestation was listed as a concern in the gray bat recovery plan (USFWS 1982). The covered activities are aimed at managing habitat for a variety of wildlife including gray bats. As such, the plan will track the amount of forest management that occurs within the areas of high-density foraging habitat.

National Conservation Efforts

Gray bats have been the subject of a highly successful national conservation effort that has identified, prioritized, and protected most of the important habitat features for the species throughout its range (USFWS 2009). In 1980, LaVal and LaVal identified key steps for the protection of Missouri bats with a particular focus on the gray bat. This document created a framework that helped MDC work with partners throughout the state to obtain protection for important gray bat caves and their surrounding habitats. Important successes have included the gating and/or purchase of caves, management of at least 20 acres of forest at the entrance of all caves on MDC managed lands, and management of suitable foraging habitat across the larger landscape.

Figures and Tables

Figure 1. Range-wide Distribution of the Gray Bat

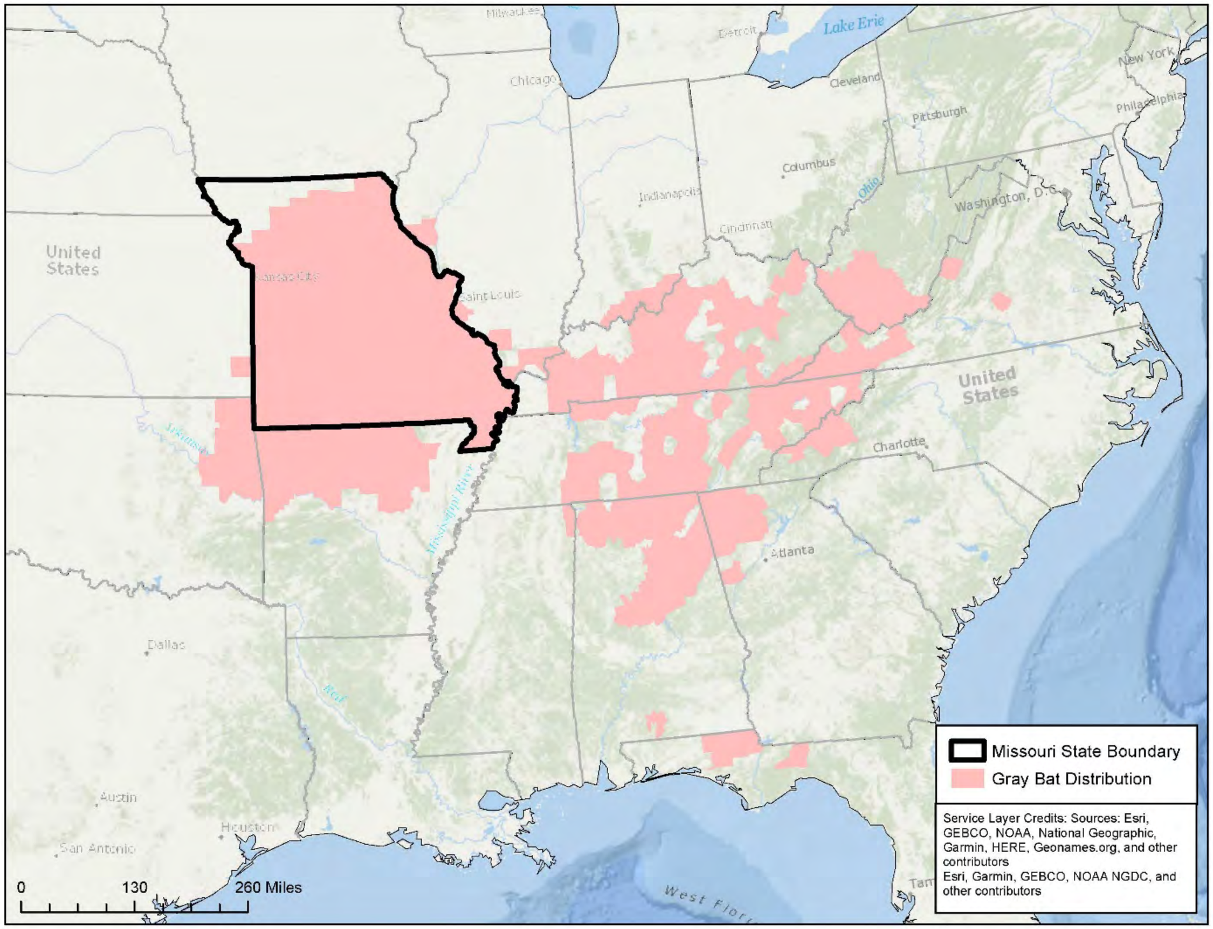

Figure 2. Known Distribution of Gray Bat in Missouri Counties during Active and Inactive Seasons.

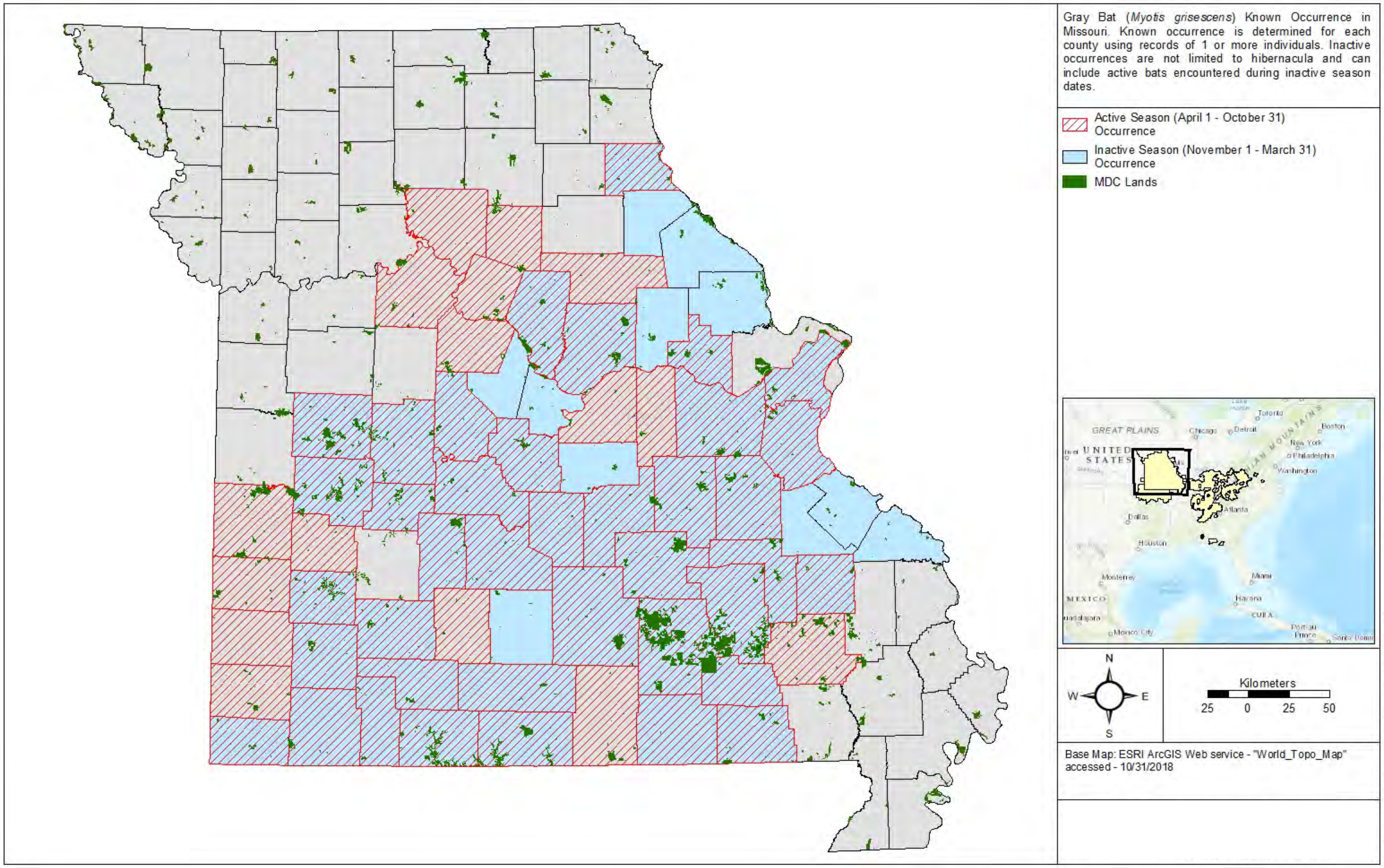

Figure 3. Modeled Distribution of Gray Bat Seasonal Habitat in Missouri.

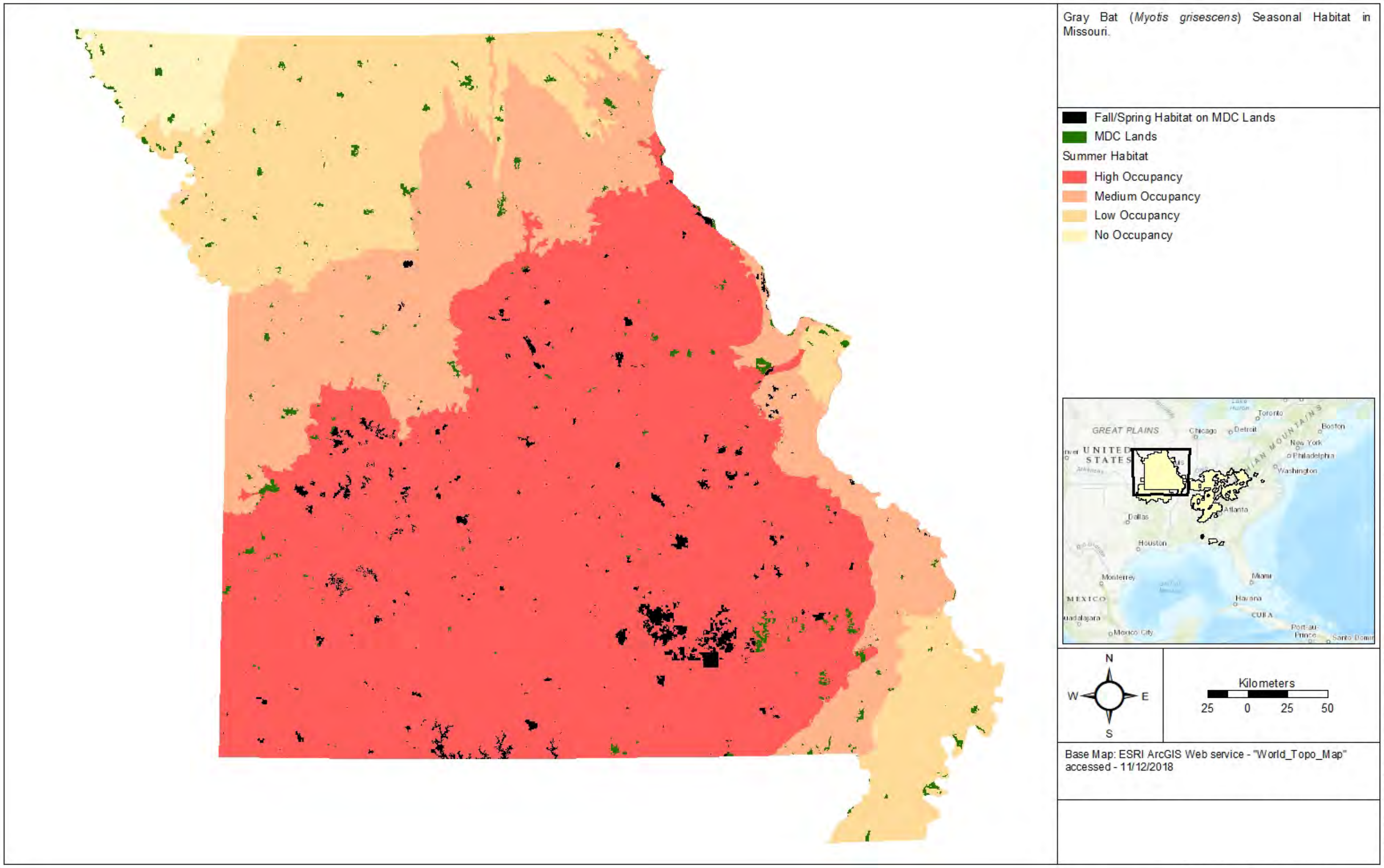

Figure 4. Seasonal Patterns of Gray Bat Activities

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
All	Hibernation (caves and mines)			Transient Caves	Maternity and Bachelor Caves		Transient Caves		Hibernation (cave and mines)			
	Inactive Season			Active Season							Inactive Season	

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Indiana Bat (*Myotis sodalis*)


Photo: Jason Duffey

Status

State: Endangered under Missouri Code of State Regulations (State of Missouri 2017). NatureServe Rank[1] S1: Critically Imperiled.

Federal: Endangered, final listing March 11, 1967 (USFWS 1967).

Critical Habitat: Final Critical Habitat September 24, 1976 (USFWS 1976).

Other: A national recovery plan for the species was completed on October 14, 1983. A draft revised recovery plan was released in April 2007 (USFWS 2007), but has not been finalized.

The Indiana bat was federally listed as endangered by the U.S. Fish and Wildlife Service (USFWS) in 1967. Listing was due to long-term population decreases across the range of the species. Range-wide estimates from 2017 totaled 530,705 bats (USFWS 2017a), a two-thirds decrease from the 1960 estimated population. Missouri is currently the most populous state for Indiana bats containing 41 percent of the 2017 population estimate (217,884 bats) (USFWS 2017a).

To aid in the species recovery processes, the USFWS can designate specific geographic areas as Critical Habitat. These areas contain features essential to the conservation of threatened and endangered species that require special management and a higher standard of protection (i.e., a Habitat Conservation Plan [HCP] cannot adversely impact designated Critical Habitat). Critical Habitat for Indiana bat was designated in 1976 and includes 11 caves and two abandoned mines in Illinois, Indiana, Kentucky, Missouri, Tennessee, and West Virginia. Missouri contains six of the 11 hibernacula designated as critical habitat: Cave 021 in Crawford County, Cave 009 and Cave 017 in Franklin County, Pilot Knob Mine in Iron County, Bat Cave in Shannon County, and Cave 029 in Washington County (USFWS 1976). These cave identification numbers do not correspond with any current numbering system, but USFWS and MDC maintain files on these locations.

All hibernacula used by Indiana bats, not just those designated as Critical Habitat, are considered important to the species. Relative importance is ranked using a priority score ranging from 1 to 4. The score is based on microclimate suitability, current number of bats occupying the hibernacula, and historical counts. Priority 1 hibernacula currently or historically have winter population counts of 10,000 or greater Indiana bats and currently appropriate microclimates, Priority 2 from 1,000 to 9,999 with appropriate microclimates, Priority 3 from 50 to 999, Priority 4 with fewer than 50, and Ecological Trap for sites with a history of repeated flooding or freezing related mortality events. Priority 1 hibernacula are further separated based on recent counts with Priority 1A hibernacula having at least one count of 5,000 or greater Indiana bats in the past 10 years and Priority 1B hibernacula consistently having 4,999 or less over the past 10 years (USFWS 2007). Missouri has 88 hibernacula of which seven are Priority 1 (3 Priority 1A and 4 Priority 1B) including an abandoned mine in Hannibal that contains a winter population of 197,419 individuals (USFWS 2017a). Additionally, Bat Cave in Shannon County, which is designated critical habitat and meets the definition of a Priority 1B hibernaculum, is designated as an Ecological Trap because of documented freezing mortality events. However, Indiana bats currently hibernating at this cave have changed roosting locations, moving away from the area susceptible to rapid temperature fluctuations, so this site may be reclassified as Priority 1B in the future (MDC unpublished data).

Description

The Indiana bat is a member of the genus *Myotis* along with three of the other covered species, gray (*Myotis grisescens*), northern long-eared (*Myotis septentrionalis*) and little brown bats (*Myotis lucifugus*). The four species have similar physical characteristics that make distinguishing them difficult. The exception is the gray bat, which is distinguished by its large size, unusual foot morphology (e.g., notched claws on the thumbs and toes), and monochromatic fur. Indiana, northern long-eared, and little brown bats are more difficult to distinguish due to overlapping ranges of weight, total length (length of head and body), and forearm length. These three species also have dark brown or black pelage and mouse-like ears which are longer than they are wide with a distinct and pointed tragus. Finally, Missouri is home to two species of *Myotis* (the eastern small footed [*Myotis leibii*] and southeastern [*Myotis austroriparious*]) that are not addressed by this plan, but are typically easy to distinguish from the Indiana bat based on color, size, and foot morphology.

The Indiana bat has a total length range of 1.61 to 1.92 inches (41to 49 mm) and forearm length range of 1.38 to 1.61 inches (35-41 mm) (Barbour and Davis 1969). Wingspread is 9.45 to 10.51 inches (240-267 mm) and winter weight averages 0.25 ounces (7.1 g) for males and 0.26 ounces (7.4 g) for females (Thomson 1982). The Indiana bat is distinguished from northern long-eared and little brown bats using the following subtle physical traits: forearm ≤1.57 inches (40 mm); the presence of a keeled calcar (cartilage that extends from the ankle to support the tail membrane); ears with shorter, more rounded tragus; and small feet with short, sparse hairs. The northern long-eared bat is differentiated from the Indiana bat by its long, pointed tragus and feet with long, dense hair; and the little brown bat by its lack of a keeled calcar and feet with long, dense hair (Barbour and Davis 1969). The Indiana bat can be further differentiated from the little brown bat by the Indiana bat's dull wing membranes and ears, light-colored nose, and sometimes tricolored pelage as opposed to the little brown bat which has shinier membranes and ears, darker nose, and contrasting pelage (Hall 1981, Thomson 1982, Barbour et al. 1999).

Range

The Indiana bat ranges from the northeast United States to the Midwest, reaching its western range limit in Iowa, Missouri, and Oklahoma (Figure 1). In winter, the range of the species is restricted to areas with caves or underground mines. Large wintering populations (more than 50,000 individuals) are found in Indiana, Illinois, Kentucky, and Missouri with smaller hibernacula occurring in 24 additional states. White-nose syndrome (WNS) has decimated hibernating populations east of Missouri.

During summer months, the Indiana bat is considered a "tree bat" because it roosts in forests, woodlands, and savannas as opposed to caves and mines. Therefore, the summer range of the Indiana bat is more widespread with distribution of individuals varying across the landscape. The summer range extends from the Eastern Seaboard to the edge of the High Plains with the highest summer occurrences in Northern Missouri, Illinois, Indiana and Southern Iowa and Michigan. Bat densities do not correlate solely to tree density, cooler summer temperatures can also affect summer distribution and reproductive success of Indiana bats (Johnson et al. 2002). Relatively warmer regions of the Midwest and higher elevations in the eastern portion of the range are less suitable for Indiana bats (Johnson et al. 2002, Loeb and Winters 2013).

Known Range in Missouri and Occurrence on MDC Lands

There are regulated hibernacula in 24 counties in Missouri (Figure 2), although there are several other counties that contain minor or historic sites. Missouri contains the largest overwintering population of Indiana bats (USFWS 2017a). The majority of hibernacula occur in karst topography of the Ozark Plateau in southeast Missouri. This region has numerous natural cave formations, as well as abandoned mines. Hibernacula are generally absent from the Till Plains that dominate portions of the state located north of the Missouri River. However, it is notable that the most populous hibernaculum is located in the northeast portion of the state on the Sodalis Nature Preserve in Hannibal, Marion County (USFWS 2017a). The hibernaculum is in an area where the Missouri River exposed a limestone seam that was subsequently quarried and abandoned.

Missouri is home to seven Priority 1 (3 Priority 1A and 4 Priority 1B), nine Priority 2, 29 Priority 3, 42 Priority 4, and one Ecological Trap hibernacula (MDC unpublished data). The Priority 1 hibernacula are in Crawford, Franklin, Iron, Marion, Pulaski, and Washington counties. The Priority 2 hibernacula are in Franklin, Pulaski, Shannon, and Washington counties. Within the MDC lands, 19 hibernacula are located in ten different counties: Boone, Crawford, Franklin, Hickory, Laclede, Pulaski, Ripley, Shannon, Washington, and Wright. Ownership of the seven Priority 1 hibernacula is variable with one each occurring on property owned by the City of Hannibal, USFWS, Missouri Department of Natural Resources – State Parks, and the U.S. Army, while three Priority 1 and the Ecological Trap hibernacula are on MDC-owned land (MDC Unpublished data). Three Priority 2 hibernacula are located on MDC-owned or managed lands.

During the active months (April-October occasional Indiana bats may be found throughout the state (USFWS 2017b). In summer, Indiana bats are relatively common in northeastern Missouri. Much of the MDC lands are within the Indiana bat's summer distribution, with over 502,029 acres (203,164 Ha) occurring within the active season range (Figure 2). Shannon and Reynolds counties contain a large portion MDC lands within the Indiana bat active season range.

Modeled Distribution in Plan Area

USFWS considers all of Missouri to be part of the Indiana bat range due to the extent of the known distribution of the species. During previous consultations related to MDC activities, USFWS and MDC have developed a map showing the potential for maternity colonies of Indiana bats to be detected within each county. The current model (Figure 3) represents a further refinement of that map. Available survey data indicate Indiana bats are either absent from or so rare within the Cherokee and Osage Plains as well as the Missouri River Alluvial Plains and the Deep Loess Hills that take from forestry operations is unlikely to occur. Low numbers of Indiana bats are likely found during the active season in the Missouri River Alluvial Basin as well as the southwestern most portion of the Ozark Highlands and most of the Loess Hills. Indiana bats have the highest potential to be located in the northeastern portion of the state as well as areas closest to high concentrations of hibernacula during the active season. Lands within 5 miles (8 Km) of known hibernacula are considered occupied during the fall/spring (Gumbert et al. 2002). In some cases; such as hibernacula containing exceptionally large populations of bats; hibernacula surrounded by limited foraging habitat, or hibernacula found in close proximity to summer colonies; bats may be found roosting at much greater distances (ESI 2005, Chenger et al. 2007). As such, the area of fall/spring habitat for the Sodalis Nature Preserve is assumed to extend out to ten miles. Based on this assumption, 156,899 acres (63,495 Ha) of MDC lands are considered fall/spring habitat.

Ecology

The Indiana bat changes its behavior depending on season and is considered tree-dependent during summer and hibernacula-dependent during winter months. The four ecologically distinct components of the annual life cycle are winter hibernation, spring staging and autumn swarming, spring and autumn migration, and the summer season of reproduction (Figure 4). The Indiana Bat Draft Recovery Plan (Recovery Plan) (USFWS 2007) provides a description of the life history. Figure 4 provides an annual chronology of seasonal activities.

Winter Hibernation

Indiana bats begin arriving at hibernacula in September and by early November the majority of individuals have entered the hibernation state. In areas with larger Indiana bat populations, such as the large hibernacula found in Missouri, individuals can be found in dense clusters of 250 or more bats per square foot. Boyles (2008) found that the main thermoregulatory benefit of clustering by the Indiana bat is to minimize heat loss during arousal, while increasing body temperature from heterothermic to euthermic levels and while remaining euthermic. Clustering during heterothermy is largely a by-product of benefits received from clustering during arousal and ensuing euthermia. Many large, complex hibernacula also contain warm locations where bats cluster during periodic arousals and such areas may provide the bats with critical energy savings during arousals.

Without efficient hibernation, individuals of many species cannot survive winter when cold ambient temperatures lead to high energy costs, and food is unavailable. During hibernation, the metabolic rate of individuals becomes greatly reduced to a fraction of the normal rate. The reduced metabolic rate is due to the suppression of metabolic activity and therefore the suppression of heat production which reduces energy expenditures (Geiser 1988, Snyder and Nestler 1990, Geiser 2004). However, at low temperatures (e.g., about 41 degrees Fahrenheit [° F] or 5 degrees Celsius [° C]), energy savings begin to decline (Geiser 1988). Below this temperature, many hibernating species of bats will raise their metabolic rate in order to maintain their body temperature (Geiser and Broome 1993, Geiser and Brigham 2000). There are costs to hibernation which include the build-up of lactic acid, loss of immune function, nerve damage, reduced motor function, reduced protein synthesis, sleep deprivation, and increased susceptibility to predation and freezing (Humphries et al. 2003). As such, hibernation is a balance between conserving energy and the associated costs of suppressing metabolic function. Hibernators have evolved mechanisms to minimize the depth and duration of the period of hibernation (Humphries et al. 2003). Several recent studies have demonstrated that bats use a variety of behavioral and physiological mechanisms to limit the depth and duration of hibernation bouts (Boyles et al. 2006, Boyles et al. 2007a, Brack 2007, Boyles and Brack 2009, Halsall et al. 2012).

Indiana bats are well-known for selecting thermally stable hibernacula (Tuttle and Kennedy 2002, Brack 2007). Temperatures ranging from 39.2° F to 46.4° F (4° C to 8° C) are preferred (USFWS 1999) by hibernating Indiana bats. Similarly, over 30 other species of bats consistently use 42.08° F to 46.4° F (5.6° C to 8° C) for hibernation (Nagel and Nagel 1991, Webb et al. 1996). Brack (2007) found that hibernating Indiana bats in an Ohio mine were restricted to thermally stable areas (Mean = 47.12 ± 35.06° F [8.4±1.7° C]), often where baffles prevented air flow. Large, complex hibernacula allow bats to select amongst a variety of thermal conditions, and size alone can provide a significant buffer against sudden changes in temperatures (Boyles et al. 2017). Thus, the optimal hibernacula for Indiana bats should contain stable areas with temperatures between 41° F and 50° F (5° C and 10° C). Multiple hibernacula within a small geographic area buffer bats against sudden changes in cave conditions (especially anthropogenic disturbance).

Unfortunately, the warmer site conditions preferred by Indiana bats also more closely correspond with optimal conditions (54.50° F to 60.44° F [12.5° C to 15.8° C]) for the growth of the fungus (*Pseudogymnoascus destructans*) which causes WNS (Verant et al. 2012). Most hibernacula are also characterized by moist conditions, but less humid sites are also less favorable for the growth of *P. destructans* causing WNS. Bats in drier sites arouse more frequently to drink, and thus must have access to water. Bats hibernating at higher latitudes and altitudes face a potentially longer and more energy-expensive winter season than bats in warmer climates (Humphries et al. 2002). Arousals are the most costly part of hibernation and a strategy used to combat this energy expense entails bats hibernating for longer periods at colder temperatures thereby requiring fewer arousals (Boyles and Brack 2009). The immune system of bats is reduced during hibernation, even during short daily torpor, which increases the virulence of diseases including WNS (Carey et al. 2003). While there is no evidence that Indiana bats are building an immunity, there have been studies indicating little brown bats may display an immune response (Lilley and Firestone 2008, Field et al. 2015, Lilley et al. 2016). Little brown bats who have survived WNS do not arouse more often than bats without the disease (Lilley et al. 2016), which may become an effective strategy for all bats. White Nose Syndrome was first discovered in Missouri in March of 2012 in Lincoln County. It has since spread across the known winter range of the species in Missouri including over 45 counties in the central and southern part of the state.

Bats exhibit a behavior known as swarming prior to entering hibernation. During this time hundreds of bats fly in, out, and around the entrances of caves and mines (Humphrey and Cope 1976, Cope and Humphrey 1977). A less intense version of this behavior occurs in spring and is known as staging. Most mating appears to occur during swarming, with some mating also occurring during staging. Most, but not all, swarming behavior is associated with hibernacula and thus protective buffers used by USFWS are aimed at protecting both swarming and hibernating bats.

Staging, Swarming, and Migration

Indiana bats make annual migrations between summer and winter ranges. There are two main methods for collecting information about migrating Indiana bats: band returns and radio telemetry. The two techniques provide different levels of data. Bands are relatively low cost and provide the potential for multiple bats to be detected across many years, whereas telemetry studies are expensive but provide detailed information about movement patterns.

Band returns have successfully linked Indiana bats to summering sites hundreds of miles from their hibernacula (Kurta and Murray 2002, Winhold and Kurta 2006). Most migration data available come from the capture of banded bats at both summer and winter sites (Gardner and Cook 2002). The longest known migration of Indiana bats comes from Michigan where a bat banded in Jackson County, Michigan was recovered in Colossal Cave, Edmonson County, Kentucky approximately 357 miles (574 Km) away (Rockey et al. 2013). Indiana bats wintering in Sodalis Nature Park have been found in Nodaway and Schuler counties Missouri along with sites in Iowa and Illinois (Marquardt, 2018).

Radio-tagged Indiana bats have been tracked using two techniques (aerial and ground-based telemetry). The first of these approaches involves tagging bats as they leave hibernacula and following them to roosts used during migration and eventually to presumed summering areas (Sanders and Chenger 2000; 2001, Butchkoski and Turner 2005, Britzke et al. 2006, Chenger 2007). These studies have documented habitat used during migration and demonstrated that migrant bats may delay migration in periods of poor weather. Most bats in these studies made short, nearly linear migrations across largely forested terrain. However, other studies suggest regional variation in migratory routes. Bats banded at a mine in Illinois were documented following wooded corridors from their hibernacula through an agricultural matrix to summer roosts (Hicks 2012). Ground-based telemetry has established Indiana bats crossing open spaces at substantial heights (Judy et al. 2010).

Several authors have provided detailed information about swarming Indiana bats (Barbour and Davis 1969, Cope and Humphrey 1977, LaVal and LaVal 1980). Some male Indiana bats may be found at the caves throughout the year, but the first females begin to arrive in late July. Swarming becomes intense by late August and (depending on the cave) continues through early October. During swarming events copulating bats are frequently observed on the ceilings and walls near the entrance to the hibernacula. Spring staging begins in April and continues into May, with most females leaving the cave in late April.

Data from these studies along with Humphrey et al. (1977) have also been used to set regulatory timetables whereby Indiana bats are presumed to migrate into the summer range between 1 April and 15 May, and begin leaving the summer range from 15 August to 1 October. The decision to move between seasonal habitats is driven by seasonality (i.e. dates) with local weather events such as temperatures and precipitation being important predictors (Pettit and O'Keefe 2017)

Summer Roosting Habitat

The summer range of the Indiana bat is larger than the winter range and includes much of the eastern deciduous forestlands between the Appalachian Mountains and Midwest prairies (Figure 2). Distribution throughout the range is not uniform and the locations of the majority of individuals remains unknown; summer occurrences are more frequent in Indiana, northern Missouri, and southern portions of Iowa, Michigan, and Illinois. Historically, these areas were vegetated in a mix of prairies, forest, and savannas (Küchler 1964). In Missouri, Indiana bat summer roosts are often found in areas containing forested habitat (Callahan 1993, Miller et al. 2002, Womack et al. 2013a). While summer roosts are found in forested habitat with approximately 20 to 80 percent canopy closure, greater tree densities do not equate to more bats (Johnson et al. 2002, Miller et al. 2002). Riparian or bottomland forested habitat in Missouri may be more important than total forested acres (Timpone 2004). Emerging evidence suggests that very warm areas in the Midwest and high elevations in the East likely do not offer suitable summer climates for the Indiana bat (Johnson et al. 2002, Loeb and Winters 2013).

Indiana bats use openings of all sizes, from trails to fields to interstate highways, and edge habitat is used routinely for foraging (Sparks et al. 2004, Sparks et al. 2005, ESI 2012, Sheets et al. 2013a, Sheets et al. 2013b). Similarly, roosts have also been located near roads of all sizes (Kiser and Elliott 1996, Schultes and Elliott 2002, Brack et al. 2004), including adjacent to an interstate highway (Sparks et al. 1998, Brack et al. 2004, Whitaker and Sparks 2008, Sparks et al. 2009). The need for solar exposure of roosts may vary with latitude with roost trees often exposed to the sun 10 hours per day (Humphrey et al. 1977, Gardner et al. 1991b, Gardner et al. 1991a, Kurta et al. 1993, Kurta et al. 1996, Kurta et al. 2002, Carter 2003, Carter and Feldhamer 2005),

Males

Some males remain near hibernacula throughout summer while others migrate varying distances (Whitaker and Brack Jr. 2002). Males can be caught at hibernacula on most nights during summer (Brack 1983, Brack and LaVal 1985), although there may be a large turnover of individuals between nights (Brack 1983). Even within close proximity of the hibernacula, males often roost in trees.

Male roosts in woodlands appear similar to maternity roosts (Kiser and Elliott 1996, Schultes and Elliott 2002, Brack and Whitaker 2004, Brack et al. 2004), although smaller diameter trees may be used (Kurta 2004). Less space may be required for a single bat than a colony of bats, or thermal requirements may differ. Males appear somewhat nomadic; over time, the number of roosts and the size of an area used increases.

Females and Maternity Colonies

When female Indiana bats emerge from hibernation, they migrate to maternity colonies that may be located up to several hundred miles away (Kurta and Murray 2002). Females form nursery colonies under exfoliating bark of dead, dying, and living trees in a variety of habitat types, including upland and riparian habitats. Nursery colonies utilize a variety of tree species, which indicates the structure or form of the tree may be more important than a particular tree species (Kurta 2004, Winhold 2007, Whitaker and Sparks 2008). For example, an important structural characteristic is the presence of cavities in dead or dying trees. Therefore, roost trees are often ephemeral and may only be habitable for one to several years, depending on the species and condition of the tree (Callahan et al. 1997, Gumbert et al. 2002, Sparks 2003, Carter and Feldhamer 2005). Indiana bats exhibit strong site fidelity to summer roosting and foraging areas (Kurta and Murray 2002, Kurta et al. 2002, Sparks et al. 2004, Whitaker et al. 2004, Winhold et al. 2005, Whitaker and Sparks 2008, Sparks et al. 2009). This fidelity is to a larger landscape, which can change over time.

Females are pregnant when they arrive at maternity roosts. Parturition typically occurs between late June and early July. A maternity colony typically consists of 25 to 325 adult females. Nursery colonies often use several roost trees (Kurta et al. 1993, Foster and Kurta 1999, Kurta and Murray 2002, Whitaker and Sparks 2008), moving among roosts within a season. The average distance female Indiana bats travel from roosts ranges from 2.33- 3.01 miles (3.75-4.85 Km) in Missouri (Womack et al. 2013b). During the maternity period, the average female home range ranges from 507 – 2810 acres (205 – 1137 ha) (Womack et al. 2013b). Most members of a colony coalesce into a single roost tree about the time of parturition. Once young are volant, the bats spend less time in these major roosts and more time in minor roosts—often roosting alone under the bark of live trees. Juveniles become volant between early July and early August. Juvenile mortality is high in bats and fledging success of a colony may range from 9 percent to more than 90 percent (Humphrey and Cope 1977, Sparks et al. 2008) and varies between years. Reproductive timing is likely dependent upon seasonal temperatures and the thermal character of the roost (Humphrey et al. 1977, Kurta et al. 1996).

Like many microchiropterans, Indiana bats make extensive use of daily torpor (Stones and Wiebers 1967), with prenatal, neonatal, and juvenile development dependent on temperature (Racey 1982).

Cooler summer temperatures associated with latitude or altitude likely affect reproductive success and therefore the summer distribution of the species (Johnson et al. 2002).

Roosts that contain large numbers of bats (more than 20) are often called primary roosts, while secondary roosts hold fewer bats. Primary roost trees are often greater than 18 inches (46 cm) dbh (diameter at breast height), and secondary roost trees are often greater than 9 inches (23cm) dbh (Gardner et al. 1991a, Callahan et al. 1997, Kurta et al. 2002, Miller et al. 2002, Carter 2003). Numerous suitable roosts may be needed to support a single nursery colony, possibly requiring a forested density of 20 stems per acre (50 stems per Ha) (Gardner et al. 1991a, Miller et al. 2002, Carter 2003).

Although Indiana bats typically roost under the exfoliating bark of dead and dying trees, they have also been found roosting in tree cracks and hollows (Humphrey et al. 1977, Kurta et al. 1993, Butchkoski and Hassinger 2002a, Kurta and Rice 2002, Kurta 2004), utility poles (ESI 2004, Hendricks et al. 2004), buildings (Butchkoski and Hassinger 2002c), V. Brack unpublished data, A. C. Hicks pers. comm.), and bat boxes (Butchkoski and Hassinger 2002a, Carter 2002, Butchkoski 2005, Butchkoski and Turner 2005, Ritzi et al. 2005, Whitaker et al. 2006). The colony of bats near the Indianapolis Airport has used both natural roosts (trees) and bat boxes every year from 2003 to 2008 (Sparks et al. 2008).

Diet, Nightly Behavior, and Foraging

The diet of Indiana bats varies substantially among bats of different ages and sexes and in relation to the availability of insects within different habitat types. Based on diets of males, Brack and LaVal (1985) considered the species selective opportunists. For example, in Indiana, aquatic-based insects were more common in the diet of a maternity colony than in the diet of males collected at caves (Brack 1983). The maternity colony was located along the Big Blue River, where only about 11 percent of the land within 2 miles (3.2 km) of the roost was forested (most was riparian), whereas males were collected at a cave where 42 percent of the area within 2 miles (3.2 km) was forested and only a small portion was riparian. In late summer, the diets of males, females, and juveniles captured at caves were similar to one another and to males' summer diets. Diets reported from maternity sites along streams (Belwood 1979, Brack 1983, Whitaker 2004, Tuttle et al. 2006) and within wooded wetlands (Kurta and Whitaker 1998, Whitaker 2004, Feldhamer et al. 2009) contained more aquatic-based insects than diets of males foraging in an upland habitat (Brack and LaVal 1985). The repeated seasonal occurrence of the Asiatic oak weevil (*Cyrtepistomus castaneus*) and sporadic abundance of hymenopterans in the diet (Brack 1983, Brack and LaVal 1985, Brack and Whitaker 2004, Tuttle et al. 2006, Feldhamer et al. 2009) are both indicative of opportunistic feeding. Insects may be less common late at night, forcing bats to eat a greater variety of insects (Brack 1983). There are observations of diet varying across the active season (Brack 1983, Brack and LaVal 1985, Tuttle et al. 2006), and by lunar cycle (Brack 1983, Brack and LaVal 1985, Murray and Kurta 2002). Murray and Kurta (2002) found that the diet was flexible across the range and potentially affected by regional and local differences in bat assemblages and availability of foraging habitat and prey. Despite variability of the diet, it should be noted that this variability is a result of eating different amounts of insects belonging to five orders: Lepidoptera (moths), Coleoptera (beetles), Diptera (true flies), Trichoptera (caddisflies), and Hymenoptera (wasps and ants) (Tuttle et al. 2006).

There are a variety of techniques that have been used to track foraging distances from roosts (Sparks et al. 2004). Using reflective wristbands, Humphrey et al. (1977) found that a maternity colony foraged in areas ranging from 3.7 to 11.1 acres (1.5 to 4.5 ha). Using telemetry, much larger distances have been recorded. The well-studied colony at Canoe Creek State Park in Pennsylvania routinely forages within 2.8 miles (4.5 km) of the roost in areas of contiguous and relatively flat forest (Butchkoski and Hassinger 2002b). Members of the Jackson County colony in Michigan foraged up to 2.6 miles (4.2 km) from their day roost, commuting 12.4 miles (20 km) a night through forested areas and along edges (Murray and Kurta 2004). These data are broadly similar to patterns from throughout the range(Gardner et al. 1991a). In Missouri, the application of radio tracking techniques found similar foraging distances with a maximum distance of 2 to 3 miles (3.2 to 4.8 km) (Womack et al. 2013b).

Indiana bats are similar to other species of bats in that they roost colonially yet forage independently of one another (Kerth et al. 2001). They often use travel corridors that consist of open flyways such as streams, woodland trails, small infrequently used roads, and possibly utility corridors, regardless of suitability for foraging or roosting (Brown and Brack 2003). Such corridors may play an important role in allowing bats to access isolated foraging areas (Murray and Kurta 2004, Sparks et al. 2004), but may not be essential as Indiana bats have been tracked crossing large open areas (Brack 1983).

Members of maternity colonies forage in a variety of woodland settings, including upland and floodplain forest (Humphrey et al. 1977, Brack 1983, Gardner et al. 1991a, Butchkoski and Hassinger 2002a). Forested canopy cover and close proximity to water sources have been found to be influential on foraging behavior of females (Womack et al. 2013a). Foraging activity is concentrated above and around foliage surfaces, such as over the canopy in upland and riparian woods, around crowns of individual or widely spaced trees, and along edges (LaVal et al. 1977). They forage less frequently over old fields, and occasionally over bushes in open pastures (Brack 1983). Forest edges, small openings, and woodlands with patchy trees provide more foraging opportunities than dense woodlands. Most species of woodland bats forage primarily along edges, less in openings, and least within forests (Grindal 1996). Openings also provide a better supply of insects than do wooded areas (Tibbels and Kurta 2003). While the centers of clear cuts may have limited value immediately after harvest, the edges may provide a high-quality foraging area and eventually become shrubby habitat that is used by foraging Indiana bats (Sheets et al. 2013a, Sheets et al. 2013b).

At the landscape scale, Indiana bats make selective use of habitat type for foraging in Illinois, Indiana, and Missouri (Menzel et al. 2005a, Sparks et al. 2005, Brack and Whitaker 2006, ESI 2012, Womack et al. 2013a). The Illinois study was on a wildlife management area with substantial blocks of bottomland hardwood forest. In this landscape, bats foraged closer to small roads, forest, and riparian areas than chance alone would predict. Grassland was used in proportion to availability and agricultural areas were avoided. In suburban Indianapolis, Indiana bats preferentially used woodlands more than agricultural, low density residential, and open water more than pasture, parks, and commercial lands, with high density residential areas being the least preferred habitat type. It should be noted, however, that most of the residential areas at this study site were new developments within what were recently large agricultural fields of poor habitat. This pattern might not hold for residential areas where high quality woodland habitat is retained. Indiana bats foraging near a hibernaculum in Virginia made preferential use of open woodlands (including those created or maintained by forestry or agricultural practices) while avoiding developed lands, closed deciduous forests, and forests with a mix of deciduous and coniferous trees (Brack and Whitaker 2006). The colony in Jackson County, Michigan foraged nightly along fencerows and forested areas and avoided adjacent cleared areas (Murray and Kurta 2004, Winhold et al. 2005). In Missouri, female Indiana bats preferentially foraged in shrubland, bottomland, and upland hardwood forests in landscapes dominated by agriculture (Womack et al. 2013a). In contrast, in landscapes dominated by forest areas, open habitats (including open woodlands) may be preferentially used by foraging Indiana bats (Sparks et al. 2004). This is not because the open areas are themselves highly valuable, but rather that open areas create edge, which is highly valuable (Sheets et al. 2013a, Sheets et al. 2013b).

Non-foraging flight behavior of Indiana bats is poorly documented. In Michigan, pregnant bats from a maternity colony foraged most of the night, but lactating females returned two to four times to feed young. Both pregnant and lactating females roosted up to six times per night for 14 minutes (*SD* = 1) each (Murray and Kurta 2004). Foraging areas were 0.3 to 2.5 miles (0.5 to 4.2 km) from diurnal roosts. Kiser et al. (2002) found 82 bats under three bridges over a 6-night period in late July and August. Temperatures under the bridges were warmer and less variable than ambient temperature, apparently providing a location to roost and digest food between foraging bouts and were 0.6 to 1.2 miles (1.0 to 1.9 km) from diurnal roost trees. Additional unpublished information about night roosting is available from the long-term study of a colony near the Indianapolis International Airport (D.W. Sparks personal communication). These bats regularly night roosted within wooded areas. When biologists entered woodlots to locate tagged bats to a specific tree, the bats moved to new roosts; this behavior was greatly reduced when human activity in the woodlot was restricted. When bats were tracked to a specific tree, they were hanging exposed on the tree rather than under bark. More rarely, individual bats night roosted in bat boxes. In one case, an Indiana bat night roosted in a prairie, apparently on big bluestem (*Andropogon gerardii*) or evening primrose (*Oenothera* sp.).

Ecological Relationships

In the summer season, Indiana bats typically roost with conspecifics, although on rare occasions individuals have been found roosting with other species including little brown bats (Carter 2002) and northern long-eared bats (MacGregor et al. 1999, Gumbert 2001, Dey 2009).

Bats of all species regularly overlap in time and space with each other during nightly foraging behavior, but the level of interaction is poorly characterized. Limited data suggest migration by female Indiana bats may be an adaptation that allows the species to inhabit high quality foraging habitats where there is limited competition with species more closely associated with caves (Brack et al. 2002, Murray and Kurta 2002).

In states with large populations of Indiana bats, like Missouri, the species often forms large aggregations, and can contain other bat species. In Michigan, aggregations of hibernating Indiana bats have been found to include little brown bats, possibly due to low statewide numbers causing them to use little browns as surrogate winter roosting partners (Kurta et al. 1997).

Survivorship

Like most bats (Tuttle and Stevenson 1982), Indiana bats likely experience substantial mortality from birth to weaning when juvenile bats tend to fall prey to a variety of accidents and predators, but then are relatively long lived once they reach adulthood. One Indiana bat in Missouri was recaptured 20 years after being banded as an adult (LaVal and LaVal 1980).

An examination of hibernating bats banded during 17 years of studies at Wyandotte Cave, Indiana provides the best available data on survivorship (Humphrey and Cope 1977, Boyles et al. 2007b). Survivorship is similar among sexes and averages 64.2 percent for the first seven years after banding. Unlike the original analysis (Humphrey and Cope 1977), an updated analysis by Boyles et al (2007b) found no evidence of sex-based differences in survivorship or of dramatic mortality during the first year after banding. Both sets of authors (Humphrey and Cope 1977, Boyles et al. 2007b) noted the challenges associated with the data set, including an inability to age bats and obtaining data primarily from a single site. Once banded, bats may have moved to other hibernacula and avoided capture. Boyles et al (2007b) noted that emigration rates of 10, 20, and 30 percent would, in turn, yield apparent survival rates of 71.4, 80.3., and 91.8 percent, respectively. Finally, it is important to recall that these data predate the apparent arrival of WNS by nearly 4 decades.

In addition to monitoring the winter population, efforts have been underway to identify techniques to monitor and estimate summer populations. No estimate of summer survivorship is available; although, efforts are underway to develop and apply molecular mark-recapture to this species (Sparks et al. 2008, Oyler-McCance et al. 2018). Emergence counts have traditionally been used to estimate the number of bats using one or multiple roosts (Humphrey et al. 1977). Simultaneous counts of multiple roost trees on multiple nights appear to provide a viable method for estimating the size and long-term trends within a maternity colony. Based on intense emergence counts, the colony at the Indianapolis airport apparently increased in size from a maximum count of 70 individuals in 1997 to 228 in 2007 (Sparks et al. 2008).

In response to the perceived risk posed by WNS, USFWS has partnered with the U.S. Geological Survey to explore the species survivorship of Indiana bats across large areas (Thogmartin et al. 2012a, Thogmartin et al. 2012b, Thogmartin et al. 2013). A review of historic hibernacula censuses indicate that major hibernacula (i.e., those designated as priority 1 and 2) are an acceptable measure of population trends throughout a Recovery Unit. Prior to the arrival of WNS, the northeast and Appalachian Recovery Units were increasing in population , the Midwest Recovery Unity was stable, and the Ozark-Central Recovery Unity had declined but stabilized (Thogmartin et al. 2012a). The entire population of the Indiana bat is now within migration range of the disease, and chances that an uninfected hibernacula will be infected are positively correlated with the size of the uninfected hibernacula and negatively correlated with the distance of the hibernacula from one that is known to be infected (Thogmartin et al. 2012b). If Indiana bats become immune to WNS after many years and the population returns to previous growth rates, major hibernacula are expected to become quasi-extinct in all USFWS regions with extirpation likely to occur in the Ozark-Central Recovery Unit (Thogmartin et al. 2013). However, as noted by the authors, these results were obtained prior to the discovery of the site near Hannibal, which likely elevates the Ozark-Central Recovery Unit from the one most likely to be extirpated to one containing the largest number of bats.

Population Trend

Long-term, detailed documentation of population changes of Indiana bats are lacking in most areas prior to the 1980s. Population changes prior to that time are best documented where the species was most abundant in Kentucky, Missouri, and Indiana (Brack et al. 1984, Clawson 2002, Johnson et al. 2002, Whitaker et al. 2002, Brack et al. 2003, Clawson 2004, Sparks et al. 2008). According to the Recovery Plan range-wide populations declined from 883,300 bats in 1965 to 678,750 bats when standardized surveys were initiated in the early 1980s (Figure 5). Declines continued through 2001 when the census estimated 381,156 bats. There was a region-wide pattern to these data as southwestern portions of the range (Missouri) declined markedly, and bats in the northeast (especially New York and West Virginia) increased rapidly. It is probable that habitat loss during summer (USFWS 2007) and winter disturbances during hibernation (Johnson et al. 1998) both contributed to historic declines of the species. However, the discovery of the largest Indiana bat hibernacula in 2012, located in Missouri, indicates that previous population estimates and trends may be inaccurate (USFWS 2017a). Immediately prior to the documented arrival of WNS, populations in both the Northeast and Appalachian Mountain recovery units were increasing, the Midwest was relatively stable, and the Ozark-Central region had declined and then stabilized (Thogmartin et al. 2012a). As such, the species had begun to meet the draft recovery criteria from the Recovery Plan (USFWS 2007). However, hibernacula counts in Missouri were indicating a contraction of the range with sites in southwestern and south-central Missouri declining, often drastically, and the few significant sites with increasing trends located in eastern parts of the state (MDC unpublished data). The arrival of WNS has now reversed the apparent gains, and the species has undergone substantial declines in the Northeast and Appalachian Mountain Recovery Units (Thogmartin et al. 2012a, USFWS 2012b; 2017a).

The current range-wide estimate for Indiana bats has remained relatively stable from 2015 to 2017 at 550,512 and 530,705 individuals, respectively; a 3.5 percent decrease in population size range-wide (USFWS 2015; 2017c). The Ozark-Central recovery unit is currently the only unit that has increased in population size growing 0.3 percent from 2015 to 2017 (USFWS 2017a). Specifically in Missouri, there was a <1 percent increase in population size, growing from an estimated 215,911 individuals to 217,884. The other units have experienced a decrease in population from 5.6 percent in the Midwest unit to up to 53.8 percent in the Appalachian Recover Unit.

White-Nose Syndrome (WNS)

Indiana bats were first observed with WNS along with several other species in 2006. Since then, their population has declined (Figure 5), but not as drastically as other species, particularly northern long-eared and little brown bats. Turner et al. (2011) demonstrated a precipitous decline of 72 percent among Indiana bats at 42 sites (from 55,028 to 15,650, a loss of 39,378) as opposed to a 98 percent decline of northern long-eared bats and a 91 percent decline of little browns. However, because the Indiana bat is already endangered, these population declines may still be severe enough to cause extirpation over large parts of its range (Thogmartin et al. 2013). Thogmartin et al. (2013) anticipated a total loss of 86 percent of the total population with only 4 percent of extant wintering populations remaining after 50 years. A more recent study asserts that of 468 winter colonies within the northeast, only 17 percent have gone extinct (Frick et al. 2015). In addition, the probability of extinction of colonies declines to zero in colony sizes greater than approximately 200 bats (Frick et al. 2015). As noted earlier, WNS was first documented in Missouri in 2012, and the disease is now established throughout Missouri.

Other Threats

The greatest danger to Indiana bats at the time of their listing was a variety of man-made and natural threats to winter hibernacula (USFWS 2007). Documented human-made threats to winter habitats include disturbance and vandalism, improper cave gates and structures, indiscriminate collecting, and flooding of caves from reservoir construction. Natural hazards include flash flooding of hibernacula (Brack et al. 2005), ceiling collapse of mines and caves (Elliot 2007), and colder or warmer than average winters. Natural and/or human-caused changes in the microclimate of caves and mines used as hibernacula can adversely affect the species (Richter et al. 1993). However, as in much of the rest of the range, these threats in Missouri have largely been addressed with the potential exception of wind energy development. As noted in Chapter 3 (3.3.2 Wind Development) the public draft of the Midwest Wind Energy HCP (USFWS 2016) predicts that 505 Indiana bats will be killed in Missouri during a 45-year permit term.

Hibernacula

All known hibernacula on MDC lands are protected from vandalism or indiscriminate collection as they are properly gated from the public. USFWS and the MDC have cooperated in an attempt to locate any additional hibernacula throughout the state, and most large construction activities in the state require a search for potential hibernacula should such activities occur in areas where mines or caves are known. The MDC carefully controls access to most hibernacula to avoid issues related to over-collecting, banding, and disturbance by biologists and the public.

Summer Habitat

Summer habitat losses are often viewed as ranging from the removal of individual roost trees to the disruption of landscape connectivity; however, this term is used here to address all threats on the summer range. Currently, the MDC removes trees as part of a program with the express purpose of protecting and enhancing wildlife habitat (Missouri Department of Conservation 2014; 2016). MDC removes trees to manage and maintain a variety of habitat types that benefit many wildlife species, including Indiana bats. This includes the removal of standing live and dead trees, which may inadvertently result in take.

The approach of MDC contrasts sharply with historic instances of habitat destruction where impacts to summer habitat were often at a much greater scale and took few steps to protect bats. Removal of riparian forest along streams and ditches also degrades summer habitat by removing potential foraging areas and links among forested blocks. Large-scale loss and degradation of wooded lands, especially when bats are present, can compound the adverse effects of lost roost trees—this is particularly true for large-scale surface mines and other disturbances. In many portions of the range, Indiana bats utilize savanna-like habitats with large trees, an open canopy, and an uncluttered understory (i.e., one that is not filled with the lower limbs of trees and shrubs). However, suppression of fire and removal of dominant grazing herbivores, combined with inappropriate silvicultural practices has often produced wooded lands of smaller trees with a closed canopy and a cluttered understory, which may have affected the quality of maternity habitat (USFWS 2007).

A major goal of the current HCP is to continue MDC's long-standing efforts to manage natural habitats for the benefit of a variety of species. This requires removal of trees from some areas as well as the use of prescribed fire in some communities. Overall, the covered activities should help maintain a landscape that is suitable for all of the covered species as well as other species managed by MDC (Missouri Department of Conservation 2014; 2016). Such activities come at a risk of killing occasional bats.

Chemical Contamination

Indiana bats are likely sensitive to a variety of chemicals including pesticides, spilled fuels, and other chemicals. Exposure to such chemicals is most likely to occur on the summer range. Chemical contamination in non-winter habitats is implicated in the decline of most North American bats (USFWS 2007). Lethal concentrations of a number of pesticides have been found in several species of bats that overlap substantially with Indiana bats in foraging habitat and thus Indiana bats face similar risk of exposure (Schmidt et al. 2001, O'Shea and Clark 2002, Schmidt et al. 2002). Of particular concern are organophosphates, which have been detected in the guano of Indiana bats and may indirectly cause mortality or decreased production by causing bats to become torpid or unconscious for long periods, potentially leading to indirect mortality through predation, exposure, or death of dependent offspring (Eidels et al. 2006, Eidels et al. 2016). However, the adverse impacts of this group of contaminants on a species-by-species basis is not clearly documented, and additional studies are needed.

Response to Roadways

Indiana bats live on anthropogenic landscapes, and recent research indicates the species responds to roadways based on a number of factors. Research into the response of Indiana bats to roadways has been ongoing during the past decade. The Jackson County, Michigan maternity colony crossed roads to travel from day roosts to night roosts, although none of the roads were high traffic (Murray and Kurta 2004). Similarly, Indiana bats foraging near the Indianapolis Airport cross roads ranging from unimproved tire paths to Interstate highways an average of 11.97 times per night, but most of this activity (11.54 crossings per night) is restricted to small rural roads, and this pattern holds when corrected for the much greater abundance of smaller roads (D.W. Sparks unpublished). Similarly, bats at this site were much more likely to abort attempts to cross a roadway when vehicles were present (Zurcher et al. 2010). Follow-up studies indicate this effect was increased when vehicles were loud and that woody vegetation helped encourage bats to cross roadways by both providing a route to cross and by masking vehicle noise (Bennett and Zurcher 2012). By combining species-specific patterns of movement with these observations, it is possible to mathematically model the impacts of roadways on bats. The willingness of a bat to cross a roadway is in part determined by three factors: value of the habitat on the opposite side of the road, size of the road, and intensity of traffic (Bennett et al. 2013a).

As such, the interaction between roads and bats is complex. Many studies have documented the inclusion of roads in foraging habitat. On Camp Atterbury, Indiana, female and juvenile Indiana bats routinely night roosted under bridges on two-lane paved roads (Kiser et al. 2002). Activity areas of nursery colonies in Illinois (Gardner et al. 1991b) and Michigan (Kurta et al. 2002) included paved roads. On the campus of Wright State University, Ohio, a roost tree was at the edge of a large parking lot, and about 20 meters (60 feet) from a moderately traveled road. Emerging bats crossed the parking lot and radio-tagged bats crossed highway 444, a four-lane divided highway, to forage in a 73-ha (180 ac) woodlot (Brown et al. 2001). In eastern Indiana, adjacent to the Newport Chemical Depot, a reproductive female Indiana bat was radio-tracked across a 4-lane divided highway to a maternity colony in a small, 0.7-ha (1.7-ac) isolated woodlot (Brack and Whitaker 2006). The roost tree was on the west edge of the woodlot (adjacent to the highway) and the woodlot was surrounded on other sides by open, farmed agricultural lands. Based on Euclidean distance analysis, small, unimproved roads were the most preferred foraging habitat at Fishhook Creek Watershed in Illinois (Menzel et al. 2005b). Thus, it is not just the roadway, but the level of vehicle activity on the road and the value of habitat across the road that creates an issue for bats (Bennett et al. 2013b). The types of roads being considered under this HCP are similar to the small rural roads which were regularly crossed by Indiana bats in Jackson County, Michigan (Murray and Kurta 2004) and at the Indianapolis Airport; and which are commonly recommended by USFWS (2007) as a location for placing mist-nets. Such roads were regularly used by Indiana bats in two state forests in Indiana (Sheets et al. 2013a).

National Conservation Efforts

Although national conservation measures aimed at protecting summer colonies of Indiana bats are often included in permits issued by USFWS, follow-up studies into these conservation measures are generally lacking from the literature. The only comprehensively studied example is an effort at the Indianapolis Airport. Here a colony discovered near the airport in 1994 essentially abandoned foraging areas north of the expanded Interstate 70 by 2008 and shifted their center of activity into a conservation area that was designed and managed for them (Sparks et al. 2009). This indicates that it is possible to shift colonies of Indiana bats across a developing landscape if suitable long-term habitat is available or developed during the move.

Similar long-term studies of how Indiana bats respond to habitat perturbations are now underway on the Shawnee National Forest, a coal mine in Pennsylvania, along the I-69 corridor in southern Indiana, and at Fort Drum in New York. All of these studies have demonstrated that Indiana bats remain on the landscape for long periods of time and are relatively robust in the face of habitat changes and anthropogenic activities.

Within the past decade USFWS has produced a number of management guidelines that are used to address national conservation issues related to the Indiana bat. The MDC has shaped its management guidelines around those suggested by the USFWS (Missouri Department of Conservation 2016). In addition, regional and national guidance has been developed to address issues related to wind energy (USFWS 2012a). All of these efforts have succeeded in providing a variety of industries with information about how their projects affect Indiana bats. These guidelines have been broadly successful in standardizing interactions between applicants and USFWS and prospective projects should consider the consequences of these guidelines during the planning stages.

Winter conservation efforts are ongoing throughout the range, and make use of tools and techniques that have been successfully implemented in Missouri for many years (LaVal and LaVal 1980, Boyles et al. 2009). Prior to the emergence of WNS, populations of Indiana bat had begun to recover (Thogmartin et al. 2012a) and much of the success was likely due to conservation efforts aimed at caves and mines (Richter et al. 1993, Currie 2002, Johnson et al. 2002, Kath 2002, Currie 2004). Guidelines are now available to convert mines that are not suitable for use by Indiana bats into highly suitable sites (Carter and Steffen 2010). Protection of hibernacula on public and private land is still a high priority for the USFWS.

Other efforts underway by USFWS include a series of population models that have served as the basis for the recent papers produced in cooperation with USGS (Thogmartin et al. 2012a, Thogmartin et al. 2012b, Thogmartin et al. 2013). These models provide a realistic mechanism to assess the population level effects of a variety of impacts in light of WNS and other developments. Using these models, FWS is able to simultaneously evaluate the impacts of multiple activities as part of the permitting process.

Figures and Tables

Figure 1. Range-wide Distribution of the Indiana Bat

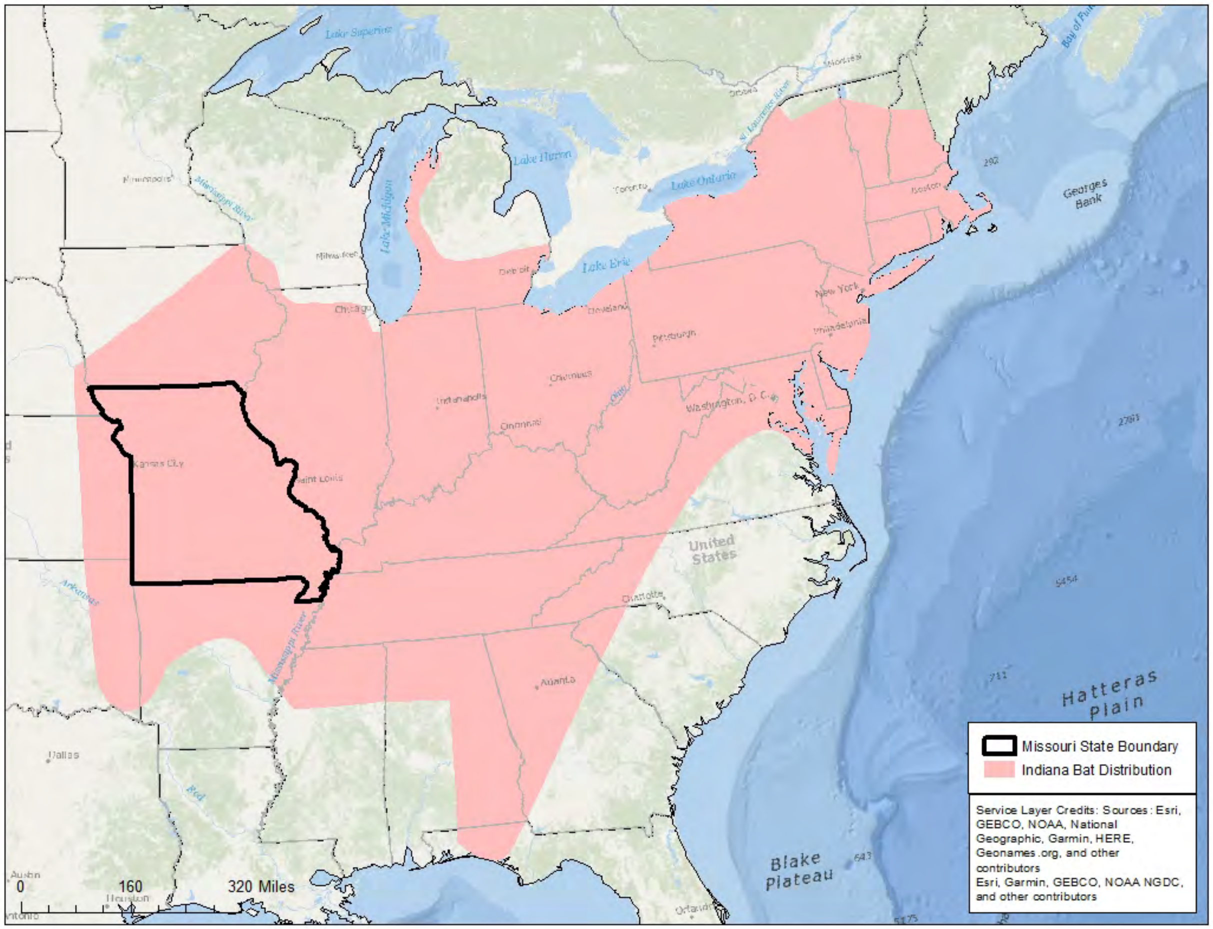


Figure 2. Known Distribution of the Indiana Bat in Missouri Counties during Active and Inactive Seasons.

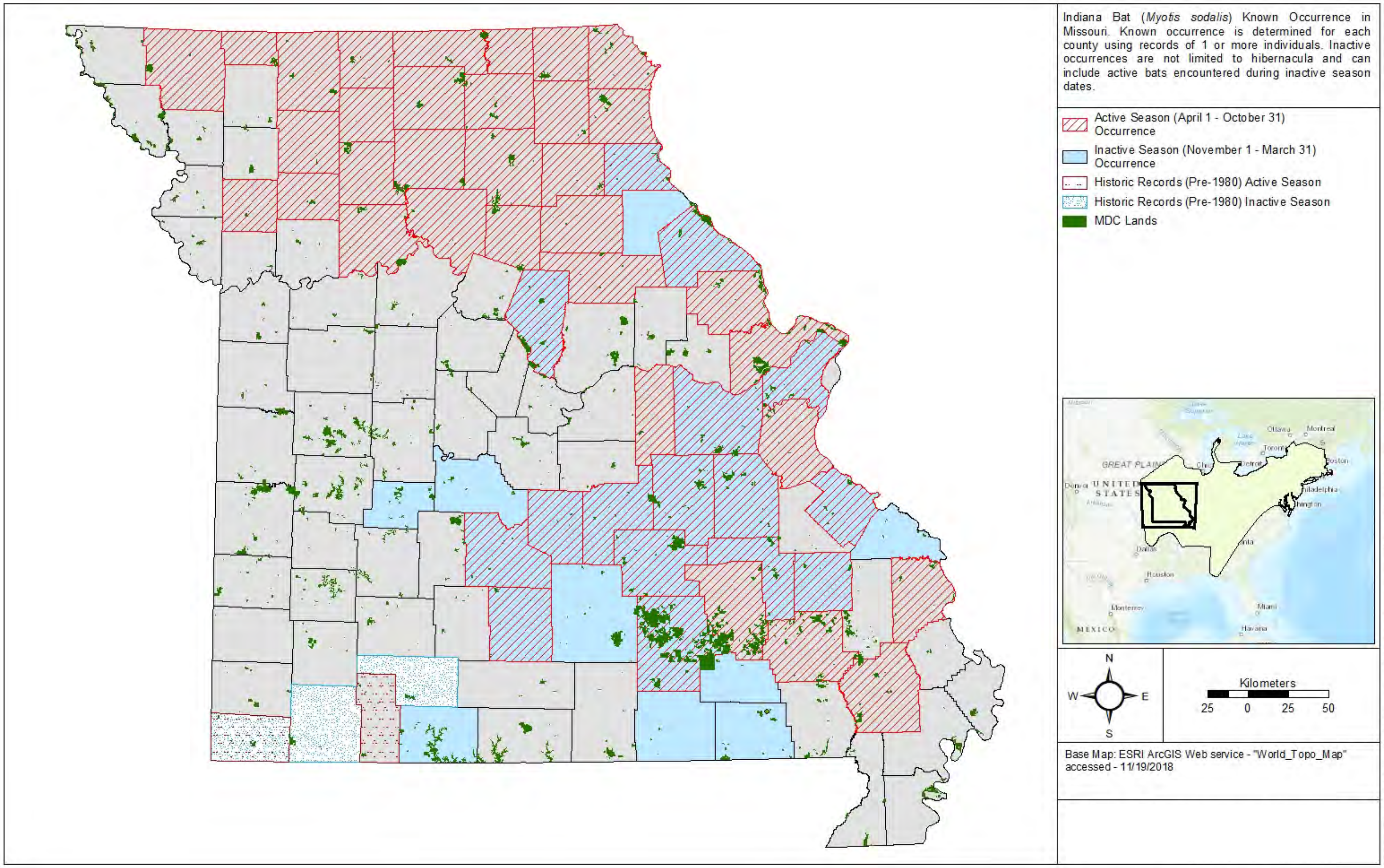


Figure 3. Modeled Distribution of Indiana Bat Seasonal Habitat in Missouri.

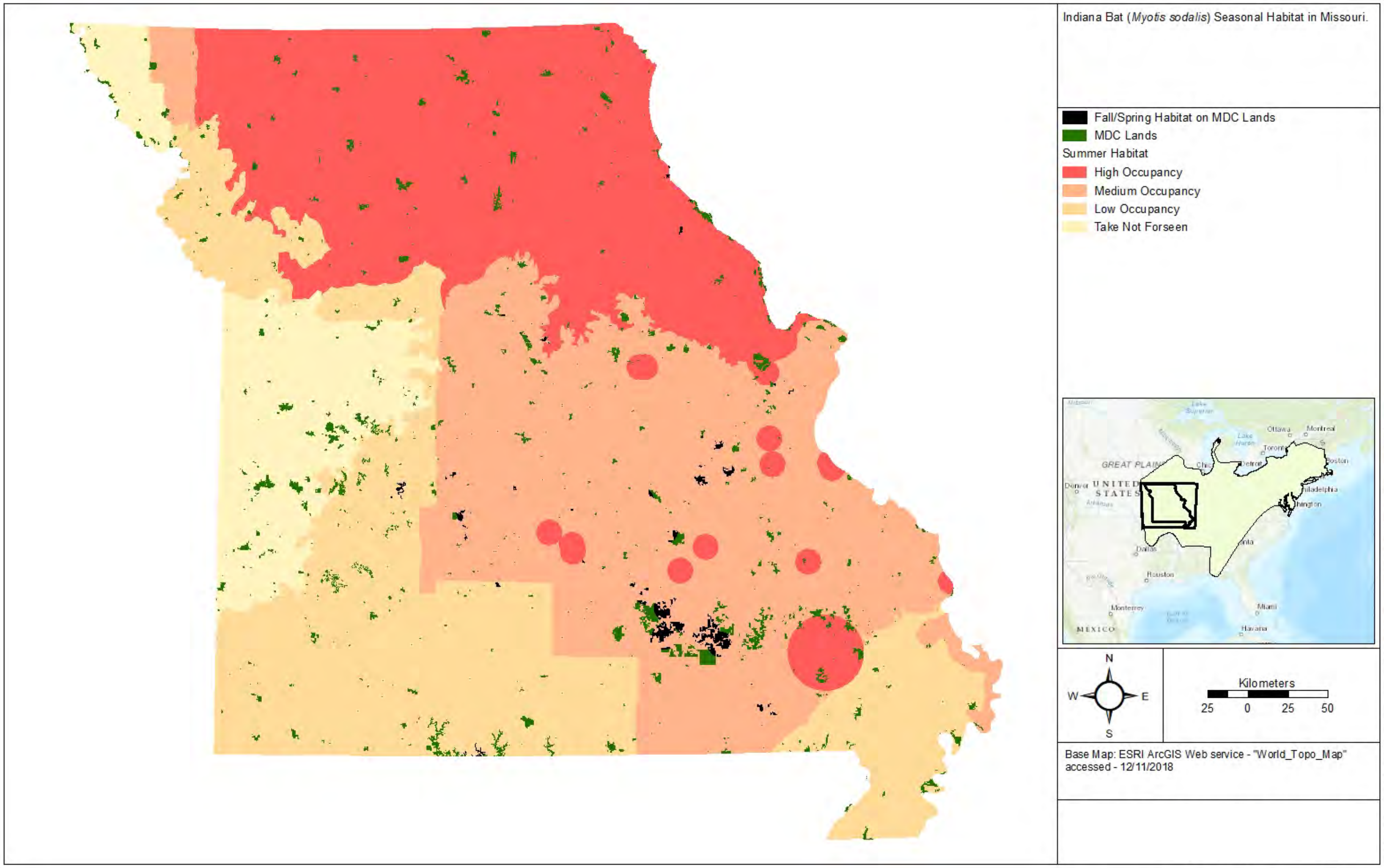
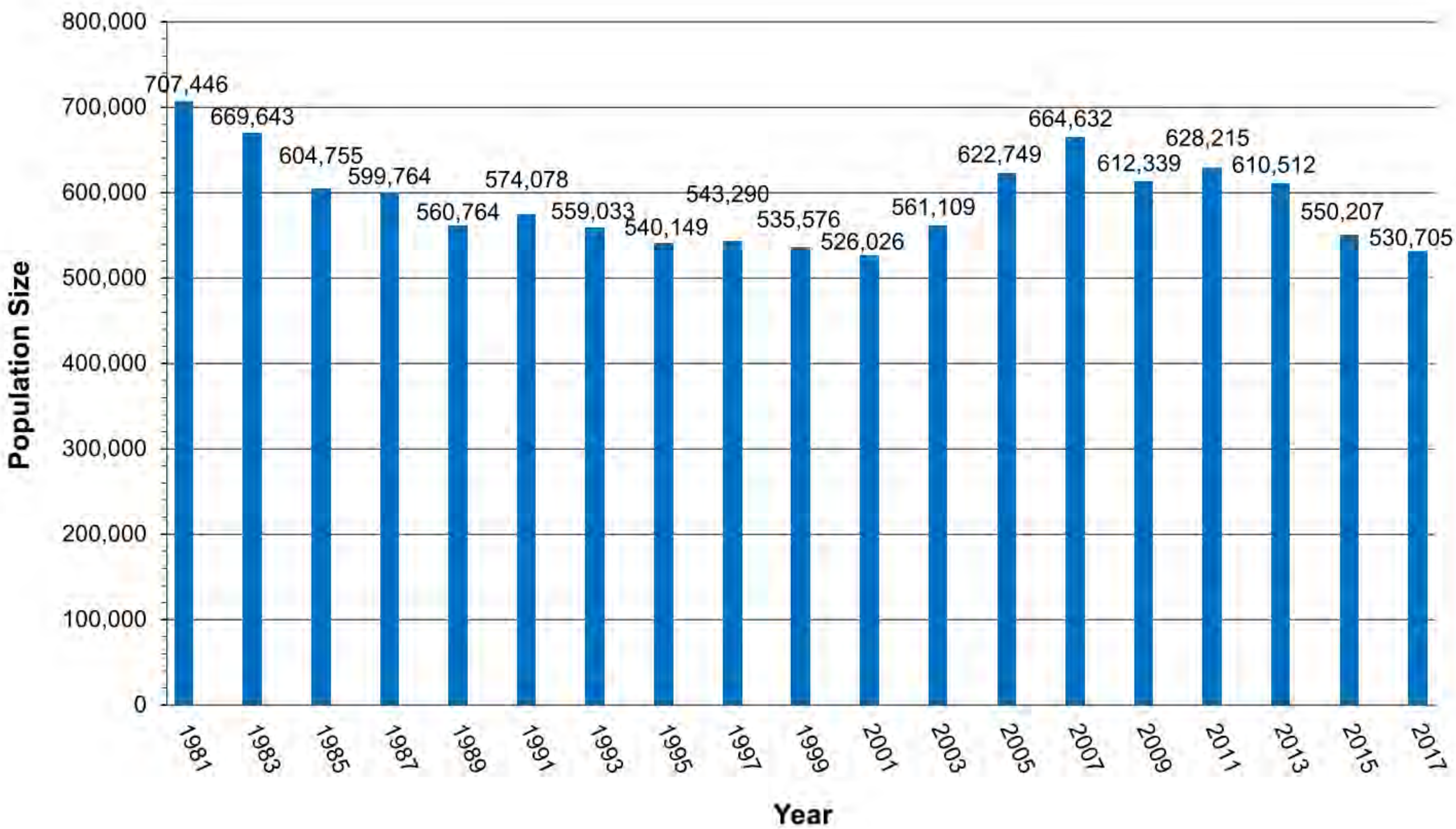


Figure 4. Seasonal Patterns of Indiana Bat Activities.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
All	Hibernation (caves and mines)		Emergence, Migration	Migration, Maternity Colony Establishment		Pups are Flightless		Maternity Colony Breakup	Migration, Swarming, Breeding		Hibernation (cave and mines)	
	Inactive Season			Active Season							Inactive Season	

Figure 5. Range-wide Indiana Bat Population Trends from 1981 to 2017 (USFWS 2017a)



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Little Brown Bat (*Myotis lucifugus*)

Status

State: Species of Conservation Concern. NatureServe Rank[1] S2: Imperiled

Federal: No formal legal protection.

Critical Habitat: No Critical Habitat designated.

The little brown bat was historically a common and widespread species in North America (Kunz and Reichard 2010). However, the species has experienced a decline, particularly in the eastern portion of its range, that is largely attributed to White Nose Syndrome (WNS). A status review of the species by Kunz and Reichard (2010) initiated a proactive review by the USFWS of the potential need to afford the species federal protection due to its susceptibility to WNS. The resulting USFWS status review focused on the eastern subspecies and their severe population decline due to WNS (Tinsley 2016), but determined that listing was not warranted at that time.

Description

The little brown bat is a medium-sized *Myotis* similar to five other members of the genus that are found in Missouri: the federally endangered Indiana (*Myotis sodalis*), federally endangered gray (*Myotis grisescens*), federally threatened northern long-eared (*Myotis lucifugus*), southeastern (*Myotis austroriparious*), and eastern small-footed (*Myotis leibii*) bats.

The little brown bat has a forearm length of 1.2 to 1.6 inches (31 to 41 mm) and a total length (head and body) of 2.1 to 2.2 inches (54 to 57 mm) (Williams and Findley 1979, Kalcounis and Brigham 1995, Kunz and Reichard 2010). The wingspan is 9.8 to 10. 6 inches (250 to 270 mm) and adults weigh 0.2 to 0.3 ounces (7 to 9 grams) (Kurta and Kunz 1987, Kalcounis and Brigham 1995, Kunz and Reichard 2010). Their appearance is variable throughout its range, with coloration varying from pale to dark brown dorsally. Ventrally, fur color is described by Fenton and Barclay (1980) as ranging from pallid to yellowish or olive brown. Other identifying characteristics include toe hairs that extend well beyond the toe nails, an unkeeled calcar (Barbour and Davis 1969, Kunz and Reichard 2010), and a glossy sheen to the fur and membranes.

Range

The little brown bat is widely distributed across North America (Figure 1) and is known to inhabit areas from central Alaska to central Mexico (Harvey et al. 1999). Prior to arrival of WNS, the largest colonies were found in the northeastern and Midwestern U.S., where some hibernacula contained tens to hundreds of thousands of individuals (Kunz and Reichard 2010). The southern edge of their distribution is limited by the lack of caves, whereas the northern edge of the range is likely defined by a limited number of suitable hibernacula and the longer length of the hibernation season (Humphries et al. 2002, Humphries et al. 2006). Like the Indiana bat,

[1]A standardized ranking system for species and community types that is compiled by partner agencies (such as MDC) and reported to NatureServe.

little brown bats migrate between subterranean habitats in winter to trees and a wide variety of anthropogenic structures during summer (Humphrey and Cope 1976). Most little brown bats stay within 62 miles (100 km) of their hibernacula, although some make longer migrations.

Known Range in Missouri and Occurrence on MDC Lands

Little brown bats are known to hibernate in 61 counties in Missouri (Figure 2), largely in the caves and mines of southern Missouri. Important exceptions to this pattern include the hibernaculum at Sodalis Nature Preserve in Hannibal, Marion County in northeastern Missouri, where little brown bats were once common. Other exceptions include some quarries in the northern portion of state and several smaller caves and quarries located along the Missouri River north of Kansas City. MDC lands in 15 counties contain hibernacula that are used by the little brown bat.

Prior to WNS, little brown bats were regularly found throughout most of Missouri in the summer. Little brown bats have been recorded in 56 counties during the active months (April-October). These counties include 585,061 acres (236,766Ha) of MDC lands.

Modeled Distribution in Plan Area

The model presented below was developed in close association with MDC staff and is based on survey data from studies conducted by MDC staff and permitted biologists. Little brown bats become less dense with increasing distance from hibernacula, and the species is virtually absent from the prairies of Kansas and Nebraska (Sparks et al. 2011). As such, three subsections of the Central Dissected Till Plains (Missouri River Alluvial Plain, Deep Loess Hills, and Loess Hills) and Cherokee Plains are areas of medium occupancy, whereas the Wooded Osage Plains of west-central Missouri are an area of low occupancy (Figure 3). The rest of the state is an area of high occupancy in summer. Lands within 5 miles (8 Km) of a known hibernacula are considered occupied during the fall/spring (Lowe 2012). In some cases; such as hibernacula containing exceptionally large populations of bats; hibernacula surrounded by limited foraging habitat, or hibernacula found in close proximity to summer colonies; bats may be found roosting at much greater distances (ESI 2005, Chenger et al. 2007). As such, the area of fall/spring habitat for the Sodalis Nature Preserve is assumed to extend out to ten miles. Based on this assumption, 212,121 acres (85,842 Ha) of MDC lands are considered fall/spring habitat.

Ecology

Tinsley (2016) completed a detailed review of the ecology of the species as part of the status review. Like the Indiana bat, the little brown bat migrates seasonally between caves and mines to summer habitats. Unlike the Indiana bat, little brown bats roost extensively in anthropogenic structures. The annual cycle of the little brown bat is broken into winter hibernation, spring staging and autumn swarming, spring and autumn migration, and the summer season of reproduction (Figure 4).

Winter Hibernation

The species account for the Indiana bat contains a detailed description of hibernation. The current account provides a general description focusing specifically on the hibernation characteristics of the little brown bat. Little brown bats are active at hibernacula entrances between late August and early November, and then enter hibernation. Bats that enter hibernation with more fat tend to make less intense use of hibernation by using warm habitats (Boyles et al. 2007). Bats in warm areas arouse more frequently (Brack and Twente 1985, Twente et al. 1985).

Within hibernacula, little brown bats do not form tightly packed clusters; bats may hang singly, in small or large loose or very loose clusters often on walls rather than ceilings, and often along shelfs or in cracks. They occupy a wider range of temperatures (45 ± 36.7 degrees Fahrenheit [˚F], 7.2 ± 2.6 degrees Celsius [˚C]) than Indiana bats, which allows them to exploit areas unsuitable for other species (Brack 2007). This ability to exploit a wide variety of hibernacula microenvironments allows for the large distribution of the species (Humphries et al. 2002, Humphries et al. 2006).

Little brown bats in Missouri typically arouse every 12 to 15 days (Brack and Twente 1985, Twente et al. 1985, Thomas 1995). These short periods of arousal can account for 80 to 95 percent of energy expenditure during hibernation (Thomas et al. 1990, Dunbar and Tomasi 2006, Boyles et al. 2009). Little brown bats infected with WNS arouse more frequently (Reeder et al. 2012). Little brown bats are declining much faster than Indiana bats (Tinsley 2016), which likely illustrates the benefit of clustering and communal rewarming by Indiana bats (Boyles et al. 2008). A population of little brown bats that has survived WNS contains individuals who do not increase their arousal rate when infected with WNS (Lilley et al. 2016).

Staging, Swarming, and Migration

Little brown bats are the species for which swarming and staging was first described (Fenton 1970, Humphrey and Cope 1976). Swarming in Missouri is most intense in August and September (LaVal and LaVal 1980) when males are abundant. During early stages of swarming, males mate with females following short flights or while roosting on the cave walls (Thomas et al. 1979). During later stages of swarming and periodic arousals through winter, males mate with torpid females. Therefore males that arouse more frequently may have more mid-winter mating opportunities (Boyles et al. 2009). In Missouri staging occurs in April when females may outnumber males by a ratio of 10 to 1 (LaVal and LaVal 1980).

Like many bats in the eastern United States, little brown bats migrate between winter hibernacula and summer roosting habitat. Spring migration occurs in parallel with staging with most bats moving from the hibernacula to the summer range in April and May; while fall migration occurs in late July through early August. Little brown bats have not been radio-tracked during migration in Missouri, although extensive banding efforts in the 1960s and 1970s provided some state-specific data (LaVal and LaVal 1980). Of approximately 1,600 banded little brown bats, only eight were found at both the hibernacula and a summer roost. Six bats made short migrations of approximately 25 miles (40.23 Km), but two migrated approximately 150 miles (241.40 Km). Myers (1964) banded 4,427 little brown bats in Missouri and adjacent states, 20 of which provided information on migration. Average migration distance was 94.3 miles (151.76 Km) with extremes of 18 (28.97 Km) and 240 miles (386.24 Km). These and other studies (Griffin 1940, Griffin 1945, Davis and Hitchcock 1965, Barbour and Davis 1969, Fenton 1970, Humphrey and Cope 1976) suggest many little brown bats migrate relatively short distances, but migrations of more than 100 miles are not unusual. This movement pattern produces an area of high summer density around important hibernacula, but scattered summer colonies in far-removed areas.

Summer Roosting Habitat

Most little brown bats in Missouri likely roost in buildings and other anthropogenic structures such as bridges and bat boxes, but in natural situations species roosted in tree cavities and under exfoliating bark (Boyles et al. 2009). The ability to use a variety of summer habitats is also key to understanding a large and diverse geographic range (Bergeson et al. 2015). Bats using the interface between developed lands (that provide roosts) and undeveloped lands and water (that provide foraging habitat) tend to be healthier and have higher reproductive rates (Coleman and Barclay 2011)

Males

Like the Indiana bat, some males can be caught near hibernacula throughout the summer (LaVal and LaVal 1980), but data from the Missouri Natural Heritage Program also indicate that males are broadly distributed. Little is known about the natural history of males during summer, but in Missouri, scattered individuals and small groups are found in a wide variety of anthropogenic roosts: behind window shutters, expansion cracks of bridges, attics, barns, under covered bridges, and in bat boxes (Robbins Personal Communication). Some males associate with maternity colonies (Davis and Hitchcock 1965). As with the Indiana bat, males tend to select cooler roosts. Males roosting in trees are thus expected to use roosts similar to male Indiana bats (i.e. smaller and shaded trees), but with an increased use of cavities and crevices (Broders and Forbes 2004).

Females and Maternity Colonies

Most known maternity colonies are in anthropogenic structures and prior to WNS contained many bats, such as colonies of at least 700 bats in Lewis County and 2000 bats in Sullivan County (Boyles et al. 2009). Like the Indiana bat, female little brown bats use warm roosts (Burnett and August 1981). In other areas little brown bats select roost trees that are large, dead or dying trees with substantial solar exposure (Crampton and Barclay 1998, Bergeson et al. 2015). Little brown bats make frequent use of cracks and hollows in trees as well as under sloughing bark (Crampton and Barclay 1998, Bergeson et al. 2015).

Barbour and Davis (1969) noted that females are pregnant when they arrive at maternity roosts in early- to mid-April, with individuals arriving throughout May and into June. In Indiana (Krochmal and Sparks 2007), females in one colony gave birth to a single pup between 3 June and 15 July. These pups began fluttering at 2 days of age, could complete coordinated wing strokes by 15 days and could fly by 21 days. Thus, most pups were flying by mid-July. Maternity colonies begin to break up as soon as the young are weaned in July and few remain by September (Barbour and Davis 1969).

Diet, Nightly Behavior, and Foraging

In some ways, the diet of little brown bats is similar to that of the Indiana bat with most of the diet composed of six orders of insects: Lepidoptera (moths), Coleoptera (beetles), Diptera (true flies), Homoptera (bugs), Trichoptera (caddisflies), and Hymenoptera (wasps and ants) (Whitaker 1972, Belwood and Fenton 1976, LaVal and LaVal 1980, Carter et al. 2003). However, the jaws of little brown bats are smaller than Indiana bats (Brack 1983), which allow the species to exploit the exponentially more abundant small insect resources (Schoener and Janzen 1968). Small aquatic flies are an important food source (Whitaker 1972, Belwood and Fenton 1976, LaVal and LaVal 1980, Carter et al. 2003) and multiple species of mosquitos are included in the diet (Wray et al. 2018). Given this reliance on aquatic insects, it should be no surprise that the foraging habitat of little brown bats is often strongly associated with aquatic habitats including streams, lakes, ponds, and wetlands (Belwood and Fenton 1976, Buchler 1980, Broders et al. 2006, Bergeson et al. 2013). Newly volant juveniles select foraging habitats near the roost and often hunt from perches, whereas adults forage further afield (Buchler 1980). When an insect outbreak killed many trees in a forest, little brown bats at the site preferentially foraged in the open areas created by dead and fallen trees (Randall et al. 2011). This same study described preferred foraging habitats as open areas with abundant prey, that were close to town (where the bats roosted) and near water (Randall et al. 2011). Following foraging bouts, little brown bats regularly use night roosts including bridges, buildings, caves, and trees (Buchler 1980, Fenton and Barclay 1980, Barclay 1982, Keeley and Tuttle 1999).

Ecological Relationships

The little brown bat occasionally shares roosts with other species, including the other species addressed in this plan (Veilleux et al. 1998, Keeley and Tuttle 1999, Butchkoski and Hassinger 2002, Timpone et al. 2010, Cervone and Yeager 2016). Bats of all species regularly overlap in time and space with each other during nightly foraging behavior but the level of interaction is poorly characterized. When co-occurring with Indiana bats, little brown bats have a much larger home range and focus on areas of open water and bottomland hardwoods (Bergeson et al. 2013). Similarly, little brown bats also use larger foraging areas than northern long-eared bats in the same area (Broders et al. 2006).

Using a wide range of hibernating conditions means little browns are commonly found sharing hibernacula with other cave-hibernating species, and little brown bats are often observed co-mingled with clusters of Indiana bats (Brack 2007, Boyles et al. 2009). In Missouri, this bat shares hibernacula with all other bats covered by this plan (Myers 1964, LaVal and LaVal 1980, Colatskie 2017).

Survivorship

As with similar bats, little brown bats are long-lived once they reach adulthood. Juvenile mortality is high for most species of bats (Tuttle and Stevenson 1982), and this is reflected in relatively low survival rates among first-year bats (Humphrey and Cope 1976, Frick et al. 2010b). Conversely, prior to the arrival of WNS, adult little brown bat survival was high. Banded bats have routinely been discovered surviving into their twenties with some bats being recaptured 30 years after banding (Keen and Hitchcock 1980). Authors measured annual survival rates of 50-90 percent (Humphrey and Cope 1976, Keen and Hitchcock 1980, Frick et al. 2010b).

Little brown bats are the only species for which post-WNS survivorship data are available, and both available studies are based on banded bats in known maternity colonies. Maslo et al. (2015) found that annual survival increased over the first four years following the arrival of WNS. Annual survival rates for male and female bats improved from 0.68 to 0.75 and from 0.65 to 0.70 respectively. This study found no evidence of emigration from other maternity colonies. Even though survival rates are increasing, current survival rates predicts the population will decline by five percent per year. Dobony and Johnson (2018) examined a maternity colony at Fort Drum, New York for eleven years (2006 to 2017) including 2 before WNS arrived at the site. Annual survival rates, post WNS (2010 to 2015), varied widely from .41 to .87 between years and individual survival was not predicted by a variety of factors including prior infection with WNS or reproductive condition. The colony suffered an initial decline of 88 percent, but has subsequently stabilized and begin to increase. This study also documented the emigration of at least one survivor from another maternity colony.

Population Trend

During the past decade, the little brown bat has gone from being a relatively common (and sometimes abundant) bat, to a species facing regional extinction (Dzal et al. 2010, Frick et al. 2010a, Tinsley 2016). A recent status assessment indicates that eastern populations declined by 93 percent at 165 hibernacula across three USFWS regions (Tinsley 2016).

In Missouri, the little brown bat has never been as common as Indiana, northern long-eared, or gray bats (Myers 1964, LaVal and LaVal 1980). Prior to WNS, the distribution of little brown bat could be summarized as widely scattered, but locally common, sometimes represented by hundreds of individuals in a hibernaculum. An exceptionally large concentration of 35,000 individuals was found in Pilot Knob Mine in 1958 (Myers 1964), although subsequent surveys have indicated much lower populations (LaVal and LaVal 1980, Elliott and Kennedy 2008). Missouri's winter populations, counted in hibernacula, have declined by approximately 87 percent since winter 2012/2013 (Colatskie 2017). A 2016/2017 survey found only 1,891 little brown bats in 51 of 502 hibernacula surveyed (Colatskie 2017). Notably, surveys of hibernating bats at Pilot Knob Mine are no longer conducted due to safety concerns (Elliott and Kennedy 2008, Colatskie 2017). However, fall trapping at the mine entrances suggests decreased swarming activity at the site, especially for little brown and northern long-eared bats (MDC unpub. data).

Threats

Tinsley (2016) reviewed potential threats to the little brown bat and determined WNS is the greatest threat faced by the species; without WNS it is unlikely the little brown bat would be a conservation priority. Other stressors of importance include deaths from other diseases, losses at wind energy sites, environmental contaminants, and loss and adverse modification of both summer and winter habitat. Like other bats, the little brown bat is frequently the subject of persecution by people. Because little brown bats can form large maternity colonies, they are often the target of exclusion efforts (Cope et al. 1991). As with other bats, chemical contamination may kill bats directly or lead to sublethal effects that eventually lead to death or reduced reproduction (Clark et al. 1978, Clark et al. 1980, Clark et al. 1982, Eidels et al. 2016). The proposed Midwest Wind Energy HCP used pre-WNS mortality rates to estimate that current and future wind energy sites in Missouri would take 29,000 little brown bats between 2016 and 2060, but that Wind Energy HCP has not been finalized. The mortality estimate did not account for population declines caused by WNS or conservation measures that would be enacted by the plan (USFWS 2016).

Potential Sources of Take

Little brown bats are included in the plan primarily due to their exposure during habitat management activities (i.e. tree removal and prescribed fire). Because some little brown bats roost in trees, there is the potential for some to be killed or harmed when trees are felled. As with other covered species, heat or smoke may result in take of both tree-roosting (Dickinson et al. 2010) or cave-roosting individuals (Tuttle 1986). Other potential sources of mortality that may result from covered activities would be the removal of an occupied roost in a building (Cope et al. 1991) and bats being struck by vehicles (Russell et al. 2009).

National Conservation Efforts

Historically, the little brown bat has benefitted from national conservation measures undertaken to benefit bats of all species, including those targeted at Indiana and gray bats. The little brown bat commonly uses bat boxes and other artificial roosts (Butchkoski and Hassinger 2002, Dobony et al. 2011, Gumbert et al. 2013, Adams et al. 2015, Cervone and Yeager 2016, Kaarakka 2016, Zalik et al. 2016). Similarly, prior to arrival of WNS, millions of little brown bats occupied mines throughout the upper Midwest and Northeast (Brack 2007, Johnson et al. 2016, Tinsley 2016). Protecting known roost and hibernacula sites with remnant populations of the little brown bat remains a priority (Sewall et al. 2016).

Efforts to address WNS, the primary threat to this and all other species covered by the plan are discussed in the species account for the Indiana bat.

Figures and Tables

Figure 1. Range-wide Distribution of the Little Brown Bat.

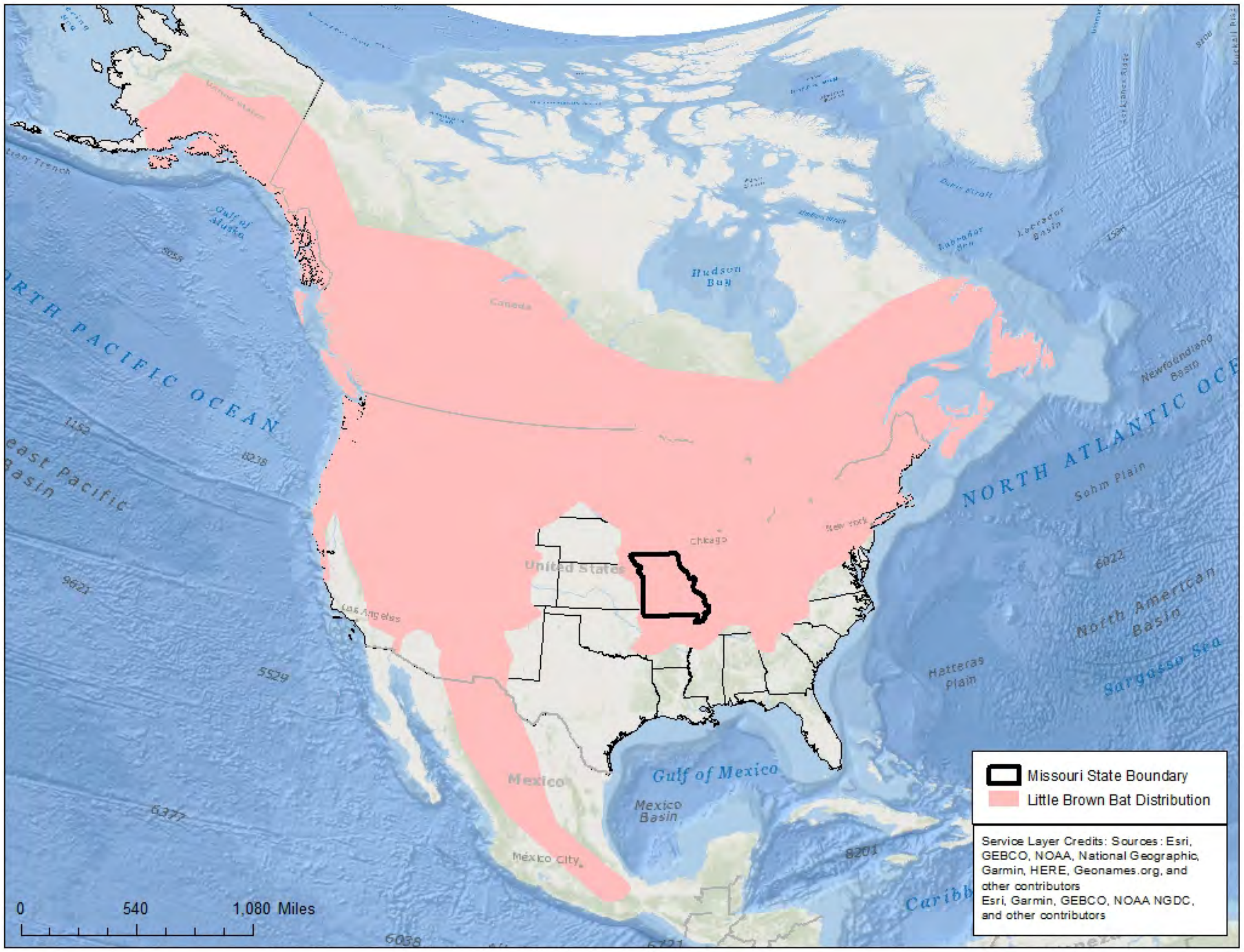

Figure 2. Known Distribution of the Little Brown Bat in Missouri during Active and Inactive Seasons.

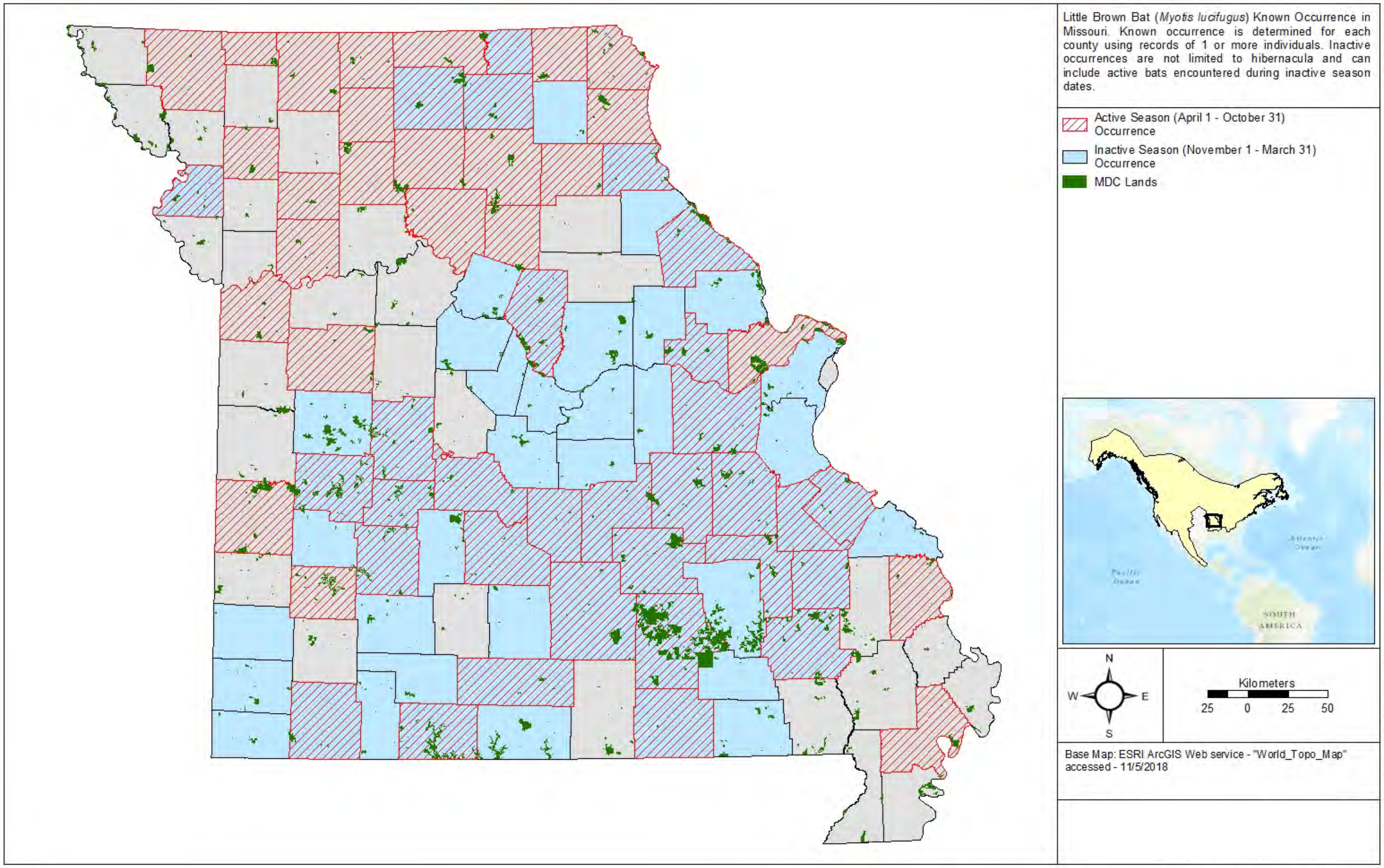

Figure 3. Modeled Distribution of Little Brown Bat Seasonal Habitat in Missouri.

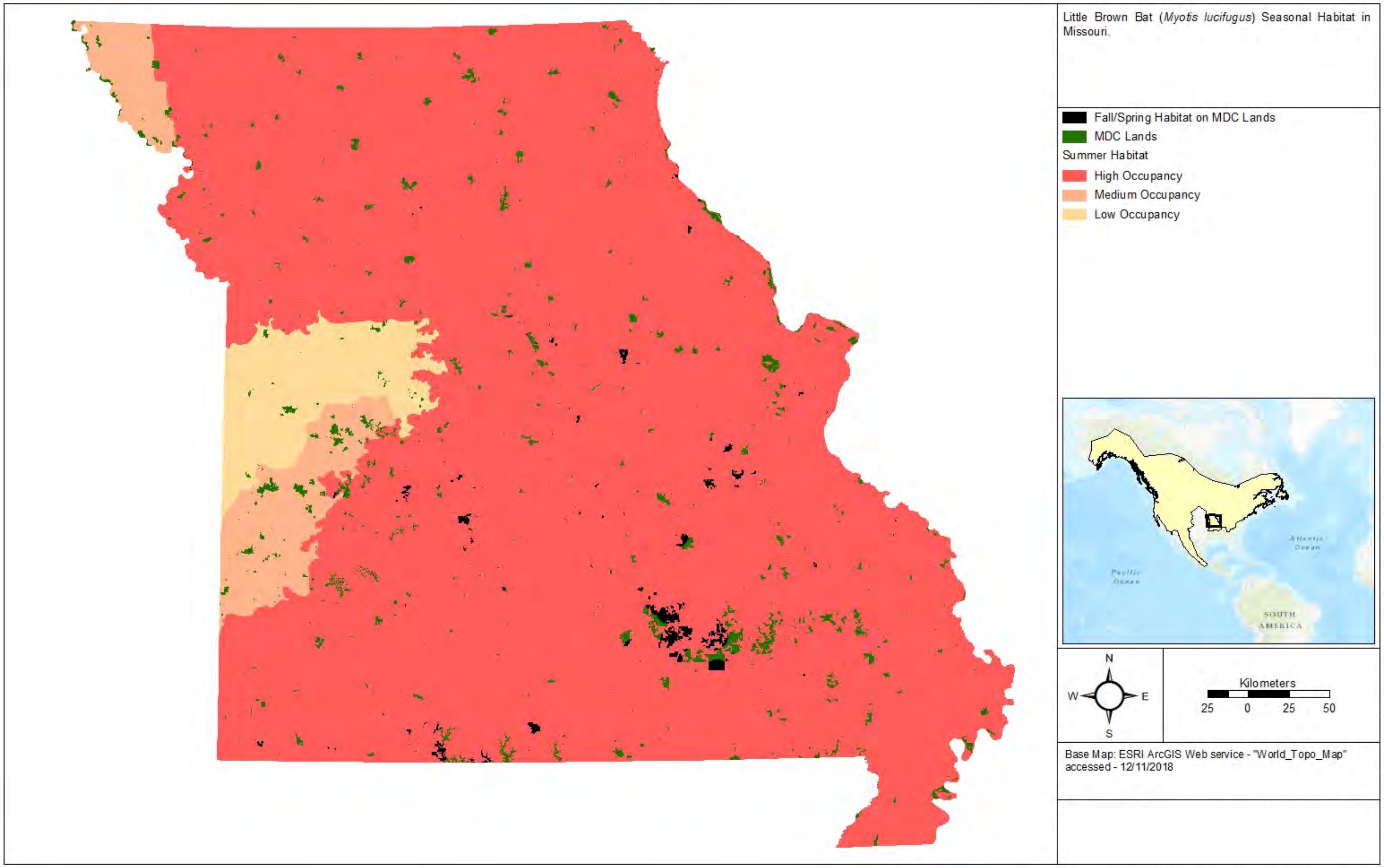

Figure 4. Seasonal Patterns of Activity by the Little Brown Bat

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
All	Hibernation (caves and mines)		Emergence & Migration	Migration, Maternity Colony Establishment		Pups are Flightless		Maternity Colony Breakup	Migration, Swarming, Breeding		Hibernation (cave and mines)	
	Inactive Season			Active Season							Inactive Season	

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Northern Long-eared Bat (*Myotis septentrionalis*)

Status

State: Endangered under Missouri Code of State Regulations (State of Missouri 2017). NatureServe Rank[1] S1: Critically Imperiled.

Federal: Listed as Threatened with interim 4(d) Exemption 2 April 2015 (80 *Federal Register* 17973–18033); finalized 4(d) Exemption 14 January 2016 (USFWS 2016b).

Critical Habitat: Designation of critical habitat has been deemed not prudent for this species (USFWS 2016a).

Other: Interim federal guidance is available (USFWS 2014).

The northern long-eared bat was proposed for federal listing as endangered on 2 October 2013. On 2 April 2015, the species was given a proposed listing of threatened with an interim 4(d) Exemption, which was finalized on 14 January 2016 (USFWS 2016b). The finalized 4(d) rule significantly increases exemptions for incidental take, and the prohibitions extend only to white-nose syndrome affected areas 1) within known hibernacula, 2) within 0.25 miles of known hibernacula, 3) if known and occupied maternity roosts are destroyed, or 4) if any tree within 150 feet of those occupied maternity roosts is destroyed. On 27 April 2016, the USFWS determined that critical habitat designation was not prudent, primarily based on the need to protect hibernacula locations (USFWS 2016a). Management guidelines are generally similar to those for Indiana bats, but the size of northern long-eared bat roost trees is typically smaller and the geographic range of the species is larger (USFWS 2014).

Description

The northern long-eared bat is a medium-sized bat in the genus *Myotis* along with three of the other covered species, Indiana bat (*Myotis sodalis*), gray bat (*Myotis grisescens*), and little brown bat (*Myotis lucifugus*). Northern long-eared bats are the eastern member of a group of long-eared *Myotis* that occurs across much of North America, and whose similarity has led to a complex taxonomy (van Zyll de Jong 1979). Also included in this long-eared group are the southwestern bat (*Myotis auriculus*), Keen's bat (*Myotis keenii*), and the long-eared bat (*Myotis evotis*). All are similar in overall appearance and ecology. At one point, northern long-eared bats were considered a subspecies of Keen's bat (Fitch and Shump 1979), which is now restricted to the Pacific Northwest. Much of the older literature appearing under the name *Myotis keenii* actually refers *to Myotis septentrionalis*.

Among bats that occur in Missouri, the northern long-eared bat's appearance most closely resembles that of congeners (bats in the same genus) little brown bat, Indiana bat, and gray bat. Northern long-eared bats, similar to Indiana and little brown bats, have a forearm length which ranges from 1.3 to 1.5 inches (33 to 38 mm). They differ from other similar eastern *Myotis* species by their long ears, which range from 0.5 to 0.7 inches (12.5 to 17.8 mm) and extend past the muzzle

[1]A standardized ranking system for species and community types that is compiled by partner agencies (such as MDC) and reported to NatureServe.

when laid forward, as well as a long and thin pointed tragus ranging from 0.3 to 0.4 inches (7.6 to 10.2 mm) (Whitaker and Mumford 2009). This becomes an easy field characteristic because the ears extend beyond the nose when laid (but not stretched) against the snout, whereas similar species extend only to the end of the nose.

Several other minor characteristics differentiate northern long-eared bats from sympatric species of *Myotis*. For instance, the species has an unkeeled or weakly keeled calcar. The fur on the back is brownish, while the fur of the chest and belly is tan to yellowish, especially on the hair tips. The back and areas underneath the northern long-eared bat contrast more strongly than that of the Indiana bat. Ears and wing membranes are usually dark brown.

Range

The summer range of the northern long-eared bat is large and includes much of the eastern deciduous forestlands, ranging from the northern border of Florida, north and west to Saskatchewan, and east to Labrador (Figure 1) (Caceres and Barclay 2000, Whitaker and Mumford 2009). Distribution throughout the range is not uniform, and summer occurrences are more common in the northern and northeastern portions of the species' range than in southern and western portions (Caceres and Barclay 2000, Amelon and Burhans 2006). Historically, these areas were primarily forested. Northern long-eared bats appear to be less abundant throughout the southern portions of its range and are thought of as rare in Alabama, South Carolina, and Georgia (Mumford and Cope 1964, Barbour and Davis 1969, Amelon and Burhans 2006, Whitaker and Mumford 2009, Timpone et al. 2010). Northern long-eared bats likely colonized the High Plains when suppression of fire and the extirpation of bison allowed extensive bands of riparian vegetation to develop along streams that were formerly not forested (Sparks and Choate 1995, Sparks et al. 1999, Benedict et al. 2000, Sparks and Choate 2000, Benedict 2004, Sparks et al. 2011). In winter, this bat hibernates in caves, abandoned mines, and occasionally in human-made structures such as railroad tunnels.

Known Range in Missouri and Occurrence on MDC Lands

Northern long-eared bats are known to hibernate in 52 counties in Missouri with most of these sites located in the caves and mines of southern Missouri (Figure 2). The species is easily overlooked because of its tendency to hibernate in cracks and crevices inside caves and mines. Recent evidence indicates they hibernate in rock faces in neighboring Nebraska (Lemen et al. 2016). Therefore, northern long-eared bats may have a much wider winter range than previously suspected. Several Missouri hibernacula historically contained large numbers of northern long-eared bats and have received special attention from MDC. MDC lands in 16 counties contain hibernacula of the northern long-eared bat.

Records of northern long-eared bats are known from 61 counties in Missouri during the active months (April-October). These counties contain 643,674acres (260,486 hectares) of MDC lands.

Modeled Distribution in Plan Area

The model presented below was developed in close association with MDC staff and is based on survey data from studies conducted by MDC staff and permitted biologists. Prior to the arrival of WNS, northern long-eared bats could be found regularly throughout most of Missouri in summer. Bats become less dense with increasing distance from hibernacula and as one moves westward onto the prairies of Kansas and Nebraska where the species occurs irregularly (Benedict et al. 2000, Benedict 2004, Geluso et al. 2004, Sparks et al. 2011). As such, three subsections of the Central Dissected Till Plains Section (Western Corn Bel Plains) and the Cherokee Plains are considered areas of medium occupancy and the Wooded Osage Plains of west-central Missouri are considered an area of low occupancy (Figure 3). The rest of the state is considered an area of high occupancy. Fall/spring habitat is modeled as lands located within 5 miles (8 km) of known hibernacula (Lowe 2012). In some cases; such as hibernacula containing exceptionally large populations of bats; hibernacula surrounded by limited foraging habitat, or hibernacula found in close proximity to summer colonies; bats may be found roosting at much greater distances (ESI 2005, Chenger et al. 2007). Based on this assumption, MDC lands contain 220,701 acres (89,315 hectares) of fall/spring habitat.

Ecology

Like three of the other species covered by this HCP, the northern long-eared bat is considered tree-dependent during summer and hibernacula-dependent during winter months. There are four ecologically distinct components of the annual life cycle: winter hibernation, spring staging and autumn swarming, spring and autumn migration, and the summer season of reproduction (see Figure 4).

Winter Hibernation

The species account of Indiana bats contains a detailed description of bat hibernation. As such, this account will provide a general description with particular attention paid to unique features of the northern long-eared bat. Most accounts of hibernating and/or swarming for northern long-eared bats are associated with the use of caves and mines (Whitaker and Mumford 2009), but the species may also use cave-like, manmade structures. These include a hydro-electric dam in Michigan (Kurta and Teramino 1994, Kurta et al. 1997) and storm sewers in Kansas (Fleharty and Farney 1965) and Minnesota. The species is often found using recessed areas of hibernacula such as cracks, crevices, and broken stalactites (Whitaker and Hamilton 1998), and individuals leaving hibernacula are often observed covered with clay and mud (Caire et al. 1979, Whitaker and Mumford 2009). Lemen et al. (2016) provided evidence that northern long-eared bats hibernate in rock crevices in neighboring Nebraska including some along the Missouri River just north of the Missouri/Iowa border. Thus, it is likely that the species uses similar habitats in Missouri and they should be checked for this presence.

The species selects areas within hibernacula that are relatively stable with a mean temperature of 32 to 48 degrees Fahrenheit (° F, 9.1 degrees Celcius [° C]) (Brack 2007), and they will often return to the same hibernaculum during successive winters (Caceres and Barclay 2000). Northern long-eared bats prefer high humidity conditions with little to no air flow in the areas where they are hibernating (Fitch and Shump 1979, van Zyll de Jong 1979), which results in noticeable build-up of water droplets on their fur (Barbour and Davis 1969). Northern long-eared bats frequently share hibernacula with other bat species, such as the little brown bat and the tricolored bat; however, they will often roost in different parts of the hibernaculum. Because they hibernate in hard-to-see places, the number of northern long-eared bats using a structure can be orders of magnitude greater than observed during interior studies (Whitaker and Rissler 1992).

Staging, Swarming, and Migration

A notable difference between the ecology of northern long-eared bats and other species covered under this plan is a period in summer when large numbers of male northern long-eared bats visit swarming sites (Caire et al. 1979, Whitaker and Rissler 1992). Activity at the caves then ceases for several weeks prior to resuming on the same schedule as the other covered species. Swarming in Missouri is most intense in August and September when males and females are both present (Caire et al. 1979, LaVal and LaVal 1980). In Missouri staging occurs late March and early April (Caire et al. 1979, LaVal and LaVal 1980).

Typical of most bat species in the eastern United States, northern long-eared bats migrate between winter hibernacula and summer roosting habitat. When female northern long-eared bats emerge from hibernation, they migrate to maternity colonies. The distance and routes traveled from winter hibernacula to summer roosting areas is not definitively known, but the species is considered to migrate shorter distances than the Indiana bat (USFWS 2014). Spring migration from winter hibernacula usually occurs between mid-March and mid-May, whereas most fall migration from summer roosting areas back to winter hibernacula occurs from mid-August through mid-October. During migration, northern long-eared bats are often observed roosting on the side of stone buildings in Kansas (Sparks et al. 2000).

Summer Roosting Habitat

Northern long-eared bats can be viewed as a roost generalist; most northern long-eared bats in Missouri likely roost in trees (Boyles et al. 2009, Timpone et al. 2010), although this species uses buildings (Krochmal and Sparks 2007) and other anthropogenic structures such as bridges (Sparks and Choate 1995, Keeley and Tuttle 1999) and bat boxes (Whitaker et al. 2006). A detailed analysis of roost selection in Missouri is available (Timpone et al. 2010).

Males

Some males and non-reproductive females remain near their winter hibernaculum throughout summer while others migrate varying distances. This may be due to a preference for cooler environments (and thus lower energetic costs) in the absence of pups (Barbour and Davis 1969, Amelon and Burhans 2006). Males can be caught at hibernacula on most nights during summer, although there may be a large turnover of individuals between nights. Structurally, summer roosts used by males are similar to those used by maternity colonies.

Females and Maternity Colonies

Maternity colonies are typically found in hollow trees and under bark, although the species sometimes uses bat houses, buildings, and other anthropogenic structures (Amelon and Burhans 2006). Tree-roosting northern long-eared bats are found in hollows, cracks, and under bark depending on the presence or availability within an area, though competition or predation from other wildlife may influence roost selection (Perry and Thill 2007, Perry et al. 2007). A wide variety of deciduous tree species, as well as occasional coniferous species, are used as nursery colonies; this indicates that it is tree form, not species, that is important for roosts (Caceres and Barclay 2000, Carter and Feldhamer 2005). This species regularly uses both live and dead trees (Sasse and Pekins 1996, Foster and Kurta 1999, Carter and Feldhamer 2005). Roost trees may be habitable for one to many years, depending on the species and condition of the tree. As noted above a wide variety of other roosts are also used (Cope et al. 1961, Barbour and Davis 1969, Cope et al. 1991, Sparks and Choate 1995, Caceres and Barclay 2000, Sparks and Choate 2000, Farrell Sparks et al. 2004, Whitaker et al. 2004), and one maternity colony in Missouri was comingled with little brown bats in a barn in NE Missouri (Timpone et al. 2010). Northern long-eared bats also make extensive use of bat houses when these structures are available (Whitaker et al. 2006).

A maternity colony typically consists of 30 to 60 individuals, although colonies containing up to 100 individuals have been observed (Whitaker and Mumford 2009). The number of individuals within a maternity colony decreases as the maternity season progresses, as fewer bats roost together during the post-lactation stage than during the pregnancy stage. Northern long-eared bats show low fidelity to roosts, switching every 2 to 3 days (Sasse and Pekins 1996, Timpone et al. 2010).

Females are pregnant when they arrive at maternity roosts and produce a single young per year, as is typical for the genus *Myotis* (Asdell 1964, Hayssen et al. 1993, Sparks et al. 1999, Krochmal and Sparks 2007). Parturition typically occurs between late May and early June (Caire et al. 1979, Krochmal and Sparks 2007, Whitaker and Mumford 2009).

Juveniles become volant between late June and early August (Caire et al. 1979, Sasse and Pekins 1996, Krochmal and Sparks 2007). As is the case with other species of bats in North America, mortality for northern long-eared bat is high during the first year (Caceres and Pybus 1997). Northern long-eared bats have been observed roosting in areas of increased solar heating, which increases their developmental rate and reduces the need to lower their body temperature and metabolic rate (i.e. enter a state of torpor) (Lacki and Schwierjohann 2001).

Diet, Nightly Behavior, and Foraging

The diet of northern long-eared bats varies substantially among ages and genders, and in relation to the availability of insects within different habitat types. Brack and Whitaker (2001) found that in Missouri and Indiana, lepidopterans constituted a large part of the northern long-eared bat's diet, as well as coleopterans, trichopterans, and dipterans. Northern long-eared bats have also been noted to feed on spiders, lepidopteran larvae, plecopterans, homopterans, hymenopterans, and a variety of other insects and arthropods by gleaning (Brack and Whitaker 2001, Feldhamer et al. 2009).

Northern long-eared bats typically emerge from day roosts near dusk to forage over forested ponds and streams and in wooded areas before resting in a night roost (Kunz 1973). Northern long-eared bats often emerge a second time in early morning for another short bout of foraging before returning to their day roosts (Kunz 1973, Brack and Whitaker 2001). The species has been documented using both hawking and gleaning foraging strategies (Griffith and Gates 1985, Faure et al. 1993, Brack and Whitaker 2001, Feldhamer et al. 2009). Gleaning bats capture prey from the substrate (often vegetation or the ground) and northern long-eared bats do more of this than other similar species with shorter ears (Faure et al. 1993). This likely explains the abundance of spiders in the diet (Brack and Whitaker 2001) and observations of light-tagged northern long-eared bats foraging close to the ground amid heavy foliage (LaVal et al. 1977, Caire et al. 1979, LaVal and LaVal 1980).

Northern long-eared bats forage in areas that are relatively close to roosts and tend to prefer areas with higher clutter than roosting areas. Unpublished studies in suburban Indianapolis and along the Wabash River near Terre Haute, Indiana indicate that this species forages almost exclusively in forested areas within 0.6 mile of the roost (D. W. Sparks unpublished data). This coincides with studies from New Hampshire that show an average distance of 0.4 mile from roosting areas to foraging areas (Sasse and Pekins 1996). Henderson and Broders (2008) found that foraging areas on Prince Edward Island were comparatively more cluttered (i.e., had thicker understories) than roosting areas, although foraging areas were also found to be predominately forested. If a bat was found to forage in an open area, it was within 0.05 mile of a forest feature.

Ecological Relationships

Northern long-eared bats are components of most bat communities throughout the east (Whitaker and Hamilton 1998). They occur in ecological communities with a variety of other bat species at various times of the year, including occasional sharing of summer roosts with other species. On one occasion, a northern long-eared bat was observed sharing a bark roost with an Indiana bat (MacGregor et al. 1999, Gumbert et al. 2002). Roosts within buildings may also contain mixes of northern long-eared, big brown, and little brown bats, although it is uncertain whether these species are co-roosting or simply using different parts of the same building (Veilleux et al. 1998, Krochmal and Sparks 2007, Timpone et al. 2010). Colonies at the Indianapolis Airport are known to use the same artificial roosts that were later occupied by Indiana bats, although no temporal overlap has been observed (Whitaker et al. 2004, Whitaker et al. 2006, Sparks et al. 2009). Similar instances of northern long-eared bat roosting sites being occupied by one or more bat species at non-concurrent time frames have been recorded (Timpone et al. 2010). Western populations have roosting behavior that is more similar to Indiana bats (i.e., a tendency to use large, dead trees) than to eastern populations of northern long-eared bats (Cryan et al. 2001). These data may represent regional variation or may hint at a deeper relationship—one in which Indiana bats occupy the large dead trees and force northern long-eared bats into suboptimal (i.e., shaded) roosts.

During summer, bats of all species overlap in foraging habitats. Northern long-eared bats are often viewed as being the most clutter-tolerant species in these communities, and use smaller foraging areas than little brown bats in the same area (Broders et al. 2006). In Missouri, this bat shares hibernacula with all other bats covered by this plan (Myers 1964, LaVal and LaVal 1980, Colatskie 2017), although its habit of hibernating in cracks and crevices can make detection difficult.

Survivorship

As with similar bats, northern long-eared bats are long-lived once they reach adulthood. Juvenile mortality is high for most species of bats (Tuttle and Stevenson 1982). No detailed assessment of survivorship is available for the species, but banded bats were regularly recaptured during field work completed at the Indianapolis International Airport (Whitaker et al. 2004). Harvey et al. (Harvey et al. 2011) noted that the lifespan of this bat likely exceeds 18 years.

Population Trend

Prior to the onset of WNS (see below), the species was abundant throughout much of the eastern United States and thus, was not a focus of detailed demographic studies. USFWS estimated the U.S. population in 2016 to be 6,500,000 individuals (adults and juveniles), including 428,923 in Missouri (USFWS 2016b). Populations are now in a period of catastrophic decline across most of the range (USFWS 2016b). Francl et al. (2012) documented a 77 percent decline in summer capture rates of northern long-eared bats in West Virginia and adjacent areas of Pennsylvania in the two years following the arrival of WNS.

As part of the listing process, USFWS completed an analysis of 103 hibernacula in 12 states and found an average rate of 92 percent decline in population with northern long-eared bats having been extirpated from 68 sites (USFWS 2016b). Observations at fall swarming sites indicates that these declines are both a result of increased adult mortality and lower recruitment following the arrival of WNS (Reynolds et al. 2016). The situation in Missouri is similar with populations in hibernacula having nearly disappeared between the winters of 2012/2013 and 2015/2016 (Colatskie 2017). Frick et al. (2017) found no evidence of population stabilization at sites where WNS has been present for 10 years, which suggests extinction in the wild is a distinct possibility.

Threats

USFWS (2016b) reviewed potential threats to the northern long-eared bat and determined that WNS is the greatest threat faced by the species. Prior to WNS, northern long-eared bats were a moderate species of concern in several states (The Center for Biological Diversity 2010) .

Other stressors of importance include adverse hibernacula modifications, loss of forests, mortality at wind energy sites, environmental contaminants and fire (including prescribed fire). Because northern long-eared bats use a wide variety of hibernacula and are often difficult to detect, efforts to close abandoned mines may have killed many individuals prior to the widespread use of bat-friendly gates (Whitaker and Stacy 1996). Loss of wooded lands can remove roosts and lead to increased forest fragmentation, compounding adverse effects from other factors. In many portions of its core range, northern long-eared bats use forested habitats with large trees, an open canopy, and a cluttered understory. Urbanization removes potential roosting and foraging habitat, and some bat species may not cross developed areas to access otherwise-suitable foraging habitat (Duchamp et al. 2004, Sparks et al. 2005). However, northern long-eared bats may be able to occupy very small remnant forests within a developed landscape or scattered trees in agricultural lands if the habitat contains suitable roosts (Whitaker et al. 2004). Northern long-eared bats frequently move among roosts which provides the species knowledge of escape roosts in case a roost is disturbed (Sparks 2008). Retention of some roosts provides resiliency in case of roost loss (Silvis et al. 2015).

The proposed Midwest Wind Energy HCP used pre-WNS mortality rates to estimate that current and future wind energy sites in Missouri would take 684 northern long-eared bats between 2016 and 2060. However, it is important to note that the Wind Energy HCP has not been finalized, and this mortality estimate did not account for population declines caused by WNS or for conservation measures included in the plan (USFWS 2016c). Chemical contamination in non-winter habitats has been implicated in the decline of most North American bats (USFWS 2007). Although mortality due to prescribed fire has not been confirmed, Dickinson al. (2010), used northern long-eared bats as a model to determine conditions under which fire would be harmful to tree-roosting bats.

Potential Sources for Take

Northern long-eared bats are included in the plan primarily due to their exposure during habitat management activities (i.e. tree removal and prescribed fire). Because most northern long-eared bats roost in trees, there is the potential for some to be killed or harmed when trees are felled (USFWS 2016b). As with other covered species, heat or smoke may result in take of both tree-roosting (Dickinson et al. 2010) or cave-roosting individuals (Tuttle 1986).

Other potential sources of mortality that may result from covered activities would be the limited potential of impacting a colony in a building that is removed (Cope et al. 1991) and bats being struck by vehicles (Sparks et al. 2000).

National Conservation Efforts

Because of the recent Threatened status, few national conservation measures have been developed and implemented. National conservation efforts for northern long-eared bats are presently similar to those for Indiana bats, as WNS is the primary threat to both species and as both species use similar habitat. However, there are some differences in the habitat preferences of northern long-eared bats that are considered regarding conservation measures for this species. First, the northern long-eared bat readily makes use of artificial roosts, and some colonies in heavily disturbed areas have been documented making almost exclusive use of such structures (Sparks 2003, Whitaker et al. 2006). Second, the species is much less selective about the types of trees it uses than Indiana or little brown bats. Younger trees (i.e., small pole-stage) and live trees with hollows are likely to be important. Third, colonies of northern long-eared bats use smaller home ranges, and so smaller woodlands (especially if connected to other woodlands by lines of trees) may be an important resource (Whitaker et al. 2004, Carter and Feldhamer 2005). Fourth, the species readily uses mines and caves that are not suitable for Indiana bats (Whitaker and Clem 1992, Whitaker and Stacy 1996). Accordingly, stabilizing and protecting these resources may prove important—especially given the tendency of northern long-eared bats to make shorter-distance migrations. Both prescribed fire and timber harvest can be important tools for creating roosts used by this species (Silvis et al. 2012, Ford et al. 2016, Silvis et al. 2016).

Figures and Tables

Figure 1. Range-wide Distribution of the Northern Long-eared Bat.

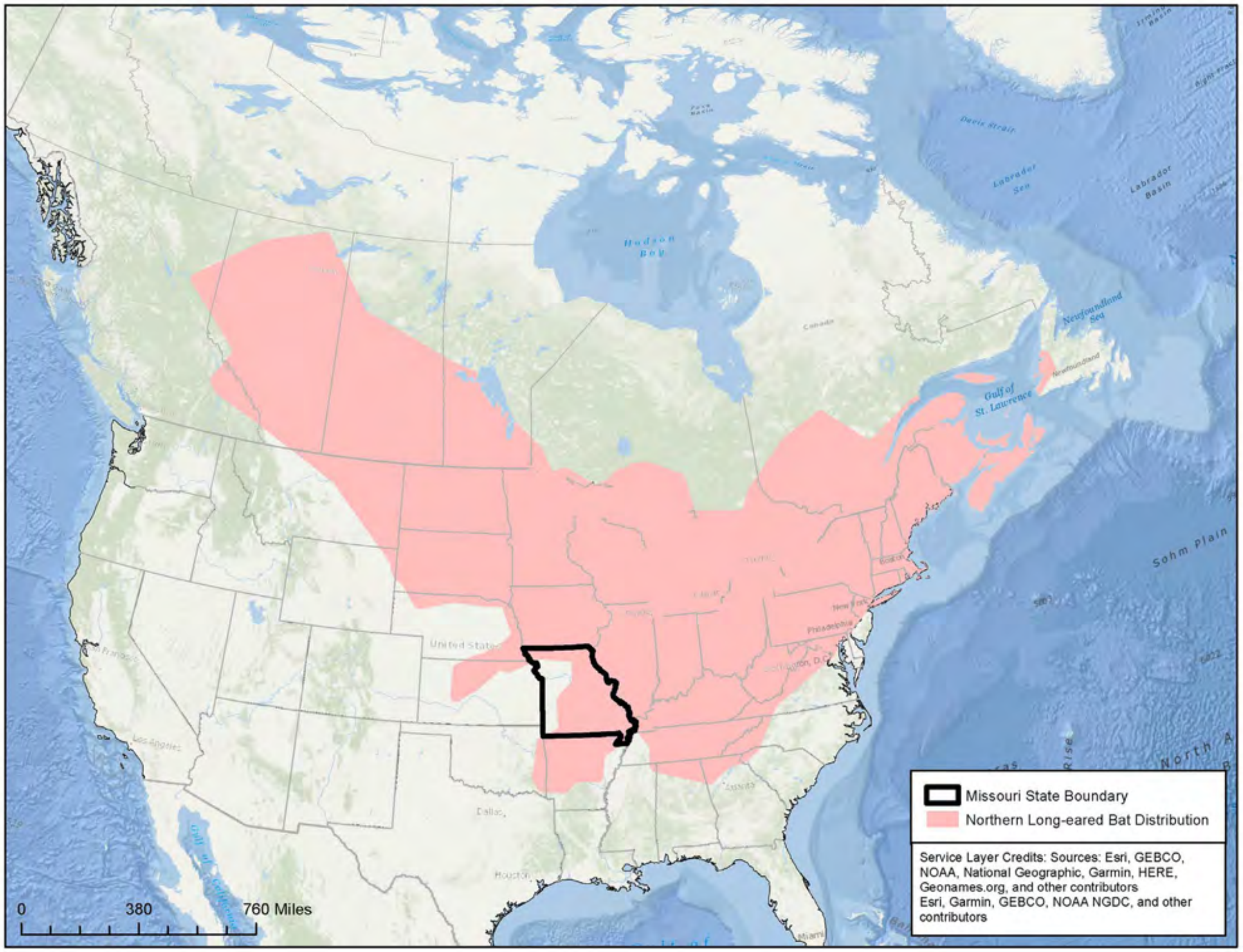

Figure 2. Known Distribution of the Northern Long-eared Bat in Missouri Counties during Active and Inactive Seasons.

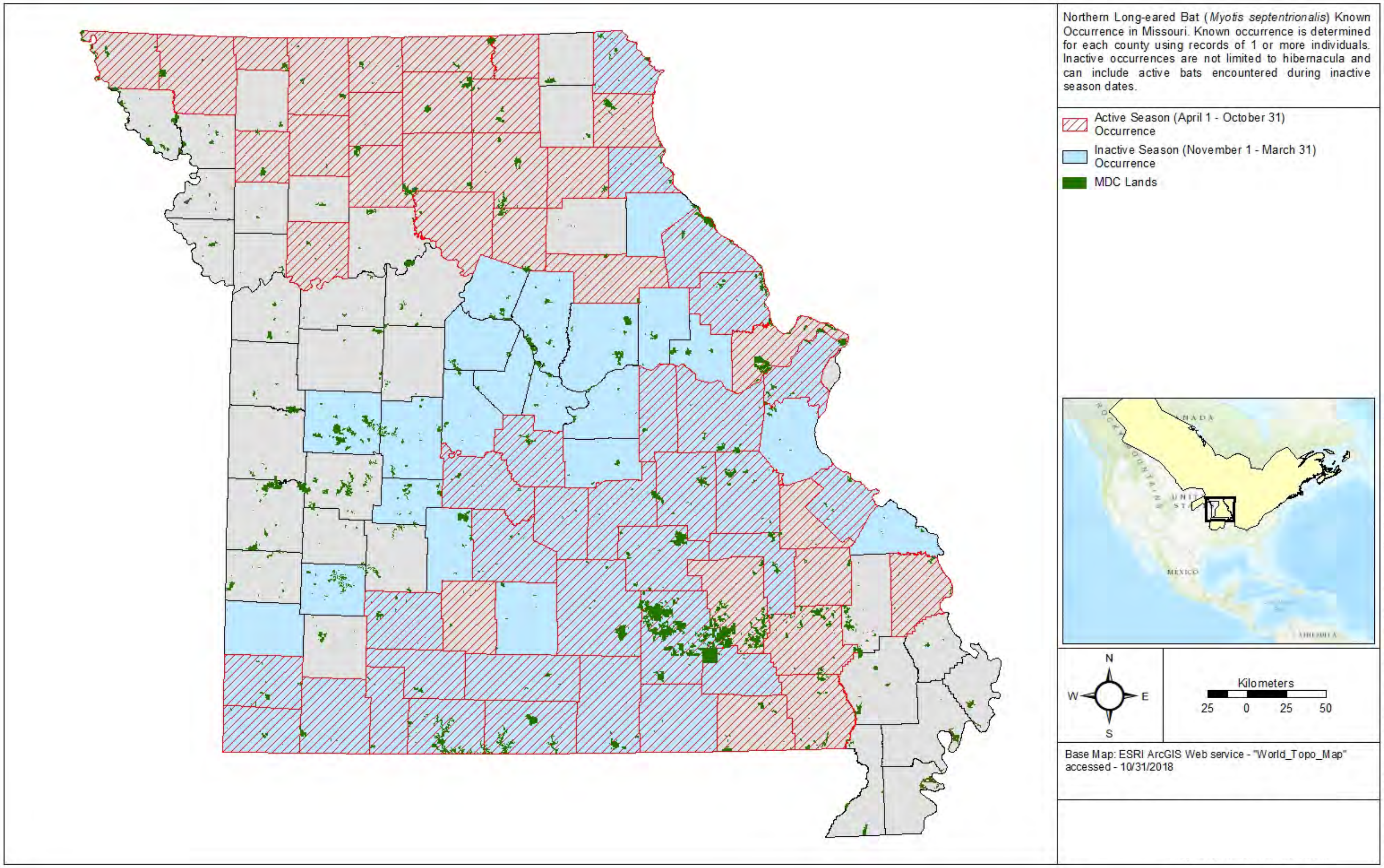

Figure 3. Modeled Distribution of Northern Long-eared Bat Seasonal Habitat in Missouri.

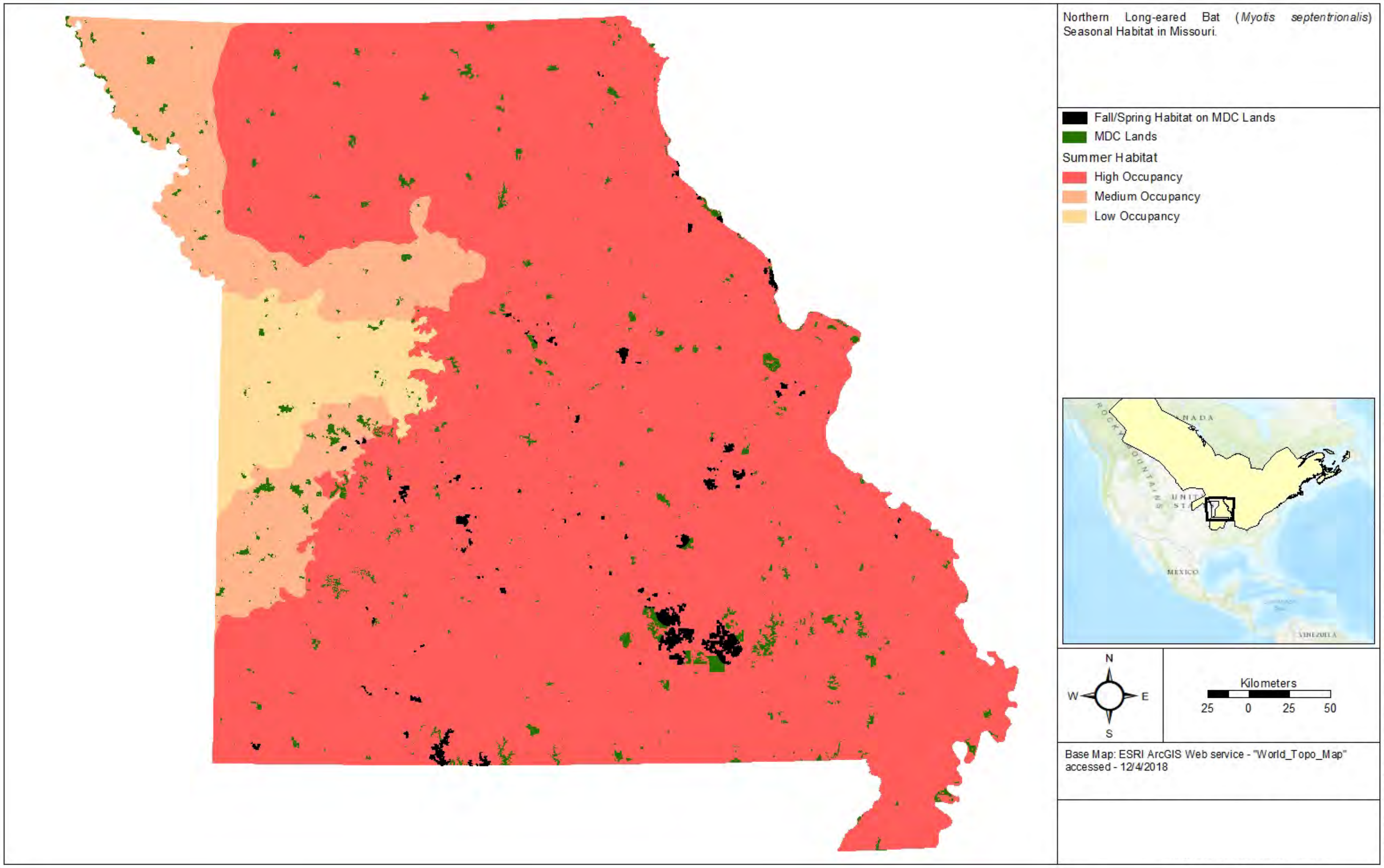

Figure 4. Seasonal Patterns of Northern Long-eared Bat Activities

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
All	Hibernation (caves and mines)		Emergence, Migration, Maternity Colony Establishment			Pups are Flightless		Maternity Colony Breakup	Migration, Swarming, Breeding		Hibernation (cave and mines)	
	Inactive Season			Active Season							Inactive Season	

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Tricolored Bat
(Perimyotis subflavus)

Status

State: Species of Conservation Concern.
NatureServe[1] Rank S2: Imperiled.

Federal: USFWS has begun a formal status review on 20 December, 2017 (82 FR: 60362-60366).

Critical Habitat: No critical habitat defined.

Other: MDC added the species to the Species of Conservation Concern list in 2018 with a State Rank of S2 and has begun assembling data on the species to determine if additional state-level listing is appropriate.

On June 14, 2016 the U.S. Fish and Wildlife Service (USFWS) received a petition from the Center for Biological Diversity and Defenders of Wildlife to protect the tricolored bat as an endangered or threatened species under the Endangered Species Act (ESA). On December 20, 2017, USFWS issued a 90-day finding that the petition presented credible evidence that listing may be warranted. Based on this finding, USFWS has formally initiated the process to determine whether the tricolored bat should be protected under ESA.

Description

The tricolored bat (formerly known as the eastern pipistrelle, *Pipistrellus subflavus*) is a small bat in the monotypic genus *Perimyotis.* It weighs 0.14-0.28 ounces (4-8 g), has a forearm length of 1.3-1.4 inches (32-36 mm) (Kurta 2008), and a body length of 2.8-3.1 inches (7-8 cm). The wingspan is 8.3-10.2 inches (21-26 cm) (Kurta 1995; 2008, WDNR 2013). Guard hairs of tricolored bats have three color bands, hence the name; they are dark at the base, yellow in the middle, and dark at the top (Kurta 2008, WDNR 2013). Overall, this bat appears golden to reddish brown in color (Kurta 2008, WDNR 2013). It is distinguished from similar species, such as the little brown bat (*Myotis lucifugus)*, Indiana bat (*Myotis sodalis*), and northern long-eared bat (*Myotis septentrionalis*), by its smaller size, red forearms, tricolored fur, heart-shaped face, half-furred tail membrane, and brown-colored ears (Kurta 2008, WDNR 2013). When hanging in a cave, it is distinguished by the red forearm, hunchback appearance, and often water droplets that form on its fur.

Range

The tricolored bat ranges from the Yucatan Peninsula to Nova Scotia, New Brunswick (Broders et al. 2001), and Quebec, and east to the Atlantic Ocean (Figure 1). In recent years, the species' range has expanded across the High Plains (Damm and Geluso 2008) and has been captured in the Intermountain West including Texas and New Mexico (Sparks and Choate 2000, Geluso et al. 2005, White et al. 2006, Valdez et al. 2009). Like three of the other covered species, this bat is currently experiencing catastrophic declines throughout the region caused by white-nose syndrome (WNS).

[1]A standardized ranking system for species and community types that is compiled by partner agencies (such as MDC) and reported to NatureServe.

Like most of the other covered species, the tricolored bat is considered a “tree bat” in summer because it roosts in forests, woodlands, and savannas and a “cave bat” in winter. Summer and winter ranges are not markedly different for this species due to its pattern of relatively short migrations.

Known Range in Missouri and Occurrence on MDC Lands

Tricolored bats are known to hibernate in 46 counties in Missouri (Figure 2), largely in the caves and mines of southern Missouri. Important exceptions to this pattern include the hibernaculum at Sodalis Nature Preserve in Hannibal, Marion County in northeastern Missouri , as well as other quarries in the northern portion of state and several smaller caves and quarries located along the Missouri River north of Kansas City where tricolored bats were once commonly encountered. Prior to arrival of WNS, tricolored bats were found in many hibernacula but rarely in large numbers. MDC lands in 22 counties contain hibernacula used by the tricolored bat.

Records of tricolored bats are known from 77 counties in Missouri during the active months (April-October). These counties contain 848,054 acres of MDC lands.

Modeled Distribution in Plan Area

The model presented below was developed in close association with MDC staff and is based on survey data from studies conducted by MDC staff and permitted biologists. Prior to WNS, tricolored bats were regularly found throughout most of Missouri in summer (Figure 3). Bats become less dense with increasing distance from hibernacula, and westward onto prairies of Kansas and Nebraska where the species is virtually absent (Sparks et al. 2011). As such, the Wooded Osage Plains of west-central Missouri are areas of medium occupancy. The rest of the state is an area of high occupancy. Based on patterns observed in similar species, Fall/spring habitat is modeled as lands within 5 miles of known hibernacula (Gumbert et al. 2002, Lowe 2012). In some cases; such as hibernacula containing exceptionally large populations of bats; hibernacula surrounded by limited foraging habitat, or hibernacula found in close proximity to summer colonies; bats may be found roosting at much greater distances (ESI 2005, Chenger et al. 2007). Based on these assumptions there are 244,796 acres (99,065 Hectares) of fall/spring habitat on MDC lands.

Ecology

Like the Indiana bat, the tricolored migrates seasonally between caves and mines to summer habitats. Unlike the other covered bats, tricolored bats routinely roost in clusters of dead leaves, on the side of buildings, and in other open habitats. A detailed species ecology was included in the petition to list the species (Center for Biological Diversity and Defenders of Wildlife 2016). As with the Indiana bat, the annual cycle of the tricolored bat is broken into winter hibernation, spring staging and autumn swarming, spring and autumn migration, and the summer season of reproduction (Figure 4).

Winter Hibernation

Tricolored bats are an obligate hibernator with populations in subtropical regions hibernating even in the absence of severe winters (McNab 1974). In Missouri, tricolored bats are the first species to enter hibernation and the last to exit, with an average beginning date of mid-October and an average ending date of mid-April (LaVal and LaVal 1980). It is likely that tricolored bats hibernate in the majority of Missouri’s caves (LaVal and LaVal 1980, Boyles et al. 2008, Colatskie 2017). In addition to caves, tricolored bats use a wide variety of other hibernacula including mines (Whitaker and Stacy 1996, Brack 2007), storm sewers (Goehring 1954), box culverts (Sandel et al. 2001), and surge tunnels at quarries (Slider and Kurta 2011). Recent evidence indicates that tricolored bats also hibernate in rock faces in neighboring Nebraska (Lemen et al. 2016) and suggests that the species may have a wider winter range than previously suspected. Hibernating tricolored bats roost mostly singly but will form small clusters and often select a roost on the walls as opposed to the ceiling of the hibernaculum (Brack 1979, Kurta 2008). Throughout most of the range, they select relatively warm, stable sites often located further from the hibernaculum entrance than other Midwestern bat species (Brack 2007). Typical microclimates used by hibernating tricolored bats in Missouri have temperatures between 45 and 52 degrees Fahrenheit (° F) (7.2 and 11.1° C), with a lower range around 35.4° F (1.9° C), and individual bouts of hibernation may last as much as 111 days (Brack and Twente 1985).

Swarming, Staging, and Migration

Bats participate in a behavior known as swarming prior to entering hibernation. During this time hundreds of bats fly in, out, and around the entrances of caves and mines (Humphrey and Cope 1976, Cope and Humphrey 1977). A less intense version of this behavior occurs in spring and is known as staging. Tricolored bats swarm from August to October (Boyles et al. 2008). Bats banded during swarming were regularly recaptured at the same swarming sites in subsequent years, but were rarely recaptured hibernating at these sites (LaVal and LaVal 1980). Whitaker and Rissler (1992) provided detailed observation of bat activity at a mine in Indiana, where activity by tricolored bats peaked during the last week of October and again in the last week of April—peaks later than those proposed for Missouri (Boyles et al. 2008).

Tricolored bats are typically thought to make relatively short migrations (Boyles et al. 2008), with the maximum distance traveled between summer and winter habitat by a banded tricolored bat being 85 miles (136.79 km) (Griffin 1940). Conversely, tricolored bats are killed in large numbers at wind energy sites—a tendency shared with long-distance migrants (Arnett and Baerwald 2013). Based on stable isotope analysis of museums specimens, Fraser et al. (2012) concluded that tricolored bats primarily make a north-to-south migrations unlike other cave-hibernating bats that tend to migrate from a hibernacula outward in all directions. During migration, tricolored bats make regular use of roosts on buildings and in leaf clusters (Whitaker 1998, Whitaker et al. 2014). These "pre-maternity" colonies may serve as an extended staging period away from the hibernacula, an assembly point for members of a maternity colony, or multiple other functions.

Summer Roosting Habitat

Unlike other bats covered in the HCP, tricolored bats make use of highly ephemeral roosts including clusters of dead leaves, lichen, Spanish moss (*Tillandsia usneoides*), squirrel nests, and piles of pine needles that accumulate in the splits of trees (Davis and Mumford 1962, Veilleux et al. 2003, Perry and Thill 2007, Poissant et al. 2010).

Females and Maternity Colonies

Once females have left the vicinity of the hibernacula, they often congregate in open areas of buildings such as covered bridges or porches (Whitaker et al. 2014). The bats may return to these same locations across multiple years leading Whitaker et al. (2014) to speculate that they may provide a permanent location that allows the members of a maternity colony to assemble prior to moving into the more ephemeral roosts used in summer—a shift that often correlates with the complete leaf-out. Whitaker et al. (2014) theorized that the move may prevent predators from discovering the bats or it may allow the bats to seek out roosts with enhanced solar exposure.

In Missouri, maternity colonies are most likely to be found roosting in umbrella-shaped clusters of dead leaves, but may also be found in live leaf foliage, lichens, patches of pine needles caught in tree limbs, buildings, caves, and rock crevices (Humphrey 1975, Veilleux et al. 2003, Veilleux and Veilleux 2004a; b, Veilleux et al. 2004, Perry and Thill 2007). Oak (genus *Quercus*) and maple (*Acer*) trees are preferred by maternity colonies of tricolored bats presumably because the ends of the branches tend to have many leaves (Veilleux et al. 2003; 2004, Perry and Thill 2007), and thus maternity colonies are more often associated with uplands than bottomland forest. Tricolored bats vary their roost position in the canopy and landscape depending on reproductive condition; reproductive female bats roost lower in the canopy and farther from forest edges than non-reproductive females. Veilleux and Veilleux (2004b) speculated that lower position in the canopy and greater distances from the forest edge may reduce wind exposure and allow for more stable temperatures.

Female tricolored bats switch roosts frequently, approximately every 4 days (± 2.5 days) in one study (Veilleux et al. 2003); and the distance between successive roosts ranges from 62.3 to 456 feet (19 to 139 m) (Veilleux et al. 2003, Veilleux and Veilleux 2004b). Average size of a woodlot containing a maternity colony in suburban Indianapolis was 123.6 acres (50 ha) and woodlots of 12.4 acres (5 ha) or less were not used (Helms 2010)

Several studies in west-central Indiana provide an opportunity to compare colonies living in trees to those living in buildings. Maternity colonies in buildings tend to give birth between May and July and contain 7 to 29 bats (Whitaker 1998). However, colonies roosting in foliage give birth in late June in Indiana (Veilleux and Veilleux 2004a), and the number of bats sharing a leaf cluster varies from 1 to 13 individuals. Bats living in buildings return to the same portions of the same building across multiple years (Hoying and Kunz 1998, Whitaker 1998). Similarly tree-roosting bats return to the same wooded area in subsequent years (Veilleux and Veilleux 2004b; a) even when the leaf clusters have disappeared. In building colonies, the adults leave as their young are weaned (Whitaker 1998), but adults of tree-roosting colonies remain in the same area through migration (Veilleux and Veilleux 2004a).

Gestation is typically 44 days (Wimsatt 1945), and females produce twins pups whose mass is approximately 44-54 percent of the size of the mother, a higher ratio than most Vespertilionid bats (Kurta and Kunz 1987). Young are volant at 3 weeks and act as adults around 4 weeks old (Hoying and Kunz 1998). Post-natal growth rates slow during cold snaps because the mothers cannot eat and available energy is used for thermoregulation (Hoying and Kunz 1998).

Males

As with other species of bats, some male tricolored bats remain at hibernacula year round (Whitaker and Rissler 1992). Most males roost in the same types of leaf clusters used by female tricolored bats (Veilleux and Veilleux 2004a), although they return to the same roost for multiple days, with one individual in Arkansas roosting in the same cluster for 33 days (Perry and Thill 2007). Male bats also select roosts in the same species of trees, although males tend to use thinner and shorter trees (Veilleux and Veilleux 2004a). Males also tend to roost at lower heights than females; often 16.4 feet (5 m) from the ground (Perry and Thill 2007).

Diet, Nightly Behavior, and Foraging

Generally, tricolored bats prefer wooded habitats near water (Whitaker and Mumford 2009) where they forage on a diet of Homoptera, Hemiptera, Diptera, and Lepidoptera (Brack and Whitaker 2004, Whitaker 2004, Caylor 2011), which they catch in mid-air while in flight (i.e. aerial hawking). Tricolored bats (especially pregnant females) have a low wing aspect ratio, which makes them highly maneuverable, but also less energy efficient as fliers (Norberg and Rayner 1987). For this reason, they are able to forage in complex woodlands with more vertical structure and are considered clutter-adapted. Observations in Missouri failed to detect any effect of local vegetation on foraging by tricolored bats (Starbuck et al. 2015). However, their low wing aspect ratio limits their ability to travel long-distances, with the maximum distance reported between foraging and roosting areas being 2.7 miles (4.3km) in Indiana (Veilleux et al. 2003).

A number of authors have provided general comments about the nocturnal behavior of tricolored bats. Boyles et al. (2008) noted the observation of several tricolored bats well before sunset. Activity areas include woods and wooded clearings, over streams, over farmland, and within more urban land types (Davis and Mumford 1962, Helms 2010).The only detailed, telemetry-based, study of the nocturnal behaviors of tricolored bats was conducted at the developing edge of Indianapolis (Helms 2010). Each night, bats would leave roosts in woodlands and travel an average of 1 mile (1.6 km) with a maximum of 1.9 miles (3.1 km) and use a home range that averaged 798 acres (323 ha) with a range of 116 to 1515 acres (67 to 613 ha). Preferred habitats for foraging included forest, old field, grasslands, and agriculture; but transportation corridors, low and high density residential, commercial, industrial, and water were also used. Although developed lands were used less than chance alone would indicate, tricolored bats would regularly forage in adjacent patches of less-developed landscapes.

Ecological Relationships

Tricolored bats generally roost in small groups and hibernate alone; therefore, information about ecological relationships with other bat species is minimal. Bats of all species regularly overlap in time and space with each other during nightly foraging behavior, but the level of these interactions is poorly characterized. Tricolored bats often share hibernacula with other bats.

Survivorship

As with the other covered species, tricolored bats are long-lived once they reach adulthood (Tuttle and Stevenson 1982). Pre-flight mortality at one site was estimated at 50% with additional mortality occurring once pups were volant (Hoying and Kunz 1998). Banding studies indicate that this species may not survive as long as the other covered species. The oldest individual on record is from Illinois and lived for 14.8 years (Kurta 2008), which is approximately half the longevity record for little brown bats.

Population Trend

Prior to the arrival of WNS, tricolored bats were rapidly increasing in population and range, especially in grassland areas like those in northwest Missouri (Benedict et al. 2000, Sparks and Choate 2000, Geluso et al. 2004). Tricolored bats were once found in virtually every cave in Missouri (Myers 1964, LaVal and LaVal 1980). WNS, however, has changed that pattern. Mortality rates for tricolored bats with WNS in the northeast are similar to that of little brown bats (Center for

Biological Diversity and Defenders of Wildlife 2016). Capture rates of tricolored bats in Pennsylvania declined by 56 percent between pre-WNS years (2001-2008) and 2013 (Butchkoski and Bearer 2016), which is remarkably similar to the 53.8 percent decline observed in Missouri hibernacula (Colatskie 2017).

Threats

As part of the petitioning process, the Center for Biological Diversity and Defenders of Wildlife (2016) reviewed potential threats to the tricolored bat. WNS is the greatest threat faced by the species, and without WNS it is unlikely the tricolored bat would be a national conservation priority. Other stressors identified in the petition included mortality from tree removals associated with a variety of activities (logging, energy extraction, and development), closure of occupied hibernacula, deaths from other diseases, losses at wind energy sites, and environmental contaminants. These threats are like those detailed for the Indiana bat and the impacts are likely also similar for tricolored bats. Maintaining and managing forest habitat is the goal of the MDC Bat HCP, but such efforts could also result in the mortality of individual bats within stands as they are managed. The tendency of tricolored bats to occupy a wide variety of hibernacula makes them especially likely to be entombed during mine closures (Whitaker and Stacy 1996). As with the Indiana bat, chemical contamination may kill bats directly or lead to sublethal effects that eventually lead to death or reduced reproduction (Eidels et al. 2016). The proposed Midwest Wind Energy HCP did not cover the tricolored bat, but the associated Environmental Impact Statement (EIS) used the same techniques to estimate that current and future wind energy sites in the Midwest would take 51,389 tricolored bats between 2016 and 2060 (USFWS 2016). The EIS also noted that reduced populations would also result in reduced mortality and that the conservation programs contained in the Midwest Wind Energy HCP would reduce predicted mortality by at least 50 percent.

Potential Sources of Take

Tricolored bats are included in the plan primarily due to their potential exposure during habitat management activities (i.e. tree removal and prescribed fire). Because most tricolored bats roost in trees, there is the potential for some to be killed or harmed when trees are felled (Center for Biological Diversity and Defenders of Wildlife 2016). As with other covered species, heat or smoke may result in take of both tree-roosting (Dickinson et al. 2010) or cave-roosting individuals (Tuttle 1986).

Other potential sources of mortality from the covered activities include building removal leading to impact on a colony (Whitaker 1998, Whitaker et al. 2014). Although mortality from vehicles has not been demonstrated, it is likely as several similar species have been found dead along roadways (Sparks and Choate 2000, Russell et al. 2009).

National Conservation Efforts

Conservation efforts for tricolored bats across the U.S. mimic those implemented for Indiana and northern long-eared bats, and tricolored bats may benefit from protective measures targeted at these species. While conservation of dead and dying trees (roosting habitat for Indiana and northern long-eared bats) does not directly conserve roosting habitat for tricolored bats, conservation of forested areas, retention of live trees, and targeted forest management will preserve those areas likely to have potential roosting and foraging spots for the tricolored bat. Gating mines and caves with tricolored bats present also protects this species. In addition, Wisconsin recommends forestry management practices that reduce clutter, increase edge habitat, and preserve linear corridors.

With reports of population decline of tricolored bats because of WNS impacts and recent interest in listing the species federally, future studies may focus more on this species.

MDC is currently conducting work in south Missouri specifically attempting to document tricolored and little brown bat maternity colonies. Additional surveys and research in north Missouri is focused on Indiana and northern long-eared bats, but will document occurrence of tricolored bats if captures occur.

Figures and Tables

Figure 1. Range-wide Distribution of the Tricolored Bat.

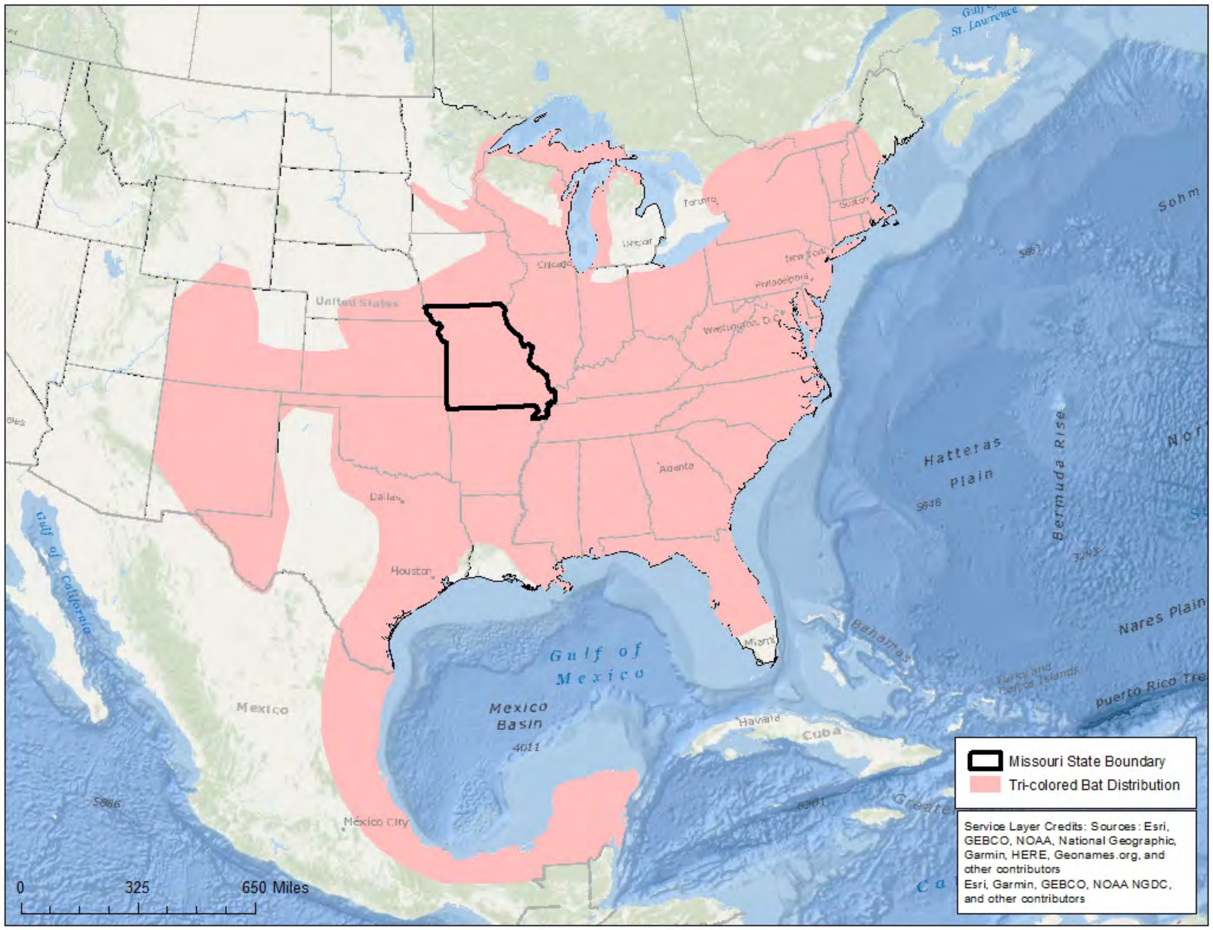

Figure 2. Known Distribution of the Tricolored Bat in Missouri Counties during Active and Inactive Seasons.

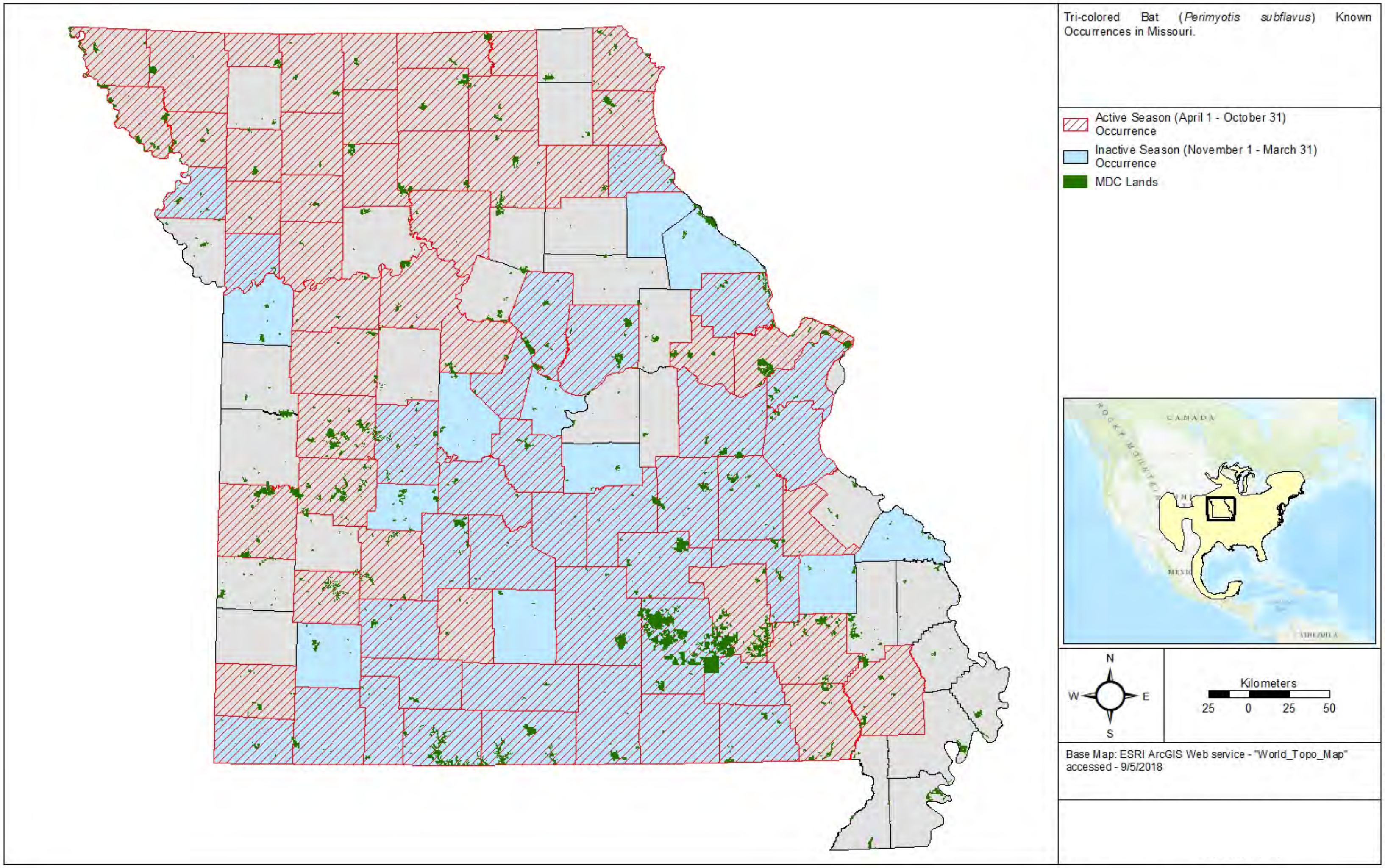

Figure 3. Modeled Distribution of Tricolored Bat Seasonal Habitat in Missouri.

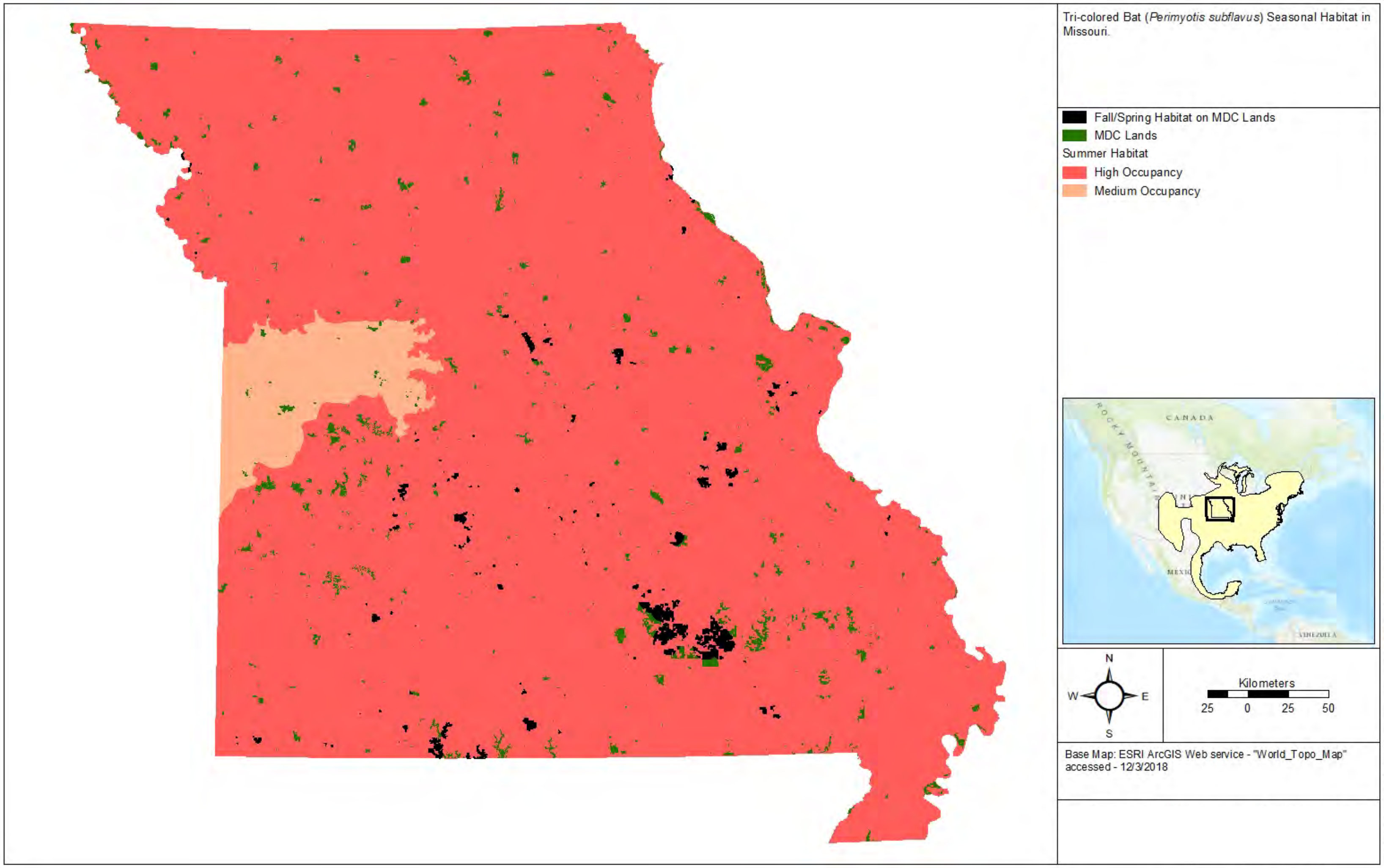

Figure 4. Seasonal patterns of Tricolored bat activities*

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
All	Hibernation (caves and mines)		Emergence, Migration	Migration, Maternity Colony Establishment		Pups are Flightless		Maternity Colony Breakup	Migration, Swarming, Breeding		Hibernation (cave and mines)	
	Inactive Season			Active Season							Inactive Season	

* (Whitaker and Rissler 1992, Whitaker 1998, Veilleux and Veilleux 2004a, Whitaker et al. 2014) .

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Appendix B
Species Evaluation

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Species Evaluation

MDC Bat HCP Species Evaluation Table—Other ESA-Listed Species in the Plan Area

Species in the Plan Area		Federal Status[a]	Notes
Plants			
Mead's milkweed	*Asclepias meadii*	T	Not widespread in plan area, therefore not appropriate for a programmatic HCP. On a case-by-case basis, MDC will screen for this species and coordinate with USFWS to address potential effects.
Decurrent false aster	*Boltonia decurrens*	T	Not widespread in plan area, therefore not appropriate for a programmatic HCP. On a case-by-case basis, MDC will screen for this species and coordinate with USFWS to address potential effects.
Geocarpon	*Geocarpon minimum*	T	Not widespread in plan area, therefore not appropriate for a programmatic HCP. On a case-by-case basis, MDC will screen for this species and coordinate with USFWS to address potential effects.
Virginia sneezeweed	*Helenium virginicum*	T	Not widespread in plan area, therefore not appropriate for a programmatic HCP. On a case-by-case basis, MDC will screen for this species and coordinate with USFWS to address potential effects.
Small whorled pogonia[b]	*Isotria medeoloides*	T	Considered extirpated; historical or accidental occurrence in Missouri.
Pondberry	*Lindera melissifolia*	E	Not widespread in plan area, therefore not appropriate for a programmatic HCP. On a case-by-case basis, MDC will screen for this species and coordinate with USFWS to address potential effects.
Missouri bladderpod	*Physaria filiformis*	T	Not widespread in plan area, therefore not appropriate for a programmatic HCP. On a case-by-case basis, MDC will screen for this species and coordinate with USFWS to address potential effects.
Eastern prairie fringed orchid	*Platanthera leucophaea*	T	Not widespread in plan area, therefore not appropriate for a programmatic HCP. On a case-by-case basis, MDC will screen for this species and coordinate with USFWS to address potential effects.

Species in the Plan Area		Federal Status[a]	Notes
Western prairie fringed orchid	*Platanthera praeclara*	T	Not widespread in plan area, therefore not appropriate for a programmatic HCP. On a case-by-case basis, MDC will screen for this species and coordinate with USFWS to address potential effects.
Running buffalo clover	*Trifolium stoloniferum*	E	Not widespread in plan area, therefore not appropriate for a programmatic HCP. On a case-by-case basis, MDC will screen for this species and coordinate with USFWS to address potential effects. Plantings are occurring on MDC and USFWS lands.
Mollusks			
Tumbling Creek cavesnail	*Antrobia culveri*	E	Site-specific impacts will be avoided.
Curtis pearlymussel	*Epioblasma curtisii*	E	Site-specific impacts will be avoided or permitted separately
Snuffbox mussel	*Epioblasma triquetra*	E	Site-specific impacts will be avoided or permitted separately.
Pink mucket	*Lampsilis abrupta*	E	Site-specific impacts will be avoided or permitted separately.
Higgins eye	*Lampsilis higginsii*	E	Site-specific impacts will be avoided or permitted separately.
Neosho mucket	*Lampsilis rafinesqueana*	E	Site-specific impacts will be avoided or permitted separately.
Scaleshell	*Leptodea leptodon*	E	Site-specific impacts will be avoided or permitted separately.
Spectaclecase	*Margaritifera monodonta*	E	Site-specific impacts will be avoided or permitted separately.
Sheepnose	*Plethobasus cyphyus*	E	Site-specific impacts will be avoided or permitted separately.
Fat pocketbook	*Potamilus capax*	E	Site-specific impacts will be avoided or permitted separately.
Winged mapleleaf	*Quadrula fragosa*	E	Site-specific impacts will be avoided or permitted separately.
Rabbitsfoot	*Theliderma cylindrica*	T	Site-specific impacts will be avoided or permitted separately.
Crustaceans			
Cave crayfish	*Cambarus aculabrum*	E	Covered activities will not affect species; any site-specific impacts will be avoided or permitted separately.

Species in the Plan Area		Federal Status[a]	Notes
Insects			
American burying beetle	*Nicrophorus americanus*	E	Considered extirpated; historical or accidental occurrence in Missouri. A reintroduced population that is considered experimental, nonessential under Section 10(j) of the ESA has been reintroduced in St. Clair and Cedar Counties. The nonessential, experimental designation covers the permitting issues.
Hine's emerald dragonfly	*Somatochlora hineana*	E	Permitting, if needed, will occur on case-by-case basis. Measures to control sedimentation and erosion will be a part of the conservation strategy.
Fish			
Ozark cavefish	*Amblyopsis rosae*	T	Covered activities not anticipated to affect aquatic species; any site-specific impacts will be avoided or permitted separately.
Grotto sculpin	*Cottus specus*	E	Covered activities not anticipated to affect aquatic species; any site-specific impacts will be avoided or permitted separately.
Niangua darter	*Etheostoma nianguae*	T	Covered activities not anticipated to affect aquatic species; any site-specific impacts will be avoided or permitted separately.
Topeka shiner	*Notropis topeka*	E	Covered activities not anticipated to affect aquatic species; any site-specific impacts will be avoided or permitted separately.
Neosho madtom	*Noturus placidus*	T	Covered activities not anticipated to affect aquatic species; any site-specific impacts will be avoided or permitted separately.
Pallid sturgeon	*Scaphirhynchus albus*	E	Covered activities not anticipated to affect aquatic species; any site-specific impacts will be avoided or permitted separately.
Shovelnose sturgeon	*Scaphirhynchus platorynchus*	T/SA	Covered activities not anticipated to affect aquatic species; any site-specific impacts will be avoided or permitted separately.
Amphibians			
Ozark hellbender	*Cryptobranchus a. bishopi*	E	Covered activities not anticipated to affect aquatic species; any site-specific impacts will be avoided or permitted separately.
Eastern hellbender	*Cryptobranchus alleganiensis*	E*	Covered activities not anticipated to affect aquatic species; any site-specific impacts will be avoided or permitted separately.
Reptiles			
Eastern massasauga	*Sistrurus catenatus*	T	Considered extirpated; historical or accidental occurrence in Missouri.

Species in the Plan Area		Federal Status[a]	Notes
Birds			
Interior least tern	*Sterna antillarum athalassos*	E	Covered activities will not impact species.
Piping plover	*Charadrius melodus*	T	Considered accidental or migratory occurrence in Missouri. Covered activities will not impact species.
Rufa red knot	*Calidris canutus rufa*	T	Considered accidental or migratory occurrence in Missouri. Covered activities will not impact species.
Mammals			
Gray wolf	*Canis lupus*	E	Considered extirpated; historical or accidental occurrence in Missouri.
Ozark big-eared bat	*Corynorhinus townsendii ingens*	E	Considered extirpated; historical or accidental occurrence in Missouri.

Source: Missouri Department of Conservation 2018

[a] Federally listed species under the Endangered Species Act (ESA) of 1973 as amended.

E = Endangered. Any species that is in danger of extinction throughout all or a significant portion of its range.

E* = Per USFWS, likely to be added by the time the MDC Bat HCP is finalized.

T = Threatened. Any species that is likely to become endangered within the foreseeable future.

T/SA = Any species listed as threatened by the U.S. Fish and Wildlife Service due to similarity of appearance with a listed species.

HCP = habitat conservation plan

MDC = Missouri Department of Conservation

USFWS = U.S. Fish and Wildlife Service

Appendix C
Covered Activity Impact Breakdown

Forestry

Activity (reasonable potential for take marked at right with an X)	Timber Harvest or Tree Removal	Prescription Burning	Collision
A. Inventory			X
i. Forestry Compartment Inventory (Gather data to management prescriptions)			X
i. Walk Through Terrestrial Habitat			
ii. Use Vehicles Off-Road			X
iii. Tree Sounding			
iv. Tree Boring (1–2 trees per stand)			
B. Timber sale	X		X
a. Tree Marking (includes marking trees for removal for meeting prescriptions, laying out haul roads, landings, and skid trails)	X		X
i. Walk Through Terrestrial Habitat			
ii. Use Vehicles Off-Road			X
iii. Tie Flagging/Survey Tape			
iv. Mark Trees with Paint			
v. Tree Sounding			
vi. Check Internal Tree Quality (see Tree Removal)	X		X
1. Tree Removal	X		X
a. Drop Trees	X		
i. Hand Felling	X		
1. Walk Through Terrestrial Habitat			
2. Use of Vehicles Off-Road			X
3. Use of Hand Tools			
4. Use of Motorized Hand Tools			

Activity (reasonable potential for take marked at right with an X)	Timber Harvest or Tree Removal	Prescription Burning	Collision
ii. Mechanical Felling	X		X
1. Use of Motorized Hand Tools			
2. Use of Vehicles Off-Road			X
3. Use of Heavy Equipment			
iii. Felled Tree (STRUCTURE)			
2. Bucking (removing tree limbs and cut into logs)	X		X
a. Use of Vehicles Off-Road			X
b. Use of Motorized Hand Tools			
c. Use of Heavy Equipment			
3. Scaling			
a. Use of Hand Tools			
b. Establish/Maintain Access Roads (Haul Roads) -Temporary, Permanent Seasonal, Permanent All-Seasonal	X		X
i. Construct Access Road	X		X
1. Road Siting			X
a. Use Vehicles Off-Road			X
b. Walk Through Terrestrial Habitat			
c. Tree Marking (see above)			
2. Vegetation Clearance	X		X
a. Cut Above-Ground Vegetation (the cutting and clearance of small-diameter vegetation)	?		
i. Use of Heavy Equipment			
ii. Use of Motorized Hand Tools			
iii. Walk Through Terrestrial Habitat			
iv. Removed Vegetation			
b. Snag Removal (Non-Hazard Tree(s))	X		X
i. Drop Trees (see above)	X		X
c. Tree Removal	X		X
i. Drop Trees (see above)	X		X
3. Dispose of Vegetative Debris			

Activity (reasonable potential for take marked at right with an X)	Timber Harvest or Tree Removal	Prescription Burning	Collision
a. Stockpile Vegetative Debris On-Site			
i. Use Heavy Equipment			
ii. Debris Stockpile (STRUCTURE)			
b. Spread Vegetative Debris			
4. Soil Removal			
a. Walk Through Terrestrial Habitat			
b. Use of Heavy Equipment			
c. Remove Soil			
5. Redistribute Soils On-Site			
a. Grading			
i. Use of Heavy Equipment			
ii. Redistribute Soils			
6. Gravel / Aggregate Placement			
a. Use of Heavy Equipment			
b. Gravel / Aggregate (STRUCTURE)			
7. Trail Abandonment			
8. Access Road (STRUCTURE)			
ii. Maintain Access Road	X		X
1. Vegetative Edge Trimming	X		
a. Use of Hand Tools			
b. Use of Motorized Hand Tools			
2. Cut Above-Ground Vegetation (see above)	X		
3. Disposal of Vegetative Debris (see above)			
4. Regrade / Resurface Existing Roads			
a. Use Heavy Equipment			
b. Placement of Aggregate			
c. Blading (leveling)			
5. Redistribute Soils On-Site (see above)			
6. Gravel / Aggregate Placement (see above)			

Activity (reasonable potential for take marked at right with an X)	Timber Harvest or Tree Removal	Prescription Burning	Collision
7. Trail Abandonment			
iii. Install Temporary Bridge or Stream Crossing			X
1. Use of Heavy Equipment			
2. Use of Vehicles Off-Road			X
3. Stream Crossing (STRUCTURE)			
iv. Haul Road (STRUCTURE)			
c. Establish Temporary Landing	X		X
i. Vegetation Clearance (see above)	X		X
ii. Vegetative Debris Removal (see above)			
iii. Site Restoration			
1. Seeding			X
a. Hand Seeding			
b. ATV Seeding			X
iv. Landing (STRUCTURE)			
d. Establish Skid Trail (Activity)	X		X
i. Vegetation Clearance (see above)	X		X
ii. Install temporary bridge or stream crossing (see above)			X
iii. Skid Trail/Road (STRUCTURE)			
e. Vegetation Clearance (see above)	X		X
f. Tree Removal (see above)	X		X
g. Tree Relocation	X		X
i. Bucking (see above)	X		X
ii. Grappling/Cable (attaching tree to machine)			
1. Use of Heavy Equipment			
iii. Skidding (move logs from the forest to a landing area) (may damage existing trees)			
1. Use of Heavy Equipment			
2. Drag Tree			
h. Grading and Selecting Logs (Following cutting and transport to landing area, trees are graded and placed in separate piles for loading onto log trucks for transport to mills, occurs on the landing)			

Activity (reasonable potential for take marked at right with an X)	Timber Harvest or Tree Removal	Prescription Burning	Collision
i. Use Motorized Hand Tools			
ii. Walk Through Terrestrial Habitat			
iii. Use of Heavy Equipment			
i. Post Sale Activities	X		X
i. Vegetation Clearance (see above)	X		X
ii. Tree Relocation (if necessary) (see above)	X		X
C. Tending Treatments (TSI, crop tree release, pre-commercial thinning, forest stand improvement)	X	X	X
i. Chemical application (Activity) (all have use of vehicles off-road)			X
i. Basal Spray (Small trees < 4” diameter)			X
1. Use of Hand Tools			
2. Walk Through Terrestrial Habitat			
3. Use of Vehicles Off-Road			X
ii. Hack n’ Squirt (Any size tree)			X
1. Use of Hand Tools			
2. Walk Through Terrestrial Habitat			
3. Use of Vehicles Off-Road			X
4. Notch Tree			
a. Use of Hand Tools			
iii. Stem Injection			X
1. Use of Hand Tools			
2. Walk Through Terrestrial Habitat			
3. Use of Vehicles Off-Road			X
4. Notch Tree			
a. Use of Hand Tools			
iv. Stump Treatment			
v. Foliar spray			X
1. Use of Hand Tools			
2. Walk Through Terrestrial Habitat			

Activity (reasonable potential for take marked at right with an X)	Timber Harvest or Tree Removal	Prescription Burning	Collision
3. Use of Vehicles Off-Road			X
4. Use of Heavy Equipment			
5. Use of aircraft			
ii. Mechanical treatment (Removal of small trees)	X		X
1. Vegetation Clearance (see above)	X		X
iii. Rx Fire	X	X	X
i. Planning			
ii. Fire Line Construction	X		X
1. Vegetation Clearance (see above)	X		X
2. Disking			
a. Use of Heavy Equipment			
3. Removal of Leaf and Litter			X
a. Use of Motorized Hand Tools			
b. Use of Vehicles Off-Road			X
iii. Ignition		X	
1. Aerial Ignition		X	
a. Use of Helicopters			
b. Use of Drones			
2. Drip Torches		X	
3. ATV Ignition		X	
iv. Mop-up	X		X
1. Tree Removal (see above)	X		X
2. Tree Relocation (see above)	X		X
v. Fire Line (Structure)			
D. Regeneration-Planting	X	X	X
i. Site Preparation (Removal of competitive vegetation)	X	X	X
i. Foliar Spray (see above)			
ii. Use of heavy equipment			

Activity (reasonable potential for take marked at right with an X)	Timber Harvest or Tree Removal	Prescription Burning	Collision
iii. Use of Motorized Hand Tools			
iv. Rx Fire (See above)	X	X	X
ii. Natural Regeneration (No Activity)			
iii. Artificial Regeneration (seed and seedling planting in dirt)			
i. Mechanized Planting			
ii. Motorized Planting Tools (Auger)			
iii. Hand Planting Tools			
iv. Direct Seeding (scattering seed)			X
i. ATV seeding			X
ii. Hand Seeding			
iii. Aerial Seeding			
E. Aerial Surveys (Aerial surveys to conduct forest health monitoring, disaster mapping, and both wildfire and Rx fire reconnaissance)			
a. Biological Surveys (Aerial)			
i. Use of Aircraft			
1. Use of Airplane			
2. Use of Drone			
3. Use of Helicopter			
F. Hazard tree removal	X		X
i. Tree Removal (see above)	X		X
G. Integrated Pest Management	X	X	X
a. Vegetation Control	X		X
i. Chemical Application (see above)			X
ii. Mechanical Treatment (see above)	X		X
iii. Aerial Application			
1. Aerial Biological Application			

Activity (reasonable potential for take marked at right with an X)	Timber Harvest or Tree Removal	Prescription Burning	Collision
1. Use of Aircraft (see above)			
iv. Aerial Chemical Application			
1. Use of Aircraft (see above)			
b. Insect Control			x
i. Chemical Application (see above)			X
ii. Biological Control			
1. Release of predators			
2. Aerial Application (see above)			
c. Aquatic Species Control			
i. Use of Pesticides			
1. Walk Through Aquatic Habitat			
2. Pesticides			
ii. Electrofishing			
1. Walk Through Aquatic Habitat			
2. Electrofish			
iii. Seining			
1. Walk Through Aquatic Habitat			
2. Use of Seines/Nets			
d. Fungi Control			X
i. Chemical Application (see above)			X
e. Biological Surveys			X
i. Biological surveys (aerial)			
1. Use of Aircraft (see above)			
ii. Trapping			X
1. Use of Hand Tools			
2. Use of Motorized hand tools			
3. Walk Through Terrestrial Habitat			
4. Use of Vehicles Off-Road			X
5. Traps (structure)			

Activity (reasonable potential for take marked at right with an X)	Timber Harvest or Tree Removal	Prescription Burning	Collision
f. Aerial Applications (see above)			
g. Rx Fire (see above)	X	X	X
H. Fishless water hole (wildlife water hole)			X
a. Construct water hole			X
i. Excavation of Soils/Sediments			X
1. Soil Removal			
a. Remove Soil			
b. Use Heavy Equipment			
c. Use Hand Tools			
2. Redistribute Soils On-Site			
a. Use Hand Tools			
b. Grading			
1. Redistribute Soils			
2. Use Heavy Equipment			
3. Restore Vegetation			X
a. Seed Disturbed Area			X
i. Disk Soil			
ii. Hydroseed			
iii. Drillseed			
iv. Use of Vehicles Off-Road			X
v. Use Hand Tools			
vi. Use Motorized Hand Tools			
vii. Use Heavy Equipment			
viii. Apply Fertilizer			
ix. Spray Exposed Soil with Water			
b. Fishless Water Hole (Structure)			

Activity (reasonable potential for take marked at right with an X)	Timber Harvest or Tree Removal	Prescription Burning	Collision
I. Boundary Line Maintenance	X		X
i. Boundary Line Maintenance	X		X
i. Mark Boundary Line			X
1. Walk Along Boundary Line			
2. Use of Vehicles Off-Road			X
3. Tie Flagging/Survey Tape			
4. Mark boundary line with Paint			
ii. Maintain Boundary Line			
1. Vegetation Clearance (see above)	X		
iii. Boundary Line (Structure)			
J. Open Land Management (Open land management is a management system designed to provide early successional habitat. Examples include food plots, old field management, and edge feathering.)	X		X
a. Chemical application (see above)			X
b. Mechanical treatment (see above)	X		X
c. Early Successional Habitat (Structure)			
K. Recreational Trails Construction and Maintenance			X
a. Construct Gravel/Aggregate/Stone Trail			X
i. Excavation of Soils/Sediments			X
1. Soil Removal			X
a. Remove Soil			
b. Use Heavy Equipment			
c. Use Hand Tools			
d. Walk Through Terrestrial Habitat			
e. Use Off Road Vehicle			X
2. Stockpile Soils On-Site			X
a. Use Heavy Equipment			
b. Use Hand Tools			

Activity (reasonable potential for take marked at right with an X)	Timber Harvest or Tree Removal	Prescription Burning	Collision
c. Walk Through Terrestrial Habitat			
d. Use Off Road Vehicle			X
e. Soil Stockpile (Structure)			
3. Dispose of Soils/Sediments			X
a. Haul Soils Offsite			
1. Use Heavy Equipment			
2. Use Hand Tools			
3. Use of Vehicles Off-Road			X
4. Walk Through Terrestrial Habitat			
b. Redistribute Soils On-Site			X
1. Use Hand Tools			
2. Use of Vehicle Off-Road			X
3. Grading			
1. Redistribute Soils			
2. Use Heavy Equipment			
ii. Install Permeable Fabric			X
1. Use Hand Tools			
2. Use Heavy Equipment			
3. Use of Vehicles Off-Road			X
iii. Addition of Fill			X
1. Deposit Imported Soil			X
a. Use Heavy Equipment			
b. Use Hand Tools			
c. Addition of Imported Soil			
d. Use of Vehicle Off-Road			X
2. Redistribute Soils On-Site (see above)			
3. Use of Borrow Areas			
iv. Compact Substrate			
1. Use Hand Tools			

Activity (reasonable potential for take marked at right with an X)	Timber Harvest or Tree Removal	Prescription Burning	Collision
2. Use Heavy Equipment			
3. Use Motorized Hand Tools			
v. Lay Gravel / Aggregate Substrate			X
1. Use Hand Tools			
2. Use Heavy Equipment			
3. Use of Vehicles Off-Road			X
b. Construct Mat Trail			X
i. Excavation of Soils/Sediments (see above)			
ii. Addition of Fill (see above)			
iii. Compact Substrate (see above)			
iv. Install Soil Stabilization Matting			X
1. Use Heavy Equipment			
2. Use of Vehicles Off-Road			X
3. Use Hand Tools			
4. Walk Through Terrestrial Habitat			
5. Soil Stabilization Matting (Structure)			
c. Maintain Trail (Activity)			X
i. Regrade / Resurface			
ii. Debris Removal			X
1. Removal of Debris			
a. Remove Debris			
b. Use Heavy Equipment			
c. Use Hand Tools			
d. Use of Vehicles Off-Road			X
e. Walk Through Terrestrial Habitat			
2. Stockpile Debris On-Site			X
a. Use Heavy Equipment			
b. Use Hand Tools			
c. Walk Through Terrestrial Habit			

Activity (reasonable potential for take marked at right with an X)	Timber Harvest or Tree Removal	Prescription Burning	Collision
d. Use of Vehicle Off-Road			X
e. Debris Stockpile (Structure)			
3. Dispose of Debris			X
a. Bury Debris Onsite			X
1. Bury Debris			
2. Use Heavy Equipment			
3. Use Hand Tools			
4. Use of Vehicle Off-Road			X
b. Haul Debris Offsite			X
1. Use of Off-Site Disposal Areas (terrestrial)			X
1. Use Hand Tools			
2. Use Heavy Equipment			
3. Use of Vehicle Off-Road			X
4. Walk Through Terrestrial Habitat			
5. Debris Stockpile (Structure)			X
6. Rock Stockpile (Structure)			
7. Soil Stockpile (Structure)			X
8. Vegetation Stockpile (Structure)			
iii. Vegetation Clearance (see above)	X		X
iv. Recreational Trail (Structure)			
L. Area Maintenance	X		X
i. Conservation Area Maintenance			X
i. Level 1 and 2 maintenance standards			X
2. Chemical Application (see above)			X
ii. Pre-emergent spray			X
1. Use of Hand Tools			
2. Walk Through Terrestrial Habitat			
3. Use of Vehicles Off-Road			X

Activity (reasonable potential for take marked at right with an X)	Timber Harvest or Tree Removal	Prescription Burning	Collision
iii. Vegetation Clearance (see above)	X		X
M. Firewood Cutting	X		X
a. Firewood Cutting	X		X
i. Hand Felling (see above)	X		X
ii. Firewood Processing			X
1. Hand Splitting			X
a. Walk Through Habitat			
b. Use of Vehicles Off-Road			X
c. Use of Hand Tools			
d. Use of Motorized Hand Tools			
2. Motorized splitter			X
a. Walk Through Habitat			
b. Use of Vehicles Off-Road			X
c. Use of Hand Tools			
d. Use of Motorized Hand Tools			
iii. Transport Firewood			X
1. Walk Through Terrestrial Habitat			
2. Use of Vehicles Off-Road			X

Wildlife

Activity (reasonable potential for take marked at right with an X)	Timber Harvest or Tree Removal	Prescription Burning	Collision
1. Habitat Management			
a. Prairie reconstruction / grassland management	X	X	X
i. Cut above-ground vegetation	X		
1. Use of Heavy Equipment			
2. Use of Brush Hog			
3. Use of Motorized Hand Tools			
4. Walk Through Terrestrial Habitat			
5. Removed Vegetation			
ii. Seed Area			X
1. Disk Soil			
2. Hydroseed			
3. Drillseed			
4. Use of Vehicles Off-Road			X
5. Use Hand Tools			
6. Use Motorized Hand Tools			
7. Use Heavy Equipment			
8. Apply Fertilizer			
9. Spray Exposed Soil with Water			
iii. Apply Fertilizer			
iv. Herbicide Application (similar to forestry chemical application)			X
1. Foliar Spray			X
a. Use of Hand Tools			
b. Walk Through Terrestrial Habitat			
c. Use of Vehicles Off-Road			X
d. Use of Heavy Equipment			
e. Use of aircraft			
2. Aerial Chemical Application			

Activity (reasonable potential for take marked at right with an X)	Timber Harvest or Tree Removal	Prescription Burning	Collision
a. Use of Aircraft			
1. Use of Airplane			
2. Use of Drone			
3. Use of Helicopter			
3. Use of Backpack Sprayer			
a. Walk Through Terrestrial Habitat			
4. ATV/Vehicle/Tractor Boom Sprayer			X
a. Use of Vehicle Off-Road			X
b. Use Heavy Equipment			
5. Use of Pesticide			
v. Rx fire	X	X	X
1. Planning			
2. Fire Line Construction	X		X
a. Vegetation Clearance (see above)	x		x
1. Cut Above-Ground Vegetation (see above)	X		
2. Snag Removal (Non-Hazard Tree) (Can be a stand of snags)	X		X
1. Drop Trees	X		X
i. Walk Through Terrestrial Habitat			
ii. Use of Vehicles Off-Road			X
iii. Use of Hand Tools			
iv. Use of Motorized Hand Tools			
b. Mechanical Felling	X		X
i. Use of Motorized Hand Tools			
ii. Use of Vehicles Off-Road			X
iii. Use of Heavy Equipment			
c. Felled Tree (STRUCTURE)			
3. Tree Removal	X		X
1. Drop Trees (see above)	X		X

Activity (reasonable potential for take marked at right with an X)	Timber Harvest or Tree Removal	Prescription Burning	Collision
b. Disking			
1. Use of Heavy Equipment			
c. Removal of Leaf and Litter			X
1. Walk Through Terrestrial Habitat			
2. Use of Motorized Hand Tools			
3. Use of Vehicles Off-Road			X
3. Ignition		X	
a. Aerial Ignition		X	
1. Use of Helicopters			
2. Use of Drones			
b. Drip Torches		X	
c. ATV Ignition		X	
4. Mop-up	X		X
a. Tree Removal (see above)	X		X
b. Tree Relocation	X		X
1. Bucking (removing tree limbs and cut into logs)			
1. Use of Vehicles Off-Road			X
2. Use of Motorized Hand Tools			
3. Use of Heavy Equipment			
2. Grappling/Cable (attaching tree to machine)			
1. Use of Heavy Equipment			
3. Skidding (move logs from the forest to a landing area) (may damage existing trees)			
1. Use of Heavy Equipment			
2. Drag Tree			
5. Fire Line (Structure)			
vi. Seed collection			X
1. Walk through terrestrial habitat			
2. Use of vehicles off road			X

Activity (reasonable potential for take marked at right with an X)	Timber Harvest or Tree Removal	Prescription Burning	Collision
3. Use of heavy equipment			
b. Woodland/Savanna Restoration			X
i. Tree marking			X
1. Walk Through Terrestrial Habitat			
2. Use Vehicles Off-Road			X
3. Tie Flagging/Survey Tape			
4. Mark Trees with Paint			
5. Tree Sounding			
ii. Tree removal (see above)	X		X
iii. Timber Sale (see Forestry)	X		X
iv. Tending (see Forestry)	X	X	X
v. Firewood cutting (see Forestry)	X		X
vi. Rx fire (see above)	X	X	X
c. Grazing	X	X	X
i. Rx fire (see above)	X	X	X
ii. Livestock grazing			
iii. Construct Barbed Wire Fencing (permanent)			X
1. Walk through terrestrial habitat			
2. Use vehicles off-road			X
3. Use of motorized hand tools			
4. Use of hand tools			
iv. Electric fence installation/removal/maintenance (temporary)			X
1. Walk through terrestrial habitat			
2. Use vehicles off-road			X
3. Use of motorized hand tools			
4. Use of hand tools			
v. Pond Creation			X
1. Excavation of Soils/Sediments			

Activity (reasonable potential for take marked at right with an X)	Timber Harvest or Tree Removal	Prescription Burning	Collision
a. Soil Removal			
1. Remove Soil			
2. Use Heavy Equipment			
3. Use Hand Tools			
b. Redistribute Soils On-Site			
1. Use Hand Tools			
2. Grading			
1. Redistribute Soils			
2. Use Heavy Equipment			
c. Restore Vegetation			X
1. Seed Area (see above)			X
2. Pond (Structure)			
vi. Water Well Creation	X		X
1. Construct Freshwater Well			X
a. Dig Well			X
1. Erect/Remove Drilling Rig			
1. Use of Heavy Equipment			
2. Use of Motorized Hand Tools			
3. Use of Vehicles Off-Road			X
4. Use of Hand Tools			
5. Drilling Rig (Structure)			
2. Excavation of Soils/Sediment (see above)			
b. Install Well Pump			
1. Use of Hand Tools			
2. Use of Motorized Hand Tools			
c. Well (Structure)			
2. Install Water Conveyance Pipeline	X		X
a. Install In-Ground Water Lines			

Activity (reasonable potential for take marked at right with an X)	Timber Harvest or Tree Removal	Prescription Burning	Collision
1. Vegetation Clearance (see above)	X		X
2. Dig Trench			
1. Excavation of Soils/Sediment (see above)			
3. Prepare Pipe Bed			
1. Addition of Fill			
a. Use of Heavy Equipment			
2. Lay Gravel Substrate			
a. Use of Heavy Equipment			
3. Install Permeable Fabric			
4. Lay Pipes			X
1. Use of Heavy Equipment			
2. Use of Vehicles Off-Road			X
5. Cover Pipes			
1. Use of Heavy Equipment			
b. Install Above-Ground Water Lines	X		X
1. Vegetation Clearance (see above)	X		
2. Construct Water Pipeline			X
1. Use of Heavy Equipment			
2. Use of Vehicles Off-Road			X
3. Use of Hand Tools			
4. Use of Motorized Hand Tools			
3. Above-Ground Water Pipeline (structure)			
3. Install Water Storage Tanks			X
a. Install Footings			X
1. Excavation of Soils/Sediment (see above)			
2. Build Concrete Forms			X
1. Use of Hand Tools			
2. Use of Motorized Hand Tools			

Activity (reasonable potential for take marked at right with an X)	Timber Harvest or Tree Removal	Prescription Burning	Collision
3. Use of Vehicles Off-Road			X
4. Walk Through Terrestrial Habitat			
3. Pour Concrete			
1. Use of Hand Tools			X
2. Use of Motorized Hand Tools			
3. Use of Vehicles Off-Road			X
4. Walk Through Terrestrial Habitat			
b. Place Water Storage Tank			
1. Use of Heavy Equipment			
2. Use of Hand Tools			
3. Use of Motorized Hand Tools			
c. Water Storage Tank (Structure)			
d. Old field management	X	X	X
a. Vegetation Clearance (see above)	X		X
ii. Herbaceous vegetation manipulation	X		
1. Herbicide Application (see above)			X
2. Mechanical Treatment	X		X
a. Vegetation Clearance (see above)	X		
iii. Rx fire (see above)	X	X	X
2. Invasive Species Treatment	X		X
a. Feral hog eradication efforts	X		
i. Trail creation	X		X
1. Vegetation Clearance (see above)	X		X
2. Install Temporary Bridge or Stream Crossing			X
a. Use of Heavy Equipment			
b. Use of Vehicles Off-Road			X
c. Stream Crossing (Structure)			X

Activity (reasonable potential for take marked at right with an X)	Timber Harvest or Tree Removal	Prescription Burning	Collision
3. Trail (Structure)			
ii. Access trap sites with ATV / UTV			X
1. Use of Vehicles Off-Road			X
iii. Antennae for remote trapping (cable attached to a tree)			
1. Use of hand tools			
iv. Remove obstacles in trail and trap location	?		
1. Use of Motorized Hand Tools (Chainsaw small diameter trees)	?		
2. Use of Electric winches			
v. Construct wire panel traps			
1. Drive Fence posts			
a. Use of hand Tools			
2. Erect Trap			
a. Use of Hand Tools			
vi. Dispatch feral hogs			X
1. Surface Level hunting			X
a. Use of Vehicles Off-Road			X
b. Walk Through Terrestrial Habitat			
c. Use of Firearms			
1. Use of Suppressed firearms			
2. Use of Unsuppressed firearms			
2. Aerial gunning			
a. Use of helicopter			
b. Use of Unsuppressed Firearms			
3. Carcass Removal			X
a. Use of Vehicles Off-Road			X
b. Walk Through Terrestrial Habitat			
b. Chemical/mechanical treatment			X
i. Vehicle Mounted Chemical Sprayer			X

Activity (reasonable potential for take marked at right with an X)	Timber Harvest or Tree Removal	Prescription Burning	Collision
1. Use Vehicles Off-Road			X
2. Use of Pesticides			
ii. Personnel Mounted Chemical Sprayer			
1. Walk Through Terrestrial Habitat			
2. Use of Motorized Hand Tools			
3. Use of Pesticides			
iii. Tractor Mounted Chemical Sprayer			
1. Use Heavy Equipment			
2. Use of Pesticides			
3. Food plot management	X	X	X
a. Disking (see above)			
b. Planting		X	X
i. Site Preparation (Removal of competitive vegetation)		X	X
1. Foliar Spray (see above)			X
2. Use of heavy equipment			
3. Use of Motorized Hand Tools			
4. Rx Fire (See above)	X	X	X
ii. Direct Seeding (scattering seed)			X
1. Use of Heavy Equipment (including large tractors)			
2. Use of Vehicles Off-Road (including smaller tractors)			X
3. ATV seeding			X
a. Use of Vehicles Off-Road			X
4. Hand Seeding			
a. Walk Through Terrestrial Habitat			
b. Use of Hand Tools			
iii. Aerial Seeding			
1. Use of Aircraft			

Activity (reasonable potential for take marked at right with an X)	Timber Harvest or Tree Removal	Prescription Burning	Collision
c. Fertilizer/Lime application			
i. Use of heavy equipment			
d. Pesticide application			X
i. Chemical/Mechanical Treatment (see above)			X
e. Mowing			
i. Cut above-ground vegetation			
f. Rx fire	X	X	X
4. Maintenance Activities	X		X
a. Fence line/boundary line creation and maintenance	X		X
i. Vegetation Clearance	X		
ii. Fence installation			X
1. Drive Fence posts			
a. Use of hand Tools			
2. String Fence Wire			
a. Use of Hand Tools			
3. Walking though terrestrial habitat			
4. Use of vehicles off road			X
iii. Remove litter			
1. Walk Through Terrestrial Habitat			
2. Use of motorized hand tools			
3. Use of Heavy Equipment			
b. Fire line creation and maintenance	X		X
i. Tree removal (see above)	X		X
ii. Cut above-ground vegetation (see above)	X		
iii. Remove litter (see above)			
c. Roadside/trail/parking lot maintenance	X		
i. Mowing			

Activity (reasonable potential for take marked at right with an X)	Timber Harvest or Tree Removal	Prescription Burning	Collision
1. Use of Riding mowers			
2. Use of Brush Hog			
3. Use Heavy Equipment			
a. Tractor with bullhog			
b. Tractor with batwing			
ii. Trim encroaching trees	X		
1. Tractor/Track excavator with boom axe/boom mower			
2. Use of hand tools			
3. Use of motorized hand tools			
5. Research, surveys, and monitoring	X		X
a. Trail Creation (see above)	X		X
b. Vegetation Clearance (see above)	X		X
Wetland Management			
1. Water Management			
a. Wetland Creation (see D&D)			
b. Water Delivery to Wetlands			
i. Electric powered			
1. Use of a Submersible pump			
2. Use of a Gearhead / Turbine / Vertical Turbine			
3. Use of a Stationary pump			
ii. Fuel Powered			
1. Use of a Diesel Power Unit; gearhead / turbine			
2. Use of a Tractor PTO driven portable pump			
3. Use of a Stationary Diesel, gasoline, or LP pump			
iii. Gravity flow via elevational difference			
1. Water control structure			
a. Sluice (Structure)			
b. Screw (Structure)			

Activity (reasonable potential for take marked at right with an X)	Timber Harvest or Tree Removal	Prescription Burning	Collision
c. Stop log (Structure)			
d. Other			
2. Manual actuation			
3. Gasoline engine actuation			
4. Electrical motor actuation			
5. Hydraulic piston actuation via tractor			
6. Pneumatic actuation via air compressor			
c. Water Removal – Dewatering			
i. Manual Operation of water control structures (WCS)			
d. Removal of debris from WCS or drainage ditches (beavers)			
1. Manual Debris Removal			
a. Use of Hand Tools			
2. Mechanized Debris Removal			
a. Use of Heavy Equipment			
i. Tractor w/blade and or front end loader			
ii. Backhoe			
iii. Track excavator			
3. Explosive Debris removal (typically beaver dams)			
a. Use of Explosives (ammonium nitrate-based binary / trinary mixtures)			
e. Hydroperiod – timing and duration of flooded wetland pools			
i. Seasonal			
ii. Semi-permanent			
iii. Permanent			
iv. Rotational			
2. Habitat Management	X	X	X
a. Moist Soil Early successional management; soil disturbance			X
i. Disking (see above)			
ii. Planting (see above)			

Activity (reasonable potential for take marked at right with an X)	Timber Harvest or Tree Removal	Prescription Burning	Collision
iii. Fertilizer application			X
1. Ground application			
a. Use of Vehicles Off-Road			X
b. Walk Through Terrestrial Habitat			
c. Use of Hand Tools			
d. Use of Motorized Hand Tools			
2. Aerial Fertilizer Application			
a. Use of Aircraft (see above)			
iv. Herbicide Application (see above)			X
v. Rx fire (see above)	X	X	X
vi. Light Seeded tree species removal	X		X
1. Cut Above-Ground Vegetation (see above)	X		X
2. Disking (see above)			
3. Plowing			
a. Use of Heavy Equipment			
4. Herbicide Application (see above)			X
5. Light Seeded Tree Removal			
a. Manual Removal			
i. Use of Motorized Hand Tools (Chainsaw)			
b. Mechanical removal			
i. Use of Heavy Equipment			
1. Track excavator w/ thumb grapple			
2. Track excavator with boom-axe			
3. Bulldozer			
4. Skidsteer with clipper / Grinder attachment			
vii. Hydroperiod (see above)			
b. Forest management – Green tree reservoirs (forest with a levee around it that is flooded but in an attempt to not kill trees)	X	X	X
i. Forest management practices (see tending in Forest Management Deconstruction)	X	X	X

Activity (reasonable potential for take marked at right with an X)	Timber Harvest or Tree Removal	Prescription Burning	Collision
ii. Hydroperiod (see above)			
3. Maintenance Activities	X	X	X
a. Ditchbanks, borrow areas and levees, pond dams	X	X	X
i. Vegetation Maintenance	X	X	X
1. Cut Above-Ground Vegetation (see above)	X		X
2. Use of Boom Mower			
3. Herbicide Application (see above)			X
4. Rx fire (see above)	X	X	X
ii. Sediment removal			
1. Remove Sediment			
a. Use of Heavy Equipment			
2. Stockpile Soils			
a. Use of Heavy Equipment			
b. Soil Stockpile (Structure)			
3. Redistribute Soils On-Site (see above)			
b. Replace Water control structure / culvert replacement	X		X
i. Vegetation Clearance (see above)	X		X
ii. Excavation of Soils (see above)			
iii. Replacement of Structure			
1. Remove Existing Structure			
a. Demolish Existing Structure			
i. Use of Heavy Equipment			
ii. Use of hand Tools			
iii. Use of Motorized Hand Tools			
b. Stockpile Debris			
i. Use of Heavy Equipment			
ii. Debris Stockpile (Structure)			

Activity (reasonable potential for take marked at right with an X)	Timber Harvest or Tree Removal	Prescription Burning	Collision
c. Remove Debris			X
i. Use of Heavy Equipment			
ii. Use of Vehicles Off-Road			X
2. Erect Replacement Structure			X
a. Build Concrete Forms (see above)			X
b. Pour Concrete (see above)			X
c. Boat lane maintenance	X		
i. Vegetation Trimming	X		X
1. Use of Hand Tools			
2. Use of Motorized Hand Tools			
3. Use of Heavy Equipment			
ii. Use of Boom Mower			
iii. Tree Removal (see above)	X		X
iv. Tree Relocation (see above)	X		X
v. Sediment Removal (see above)			
d. Well and pump repair / maintenance / construction (also applicable to fisheries)	X		X
i. Construct Freshwater Well (see above)	X		X
ii. Maintain Well	X		X
1. Cut above-ground vegetation (see above)	X		X
2. Chemical Screen Wash (acids are generally neutralized into their respective salts when reacting with the mineral scale and discharged in the pool)			
a. Use of Acid Wash (diluted hydrochloric acid, phosphoric acid, or sulfamic acid)			
b. Use of Detergents (sodium tripolyphosphate)			
c. Discharge of Chemicals			
iii. Repair Well			
1. Screen Clearing			
a. Use of Detonation Cord			
b. Use of Compressed Air			

Activity (reasonable potential for take marked at right with an X)	Timber Harvest or Tree Removal	Prescription Burning	Collision
4. Public Use Management	X		X
a. Waterfowl hunting blind opening maintenance	X		
i. Tree Trimming	X		X
1. Use of Hand Tools			
2. Use of Motorized Hand Tools			
3. Use of Vehicles Off-Road			X
4. Walk Through Terrestrial Habitat			
ii. Vegetation Clearance (see above)	X		X
b. Construct / repair existing waterfowl hunting blinds	X		
i. Vegetation Clearance (see above)	X		X
ii. Erect Support Poles			
1. Use of heavy Equipment (tractor with hole auger)			
iii. Set foundation poles			
1. Use of Hand Tools			
iv. Construct wooden / concrete hunting blinds (split)			X
1. Construct Wooden Blind			X
a. Use of Hand Tools			
b. Use of Motorized Hand Tools			
c. Use of Vehicles Off-Road			X
d. Walk Through Terrestrial Habitat			
2. Construct Concrete Blind			
a. Build Concrete Forms (see above)			
b. Pour Concrete (see above)			
3. Hunting Blind (Structure)			
v. Apply camouflage (mainly overcup oak)			
1. Tree Trimming (see above)			
2. Use of Hand Tools			

Activity (reasonable potential for take marked at right with an X)	Timber Harvest or Tree Removal	Prescription Burning	Collision
c. Artificial Regeneration (seed and sapling planting in dirt)			
i. Mechanized Planting			
ii. Motorized Planting Tools (Auger)			
iii. Hand Planting Tools			

Fisheries

Activity (reasonable potential for take marked at right with an X)	Timber Harvest or Tree Removal	Prescription Burning	Collision
1. Fish Hatchery Infrastructure construction, improvement and maintenance	X		X
a. Water structures (intakes, outlets, valves, gates, pumps, wells)	X		X
i. Site Survey for Planning			X
1. Use vehicles off-road			X
2. Walk through terrestrial habitat			
3. Use hand tools (GPS, plotter)			
ii. Vegetation Clearance	X		X
1. Cut Above-Ground Vegetation	X		
a. Use of Heavy Equipment			
b. Use of Brush Hog			
c. Use of Motorized Hand Tools			
d. Walk Through Terrestrial Habitat			
e. Removed Vegetation			
2. Snag Removal (Non-Hazard Tree) (Can be a stand of snags)	X		X
a. Drop Trees	X		
i. Hand Felling	X		
1. Walk Through Terrestrial Habitat			
2. Use of Vehicles Off-Road			X
3. Use of Hand Tools			
4. Use of Motorized Hand Tools			
ii. Mechanical Felling	X		X
1. Use of Motorized Hand Tools			X
2. Use of Vehicles Off-Road			
3. Use of Heavy Equipment			
iii. Felled Tree (STRUCTURE			
3. Tree Removal	X		X
a. Drop Trees (see above)	X		X
4. Tree Relocation	X		X

Activity (reasonable potential for take marked at right with an X)	Timber Harvest or Tree Removal	Prescription Burning	Collision
a. Bucking (removing tree limbs and cut into logs)	X		X
i. Use of Vehicles Off-Road			X
ii. Use of Motorized Hand Tools			
iii. Use of Heavy Equipment			
b. Grappling/Cable (attaching tree to machine)			
i. Use of Heavy Equipment			
c. Skidding (move logs from the forest to a landing area) (may damage existing trees)			
i. Use of Heavy Equipment			
ii. Drag Tree			
5. Rx Fire	X	X	X
a. Planning			
b. Fire Line Construction	X		X
i. Vegetation Clearance (see above)	X		X
ii. Disking			
1. Use of Heavy Equipment			
iii. Removal of Leaf and Litter			X
1. Use of Motorized Hand Tools			
2. Use of Vehicles Off-Road			X
c. Ignition		X	
i. Aerial Ignition			
1. Use of Helicopters			
2. Use of Drones			
ii. Drip Torches		X	
iii. ATV Ignition		X	
d. Mop-up			
i. Tree Removal (see above)	X		X
ii. Tree Relocation (see above)	X		X
e. Fire Line (Structure)			
iii. Vegetative Debris Removal			X

Activity (reasonable potential for take marked at right with an X)	Timber Harvest or Tree Removal	Prescription Burning	Collision
1. Removal of Debris			
a. Remove Debris			X
i. Use Heavy Equipment			
ii. Use Hand Tools			
iii. Use of Vehicles Off-Road			X
iv. Walk Through Terrestrial Habitat			
2. Stockpile Debris On-Site			X
a. Use Heavy Equipment			
b. Use Hand Tools			
c. Walk Through Terrestrial Habit			
d. Use of Vehicle Off-Road			X
e. Debris Stockpile (Structure)			
iv. Dispose of Debris			X
1. Bury Debris Onsite			X
a. Bury Debris			
b. Use Heavy Equipment			
c. Use Hand Tools			
d. Use of Vehicle Off-Road			X
2. Haul Debris Offsite			X
a. Use of Off-Site Disposal Areas (terrestrial)			X
b. Use Hand Tools			
c. Use Heavy Equipment			
d. Use of Vehicle Off-Road			X
e. Walk Through Terrestrial Habitat			
f. Vegetation Stockpile (Structure			
3. Burn Vegetative Debris	X	X	X
a. Rx Fire (see above)	X	X	X
v. Establish/Maintain Access Roads (Temporary, Seasonal)	X		X
1. Construct Access Road	X		X

Activity (reasonable potential for take marked at right with an X)	Timber Harvest or Tree Removal	Prescription Burning	Collision
a. Road Siting			X
i. Use Vehicles Off-Road			X
ii. Walk Through Terrestrial Habitat			
iii. Tree Marking			X
1. Walk Through Terrestrial Habitat			
2. Use Vehicles Off-Road			X
3. Tie Flagging/Survey Tape			
4. Mark Trees with Paint			
5. Tree Sounding			
b. Vegetation Clearance (see above)	X		X
c. Dispose of Vegetative Debris (see above)			X
d. Soil Removal			
i. Walk Through Terrestrial Habitat			
ii. Use of Heavy Equipment			
iii. Remove Soil			
e. Redistribute Soils On-Site			
i. Grading			
1. Use of Heavy Equipment			
2. Redistribute Soils			
f. Gravel / Aggregate Placement			X
i. Stockpile Gravel / Aggregate On-Site			X
1. Use Heavy Equipment			
2. Use Hand Tools			
3. Walk Through Terrestrial Habitat			
4. Use Off Road Vehicle			X
5. Gravel / Aggregate Stockpile (Structure)			
ii. Use of Heavy Equipment			
iii. Gravel / Aggregate (STRUCTURE)			
g. Trail Abandonment			

Activity (reasonable potential for take marked at right with an X)	Timber Harvest or Tree Removal	Prescription Burning	Collision
h. Access Road (STRUCTURE)			
2. Maintain Access Road	X		X
a. Vegetative Edge Trimming	X		
i. Use of Hand Tools			
ii. Use of Motorized Hand Tools			
b. Cut Above-Ground Vegetation (see above)	X		
c. Disposal of Vegetative Debris (see above)			X
d. Regrade / Resurface Existing Roads			
i. Use Heavy Equipment			
ii. Placement of Aggregate			
iii. Blading (leveling)			
e. Redistribute Soils On-Site (see above)			
f. Gravel / Aggregate Placement (see above)			X
g. Trail Abandonment			
3. Install Temporary Bridge or Stream Crossing			X
a. Build Temporary Bridge			X
i. Use of Heavy Equipment			
ii. Use of Vehicles Off-Road			X
iii. Bridge (STRUCTURE)			
b. Build Temporary Stream Crossing			X
i. Install pipes			
1. Use Vehicles Off-Road			
2. Use Heavy Equipment			
3. Hand tools			
ii. Install rock over pipes			X
1. Use Heavy equipment			
2. Use Hand tools			
3. Use Vehicles Off-Road			X
4. Stream Crossing (Structure)			

Activity (reasonable potential for take marked at right with an X)	Timber Harvest or Tree Removal	Prescription Burning	Collision
4. Haul Road (STRUCTURE)			
vi. Excavation of Soils/Sediments			X
1. Soil Removal			
a. Remove Soil			
b. Use Heavy Equipment			
c. Use Hand Tools			
2. Stockpile Soils On-Site			X
a. Use Heavy Equipment			
b. Use Hand Tools			
c. Walk Through Terrestrial Habitat			
d. Use Off Road Vehicle			X
e. Soil Stockpile (Structure)			
3. Redistribute Soils On-Site			
a. Use Hand Tools			
b. Grading			
c. Redistribute Soils			
d. Use Heavy Equipment			
vii. Construct Freshwater Well			X
1. Dig Well			X
a. Erect/Remove Drilling Rig			X
i. Use of Heavy Equipment			
ii. Use of Motorized Hand Tools			
iii. Use of Vehicles Off-Road			X
iv. Use of Hand Tools			
v. Drilling Rig (Structure)			
2. Excavation of Soils/Sediment (see above)			X
3. Restore Vegetation			X
a. Seed Area			X
i. Disk Soil			

Activity (reasonable potential for take marked at right with an X)	Timber Harvest or Tree Removal	Prescription Burning	Collision
ii. Hydroseed			
iii. Drillseed			
iv. Use of Vehicles Off-Road			X
v. Use Hand Tools			
vi. Use Motorized Hand Tools			
vii. Use Heavy Equipment			
viii. Apply Fertilizer			
ix. Spray Exposed Soil with Water			
4. Install Well Pump			
a. Use of Hand Tools			
b. Use of Motorized Hand Tools			
5. Well (Structure)			
viii. Construct Structures			X
1. Install Footings			X
a. Excavation of Soils/Sediment (see above)			X
b. Build Concrete Forms			X
i. Use of Hand Tools			
ii. Use of Motorized Hand Tools			
iii. Use of Vehicles Off-Road			X
iv. Walk Through Terrestrial Habitat			
c. Install Reinforcing Rebar or Wire			
i. Use Hand Tools			
d. Pour Concrete			X
i. Use of Hand Tools			
ii. Use of Motorized Hand Tools			
iii. Use of Vehicles Off-Road			X
iv. Walk Through Terrestrial Habitat			
e. Remove forms and cut joints			
i. Heavy equipment			

Activity (reasonable potential for take marked at right with an X)	Timber Harvest or Tree Removal	Prescription Burning	Collision
ii. Hand tools			
f. Structure (Structure)			
ix. Install In-Ground Water Lines			X
1. Vegetation Clearance (see above)			X
2. Dig Trench			X
a. Excavation of Soils/Sediment (see above)			X
3. Prepare Pipe Bed			
a. Addition of Fill			
i. Use of Heavy Equipment			
b. Lay Gravel Substrate			
i. Use of Heavy Equipment			
c. Install Permeable Fabric			
i. Use Hand Tools			
4. Lay Pipes			X
a. Use of Heavy Equipment			
b. Use of Vehicles Off-Road			X
5. Cover Pipes			
a. Use of Heavy Equipment			
6. Restore vegetation (see above)			X
1. Aquaculture rearing units (ponds, raceways)	X		X
a. Site Survey (see above)			X
b. Vegetation Clearance (see above)	X		X
c. Vegetative Debris Removal (see above)			X
d. Establish/Maintain Access Roads (see above)	X		X
e. Pond Creation			X
i. Excavation of Soils/Sediment (see above)			X
ii. Install Non-Permeable Membrane			X
1. Use Hand Tools			

Activity (reasonable potential for take marked at right with an X)	Timber Harvest or Tree Removal	Prescription Burning	Collision
2. Use Heavy Equipment			
3. Use Vehicles Off-Road			X
iii. Placement of Riprap			
1. Use of Heavy Equipment			
2. Riprap (Structure)			
f. Construct Structures (see above) (Kettles, Raceways, Intakes, Outlets, Pads for Bulk tanks)	X		X
g. Construct In-Ground Water Line (see above)			X
h. Seed Area (see above)			X
i. Pond, Raceway (Structure)			
2. Aquaculture waste treatment and disposal (settling basins, inlets, outlets, utilities)	X		X
a. Site Survey (see above)			X
b. Vegetation Clearance (see above)	X		X
c. Vegetative Debris Removal (see above)			X
d. Establish/Maintain Access Roads (see above)	X		X
e. Excavation of Soils/Sediment (see above)			X
f. Construct Settling Basin			X
i. Excavation of Soils/Sediment (see above)			X
ii. Install Non-Permeable Membrane (see above)			X
iii. Placement of Riprap (see above)			
g. Construct Structures (see above)	X		X
h. Construct In-Ground Water Line (see above)			X
i. Seed Area (see above)			X
j. Basin (Structure)			
3. Parking lots, sidewalks, driveways and other surface areas	X		X
a. Site Survey (see above)			X
b. Vegetation Clearance (see above)	X		X
c. Vegetative Debris Removal (see above)			X
d. Rough Grading			X

Activity (reasonable potential for take marked at right with an X)	**Timber Harvest or Tree Removal**	**Prescription Burning**	**Collision**
i. Excavation of Soils/Sediment (see above)			X
ii. Addition of Fill (see above)			
iii. Compact Substrate			
1. Use Heavy Equipment			
2. Use Hand Tools			
3. Use Motorized Hand Tools			
iv. Gravel / Aggregate Placement			X
e. Finish Grading			
i. Gravel / Aggregate Placement (see above)			X
ii. Grading (see above)			
iii. Compact Substrate (see above)			
f. Apply Surface Layer			
i. Apply Asphalt Surface			
1. Use Heavy Equipment			
g. Build Concrete Road Surface			X
i. Build Concrete Forms (see above)			X
ii. Install Rebar			
1. Use Hand Tools			
iii. Pour Concrete (see above)			X
iv. Remove forms and cut joints (see above)			
h. Stripe Surface			
i. Use Heavy Equipment			
i. Install rock if a rock structure			
i. Use Heavy equipment			
j. Seed Area (see above)			X
k. Parking Lot, Sidewalk, Driveway (Structure)			
4. Walls	X		X
a. Site Survey (see above)			X

Activity (reasonable potential for take marked at right with an X)	Timber Harvest or Tree Removal	Prescription Burning	Collision
b. Vegetation Clearance (see above)	X		X
c. Vegetative Debris Removal (see above)			X
d. Establish/Maintain Access Roads (see above)	X		X
e. Rough Grading (see above)			X
f. Finish Grading (see above)			X
g. Construct Structures (see above)			X
h. Seed Area (see above)			X
i. Wall (Structure)			
5. Hatchery buildings (feed towers, storage buildings, offices, housing)	X		X
a. Site Survey (see above)			X
b. Vegetation Clearance (see above)	X		X
c. Vegetative Debris Removal (see above)			X
d. Establish/Maintain Access Roads (see above)	X		X
e. Rough Grading (see above)			X
f. Finish Grading (see above)			X
g. Construct Structures (see above)			X
h. Install In-Ground Utilities			X
i. Dig Trench (see above)			X
ii. Prepare Pipe Bed (see above)			
iii. Run Utility Lines			X
1. Use of Heavy Equipment			
2. Use of Vehicles Off-Road			X
iv. Cover Utility Lines			
1. Use of Heavy Equipment			
i. Interior Finish			
i. Rough-In Utilities			
1. Install Plumbing			
i. Use Hand Tools			

Activity (reasonable potential for take marked at right with an X)	Timber Harvest or Tree Removal	Prescription Burning	Collision
ii. Use Motorized Hand Tools			
2. Install Electrical Wiring			
i. Use Hand Tools			
ii. Use Motorized Hand Tools			
ii. Install Insulation			
1. Use Hand Tools			
iii. Install Drywall			
1. Use Hand Tools			
2. Use Motorized Hand Tools			
iv. Finish Work			
1. Use Hand Tools			
2. Use Motorized Hand Tools			
j. Seed Area (see above)			X
k. Building (Structure)			
6. Aeration systems (liquid oxygen, paddlewheel, fountain, forced aeration)	X		X
a. Site Survey (see above)			X
b. Vegetation Clearance (see above)	X		X
c. Vegetative Debris Removal (see above)			X
d. Establish/Maintain Access Roads (see above)	X		X
e. Rough Grading (see above)			X
f. Finish Grading (see above)			X
g. Construct Concrete Pads			X
i. Build Concrete Forms (see above)			X
ii. Install Rebar (see above)			
iii. Pour Concrete (see above)			X
iv. Remove forms and cut joints (see above)			
h. Install In-Ground Utility Lines (see above)			X
i. Install Rock/Sand if Needed			

Activity (reasonable potential for take marked at right with an X)	Timber Harvest or Tree Removal	Prescription Burning	Collision
i. Use Heavy Equipment			
j. Seed Area (see above)			X
k. Structure (Structure)			
7. Fences	X		X
a. Site Survey (see above)			X
b. Vegetation Clearance (see above)	X		X
c. Vegetative Debris Removal (see above)			X
d. Excavation of Soils/Sediment (see above)			X
e. Install Fencing			X
i. Install Fence Posts			X
1. Use of vehicles Off Road			X
2. Use of Motorized Hand Tools			
3. Use of Hand Tools			
4. Walk Through Terrestrial Habitat			
ii. Install Fence			X
1. Use of vehicles Off Road			X
2. Use of Motorized Hand Tools			
3. Use of Hand Tools			
4. Walk Through Terrestrial Habitat			
iii. Install Gate			X
1. Use of vehicles Off Road			X
2. Use of Motorized Hand Tools			
3. Use of Hand Tools			
4. Walk Through Terrestrial Habitat			
iv. Fence (Structure)			
f. Seed Area (see above)			X
8. Gravel and debris removal in hatcheries and trout parks	X	X	X
a. Site Survey (see above)			X

Activity (reasonable potential for take marked at right with an X)	Timber Harvest or Tree Removal	Prescription Burning	Collision
b. Vegetation Clearance (see above)	X		X
c. Vegetative Debris Removal (see above)			X
d. Gravel Removal			X
i. Remove Gravel			X
1. Use Heavy Equipment			
2. Use Hand Tools			
3. Use of Vehicles Off-Road			X
4. Walk Through Terrestrial Habitat			
ii. Stockpile Gravel On-Site			X
1. Use Heavy Equipment			
2. Use Hand Tools			
3. Walk Through Terrestrial Habit			
4. Use of Vehicle Off-Road			X
5. Gravel Stockpile (Structure)			
iii. Dispose of Gravel			X
1. Bury Gravel Onsite			X
i. Bury Gravel			
ii. Use Heavy Equipment			
iii. Use Hand Tools			
iv. Use of Vehicle Off-Road			X
2. Haul Gravel Offsite			X
i. Use of Off-Site Disposal Areas (terrestrial)			X
i. Use Hand Tools			
ii. Use Heavy Equipment			
iii. Use of Vehicle Off-Road			X
iv. Walk Through Terrestrial Habitat			
ii. Gravel Stockpile (Structure			
e. Debris Removal	X	X	X
i. Removal of Debris (see above)			X

Activity (reasonable potential for take marked at right with an X)	Timber Harvest or Tree Removal	Prescription Burning	Collision
ii. Stockpile Debris On-Site (see above)			X
iii. Dispose of Debris			X
1. Bury Debris Onsite (see Above)			X
2. Bury Debris (see above)			X
3. Haul Debris Offsite (see above)			X
4. Burn Debris	X	X	X
i. Rx Fire (see above)	X	X	X
iv. Debris Stockpile (Structure)			
f. Seed Area (see above)			X
9. Grounds maintenance (boom mowers, pullers, chainsaws)	X		X
a. Cut Above-Ground Vegetation (see above)	X		
b. Vegetative Debris Removal (see above)			X
c. Debris Removal (see above)			X
d. Use of Herbicides			X
i. Use Vehicles Off-Road			X
ii. Use Motorized Hand Tools			
iii. Use of Herbicides			
iv. Walk Through Terrestrial Habitat			
v. Walk Through Aquatic Habitat			
e. Landscaping			X
i. Establish Plants			X
1. Use Vehicles Off-Road			X
2. Walk Through Terrestrial Habitat			
3. Use Hand Tools			
4. Use heavy Equipment			
ii. Seed area (see above)			X
iii. Apply Mulch			X
1. Use Vehicles Off-Road			X

Activity (reasonable potential for take marked at right with an X)	Timber Harvest or Tree Removal	Prescription Burning	Collision
2. Walk Through Terrestrial Habitat			
3. Use Hand Tools			
4. Use heavy Equipment			
f. Sign Installation			X
i. Install Signs			X
1. Install Support post			X
i. Install Support in Concrete			X
i. Install Footings (see above)			X
ii. Install Support Post			
1. Use Hand Tools			
2. Use Heavy Equipment			
ii. Drive Support Post			
i. Use of Motorized Hand Tools			
ii. Use of Hand Tools			
2. Install Sign			
i. Use of Motorized Hand Tools			
ii. Use of Hand Tools			
g. Trail maintenance	X		X
i. Cut Above-Ground Vegetation (see above)	X		
ii. Vegetative Debris Removal (see above)			X
iii. Debris Removal (see above)			X
10. Aquatic invasive species control	X		X
a. Site Survey (see above)			X
b. Vegetation Clearance (see above)	X		
c. Vegetative Debris Removal (see above)			X
d. Invasive Aquatic Vegetation Control			X
i. Chemical			
1. Boat Mounted Chemical Sprayer			

Activity (reasonable potential for take marked at right with an X)	Timber Harvest or Tree Removal	Prescription Burning	Collision
i. Use of Boats			
ii. Use of Pesticides			
2. Personnel Mounted Chemical Sprayer			
i. Walk Through Terrestrial Habitat			
ii. Use of Motorized Hand Tools			
iii. Use of Pesticides			
ii. Manual			
1. Use Hand Tools			
iii. Mechanical			
1. Use of Boats			
iv. Biological			X
1. Stocking Grass Carp			X
i. Use Vehicle Off-Road			X
ii. Walk Through Aquatic Habitat			
e. Install Signs (see above)			X
11. Old-field management	X	X	X
a. Vegetation Clearance (see above)	X		X
b. Herbicide Application to Trees			
i. Chemical application (Activity) (all have use of vehicles off-road)			X
1. Basal Spray (Small trees < 4” diameter)			
i. Use of Hand Tools			
ii. Walk Through Terrestrial Habitat			
iii. Use of Vehicles Off-Road			X
2. Hack n’ Squirt (Any size tree)			
i. Use of Hand Tools			
ii. Walk Through Terrestrial Habitat			
iii. Use of Vehicles Off-Road			X
iv. Notch Tree			

Activity (reasonable potential for take marked at right with an X)	Timber Harvest or Tree Removal	Prescription Burning	Collision
i. Use of Hand Tools			
3. Stem Injection			
i. Use of Hand Tools			
ii. Walk Through Terrestrial Habitat			
iii. Use of Vehicles Off-Road			X
iv. Notch Tree (see above)			
4. Stump Treatment			
i. Use of Hand Tools			
ii. Walk Through Terrestrial Habitat			
iii. Use of Vehicles Off-Road			X
iv. Notch Tree (see above)			
5. Foliar spray			
i. Use of Hand Tools			
ii. Walk Through Terrestrial Habitat			
iii. Use of Vehicles Off-Road			X
iv. Use of Heavy Equipment			
v. Use of aircraft			
c. Rx Fire (see above)	X	X	X
12. Stream habitat improvement projects	X		X
a. Notching and Removing Levees	X		
i. Site Surveys (see above)			X
ii. Install temporary erosion control measures			X
1. Install Silt Fencing			
i. Use Heavy Equipment			
ii. Use Hand Tools			
2. Install ditch checks			X
i. Use Heavy Equipment			
ii. Use Hand Tools			

Activity (reasonable potential for take marked at right with an X)	Timber Harvest or Tree Removal	Prescription Burning	Collision
iii. Use Vehicles Off-Road			X
iii. Cut Above-Ground Vegetation (see above)	X		
iv. Vegetative Debris Removal (see above)			X
v. Establish/Maintain Access Roads (see above)	X		X
vi. Install temporary stream crossing (see above)			X
vii. Excavate portion of levee			X
1. Excavation Soils/Sediment (see above)			X
viii. Levee Notch Construction			X
1. Excavate Soils/Sediment (see above)			X
2. Compact Substrate (see above)			
3. Placement of Riprap (see above)			
ix. Levee Removal			X
1. Excavation Soils/Sediment (see above)			X
2. Compact Substrate (see above)			
x. Seed Area			X
xi. Remove Erosion Control Measures			
1. Use Heavy Equipment			
2. Use Hand Tools			
b. Streambank Stabilization	X		X
i. Site Surveys (see above)			X
ii. Vegetation Clearance (see above)	X		X
iii. Vegetative Debris Removal (see above)			X
iv. Establish/Maintain Access Roads (see above)	X		X
v. Install temporary stream crossing (see above)			X
vi. Excavation Soils/Sediment (see above) (grade banks and excavate within stream channel)			X
vii. Streambank Armoring (may include boulders, riprap rock, rock gabions, live stakes, vegetative plantings, erosion control fabric, fiber rolls, rootwads, tree revetments, etc.)	X		X
1. Placement of Riprap (see above)			
2. Establish Plants (see above)			X

Activity (reasonable potential for take marked at right with an X)	Timber Harvest or Tree Removal	Prescription Burning	Collision
3. Install Tree Revetments	X		X
a. Relocate Trees (see above)	X		X
b. Place Trees			
i. Use of Heavy Equipment			
c. Cable Trees			X
i. Walk Through terrestrial Habitat			
ii. Walk Through Aquatic Habitat			
iii. Use Vehicles Off-Road			X
iv. Use of Hand Tools			
d. Anchor Trees			X
i. Drive Earth Anchors			X
1. Walk Through terrestrial Habitat			
2. Walk Through Aquatic Habitat			
3. Use Vehicles Off-Road			X
4. Use of Hand Tools			
e. Tree Revetment (Structure)			
4. Placement of Erosion Control Blanket			X
a. Use of Heavy Equipment			
b. Walk Through terrestrial Habitat			
c. Walk Through Aquatic Habitat			
d. Use Vehicles Off-Road			X
e. Use of Hand Tools			
5. Placement of Rootwads			X
a. Walk Through Aquatic Habitat			
b. Use Vehicles Off-Road			X
c. Use of Heavy Equipment			
d. Rootwads (Structure)			
viii. Seed Area (see above)			X
ix. Remove Access Road			

Activity (reasonable potential for take marked at right with an X)	Timber Harvest or Tree Removal	Prescription Burning	Collision
1. Use Heavy Equipment			
2. Use Hand Tools			
c. In-stream grade control structures	X		X
i. Site Surveys (see above)			X
ii. Vegetation Clearance (see above)	X		
iii. Vegetative Debris Removal (see above)			X
iv. Establish/Maintain Access Roads (see above)	X		X
v. Install temporary stream crossing (see above)			X
vi. Construct In-Stream Work Pad			
1. Use Heavy Equipment			
2. Use of Borrow Areas			
3. Work Pad in Aquatic Habitat (Structure)			
vii. Construct Temporary Cofferdam			
1. Construct Shallow-Water Cofferdam			
a. Construct Earthen Cofferdam			
i. Use Heavy Equipment			
b. Construct Rock-Fill Cofferdam			
i. Placement of Riprap (see above)			
ii. Addition of Fill (see above)			
c. Cofferdam (Structure)			
2. Construct Deep-Water Cofferdam			
a. Construct Walled Cofferdam			
i. Drive Guide Piles			
1. Use Heavy Equipment			
ii. Connect Wales			
1. Use Heavy Equipment			
2. Use Hand Tools			
3. Use Motorized Hand Tools			
iii. Drive Sheet Piles			

Activity (reasonable potential for take marked at right with an X)	Timber Harvest or Tree Removal	Prescription Burning	Collision
1. Use Heavy Equipment			
iv. Use of Sandbags			
b. Construct Cribbed Cofferdam			X
i. In-Stream Dredging			X
1. Use Heavy Equipment			
2. Use of Motorized Boats			
3. Stockpile Soils On-Site			
a. Use Heavy Equipment			
b. Use Hand Tools			
c. Walk Through Terrestrial Habitat			
d. Soil Stockpile			
4. Screen/Grade Mined Sediment			X
a. Construct Sediment Settling Pit			
i. Excavation of Soils/Sediments (see above)			X
b. Discharge Wash Water to Settling Pit			
c. Discharge Water to Streambed			
5. Haul Soils Offsite (see above)			X
6. Barge Staging			
ii. Construct Cribbing			
1. Use Heavy Equipment			
2. Use Hand Tools			
3. Use Motorized Hand Tools			
iii. Addition of Fill (see above)			
iv. Drive Sheet Piles (see above)			
3. Construct Cellular Cofferdam			
a. Drive Sheet Piles (see above)			
b. Addition of Fill (see above)			
4. Dewater			
5. Cofferdam (STRUCTURE)			

Activity (reasonable potential for take marked at right with an X)	Timber Harvest or Tree Removal	Prescription Burning	Collision
viii. Excavation Soils/Sediment (see above) (within stream channel and along streambank)			X
ix. Addition of Fill (see above)			
x. Compact Substrate (see above)			
xi. Placement of Riprap (see above)			
xii. Seed Area (see above)			X
xiii. Remove Access Road (see above)			
xiv. In-Stream Grade Control Structure (Structure)			
d. In-stream habitat structures (boulders, rootwads, etc.)	X		X
i. Site Surveys (see above)			X
ii. Vegetation Clearance (see above)	X		
iii. Vegetative Debris Removal (see above)			X
iv. Establish/Maintain Access Roads (see above)	X		X
v. Install temporary stream crossing (see above)			X
vi. Excavation Soils/Sediment (see above) (within stream channel and along streambank)			X
vii. Install habitat structures			X
1. Construct Temporary Cofferdam (see above)			
2. Construct In-Stream Work Pad (see above)			
3. Placement of Rootwads into streambank			
a. Placement of Rootwads (see above)			
4. Install boulders in stream channel and into streambank			
a. Placement of Riprap (see above)			
5. In-stream Habitat Structure (Structure)			
viii. Seed Area (see above)			X
ix. Remove Access Road (see above)			
e. Developing Side Channels	X		X
i. Site Surveys (see above)			X
ii. Install temporary erosion control measures (see above)			X
iii. Vegetation Clearance (see above)	X		X
iv. Vegetative Debris Removal (see above)			X

Activity (reasonable potential for take marked at right with an X)	Timber Harvest or Tree Removal	Prescription Burning	Collision
v. Establish/Maintain Access Roads (see above)	X		X
vi. Install temporary stream crossing (see above)			X
vii. Excavate new side channel			X
1. Excavation Soils/Sediment (see above)			X
viii. Compact Substrate (see above)			
ix. Placement of Riprap (see above)			
x. Seed Area (see above)			X
xi. Remove Access Road (see above)			
xii. Side Channel (Structure)			
f. Temporary Stream Access Road	X		X
i. Establish/Maintain Access Roads (see above)	X		X
ii. Install temporary stream crossing (see above)			X
iii. Construct In-Stream Work Pad (see above)			
iv. Placement of Riprap (see above)			
v. Seed Area (see above)			X
vi. Remove Access Road (see above)			
13. Lake habitat improvement projects	X		X
a. Install Fish Attractors and Habitat (trees, rocks, etc.)	X		X
i. Build Wood Attractors	X		X
1. Hinge Cutting			
i. Drop Trees (see above)	X		X
2. Cedar Tree Placement			
i. Drop Trees (see above)	X		X
ii. Tree Relocation (see above)	X		X
iii. Place Trees (see above)			
ii. Build Rock Attractors			X
1. Transport Rock/Concrete			X
i. Use Heavy Equipment			

Activity (reasonable potential for take marked at right with an X)	Timber Harvest or Tree Removal	Prescription Burning	Collision
ii. Use Vehicles Off-Road			X
2. Stockpile Rock/Concrete On-Site			X
i. Use Heavy Equipment			
ii. Use Hand Tools			
iii. Walk Through Terrestrial Habit			
iv. Use of Vehicle Off-Road			X
v. Debris Stockpile (Structure)			
3. Placement of Rock/Concrete			
i. Use Heavy Equipment			
iii. Wood and Rock Fish Attractors (Structure)			
14. Lake Shoreline stabilization	X		X
a. Install Shoreline Stabilization			
i. Install Wood Shoreline Stabilization			
1. Drop Trees (see above)	X		X
2. Tree Relocation (see above)	X		X
3. Place Trees (see above)			
ii. Install Rock Shoreline Stabilization			X
1. Transport Rock/Concrete (see above)			X
2. Stockpile Rock/Concrete On-Site (see above)			X
3. Placement of Riprap (see above)			
15. Installing aeration systems	X		X
a. Site Survey (see above)			
b. Vegetation Clearance (see above)	X		X
c. Vegetative Debris Removal (see above)			X
d. Excavation of Soils/Sediment (see above)			X
e. Construct Concrete Pads (see above)			X
f. Build Concrete Forms (see above)			X
g. Install In-Ground Utility Lines (see above)			X

Activity (reasonable potential for take marked at right with an X)	Timber Harvest or Tree Removal	Prescription Burning	Collision
h. Install Rock/Sand if Needed			
i. Pour Concrete (see above)			X
j. Remove forms and cut joints (see above)			
k. Seed Area (see above)			X
l. Aeration System (Structure)			
16. Deepening lakebed and shoreline areas	X		X
a. Site Survey (see above)			X
b. Vegetation Clearance (see above)	X		X
c. Vegetative Debris Removal (see above)			X
d. Excavation of Soils/Sediment (see above)			X
e. Dredging			X
i. Excavation Soils/Sediment (see above)			X
ii. Grade, Shape, and Compact Lake Bottoms and Banks			X
1. Excavation Soils/Sediment (see above)			X
f. Soil Disposal (permanent)			X
i. Transport soil			X
1. Use Heavy Equipment			
2. Use Vehicles Off-Road			X
ii. Compact Substrate (see above)			
iii. Install temporary soil erosion control measures (see above)			X
iv. Seed Area (see above)			X
g. Install Fish Attractors and Habitat (see above)	X		X
h. Install Shoreline Stabilization (see above)	X		X
i. Seed Area (see above)			X
17. Dam/levee repair and replacement	X		X
a. Site Survey (see above)			X
b. Install temporary erosion control measures (see above)			X
c. Vegetation Clearance (see above)	X		X

Activity (reasonable potential for take marked at right with an X)	Timber Harvest or Tree Removal	Prescription Burning	Collision
d. Vegetative Debris Removal (see above)			X
e. Levee Repair (water draw down)			X
i. Excavate portion of levee (see above)			X
ii. Addition of Fill (see above)			
iii. Compact Substrate (see above)			
iv. Placement of Riprap (see above)			
f. Replace water control structure in dam or levee			X
i. Excavation of Soils/Sediment (see above)			X
ii. Replace Existing Structure and piping			
1. Use Heavy Equipment			
2. Use Hand Tools			
3. Use Motorized Hand Tools			
iii. Addition of Fill (see above)			
iv. Compact Substrate (see above)			
v. Placement of Riprap (see above)			
g. Repair Earthen Spillway			X
i. Excavation of Soils/Sediment (see above)			X
ii. Addition of Fill (see above)			
iii. Compact Substrate (see above)			
iv. Placement of Riprap (see above)			
h. Seed Area (see above)			X
i. Remove Temporary Erosion Control Measures			
i. Use Hand Tools			
18. Water crossings construction, improvement and maintenance			
a. Bridge Construction	X		X
i. Bridge Site Preparation			X
1. Site Survey (see above)			X
2. Install temporary erosion control measures (see above)			X

Activity (reasonable potential for take marked at right with an X)	Timber Harvest or Tree Removal	Prescription Burning	Collision
3. Vegetation Clearance (see above)	X		X
4. Vegetative Debris Removal (see above)			X
5. Construct Temporary Stream Access			X
i. Excavation of Soils/Sediment (see above)			X
ii. Addition of Fill (see above)			
iii. Compact Substrate (see above)			
iv. Placement of Riprap (see above)			
v. Build Temporary Stream Crossing (see above)			X
ii. Construct Bridge			X
1. Construct Concrete Bridge Abutments			X
i. Construct Temporary Cofferdam (see above)			
ii. Construct Footing, Wing Wall, or Pier			X
i. Excavation of Soils/Sediment (see above)			X
ii. Build Concrete Forms (see above)			X
iii. Install Reinforcing Rebar or Wire			
1. Use Hand Tools			
iv. Pour Concrete (see above)			X
v. Remove forms and cut joints (see above)			
2. Construct Bridge Superstructure			X
i. Place Stringers			
i. Use Heavy Equipment			
ii. Use Hand Tools			
iii. Use Motorized Hand Tools			
ii. Install Pre-Cast Bridge Deck			
i. Use Heavy Equipment			
ii. Use Hand Tools			
iii. Use Motorized Hand Tools			
iii. Build Bridge Deck			X
i. Place Steel Beams			

Activity (reasonable potential for take marked at right with an X)	Timber Harvest or Tree Removal	Prescription Burning	Collision
1. Use Heavy Equipment			
2. Use Hand Tools			
3. Use Motorized Hand Tools			
ii. Lay Bridge Deck Forms			
1. Use Heavy Equipment			
2. Use Hand Tools			
3. Use Motorized Hand Tools			
iii. Install Concrete Support			
1. Use Heavy Equipment			
2. Use Hand Tools			
3. Use Motorized Hand Tools			
iv. Pour Concrete (see above)			X
3. Armor Bridge and Streambanks			
i. Install Non-Permeable Membrane (see above)			
ii. Placement of Riprap (see above)			
4. Bridge (Structure)			
iii. Replace or Improve Bridge			X
1. Remove Existing Bridge/Abutments			X
i. Construct Temporary Cofferdam (see above)			
ii. Remove Existing Substructure			
i. Use Heavy Equipment			
ii. Use Hand Tools			
iii. Use Motorized Hand Tools			
iv. Debris Removal (see above)			X
iii. Remove Existing Superstructure			X
i. Use Heavy Equipment			
ii. Use Hand Tools			
iii. Use Motorized Hand Tools			
iv. Debris Removal (see above)			X

Activity (reasonable potential for take marked at right with an X)	Timber Harvest or Tree Removal	Prescription Burning	Collision
2. Construct Bridge (see above)			X
iv. Upgrade low-water crossing with a clear span bridge			X
1. Remove Existing Low-Water Crossing			X
i. Construct Temporary Cofferdam (see above)			
ii. Remove Existing Low-Water Crossing Structure			X
i. Use Heavy Equipment			
ii. Use Hand Tools			
iii. Use Motorized Hand Tools			
iv. Debris Removal (see above)			X
2. Construct Bridge (see above)			X
3. Clear-Span Bridge (Structure)			
v. Remove Temporary Stream Access			X
1. Use Heavy Equipment			
2. Use Hand Tools			
3. Debris Removal (see above)			X
vi. Seed Area (see above)			X
vii. Remove Temporary Erosion Control Measures (see above)			
19. Low-water crossings	X		X
a. Site Survey (see above)			X
b. Install temporary erosion control measures (see above)			X
c. Vegetation Clearance (see above)	X		
d. Vegetative Debris Removal (see above)			X
e. Construct Temporary Stream Access (see above)			X
f. Construct Low-Water Crossing			X
i. Construct Temporary Cofferdam (see above)			
ii. Excavation of Soils/Sediment (see above)			X
iii. Addition of Fill (see above)			
iv. Compact Substrate (see above)			

Activity (reasonable potential for take marked at right with an X)	Timber Harvest or Tree Removal	Prescription Burning	Collision
v. Construct Concrete Headwall or Wingwall			X
1. Excavation of Soils/Sediment (see above)			X
2. Build Concrete Forms (see above)			X
3. Install Reinforcing Rebar or Wire (see above)			
4. Pour Concrete (see above)			X
5. Remove forms and cut joints (see above)			
6. Backfill Headwall or Wingwall			
i. Addition of Fill (see above)			
ii. Compact Substrate (see above)			
vi. Install bed material in stream channel and overlay series of culverts			X
1. Prepare Culvert Bed			X
i. Excavate Soils/Sediment (see above)			X
ii. Install Permeable Fabric (see above)			
iii. Gravel / Aggregate Placement (see above)			X
2. Install Culvert			X
i. Place Culverts			X
i. Place Pre-Cast Culvert			X
1. Use Hand Tools			
2. Use Heavy Equipment			
3. Use Vehicles Off-Road			X
ii. Build Formed Culvert On-Site			X
i. Build Concrete Forms (see above)			X
ii. Pour Concrete (see above)			X
iii. Remove forms and cut joints (see above)			
iii. Install Drainage Pipes			
i. Prepare Pipe Bed (see above)			
iv. Lay Pipes (see above)			X
v. Cover Pipes (see above)			
vii. Placement of Riprap (see above)			

Activity (reasonable potential for take marked at right with an X)	Timber Harvest or Tree Removal	Prescription Burning	Collision
viii. Finish concrete driving surface			
1. Use Heavy Equipment			
2. Use Hand Tools			
g. Remove Temporary Stream Access (see above)			X
h. Seed Area (see above)			X
i. Remove Temporary Erosion Control Measures (see above)			
j. Low-Water Crossing (Structure)			
20. Culverts	X		X
a. Site Survey (see above)			X
b. Install temporary erosion control measures (see above)			X
c. Vegetation Clearance (see above)	X		X
d. Vegetative Debris Removal (see above)			X
e. Construct Temporary Stream Access (see above)			X
f. Construct Temporary Cofferdam (see above)			
g. Excavation of Soils/Sediment (see above)			X
h. Addition of Fill (see above)			
i. Compact Substrate (see above)			
j. Construct Concrete Headwall or Wingwall (see above)			X
k. Install bed material in stream channel and overlay series of culverts (see above)			X
l. Construct Driving Surface			X
i. Rough Grading			X
1. Excavation of Soils/Sediments (see above)			X
2. Addition of Fill (see above)			
3. Compact Substrate (see above)			
ii. Finish Grading			X
1. Gravel / Aggregate Placement (see above)			X
2. Grading (see above)			
3. Compact Substrate (see above)			

Activity (reasonable potential for take marked at right with an X)	Timber Harvest or Tree Removal	Prescription Burning	Collision
iii. Apply Road Surface Layer			X
1. Apply Asphalt Surface			X
i. Wet Sub-Soil			
i. Use Hand Tools			
ii. Addition of Fill (see above)			
iii. Gravel / Aggregate Placement (see above)			X
iv. Compact Substrate (see above)			
v. Apply Asphalt			X
i. Use Heavy Equipment			
ii. Use Hand Tools			
iii. Use Vehicle Off-Road			X
2. Build Concrete Road Surface			X
i. Build Concrete Forms (see above)			X
ii. Install Non-Permeable Membrane (see above)			
iii. Install Reinforcing Rebar or Wire (see above)			
iv. Pour Concrete (see above)			X
v. Remove forms and cut joints (see above)			
3. Build Gravel Road Surface			X
i. Install Permeable Membrane (see above)			
ii. Gravel / Aggregate Placement (see above)			X
m. Remove Temporary Stream Access (see above)			X
n. Seed Area (see above)			X
o. Remove Temporary Erosion Control Measures (see above)			
p. Culvert (Structure)			
21. At-grade stream crossings (no change in elevation)	X		X
a. Site Survey (see above)			X
b. Vegetation Clearance (see above)	X		
c. Vegetative Debris Removal (see above)			X

Activity (reasonable potential for take marked at right with an X)	Timber Harvest or Tree Removal	Prescription Burning	Collision
d. Construct Temporary Stream Access (see above)	X		X
e. Build Temporary Stream Crossing (see above)			X
f. Excavation Soils/Sediment (see above) (within stream channel and along streambank)			X
g. Addition of Fill (see above)			
h. Compact Substrate (see above)			
i. Placement of Riprap (see above)			
j. Remove Temporary Stream Access (see above)			X
k. Seed Area (see above)			X
l. At-grade Stream Crossing (Structure)			
22. Fishing and boating infrastructure construction, improvement and maintenance			
a. Construct Boat Ramps and Slides (slides for small boats)	X		X
i. Site Survey (see above)			X
ii. Vegetation Clearance (see above)	X		
iii. Vegetative Debris Removal (see above)			X
iv. Excavation of Soils/Sediment (see above)			X
v. Addition of Fill (see above)			
vi. Compact Substrate (see above)			
vii. Construct Concrete Boat Ramp			X
1. Lay Base Rock			X
i. Gravel / Aggregate Placement (see above)			X
ii. Compact Substrate (see above)			
2. Build Concrete Forms (see above)			X
3. Install Reinforcing Rebar or Wire (see above)			
4. Pour Concrete (see above)			X
5. Remove forms and cut joints (see above)			
6. Push Forms into Water			
i. Use Heavy Equipment			
ii. Use Hand Tools			

Activity (reasonable potential for take marked at right with an X)	Timber Harvest or Tree Removal	Prescription Burning	Collision
7. Placement of Riprap (see above)			
8. Concrete Boat Ramp (Structure)			
viii. Construct Gravel Boat Ramp or Slide			X
1. Gravel / Aggregate Placement (see above)			X
2. Compact Substrate (see above)			
3. Placement of Riprap (see above)			
4. Gravel Boat Ramp or Slide (Structure)			
23. Floating docks (courtesy and fishing)	X		X
a. Site Survey (see above)			X
b. Vegetation Clearance (see above)	X		
c. Vegetative Debris Removal (see above)			X
d. Excavation of Soils/Sediment (see above)			X
e. Addition of Fill (see above)			
f. Compact Substrate (see above)			
g. Construct Concrete Headwall or Wingwall (see above)			X
h. Install Pre-Fabricated Floating Dock, Walkway, and Stiff Arm			X
i. Place Dock, Walkway, and Stiff Arm into Water			X
1. Use Heavy Equipment			
2. Use Hand Tools			
3. Use Motorized Hand Tools			
4. Use Vehicles Off-Road			X
ii. Connect Cables to Dock, Walkway, and Stiff Arm			
1. Use Heavy Equipment			
2. Use Hand Tools			
3. Use Motorized Hand Tools			
i. Placement of Riprap (see above)			
j. Floating Courtesy or Fishing Dock (Structure)			

Activity (reasonable potential for take marked at right with an X)	Timber Harvest or Tree Removal	Prescription Burning	Collision
24. Stationary docks (courtesy and fishing)	X		X
a. Site Survey (see above)			X
b. Vegetation Clearance (see above)	X		
c. Vegetative Debris Removal (see above)			X
d. Excavation of Soils/Sediment (see above)			X
e. Compact Substrate (see above)			
f. Construct Temporary Cofferdam (see above)			
g. Install Piles in Water and Along Shore			X
i. Install Metal or Wooden Piles			
1. Pound Piles into Sediment using Auger			
i. Use Heavy Equipment			
ii. Use Hand Tools			
2. Jet Piles into Sediment (jetting pipe and water pump)			
i. Use Heavy Equipment			
ii. Use Hand Tools			
ii. Construct Concrete Piles			X
1. Excavation of Soils/Sediment (see above)			X
2. Install Reinforcing Rebar or Wire (see above)			
3. Pour Concrete (see above)			X
h. Placement of Riprap (see above)			
i. Connect Dock to Piles			
i. Use Hand Tools			
ii. Use Motorized Hand Tools			
iii. Use Heavy Equipment			
j. Construct Decking and Railings			
i. Attach Decking			
1. Use Hand Tools			
2. Use Motorized Hand Tools			
3. Use Heavy Equipment			

Activity (reasonable potential for take marked at right with an X)	Timber Harvest or Tree Removal	Prescription Burning	Collision
ii. Attach Railings			
1. Use Hand Tools			
2. Use Motorized Hand Tools			
3. Use Heavy Equipment			
k. Courtesy or Fishing Stationary Dock (Structure)			
25. Roads, parking lots, parking pads and sidewalks			
a. Construct Roads, Parking Lots, Parking Pads, and Sidewalks	X		X
i. Site Survey (see above)			X
ii. Install Temporary Erosion Control Measures (see above)			X
iii. Vegetation Clearance (see above)	X		X
iv. Vegetative Debris Removal (see above)			X
v. Construct Temporary Stream Access (see above)			X
vi. Build Temporary Stream Crossing (see above)			X
vii. Excavation of Soils/Sediment (see above)			X
viii. Compact Substrate (see above)			
ix. Construct Cofferdam (see above)			
x. Install Culverts (see above)			X
xi. Build Road, Parking Lot, Parking Pad, and Sidewalks			X
1. Construct Driving/Walking Surface (see construct driving surface above)			X
2. Remove Temporary Stream Access (see above)			X
3. Seed Area (see above)			X
4. Remove Temporary Erosion Control Measures (see above)			
xii. Remove Temporary Stream Access (see above)			X
xiii. Seed Area (see above)			X
xiv. Remove Temporary Erosion Control Measures (see above)			
b. Maintain Road, Parking Lot, Parking Pad, and Sidewalk			X
i. Maintain Concrete Road, Parking Lot, Parking Pad, and Sidewalk			X
1. Break and Remove Sections of Concrete			

Activity (reasonable potential for take marked at right with an X)	Timber Harvest or Tree Removal	Prescription Burning	Collision
2. Construct Driving/Walking Surface (see above)			X
ii. Maintain Asphalt Road, Parking Lot, Parking Pad, and Sidewalk			X
1. Patch Asphalt			X
i. Remove Loose Asphalt			
i. Use of Heavy Equipment			
ii. Use Hand Tools			
ii. Wet Subsoil			
i. Use Hand Tools			
iii. Gravel / Aggregate Placement (see above)			X
iv. Deposit layer of asphalt mix on top and compact (see above)			
v. Apply Sealcoat			X
i. Use of Heavy Equipment			
ii. Use of Vehicles			X
iii. Use Hand Tools			
2. Sealcoat Asphalt			X
i. Clean Asphalt Surface			
i. Use of Heavy Equipment			
ii. Use Hand Tools			
iii. Use of Chemical Agents			
ii. Patch Asphalt (see above)			X
iii. Apply Sealcoat (see above)			X
iii. Maintain Gravel Road, Parking Lot, Parking Pad, and Sidewalk			X
1. Grading (see above)			X
2. Gravel / Aggregate Placement (see above)			X
3. Compact Substrate (see above)			
iv. Road, Parking Lot, Parking Pad, or Sidewalk (Structure)			
26. Construct Privies	X		X
a. Site Survey (see above)			X

Activity (reasonable potential for take marked at right with an X)	Timber Harvest or Tree Removal	Prescription Burning	Collision
b. Install Temporary Erosion Control Measures (see above)			X
c. Vegetation Clearance (see above)	X		X
d. Vegetative Debris Removal (see above)			X
e. Construct Temporary Stream Access (see above)			X
f. Build Temporary Stream Crossing (see above)			X
g. Excavation of Soils/Sediment (see above)			X
h. Compact Substrate (see above)			
i. Lay out building and vault locations			
i. Use Hand tools			
j. Install Sanitary Vault			X
i. Excavation of Soils/Sediment (see above)			X
ii. Install Footings (see above)			X
iii. Set Sanitary Vault on Footings			X
1. Use of Heavy Equipment			
2. Use Hand Tools			
3. Use Motorized Hand Tools			
4. Use of Vehicles			X
iv. Backfill Vault and Footings with Concrete			X
1. Pour Concrete (see above)			X
k. Construct Concrete Pads (see above)			X
l. Set Pre-Fabricated Privy onto Pad			
i. Use of Heavy Equipment			
ii. Use Hand Tools			
iii. Use Motorized Hand Tools			
iv. Privy (Structure)			
m. Remove Temporary Stream Access (see above)			X
n. Seed Area (see above)			X
o. Remove Temporary Erosion Control Measures (see above)			

Activity (reasonable potential for take marked at right with an X)	Timber Harvest or Tree Removal	Prescription Burning	Collision
27. Construct Restrooms	X		X
a. Site Survey (see above)			X
b. Install Temporary Erosion Control Measures (see above)			X
c. Vegetation Clearance (see above)	X		X
d. Vegetative Debris Removal (see above)			X
e. Construct Temporary Stream Access (see above)			X
f. Build Temporary Stream Crossing (see above)			X
g. Excavation of Soils/Sediment (see above)			X
h. Compact Substrate (see above)			
i. Lay out building locations			
i. Use Hand Tools			
j. Construct Building Pad			X
i. Compact Substrate (see above)			
ii. Build Concrete Forms (see above)			X
iii. Install Roughed-In Utilities			
1. Use Hand Tools			
2. Use Motorized Hand Tools			
iv. Gravel / Aggregate Placement (see above)			X
v. Compact Substrate (see above)			
vi. Install Non-Permeable Membrane (see above)			
vii. Install Reinforcing Rebar or Wire (see above)			
viii. Pour Concrete (see above)			X
ix. Remove forms and cut joints (see above)			
k. Set Pre-Fabricated Restroom on Building Pad			X
i. Connect Pre-Fabricated Restroom to Pad			
1. Use of Heavy Equipment			
2. Use Hand Tools			
3. Use Motorized Hand Tools			
ii. Install In-Ground Utilities (see above)			X

Activity (reasonable potential for take marked at right with an X)	Timber Harvest or Tree Removal	Prescription Burning	Collision
iii. Connect Utilities			
1. Use Hand Tools			
2. Use Motorized Hand Tools			
iv. Attach Roof, Vent Pipes, etc.			
1. Use Hand Tools			
2. Use Motorized Hand Tools			
v. Restroom (Structure)			
l. Remove Temporary Stream Access (see above)			X
m. Seed Area (see above)			X
n. Remove Temporary Erosion Control Measures (see above)			
28. Construct Fishing jetties	X		X
a. Site Survey (see above)			X
b. Install Temporary Erosion Control Measures (see above)			X
c. Vegetation Clearance (see above)	X		X
d. Vegetative Debris Removal (see above)			X
e. Construct Temporary Stream Access (see above)			X
f. Dredge Lake Sediment			X
i. Excavation of Soils/Sediment (see above)			X
g. Grade on shore			X
i. Excavation of Soils/Sediment (see above)			X
ii. Compact Substrate (see above)			
h. Construct Temporary Cofferdam (see above)			
i. Rough Grading (see above)			X
j. Placement of Riprap (to form Jetty) (see above)			
k. Construct Sidewalk along length of jetty (see construct roads, parking lots, parking pads, and sidewalks above)	X		X
l. Install parking blocks (around sidewalk along length of jetty)			
i. Use Heavy Equipment			
m. Placement of Riprap (adjacent to Jetty) (see above)			

Activity (reasonable potential for take marked at right with an X)	Timber Harvest or Tree Removal	Prescription Burning	Collision
n. Remove Temporary Stream Access (see above)			X
o. Seed Area (see above)			X
p. Remove Temporary Erosion Control Measures (see above)			
q. Jetty (Structure)			
29. Fishing platforms	X		X
a. Site Survey (see above)			X
b. Vegetation Clearance (see above)	X		X
c. Vegetative Debris Removal (see above)			X
d. Excavation of Soils/Sediment (see above)			X
e. Compact Substrate (see above			
f. Lay out section of platform that extends into water			
i. Use Hand tools			
g. Construct Temporary Cofferdam (see above)			
h. Construct Concrete Wall with Footings			X
i. Install Footings (see above)			X
ii. Construct Concrete Wall			
1. Build Concrete Forms (see above)			X
2. Install Reinforcing Rebar or Wire (see above)			
3. Pour Concrete (see above)			X
4. Remove forms and cut joints (see above)			
iii. Back fill behind wall (see backfill headwall or wingwall above)			
i. Construct sheet metal wall			
i. Install wall of sheet metal			
1. Use of Heavy equipment			
2. Use Hand tools			
3. Use Motorized Hand Tools			
ii. Back fill behind wall (see above)			

Activity (reasonable potential for take marked at right with an X)	Timber Harvest or Tree Removal	Prescription Burning	Collision
j. Construct Concrete Platform			X
i. Construct Concrete Pad (see above)			X
k. Install parking blocks (see above)			
l. Seed Area (see above)			X
m. Placement of Riprap (base of platform and along shore adjacent to the platform) (see above)			
n. Fishing Platform (Structure)			
30. Pavilions	X		X
a. Site Survey (see above)			X
b. Install Temporary Erosion Control Measures (see above)			X
c. Vegetation Clearance (see above)	X		
d. Vegetative Debris Removal (see above)			X
e. Excavation of Soils/Sediment (see above)			X
f. Compact Substrate (see above)			
g. Lay out building locations (see above)			
h. Install Corner Posts			X
i. Excavate Post Holes			X
1. Excavation of Soils/Sediment (see above)			X
ii. Place Poles			
1. Use of Heavy Equipment			
2. Use Hand Tools			
3. Use Vehicles			
iii. Fill Around Post Holes			
1. Fill Post Holes with Concrete			X
i. Pour Concrete (see above)			X
2. Fill Post Holes with Gravel			X
i. Gravel / Aggregate Placement (see above)			X
i. Install Concrete Building Pad (see above)			X
j. Build Roof			

Activity (reasonable potential for take marked at right with an X)	Timber Harvest or Tree Removal	Prescription Burning	Collision
i. Use Hand Tools			
ii. Use of Heavy Equipment			
k. Attach Roof to Support Posts			
i. Use Hand Tools			
ii. Use Motorized Hand Tools			
iii. Use of Heavy Equipment			
l. Run Utilities to Structure			X
i. Install In-Ground Utilities (see above)			X
ii. Connect Utilities (see above)			
m. Seed Area (see above)			X
n. Remove Temporary Erosion Control Measures (see above)			
o. Pavilion (Structure)			
31. Install Lighting	X		X
a. Site Survey (see above)			X
b. Vegetation Clearance (see above)	X		X
c. Vegetative Debris Removal (see above)			X
d. Lay Out Light Pole Locations and Electric Cable Route (see lay out building locations above)			
e. Install Light Pole			X
i. Excavate Post Hole			X
1. Excavation of Soils/Sediment (see above)			X
ii. Fill Bottom of Post Hole with Gravel			X
1. Gravel / Aggregate Placement (see above)			X
iii. Place Light Post			
1. Use of Heavy Equipment			
iv. Brace Pole (alternate gravel and concrete)			X
1. Gravel / Aggregate Placement (see above)			X
2. Pour Concrete (see above)			X
f. Run Electricity to Light Pole			X

Activity (reasonable potential for take marked at right with an X)	Timber Harvest or Tree Removal	Prescription Burning	Collision
i. Install In-Ground Utilities (see above)			X
g. Seed Area (see above)			X
h. Light Pole (Structure)			
32. Utility lines	X		X
a. Site Survey (see above)			X
b. Lay Out Utility Line Route (see lay out building locations above)			X
c. Vegetation Clearance (see above)	X		X
d. Vegetative Debris Removal (see above)			X
e. Connect Electrical, Water, and Sewer Lines to Nearest Source			X
i. Install In-Ground Utilities (see above)			X
ii. Seed Area (see above)			X
33. Aquatic invasive species prevention areas	X		X
a. Install Temporary Erosion Control Measures (see above)			X
b. Field Surveys			X
i. Elevation Survey			X
1. Use Hand Tools			
2. Use of Vehicles Off-Road			X
3. Walk Through Terrestrial Habitat			
ii. Utilities Survey			X
1. Use Hand Tools			
2. Use of Vehicles Off-Road			X
3. Walk Through Terrestrial Habitat			
iii. Soil Survey			X
1. Take Soil Cores			X
i. Use Hand-Coring Tools			
i. Use Hand Tools			
ii. Use Motorized Hand Tools			
ii. Use Vehicle-Mounted Coring Tools			

Activity (reasonable potential for take marked at right with an X)	Timber Harvest or Tree Removal	Prescription Burning	Collision
iii. Use Vehicles Off-Road			X
iv. Walk Through Terrestrial Habitat			
2. Backfill Soil Core Holes			X
i. Use Hand Tools			
ii. Use Vehicles Off-Road			X
iii. Walk Through Terrestrial Habitat			
iv. Cultural Resource Survey			X
1. Trench Sampling (ACTIVITY)			X
i. Dig Trench (ACTIVITY)			X
i. Vegetation Clearance (see above)	X		X
ii. Vegetative Debris Removal (see above)			X
2. Excavation of Soils/Sediments (see above)			X
3. Backfill Trench			
i. Addition of Fill (see above)			
ii. Compact Substrate (see above)			
4. Seed Area (see above)			X
v. Existing Structure Survey			X
1. Use of Vehicles Off-Road			X
2. Walk Through Terrestrial Habitat			
c. Vegetation Clearance (see above)	X		X
d. Vegetative Debris Removal (see above)			X
e. Lay out Structure Locations (see lay out building locations above)			
f. Culvert Installation			X
i. Construct Temporary Cofferdam (see above)			
ii. Excavation of Soils/Sediment (see above)			X
iii. Addition of Fill (see above)			
iv. Compact Substrate (see above)			
v. Construct Concrete Headwall or Wingwall (see above)			X
vi. Install bed material in stream channel and overlay series of culverts (see above)			X

Activity (reasonable potential for take marked at right with an X)	Timber Harvest or Tree Removal	Prescription Burning	Collision
vii. Placement of Riprap (see above)			
g. Excavation of Soils/Sediment (see above)			X
h. Compact Substrate (see above)			
i. Construct Roads, Parking Lots, Parking Pads, and Sidewalks (see above)	X		X
j. Install Underground Stormwater Collection Vault and Associated Holding Tanks, Treatment Systems and Disposal			X
i. Excavate Area for Stormwater Collection, Treatment and Disposal			X
1. Excavation of Soils/Sediment (see above)			X
ii. Install Foundation and Bedding material			X
1. Gravel / Aggregate Placement (see above)			X
iii. Set Stormwater Vault, Tanks and Pipes			
1. Place Vault, Tanks, and Pipes			
i. Use Heavy Equipment			
2. Backfill around Vault, Tanks, and Pipes			
i. Addition of Fill (see above)			
ii. Compact Substrate (see above)			
iv. Install In-Ground Utilities (see above)			X
k. Build Concrete Boat Wash Station Pad			X
i. Compact Substrate (see above)			
ii. Construct Concrete Building Pad (see above)			X
l. Seed Area (see above)			X
m. Remove Temporary Erosion Control Measures (see above)			
n. Aquatic Invasive Species Prevention Area (Structure)			
34. Floating Restrooms (CVA Program)	X		X
a. Site Survey (see above)			X
b. Vegetation Clearance (see above)	X		
c. Vegetative Debris Removal (see above)			X
d. Excavation of Soils/Sediment (see above)			X
e. Addition of Fill (see above)			

Activity (reasonable potential for take marked at right with an X)	Timber Harvest or Tree Removal	Prescription Burning	Collision
f. Compact Substrate (see above)			
g. Construct Concrete Headwall or Wingwall (see above)			X
a. Install Sanitary Vault for holding waste onshore			X
i. Excavation of Soils/Sediment (see above)			X
ii. Install Footings (see above)			X
iii. Set Sanitary Vault on Footings			X
1. Use of Heavy Equipment			
2. Use Hand Tools			
3. Use Motorized Hand Tools			
4. Use of Vehicles			X
iv. Backfill Vault and Footings with Concrete			X
1. Pour Concrete (see above)			X
b. Construct Concrete Pad for sanitary vault			X
i. Build Concrete Forms (see above)			X
ii. Install Rebar (see above)			
iii. Pour Concrete (see above)			X
iv. Remove forms and cut joints (see above)			
c. Install Pump			
i. Use of Hand Tools			
ii. Use of Motorized Hand Tools			
iii. Pump for Waste (Structure)			
d. Utility lines	X		X
i. Site Survey (see above)			X
ii. Lay Out Utility Line Route (see lay out building locations above)			
iii. Vegetation Clearance (see above)	X		X
iv. Vegetative Debris Removal (see above)			X
e. Connect Electrical, Water, and Sewer Lines from pump to nearest source			X
i. Install In-Ground Utilities (see above)			X
ii. Install Utility cables to dock			

Activity (reasonable potential for take marked at right with an X)	Timber Harvest or Tree Removal	Prescription Burning	Collision
1. Use of Hand Tools			
2. Use of Motorized Hand Tools			
iii. Seed Area (see above)			X
f. Install Pre-Fabricated Floating Restroom, Walkway, and Stiff Arm			X
i. Place Floating Restroom, Walkway, and Stiff Arm into Water			X
1. Use Heavy Equipment			
2. Use Hand Tools			
3. Use Motorized Hand Tools			
4. Use Vehicles Off-Road			X
ii. Connect Cables to Floating Restroom, Walkway, and Stiff Arm			
1. Use Heavy Equipment			
2. Use Hand Tools			
3. Use Motorized Hand Tools			
g. Install Pump (see above)			
h. Placement of Riprap (see above)			
i. Floating Restroom (Structure)			
35. Pumpouts, Dump stations, waste treatment systems (CVA Program)	X		X
a. Site Survey (see above)			X
b. Vegetation Clearance (see above)	X		
c. Vegetative Debris Removal (see above)			X
d. Excavation of Soils/Sediment (see above)			X
e. Compact Substrate (see above)			
f. Install Sanitary Vault for holding waste onshore			X
i. Excavation of Soils/Sediment (see above)			X
ii. Install Footings (see above)			X
iii. Set Sanitary Vault on Footings			X
1. Use of Heavy Equipment			
2. Use Hand Tools			

Activity (reasonable potential for take marked at right with an X)	Timber Harvest or Tree Removal	Prescription Burning	Collision
3. Use Motorized Hand Tools			
4. Use of Vehicles			X
iv. Backfill Vault and Footings with Concrete			X
1. Pour Concrete (see above)			X
g. Construct Concrete Pad for sanitary vault			X
i. Build Concrete Forms (see above)			X
ii. Install Rebar (see above)			
iii. Pour Concrete (see above)			X
iv. Remove forms and cut joints (see above)			
h. Install Pump (see above)			
i. Utility lines (see above)	X		X
j. Connect Electrical, Water, and Sewer Lines from pump to nearest source (see above)			X
k. Seed Area (see above)			X
l. Pumpouts, Dump stations, Waste treatment systems (Structure)			
36. Docks (Floating, Stationary, and Piers) (BIG Program)	X		X
a. Site Survey (see above)			X
b. Vegetation Clearance (see above)	X		
c. Vegetative Debris Removal (see above)			X
d. Excavation of Soils/Sediment (see above)			X
e. Addition of Fill (see above)			
f. Compact Substrate (see above)			
g. Construct Concrete Headwall or Wingwall (see above)			X
h. Install Floating Dock (see above)	X		X
i. Install Stationary Dock (see above)	X		X
j. Install Sanitary Vault (see above)			X
k. Install Utilities (see above)	X		X
l. Install Fuel stations, restrooms, showers, and laundry facilities			
i. Install pre-fabricated storage tanks to dock			

Activity (reasonable potential for take marked at right with an X)	Timber Harvest or Tree Removal	Prescription Burning	Collision
1. Use Heavy Equipment			
2. Use Hand Tools			
3. Use Motorized Hand Tools			
ii. Install pumps for fuel, restrooms, gray water tanks (see above)			
m. Install Lighting, Security, and signage on Dock			
i. Use of Hand Tools			
ii. Use of Motorized Hand Tools			
n. Connect Electrical, Water, Communication, and Sewer Lines to nearest source			X
i. Install In-Ground Utilities (see above)			X
ii. Install Utility cables to dock			
1. Use of Hand Tools			
2. Use of Motorized Hand Tools			
iii. Seed Area (see above)			X
o. Placement of Riprap (see above)			
p. Dock (structure)			
37. Buoys, signals, markers			
a. Construct Anchors			
i. Build Concrete Forms			
1. Use of Hand Tools			
2. Use of Motorized Hand Tools			
ii. Install Reinforcing Rebar or Wire			
1. Use Hand Tools			
iii. Install attachment hardware			
1. Use of Hand tools			
iv. Pour Concrete			
1. Use of Hand Tools			
v. Remove forms			
1. Use of Hand tools			

Activity (reasonable potential for take marked at right with an X)	Timber Harvest or Tree Removal	Prescription Burning	Collision
b. Attach anchor lines			
i. Use of Hand Tools			
c. Attach Buoys, signals, and markers to anchor lines and anchor			
i. Use of Hand Tools			
d. Install Completed Buoys, signals, and markers in water 6-foot minimum depth			
i. Use of Heavy Equipment			
ii. Use of Hand Tools			
e. Buoys, signals, and markers (structure)			
38. Beacons	X		X
a. Site Survey (see above)			X
b. Vegetation Clearance (see above)	X		X
c. Vegetative Debris Removal (see above)			X
d. Establish/Maintain Access Roads (see above)	X		X
e. Rough Grading (see above)			X
f. Finish Grading (see above)			X
g. Construct Structures (see above)			X
h. Install In-Ground Utilities (see above)			
i. Interior Finish (see above)			
j. Seed Area (see above)			X
k. Beacon (Structure)			
39. Retaining Walls, bulkheads	X		X
a. Site Survey (see above)			X
b. Vegetation Clearance (see above)	X		X
c. Vegetative Debris Removal (see above)			X
d. Establish/Maintain Access Roads (see above)	X		X
e. Rough Grading (see above)			X
f. Finish Grading (see above)			X
g. Construct Structures (see above)			X

Activity (reasonable potential for take marked at right with an X)	**Timber Harvest or Tree Removal**	**Prescription Burning**	**Collision**
h. Seed Area (see above)			X
i. Retaining Walls and Bulkheads (Structure)			
40. Pilings and Living Shorelines	X		X
a. Site Survey (see above)			X
b. Vegetation Clearance (see above)	X		X
c. Vegetative Debris Removal (see above)			X
d. Establish/Maintain Access Roads (see above)	X		X
e. Rough Grading (see above)			X
f. Finish Grading (see above)			X
g. Construct Structures (see above)			X
h. Install sediments/aggregate			
i. Use of Heavy Equipment			
ii. Use of Hand Tools			
i. Install vegetation/natural material			
i. Use Heavy Equipment			
ii. Use Hand Tools			
j. Seed Area (see above)			X
k. Pilings and Living Shorelines (structure)			
41. Breakwaters (Fixed, sea walls, and wave attenuators)	X		X
a. Site Survey (see above)			X
b. Install Temporary Erosion Control Measures (see above)			X
c. Vegetation Clearance (see above)	X		X
d. Vegetative Debris Removal (see above)			X
e. Construct Temporary Access (see above)	X		X
f. Dredge Lake Sediment			X
i. Excavation of Soils/Sediment (see above)			X
g. Grade on shore			X
i. Excavation of Soils/Sediment (see above)			X

Activity (reasonable potential for take marked at right with an X)	Timber Harvest or Tree Removal	Prescription Burning	Collision
ii. Compact Substrate (see above)			
h. Construct Temporary Cofferdam (see above)			
i. Construct Structures (see above)			X
j. Install Wave Attenuators (see buoys, signals, markers)			
k. Install Debris Deflector			
i. Use of Heavy Equipment			
l. Placement of Riprap (to form Jetty) (see above)			
m. Placement of Riprap (adjacent to Jetty) (see above)			
n. Remove Temporary Stream Access (see above)			X
o. Seed Area (see above)			X
p. Remove Temporary Erosion Control Measures (see above)			
q. Breakwaters (Fixed, sea walls, and wave attenuators) (structure)			
42. Dredging and Water Hazard Removal	X		X
a. Site Survey (see above)			X
b. Vegetation Clearance (see above)	X		X
c. Vegetative Debris Removal (see above)			X
d. Excavation of Soils/Sediment (see above)			X
e. Construct Temporary Access (see above	X		X
f. Dredging			
i. Excavation Soils/Sediment (see above)			X
ii. Grade, Shape, and Compact Lake Bottoms and Banks			
1. Excavation Soils/Sediment (see above)			X
g. Soil Disposal (permanent)			X
i. Transport soil			
1. Use Heavy Equipment			
2. Use Vehicles Off-Road			X
ii. Compact Substrate (see above)			
iii. Install temporary soil erosion control measures (see above)			
iv. Seed Area (see above)			X

Activity (reasonable potential for take marked at right with an X)	**Timber Harvest or Tree Removal**	**Prescription Burning**	**Collision**
h. Remove Water Hazards			
i. Use of Heavy Equipment			
ii. Use of Motorized boats			
i. Seed Area (see above)			X
j. Dredging and Water Hazard Removal (activity)			

Private Lands

Activity (reasonable potential for take marked at right with an X)	Timber Harvest or Tree Removal	Prescription Burning	Collision
1. Site Survey for Planning			X
a. Use vehicles off-road			X
b. Walk through terrestrial habitat			
c. Use hand tools (GPS, plotter)			
2. Tree Removal—includes trees for ponds, pipeline and fence.	X		X
a. Drop Trees	X		X
i. Hand Felling	X		X
1. Walk Through Terrestrial Habitat			
2. Use of Vehicles Off-Road			X
3. Use of Hand Tools			
4. Use of Motorized Hand Tools			
ii. Mechanical Felling	X		X
1. Use of Motorized Hand Tools			
2. Use of Vehicles Off-Road			X
3. Use of Heavy Equipment			
iii. Felled Tree (STRUCTURE)			
b. Tree Relocation	X		X
i. Bucking (removing tree limbs and cut into logs)	X		X
1. Use of Vehicles Off-Road			X
2. Use of Motorized Hand Tools			
3. Use of Heavy Equipment			
ii. Grappling/Cable (attaching tree to machine)			
1. Use of Heavy Equipment			
iii. Skidding (move logs from the forest to a landing area) (may damage existing trees)			
1. Use of Heavy Equipment			
2. Drag Tree			
c. Rx Fire	X	X	X
i. Planning			

Activity (reasonable potential for take marked at right with an X)	Timber Harvest or Tree Removal	Prescription Burning	Collision
ii. Fire Line Construction	X		
1. Vegetation Clearance	X		
a. Cut Above-Ground Vegetation	X		
i. Use Hand Tools			
ii. Use of Heavy Equipment			
iii. Use of Brush Hog			
iv. Use of Motorized Hand Tools			
v. Walk Through Terrestrial Habitat			
vi. Removed Vegetation			
2. Snag Removal (Non-Hazard Tree) (Can be a stand of snags)	X		X
a. Drop Trees (see above)	X		X
3. Tree Removal (see above)	X		X
4. Disking			
a. Use of Heavy Equipment			
5. Removal of Leaf and Litter			X
a. Use Hand Tools			
b. Use of Motorized Hand Tools			
c. Use of Vehicles Off-Road			X
iii. Ignition		X	
1. Aerial Ignition		X	
a. Use of Helicopters			
b. Use of Drones			
2. Drip Torches		X	
3. ATV Ignition		X	
iv. Mop-up	X		
1. Tree Removal (see above)	X		X
2. Tree Relocation (see above)	X		X
v. Fire Line (Structure)			

Activity (reasonable potential for take marked at right with an X)	Timber Harvest or Tree Removal	Prescription Burning	Collision
3. Water Source Development			X
a. Construct Freshwater Well			X
i. Dig Well			X
1. Erect/Remove Drilling Rig			X
a. Use of Heavy Equipment			
b. Use of Motorized Hand Tools			
c. Use of Vehicles Off-Road			X
d. Use of Hand Tools			
e. Drilling Rig (Structure)			
2. Excavation of Soils/Sediment			X
a. Soil Removal			
i. Remove Soil			
ii. Use Heavy Equipment			
iii. Use Hand Tools			
b. Redistribute Soils On-Site			
i. Use Hand Tools			
ii. Grading			
1. Redistribute Soils			
2. Use Heavy Equipment			
c. Restore Vegetation			X
i. Seed Area			
1. Disk Soil			
2. Hydroseed			
3. Drillseed (e.g., no-till drill)			
4. Use of Vehicles Off-Road			X
5. Use Hand Tools			
6. Use Motorized Hand Tools			
7. Use Heavy Equipment			
8. Apply Fertilizer			

Activity (reasonable potential for take marked at right with an X)	Timber Harvest or Tree Removal	Prescription Burning	Collision
9. Spray Exposed Soil with Water			
ii. Install Well Pump			
1. Use of Hand Tools			
2. Use of Motorized Hand Tools			
iii. Well (Structure)			
b. Pond Construction			
i. Excavation of Soils/Sediments (see above)			
ii. Pond (Structure)			
c. Spring Development			X
i. Water Collector in Spring Branch			X
1. Use of Motorized Hand Tools			
2. Use of Vehicles Off-Road			X
3. Use of Hand Tools			
4. Water Collector (Structure)			
4. Installation of Water System (Water line Installation, water tanks) (No bedding)	X		X
a. Connect to Water Supply (Install Water Conveyance Pipeline)	X		
i. Install In-Ground Water Lines	X		
1. Vegetation Clearance (see above)	X		X
2. Dig Trench			
a. Excavation of Soils/Sediment (see above)			X
3. Prepare Pipe Bed			
a. Addition of Fill			
i. Use of Heavy Equipment			
b. Lay Gravel Substrate			
i. Use of Heavy Equipment			
c. Install Permeable Fabric			
4. Lay Pipes			X
a. Use of Heavy Equipment			
b. Use of Vehicles Off-Road			X

Activity (reasonable potential for take marked at right with an X)	Timber Harvest or Tree Removal	Prescription Burning	Collision
5. Cover Pipes			
a. Use of Heavy Equipment			
6. Restore vegetation (see above)			
ii. Install Above-Ground Water Lines	X		X
1. Vegetation Clearance (see above)	X		
2. Construct Water Pipeline			X
a. Use of Heavy Equipment			
b. Use of Vehicles Off-Road			X
c. Use of Hand Tools			
d. Use of Motorized Hand Tools			
3. Above-Ground Water Pipeline (structure)			
b. Install Water Storage Tanks			X
i. Install Footings			X
1. Excavation of Soils/Sediment (see above)			
2. Build Concrete Forms			X
a. Use of Hand Tools			
b. Use of Motorized Hand Tools			
c. Use of Vehicles Off-Road			X
d. Walk Through Terrestrial Habitat			
3. Pour Concrete			X
a. Use of Hand Tools			
b. Use of Motorized Hand Tools			
c. Use of Vehicles Off-Road			X
d. Walk Through Terrestrial Habitat			
ii. Place Water Storage Tank			
1. Use of Heavy Equipment			
2. Use of Hand Tools			
3. Use of Motorized Hand Tools			
iii. Water Storage Tank (Structure)			

Activity (reasonable potential for take marked at right with an X)	Timber Harvest or Tree Removal	Prescription Burning	Collision
5. Seed Area (see above)			X
Critical Area Treatment—Grading and Shaping heavily eroded areas – Deconstruction	X		X
1. Site Survey for Planning (see above)			
2. Tree Removal (see above)	X		
3. Seed Area (see above)			
4. Straw Mulching (scattering straw or grinding straw and blowing)			X
a. Use of Vehicles Off Road			X
b. Use of Hand Tools			
c. Walk Through Terrestrial Habitat			
Forest Harvest BMP Implementation– Deconstruction	X		X
1. Site Survey for planning (see above)			X
2. Site Preparation	X		X
a. Tree Removal (see above)	X		
b. Snag Removal (see above)	X		
c. Rock Removal			X
i. Rock Removal			
1. Remove Rocks			
2. Use Heavy Equipment			
3. Use Hand Tools			
4. Walk Through Terrestrial Habitat			
ii. Dispose of Rocks			X
1. Bury Rocks Onsite			
a. Bury Rocks			
b. Use Hand Tools			
c. Use Heavy Equipment			
d. Walk Through Terrestrial Habitat			
2. Crush Rocks Onsite			
a. Use Heavy Equipment			

Activity (reasonable potential for take marked at right with an X)	Timber Harvest or Tree Removal	Prescription Burning	Collision
b. Walk Through Terrestrial Habitat			
c. Rock Stockpile			
3. Haul Rocks Offsite			X
a. Use Heavy Equipment			
b. Use Vehicles Off-Road			X
c. Walk Through Terrestrial Habitat			
4. Redistribute Rocks Onsite			
a. Redistribute Rocks			
b. Use Heavy Equipment			
c. Stockpile Rocks On-Site			
d. Use Heavy Equipment			
e. Rock Stockpile (Structure)			
3. Grading			
a. Grading			
i. Redistribute Soils			
ii. Use Heavy Equipment			
1. Build Stream Crossings			X
a. Armored crossing			X
i. Excavate Soils/Sediment (base of stream and approaches)			
1. Soil Removal			
a. Remove Soil			
b. Use Heavy Equipment			
c. Use Hand Tools			
2. Redistribute Soils On-Site			
a. Use Hand Tools			
b. Grading (see above)			
ii. Lay Gravel / Aggregate Substrate			X
1. Use Hand Tools			
2. Use Heavy Equipment			

Activity (reasonable potential for take marked at right with an X)	Timber Harvest or Tree Removal	Prescription Burning	Collision
3. Use Vehicles Off-Road			X
b. Install Culvert			X
i. Excavate Soils/Sediment (see above)			
ii. Install culvert			X
1. Prepare Culvert Bed			X
a. Install Permeable Fabric			X
i. Use Hand Tools			
ii. Use Vehicles Off-Road			X
b. Lay Gravel / Aggregate Substrate			X
i. Use Hand Tools			
ii. Use Heavy Equipment			
iii. Use Vehicles Off-Road			X
c. Place Culverts			X
i. Place Pre-Cast Culvert			X
1. Use Hand Tools			
2. Use Heavy Equipment			
3. Use Vehicles Off-Road			X
ii. Build Formed Culvert On-Site			
1. Build Concrete Forms (see above)			
2. Pour Concrete (see above)			
d. Install Drainage Pipes			X
i. Prepare Pipe Bed			X
1. Addition of Fill (see above)			
2. Lay Gravel / Aggregate Substrate (see above)			X
3. Install Permeable Fabric (see above)			
e. Lay Pipes (ACTIVITY)			X
i. Use Heavy Equipment			
ii. Use Hand Tools			
iii. Use Vehicles Off-Road			X

Activity (reasonable potential for take marked at right with an X)	Timber Harvest or Tree Removal	Prescription Burning	Collision
f. Cover Pipes			X
i. Install Permeable Fabric (see above)			X
ii. Lay Gravel / Aggregate Substrate (see above)			X
iii. Addition of Fill (see above)			
iv. Redistribute Soils On-Site (see above)			
iii. Lay Gravel / Aggregate Substrate (see above)			X
2. Water Bar installation, rolling dips, turnouts, road crowning			
a. Grading (see above)			
3. Establish Skid Trail	X		X
a. Vegetation Clearance (see above)	X		X
b. Install Temporary Bridge or Stream Crossing			X
i. Use of Heavy Equipment			
ii. Use of Vehicles Off-Road			X
iii. Stream Crossing (Structure)			X
c. Skid Trail/Road (Structure)			
4. Establish Temporary Landing	X		X
a. Vegetation Clearance (see above)	X		X
b. Vegetative Debris Removal			X
i. Removal of Debris			X
1. Remove Debris			X
a. Use Heavy Equipment			
b. Use Hand Tools			
c. Use of Vehicles Off-Road			X
d. Walk Through Terrestrial Habitat			
ii. Stockpile Debris On-Site			X
1. Use Heavy Equipment			

Activity (reasonable potential for take marked at right with an X)	Timber Harvest or Tree Removal	Prescription Burning	Collision
2. Use Hand Tools			
3. Walk Through Terrestrial Habit			
4. Use of Vehicle Off-Road			X
5. Debris Stockpile (Structure)			
iii. Dispose of Debris			X
1. Bury Debris Onsite			X
a. Bury Debris			
b. Use Heavy Equipment			
c. Use Hand Tools			
d. Use of Vehicle Off-Road			X
iv. Haul Debris Offsite			X
1. Use of Off-Site Disposal Areas (terrestrial)			X
a. Use Hand Tools			
b. Use Heavy Equipment			
c. Use of Vehicle Off-Road			X
d. Walk Through Terrestrial Habitat			
e. Vegetation Stockpile (Structure)			
c. Site Restoration			
i. Seeding Area (see above)			X
d. Landing (Structure)			
5. Gate installation (no fencing)	X		X
a. Vegetation clearance (see above)	X		X
b. Install Gate			X
i. Use of vehicles Off Road			X
ii. Use of Motorized Hand Tools			
iii. Use of Hand Tools			
iv. Walk Through Terrestrial Habitat			
v. Gate (Structure)			

Activity (reasonable potential for take marked at right with an X)	Timber Harvest or Tree Removal	Prescription Burning	Collision
6. Seed Area (see above) (typically turned into food plot)			X
Forest Management – Deconstruction			
See Forestry Division's Deconstructed Activities			
Heavy Site prep for direct seeding pine in Ozarks (dozer) – Deconstruction	X	X	X
1. Site Survey for Planning (see above)			X
2. Tree Removal (see above)	X		X
3. Rx Fire (see above)	X	X	X
4. Seed Area (see above)			X
Linear Tree Row Removal – Deconstruction	X		X
1. Site Survey for planning (see above)			X
2. Tree Removal (see above)	X		X
3. Seed Area (see above)			X
Permanent Forest Opening – Deconstruction	X	X	X
1. Site Survey for planning (see above)			X
2. Tree Removal (see above)	X		
3. Site Preparation / Vegetation Establishment		X	X
a. Vegetative Debris Removal (see above)	X		X
b. Rx Fire (see above)	X	X	X
c. Seed Area (see above)			X
Prescribed Fire – Deconstruction	X	X	X
1. Rx Fire (see above)	X	X	X

Activity (reasonable potential for take marked at right with an X)	Timber Harvest or Tree Removal	Prescription Burning	Collision
Streambank Restoration – Deconstruction			
1. Site Survey for planning (see above)			X
2. Streambank Site Preparation	X		X
a. Vegetation Clearance (see above)	X		X
b. Excavation of soils/Sediment (see above)			X
c. Grading			
3. Install Bank Protection	X		X
a. Install Tree Revetment	X		X
i. Relocate Trees (see above)	X		X
ii. Place Trees			
1. Use of Heavy Equipment			
iii. Cable Trees			X
1. Walk Through terrestrial Habitat			
2. Walk Through Aquatic Habitat			
3. Use Vehicles Off-Road			X
4. Use of Hand Tools			
iv. Anchor Trees			X
1. Drive Earth Anchors			X
a. Walk Through terrestrial Habitat			
b. Walk Through Aquatic Habitat			
c. Use Vehicles Off-Road			X
d. Use of Hand Tools			
v. Tree Revetment (Structure)			
4. Install Rock Blanket			
a. Placement of Riprap			
i. Use of Heavy Equipment			
b. Riprap (Structure)			

Activity (reasonable potential for take marked at right with an X)	Timber Harvest or Tree Removal	Prescription Burning	Collision
5. Install Rock Weir			
a. Placement of Riprap (see above)			
b. Rock Weir (Structure)			
6. Install Log Barbs (weir)			X
a. Place Trees (see above)			X
b. Log Barb (Structure)			
7. Seed Area (see above)			X
Temporary Forest Opening – Deconstruction	X		X
1. Site Survey for planning (see above)			X
2. Site Preparation	X		X
a. Tree removal (see above)	X		X
3. Herbicide Application			X
a. Chemical application (Activity) (all have use of vehicles off-road)			
i. Basal Spray (Small trees < 4” diameter)			X
1. Use of Hand Tools			
2. Walk Through Terrestrial Habitat			
3. Use of Vehicles Off-Road			X
ii. Hack n’ Squirt (Any size tree)			X
1. Use of Hand Tools			
2. Walk Through Terrestrial Habitat			
3. Use of Vehicles Off-Road			X
4. Notch Tree			
iii. Stem Injection			X
1. Use of Hand Tools			
2. Walk Through Terrestrial Habitat			
3. Use of Vehicles Off-Road			X
4. Notch Tree (see above)			
iv. Stump Treatment			X

Activity (reasonable potential for take marked at right with an X)	Timber Harvest or Tree Removal	Prescription Burning	Collision
1. Use of Hand Tools			
2. Walk Through Terrestrial Habitat			
3. Use of Vehicles Off-Road			X
4. Notch Tree (see above)			
v. Foliar spray			X
1. Use of Hand Tools			
2. Walk Through Terrestrial Habitat			
3. Use of Vehicles Off-Road			X
4. Use of Heavy Equipment			
5. Use of aircraft			
Timber Stand Improvement – Deconstruction	X		X
1. Timber Inventory Survey (Gather data to management prescriptions)			X
a. Walk Through Terrestrial Habitat			
b. Use Vehicles Off-Road			X
c. Tree Sounding			
d. Tree Boring (1-2 trees per stand)			
2. Timber Manipulation	X		X
a. Tree Removal (see above)	X		X
b. Chemical Application (see above)			X
Crop Tree Pruning/Tree and Shrub Pruning– Deconstruction	X		X
1. Site Survey for planning (see above)			X
2. Tree/Shrub Pruning	X		X
a. Use of Hand Tools (shears and saws)			
b. Use of Motorized Hand Tools (chainsaws, polesaws, powered brush cutters)			
c. Use of Heavy Equipment (tractors, bucket trucks)			
d. Use of Vehicles Off-Road (AWD/Off with scissor or fork lift)			X
e. Walk Through Terrestrial Habitat			
f. Removed Vegetation (Structure)			

Activity (reasonable potential for take marked at right with an X)	**Timber Harvest or Tree Removal**	**Prescription Burning**	**Collision**
3. Forest Residue Treatment			
a. Use of Heavy Equipment (tractors with brush-hog)			X
b. Use of Vehicles Off-Road			
c. Walk Through Terrestrial Habitat			X
Wildlife Water Hole Construction and Maintenance – Deconstruction	X		X
1) Site Survey for Planning (see above)			X
2) Tree Removal (see above)	X		X
3) Create Water Hole			X
a. Excavation of Soils/Sediment (see above)			X
4) Seed area (see above			X

Design and Development

Activity (reasonable potential for take marked at right with an X)	Timber Harvest or Tree Removal	Prescription Burning	Collision
I. Environmental Compliance			X
1. Preconstruction clearance surveys for natural resources (not sure what this entails?)			
2. Cultural Resource Surveys			X
A. (Need a Descriptor) Sampling			
1. Remove Vegetation			
2. Use Heavy Equipment			
3. Use Hand Tools			
B. Visual Survey			
C. Use of Aircraft			
1. Use of Airplane			
2. Use of Drone			
3. Use of Helicopter			
D. Use Vehicles Off-Road			X
E. Walk Through Aquatic Habitat			
F. Walk Through Terrestrial Habitat			
II. Terrestrial Project Sighting			X
1. Biological Surveys			X
A. Biological surveys (aerial)			
1. Use of Aircraft			
a. Use of Airplane			
b. Use of Drone			
c. Use of Helicopter			
B. Biological surveys (aquatic)			
1. Dive/Snorkel			
2. Electrofishing			
3. Use of Boats			
a. Use of Motorized Boats			

Activity (reasonable potential for take marked at right with an X)	Timber Harvest or Tree Removal	Prescription Burning	Collision
b. Use of Non-Motorized Boats			
4. Use of Seines/Nets			
5. Walk Through Aquatic Habitat			
C. Biological surveys (terrestrial)			X
1. Use of Amplified Sound Equipment			X
a. Use Vehicles Off-Road			X
b. Walk Through Terrestrial Habitat			
2. Use of Terrestrial Wildlife Capture Devices			X
a. Use Hand Tools			
b. Use Vehicles Off-Road			X
c. Walk Through Terrestrial Habitat			
d. Biological Traps (Structure)			
3. Visual Survey			X
a. Use Vehicles Off-Road			X
b. Walk Through Terrestrial Habitat			
4. Biological Soil Core Sampling			X
a. Use Hand Tools			
b. Use Vehicle-Mounted Coring Tools			
c. Use Vehicles Off-Road			X
III. Geotechnical Investigation	X		X
A. Use of Ground Penetrating Radar	X		X
1. Cut Above-Ground Vegetation	X		X
a. Remove Vegetation			
b. Use Heavy Equipment			
c. Use Motorized Hand Tools			
d. Use Vehicles Off-Road			X
e. Walk Through Terrestrial Habitat			
2. Drag Ground Penetrating Radar			
3. Use Vehicles Off-Road			X

Activity (reasonable potential for take marked at right with an X)	**Timber Harvest or Tree Removal**	**Prescription Burning**	**Collision**
4. Walk Through Terrestrial Habitat			
B. Seismic Refraction Surveys			X
1. Use of Thumper Truck			X
a. Use Heavy Equipment			
b. Lay Seismic Data Capturing Equipment			X
1. Use Vehicles Off-Road			X
2. Walk Through Terrestrial Habitat			
3. Use Hand Tools			
c. Induce Seismic Activity			
2. Use of Subterranean Explosives			X
a. Place Geomarkers			X
1.Use Hand Tools			
2. Use Vehicles Off-Road			X
3. Walk Through Terrestrial Habitat			
4. Geomarker (Structure)			
b. Use Hand-Coring Tools			
1. Use Hand Tools			
2. Use Motorized Hand Tools			
c. Use Vehicle-Mounted Coring Tools			
d. Induce Seismic Activity			
e. Backfill Soil Core Holes			X
1. Use Hand Tools			
2. Use Vehicles Off-Road			X
3. Walk Through Terrestrial Habitat			
f. Lay Seismic Data Capturing Equipment (see above)			
g. Blasting			
C. Trench Sampling	X		X
1. Dig Trench	X		X
a. Cut Above-Ground Vegetation (see above)	X		X

Activity (reasonable potential for take marked at right with an X)	Timber Harvest or Tree Removal	Prescription Burning	Collision
b. Excavation of Soils/Sediment			X
1. Soil Removal			X
Remove Soil			
Use Heavy Equipment			
Use Hand Tools			
Walk Through Terrestrial Habitat			
Use Off Road Vehicle			X
2. Stockpile Soils On-Site (Activity)			X
Use Heavy Equipment			
Use Hand Tools			
Walk Through Terrestrial Habitat			
Use Off Road Vehicle			X
Soil Stockpile (Structure)			
3. Dispose of Soils/Sediments (Activity)			X
Haul Soils Offsite (Activity)			X
Use Heavy Equipment			
Use Hand Tools			
Use Vehicles Off-Road			X
Walk Through Terrestrial Habitat			
Redistribute Soils On-Site			X
Use Hand Tools			
Use Off Road Vehicle			X
Grading			
Redistribute Soils			
Use Heavy Equipment			
IV. Geomorphic, Hydrology, Hydraulics, and Sediment Transport Analysis Field Work			X
1. Soil Core Sampling			X
A. Take Soil Cores			X
1. Use Hand-Coring Tools			X

Activity (reasonable potential for take marked at right with an X)	Timber Harvest or Tree Removal	Prescription Burning	Collision
a. Use Hand Tools			
b. Use Motorized Hand Tools			
c. Use Vehicles Off-Road			X
2. Use Vehicle-Mounted Coring Tools			X
a. Use Heavy Equipment			
b. Use Vehicles Off-Road			X
3. Walk Through Terrestrial Habitat			
B. Backfill Soil Core Holes (see above)			
2. Trench Sampling (see above)			
3. Hydrology and Hydraulics Survey (Not sure what this entails)			
4. Geochemical Survey			X
A. Take Soil Cores (see above)			
B. Backfill Soil Core Holes (see above)			
C. Field Wet Chemical Analysis			X
1. Use Hand Tools			
2. Walk Through Terrestrial Habitat			
3. Use Vehicles Off-Road			X

Appendix D

Literature Review for the Benefits of Forestry on Bats

ESI

ENVIRONMENTAL SOLUTIONS & INNOVATIONS, INC.

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Pesi 1121 4 February 2020

Ms. Paola Bernazzani
Principal, Habitat Conservation Planning
80 West Washington Street
Chagrin Falls, OH 44022 USA

RE: Literature Review for the Benefits of Forestry on Bats.

Dear Ms. Bernazzani:

The Missouri Department of Conservation (MDC) and the ICF Team are drafting a Habitat Conservation Plan (HCP) for MDC with an understanding that sustainable forestry and prescribed fire can improve habitat for bats, support the existing population, and promote species recovery from white-nose syndrome, should a cure be identified. This letter provides an overview of literature supporting this contention.

Perhaps the most important point, made elsewhere in the letter, is that forestry manages habitat, maintains natural cover on the landscape, and prevents conversion of natural to nonnatural habitat (Radeloff et al. 2005). Within MDC, forestry is practiced with the intent of producing multiple public benefits, including conservation of a variety of natural resources such as soil, water, wildlife habitat, and rare species (Missouri Department of Conservation 2014). Forest management produces public benefits on private lands as well, by encouraging landowners to retain and manage forest lands for the financial and cultural benefits the lands provide (Kobilinsky 2019; Miller et al. 2019). Contemporary silviculture, the art and science of managing forests, is a viable tool for managing bats and their habitat.

Any informed discussion of the subject should encompass the complexity of the topic as outlined in several recent reviews (Guldin et al. 2007; Sheets et al. 2013, Silvis et al. 2016). Given the virtually endless ways in which silvicultural techniques can interact with abiotic and biotic conditions at the site level (these vary in their timing, frequency, intensity, spatial patterns, and management intent), statements that forestry outcomes are exclusively good or bad should be avoided. MDC manages forests for the many varied public benefits they provide, and evidence indicates at the landscape level that well managed forests (specific citations provided below) are beneficial to bat habitat. In fact, the two most recent reviews that examined the impact of forestry on covered bats took a perspective that forestry should be viewed in light of its effect on habitat used by bats (Sheets et al. 2013; Silvis et all. 2016). With that in mind, the models presented in Chapters 4 and 5 of the HCP are based on forestry practices as currently enacted on MDC lands. The HCP development team consists of contractors, including forest management professionals and wildlife biologists, who work with their professional counterparts within MDC to gain an understanding of how multiple silvicultural techniques are implemented in Missouri.

A review of how habitat value within a typical stand is expected to change over time is necessary to capture the wide range of effects. Analysis used to characterize effects of timber harvest on bats in Missouri consists of the following key assumptions: (1) habitat management has both short- and long-term impacts on habitat within a given stand, (2) habitat management can impact both roosting and foraging habitat in different ways, (3) roosting habitat is more critical than foraging habitat for endangered/vulnerable bats; (4) one can deconstruct and understand impacts by examining how a stand changes following management and how the stand will respond over time to those changes; and (5) follow-up management activities can then be added and assessed separately. The approach allows an understanding of impacts suitable for a programmatic plan such as the MDC HCP. Most importantly, it allows additional analyses that capture both the short- and long-term effects of habitat management. However, a stand-specific approach does not address changes in the surrounding landscape that are not the result of a covered activity. In cases where habitat management is spread across a large landscape with some areas reserved from harvest and some areas harvested intensively; the result is a mosaic of habitat that provides all habitats needed by the covered bats.

Identification of Residential Sprawl as a Key Issue in the Midwest

Radeloff, V. C., R. B. Hammer, and S. I. Stewart. 2005. Rural and suburban sprawl in the U.S. Midwest from 1940 to 2000 and its relation to forest fragmentation. *Conservation Biology* 19:793–805.

Provides a detailed assessment of region-wide changes associated with residential development along the edges of existing metropolitan areas and in rural areas.

- Contains a comprehensive, GIS-based assessment that provides details on how residential development in both suburban and rural areas is impacting forests.
- Noted that residential development is most intense in areas with abundant natural resources such as forests, parks, and rivers.
- This is the background against which MDC proposes to protect 200,000 acres of open land and 700,000 acres of forests, woodlands, and glades.

Conservation Benefits of Forest Management on Private Lands

Kobilinsky, D. 2019. Certified to conserve: forest certification gives landowners a key role in wildlife conservation. *The Wildlife Professional* 13:18–26.

Miller, D. A., J. F. Bullock Jr, W. R. Murray, C. K. Dohner, and C. Czarnecki. 2019. Conservation through collaboration: a novel partnership ensures a place for wildlife in private, working forests. *The Wildlife Professional* 13:28–31.

Back-to-back publications providing a high-level overview of the value of privately managed forests for wildlife.

Landscape-Scale Determinants of Bat Habitat in Missouri

Yates, M. D. and R. M. Muzika. 2006. Effect of forest structure and fragmentation on site occupancy of bat species in Missouri Ozark forests. *Journal of Wildlife Management* 70:1238–1248.

Used bat detectors and maximum likelihood models to assess presence of bat species in southeastern Missouri at both local and landscape scales. It is important to note this paper examines bats as they travel at night.

- Indiana bats: presence was associated with both local-scale (i.e., large diameter snags for roosting) and landscape-scale variables (larger woodlands mixed with open habitats.
- Gray bats: were not readily modeled, suggesting they use a wide variety of nocturnal habitat types.
- Northern long-eared bats: were most likely detected in areas with limited forest edge.

  Tricolored bats: were most likely found in areas with scattered large trees, high degree of canopy closure, and substantial understory vegetation at the height of 2–3 meters.

Amelon, S. K. 2007. Multi-scale factors influencing detection, site occupancy and resource use by foraging bats in the Ozark Highlands of Missouri. Doctoral Dissertation, University of Missouri-Columbia, Columbia, Missouri. 227 pp.

Used bat detectors and maximum likelihood models to assess presence of bat species at multiple scales in the Ozarks of Missouri. It is important to note this paper examines bats as they travel during the night, and some variables (e.g., clutter) were measured at scales potentially not applicable to the MDC HCP.

- Gray bats: were positively associated with sites with access to water sources (ponds, streams, and even pools of water in roads [road ruts]), landscapes with a mix of open and forested lands, access to water, bottomland forest; and negatively associated with young oak-pine and pine forests and wide open habitat types.

- Little brown bats: were positively associated with forested habitat, bottomland forest, water sources (ponds, streams, and even pools of water in roads [road ruts]), and negatively associated with roads and non-forested lands.
- Northern long-eared bats: were positively associated with dense, somewhat cluttered forests, larger mature forests of oak/hickory or bottomland types, water; and were negatively associated with non-forest habitats, and very young forests.
- Tricolored bats: were positively associated forested habitat, with limited clutter, and water; and were negatively associated with non-forest habitats, and young, highly cluttered forests.

Starbuck, C. A., S. K. Amelon, and F. R. Thompson, III. 2015. Relationships between bat occupancy and habitat and landscape structure along a savanna, woodland, forest gradient in the Missouri Ozarks. *Wildlife Society Bulletin* 39:20–30.

The authors used single-species occupancy models to understand the pattern of presence/absence of bats at multiple spatial scales in the Ozarks. These data were used to understand how several species of bats made use of restored savannas and areas that had succeeded to closed-canopy forests.

- Northern long-eared bats: were positively associated with pole-stage, closed canopy stands with little understory clutter located away from urban habitats and near water.
- Tricolored bats: were found in landscapes dominated by forest, located away from urban areas, and in areas that had recently been burned.

Womack, K. M. 2017. Multi-scale factors related to abundance of bats and insect prey in savannas, woodlands, and forests in the Ozark Highlands, USA. Doctoral Dissertation, University of Missouri-Columbia, Columbia, Missouri. 156 pp.

Used a variety of tools to examine how four bats species (evening, eastern red, northern long-eared, and tricolored bats) responded to a restoration of savanna woodlands in the Ozarks. Key among these was extrapolating actual populations from capture events, developing an understanding of insect abundance, and examining how bat abundance was associated with management activities at multiple scales ranging from an individual site to multiple, nested landscape scales.

- Northern long-eared bats: were most abundant at sites with high pole and saw timber densities, with the amount of forest and savanna within 1 kilometer.

- Tricolored bats: increased in abundance at sites burned within 6 years.
- A recommendation for all species is that managers should create a mosaic of habitat types including some with high densities of large trees and more open sites.

Womack, K. M., S. K. Amelon, and F. R. Thompson III. 2013. Resource selection by Indiana bats during the maternity season. *Journal of Wildlife Management* 77:707–715.

Radio-tracked 29 bats to their nocturnal habitats used for commuting and foraging in northern Missouri. Data from this study were then analyzed to create behavioral models for individual bats and for all 29 bats as a population.

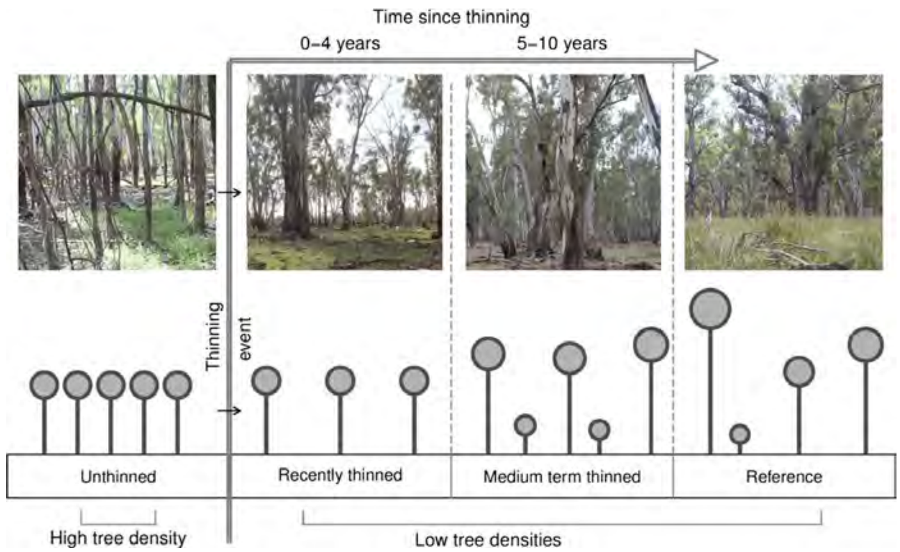
- Found no evidence that habitat selection changed with reproductive state.
- Eighteen bats preferentially foraged in areas of high canopy cover (i.e., woodlands).
- Five of six bats with home ranges that included burned areas preferentially used burned habitat for foraging.
- Landcover was an important variable as 13 bats preferentially foraged in forest and shrublands as opposed to agricultural fields, dominating the site.
- The study indicated maintaining woody habitat in agricultural landscapes is crucial to the survival of Indiana bat colonies.
- The study also found that low intensity prescribed fire improves foraging habitat by removing understory vegetation.

Bats Benefit When Dense Stands Are Thinned

Blakey, R. V., B. S. Law, R. T. Kingsford, J. Stoklosa, P. Tap, and K. Williamson. 2016. Bat communities respond positively to large-scale thinning of forest regrowth. *Journal of Applied Ecology* 53:1694–1703.

Paper is drawn from acoustic data collected in Eucalyptus stands in New South Wales Australia and reviews data from North American Studies.

- Data indicate young, dense stands become too cluttered for bats—at/near a cut-off of 1100 stems per acre.
- Photographs on page 1696 of the paper (see below) are especially useful for visualization purposes.



- Review of data indicates clutter-adapted bats [such as northern long-eared bats] benefit from thinning.

Well-Practiced Silviculture Can Benefit Bats

Guldin, J. M., W. H. Emmingham, S. A. Carter, and D. A. Saugey. 2007. Silviculture practices and management of habitat for bats. Pages 176–205 *in* Bats in Forests: Conservation and Management (M. J. Lacki, J. P. Hayes, A. Kurta, eds.). Johns Hopkins University Press. Baltimore, Maryland. 329 pp.

- Provided an assessment of ways to reduce negative impacts of harvest.
- Noted response of bats to forestry is species-specific and based on preferred habitat.
- Provided guidance on the use of silviculture to create bat habitat including:
  - use of thinning to promote access to highly cluttered stands by foraging bats;
  - use of retentions to maintain and create large trees suitable for foraging;
  - use of tree harvest to promote a mosaic of forest types including types benefiting species targeted for management.
- Noted modern silviculture is substantially more bat-friendly than techniques used as recently as the 1960s.

Pauli, B. P., H. A. Badin, G. S. Haulton, P. A. Zollner, and T. C. Carter. 2015a. Landscape features associated with the roosting habitat of Indiana bats and northern long-eared bats. *Landscape Ecology* 30:2015–2029.

- Used data from prior telemetry studies in combination with presence-only modeling tool to identify areas most likely to be used by northern long-eared and Indiana bats in southern Indiana.
- Models indicated Indiana bats are most likely found in areas with the following characteristics:
    - Heavily forested areas (>80% within 1 Km) within a less forested landscape (<40% forest beyond 1 Km);
    - Within 1 kilometer of perennial streams, but farther than 1 kilometer from intermittent streams;
- Models indicated northern long-eared bats are most likely found in areas with the following characteristics:
    - Heavily forested areas (>80% within 1 Km), but near areas where forest intersects with other landscape types;
    - At least 4 kilometers from a road with a rate of more than two cars per minute.
- Data were subsequently entered into Pauli et al. 2015b (see below).

Pauli, B. P., P. A. Zollner, G. S. Haulton, G. Shao, and G. Shao. 2015b. The simulated effects of timber harvest on suitable habitat for Indiana and northern long-eared bats. *Ecosphere* 6:1–24.

- Created a forest succession model in LANDIS based on parameters developed from the 2015a paper (see above).
- Compared high (60%–100% of biomass harvested annually), medium, and low intensities of harvest.
- Found evidence for trade-off between foraging and roosting habitat with roosting habitat a driving factor.
- Low intensity harvests (90–681 ha per year) maximized foraging habitat for Indiana bats, but minimized foraging habitat for northern long-eared bats.
- Medium-to-high intensity harvests (2,100–7,197 ha per year with up to 4,047 ha per year of single-tree selection) maximized foraging habitat by creating openings, but maximized roosting habitat using selective harvests.
- Habitat for both species could be maintained by implementing a mosaic of harvest regimes featuring retention of potential roost trees.
- Elimination of harvest would, in the long term, negatively impact both species.

Sheets, J. J., J. O. Whitaker Jr., V. Brack Jr., and D. W. Sparks. 2013. Bats of the hardwood ecosystem experiment before timber harvest: assessment and prognosis. Pages 191-202 *in* The Hardwood Ecosystem Experiment: a framework for studying responses to forest management (R. K. Swihart, M. R. Saunders, R. A. Kalb, G. S. Haulton, C. H. Michler, eds.). General Technical Report NRS-P-108. U.S. Department of Agriculture, Forest Service, Northern Research Station. Newtown Square, Pennsylvania.

- Summarized known records of bats on two state forests in Indiana comprising the subject of ongoing timber harvest and research for the subsequent 100 years.
- Projected potential impacts of different silviculture systems on bat habitat based on expected harvest prescriptions (subsequently changed) and known habitat associations with bats.
- Provided diagrams of the interactions between different harvest types and habitat quality over multiple periods of time.
- Noted activities that improve foraging habitat often lead to a decline in roosting habitat and vice/versa.

Silvis, A., W. M. Ford, E. R. Britzke, N. R. Beane, and J. B. Johnson. 2012. Forest succession and maternity day roost selection by *Myotis septentrionalis* in a mesophytic hardwood forest. International Journal of Forestry Research. 8 pp.

- Compared roost locations of northern long-eared bats to historic timber harvests.
- Noted current habitat appears to be high quality for target bats.
- Continued application of diameter-width harvests will lead to a decline in habitat quality across the region.
- Implementation of more aggressive silviculture techniques can reverse the decline.

Silvis, A., R. W. Perry, and W. M. Ford. 2016. Relationships of three species of bats impacted by white-nose syndrome to forest condition and management. General Technical Report SRS-214. U.S Department of Agriculture, Forest Service, Research & Development Southern Research Station. 57 pp.

- Provided a review of known case studies regarding bat response to silviculture for northern long-eared, Indiana, and tricolored bat.
- Assessed potential changes for a variety of treatments on each species.
- Noted that forest management should be viewed as a habitat disturbance.

- Timber harvest can benefit bats via retention of suitable roosts, creating foraging habitat, and directing stand development toward conditions more desirable for a given target species.
- Timber harvest can also negatively impact bats if roosts or foraging habitat is removed or stand development is directed toward conditions less desirable for a given target species.

Mitigation Approaches Can Positively Affect Bats

Sparks, D. W., V. Brack, Jr., J. O. Whitaker, Jr., and R. Lotspeich. 2009. Reconciliation ecology and the Indiana Bat at Indianapolis International Airport, Chapter 3. *in* Airports: Performance, Risks, and Problems, (P. B. Larauge and M. E. Castille, eds.). Nova Science Publishers, Inc., Hauppauge, New York.

- A multi-disciplinary review of habitat management efforts associated with the first HCP permitting take of Indiana bats.
- Synthesized multiple published studies from the site with unpublished observations including data on all species covered under the MDC HCP.
- Documented successful management efforts.
- Noted successful mitigation efforts can be measured in a variety of ways including:
    - Allowing economic activity otherwise not allowed;
    - Use of restoration areas by a variety of wildlife (including bats of multiple species);
    - Completion of research projects informing future management decisions;
    - Indiana bats and several other species made extensive use of young forests for foraging.

Documented Effects of Other Covered Activities

Effect of Large Roads on Bats

Bennett, V., D. W. Sparks, and P. A. Zollner. 2013. Modeling the indirect effects of road networks on the foraging activities of endangered bats. Landscape Ecology 28:979–991.

- Used data from previous studies of bats at Indianapolis International Airport to parameterize a model exploring how habitat quality and traffic levels influence the ability of bats to move through a landscape.
    - The model allowed bats to interact with multiple levels of traffic.
    - Roads with more than two vehicles per minute (at night) restricted the ability of bats to cross a road.

    - Roads with more than 40 vehicles per minute (at night) were impassible to bats.
    - Other important factors included the physical size of the roadway and habitat quality on the other side.
- To negatively affect bat movements, roads must be either very large in size or have regular traffic.

Prescribed Fire Benefits Bats

Boyles, J. G., and D. P. Aubrey. 2006. Managing forests with prescribed fire: implications for a cavity-dwelling bat species. *Forest Ecology and Management* 221:108–115.

- The authors comprised two biologists working on the same managed forest (a mix of oak/hickory and glades) in Missouri—one studying fire ecology the other studying bat roosting biology, especially the evening bat.
- Compared locations of known roosts to areas subjected to prescribed fire.
- Found bats were much more likely to roost in burned areas where fire created roosts by killing and damaging trees.
- Based on known roosting preferences of other species of bats (especially the Indiana bat), noted this pattern could be generalized across most bark and cavity-roosting bats.
- Fires created roosts and improved foraging habitat by removing clutter.

Ford, W. M., A. Silvis, J. B. Johnson, J. W. Edwards, and M. Karp. 2016. Northern long-eared bat day-roosting and prescribed fire in the central Appalachians, USA. *Fire Ecology* 12:13–27.

- A paper reviewing the impacts of prescribed fire on bats.
- Noted that lethal take may occur and is most likely with a hot fire during times when bats are slow to arouse.
- Noted that prescribed fire (and associated control measures) can remove some potential roosts (suitable black locusts declined over time).
- Additional potential roosts are created by the fire (suitable maples increased by more than three-fold and were also more likely used by colonies of bats).
- The balance between roost creation and destruction is tied to the prior history of the stand, as the stands had been without fire for 50 years, allowing establishment of fire intolerant species. The authors noted rapid, successional fires (often used when fire is reintroduced) may result in a short-term loss of roosts by removing fire-intolerant species from the stand.

- Prescribed fire may also stimulate understory vegetation, remove clutter, and enhance foraging habitat.

Forest Management in Missouri

Missouri Department of Conservation. 2014. Missouri Forest Management Guidelines: Voluntary recommendations for well-managed forests. Missouri Department of Conservation, Jefferson City, Missouri. 236 pp.

Provides an overview of how forests in Missouri can be managed for a wide variety of resources including protected bats.

Final Comments

Please note many of these publications are review papers, and the ICF team also reviewed most literature cited in the papers. Specific papers regarding habitat selection are included in the species accounts contained in Chapter 3.

If you have any questions or we can be of further assistance, please let us know.

Sincerely,

Dale W. Sparks, PhD
Senior Project Manager
DSparks@ENVSI.com
Mobile: 513.503.2667

Appendix E
Priority Bat Management Zones

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The priority bat management zones (PBMZs) will total at least 28,000 acres with an approximately equal share of acres targeted at each of the four covered tree-roosting species (i.e., about 7,000 acres each). The PBMZ development process includes three basic steps.

- Identify areas with the highest probability of maternity activity occurrence for each species.
- Overlay the locations of high probability of maternity activity occurrence with lands owned and managed by Missouri Department of Conservation (MDC).
- Refine the boundaries to consider local constraints and a balance with other MDC priorities.

Identification of locations with the highest probability of occurrence of summer maternity activities for each species is accomplished as described in this Appendix.

- Perform a geospatial kernel density interpolation of the point data for summer maternity activity of the four bat species using a neighborhood value of 5 miles (based on the known flight distance of Indiana bats) and a cell size of 30 meters.
- Determine the mean value of the resulting kernel density output and reselect for values above the mean to refine the results to those areas most likely to contain the target species.

Examine the locations with the highest probability of summer maternity activity for each species in relation to the location of lands owned and managed by MDC to focus on areas that might provide habitat suitable for PBMZs.

Identify preliminary PBMZs for each species and rank them based on the following criteria.

- Proximity to known maternity roost trees (for species with no recorded maternity roosts use proximity to high-value kernel density areas).
- Presence of suitable habitat based on aerial imagery and the in-field experience of MDC biologists.
- Presence of factors that would affect the ability to practice avoidance, such as areas with site conditions that are not conducive to work within the seasonal restrictions.
- Presence of sites dedicated to other high-priority MDC initiatives (e.g., grassland restoration or long-term research projects that would conflict with PBMZ requirements).
- Ability to reasonably maintain habitat in the PBMZ through natural disturbances (such as hydrologic events) or management activities.
- Distribution of PBMZs throughout the state.
- Expert opinion of MDC bat biologists familiar with bat habitat needs, current information, and undocumented maternity colonies or captures.
- Input from USFWS Missouri Field Office where acceptable and feasible.

Once identified, refine PBMZ boundaries using aerial imagery, roost point data, and boundaries of MDC units including forestry compartments, natural areas, roads, landmarks and buffered second order or higher streams. This process results in PBMZs that meet the biological need (i.e., protection of important bat habitat) and can be reliably recognized by MDC and contractor staff while in the field. The PBMZs are illustrated in *PBMZ Figures* and described in Table E-1.

Table E-1. Acres of MDC Priority Bat Management Zones by Covered Species

Species	Number of PBMZs	Total Acres within the PBMZs	Number of Overlapping PBMZs[a]	Number of PBMZ Acres That Are Overlapping[a]
Indiana Bat	8	7435.24	1	1,648
Little Brown Bat	10	7013.38	5	6,847
Northern Long-Eared Bat	6	7082.23	1	1,395
Tricolored Bat	7	7082.68	4	5,221
Total Acreage of PBMZs	31	**28613.54**	–	–

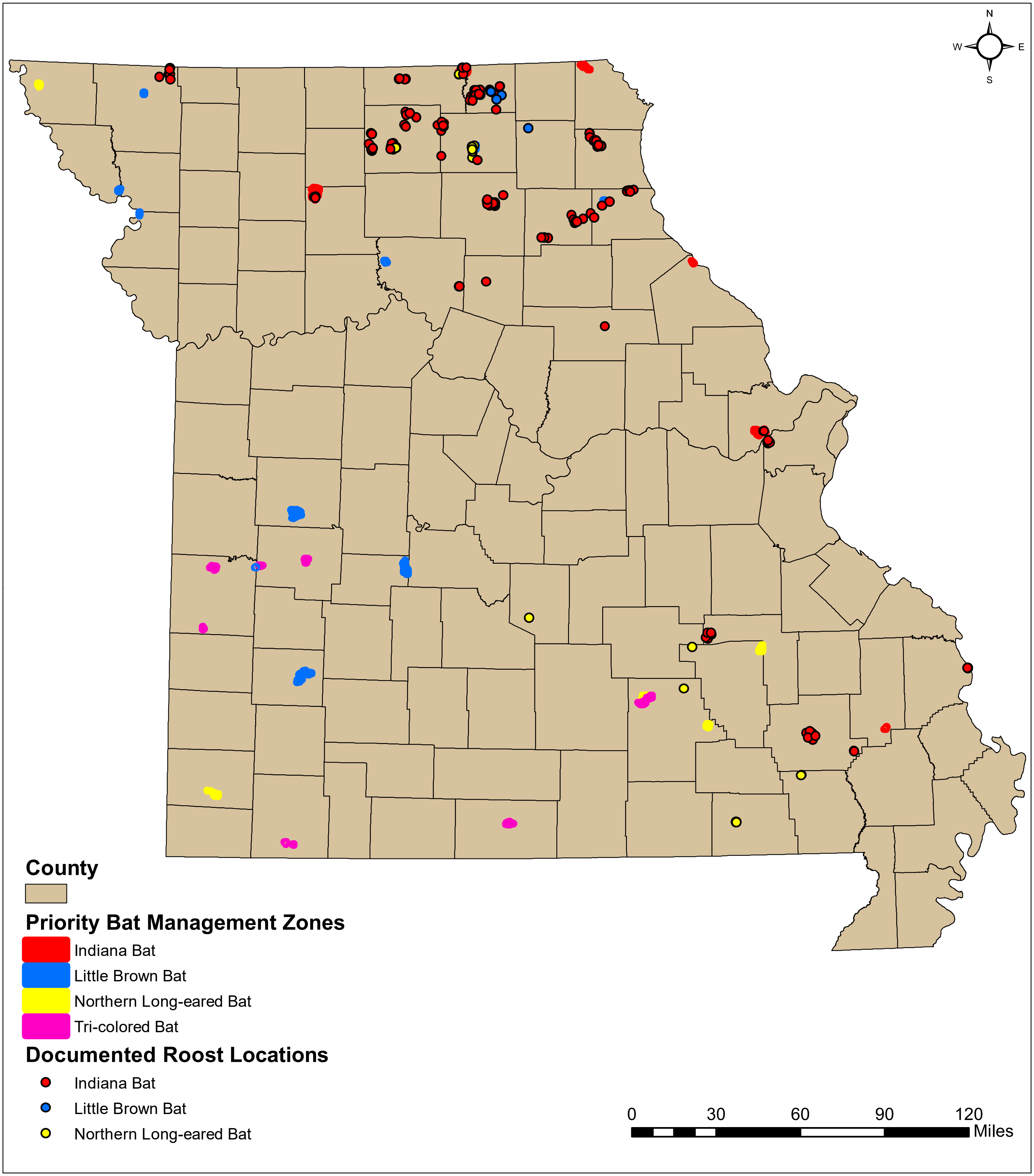
[a] Overlapping occurs when a PBMZ targeted for one species also contains high priority areas for additional covered species. For example, areas protected for the Indiana bat at Deer Ridge Conservation Area also contain summer roosts of northern long-eared bats and capture sites of little brown and tricolored bats.

PBMZ = priority bat management zone

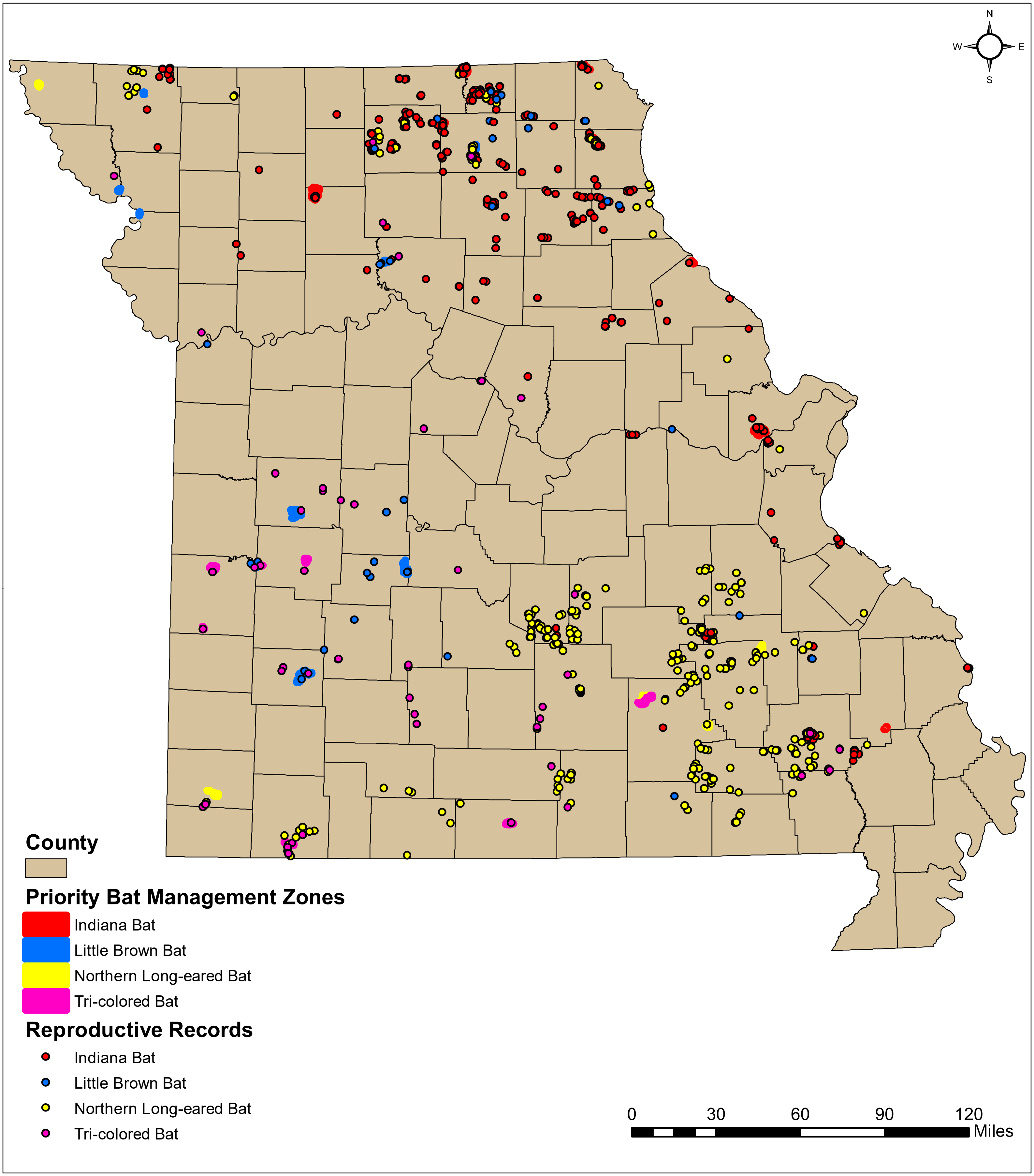
It is foreseeable that bats may shift from the current PBMZs into adjacent areas where active management has created habitat of higher suitability. As such, the adaptive management program provides for revision of the PBMZs every 10 years in coordination with the U.S. Fish and Wildlife Service.

PBMZ Figures

Missouri Department of Conservation Habitat Conservation Plan - Priority Bat Management Zones and Documented Roost Locations

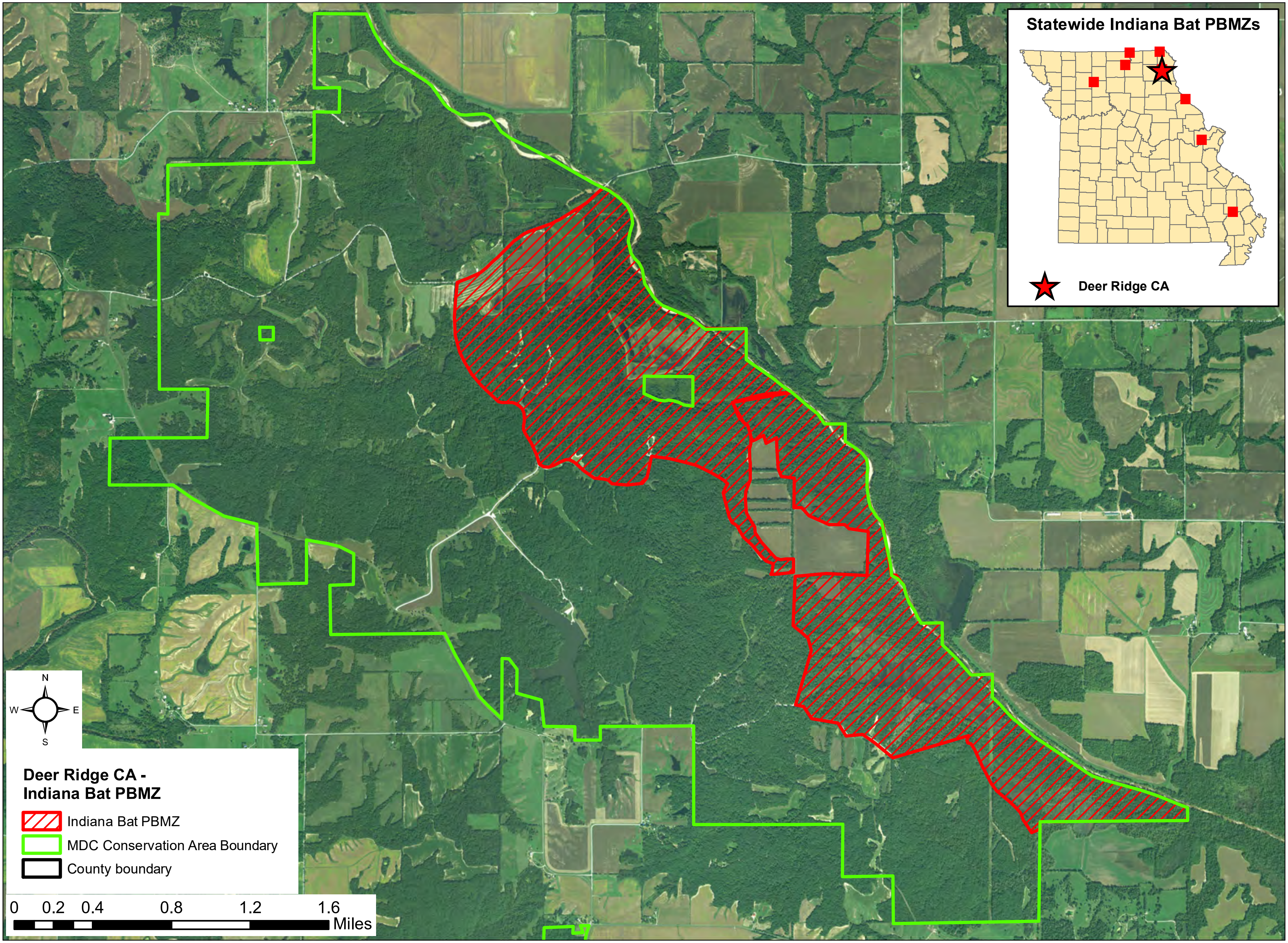


Missouri Department of Conservation Habitat Conservation Plan - Priority Bat Management Zones and Species Reproductive Records*

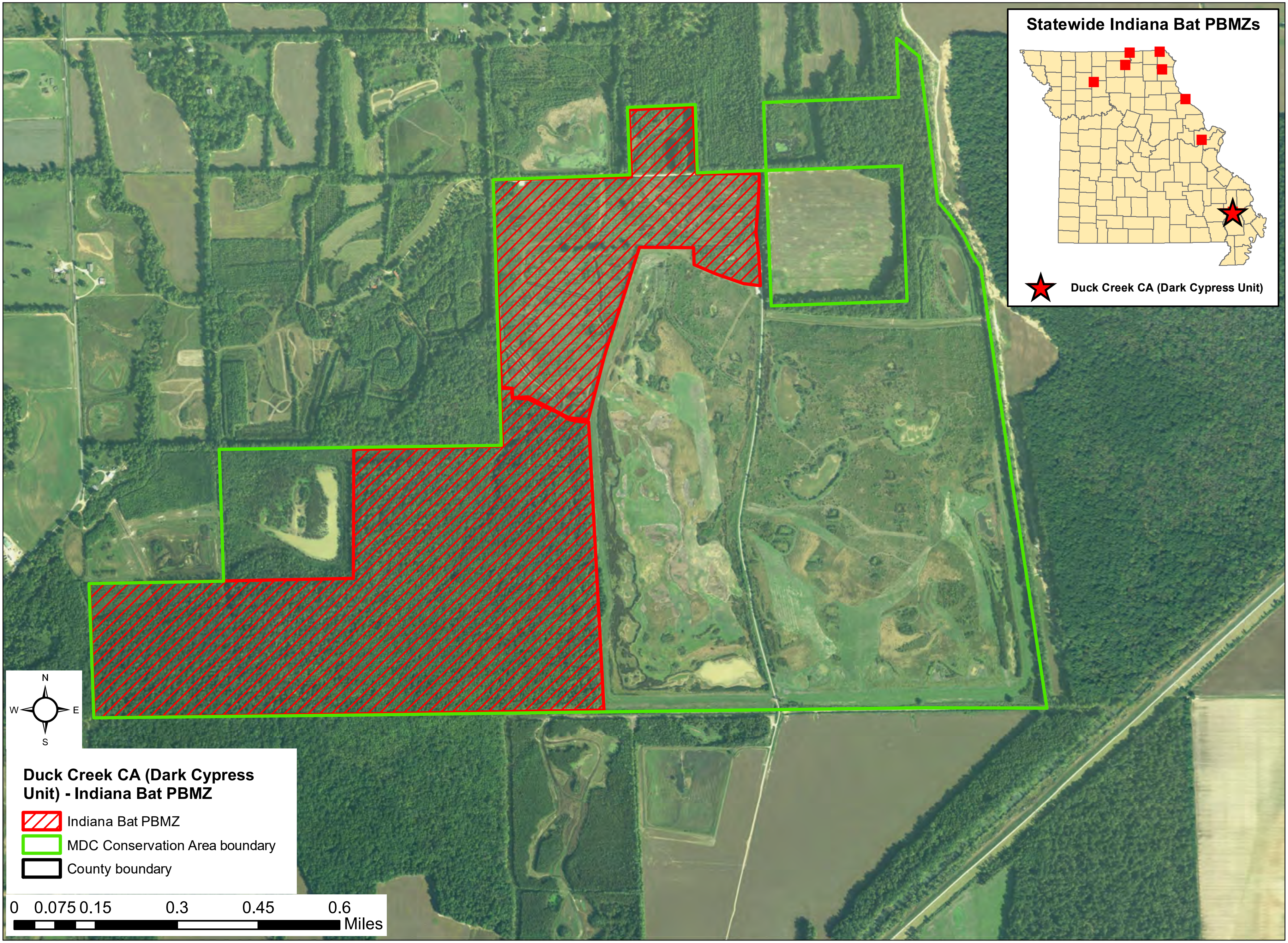


* Reproductive records include documented roost tree locations, captures of adult females between May 15 and August 15, and captures of juveniles before August 15.

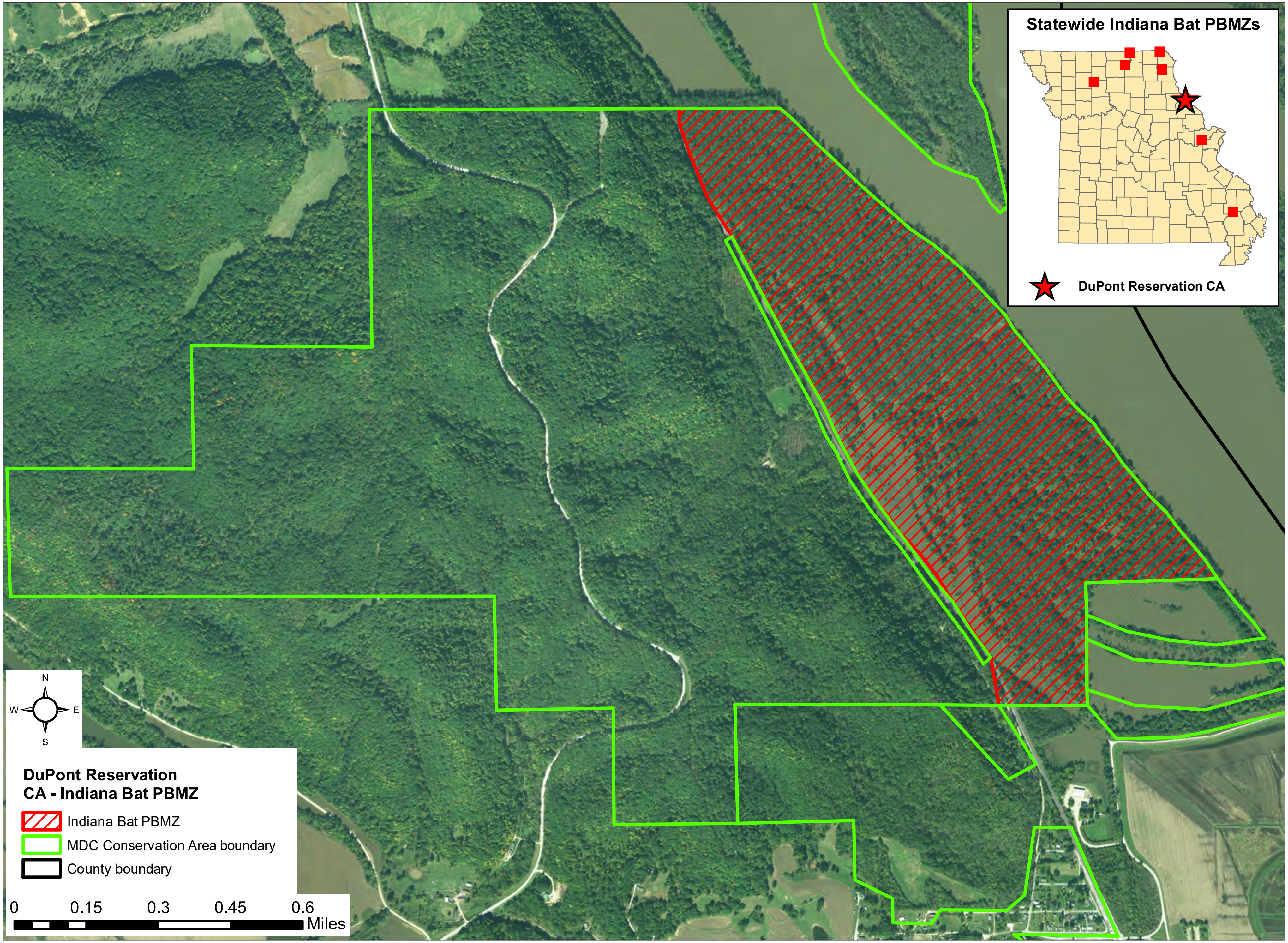
Missouri Department of Conservation Habitat Conservation Plan - Priority Bat Management Zones



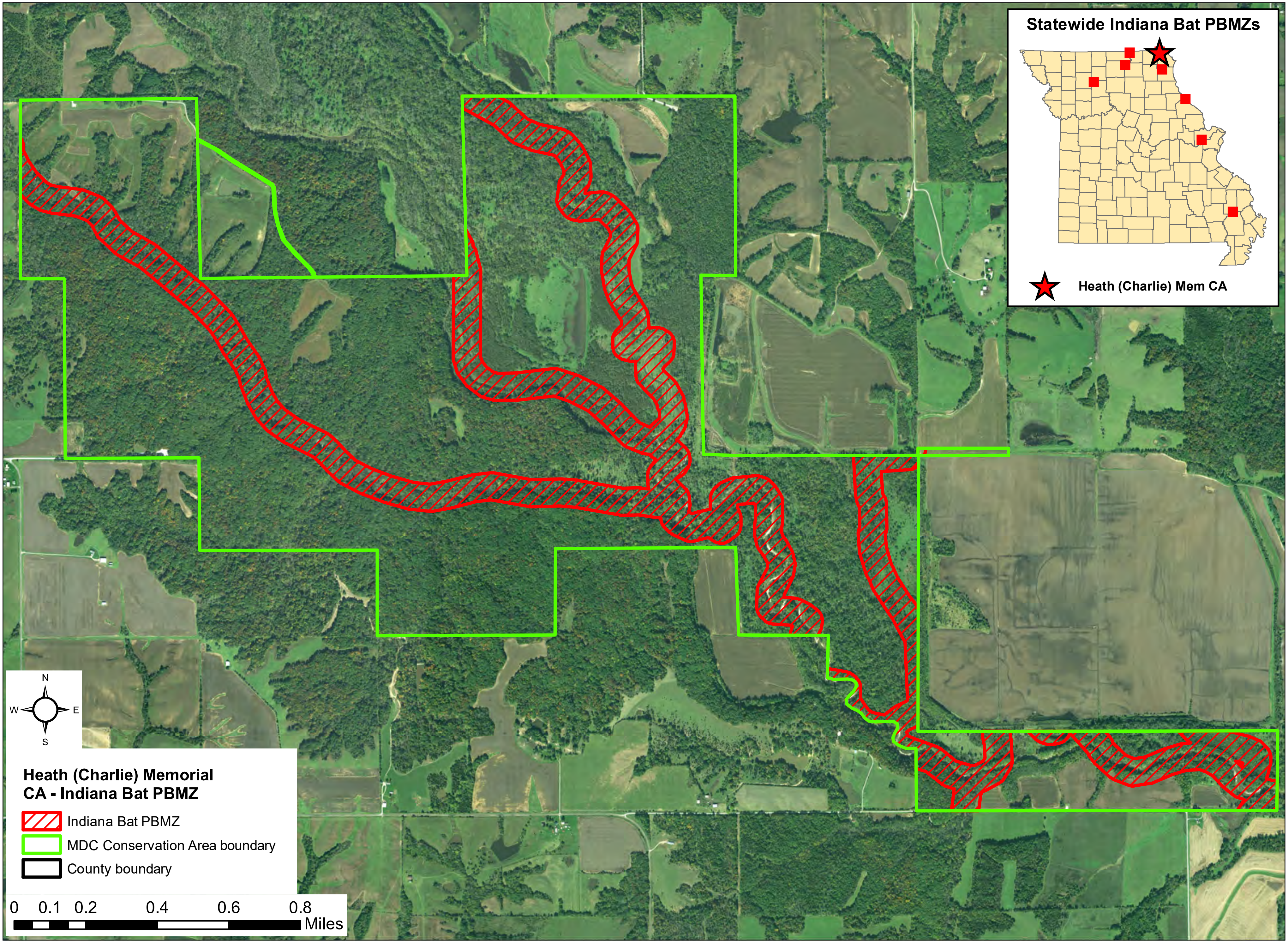
Missouri Department of Conservation Habitat Conservation Plan - Priority Bat Management Zones



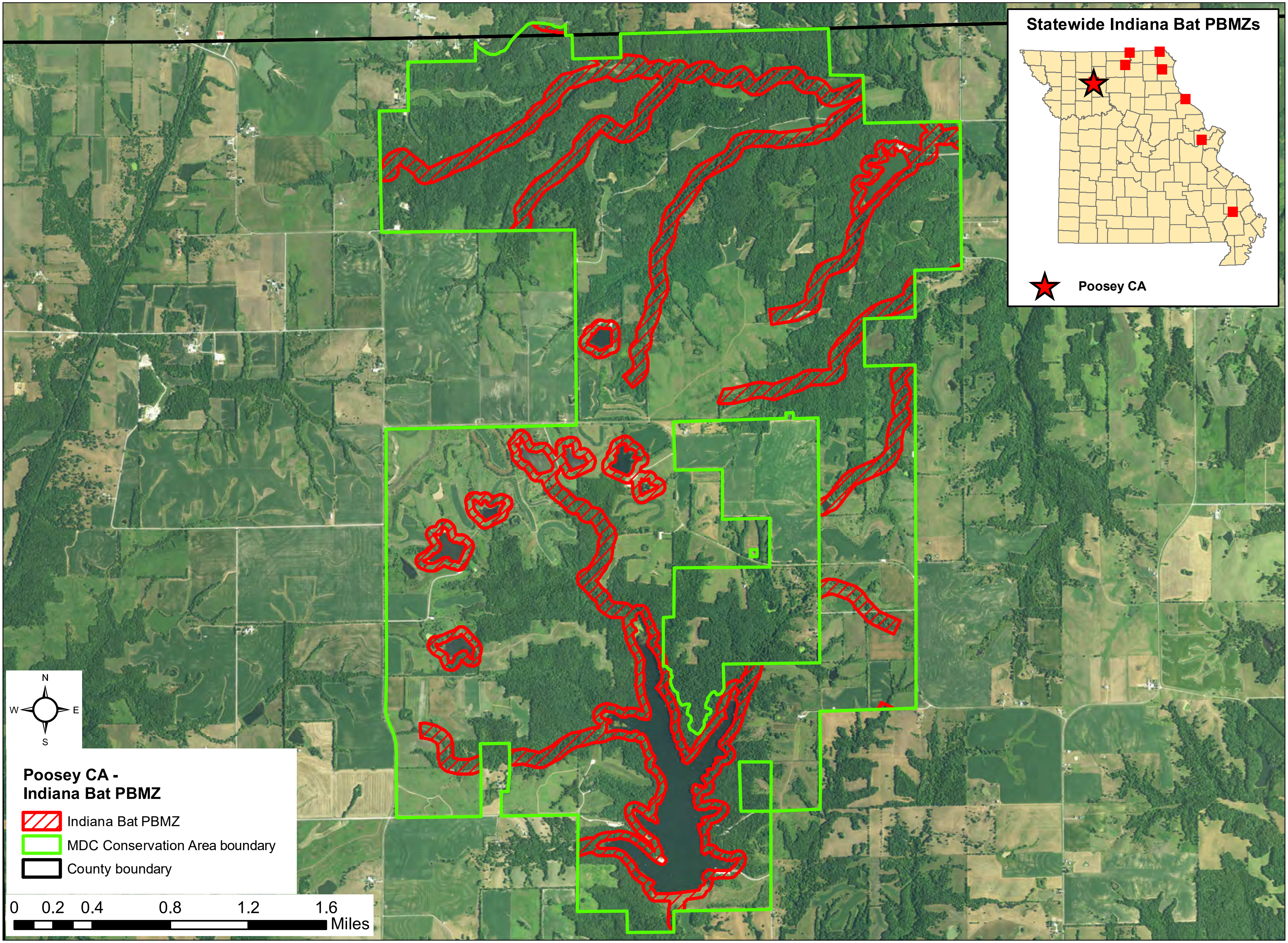
Missouri Department of Conservation Habitat Conservation Plan - Priority Bat Management Zones



Missouri Department of Conservation Habitat Conservation Plan - Priority Bat Management Zones



Missouri Department of Conservation Habitat Conservation Plan - Priority Bat Management Zones



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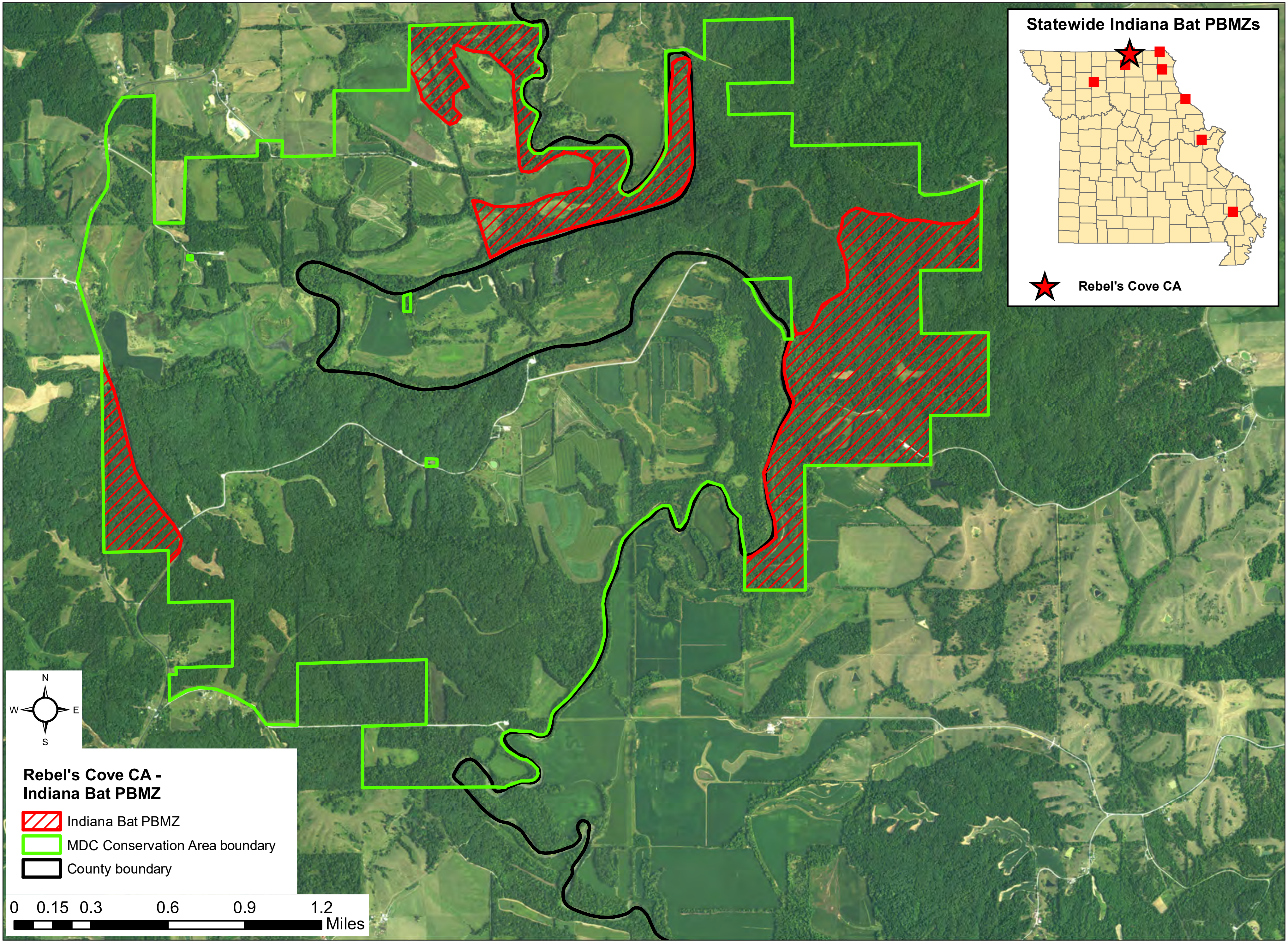

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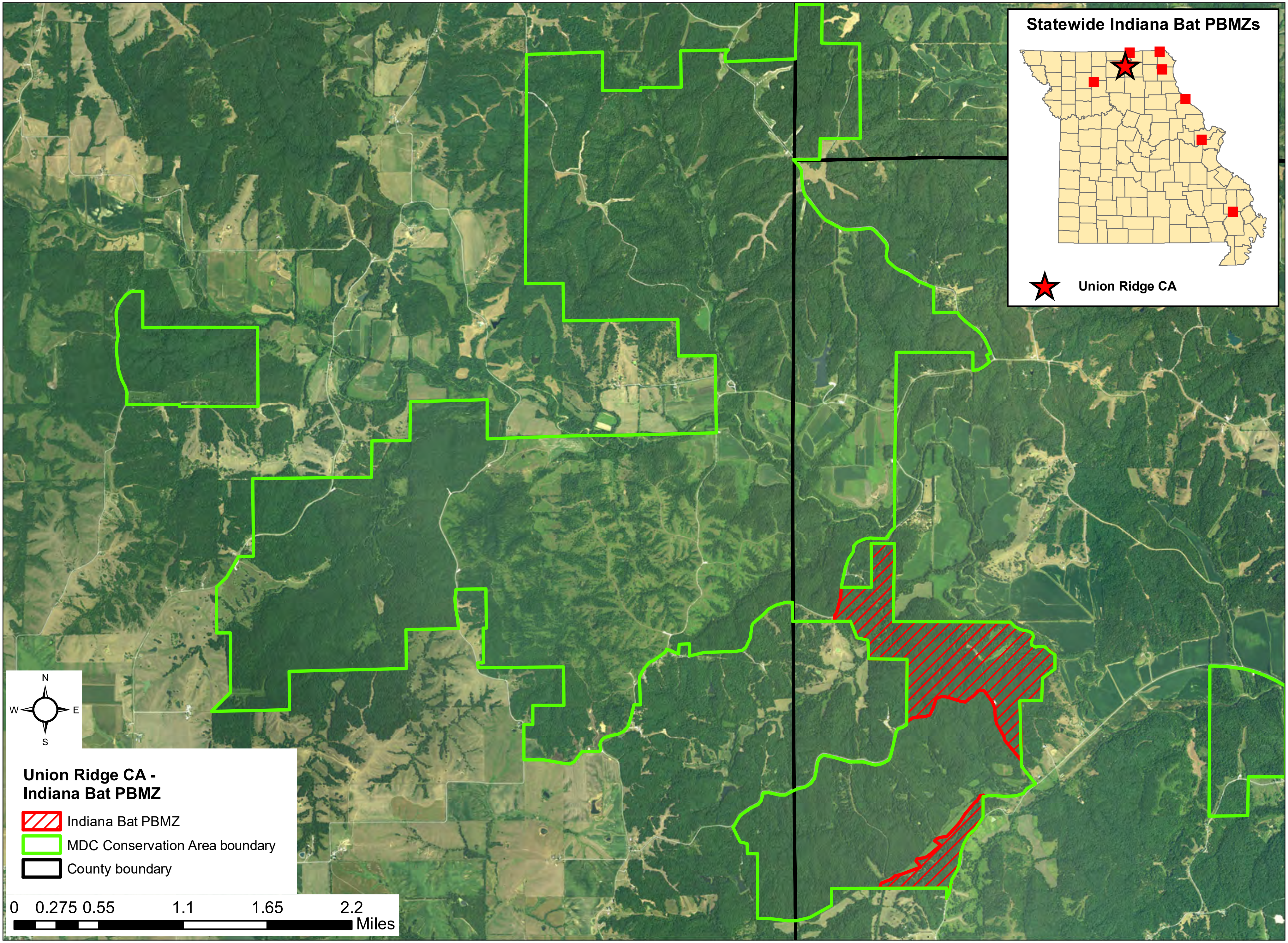

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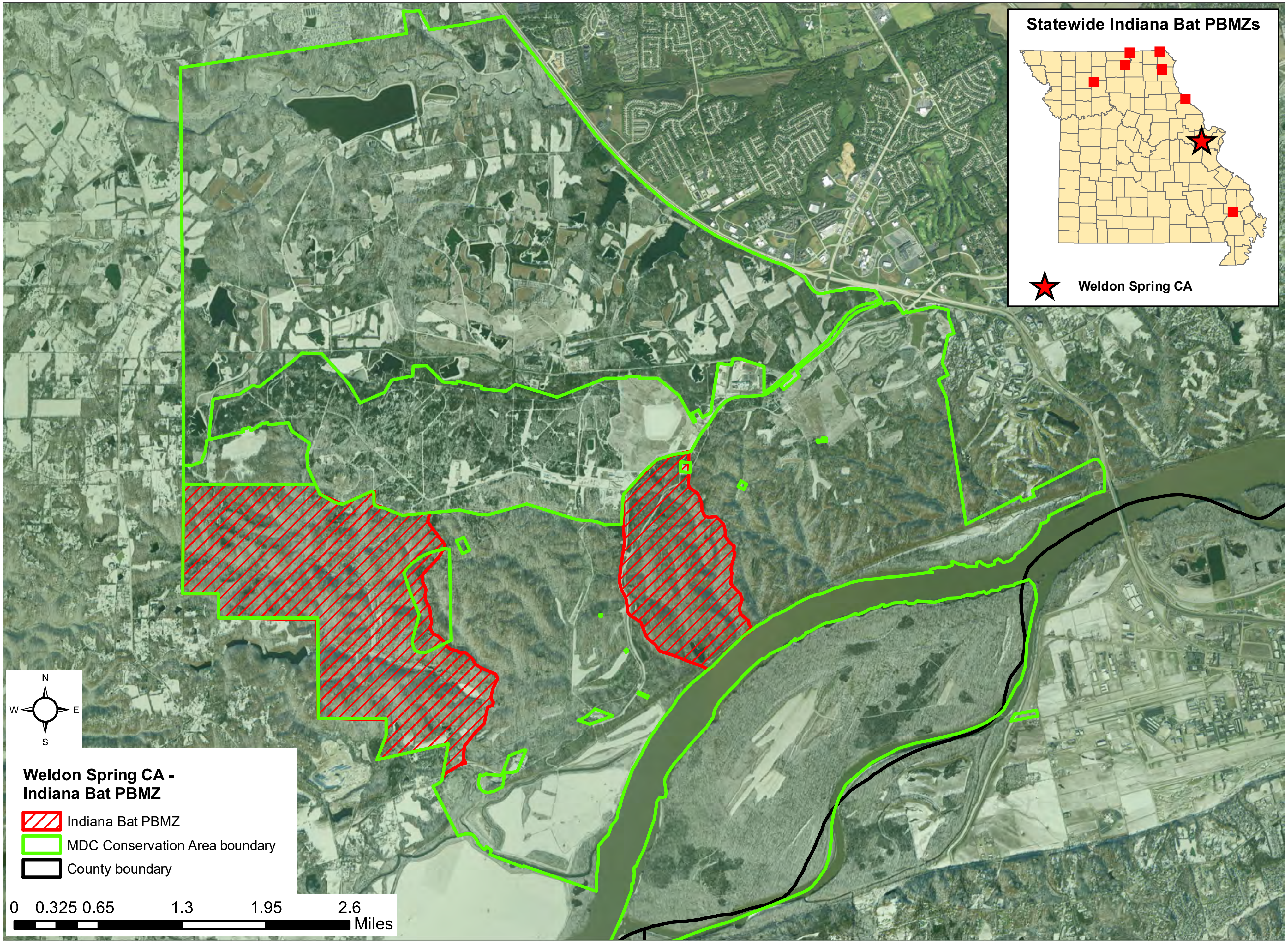

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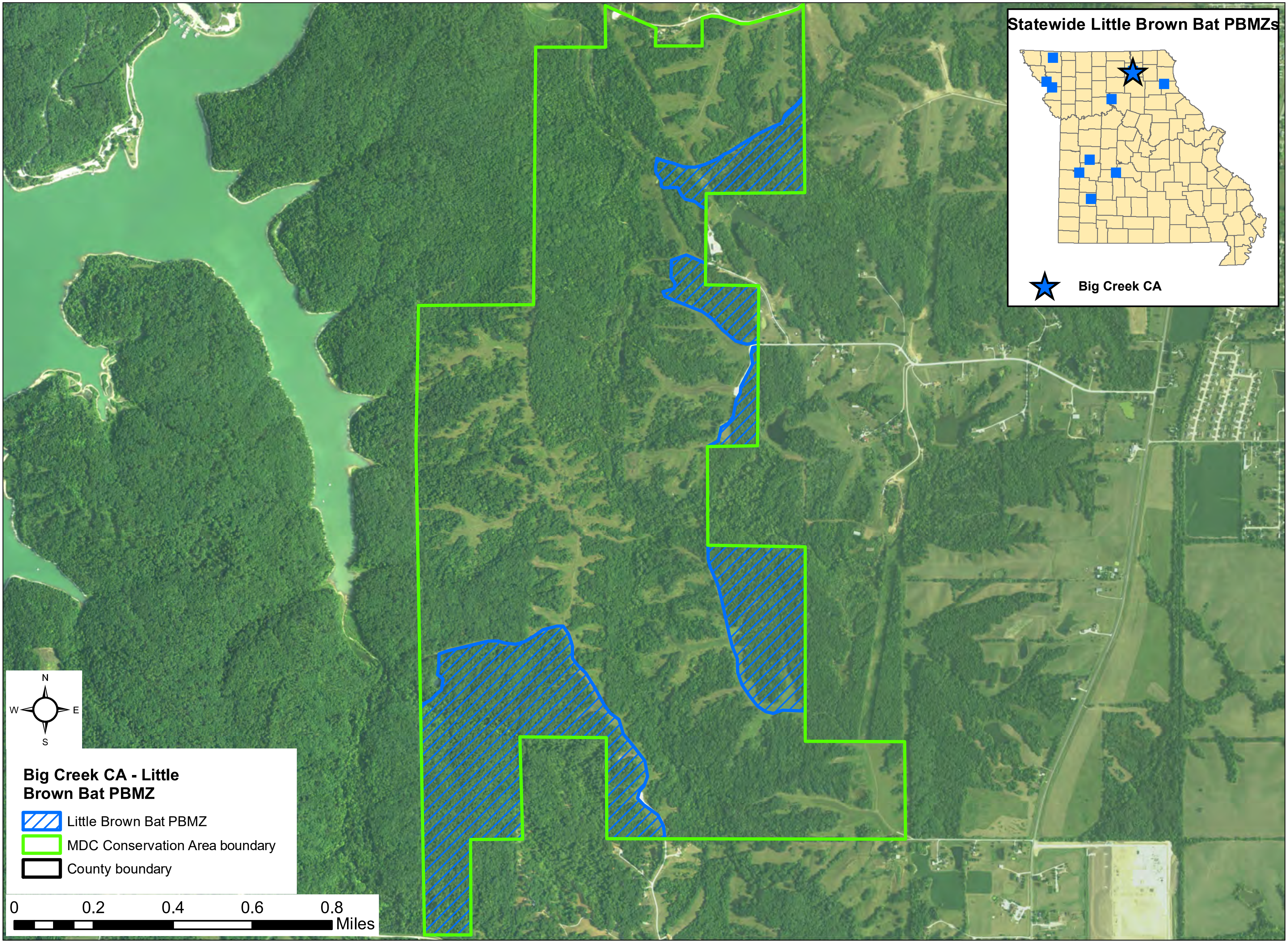

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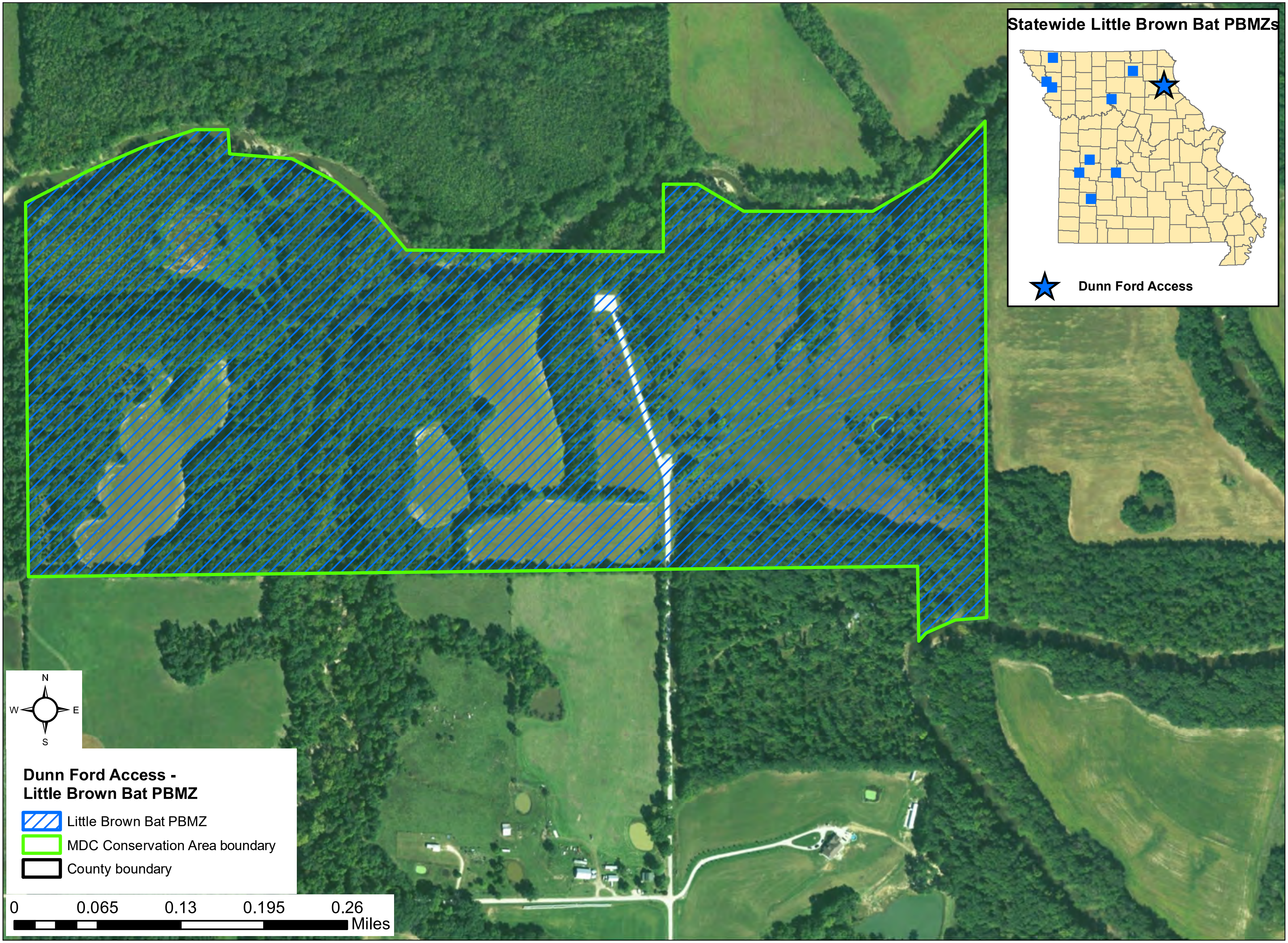

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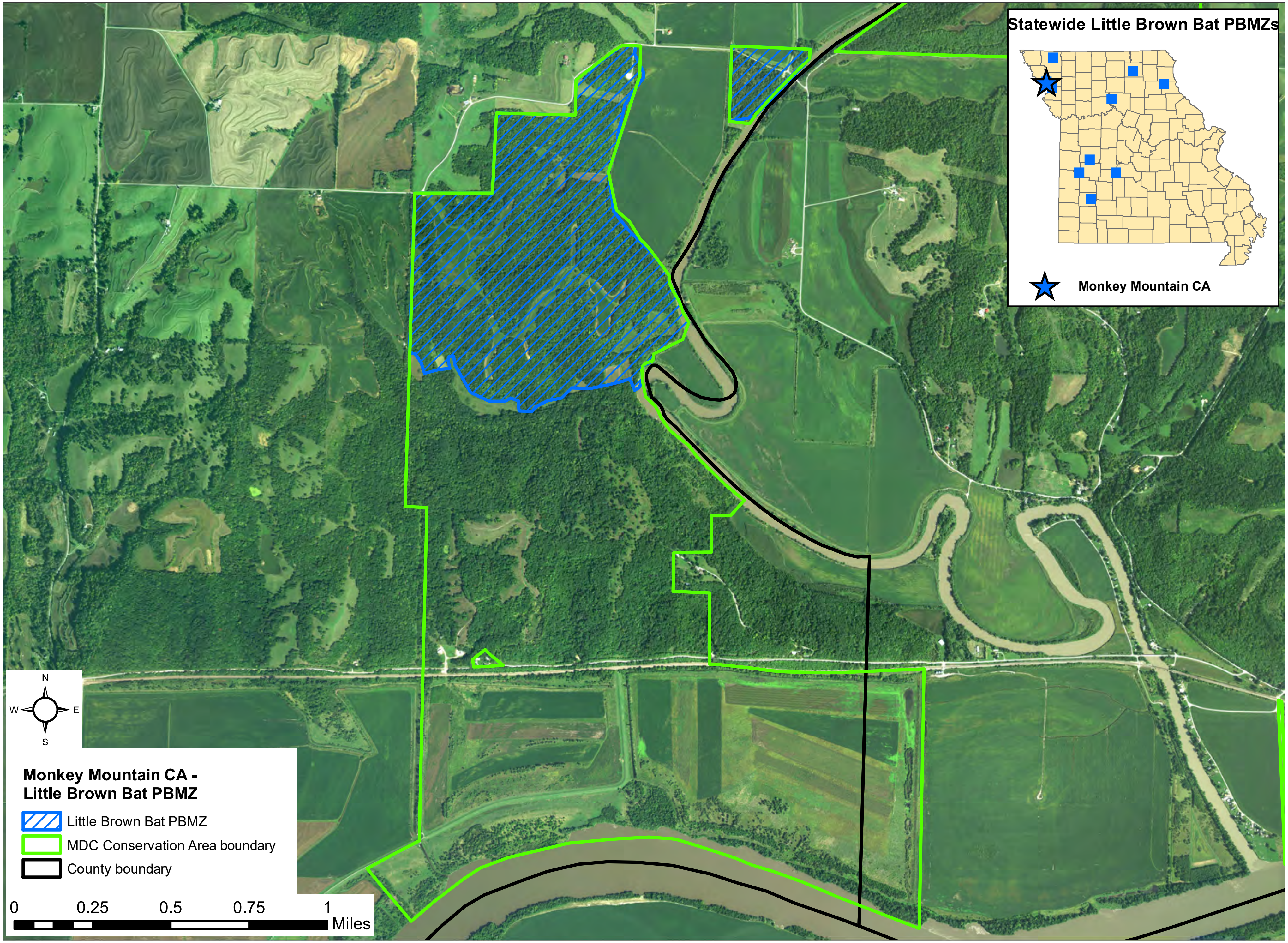

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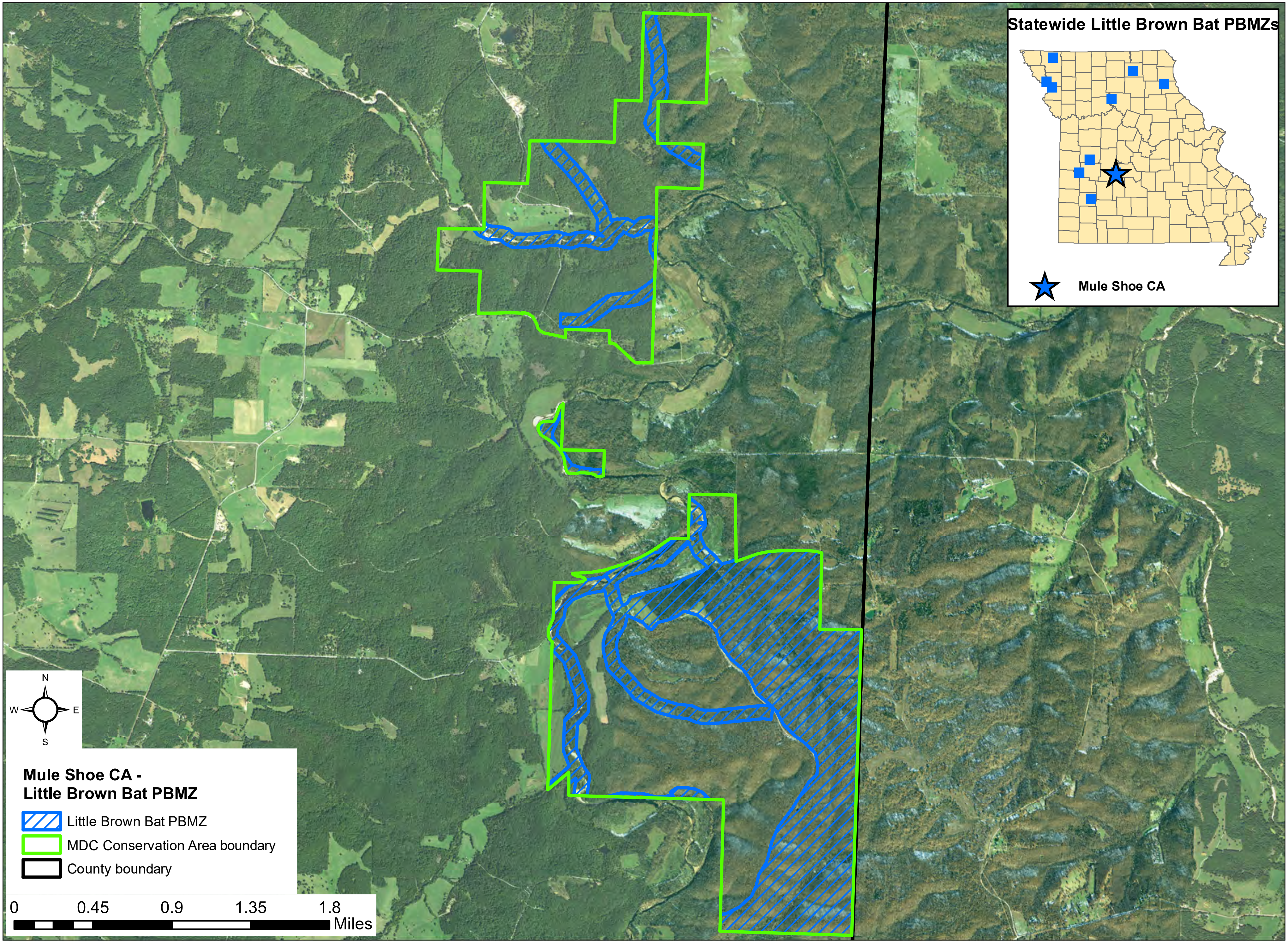

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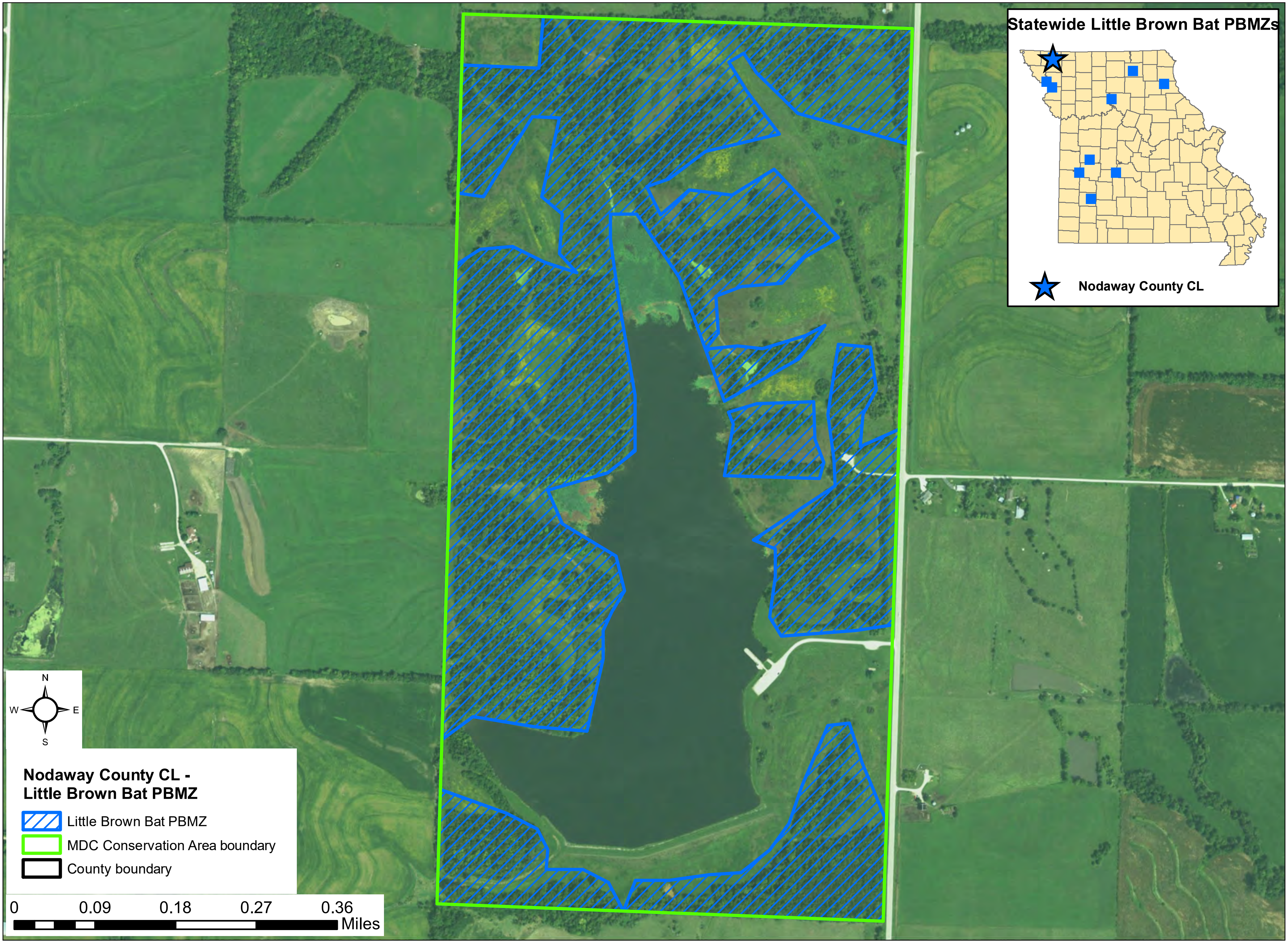
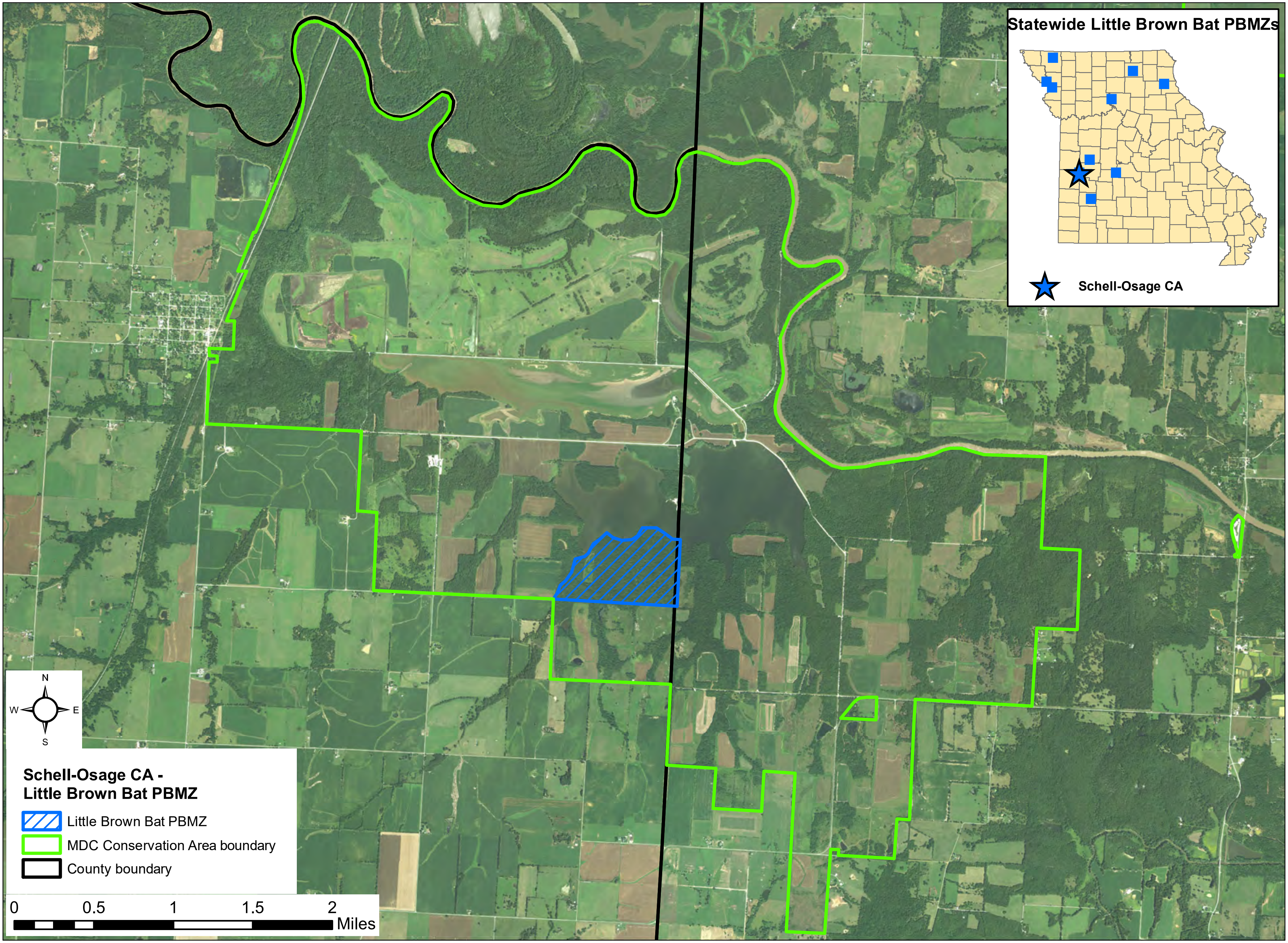
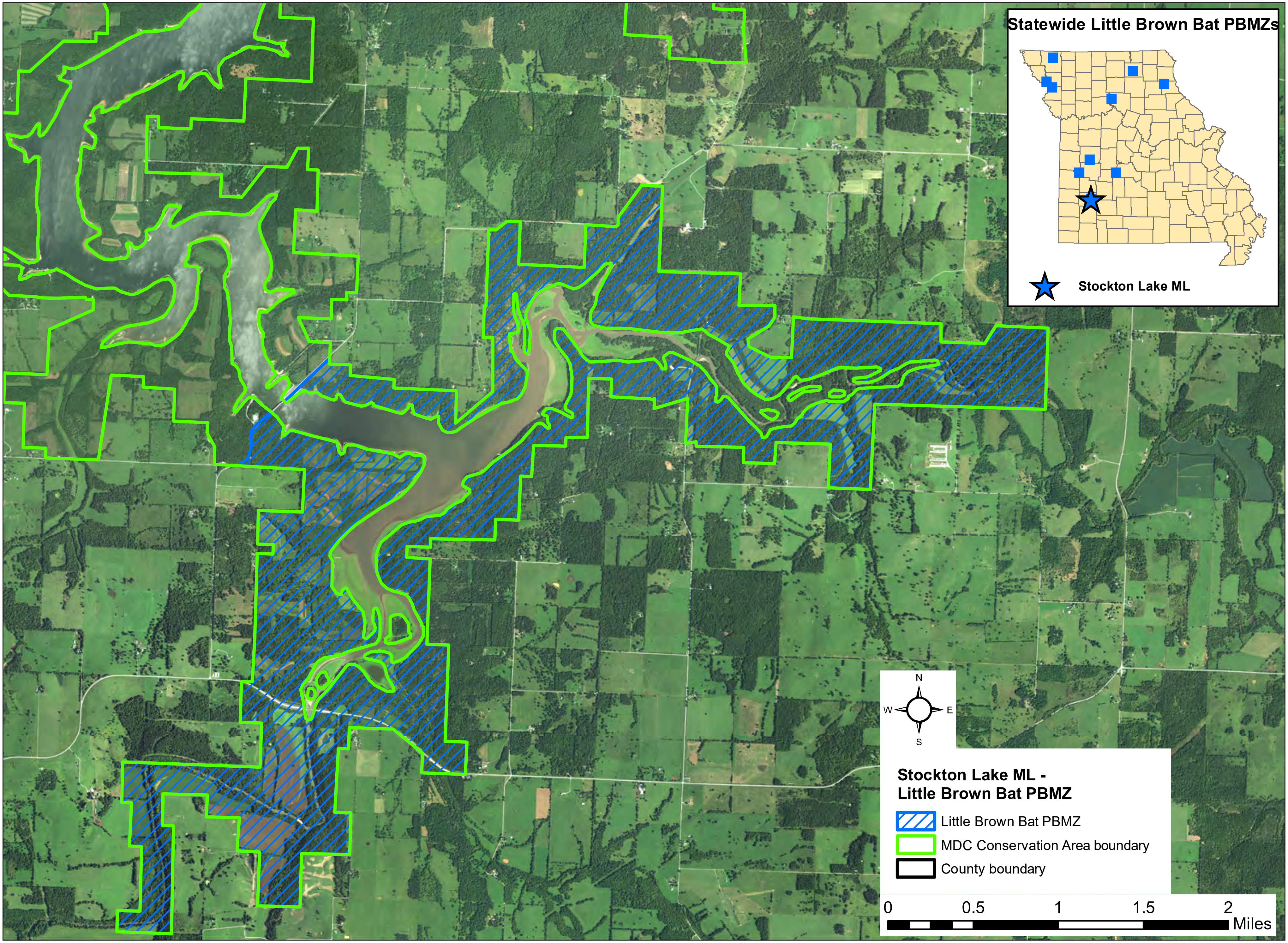


Missouri Department of Conservation Habitat Conservation Plan - Priority Bat Management Zones



Missouri Department of Conservation Habitat Conservation Plan - Priority Bat Management Zones



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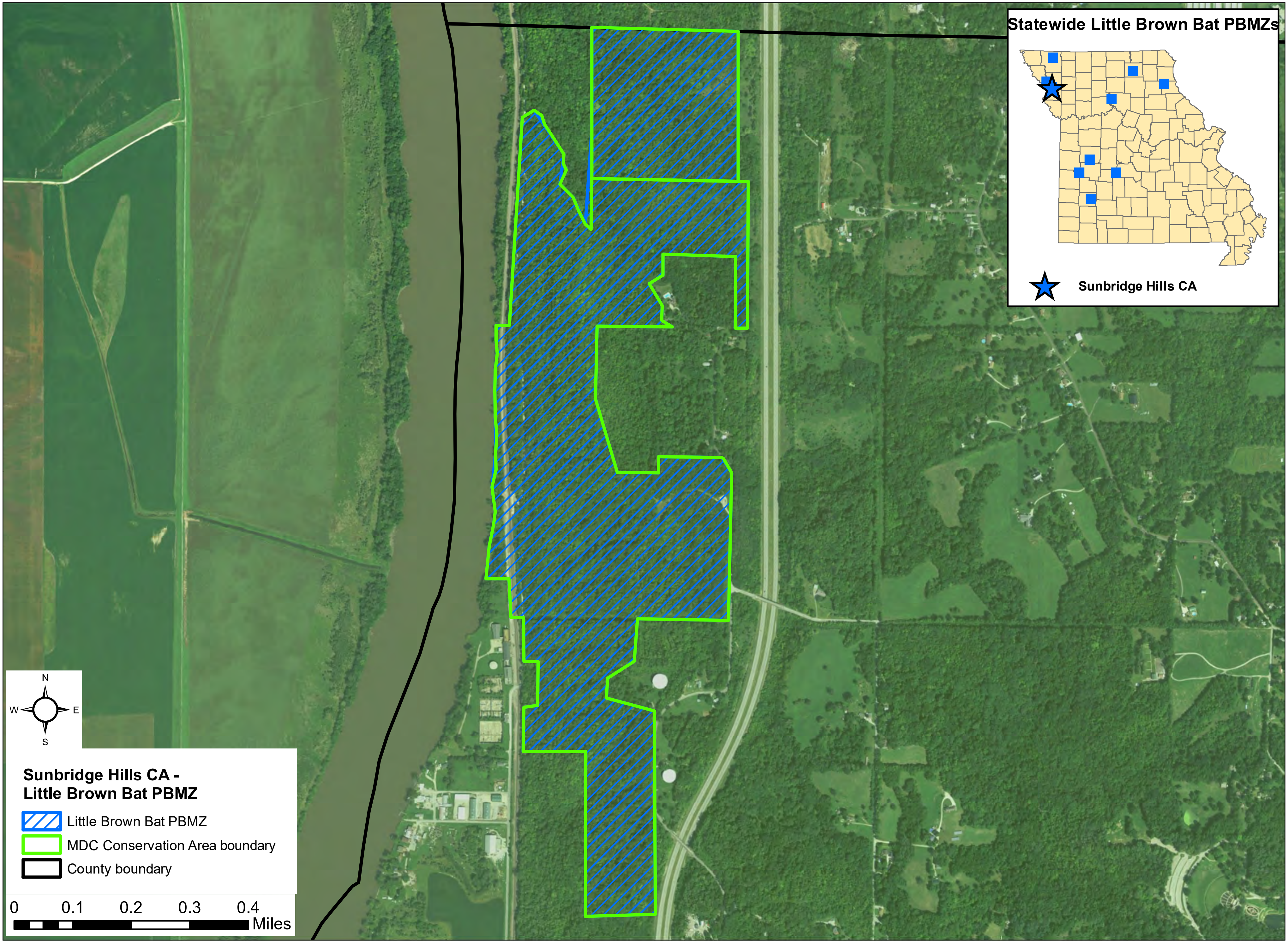

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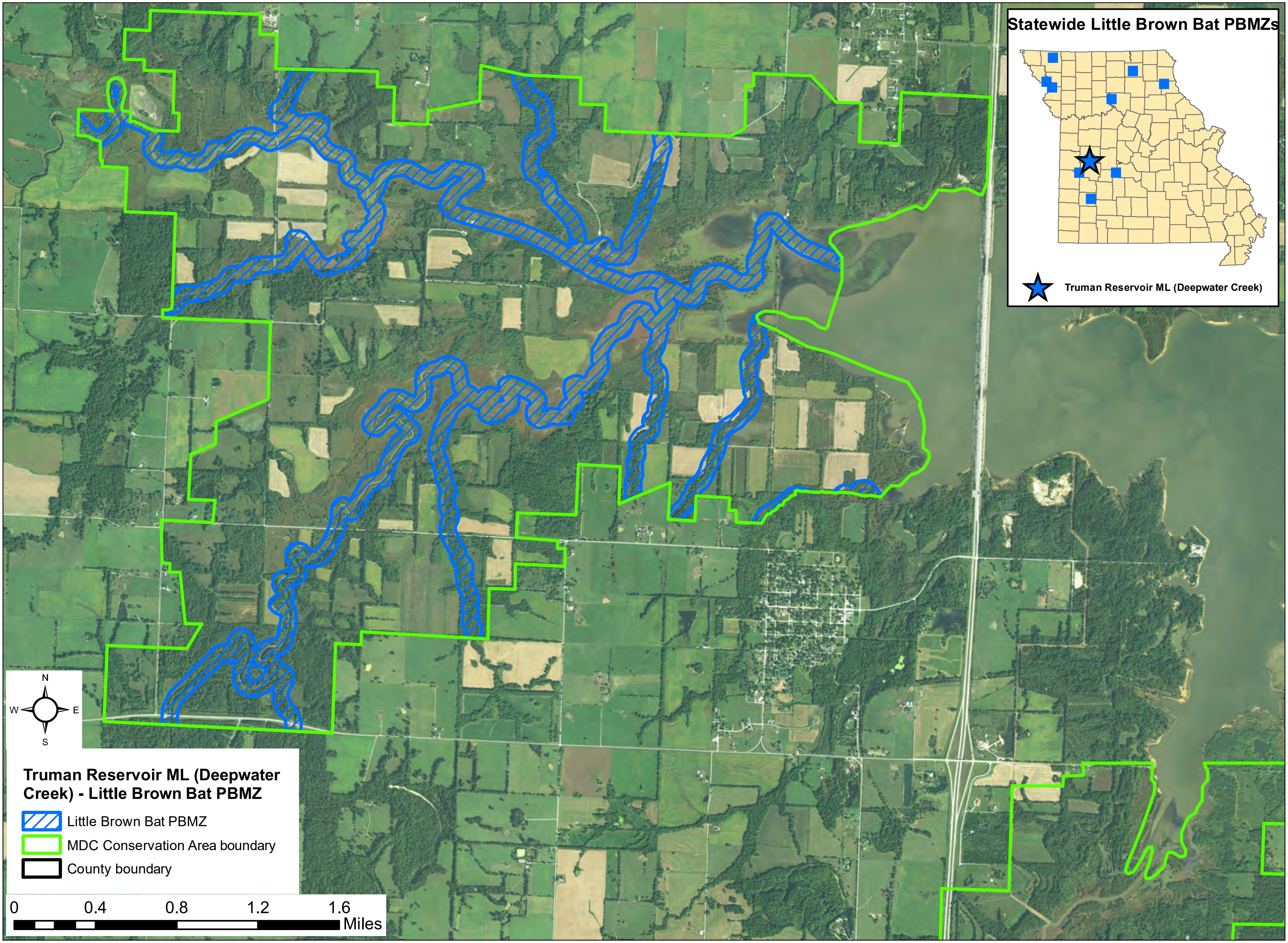

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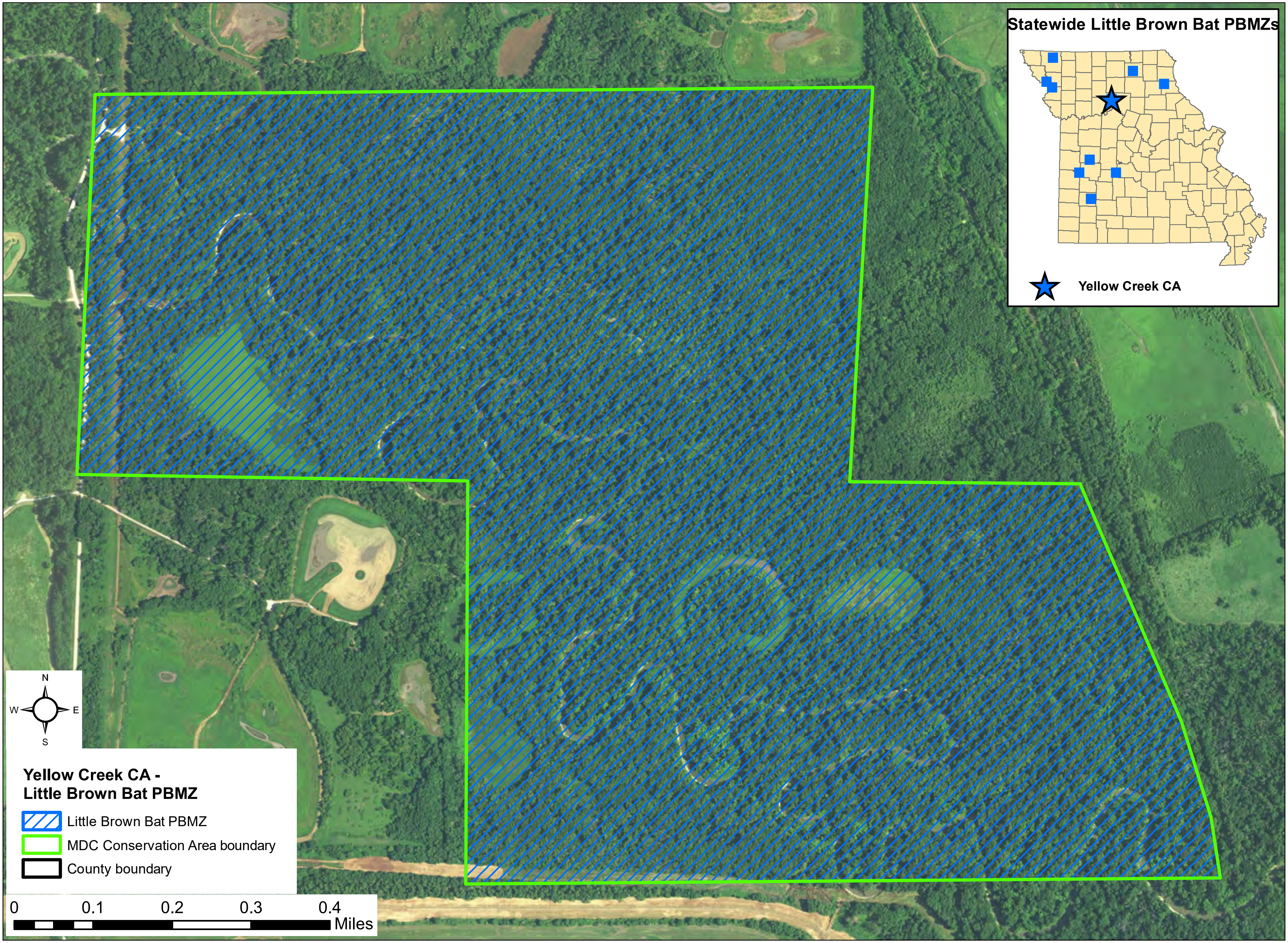

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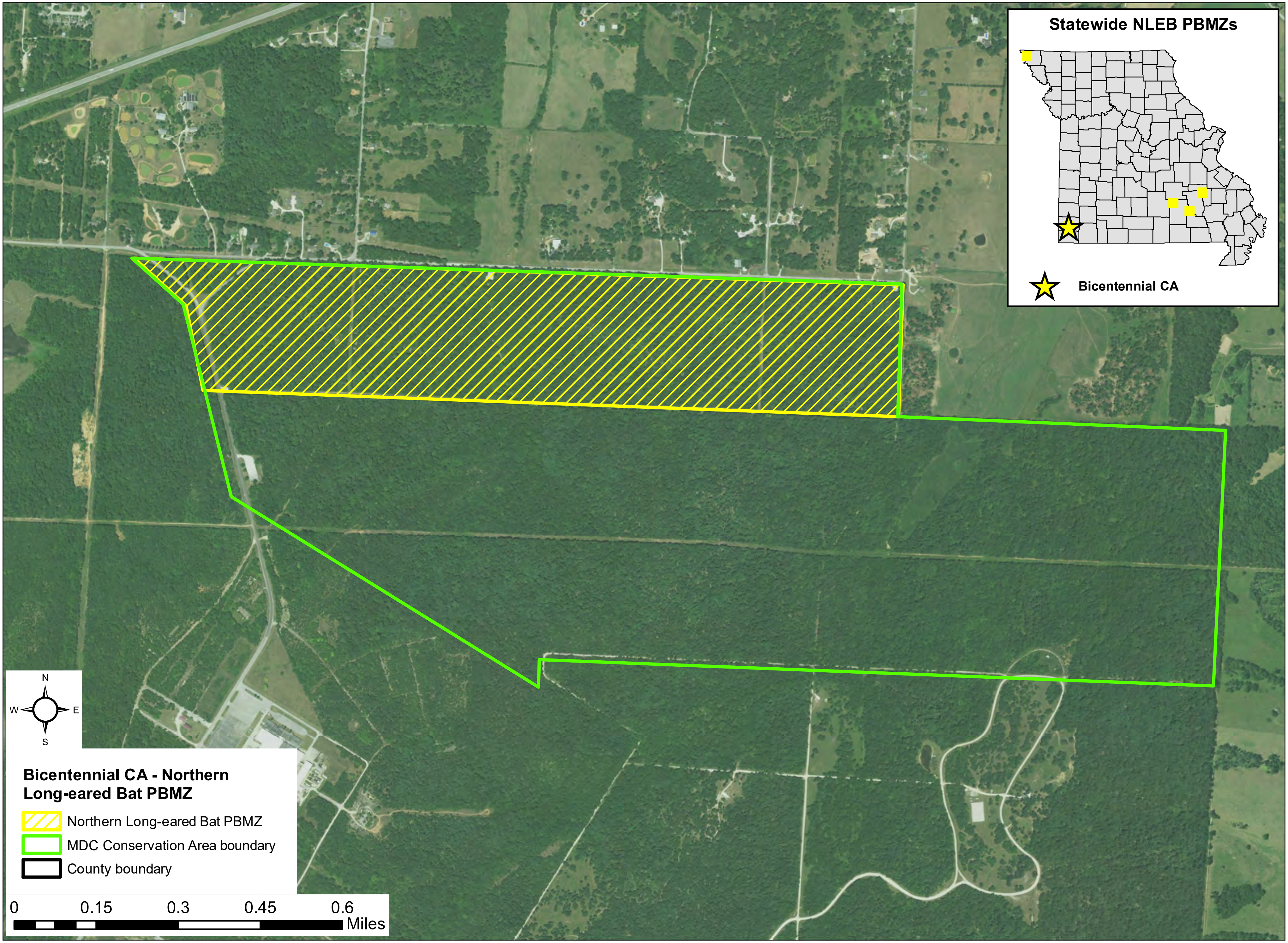

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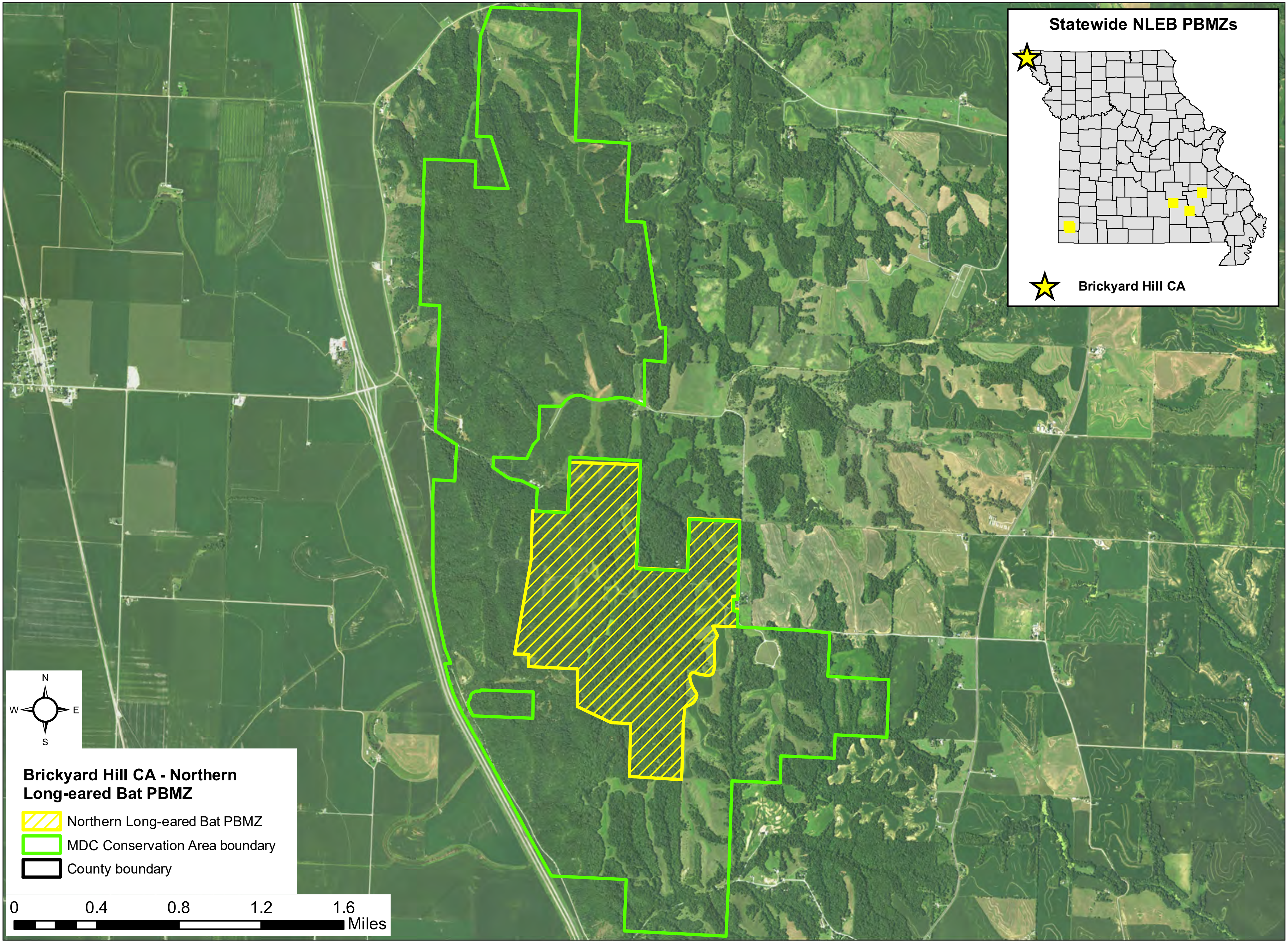

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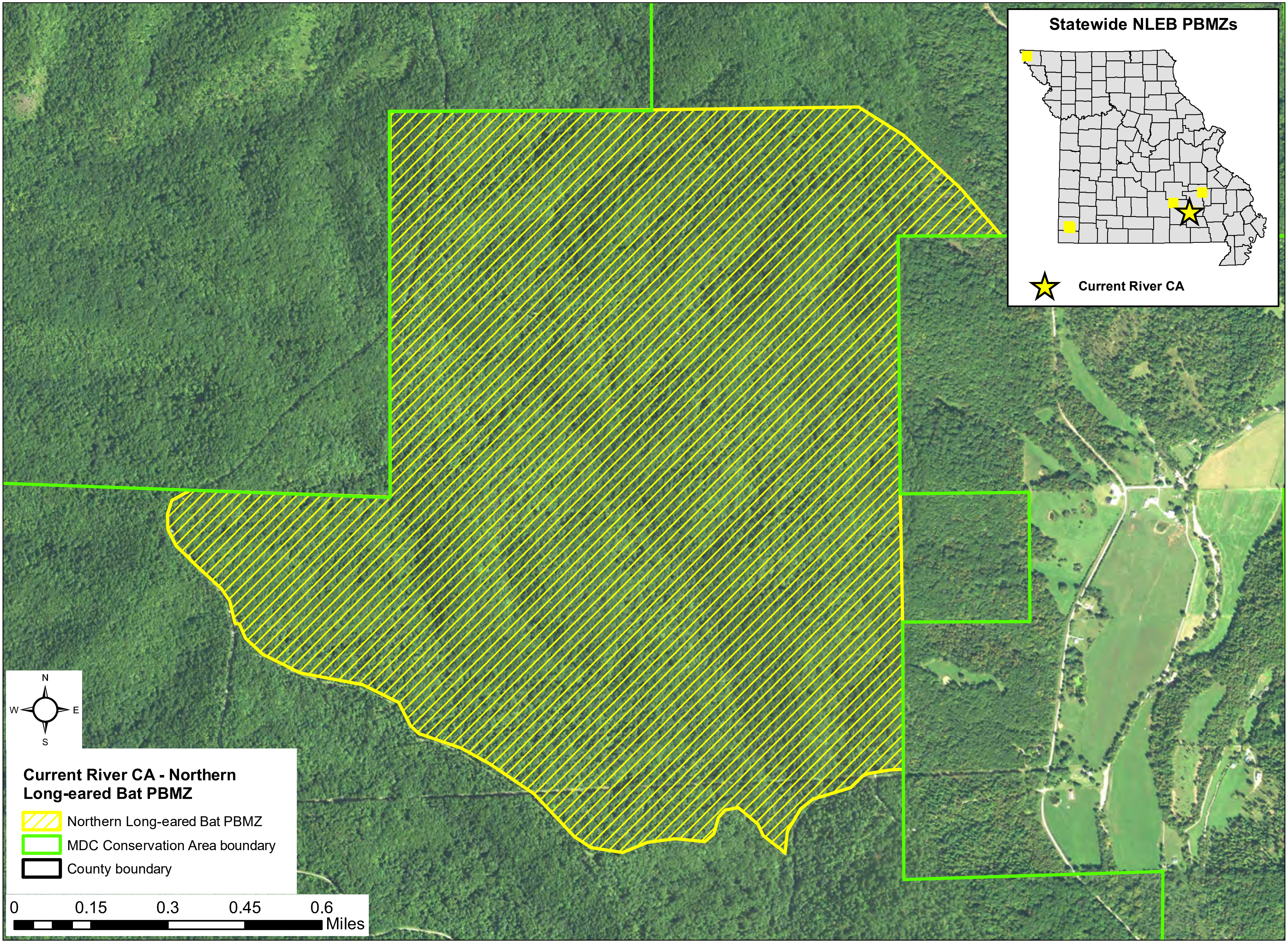

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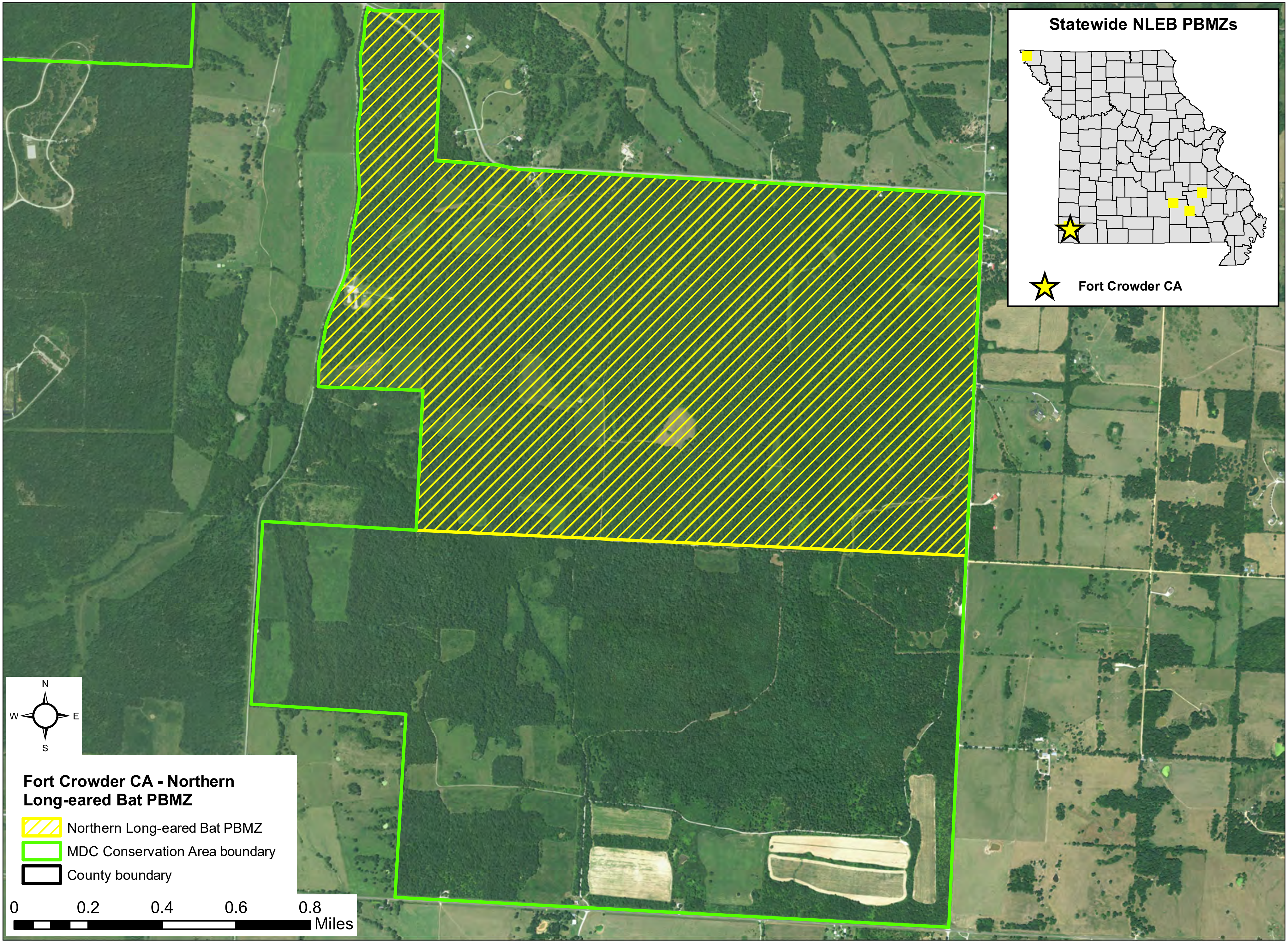

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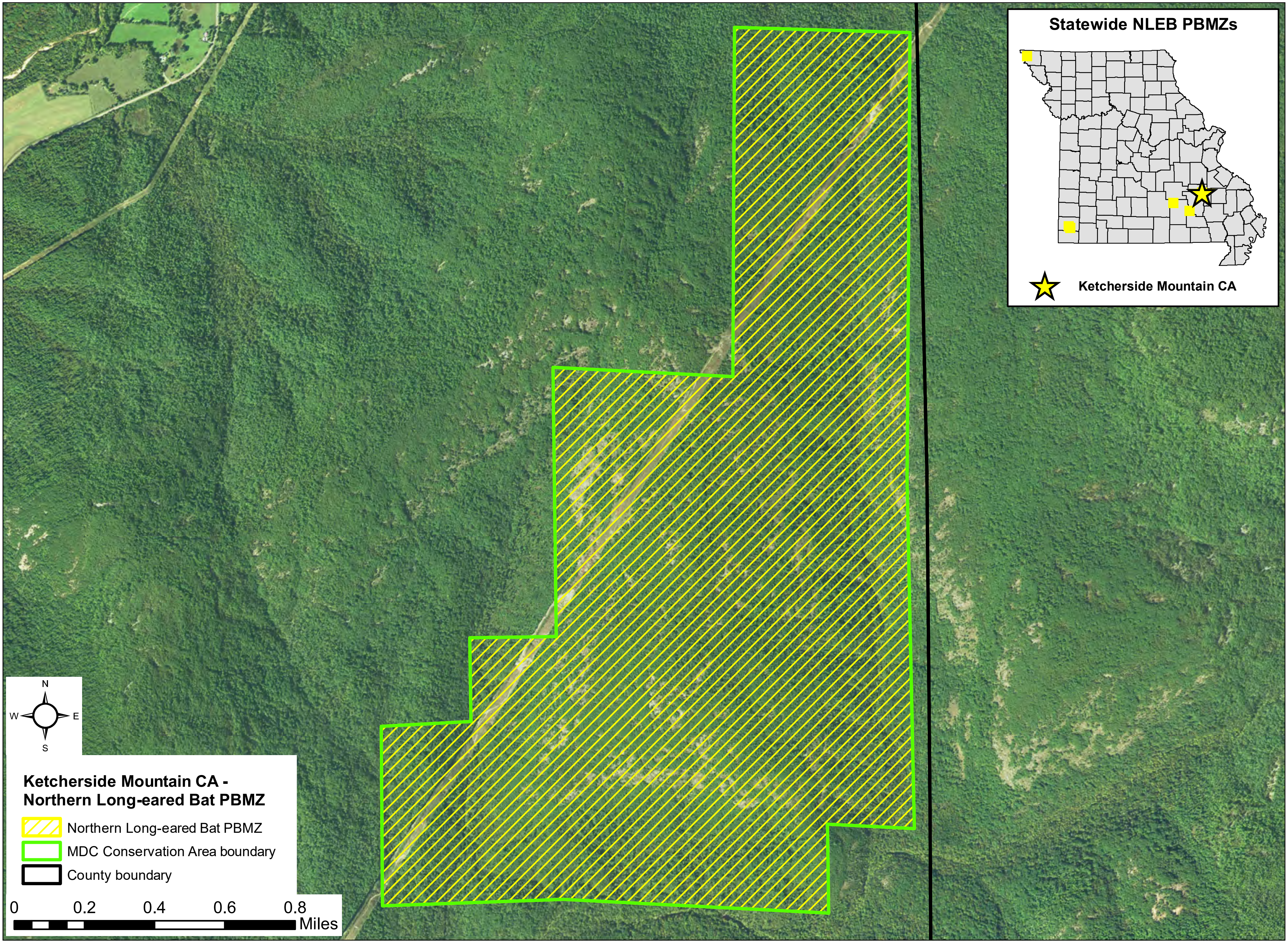

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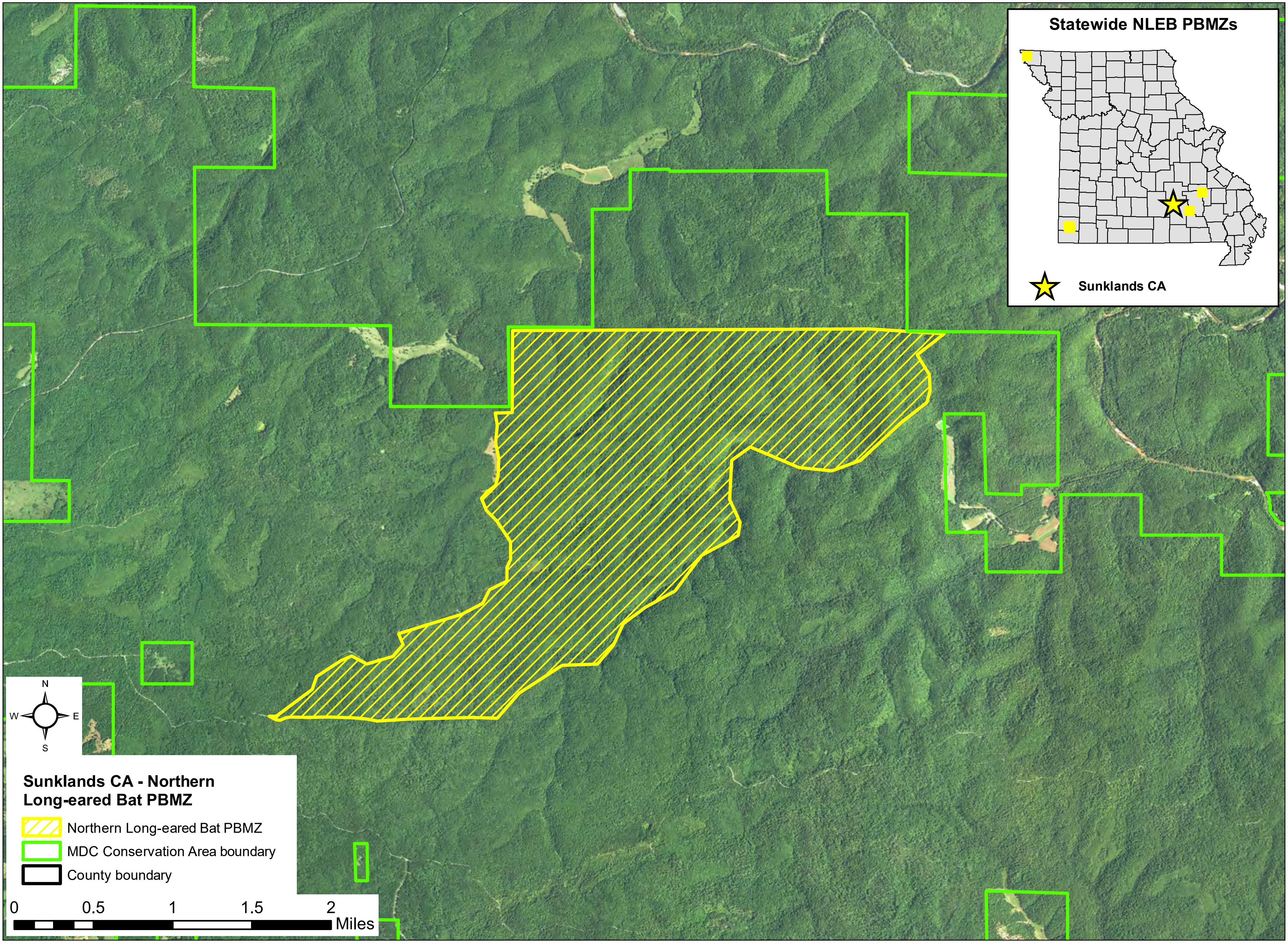

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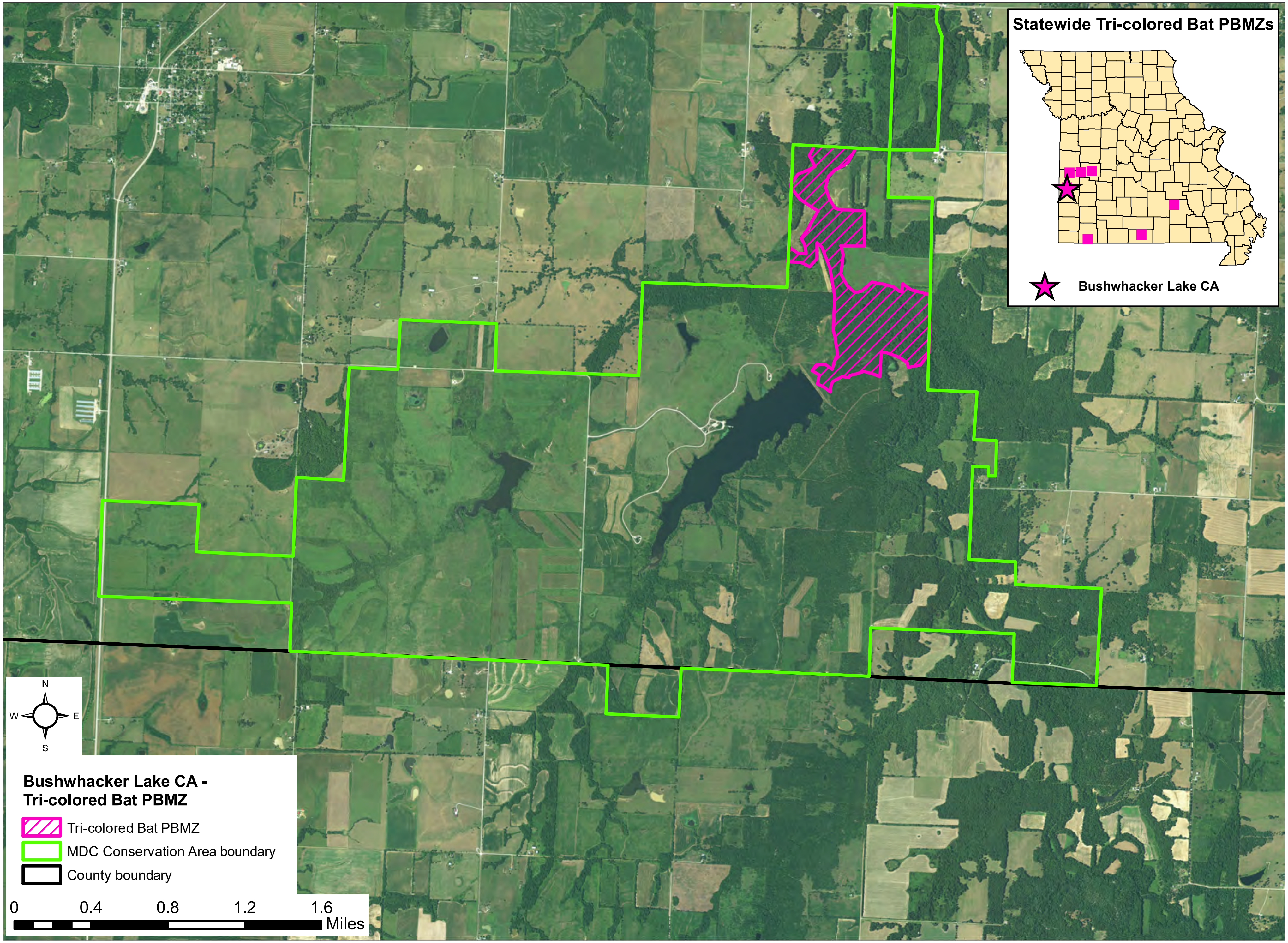

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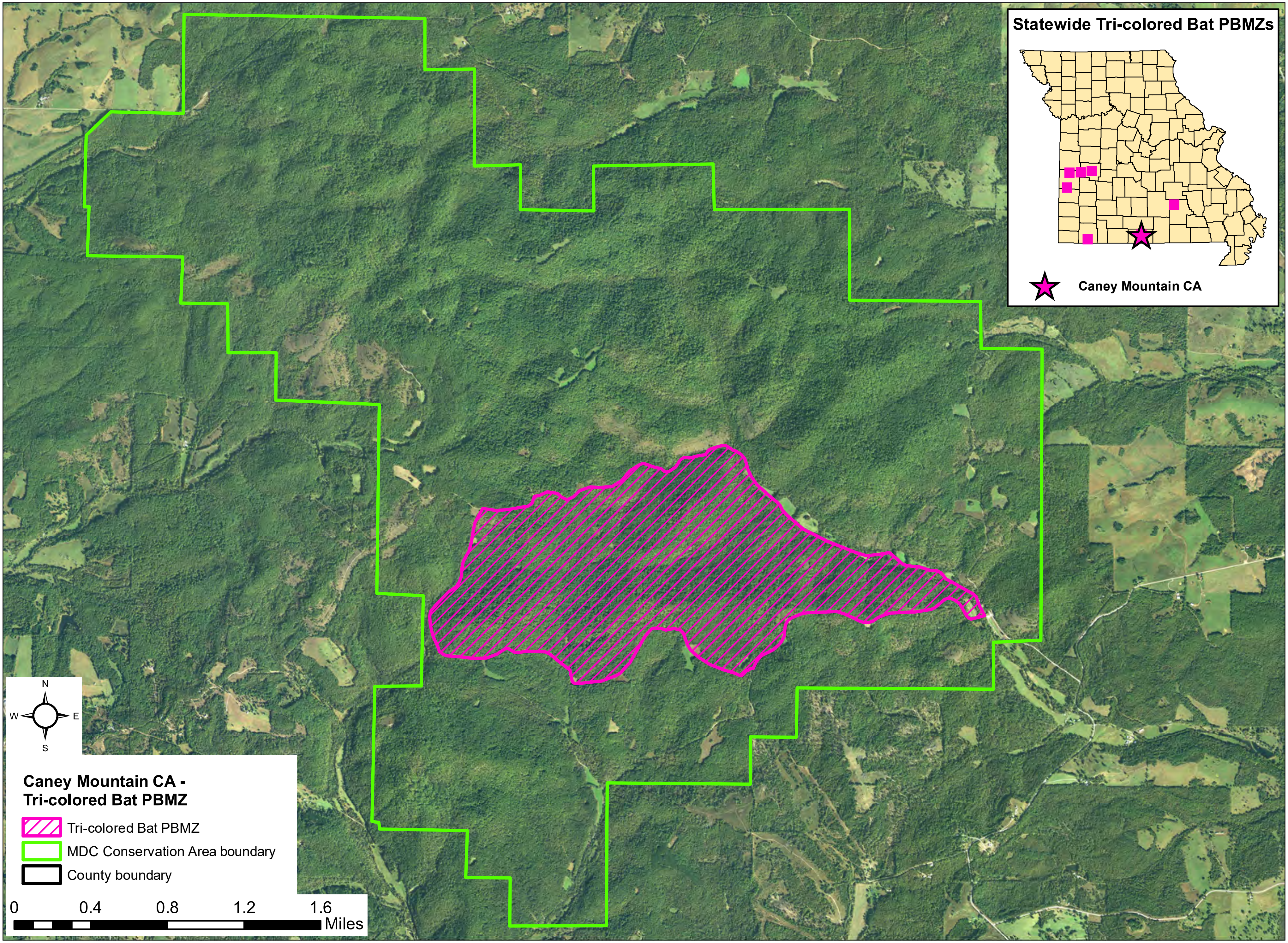

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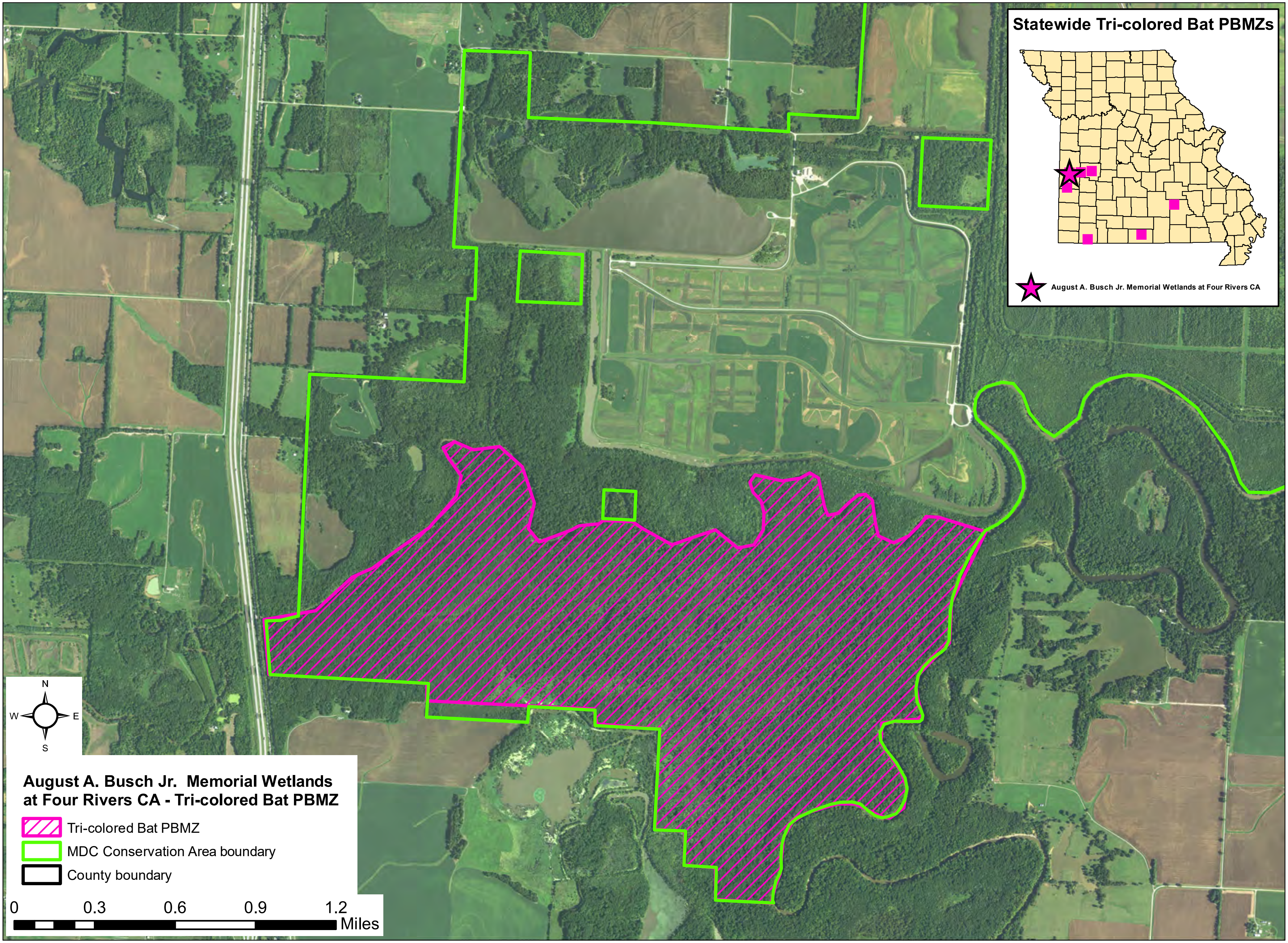

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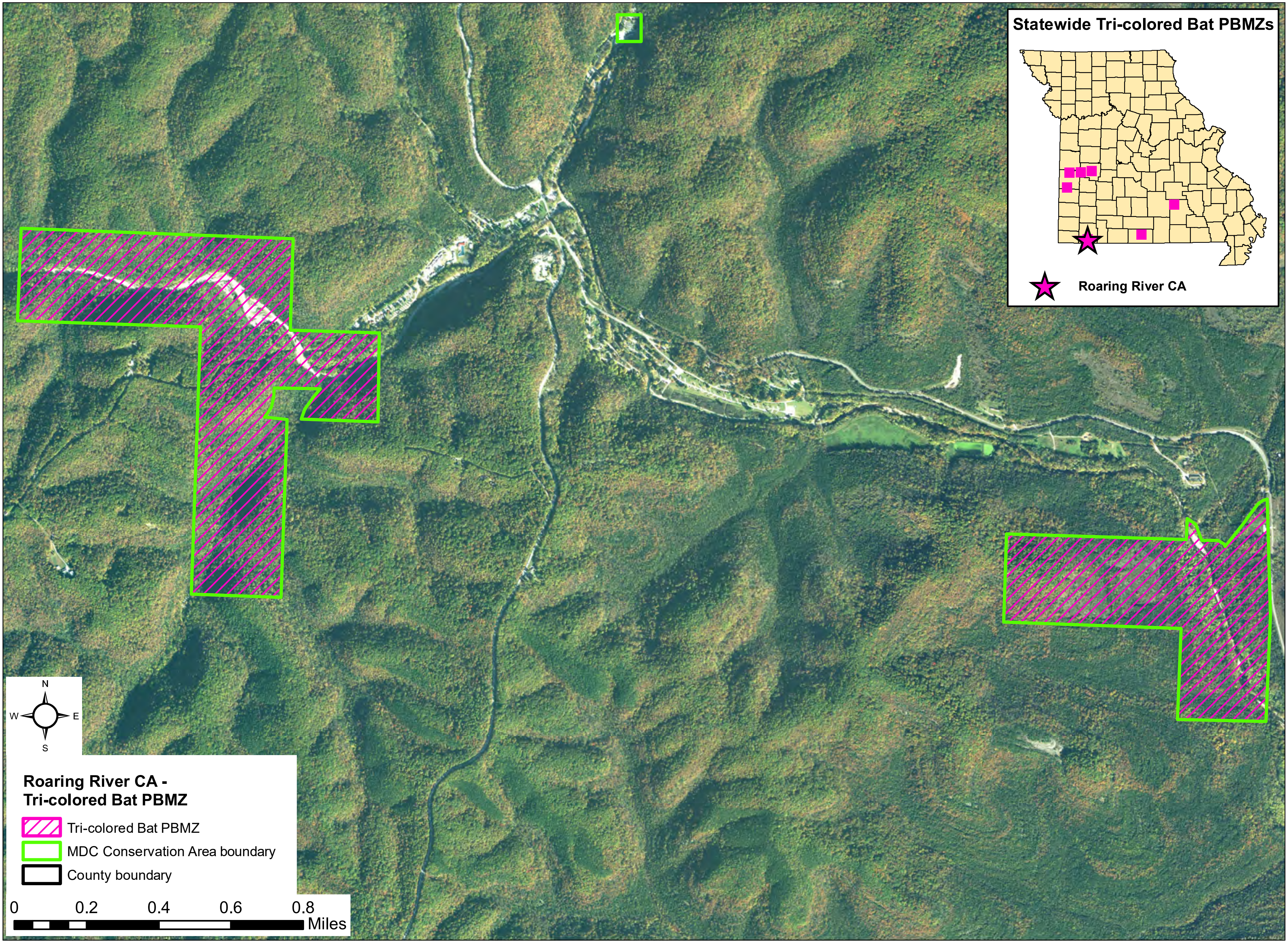

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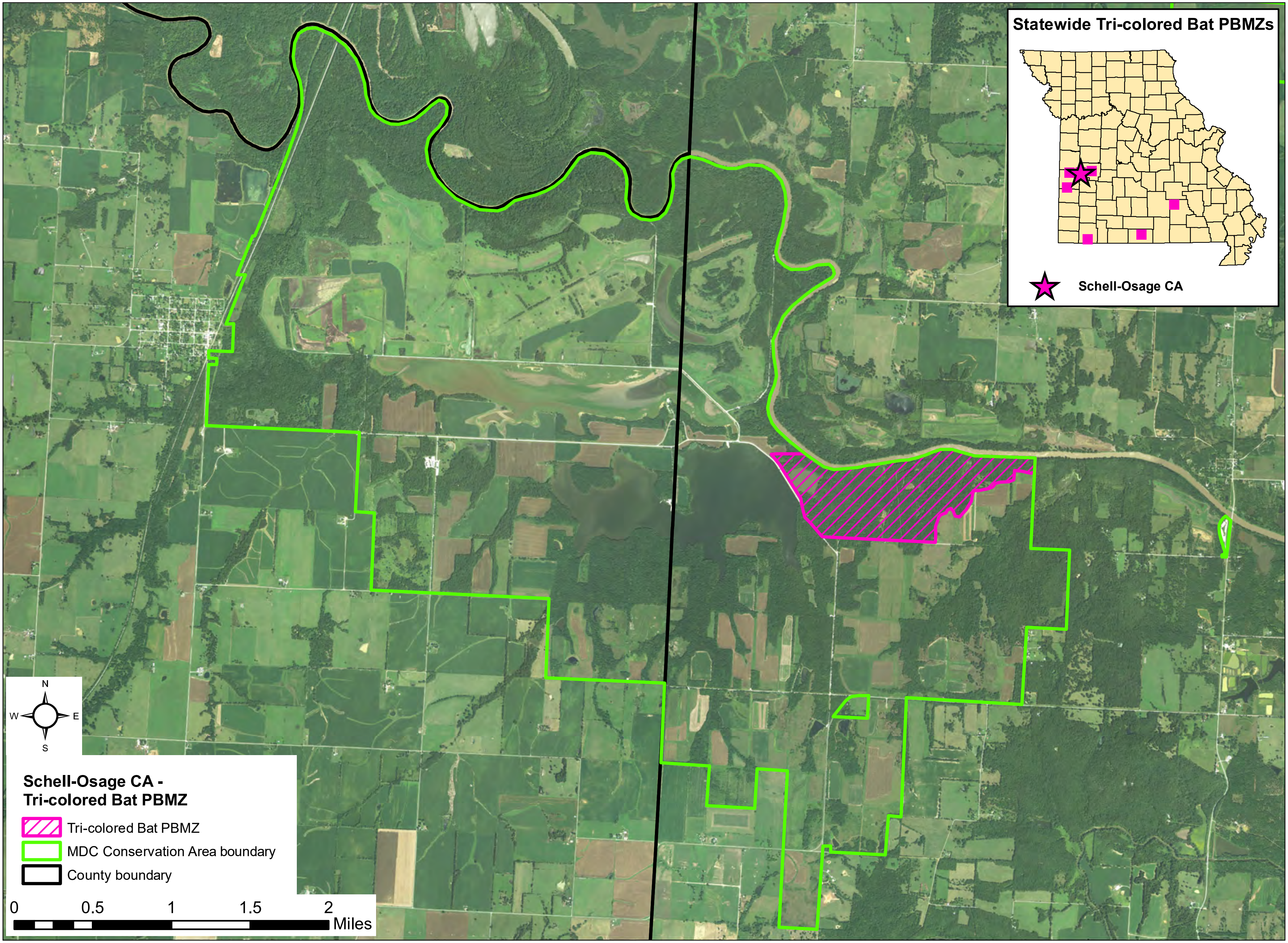

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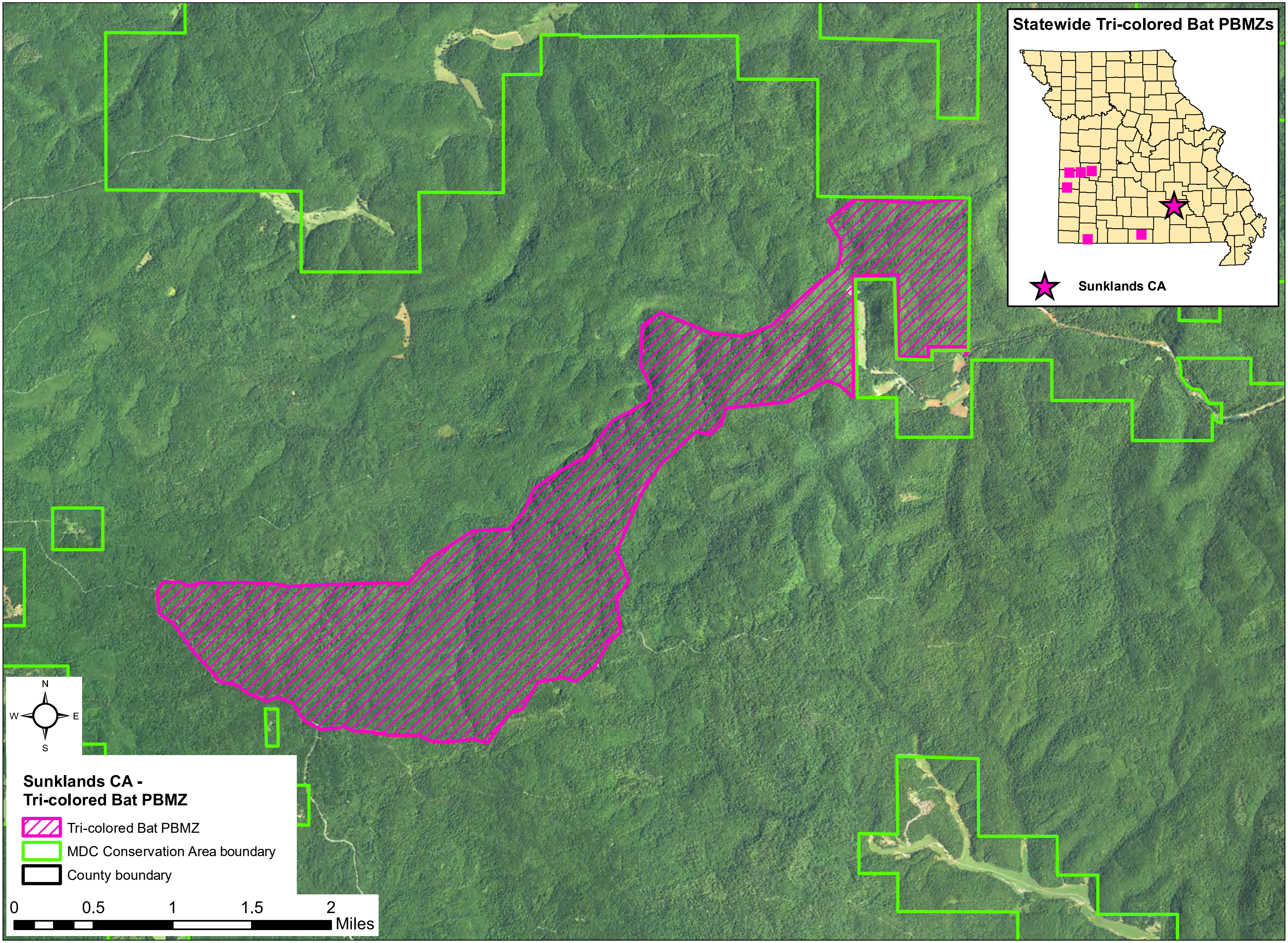

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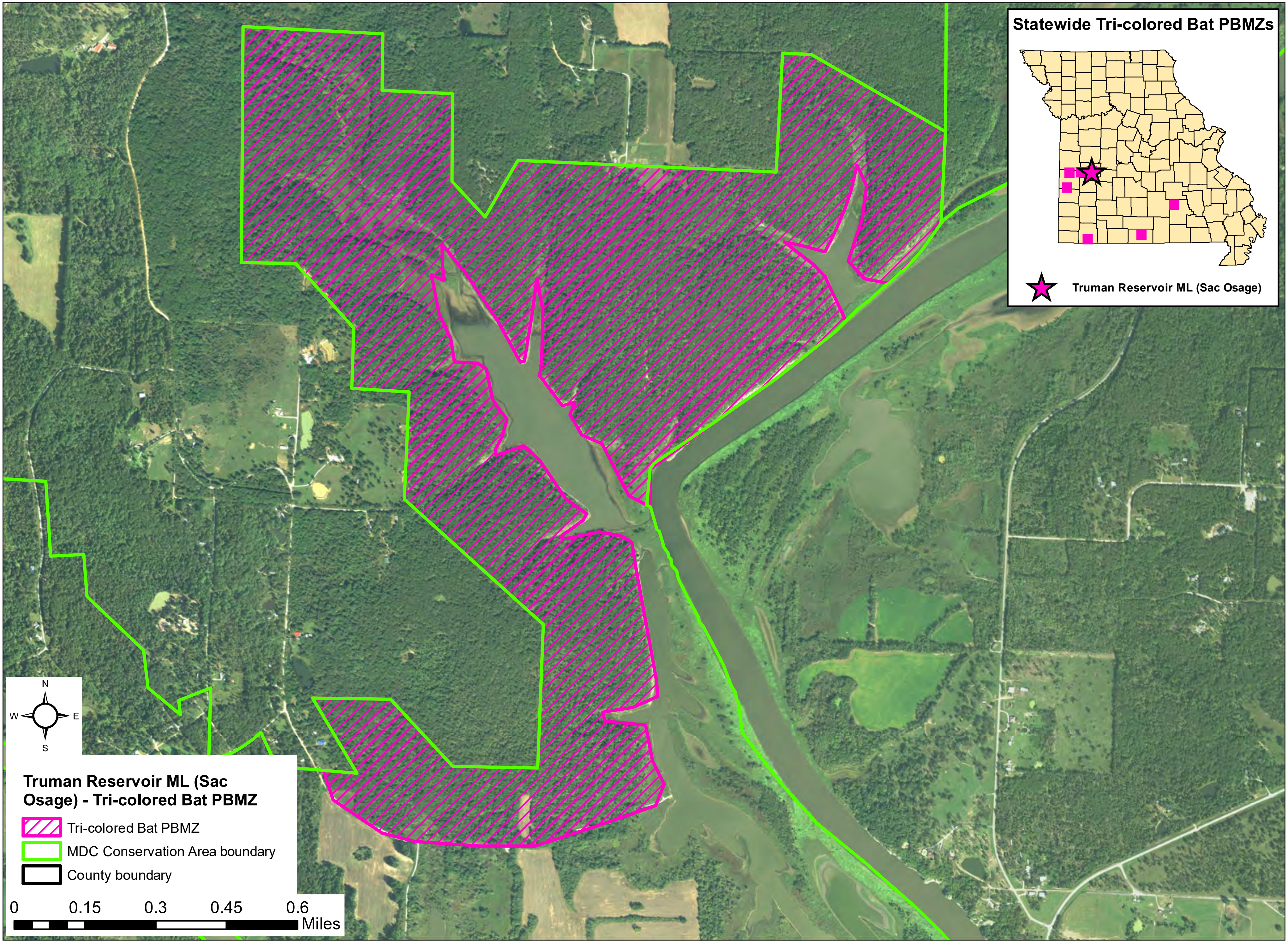

Appendix F

Desired Future Conditions Within Priority Bat Management Zones (PBMZs)

Appendix F
Desired Future Conditions Within Priority Bat Management Zones (PBMZs)

Within Priority Bat Management Zones (PBMZs), MDC will manage for habitat conditions suitable for the target bat species, using best available science. These desired future conditions are based on information known about each of the covered species —much of which is specific to Missouri (Yates and Muzika 2006; Amelon 2007; Womack et al. 2013; Starbuck et al. 2015; Womack 2017).

The goals of the PBMZs are to provide each species with areas of high-quality foraging, roosting, and drinking habitat within focused areas across the landscape and to avoid impacts to maternity colonies on MDC lands. As noted by previous authors (Sparks et al. 2004; Yates and Muzika 2006; Amelon 2007; Guldin et al. 2007; Sparks et al. 2009; Sheets et al. 2013; Womack et al. 2013; Pauli et al. 2015; Starbuck et al. 2015; Womack 2017; Johnson and King 2018), successful management of bats requires providing habitat at multiple scales ranging from a specific roost tree to a landscape that supports a diversity of bat habitats and resources. An effective tool for managing multiple species of bats is to manage a mosaic of land covers of varying seral stages or age classes that provide suitable habitats for each of the species (Pauli et al. 2015; Womack 2017; Johnson and King 2018)—such an approach also has the advantage of ensuring that multiple ages and types of habitat are available.

Roosting Habitat

As described in the HCP, 28,000 acres of PBMZs will be delineated as part of the Plan. These PBMZs will be created on MDC lands and will target one of four tree-roosting bats covered by the HCP. Whenever possible, PBMZs will be defined using known areas of bat use, including roosts, on MDC lands. In cases where areas are known, PBMZs will be placed (1) near known roosts on other landowners' lands, or (2) in areas where roosting and foraging conditions are appropriate. Within each PBMZ, area managers will use habitat management techniques (see Chapter 2, *Covered Lands and Activities*) to produce habitat conducive for bat use.

MDC recognizes not every acre of a PBMZ is wooded. Bats use a wide variety of habitats outside of the treed environment. Therefore, the following guidance pertains to treed areas within the PBMZ. Big trees are an important roosting habitat feature for most bats. PBMZs will strive to contain upwards of 10% old growth habitat, either now or in the future. Old growth habitat should produce the largest of the big trees that are preferred by bats. Other portions of the wooded areas should be managed for early successional forest habitat to ensure a continued forest in the future. Early successional forest habitat is dominated by seedlings, saplings, and brush less than 15 years old. Overall, the entire wooded area within a given PBMZ should contain trees of different age classes, sizes, and species composition. Vertical structure is also important and should be tailored toward the primary PBMZ bat species.

Other natural communities within the PBMZ will be managed to produce a diverse assemblage of native species. These communities, such as glades, grasslands, and prairies, also play a critical role in providing diverse habitat for bats. Although these communities do not directly support roosting habitat, they still provide important bat foraging and commuting habitat. Our overall goal for the PMBZ is to produce the highest quality biodiversity possible for bats.

Management of the PBMZs will be carried out using the recommended habitat conservation measures as stated throughout this Missouri Department of Conservation Bat Habitat Conservation Plan (MDC Bat HCP) for snag retention and tree characteristics. Table F-1 below provides the minimum and preferred densities of snags and cavity trees.

Roosts appropriate to the target species will be created within PBMZs that do not currently meet the minimum conditions (Table F-1) as follows:

- **All species**: Where appropriate, low-intensity prescribed fire may create snags or encourage cavity formation within certain tree species.
- **Indiana, northern long-eared, and little brown bats**: Roosts will be created by girdling or otherwise killing large-diameter trees.
- **Little brown bats**: If creation of natural roosts is not possible or desired, MDC will install artificial roosts.

Figure F-1. Minimum and Optimum Snag and Cavity Tree Recommendations for Priority Bat Management Zones

Minimum Recommendations
Snag and Cavity Trees per Acre of Forest

Diameter Class DBH (inches)	Forest Cover Pattern							
	Heavily Forested		Semi-Open and Open		Riparian Corridor		Bottomland Hardwood	
	Cavity	Snags	Cavity	Snags	Cavity	Snags	Cavity	Snags
>19 inches	0.5	0	1.5	0	2	1	1	0
10–19 inches	2	2	2	2	14	7	7	2
<10 inches	1	1	1.5	1	9	4	4.5	1
TOTAL	3–4	3	5	3	25	12	12–13	3

Optimum Recommendations
Snag and Cavity Trees per Acre of Forest

Diameter Class DBH (inches)	Forest Cover Pattern							
	Heavily Forested		Semi-Open and Open		Riparian Corridor		Bottomland Hardwood	
	Cavity	Snags	Cavity	Snags	Cavity	Snags	Cavity	Snags
>19 inches	1	0	3	0	2	1	2	0
10–19 inches	4	4	4	4	14	7	14	4
<10 inches	2	2	3	2	9	4	9	2
TOTAL	7	6	10	6	25	12	25	6

DBH = diameter at breast height

These conditions will provide roosting habitat for all four "tree" bats covered by the HCP. As noted in the respective species accounts (Appendix A, *Species Accounts*) Indiana, little brown, northern long-eared, and tricolored bats are all known to preferentially use large trees but also readily use pole timber. Northern long-eared and tricolored bats occasionally use saplings. Seedlings provide limited roosting habitat for tricolored bats. The primary roles of pole trees, seedlings, and saplings within the PBMZs is to grow large trees that can provide long-term roosting habitat. Such areas also provide suitable foraging habitat, especially along edges.

Foraging Habitat

As noted above, seedlings and saplings provide suitable foraging habitat within the PBMZs even when they are not usable as roosts. Similarly, open areas within the PBMZs will be managed to provide high-suitability foraging habitat. Most PBMZs are expected to occupy only a portion of larger MDC lands that provide suitable foraging habitat including a mix of forests, woodlands, glades, and open habitats such as prairies, wetlands, and agricultural fields.

Open areas (including rights-of-ways) can be managed to encourage the growth of plants that attract moths and other high-quality insect prey. As noted under *Drinking Habitat*, MDC will provide ponds on those PBMZs (one drinking source for every 160 acres) that do not contain a natural drinking source. In addition to providing drinking habitat, water is also an important source of aquatic insects eaten by these species.

Drinking Habitat

Water was identified as a key life history requirement for nearly every species of bat examined by Amelon (2007), and is considered a key resource for managing bats in forests (Johnson and King 2018). If a PBMZ is created in an area where there is no natural water source, MDC will provide a fishless pond.

Monitoring Criteria

MDC will use the following monitoring criteria for PBMZs.

- Ensure permanent water is available by establishing a fishless pond per 160 acres within the PBMZ if no permanent water is available.
- Ensure minimum snag and cavity trees are being maintained.
- Ensure appropriate mix of size and age classes of forest within forested habitats.

Cave Management Zones

MDC will manage 20 acres around every known cave on MDC lands as old-growth forest. Old growth-forests can vary widely in structural characteristics, depending on the site, species composition, and past management history. Old-growth characteristics in Missouri include the following.

- 40% or more stocking of live trees greater than 14 inches diameter at breast height with an average age usually more than 120 years for dominant trees (depending on site index).
- Multilayered canopy (well-defined overstory, midstory, and understory).
- Evidence of value as potential foraging and roosting habitat including:
    - Large snags,
    - Large fallen logs, and
    - Evidence of tree decadence (cavities, crevices and broken limbs).

The long-term goal is to create old-growth habitats near hibernacula. Some sites have yet to be managed long enough to reach desired conditions. Thus, monitoring should focus on progressing toward those desired conditions. Similarly, some hibernacula are located adjacentto other desirable land covers. For example, Coffin Cave, one of the state's most important gray bat sites, is in a forested ridge that faces a glade. In this case, the 20-acre buffer is not circular and excludes the glade.

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Appendix G
Template Landowner Agreement

APPENDIX G – TEMPLATE LANDOWNER AGREEMENT

[Note to Reader: This Template Landowner Agreement is intended to be used by MDC in one of two ways. First, the Agreement could be used as a stand-alone document to be signed by a participating landowner and attached to an MDC program agreement. Second, the relevant elements of the Agreement can be incorporated into an existing MDC program agreement (see Chapter 6 and Table 6-1 for a list of covered MDC programs and explanation of how this Template Landowner Agreement will be used.)

This Agreement is being executed in association with the [insert program name, e.g., Missouri Managed Woods Program] and shall be an Appendix/Exhibit to Agreement No. [insert agreement number] (hereafter "MDC Program Agreement").

The U.S. Fish and Wildlife Service (USFWS) issued the Missouri Department of Conservation (MDC) an Incidental Take Permit (ITP) under the Endangered Species Act, 16 U.S.C. §§ 1531, et seq. (ESA), and implementing regulations at 50 C.F.R. Parts 13 and 17, providing incidental take exemption for the endangered or threatened Indiana bat, little brown bat, northern long-eared bat, gray bat and tricolored bat (Covered bats) while undertaking certain forestry activities (Covered Activities) described in the MDC Bat Habitat Conservation Plan (MDC Bat HCP). By entering into this Agreement with the Missouri Department of Conservation (MDC), and complying with the terms of the MDC Bat HCP and ITP, the undersigned landowner (Recipient) is authorized to carry out the Covered Activities in the MDC Bat HCP and ITP under the "direct control" of the MDC. When performing MDC Bat HCP Covered Activities under the direct control of the MDC, MDC's incidental take exemption for Covered bats is extended to the Recipient. 50 C.F.R. § 13.25(d) and (e) (authorizing individuals under the "direct control" of the ITP holder to carry out the activities authorized by the ITP). This incidental take coverage is specifically conditioned upon the Recipient's compliance with this Agreement and therefore the MDC Bat HCP and ITP, including the following terms and conditions:

- Recipient will implement the following conservation measures consistent with Section 5.2.2, *Site-Level Conservation*, of the MDC Bat HCP, and, if applicable, the site-specific management plan, in the conduct of the activities conducted under the MDC Program Agreement for which the Recipient is receiving financial assistance:
  - Retain all snags except where public or worker safety concerns exist (e.g., prescribed fire line, catastrophic weather events) or MDC has determined that disease/insect outbreaks in a stand constitute a threat to the health of the surrounding forest
  - Retain known maternity roosts[1] for Covered bats
  - Retain patches or aggregations of trees per even-aged and uneven-aged management prescriptions below (Table G-1)
  - Retain a minimum of three den trees per acre in heavily forested areas and up to 25 den trees per acre in riparian forest. Prioritize den trees with cavities greater than 20 feet above the ground. When den trees are not present, retain a 0.2-acre (105-foot-diameter) group of trees around at least one large-diameter tree that may potentially serve as a den tree
  - On average, retain two to four super-canopy trees (trees that are taller than the surrounding trees), or those with potential to become such trees, per acre in riparian areas and bottomland forests
  - If MDC determines that sufficient snags do not exist, create snags based on average per-acre targets (Table G-1)

[1] Known maternity roost locations are documented by the Natural Heritage Database. MDC will notify landowners participating in the HCP if there are known maternity roosts on or adjacent to their property based on this data.

- Perform even- or uneven-aged stand management per Table G.1 below.
- Do not conduct timber harvests and prescribed burns within a 150-foot radial area around a known Covered bat maternity roost between April 1 and August 31
- For prescribed burns within high-occupancy modeled habitat (as defined in Appendix A, *Species Accounts*, of the MDC Bat HCP)
  - Use ignition tactics that reduce fire intensity and flame length
  - Use a fire behavior model to ensure scorch heights are maintained below 15 feet between April 1 and August 31
  - Burn under conditions that maximize smoke dispersal and will carry smoke away from hibernacula entrances
  - Retain snags within firelines when and where they do not pose a hazard to public or worker health and safety

- Recipient will allow MDC staff to inspect the site as needed to confirm the conservation measures have been implemented and maintained consistent with the site-specific management plan (if applicable) and Section 5.2.2, *Site-Level Conservation*, of the MDC Bat HCP and ITP. Inspections would occur for the term of the MDC Program Agreement and the activities covered under the MDC Program Agreement.
- Recipient will allow MDC to report to USFWS in MDC's annual reports the Recipient's execution of this Agreement and the Recipient's compliance with the conservation measures listed above.
- Recipient acknowledges that compliance with the conservation measures in this Agreement is a condition of the MDC Program Agreement, and failure to comply will constitute a violation of the MDC Program Agreement resulting in automatic suspension of the incidental take exemption for Covered bats, as described in Section 6.1.1 *Coverage to Other Nonfederal Landowners* of the MDC Bat HCP. The Recipient must report any activities that are not in compliance with the MDC Program Agreement or this Agreement to MDC within 30 days. If a violation occurs, MDC will notify the Recipient with a noncompliance letter within 30 days of detection. The letter to the Recipient will include the actions necessary for the Recipient to bring the site back into compliance within a specific timeframe (deadlines will vary depending on the nature of the violation). The Recipient will be required within 30 days of receiving the letter to acknowledge the noncompliance letter and either (1) agree to implement the recommended actions, (2) relinquish the Agreement, or (3) agree to MDC withdrawing the Agreement. Within 90 days of the detection of the violation, MDC will notify USFWS, in writing, and send USFWS copies of the correspondence sent to and received from the Recipient.
- Recipient acknowledges that MDC may, if the Recipient fails to comply with the actions listed in the noncompliance letter, rectify or enforce noncompliance through means such as withdrawing technical or financial support, disqualifying the Recipient from future participation in MDC programs, or similar actions consistent with the scale of the violation and the applicable MDC program. Depending on the scale and nature of the violation, MDC may seek reimbursement, through legal means if necessary, of any funds granted to Recipient under the MDC Program Agreement.
- Recipient acknowledges that Recipient noncompliance results in an automatic suspension of the incidental take exemption extended to Recipient under this Agreement.
- Recipient may terminate this Agreement at any time by notifying MDC in writing. Recipient is responsible for implementing all applicable conservation measures up until the time the Agreement is terminated.

By signing this Agreement, ____________________[Recipient's printed name here] acknowledges that I have read and understand this Agreement, and I commit to implementing the applicable conservation measures identified above and in the MDC Bat HCP and ITP. I further understand that failure to comply with this Agreement may make me ineligible for participation in future MDC cost share programs. Failed practices due to causes beyond the Recipient's control (e.g., drought, flood, etc.) as determined by MDC, will not result in ineligibility of the Recipient or be considered as a failure to comply with this Agreement.

Recipient's Signature________________________________ Date_______________

MDC's Signature____________________________________ Date________________

Table G-1 Even- and Uneven-Aged Stand Management Requirement

Even-Aged Stand Management Conservation Measures	Uneven-Aged Stand Management Conservation Measures
Snag Retention	
Retain all snags except where public or worker safety concerns exist or where catastrophic weather events or disease or insect outbreaks in a stand constitute a threat to the health of the surrounding forest.	Retain all snags except where public or worker safety concerns exist or where catastrophic weather events or disease or insect outbreaks in a stand constitute a threat to the health of the surrounding forest.
Retain Patches/Leave Trees	
In even-aged stands greater than or equal to 20 acres where harvest reduces basal area below 30 square feet per acre, uncut patches totaling at least 5% of the harvested area will be retained.	Maintain a minimum basal area of 30 square feet and where possible retain at least 16 live trees greater than 9 inches in diameter at breast height per acre (with at least 6 trees per acre of the largest available trees of species favored by roosting bats, which will vary by bat species and geographic location).
In stands greater than or equal to 20 acres where harvest reduces basal area below 30 square feet per acre, create leave-tree patches that are variable in size (but a minimum of 0.25 acre) and located throughout the harvest unit.	Where insufficient large trees (9 inches in diameter or greater) are available to meet silvicultural management needs while providing the number and size of trees noted above, use the 16 largest trees available per acre, to provide adequate canopy cover and roost-tree availability.
When working in a riparian corridor, always leave at least one-third of the typical-sized trees and 40 square feet of basal area or greater but not below C-level stocking,[a] One-half to two-thirds of typical-sized trees is recommended.	When working in a riparian corridor, always leave *at least* one-third of the typical-sized trees.
In stands greater than or equal to 20 acres where harvest reduces basal area below 30 square feet per acre, e leave one or more large live trees (retain hickory 16 inches or greater diameter at breast height if available), otherwise retain trees greater than 18 inches diameter at breast height, or as large as available) to provide for a continuous supply of future roost trees.	
In stands greater than or equal to 20 acres where harvest reduces basal area below 30 square feet	

Even-Aged Stand Management Conservation Measures	Uneven-Aged Stand Management Conservation Measures
per acre, locate leave-tree patches near or adjacent to riparian management zones, wetlands, or seasonal pools. Wildlife openings are encouraged; however, riparian buffers should not be used for all reserve islands because snag and leave-tree patches are also important in upland forest treatments.	
Locate patches in draws and along protected slopes, near the edge of the stand on ridge-top locations, or just below the ridge, if possible, to reduce the potential for windthrow.	
Focus patches to coincide with such features as wetland inclusions, ponds, one or more active dens trees or cavity trees, or at least good candidates for potential cavities.	

Even-Aged Stand Management Conservation Measures	Uneven-Aged Stand Management Conservation Measures
Openings	
If openings are created for forest regeneration, those stands will be thinned and/or burned during appropriate seral stages to create and maintain high-quality foraging habitat in the future.	Create relatively small openings (less than 5 acres) where practicable because they may provide the best balance between maintaining foraging and roosting habitat across the landscape.
	Where practicable, maximize the amount of edge habitat (e.g., through the creation of long and narrow openings) to provide a greater amount of foraging habitat and additional predator protection.
	When creating openings, consider both the bat species and the amount of sunlight needed for forest regeneration. Larger openings provide more sunlight to regenerate future roost trees. However too large an opening (greater than 45 acres) may affect bat occupancy.

[a] C-level stocking is a forestry term that is determined by the average stand diameter, basal area per acre, and trees per acre. Between C-level and B-level, a forest is considered understocked, between B- and A-level is fully stocked, and above A-level is considered overstocked. Below C-level stocking is considered non-stocked and is an undesirable condition for riparian areas (Gingrich 1967).

Gingrich, S. F. 1967. Measuring and Evaluating Stocking and Stand Density in Upland Hardwood Forests in the Central States. *Forest Science* 13(1):38–53.