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Biological Assessment of a Proposed Vegetation Management Program to Benefit Tribes in Eastern Oklahoma

Open-File Report 2020–1013

U.S. Department of the Interior
U.S. Geological Survey

Cover. Forest management practices (fuels management, prescribed fire, and control of eastern redcedar) in the Eastern Oklahoma Region of the Bureau of Indian Affairs. Photographs courtesy of the Bureau of Indian Affairs, used with permission.

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Conversion Factors

U.S. customary units to International System of Units

Multiply	By	To obtain
	Length	
inch (in.)	2.54	centimeter (cm)
inch (in.)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
yard (yd)	0.9144	meter (m)
	Area	
acre	4,047	square meter (m^2)
acre	0.4047	hectare (ha)
acre	0.4047	square hectometer (hm^2)
acre	0.004047	square kilometer (km^2)
square foot (ft^2)	929	square centimeter (cm^2)
square foot (ft^2)	0.0929	square meter (m^2)
square inch (in^2)	6.452	square centimeter (cm^2)
square mile (mi^2)	259	hectare (ha)
square mile (mi^2)	2.59	square kilometer (km^2)
	Weight	
ounce (oz.)	28.35	grams (g)

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as $°F = (1.8 \times °C) + 32$.

Temperature in degrees Fahrenheit (°F) may be converted to degrees Celsius (°C) as $°C = (°F\ 32) / 1.8$.

Abbreviations

ABB	American burying beetle
BMPs	best management practices
BIA	Bureau of Indian Affairs
DDT	Dichlorodiphenyltrichloroethane
EOR	Eastern Oklahoma Region
ESA	Endangered Species Act
FWS	U.S. Fish and Wildlife Service

Biological Assessment of a Proposed Vegetation Management Program to Benefit Tribes in Eastern Oklahoma

By Benjamin R. Harms,[1] Heidi L. Bencin,[1] and Natasha B. Carr[2]

Abstract

Tribal communities may benefit from land management activities that enhance their use of resources on tribal lands. The Bureau of Indian Affairs is implementing a 5-year vegetation management program to provide support for projects that develop and use natural and cultural resources and improve opportunities for agricultural activities to benefit 20 Indian Tribes and Nations in the Eastern Oklahoma Region of the Bureau of Indian Affairs. The bureau is working with individual Tribes to identify project objectives and design treatments, which include prescribed burning, timber removal, thinning, and reduction of hazardous fuels. The total action area for the vegetation management program is estimated to be 236,575 acres, representing approximately 1 percent of the region.

A biological assessment was prepared, in cooperation with the bureau and U.S. Fish and Wildlife Service, to evaluate the potential effects of the proposed vegetation management program on 22 federally threatened, endangered, and candidate species that may occur within the Eastern Oklahoma Region. The species evaluated included one plant, two insects, one reptile, five freshwater mussels, four fishes, five birds, and four bats. Because the proposed treatments will be largely restricted to terrestrial systems, it is expected that there will be no adverse effects on the 15 species associated with aquatic habitats, provided that best management practices are followed. The proposed treatments may affect but are unlikely to adversely affect six of the primarily terrestrial species (the *Papaipema eryngii* [rattlesnake master borer], *Picoides borealis* [red-cockaded woodpecker], *Myotis grisescens* [gray bat], *Myotis sodalis* [Indiana bat], *Myotis septentrionalis* [northern long-eared bat], and *Corynorhinus townsendii ingens* [Ozark big-eared bat]), provided that best management practices are followed, including avoidance of critical habitat features.

The only species likely to be adversely affected by the proposed treatments is *Nicrophorus americanus* (American burying beetle) as a consequence of short-term disturbances to soils and vegetation. Most adverse effects of the treatments (such as soil compaction and decreased cover in the forest understory) are expected to be short term (habitat will recover or be restored within 5 years of treatments). Less than 1 percent of the action area is expected to result in long-term adverse effects to the American burying beetle as a result of permanent cover changes that persist for more than 5 years. It is expected that the primary treatments will be largely beneficial to the American burying beetle population in the region by reducing the risk of high-severity fires and expansion of invasive woody shrubs, such as *Juniperus virginiana* (eastern redcedar) within potential beetle habitat and the surrounding landscape. Overall, the proposed management program is expected to provide long-term benefits to American burying beetle habitat across 91 percent of the action area.

Introduction

The mission of the Bureau of Indian Affairs (BIA) is to "enhance the quality of life, to promote economic opportunity, and to carry out the responsibility to protect and improve the trust assets of American Indians, Indian Tribes, and Alaska Natives." To that end, the BIA has initiated a vegetation management program to enhance the use of natural and cultural resources and improve opportunities for agricultural activities for the benefit of 20 Indian Tribes or Nations in the Eastern Oklahoma Region (EOR) of the bureau (table 1; fig. 1). The BIA is partnering with Tribes to identify and implement vegetation management

[1]Under contract to the U.S. Geological Survey.

[2]U.S. Geological Survey.

projects and associated treatments, including prescribed burning and timber harvests. The management program is also intended to restore forests that have been altered by decades of fire suppression and the expansion of *Juniperus virginiana* (eastern redcedar), as well as reduce the risk of **high-severity fire**.[1]

Table 1. Indian Tribes and Nations in the Eastern Oklahoma Region of the Bureau of Indian Affairs.

Tribe or Nation
Alabama-Quassarte Tribal Town
Cherokee Nation
Delaware Tribe of Indians
Eastern Shawnee Tribe of Oklahoma
Kialegee Tribal Town
Miami Tribe of Oklahoma
Modoc Tribe of Oklahoma
Ottawa Tribe of Oklahoma
Peoria Tribe of Indians of Oklahoma
Quapaw Tribe of Indians
Seneca-Cayuga Nation
Shawnee Tribe
The Chickasaw Nation
The Choctaw Nation of Oklahoma
The Muscogee (Creek) Nation
The Osage Nation
The Seminole Nation of Oklahoma
Thlopthlocco Tribal Town
United Keetoowah Band of Cherokee Indians in Oklahoma
Wyandotte Nation

Because the BIA is funding the management program (a Federal nexus), the National Environmental Policy Act (42 U.S.C. § 4321 et seq.) stipulates that a biological assessment is necessary even if work will be conducted on non-Federal lands. The purpose of this biological assessment is to review the proposed vegetation management program in sufficient detail to determine whether the proposed action may affect any federally threatened, endangered, or candidate species that may occur within the Eastern Oklahoma Region (appendix 1). This biological assessment is prepared in accordance with legal requirements set forth under Section 7 of the Endangered Species Act of 1973 (ESA; 16 U.S.C. 1536 et seq.).

The U.S. Geological Survey prepared this biological assessment, in cooperation with the Bureau of Indian Affairs and the U.S. Fish and Wildlife Service, to assess the potential effects of the proposed management program on the 22 endangered, threatened, and candidate species for the 5-year duration of the program. The biological assessment addresses the potential effects of vegetation treatments on an estimated total **action area** of 236,575 acres over the project duration (table 2), averaging 47,315 acres annually (table 3). The estimated action area is approximately 1 percent of the EOR, which covers 21,316,045 acres in eastern Oklahoma (fig. 1).

[1]Terms listed in the glossary at the back of this report are in bold type where first used in the text.

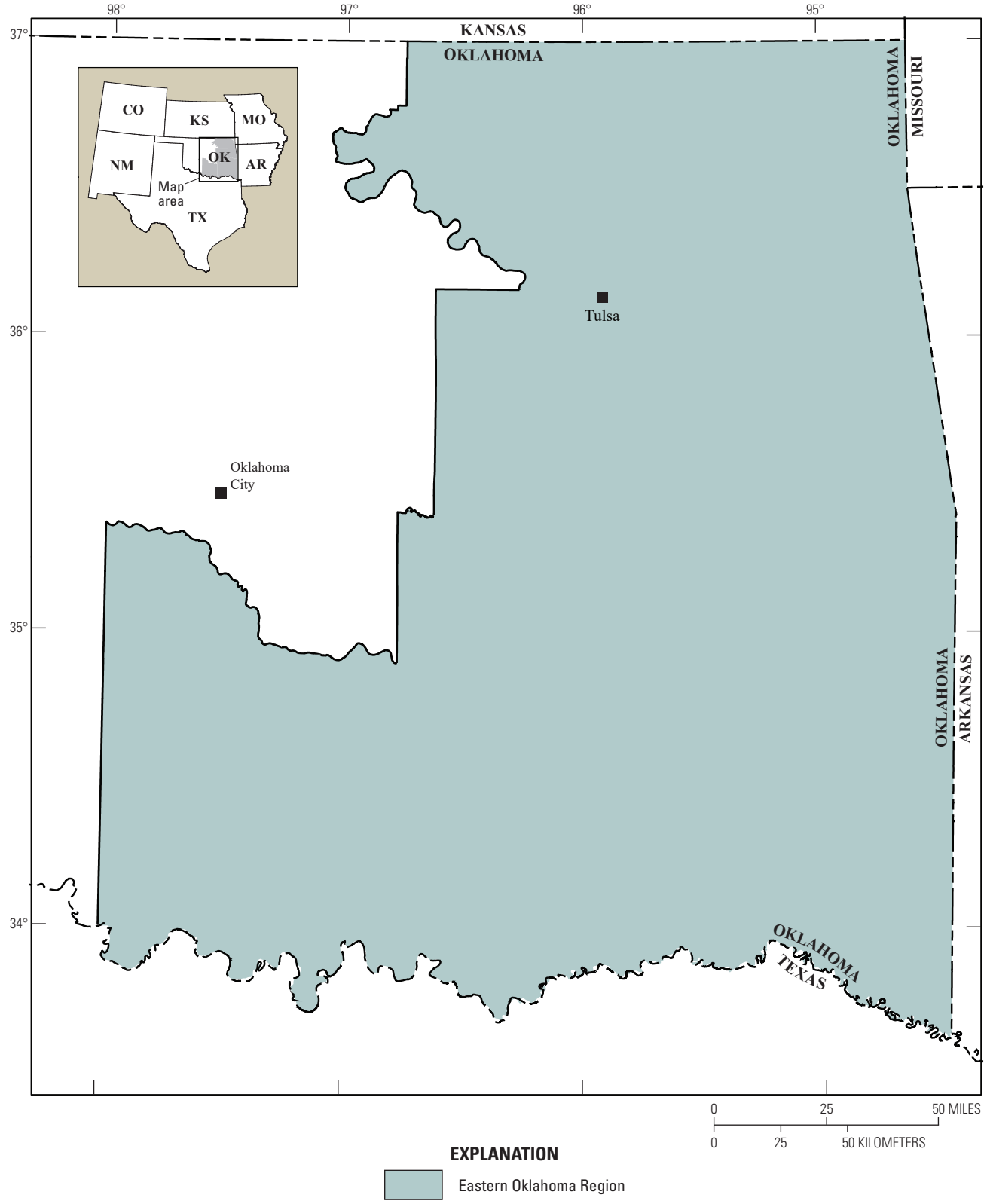

Figure 1. Map showing the Eastern Oklahoma Region of the Bureau of Indian Affairs. See table 1 for a list of the Tribes and Nations in the region. The total area of the Eastern Oklahoma Region is 21,316,045 acres.

Table 2. Overview of proposed treatments, treatment area, and example objectives for each treatment.

[Action area is the sum of the estimated treatment areas for the 5-year duration of the vegetation management program in the Eastern Oklahoma Region of the Bureau of Indian Affairs]

Treatment	Treatment area (acres)	Example management objectives[1]
Primary treatments		
Prescribed fire	189,540	Reduce fuels; restore historical fire regimes
Timber removal	33,250	Commercial timber sale; reduction of hazardous fuels
Species composition and stand density management	2,000	Enhance stands for harvest, grazing, or cultural uses; control invasive species and pests
Total area of primary treatments	**224,790**	
Secondary treatments		
Activities associated with primary treatments	11,450	Pretreatment to support project objectives
Road creation	335	Provide access to treatment areas
Total area of secondary treatments	**11,785**	
Action area[2]	**236,575**	

[1]Multiple treatments may be used for a single management objective. For example, reducing hazardous fuels can include thinning followed by broadcast burning in the same treatment area.

[2]The actual action area is likely to be less than the sum of all treatment areas because some areas will receive multiple treatments.

Table 3. Proposed treatments and associated activities for the vegetation management program in the Eastern Oklahoma Region of the Bureau of Indian Affairs.

[Estimated annual and total treatment acreages are provided]

Treatment	Activities	Estimated treatment area (acres)[1]		Description
		Annual	Total	
Primary treatments				
Prescribed fire	Broadcast burning	37,440	187,200	Low-severity (primarily forest understory) burning
	Constructing fire line	468	2,340	Clearing vegetation using heavy machinery or hand tools
Timber removal	Clearcutting	315	1,575	Complete removal of forest canopy using heavy machinery or hand felling
	Shelterwood or seed tree cutting	115	575	Near complete removal of forest canopy using heavy machinery or hand felling
	Thinning	6,220	31,100	Partial removal of forest canopy using heavy machinery or hand felling
Species composition and stand density management	Restoring grasslands and pasturelands	200	1,000	Conversion of forests, particularly in areas that were historically grasslands or savannas, where eastern redcedar is expanding
	Managing forest stands for harvest	200	1,000	Forest stand management for nut or fruit orchards, timber harvest, or grazing

Table 3. Proposed treatments and associated activities for the vegetation management program in the Eastern Oklahoma Region of the Bureau of Indian Affairs.—Continued

[Estimated annual and total treatment acreages are provided]

Treatment	Activities	Estimated treatment area (acres)[1]		Description
		Annual	Total	
		Secondary treatments		
Activities associated with primary treatments	Slash piling	332	1,660	Piling and burning of slash on site
	Mechanical ripping	100	500	Soil tilling to reduce compaction using heavy machinery
	Applying chemicals	1,220	6,100	Application of pesticides and fertilizers
	Pruning	75	375	Removal of branches from standing trees
	Mowing	133	665	Removal of brush and forest understory using machinery
	Planting	430	2,150	Planting bare root or container trees following treatments
Road construction	Constructing permanent roads	49	245	Construction of permanent roads to allow repeated treatments such as prescribed fire
	Constructing temporary roads	7	35	Construction of access roads that will be restored by the end of the program
	Installing bridges	1	5	Construction of stream crossings in association with permanent roads
	Installing culverts	10	50	Construction of stream crossings in association with permanent or temporary roads
Total estimated action area[2]		**47,315**	**236,575**	

[1]Multiple treatments may be used for a project. For example, a management objective to reduce hazardous fuels can include thinning followed by broadcast burning in the same treatment area, and some treatment areas may be repeatedly burned.

[2]The actual action area is likely to be less than the sum of all treatment areas because some areas will receive multiple treatments.

Project Overview.—The overall management program will include a variety of projects developed in conjunction with Tribes in the EOR (table 1). Landownership and jurisdictions include tribal lands (tribal trust or restricted, tribal fee, and individual Indian trust or restricted lands), Federal, State, county, and privately owned fee lands. The individual projects will primarily occur on tribal lands but can include other landownerships or jurisdictions if the treatment benefits the Tribes or adjacent landowners.

Individual projects will be designed to maintain, protect, enhance, and develop tribal forest and grassland resources and to reduce the negative effects of wildfires on communities, natural resources, and cultural resources. All projects are intended to accomplish the BIA mission to protect and improve the assets of American Indians. The BIA is working with individual Tribes to identify specific project objectives and design treatments to meet these objectives. Potential objectives include the following:

- **prescribed fires** to reduce fuels or improve livestock forage;
- timber removal for timber sales, firewood, fuels reduction, or to enhance grazing;
- management of stands for future timber sales, nut or fruit orchards, or nontimber products;
- cultural use of forest resources including harvesting of kanuchi nuts, medicines, and wood for use in making bow staves; and
- invasive species control, such as eastern redcedar removal and pest management.

Proposed Treatments

The proposed treatments include all potential management activities that could be used to accomplish project objectives. **Primary treatments** include prescribed fire, timber removal, and activities to manage **species composition** and stand density (table 2). **Secondary treatments** are activities that support the implementation of primary treatments and may overlap primary treatment areas. For each treatment type, we provide an estimate of the total area to be treated over the program duration in addition to general descriptions of the methods. The total estimated action area is the maximum expected for all treatments over the duration of the project. Because some areas may receive multiple treatments, the total action area is likely to be less than the sum of all treatment areas. For example, **thinning** may be followed by prescribed burning, or **clearcuts** may include slash piling and mechanical removal. The potential effects on threatened and endangered species can vary by treatment and among species (see "Effects Analysis for Federally Threatened, Endangered, and Candidate Species" section of this report).

Primary Treatments

All forestry treatments will follow the Oklahoma Forestry Services **best management practices** (BMPs; Oklahoma Forestry Services, 2016), in accordance with BIA guidance on forest management plans (Bureau of Indian Affairs, 2009). Additional BMPs will be used as appropriate to avoid and minimize adverse effects on threatened and endangered species in the EOR (appendix 2). Activities associated with each treatment in table 2 are described in the following sections and summarized in table 3. Posttreatment restoration activities are also described.

Prescribed Fire

Treatments to reduce **hazardous fuels** and restore the frequency of **low-severity fires** on the landscape will be conducted on approximately 37,440 acres of forested lands per year, with a maximum of 187,200 acres of prescribed burn treatments for the project duration (table 3). **Fire line** construction could affect an additional 2,340 acres. Reduction of hazardous fuels prior to burning reduces fuel loads and **fuel connectivity** by reducing stand **basal area**, removing **ladder fuels**, and reducing **forest understory** woody vegetation. Activities include timber removal and piling, burning, and **masticating** timber on site (see "Timber Removal" section of this report). Low-severity **broadcast burning** can reduce fine **surface fuels**, litter, shrub cover, and the density of invasive woody species but does not typically consume organic matter in the soil (DeBano, 1991; Certini, 2005). Litter and vegetation consumed by fire are expected to be quickly replenished by a postfire increase in productivity (Brockway and Lewis, 1997; Carter and Foster, 2004). Repeated prescribed burns will help maintain reduced fuel loads. Creation of fire lines and reduction of woody fuels often involve the use of machinery such as masticators, tracked loaders, and bulldozers. Some woody fuels may be piled and burned prior to the broadcast burn. Burning operations will be conducted by trained personnel during suitable weather conditions.

Timber Removal

Timber removal will be conducted on an estimated 6,650 acres of forests annually for a maximum of 33,250 acres over the project duration (tables 2 and 3). Treatments include clearcuts, **shelterwood** or **seed tree** cuts, and thinning, depending on the management objectives of the project. Clearcuts remove most or all of the **forest canopy**. Most clearcuts will be 10 to 40 acres with an estimated maximum size of 100 acres. Shelterwood and seed tree cuts remove most of the forest canopy but retain residual trees, typically with 10 to 30 percent canopy closure, to promote regeneration of preferred species. Thinning is used to reduce basal area and fuel loading by means of **thinning from below** or **above**, forest canopy removal, or **precommercial thinning**, depending on current and desired **stand conditions**.

Timber removal includes cutting, removal and processing of timber, and postharvest activities. Standing timber is cut by hand **felling**, typically using a chainsaw, or by mechanical felling using equipment, such as a **feller buncher**, harvester, or **mounted hydraulic shears**. Hand felling typically has minimal soil compaction, whereas mechanical felling generally has the greatest soil compaction. **Skidders** with rubber tires, or less often a tracked **skid steer** or other equipment capable of pulling logs, are used to move felled timber to a **timber landing** location for processing on or off site. Timber is loaded onto log trucks, **chip vans**, and dump trucks using a variety of mechanical devices at a central landing location adjacent to haul roads. Processing of cut trees can include piling, masticating, landing and skid trail rehabilitation, felling and **bucking** of damaged residual trees, **slash pile** or broadcast burning, and site preparation.

Management of Species Composition and Density

Some forest development projects promote agricultural use of forests, including nut and fruit tree plantations, enhancement of understory forage for livestock grazing, and management for selected species composition and densities for subsequent timber harvest. This treatment may also include removal of eastern redcedar and other woody species from grasslands and pastures. Alteration or restoration of species composition will occur on an estimated 400 acres per year for a maximum of 2,000 acres for the project duration (tables 2 and 3).

Other cover type changes may occur following treatments if landowners choose to convert a treated area to pasture or croplands. Crops planted in these areas will depend on the objectives of the landowner and may involve the use of pesticides and fertilizers. Because the BIA does not intend to directly facilitate, fund, or conduct conversion of cover types except as described in this biological assessment, any subsequent management activities by landowners are not addressed by this assessment.

Secondary Treatments

Secondary treatments used in conjunction with primary treatments include site preparation, maintenance, and processing, as well as road construction and associated stream crossings (tables 2 and 3). Site preparation, maintenance, and processing activities include slash piling, **mechanical ripping**, chemical applications, and **pruning** on 2,290 acres annually, for a total of 11,450 acres for the program duration. To facilitate timber removal, permanent unpaved and temporary roads will be created on a total of 335 acres. The creation of roads may require the construction of temporary or permanent stream crossings. Chemical applications of pesticides and fertilizer may be used before, during, and after primary treatments. Application methods include aerial spraying, tractor spraying, individual tree application following bark removal, and spot application. Site preparation and processing activities will vary by treatments and sites.

Restoration Activities

To facilitate natural regeneration and recovery following treatments, restoration activities will be conducted. Temporary roads will be decommissioned and culverts, hardened stream crossings, and **hardened fords** will be removed. Mechanical ripping and planting of **bare root** or **container trees** will be used to decrease erosion potential and promote vegetation recovery on temporary roads and other areas where heavy machinery is used (Reisinger and others, 1988). Permanent roads will not be restored during the project duration. To reduce risk of invasive species colonization and to enhance vegetation recovery following slash pile burning, large burn scars will be restored by seeding with native species. Small burn scars (less than 5 percent of a project's area) will be restored as needed.

Ecological Setting

The EOR is ecologically diverse and includes 10 level III **ecoregions** (table 4; Omernik, 1987). Cross Timbers is the largest ecoregion in the EOR (table 4) and is characterized by a mosaic of forests, grasslands, and savannas that form a transition between oak-hickory and pine forests to the east and prairie grasslands of the Great Plains to the west (Omernik, 1987). The EOR also includes portions of the Arkansas Valley, Boston Mountains, Central Great Plains, Central Irregular Plains, East Central Texas Plains, Flint Hills, Ouachita Mountains, Ozark Highlands, and the South-Central Plains ecoregions (table 4).

The dominant native vegetation types in the EOR vary by ecoregion (tables 4 and 5) and include mixed-grass and tallgrass prairies; oak, pine, and mixed deciduous forests, woodlands, and savannas; as well as bottomland (floodplain) forests (Hoagland, 2000). Oak forests typically include *Quercus stellata* (post oak) and *Q. velutina* (blackjack oak). Pine forests often include *Pinus palustris* (longleaf pine) and *P. echinata* (shortleaf pine). Historically, *Pinus taeda* (loblolly pine) forests were only present in the South-Central Plains (Hoagland, 2000), but this species has been planted elsewhere in the EOR. Other common deciduous trees that may occur in association with oak or pine forests include hickories (*Carya* spp.), *Fraxinus pennsylvanica* (green ash), *Liquidambar styraciflua* (sweetgum), *Nyssa sylvatica* (blackgum), *Platanus occidentalis* (American sycamore), *Populus deltoides* (eastern cottonwood), and *Ulmus americana* (American elm). Many of the deciduous species occur in bottomland forests, depending on the flood regime. In addition, *Taxodium distichum* (bald cypress) historically occurred in bottomland forests of the South-Central Plains but has been planted elsewhere in the EOR (Hoagland, 2000).

Table 4. Level III ecoregions and their percentage of the Eastern Oklahoma Region of the Bureau of Indian Affairs.

[Native upland vegetation types characteristic of each ecoregion are provided. EOR, Eastern Oklahoma Region]

Ecoregion[1]	Dominant upland vegetation types	Percentage of the EOR
Arkansas Valley	Prairie and oak, oak-pine, and oak-hickory forests	14.4
Boston Mountains	Oak-hickory forests	2.5
Central Great Plains	Mixed-grass prairie and hickory-pine forests	7.2
Central Irregular Plains	Tallgrass prairie and oak-hickory forests	15.6
Cross Timbers	Oak woodlands and forests; tallgrass prairie	29.6
East Central Texas Plains	Tallgrass prairie and oak savannas	1.1
Flint Hills	Mixed-grass prairie and scattered oak savannas	2.5
Ouachita Mountains	Oak-hickory-pine forests	12.2
Ozark Highlands	Oak-hickory forests	7.1
South-Central Plains	Oak-hickory-pine forests	7.8

[1]Omernik (1987).

Prior to Euro-American settlement, eastern Oklahoma had frequent (less than 10-year **fire return interval**) low-severity fires, and forests or grasslands in this region generally exhibit resilience to low-severity fires (Brown and Smith, 2000; Clark and others, 2007). Fire exclusion, however, has led to increased fuel loading and risk of high-severity fires that pose threats to lives, property, and natural resources. Fire exclusion has also contributed to the expansion of eastern redcedar. For example, in the absence of fire, eastern redcedar expansion can convert tallgrass prairies to redcedar woodlands within a few decades in the Flint Hills (Briggs and others, 2002).

Table 5. Land cover types and their percentage of the Eastern Oklahoma Region (EOR) of the Bureau of Indian Affairs.

Land cover type[1]	Percentage of the EOR
Conifer forests and woodlands	1.2
Deciduous forests and woodlands	30.8
Developed and altered vegetation	39.1
Grasslands and shrublands	17.3
Mixed forests and woodlands	6.2
Open water, riparian, and wetlands	5.3
Sparsely vegetated	0.1

[1]From LANDFIRE (2016).

General Ecological Benefits of Proposed Treatments

In addition to directly benefiting the Tribes, the proposed treatments may help restore altered ecological communities and promote resistance to, and resilience from, disturbances such as fire and insect or disease outbreaks. Approximately one-third of the EOR is considered at moderate to high risk of wildfire (table 6). In ecological communities that historically experienced frequent low-severity fires, the occurrence of high-severity wildfires can negatively affect natural resources, including habitats for threatened and endangered species. For example, high-severity fires consume or kill a greater proportion of vegetation and organic matter including litter (Certini, 2005) compared to low-severity fires (Brown and Smith, 2000).

Table 6. Wildfire hazard potential and percentage of the Eastern Oklahoma Region (EOR) of the Bureau of Indian Affairs.

Wildfire hazard potential[1]	Percentage of the EOR
Very low	24.0
Low	31.9
Moderate	22.6
High	10.5
Very high	0.3
Nonburnable and water	10.7

[1]From Dillon (2018).

Fire exclusion not only increases fuel loads and risk of high-severity fires; it can lead to the expansion of woody species such as eastern redcedar in forested and grassland systems. Expansion of eastern redcedar can degrade wildlife habitats, reduce biological diversity, alter hydrological functions, and increase the risk of high-severity fire (Briggs and others, 2002, 2005; Horncastle and others, 2005; Zou and others, 2014; Hoff and others, 2018). The proposed management activities will also help restore areas converted to dense single-species stands of eastern redcedar and reduce the risk of further expansion.

Treatments with the primary goal of reducing hazardous fuels can be beneficial to plants and animals adapted to low-severity fire regimes by helping restore the structure and dynamics of heterogeneous pine-oak forests, woodlands, and savannas. By reducing the risk of high-severity fire and invasive species expansion, it is expected that the proposed treatments will provide longer term benefits for terrestrial threatened and endangered species that will offset shorter term adverse effects that result from disturbance to vegetation and soils.

Effects Analysis for Federally Threatened, Endangered, and Candidate Species

The U.S. Fish and Wildlife Service (FWS) identified 22 threatened, endangered, or candidate species that may occur within the EOR (U.S. Fish and Wildlife Service, 2019a). These species include one plant, five freshwater mussels, two insects, four fishes, one reptile, five birds, and four bats (tables 7 and 8). Potential habitat for each of these species was used to evaluate the potential for occurrence in the EOR.

The potential effects of the proposed treatments were evaluated for aquatic and terrestrial species separately (tables 7 and 8, respectively). Because primary treatments will be conducted in terrestrial cover types, there are no anticipated direct effects on the 15 species associated with aquatic systems (table 7). The use of BMPs in adjacent uplands (tables 2.3, 2.4, and 2.5) and for secondary treatments (such as stream crossings) in aquatic systems (tables 2.1 and 2.2) will minimize the potential for indirect effects on aquatic habitats for threatened and endangered species (table 7). In contrast, the proposed treatments have the potential to adversely affect all seven terrestrial species (table 8). Avoidance of critical habitats, timing stipulations, and the use of BMPs are expected to minimize the likelihood of adverse effects for all terrestrial species, but some adverse effects will be unavoidable for *Nicrophorus americanus* (American burying beetle).

We evaluated the three types of anticipated effects as required by the ESA: “no effect” (all aquatic species), “may affect but unlikely to adversely affect” (six terrestrial species), and “may affect and is likely to adversely affect” (American burying beetle).

No effect.—Defined as having no impacts, positive or negative, and the species will not likely be exposed to the action and its environmental consequences.

May affect but not likely to adversely affect.—Defined as effects that are beneficial (but not adverse), insignificant (undetectable, not measurable, or cannot be evaluated), or **discountable** (extremely unlikely to occur).

May affect and is likely to adversely affect.—Defined as a negative response to an action or its environmental consequences.

Table 7. Federally threatened and endangered species associated with aquatic systems, listing status, habitat requirements, and potential for occurrence in the Eastern Oklahoma Region of the Bureau of Indian Affairs.

[No direct adverse effects are expected because aquatic habitats for these species are unlikely to occur within the action area. Best management practices for riparian and aquatic systems are expected to minimize the potential for adverse effects. EOR, Eastern Oklahoma Region; FE, federally endangered species; FT, federally threatened species; TS, threatened by similarity of appearance]

Species, scientific name (common name)	Listing status	Habitat requirements	Potential for occurrence in the EOR[4]
		Flowering plants	
Ptilimnium nodosum (harperella)	FE	Wet soils near bodies of water; requires periodic, moderate flooding[1]	Occurs in the lower Mountain Fork River, downstream of Broken Bow Reservoir
		Freshwater mussels	
Lampsilis rafinesqueana (Neosho mucket)	FE	Large streams; primarily occurs in shallow riffles and runs with a gravel substrate[2]	Occurs in the Illinois River; uncommon in the Neosho, Spring, and Verdigris Rivers
Arcidens wheeleri (Ouachita rock pocketbook)	FE	Pools, backwaters, and side channels of streams in stable substrates; juveniles occur in sand bars and muddy bottoms with little or no current[1]	Occurs in the Kiamichi and Little Rivers
Theliderma cylindrica (rabbitsfoot)	FT	Streams with clear, shallow waters and moderate flow; prefers mixed sand and gravel substrates free of algae[2]	Occurs in the Verdigris, Illinois, and Little Rivers
Leptodea leptodon (scaleshell mussel)	FE	Unpolluted waters with strong currents; typically found in riffles with gravel substrates[1]	Occurs within the Kiamichi and Little Rivers
Quadrula fragosa (winged mapleleaf)	FE	Shallow areas of unpolluted streams with consistent stream flow and substrates of gravel, sand, mud, or rubble[1]	Occurs in the Little River
		Fishes	
Notropis girardi (Arkansas River shiner)	FT	Wide and shallow prairie streams with sandy bottoms; congregates on the downstream side of transverse sand ridges; spawning occurs in main stream channels; eggs travel with current; larvae occur in backwater pools and side channels[2]	Occurs in large rivers throughout the Arkansas River Basin, including the Arkansas, Cimarron, and Canadian Rivers
Percina pantherina (Leopard darter)	FT	Clear small to medium-sized streams; eggs buried in deposits of gravel or rubble[2]	Occurs in Mountain Fork, Glover, and Upper Little Rivers
Noturus placidus (Neosho madtom)	FT	Permanent flow of medium-sized to moderately large streams, in clear water under rocks and in loosely compacted gravel bars; eggs are deposited under large objects[1]	Occurs in 5- to 8-mile stretches of the Neosho and Spring Rivers south of the Oklahoma-Kansas State line
Amblyopsis rosae (Ozark cavefish)	FT	Dark cave waters; requires clear streams with chert or rubble substrates, or pools with silty or sandy substrates[1]	Occurs in karst topography in Ottawa and Delaware Counties

Table 7. Federally threatened and endangered species associated with aquatic systems, listing status, habitat requirements, and potential for occurrence in the Eastern Oklahoma Region of the Bureau of Indian Affairs.—Continued

[No direct adverse effects are expected because aquatic habitats for these species are unlikely to occur within the action area. Best management practices for riparian and aquatic systems are expected to minimize the potential for adverse effects. EOR, Eastern Oklahoma Region; FE, federally endangered species; FT, federally threatened species; TS, threatened by similarity of appearance]

Species, scientific name (common name)	Listing status	Habitat requirements	Potential for occurrence in the EOR[4]
		Reptiles	
Alligator mississippiensis (American alligator)	TS	Freshwater or brackish systems; nests in sheltered areas of vegetation near water; feeds primarily on fish, turtles, mammals, birds, and other reptiles[1]	Potential habitat restricted to southeastern portions of the EOR.
		Birds[5]	
Sternula antillarum (interior least tern)	FE	Nests on sandy or gravel substrates along or near water bodies; feeds on aquatic organisms, primarily fish[1]	Potential migratory habitat along bodies of water throughout eastern Oklahoma; breeding habitat occurs along the Canadian, Arkansas, and Red Rivers
Charadrius melodus (piping plover)	FT	Nests on sandy or gravel substrates along alkaline lakes, and reservoirs; brood-rearing habitat includes ephemeral pools, bay tidal flats, and open vegetation; feeds on small arthropods[3]	Potential migratory habitat along bodies of water throughout eastern Oklahoma; no recent documented breeding within the EOR
Calidris canutus rufa (rufa red knot)	FT	Breeds in the high Arctic; primarily coastal during migration; feeds mainly on invertebrates[1]	Potential migratory habitat along bodies of water in eastern Oklahoma; does not breed within the EOR
Grus americana (whooping crane)	FE	Breeds in prairie wetlands, shallow lakes and ponds, marshes, mudflats and sedge meadows; winters outside Oklahoma[3]	Uncommon migrant in eastern Oklahoma; does not breed within the EOR

[1]Critical habitat not designated.

[2]Designated critical habitat occurs within the EOR.

[3]Designated critical habitat occurs outside of the EOR.

[4]Primary data sources for evaluating potential for occurrence in the EOR: Buthod and Hoagland (2013), U.S. Geological Survey (2018), International Union for the Conservation of Nature (2019), U.S. Fish and Wildlife Service (2019b).

[5]Migratory species that do not winter in Oklahoma.

Table 8. Federally threatened, endangered, and candidate species associated with terrestrial systems, listing status, habitat requirements, and potential for occurrence in the Eastern Oklahoma Region of the Bureau of Indian Affairs.

[EOR, Eastern Oklahoma Region; FE, federally endangered species; FC, Federal candidate species; FT, federally threatened species]

Species, scientific name (common name)	Listing status	Habitat requirements[1]	Potential for occurrence in the EOR[2]
		Insects	
Nicrophorus americanus (American burying beetle)	FE	Grasslands, shrublands and forests, primarily in areas with limited development; requires suitable soils for burrowing and suitable carrion for brood rearing	Occurs throughout eastern Oklahoma
Papaipema eryngii (rattlesnake master borer)	FC	Requires *Eryngium yuccafolium* (rattlesnake master plant) for all life stages; host plant is restricted to mesic prairies and associated wetlands	Potential habitat restricted to Osage County
		Birds	
Picoides borealis (red-cockaded woodpecker)	FE	Open, mature pine forests, typically dominated by *Pinus palustris* (longleaf pine); requires nesting trees greater than 60 years old; diet consists primarily of adults, larvae, and eggs of arthropods	Occurs in McCurtain County Wilderness Area and Ouachita National Forest
		Bats	
Myotis grisescens (gray bat)	FE	Hibernation, roosting, and maternity sites in caves; forages primarily on aquatic insects in riparian zones, ponds, fields, and forests	Occupied caves and adjacent areas in Adair, Delaware, Ottawa, and Cherokee Counties
Myotis sodalis (Indiana bat)	FE	Hibernation in caves or mines; roosting and maternity sites include trees in wooded areas; forages on insects along forest edges	Occupied cave in LeFlore County; active season in eastern Oklahoma
Myotis septentrionalis (northern long-eared bat)	FT	Hibernation in caves or mines; roosting and maternity sites include live and dead trees and sometimes caves; forages on insects in forest understory	Occupied caves in eastern Oklahoma; active season in eastern Oklahoma
Corynorhinus townsendii ingens (Ozark big-eared bat)	FE	Hibernation, roosting, and maternity sites in caves; forages primarily on moths in mature forests near caves	Occupied caves and adjacent areas in Adair, Cherokee, and Sequoyah Counties

[1]Critical habitat not designated in the EOR.

[2]Primary data sources for evaluating the potential for occurrence in the EOR: U.S. Geological Survey (2018), U.S. Fish and Wildlife Service (2019b).

No Anticipated Effects

The proposed treatments will be primarily restricted to forests and grasslands in the EOR and are not expected to directly affect aquatic systems. Avoidance of potential habitat for the 15 aquatic species (table 7) and the use of aquatic BMPs (tables 2.1 and 2.2), including avoidance of stream management zones, limiting instream equipment, and revegetation of disturbed areas, will help to avoid adverse effects on aquatic habitats for these species. Aquatic BMPs have been shown to be effective in minimizing the potential for negative effects on soils, water quality, and in preventing erosion and sedimentation (Aust and Blinn, 2004; Turton and others, 2009; Boggs and others, 2015; Witt and others, 2015; Cristan and others, 2016; Warrington and others, 2017).

Aquatic Plant—Harperella

Ptilimnium nodosum (harperella) is federally endangered (Maddox and Bartgis, 1990). This primarily annual plant is a member of the Apiaceae (carrot) family, ranges in size from 4 to 47 inches (in.), and produces a cluster of small white flowers in July and August (Buthod and Hoagland, 2013). It is restricted to sandy shoals or muddy banks of seasonally flooded rocky streams and coastal plain ponds across eight states of the southeastern United States (Maddox and Bartgis, 1990; Kress and others, 1994; Buthod and Hoagland, 2013). Harperella occurrence is positively associated with fine sediments and sites providing shelter from erosion, such as large rocks or exposed bedrock crevices (Frye and Tessel, 2012).

Harperella requires a narrow but variable range of water depths and conditions. This plant cannot survive in either continuously inundated or dry areas and changes in flow regime can alter habitat availability. Harperella is also sensitive to changes in water quality and chemistry. Increased siltation and turbidity associated with development such as construction and agriculture have been shown to significantly reduce harperella growth rates (Maddow and Bartgis, 1990). Limited water flow can affect the dispersal of its floating seeds. The plants will germinate and establish roots on wet soils but can survive indefinitely while floating in water (Maddow and Bartgis, 1990). Because suitable sites are uncommon, colonization of new sites is assumed to be rare (Maddow and Bartgis, 1990). The only known population of harperella in Oklahoma occurs on the lower Mountain Fork River, downstream of Broken Bow Reservoir (Buthod and Hoagland, 2013).

Freshwater Mussels

There are five freshwater mussel species in the family Unionidae that are listed as federally threatened or endangered in the EOR: *Lampsilis rafinesqueana* (Neosho mucket); *Arcidens wheeleri*, previously *Arkansia wheeleri* (Ouachita rock pocketbook); *Theliderma cylindrica*, previously *Quadrula cylindrica cylindrica* (rabbitsfoot); *Leptodea leptodon* (scaleshell mussel); and *Q. fragosa* (winged mapleleaf; table 7). All five species occur throughout the Midwest, but within Oklahoma, they are restricted to the eastern extent of the EOR. Critical habitat for the Neosha mucket and rabbitsfoot occurs in the EOR.

Unionid mussels require host fishes for the development and metamorphosis of their parasitic larvae (**glochidia**). Host species vary among mussel species (Barnhart and Roberts, 1997; Barnhart, 2001; Fobian, 2007; Barnhart, 2010; Roe and Boyer, 2015). The glochidia attach to the gills of the fish host, where they will remain encysted up to several weeks, depending on the species. The glochidia metamorphosize into the juvenile stage, then detach from the host and burrow into streambed sediments where they become established as adults (Barnhart, 2003, 2010; Fobian, 2007). Adult freshwater mussels feed on suspended detritus, algae, bacteria, phytoplankton, zooplankton, and other microorganisms (Winged Mapleleaf Mussel Recovery Team, 1997; Martinez, 2004; Butler, 2005; Roberts, 2010; The Neosho Mucket Recovery Team, 2018).

Freshwater mussels are very sensitive to altered flow regimes and degraded water quality resulting from channelization and impoundments, sedimentation, and chemical contaminants from adjacent agriculture, mining, and energy development (Vaughn and Pyron, 1995; Winged Mapleleaf Mussel Recovery Team, 1997; Martinez, 2004; Butler, 2005; Galbraith and others, 2008; Roberts, 2010; The Neosho Mucket Recovery Team, 2018). Threats to mussels can be exacerbated by urbanization leading to decreased resiliency of populations (The Neosho Mucket Recovery Team, 2018).

Neosho Mucket

The Neosho mucket is federally endangered (The Neosho Mucket Recovery Team, 2018). This species can reach a length of 7 in. (The Neosho Mucket Recovery Team, 2018). The shell is olive-yellow or brown with green rays, becoming dark brown with age (Mather, 2005). In Oklahoma, this species occurs within the Arkansas River drainage, including the Illinois River upstream of Lake Tenkiller, as well as the Neosho and Verdigris River Basins (Mather, 2005; The Neosho Mucket Recovery Team, 2018). Neosho muckets occur in shallow riffles and runs with gravel substrates and moderate to swift currents. Host fishes include *Micropterus dolomieu* (smallmouth bass), *M. salmoides* (largemouth bass), and *M. punctulatus* (spotted bass; Barnhart and Roberts [1997]). Females produce glochidia between May and August and inflate an extension of the mantle that resembles a small fish to lure and infect the host fish with glochidia (Shiver, 2002; Barnhart, 2003; The Neosho Mucket Recovery Team, 2018).

Ouachita Rock Pocketbook

The Ouachita rock pocketbook is federally endangered (Martinez, 2004). This species can reach a length of 4 in. (Martinez, 2004). The shell is circular, with chestnut brown or black coloration. In Oklahoma, the Ouachita rock pocketbook occurs in the Kiamichi River upstream of Hugo Reservoir and in isolated reaches of the Little River (Vaughn and Pyron, 1995; Vaughn and others, 1996; Martinez, 2004; Mather, 2005). Their habitat includes side channels, backwaters, or pools with mud bottoms and limited currents that are adjacent to riffles or other areas of moderate to fast currents (Vaughn and Pyron, 1995; Martinez, 2004). Host fishes include *Notemigonus crysoleucas* (golden shiner), *Luxilus pilsbryi* (duskystripe shiner), and *Aplodinotus grunniens* (freshwater drum; Barnhart, 2010).

Rabbitsfoot

The rabbitsfoot is federally threatened (U.S. Fish and Wildlife Service, 2013b). This species can reach a length of 6 in. (U.S. Fish and Wildlife Service, 2013b). The shell is an elongated rectangular shape with yellow, green, or olive coloration that becomes yellow-brown with age. In Oklahoma, the species occurs in the Arkansas and Red River drainages, including the Verdigris, Neosho, Illinois, Little, and Glover Rivers (U.S. Fish and Wildlife Service, 2012a). The rabbitsfoot occurs in deep water or shallow areas near shorelines adjacent to faster currents, typically beneath submerged logs (Fobian, 2007; U.S. Fish and Wildlife Service, 2013b). Adults remain on sand or gravel surfaces rather than burying in the substrate. Rabbitsfoot populations are often isolated and have low densities (Fobian, 2007). Host fishes include *Cyprinella venusta* (blacktail shiner), *Luxilus cardinalis* (cardinal shiner), *C. lutrensis* (red shiner), *C. spiloptera* (spotfin shiner), and *C. camura* (bluntface shiner) (Fobian, 2007). Females produce around 114,000 glochidia typically between May and July and attract their host fish with a bright orange, black, and white lure (Fobian, 2007; U.S. Fish and Wildlife Service, 2013b).

Scaleshell Mussel

The scaleshell mussel is federally endangered (Roberts, 2010). This species can reach a length of 4 in. (Roberts, 2010). The shell is long, thin, and smooth with yellowish green or brown coloration and faint green rays. In Oklahoma, this species occurs within the Kiamichi and Little River Basins, where it occupies riffle habitat of clear, unpolluted water with gravel, cobble, mud, or sand substrates (Galbraith and others, 2008; Roberts, 2010). Scaleshell mussels typically bury in the substrate to a depth of 5 in. (Roberts, 2010). There is limited life history information on the scaleshell mussel. *Aplodinotus grunniens* (freshwater drum) is the only known host species. During the summer months, female scaleshell mussels produce around 400,000 glochidia. The host fish ingest the female mussels, which facilitates attachment of the glochidia to the gills of the host fish (Barnhart, 2001). This process of "female sacrifice" is unusual among Unionid mussels and may account for a significantly skewed sex ratio in scaleshell mussel populations (Barnhart, 2001).

Winged Mapleleaf

The winged mapleleaf is federally endangered (Winged Mapleleaf Mussel Recovery Team, 1997). This species can reach a length of 4 in. (Winged Mapleleaf Mussel Recovery Team, 1997). It has a rounded shell that is dull brown in color, with several broad green rays. In Oklahoma, it occurs in the Little River in clear, unpolluted riffles with gravel, sand, or rubble substrates (Winged Mapleleaf Mussel Recovery Team, 1997). From September to October, winged mapleleafs produce glochidia (Hove and others, 2012; Roe and Boyer, 2015), which require *Ictalurus furcatus* (blue catfish) or *I. punctatus* (channel catfish) as host fishes (Roe and Boyer, 2015). The timing of metamorphosis and detachment from the host fish depends on water temperature (Hove and others, 2012). Successful recruitment of glochidia to juvenile and adult stages is apparently lower than is typical for other mussel species, potentially contributing to population declines (Hove and others, 2012; Roe and Boyer, 2015).

Freshwater Fishes

There are four species of fish listed as federally threatened within the EOR (table 7): *Notropis girardi* (Arkansas River shiner), *Percina pantherina* (leopard darter), *Noturus placidus* (Neosho madtom), and *Amblyopsis rosae* (Ozark cavefish). Critical habitat has been designated for the Arkansas River shiner and leopard darter within the EOR.

Arkansas River Shiner

The Arkansas River shiner is federally threatened (U.S. Fish and Wildlife Service, 1998). The Arkansas River shiner is a small minnow in the Cyprinidae family and can reach a length of 2 in. (Moore, 1944) with a typical lifespan less than 3 years. Their habitat includes turbid main channels of wide but shallow creeks and rivers with shifting sandy or silty substrates (Bestgen and others, 1989). Adults are typically associated with bank, island, or underwater sand ridges, and are uncommon in deep water and substrates of mud or stone (Polivka, 1999). Within the EOR, the Arkansas River shiner is restricted to the Canadian River upstream of Eufaula Lake. Juveniles are typically associated with slow currents in backwater pools and the mouths of tributaries (Polivka, 1999).

The Arkansas River shiner usually spawns in June and July, often coinciding with high water following heavy rains (Bestgen and others, 1989; U.S. Fish and Wildlife Service, 1998). Their eggs are nonadhesive and drift with currents during peak streamflow. Hatching occurs within 24 to 48 hours after spawning, and larvae are capable of swimming within 3 to 4 days of hatching (Moore, 1944). Reduction of surface water, construction of impoundments, and degradation of water quality are the main threats to the fish (U.S. Fish and Wildlife Service, 1998).

Leopard Darter

The leopard darter is federally threatened (James and Collins, 1993). This species is in the Percidae family, with an average length of 3 in. They have several dark spots on their sides, with saddles and bars along their back (Oklahoma Department of Wildlife Conservation, 2018). In Oklahoma, the leopard darter is restricted to the southeastern extent of the EOR, with scattered populations in the Mountain Fork, Glover, and Upper Little River Basin drainages. Their habitat includes intermediate to large streams with clear water and gravel substrates, and they generally occur in pools 8 to 31 in. deep. Typically, leopard darters live less than 2 years and spawn only once. Spawning occurs in stream riffles from March to April and eggs are buried in gravel or rubble until hatching in April and May (James and Collins, 1993). Their diet includes insects and microcrustaceans (Oklahoma Department of Wildlife Conservation, 2018). The historical distribution of the leopard darter was likely limited, which may have contributed to greater vulnerability to population declines from habitat loss and degraded water quality resulting from reservoir construction, logging, agriculture, and industrial runoff (James and Collins, 1993).

Neosho Madtom

The Neosho madtom is federally threatened (U.S. Fish and Wildlife Service, 2013d). This species is a member of the Ictaluridae family and can reach a length of 3 in. (U.S. Fish and Wildlife Service, 2013d). In Oklahoma, it is restricted to the Neosha River Basin in the northeastern extent of the EOR (Fuselier and Edds, 1994). Their habitat includes loose gravel bars in fast moving water, usually associated with riffles (Bulger and Edds, 2001). The Neosho madtom is nocturnal and feeds on insect larvae and other aquatic invertebrates (U.S. Fish and Wildlife Service, 2013d). It lives for 1 year and spawns during the summer in nesting cavities excavated by males, typically in gravel substrates (Bryan and others, 2006).

Habitat modification and altered streamflow dynamics caused by dams are the primary threat to the Neosho madtom (U.S. Fish and Wildlife Service, 2013d). Summer discharge from dams reduces the ability of this fish to construct and maintain nests, which can lead to decreased reproductive success (Bryan and others, 2006). Contamination from past mining activities may also adversely affect the Neosho madtom (U.S. Fish and Wildlife Service, 2013d).

Ozark Cavefish

The Ozark cavefish is federally threatened (U.S. Fish and Wildlife Service, 2011b). This cave-dwelling fish can reach a length of 3 in. (U.S. Fish and Wildlife Service, 2011b). Lacking pigments, they appear pinkish-white because their translucent skin reveals blood and organs. Their eyes are vestigial and adults lack optic nerves. The distribution of the cavefish is limited to the Springfield Plateau Aquifer in Arkansas, Missouri, and Oklahoma (Poulson, 1963; Willis, 1986; Graening and Brown, 1999; Graening and others, 2010), and they only occur in the northeastern extent of the EOR. They are largely restricted to cave streams with chert rubble substrates but also may occur in wells and sinkholes (Graening and others, 2010). Ozark cavefish life history is poorly understood. A protracted reproductive cycle may contribute to slow population growth rates. Females may breed for the first time at 3 years, and it is estimated that only 20 percent of females breed per year (Poulson, 1963). The average brood size is 23. Their diet includes small salamanders, crayfish, isopods, amphipods, and young of their own species (Poulson, 1963). The decline in Ozark cavefish populations is primarily the result of reduced water levels and degraded water quality caused by agriculture and urbanization (U.S. Fish and Wildlife Service, 2011b).

Aquatic Reptile—American Alligator

Alligator mississippiensis (American alligator) is federally threatened based on similarity of appearance to other threatened or endangered crocodilians (U.S. Fish and Wildlife Service, 1987). It is a large reptile ranging in length from 6 to 16.5 feet (ft; Conant and Collins, 1991). This species is native to swamps, lakes, marshes, and other water bodies within the Gulf of Mexico and lower Atlantic Coastal Plain (Conant and Collins, 1991). In the EOR, alligators only occur in McCurtain County, which is the northern periphery of its range (U.S. Fish and Wildlife Service, 1987).

Aquatic Birds

There are four species of federally threatened and endangered migratory birds that are strongly associated with aquatic systems for nesting, foraging, and migratory stopover sites: *Sternula antillarum* (interior least tern), *Charadrius melodus* (piping plover), *Calidris canutus rufa* (rufa subspecies of the red knot), and *Grus americana* (whooping crane). Only the interior least tern currently nests within the EOR (table 7). Confirmed nesting sites of piping plovers in Oklahoma are outside of the EOR. The red knot and whooping crane are infrequently observed during migration in eastern Oklahoma.

Interior Least Tern

The interior least tern is a geographically and ecologically separate population from the east coast population of the least tern (U.S. Fish and Wildlife Service, 2013c). The interior least tern is federally endangered, but because recovery goals have been reached, the FWS has proposed that this species be delisted under the ESA (U.S. Fish and Wildlife Service, 2013c). The least tern is the smallest tern in North America, with a wingspan of approximately 21 in. (U.S. Fish and Wildlife Service, 2013c). Interior least terns migrate from their winter range in Central and South America to breeding areas throughout the midwestern United States, primarily along the lower Mississippi River (Lott and others, 2013; U.S. Fish and Wildlife Service, 2013c). The terns nest in colonies on sparsely vegetated shorelines or sandbars of large rivers, exposed salt flats, or reservoir beaches with sandy or coarse substrates. Their diet consists of small fish and they may forage more than 4 miles (mi) from their nests (U.S. Fish and Wildlife Service, 2013c). Loss of shoreline and sandbar habitat resulting from water flow regulation and channelization is a primary threat to the interior least tern, but conservation measures, including those implemented by the Army Corps of Engineers on the lower Mississippi River, have been instrumental in population recovery (U.S. Fish and Wildlife Service, 2013c).

Piping Plover

The piping plover is federally threatened (Northern Great Plains Piping Plover Recovery Team, 2016). This small migratory shorebird has a short, stout bill; pale underparts; and orange legs (Northern Great Plains Piping Plover Recovery Team, 2016). During spring and fall migration, the plovers use shorelines, such as sandbars of major rivers, salt flats, and mudflats of reservoirs, where they forage for small invertebrates (Northern Great Plains Piping Plover Recovery Team, 2016). Their wintering range includes the Gulf Coast of the southern U.S. The most recent breeding records in Oklahoma were from 1987 and 1988 at Optima Reservoir in the western part of the State (Boyd, 1991; U.S. Fish and Wildlife Service, 2002). Habitat loss resulting from dams and water withdrawals is a major threat to piping plovers (Northern Great Plains Piping Plover Recovery Team, 2016).

Red Knot

The rufa subspecies of the red knot is federally threatened (U.S. Fish and Wildlife Service, 2015b). This shorebird migrates long distances between breeding grounds in the high Arctic and wintering grounds in the southeast U.S., Gulf of Mexico, Brazil, and southern Argentina (Piersma and Davidson, 1992; Buehler and others, 2006; U.S. Fish and Wildlife Service, 2015b). Red knots typically migrate along the coasts, although small numbers have been reported from nearly every interior state (U.S. Fish and Wildlife Service, 2015b). In Oklahoma, only 40 occurrences have been documented between 1941 and 2012 (U.S. Fish and Wildlife Service, 2014). Stopover habitat includes large expanses of exposed sediments in primarily marine and estuarine systems (U.S. Fish and Wildlife Service, 2015b). Their diet includes shrimp, horseshoe crab eggs, and other mollusks (U.S. Fish and Wildlife Service, 2014). Primary threats to the rufa red knot include a decline in availability of stopover food resources in Delaware Bay (Niles and others, 2008) and vulnerability of nesting habitat to projected climate change scenarios (Galbraith and others, 2002; Meltofte and others, 2007; U.S. Fish and Wildlife Service, 2015b).

Whooping Crane

The whooping crane is federally endangered (International Whooping Crane Recovery Team, 2007). This species is the tallest North American bird reaching a height of almost 5 ft (International Whooping Crane Recovery Team, 2007). The cranes migrate annually between their winter range in coastal marshes in Texas and breeding grounds in Wood Buffalo National Park, Canada. Whooping cranes occur infrequently in Oklahoma during migration from March to May and from September to November. Stopover habitat includes river shorelines and shallow, seasonally flooded wetlands. They forage in emergent wetlands and croplands (International Whooping Crane Recovery Team, 2007). Whooping cranes are omnivorous and eat plant tubers, insects, crayfish, frogs, fish, and agricultural grains. Loss of migratory habitat and collisions with powerlines are the primary threats to whooping cranes (International Whooping Crane Recovery Team, 2007).

Unlikely to Adversely Affect

Six of the federally threatened, endangered, and candidate species primarily associated with terrestrial habitat types (table 8) have the potential to be adversely affected by the proposed treatments, but avoidance of vulnerable habitat features (such as riparian zones, wetlands, cavity trees, maternity trees, and caves), timing stipulations, and other BMPs (appendix 2) decrease the likelihood that the treatments will have adverse effects (discountable). The terrestrial species include a moth, *Papaipema eryngii* (rattlesnake master borer); a forest-dwelling bird, *Picoides borealis* (red-cockaded woodpecker); and four species of bats: *Myotis grisescens* (gray bat), *M. sodalis* (Indiana bat), *M. septentrionalis* (northern long-eared bat), and *Corynorhinus townsendii ingens* (Ozark big-eared bat).

Insect—Rattlesnake Master Borer

The rattlesnake master borer is a Federal candidate species (U.S. Fish and Wildlife Service, 2013a). This designation indicates the potential for subsequent listing as federally threatened or endangered. All life stages of this moth are dependent on their host plant, *Eryngium yuccafolium* (rattlesnake master). The rattlesnake master borer is restricted to undisturbed prairies and woodlands where its host plant is present (U.S. Fish and Wildlife Service, 2013a). Although their host plant is widely distributed throughout the eastern and central U.S. (Natural Resources Conservation Service, 2002), the moth only occurs in 16 sites across 5 states (U.S. Fish and Wildlife Service, 2013a). In Oklahoma, rattlesnake master borers only occur in the Tallgrass Prairie Preserve, operated by The Nature Conservancy in Osage County, at the northern extent of the EOR (U.S. Fish and Wildlife Service, 2013a). Alteration and conversion of prairie habitat by agriculture and other development activities have fragmented and isolated populations of this moth, leading to population declines (U.S. Fish and Wildlife Service, 2016b).

The lifespan of the moth is 1 year. Adults emerge in September and October and are strictly nocturnal. Adult dispersal is typically less than 400 ft, although they may fly up to 2 mi in search of suitable rattlesnake master plants (U.S. Fish and Wildlife Service, 2013a). The adults have underdeveloped mouth parts and large fat stores, indicating that they likely do not feed although they may obtain moisture from dew or sap (U.S. Fish and Wildlife Service, 2013a). In October, females lay eggs at the base of rattlesnake master plants, after which the females die (U.S. Fish and Wildlife Service, 2013a). The larvae emerge in May or June and feed exclusively on rattlesnake master plant leaves and subsequently burrow into the stem and roots of the plant (Howard, 2017), which typically prevents the rattlesnake master plant from producing flowers and may lead to plant death.

Although the proposed treatments have the potential to negatively affect rattlesnake master borer populations (Betz and others, 1996; Panzer, 2002), the treatments are unlikely to occur within any known populations in Oklahoma. Consequently, the management program is unlikely to adversely affect this species. Prior to treatments, surveys for this moth can determine if this species is present in grassland cover types within Osage County. If the moths are present, further consultation with the FWS is required.

Forest-Dwelling Bird—Red-Cockaded Woodpecker

The red-cockaded woodpecker is federally endangered (Red-Cockaded Woodpecker Recovery Team, 2003). This small woodpecker is approximately 7 in. long (U.S. Fish and Wildlife Service and Costa, 2002). It is nonmigratory and endemic to mature and old-growth pines in open woodlands and savannas of the southeastern United States (U.S. Fish and Wildlife Service and Costa, 2002; Red-Cockaded Woodpecker Recovery Team, 2003; Oklahoma Department of Wildlife Conservation, 2018). In eastern Oklahoma, the red-cockaded woodpecker is restricted to pine stands in McCurtain and Pushmataha Counties, which is the northwestern extent of its range (Red-Cockaded Woodpecker Recovery Team, 2003).

The red-cockaded woodpecker typically excavates nesting and roosting cavities in live or recently dead large pines, including longleaf pine, loblolly pine, and shortleaf pine. Cavity excavation may take several years (Red-Cockaded Woodpecker Recovery Team, 2003). Cavity trees are often clustered in open pine stands with little or no midstory deciduous trees. This woodpecker breeds cooperatively in family groups that may consist of a breeding pair and one or two helpers (Red-Cockaded Woodpecker Recovery Team, 2003). Fire exclusion can lead to the expansion of deciduous trees and concomitant loss of potential cavity sites and abandonment of breeding areas (Red-Cockaded Woodpecker Recovery Team, 2003). Logging in the early 1900s reduced availability of suitable cavity trees, fragmented habitats, and increased isolation of breeding groups (Neal and Montague, 1991; Red-Cockaded Woodpecker Recovery Team, 2003). Recovery plan guidelines for treatments in potential habitat (table 2.3) can be used to avoid, minimize, or mitigate adverse effects (Red-Cockaded Woodpecker Recovery Team, 2003). For example, treatments can help maintain or promote habitat suitability by retaining large, old pines, potential cavity trees (pines more than 60 years in age), and pines scarred by turpentine harvesting or lightning.

Bats

There are four species of federally threatened or endangered bats that have documented or potential habitat within the EOR (table 8). All four species use caves as **hibernacula** but may use either trees or caves for maternity sites and summer roosting (table 9). These species are generally restricted to the Arkansas Valley, Boston Mountains, Central Irregular Plains, Ouachita Mountains, and Ozark Highlands ecoregions in the EOR (table 9). Major threats include mortality caused by collisions with wind turbines (O'Shea and others, 2016), white nose syndrome (Loeb and others, 2011; Langwig and others, 2012; U.S. Fish and Wildlife Service, 2012b; Thogmartin and others, 2013; Law and others, 2016), pesticide use (Clark and others, 1978; Clark, 1988; O'Shea and Clark, 2002), human disturbance (Tuttle, 1979; Johnson and others, 1998; Graening and others, 2011), and habitat loss or degradation (Humphrey, 1978; Russo and Ancillotto, 2014; Silvis and others, 2016).

Table 9. Cave and tree use and geographical extent of federally threatened and endangered bats in the Eastern Oklahoma Region of the Bureau of Indian Affairs.

Species	Use of caves		Use of trees		Geographical extent (ecoregion code)[1]
	Winter	Active season	Winter	Active season	
Gray bat	Yes	Yes	No	No	38, 39, 40
Indiana bat	Yes	Yes	No	Yes	36, 37, 38, 39
Northern long-eared bat	Yes	Yes	No	Yes	36, 37, 38, 39, 40
Ozark big-eared bat	Yes	Yes	No	No	37, 38, 39

[1]Ecoregion codes (from Omernik, 1987): 36, Ouchita Mountains; 37, Arkansas Valley; 38, Boston Mountains; 39, Ozark Highlands; 40, Central Irregular Plains.

Gray Bat

The gray bat is federally endangered (U.S. Fish and Wildlife Service, 2009). It is one of the largest North American *Myotis* species (Decher and Choate, 1995). Gray bats reach reproductive age at 2 years and may live as long as 14 to 17 years (Miller, 1939; Harvey, 1992; Tuttle and Kennedy, 2005). In Oklahoma, they are most common in oak-hickory forests of the Ozark Highlands (Oklahoma Department of Wildlife Conservation, 2018). Gray bats are dependent on karst cave systems for hibernation, maternity sites, and summer roosting. The bats are present in Oklahoma year round, though most individuals migrate to other states to overwinter (Caire and others, 1989). Caves used by the gray bats occur in Adair, Delaware, Ottawa, and Cherokee Counties (Oklahoma Department of Wildlife Conservation, 2018). Gray bats typically give birth to pups in late May or early June. Pups become **volant** 21 to 33 days after birth (U.S. Fish and Wildlife Service, 2011a). Their diet consists primarily of aquatic insects and most maternity colonies are located within a few miles of riparian foraging areas (U.S. Fish and Wildlife Service, 2009).

Indiana Bat

The Indiana bat is federally endangered (Pruitt and TeWinkel, 2007). This medium-sized bat is similar in appearance to other *Myotis* species (Oklahoma Department of Wildlife Conservation, 2018). They reach reproductive maturity at one year of age and may live as long as 14 years (Pruitt and TeWinkel, 2007; Harvey and others, 2011). Indiana bats use karst cave systems or mines for hibernation or roosting and use trees for maternity sites or roosting (Menzel and others, 2001). In Oklahoma, Indiana bats are restricted to mixed oak-hickory-pine forests primarily within the Ouachita Mountains and the Ozark highlands (Oklahoma Department of Wildlife Conservation, 2018). In Oklahoma, the only cave used for hibernation is in LeFlore County, which is managed by the U.S. Forest Service (Oklahoma Department of Wildlife Conservation, 2018). Indiana bats give birth in June, after which pups are raised underneath loose bark on trees (Harvey and others, 2011). Pups become volant 3 to 5 weeks after birth (Pruitt and TeWinkel, 2007). The species is insectivorous, and their diet consists primarily of flying insects.

Northern Long-Eared Bat

The northern long-eared bat is federally threatened (U.S. Fish and Wildlife Service, 2016a). In Oklahoma, this medium-sized bat is primarily restricted to the Ozark highlands and Ouachita mountains (Oklahoma Department of Wildlife Conservation, 2018). They may live as long as 18 years (Hall and others, 1957). Northern long-eared bats hibernate in caves or abandoned mines during the winter (Caceres and Barclay, 2000). Unlike many other bat species, they generally do not form large colonies for hibernation (Oklahoma Department of Wildlife Conservation, 2018). In Oklahoma, there are nine known hibernacula (Oklahoma Department of Wildlife Conservation, 2018). Live and dead trees are used as summer roosts and maternity sites, with maternity colonies containing as many as 50 bats (Caceres and Barclay, 2000; U.S. Fish and Wildlife Service, 2015a; Oklahoma Department of Wildlife Conservation, 2018). Northern long-eared bats give birth between May and June each year (Caceres and Barclay, 2000), and pups become volant around 18 to 21 days after birth (U.S. Fish and Wildlife Service, 2015a). They are insectivorous and forage over water, forest interiors, and along forest edges (Fenton and others, 1983; Faure and others, 1993).

Ozark Big-Eared Bat

The Ozark big-eared bat is federally endangered (Stark, 2008). This medium-sized bat is a nonmigratory cave obligate. Limestone and sandstone talus caves are used for hibernation, roosting, and maternity sites (Oklahoma Department of Wildlife Conservation, 2018). As of 2008, their population was estimated at 1,900 individuals (Stark, 2008). In Oklahoma, they are

endemic to the oak-hickory forests of the Ozark Highlands and populations are known to occupy approximately 20 caves in Adair, Cherokee, and Sequoyah Counties (Stark, 2008; Oklahoma Department of Wildlife Conservation, 2018). Females give birth in May or June after a gestational period of 2 to 3 months, and pups become volant at 6 weeks (Stark, 2008). They are insectivorous, consuming primarily moths, and typically forage along forest edges within 5 mi of caves (Leslie and Clark, 2002; Stark, 2008; Oklahoma Department of Wildlife Conservation, 2018).

Avoidance and Minimization Measures and Best Management Practices for Bats

Bats are particularly sensitive to disturbance around hibernacula and maternity sites and removal of roost or maternity trees (Tuttle, 1979; Sasse and others, 2007; Johnson and King, 2018; Oklahoma Department of Wildlife Conservation, 2018). Disturbance and smoke from site preparation and management activities near key habitat features associated with vulnerable periods (hibernation, pup rearing, and active seasons) may adversely affect bats. In Oklahoma, the bats hibernate in karst features during mid-Novermber through March. Pup-rearing in trees and karst features occurs in May through July. Smoke, tree removal, and other disturbances from management activities during winter may awaken bats from hibernation, which can deplete energy stores and cause mortality. Spring and summer timber removal and burning may lead to pup abandonment and can cause direct mortality of tree-roosting females and their pups. In addition, the degradation of waterways and use of pesticides can decrease food availability or expose bats to bioaccumulation of chemicals (Taylor, 2006; U.S. Fish and Wildlife Service, 2011a; Johnson and King, 2018). Key habitat features include occupied caves and foraging habitat adjacent to occupied caves (all four species), forests and forest edges (Indiana bats and northern long-eared bats), and riparian zones (gray bats).

Recommended avoidance and minimization measures can reduce the risk of adverse effects on bats. To avoid disturbance to bats near critical habitat features during vulnerable periods, timing stipulations for management activities (table 10) and best management practices (table 2.4) will be followed. To prevent disturbance near known hibernacula, maternity, and roost caves, the FWS has delineated foraging buffers that include vulnerable caves and adjacent foraging areas for gray, Ozark big-eared, and Indiana bats in Oklahoma (table 10). For gray bats and Indiana bats, foraging buffer 1 delineates the area immediately surrounding caves, and foraging buffer 2 includes surrounding areas (table 10). For Ozark big-eared bats, the foraging buffer includes vulnerable caves and adjacent foraging areas. To identify additional karst features that may be used by all bat species in a treatment area, karst surveys will be conducted prior to the start of management activities. If new karst features are observed, FWS will be contacted for further consultation (table 10).

In conjunction with timing stipulations for treatments within foraging buffers and for key habitat features (such as riparian areas and snags), the use of BMPs within potential habitat for these four species can circumvent or minimize adverse effects of treatments (tables 10 and 2.4). Avoidance of riparian areas and use of aquatic BMPs (tables 2.1 and 2.2) for management activities near aquatic systems minimizes the risk for adverse effects on potential bat foraging habitat. For example, management activities will only occur more than 300 ft from the ordinary high-water mark during the active season within gray bat habitat buffers. There are additional BMPs to protect potential roost trees and maternity sites for Indian bats and northern long-eared bats such as the retention of larger **snags** (standing dead or dying trees) with loose bark, cracks, or cavities, as well as wintertime removal of **hazard trees** and fire line creation to avoid disturbance during active periods (table 2.4).

Depending on the foraging habitat of the bat species and the type and timing of management activities, the proposed treatments can have beneficial or adverse effects. Foraging habitat depends in part on echolocation characteristics, body size, and wing morphology. Typically, larger bats forage along forest edges, and smaller bats forage within forest interiors (Aldridge and Rautenbach, 1987; Norberg and Rayner, 1987; Patriquin and Barclay, 2003; Blakey and others, 2019). Indiana and northern long-eared bats are considered to be **clutter adapted** species, which is conducive to foraging among dense trees in forest interiors. These two species may avoid clearcuts as small as 10 to 15 acres (Patriquin and Barclay, 2003; Owen and others, 2004). Smaller or more linear clearcuts are assumed to have less adverse effects compared to larger cuts and can contribute to beneficial heterogeneity within the landscape (Taylor, 2006). Gray and Ozark big-eared bats more commonly forage along forest edges and openings including larger clearcuts.

If conducted during the pup-rearing season, thinning and prescribed burning have the potential to adversely affect Indiana and northern long-eared bats in the short term if trees used for roosting or maternity sites are disturbed, but in the long term, these treatments may improve habitat suitability for all four bat species by creating early successional conditions, reducing tree density, and creating corridors that can benefit movement and foraging (Perry and Thill, 2007; Loeb and O'Keefe, 2011; Loeb and O'Keefe, 2014). In addition, treatments that remove invasive woody shrubs and reduce the risk of high-severity fire are expected to help maintain habitat suitability for all bat species. Forest management activities that maintain or enhance a diversity of tree species and size classes, snag characteristics, and landscape heterogeneity can help support diverse bat assemblages (Johnson and Chambers, 2017; Johnson and King, 2018).

Table 10. Survey requirements and timing stipulations for tree removal or prescribed burning to avoid adverse effects on federally threatened or endangered bats during active, pup-rearing, and hibernation periods.

[Active periods are from April through mid-November, pup-rearing periods are from May through July, and hibernation periods are from mid-November through March. FWS, U.S. Fish and Wildlife Service; BMPs, best management practices; ft, foot; OHWM, ordinary high-water mark]

Species	Habitat features[1]	Survey requirements	Timing stipulations			
			April	May through July	August through mid-November	Mid-November through March
All species	Karst topography	Karst surveys	BMPs	BMPs	BMPs	BMPs
Gray bat	Foraging buffer[1]	Assumed present	BMPs	No tree removal within 300 ft of OHWM	BMPs	BMPs
	Foraging buffer[2]	Assumed present	No tree removal within 300 ft of OHWM	No tree removal within 300 ft of OHWM	No tree removal within 300 ft of OHWM	BMPs
Ozark big-eared bat	Foraging buffer	Assumed present	Contact FWS[2]	Contact FWS[2]	Contact FWS[2]	BMPs
Indiana bat	Foraging buffers 1 and 2	Assumed present	Contact FWS[2,3]	No tree removal	Contact FWS[2,3]	Contact FWS[2,3]
	Summer range	Assumed present or conduct bat surveys[4]	Contact FWS[2,3]	Contact FWS[2,3]	Contact FWS[2,3]	Contact FWS[2,3]
Northern long-eared bat	Summer range	Assumed present or conduct bat surveys[4]	Contact FWS[2,3]	No tree removal	Contact FWS[2,3]	BMPs

[1]Foraging buffers are provided by the FWS.

[2]May require further consultation with the FWS Oklahoma Ecological Services Office. FWS will be contacted during site planning to determine if tree removal will be permitted. Tree removal may not be permitted if potential habitat is present in a proposed treatment area, if bat surveys in the treatment area are positive, or if new karst features are discovered (U.S. Fish and Wildlife Service, 2019c).

[3]Tree removal is permitted using BMPs if bat surveys are negative.

[4]Guidelines for bat surveys are provided by the U.S. Fish and Wildlife Service (2019c).

Likely to Adversely Affect—American Burying Beetle

The proposed treatments are likely to have adverse effects on only one species, the American burying beetle (ABB). The adverse effects (table 11) are expected to be largely minimal or temporary, however, and the overall effects are expected to be primarily beneficial for the ABB. In this section, we summarize the status of the beetle, provide an overview of its unique life-history attributes, and evaluate the potential adverse and beneficial effects of the proposed treatments on the ABB and its habitat.

Status and Threats

The estimated historical range of the ABB once spanned the eastern half of the United States, but populations have been extirpated from much of the documented historical range (Sikes and Raithel, 2002). Extant populations are isolated and largely restricted to the periphery of the historical range in Arkansas, Kansas, Nebraska, Oklahoma, Rhode Island, and South Dakota. ABB presence has not been documented in Texas since 2008 (U.S. Fish and Wildlife Service, 2019e). Reintroduction efforts are ongoing in Massachusetts, Missouri, and Ohio.

The reasons for the widespread decline are uncertain, but it is generally assumed that the primary drivers were habitat conversion by agricultural and urban development (Sikes and Raithel, 2002), decreased availability of suitable carrion for brood rearing caused by declines in populations of potential carrion sources (such as passenger pigeons), and competition from increased populations of vertebrate scavengers (such as racoons, skunks, and crows) associated with human activities (Kozol, 1995; Lomolino and Creighton, 1996; Bedick and others, 1999; Creighton and others, 2009). Other potential contributing factors to the ABB decline include interspecific competition for carrion among burying beetles, increased edge creation, fire

suppression, loss of genetic diversity in isolated populations, disease or pathogens, the use of DDT, grazing practices, and more recently, invasive species including eastern redcedar (Sikes and Raithel, 2002). A detailed review of the evidence for potential causes of ABB declines is summarized by the ABB species status assessment, which is a comprehensive summary and review of the best available information for use in assessing population status, current and potential future threats, and condition of resources necessary for long-term viability of ABB populations (U.S. Fish and Wildlife Service, 2019e).

The ABB was listed as federally endangered in 1989 when there were only two known extant populations in Block Island, Rhode Island, and Latimer County, Oklahoma (Raithel, 1991). In 2019, the FWS proposed to reclassify this species as threatened, primarily because additional populations have been identified, including relatively large populations throughout eastern Oklahoma (U.S. Fish and Wildlife Service, 2019a, 2019b). The FWS concurrently proposed a rule under section 4(d) of the ESA that would refine previously recommended protections to allow exemptions for **incidental take** (direct harm to individual beetles or habitat degradation) if the species is reclassified as threatened (U.S. Fish and Wildlife Service, 2019d). The final 12-month finding on the proposed downlisting and 4(d) rule will be completed in 2020. The species status assessment was used as the basis for changing the endangered status of the ABB (U.S. Fish and Wildlife Service, 2019e).

Table 11. Potential effects of treatments on *Nicrophorus americanus* (American burying beetle) habitat components for the proposed vegetation management program in the Eastern Oklahoma Region of the Bureau of Indian Affairs.

[Habitat components include soils, forest understory, and forest canopy; NA, not applicable]

Treatment	Potential beneficial effects	Potential adverse effects		
		Soils	Understory	Canopy
		Prescribed fire		
Constructing fire line	Reduced risk of high-severity fire	Soil disturbance and compaction; increased erosion; direct mortality[1]	Partial and localized removal of understory	Minimal canopy removal
Broadcast burning	Restoration of historical fire regime; reduced risk of high-severity fire; reduction of invasive woody species	Removal of surface litter; decreased soil moisture	Partial to complete mortality of understory	Minimal canopy mortality
		Timber removal		
Clearcutting	Open forest structure; reduction of invasive woody species	Moderate to high soil disturbance and compaction; increased soil temperature	Disturbance and removal of understory; decreased leaf litter; potential decrease in carrion; increased air temperature	Complete removal of canopy; potential decrease in carrion; increase in forest edges
Shelterwood and seed tree cutting	Open forest structure; reduction of invasive woody species	Moderate to high soil disturbance and compaction; increased soil temperature	Disturbance and removal of understory; decreased leaf litter; potential decrease in carrion; increased air temperature	Major removal of canopy; potential decrease in carrion; increase in forest edges
Thinning	Restoration of historical forest structure; reduction in risk of high-severity fire, reduction of invasive woody species	Moderate to high soil disturbance and compaction	Disturbance and removal of understory; decreased leaf litter; potential decrease in carrion; increased air temperature	Partial removal of canopy; potential decrease in carrion
		Management of species composition and stand density		
Restoring grasslands and pasturelands	Restoration of woodland and grassland mosaic; reduction of invasive woody species	Minimal to moderate soil compaction	NA	Potential decrease in carrion

Table 11. Potential effects of treatments on *Nicrophorus americanus* (American burying beetle) habitat components for the proposed vegetation management program in the Eastern Oklahoma Region of the Bureau of Indian Affairs.—Continued

[Habitat components include soils, forest understory, and forest canopy; NA, not applicable]

Treatment	Potential beneficial effects	Potential adverse effects		
		Soils	Understory	Canopy
Managing forest stands for harvest	NA	Removal of habitat; chemical contamination of soils	Inhibition of understory regeneration; potential decrease in carrion; altered species composition and density	Inhibition of canopy regeneration; potential decrease in carrion, altered species compostion and density
Secondary treatments				
Slash piling	NA	Soil compaction	Disturbance and removal of understory	NA
Mechanical ripping	NA	Direct mortality[1]	Disturbance and removal of understory	NA
Applying chemicals	NA	Chemical contamination of soils; direct mortality[2]	Removal of understory	NA
Pruning	NA	NA	Partial and localized removal of understory	NA
Mowing	NA	Soil compaction; direct mortality	Removal of understory	NA
Planting	NA	Soil compaction; direct mortality	NA	NA
Road construction				
Constructing permanent roads	NA	Soil compaction; increased erosion and runoff; direct mortality	Removal of understory	Minimal canopy removal; increase in forest edges
Constructing temporary roads	NA	Soil compaction; increased erosion and runoff; direct mortality	Removal of understory	Minimal canopy removal; increase in forest edges
Installing bridges	NA	Soil disturbance and compaction; increased erosion	Removal of understory	NA
Installing culverts	NA	Soil disturbance and compaction; increased erosion	Removal of understory	NA

[1]There is potential for American burying beetle mortality during May through September (active season) or from October through April (overwintering) if soils are disturbed below the overwintering depth of 8 inches.

[2]The duration and severity of toxic effects vary among chemicals (International Union of Pure and Applied Chemistry, 2007; U.S. Department of Agriculture, 2017). Commonly used chemicals, including malathion and diflubenzuron, may persist in the environment for less than 1 month (International Union of Pure and Applied Chemistry, 2007; U.S. Department of Agriculture, 2017).

Extant populations of the ABB are separated into three distinct geographic areas: New England, the Northern Plains, and the Southern Plains, which includes eastern Oklahoma and adjacent areas in Arkansas, Kansas, and Texas (U.S. Fish and Wildlife Service, 2019e, fig. 1–1, p. 1). In the Southern Plains, the proposed 4(d) rule would allow incidental take only in areas not designated as conservation lands. The basis for this proposed rule is the determination that land management activities do not pose a threat to the ABB because land conversion during the next 80 years is expected to result in a net loss of less than 2 percent of favorable habitat within the Southern Plains (U.S. Fish and Wildlife Service, 2019e). Incidental take would not be permitted on designated conservation lands including McAlester Army Ammunition Plant, Camp Gruber, Cherokee Wildlife Management Area, and The Nature Conservancy Tallgrass Prairie Preserve (U.S. Fish and Wildlife Service, 2019d). It is not anticipated that the proposed treatments addressed by this biological assessment will occur on any ABB conservation lands. If the proposed 4(d) rule is approved as written, the estimated incidental take for the vegetation management program is expected to be in compliance with the rule. Furthermore, the use of BMPs (table 2.5) and consultation with the FWS will help to avoid or minimize the potential adverse effects and enhance the potential beneficial effects of the proposed treatments for ABB habitat and populations.

An ABB habitat suitability model was developed for the species status assessment using LANDFIRE Existing Vegetation Types (NatureServe, 2016) that were ranked as favorable, conditional, marginal, or unsuitable as habitat for the ABB (appendix 2; U.S. Fish and Wildlife Service, 2019e). All forests and grasslands that are not managed for agriculture were ranked as favorable. Recently burned or logged areas, and areas that are intermittently suitable, such as grazed or mowed grasslands and wetlands, were ranked as conditional. Permanently or frequently flooded, agricultural (croplands, orchards, plantations), ruderal, urban, and barren or mined areas were ranked as marginal or unfavorable. We mapped potential ABB habitat for their current range within the EOR using the species status assessment habitat suitability matrix (derived using LANDIFRE [2016]). To identify additional unsuitable areas converted by development but not captured by LANDFIRE, we augmented the habitat model output using the surface disturbance footprint from agricultural (croplands), energy and minerals, transportation, and urban development (Bencin and others, 2020; fig. 2).

The ABB range covers 86 percent of the the EOR. Within this range, cover types ranked as favorable represent 41 percent of their range. An additional 33 percent of their range was ranked as conditional, with the remaining 26 percent ranked as marginal or unsuitable. Potential habitat ranked as favorable or conditional may not be occupied by the ABB (Bencin and others, 2020) because factors in addition to cover type (such as climate, soils, and availability of carrion) can strongly affect ABB occurrence.

Overview of American Burying Beetle Life History

The American burying beetle is the largest carrion beetle in North America, ranging from 1 to 1.8 in. long. All *Nicrophorus* species exhibit an unusual degree of biparental care compared to most insects and bury vertebrate carrion, which they use for raising broods (Trumbo, 1990). This beetle is readily distinguishable from other *Nicrophorus* species on the basis of size and the pattern of orange coloration on the **pronotum** (the hard plate on the front portion of the thorax). The ABB is nocturnal and typically completes its life cycle within 1 year. Adults are primarily active May through September and die shortly after breeding. Immature beetles (**tenerals**) emerge in late summer, overwinter underground as adults, and emerge to breed the following summer (Kozol and others, 1988; Raithel, 1991). ABBs are strong fliers and can move as much as 18.6 mi in one night (Creighton and Schnell, 1998; Bedick and others, 1999; Jurzenski and others, 2011), although daily movements of less than 1 mi are more common (Creighton and Schnell, 1998; Bedick and others, 1999).

Trapping results indicate that the ABB uses a broad variety of cover types including grasslands, forests, and some wetlands (Lomolino and Creighton, 1996; Jurzenski, 2012). The beetles may be more selective of soil characteristics, including litter depth, soil type, and moisture level, that can affect vulnerability to desiccation and their ability to burrow or excavate brood chambers (Lomolino and Creighton, 1996; Hoback, 2016). In eastern Oklahoma, the ABB typically occurs in mature oak-hickory and oak-pine forests and woodlands with moderate undergrowth and deep, loamy soils, as well as grasslands (Lomolino and Creighton, 1996; McPherron and others, 2012).

The ABB diet includes mammal, bird, reptile, fish, and insect carcasses. Generally, mammal and bird carcasses between 3.5 to 7 ounces are used for brood rearing, but adults may feed on a broader range of sizes and taxa (Trumbo, 1992; Lomolino and others, 1995; Holloway and Schnell, 1997; Schnell and others, 2014). It is generally assumed that carrion used for reproduction is a key limiting resource for ABBs based on interspecific size differentiation and unusual characteristics, including exceptional levels of parental care and symbiotic mites (which feed on competing fly eggs on brood-rearing carcasses) that collectively indicate strong selective pressures relating to competition for carrion (Trumbo, 1994). ABBs can compete with congeneric species, other insects, and vertebrate scavengers for carrion (Mckenna-Foster and others, 2016).

Brood rearing behavior is highly specialized. The ABB pair bury a carcass, strip off the hair or feathers, roll it into a ball, and treat it with secretions that prevent growth of mold or bacteria. Females lay eggs near the carcass, with broods ranging from 3 to 31 larvae (Raithel, 1991). Both females and males typically feed the larvae until they are able to feed themselves (Trumbo, 1990; Raithel, 1991). The duration of brood rearing, from carcass burial to **eclosure** (emergence from pupae), is approximately 48 to 65 days (Ratcliffe, 1996; Bedick and others, 1999).

The historical structure and dynamics of forest and grassland mosaics of eastern Oklahoma inhabited by the ABB were driven, in part, by a frequent low-severity fire regime. Immediately following low-severity fires, the local-scale suitability for use by ABB may be altered as a result of a reduction in litter and ground cover, which could increase risk of desiccation (Hoback, 2016). These effects are short-lived, however, and ground cover in forests and grasslands can rapidly return to prefire conditions, particularly if the vegetation resprouts and seed banks are intact (Brown and Smith, 2000). In eastern Oklahoma, accumulation of litter can occur quickly after burning because of high rainfall and rapid postfire plant regrowth. Over broader spatial and temporal scales, ABB habitat could be created and maintained by a shifting mosaic resulting from variation in time since burning. Recent fires also help to reduce fuel loads and the risk of high-severity fires, which can extend the time required for postfire recovery and thereby delay postfire use by the ABB (Brown and Smith, 2000). Fire exclusion can also contribute to the expansion of eastern redcedar, which reduces the suitability and availability of ABB habitat.

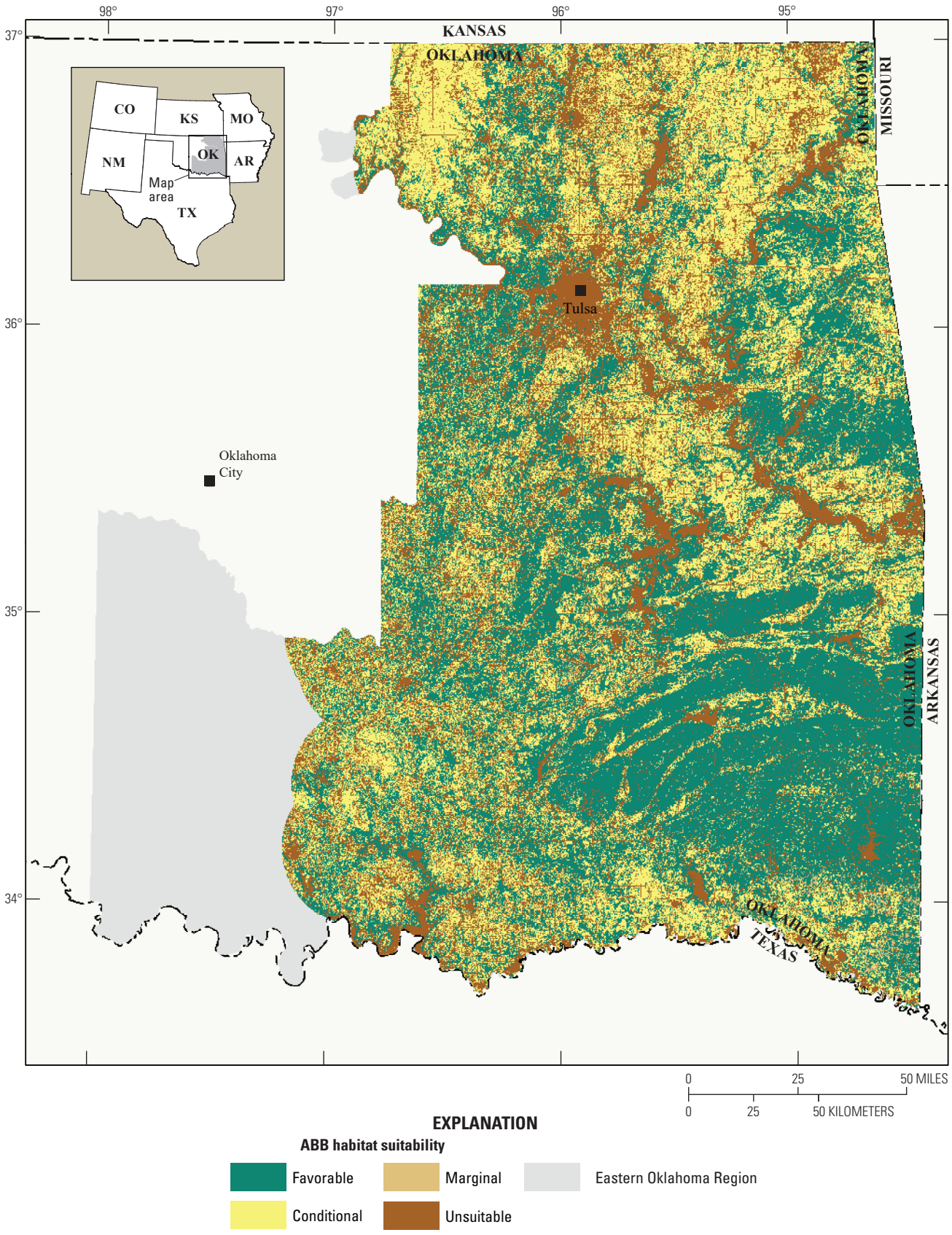

Figure 2. Map showing habitat suitability rankings for the American burying beetle range within the Eastern Oklahoma Region (modified from Bencin and others, 2020). Rankings were defined by the U.S. Fish and Wildlife Service (2019e).

Effects of the Action

Given the historical dynamics of grasslands and forests in eastern Oklahoma, we assumed that treatments most consistent with low-severity disturbance regimes (such as broadcast burning and thinning) will be beneficial to ABB populations over the long term and help offset short-term adverse effects. Treatments that could change habitat suitability from favorable or conditional to marginal or unsuitable were considered to be adverse over the 5-year duration of the program. The magnitude of the potential effects, both beneficial and adverse, depends on the size and conditions of the treatment area, types and degree of change to soils and vegetative cover, time since treatment, and posttreatment activities including restoration or maintenance of cover type changes. Although the effects of the treatments can vary with the magnitude of a project, the maximum potential adverse effects were evaluated.

Time Period of Effects

Adverse effects on ABB habitat were classified as short term, less than 5 years for recovery; long term, greater than 5 years for recovery; or permanent, changed to a cover type not regularly used by the ABB. The time periods for evaluating adverse effects on the ABB were recommended by the FWS during the consultation process (appendix 1). Posttreatment restoration was not included in the evaluation of treatment time periods. However, the use of BMPs and restoration activities will likely decrease the time required for recovery from adverse effects.

Adverse Effects

The potential for adverse effects were evaluated for three ABB habitat components: soils, forest understory, and forest canopy. The magnitude and duration of effects for each component can vary among treatments (table 11). In addition to effects on habitat, treatments during the active season could cause direct mortality to ABBs, displace broods, and separate adults from eggs or larvae. In the winter, adults could be harmed by soil compaction, which could kill overwintering adults or inhibit their emergence in late spring or early summer. The use of BMPs, including treatment timing and restoration activities, can help reduce the magnitude and duration of adverse effects (table 2.5).

Soils

Heavy machinery used in tree removal and site preparation can negatively affect the ABB by compacting soils and damaging or removing understory vegetation. Permanently disturbed soils could decrease local habitat suitability and temporary soil compaction could cause short-term habitat degradation or direct mortality if it occurs during brood rearing or overwintering (Reisinger and others, 1988; Han and others, 2006; Hoback, 2016). Soil compaction is typically greatest for the first three passes and can compact soil up to 9 in. deep, which is deeper than the typical ABB burial depth of 8 in. (Willemssens, 2015). Parked vehicles cause soil compaction pressures that could result in ABB mortality (Hoback, 2016). Activities that disturb soils could also kill or uncover adult ABBs or brood chambers, increase predation risk, and create adverse environmental conditions (Hoback, 2016). Heavily compacted soils could take as long as two decades to recover (Reisinger and others, 1988), but soils could be suitable for the ABB once restoration activities are completed.

Pesticides and other chemicals can affect ABBs by killing adults or contaminating soils (Jurzenski, 2012; Leasure and Hoback, 2017). Residual pesticides and other treatment chemicals in soils could limit use of a site until toxicity levels no longer preclude beetle use, which can take from a few days to several years, depending on the chemicals used (International Union of Pure and Applied Chemistry, 2007; U.S. Department of Agriculture, 2017). Accidental spilling of petroleum products and chemicals could also cause mortality and soil contamination (Bünemann and others, 2006).

Forest Understory

Prescribed fire is expected to have only limited and short-term adverse effects. The magnitude of the effects from burning depends on the season, severity, and time since burning. Low-severity fires are expected to primarily affect the litter and understory. Prescribed burning in tallgrass prairie during the active season has the potential to kill adult ABBs (Hoops, 2017), but they may be able to avoid approaching flames by burrowing or flying (Kral and others, 2017). Prescribed burning during the inactive season is not expected to cause direct mortality because surface fires are unlikely to substantially heat soil below 4 in., which is less than typical ABB burial depth (Raison and others, 1986; Iverson and Hutchinson, 2002; Willemssens, 2015; Kral and others, 2017). It is likely that ABB will use recently burned areas as the understory vegetation and litter are reestablished (Hoback, 2016).

Forest Canopy

There is limited empirical evidence for the effects of timber removal on the ABB. Beetle occurrence has been shown to decrease immediately following clearcuts and seed tree or shelterwood cuts, possibly because of site disturbance (Creighton and others, 2009). Similarly, clearcuts are associated with decreased beetle abundance compared to mature and second-growth forests (Lomolino and Creighton, 1996). Beetle abundance has been shown to return to pretreatment levels within 3 years of tree removal (Creighton and others, 2009), indicating that adverse effects of canopy removal may be short lived. The effects of forest thinning and fuel reduction on the ABB may be minimal and their occurrence appears to be unaffected by treatments that do not substantially reduce forest cover (Creighton and others, 2009).

The removal of canopy trees and road construction can increase the proportion of forest edges, which could potentially decrease carrion availability if the edges are used by competing vertebrate scavengers, such as raccoons and skunks (Bixler and Gittleman, 2000; Dijak and Thompson, 2000; Trumbo and Bloch, 2000; Sikes and Raithel, 2002; DeVault and others, 2003; Hoops, 2017). Fragmentation of forests into small and isolated patches could increase competition from other carrion feeding insects (such as *Nicrophorus tomentosus*) that more readily use small forest patches (Gibbs and Stanton, 2001; Mckenna-Foster and others, 2016). The small sizes of most proposed clearcuts (for example, less than 40 acres), however, are expected to create forest openings rather than forest fragments. Such small clearcuts are also assumed to have minimal effects on populations of vertebrate scavengers.

Conversion of forests to orchards or plantations could have adverse effects on ABB habitat suitability, depending on how they are managed, but conversion to cultivated croplands will likely have adverse effects on the ABB. Croplands are generally not used by the ABB, and landscapes with more than 20 percent croplands are associated with significantly lower ABB occurrence (McPherron and others, 2012). Further, the use of pesticides like malathion and diflubenzuron may exclude the ABB from using otherwise suitable areas (Jurzenski, 2012; Leasure and Hoback, 2017). Tree plantations could decrease habitat suitability as a result of ongoing management including chemical applications and understory removal. Conversion of ABB habitat for agricultural uses can adversely affect beetles by reducing habitat availability, and depending on the scale of conversion, isolate existing habitat and create edge habitat favorable to carrion competitors (Bixler and Gittleman, 2000; Dijak and Thompson, 2000; DeVault and others, 2003; Hoops, 2017).

Table 12. Treatment area by time period of effects on *Nicrophorus americanus* (American burying beetle) habitat for the proposed vegetation management program for the Eastern Oklahoma Region of the Bureau of Indian Affairs.

[Potential effects on American burying beetle habitat were evaluated for the 5-year duration of the program]

Treatment	Activities	Treatment area (acres), by period of effects[1]			
		Less than 5 years	Greater than 5 years	Permanent cover change	Overall
	Primary treatments				
Prescribed fire	Broadcast burning	187,200	0	0	187,200
	Constructing fire lines	0	2,340	0	2,340
Timber removal	Clearcutting	1,244	331	0	1,575
	Shelterwood or seed tree cutting	454	121	0	575
	Thinning	25,813	5,287	0	31,100
Species composition and stand density	Restoring grasslands and pasturelands[2]	1,000	0	0	1,000
	Managing forest stands for harvest	0	0	1,000	1,000
Total primary treatment area		**215,711**	**8,079**	**1,000**	**224,790**
	Secondary treatments				
Activities associated with primary treatments	Slash piling	1,660	0	0	1,660
	Mechanical ripping	500	0	0	500
	Applying chemicals[3]	6,100	0	0	6,100
	Pruning	375	0	0	375
	Mowing	665	0	0	665
	Planting	2,150	0	0	2,150

Table 12. Treatment area by time period of effects on *Nicrophorus americanus* (American burying beetle) habitat for the proposed vegetation management program for the Eastern Oklahoma Region of the Bureau of Indian Affairs.—Continued

[Potential effects on American burying beetle habitat were evaluated for the 5-year duration of the program]

Treatment	Activities	Treatment area (acres), by period of effects[1]			
		Less than 5 years	Greater than 5 years	Permanent cover change	Overall
Road creation	Constructing permanent roads	0	0	245	245
	Constructing temporary roads	0	35	0	35
	Installing bridges	0	0	5	5
	Installing culverts	0	0	50	50
Total secondary treatment area		**11,450**	**35**	**300**	**11,785**
Total action area		**227,161**	**8,114**	**1,300**	**236,575**

[1]The time period for each activity does not include restoration. Implementation of best management practices and restoration activities will typically decrease the time period of effects to less than 5 years.

[2]An objective of grassland restoration is to reduce expansion of woody species, primarily eastern redcedar.

[3]The persistence of chemicals following application varies but is typically less than 5 years.

Over the long term and across the entire EOR, it is estimated that primary treatments will be beneficial to the ABB on 91 percent (215,711 acres) of the action area because any adverse effects of these treatments will likely last less than 5 years (table 12) and the treatments will help to decrease the risk of high-severity fires and redcedar expansion (table 11). Forests managed for timber production and harvesting can create early seral conditions, which could increase small vertebrate populations for carrion production suitable as adult ABB food sources. Small clearcuts and other even-aged timber removal may create forest openings in ABB habitat and enhance heterogeneity in forest structure at broad scales thereby contributing to ecosystem resilience and resistance. Thinning and prescribed burning are also likely to have longer term beneficial effects on ABB habitat by restoring open forest structure and reducing the density of eastern redcedar and other invasive woody species (Howard and others, 2007; Walker and Hoback, 2007; Leasure and Garner, 2009; Verschuyl and others, 2011). Indeed, much of the ABB habitat is at risk from expansion of eastern redcedar, which is prevalent throughout the ABB range in eastern Oklahoma (Wilson and others, 2013).

Thinning and prescribed burning will also decrease the risk for habitat loss and degradation caused by uncharacteristically severe wildfires. Periodic prescribed burning can increase ABB occurrence (Howard and others, 2007), whereas fire exclusion can decrease ABB occurrence (Walker and Hoback, 2007; Leasure and Garner, 2009). Currently, 38 percent of favorable or conditional habitat within the ABB range in the EOR is classified as having moderate, high, or very high risk of wildfire (Dillon, 2018). There were 162 wildfires within the ABB range in eastern Oklahoma between 2010 and 2016, totaling 627,114 acres (Monitoring Trends in Burn Severity, 2019). More than half of the burned area was within favorable ABB habitat.

Restoring former grasslands that have been converted to redcedar woodlands is expected to benefit the ABB unless the grasslands are intensively grazed or mowed (Raithel, 1991; Creighton and others, 1993; Lomolino and Creighton, 1996). Grazing of restored grasslands is unlikely to negatively affect the ABB unless the vegetation remains below 8 in. in height (Hoback, 2016). Localized and prolonged use by cattle can compact soils up to 4 in. deep, which could preclude ABB use for carrion burial or overwinter refugia.

Over the long term, treatments that are largely neutral (recovery or restoration creates habitat conditions that are similar to pretreatment conditions) or primarily adverse (permanent change to unsuitable for the ABB) are estimated to cover only 9 percent (20,864 acres) of the action area (table 12). This acreage includes treatments that are not expected to have lasting adverse effects on the ABB, specifically secondary treatments lasting less than 5 years (11,450 acres), all treatments lasting longer than 5 years that are not permanent (8,114 acres), as well as adverse effects that are permanent (1,300 acres). The permanent changes would likely affect less than 1 percent of the action area.

The action area could include areas ranked as marginal or unsuitable for the ABB (fig. 2). However, we evaluated the potential adverse effects of the treatments on the ABB for the entire action area because the locations of treatments relative to potential ABB habitat have not yet been determined. If projects occur in marginal or unsuitable areas, potential adverse effects will occur in less than 1 percent of the total action area.

Cumulative Effects

As defined by the Endangered Species Act, cumulative effects include the effects of future activities conducted by State, Tribal, local, private, or other non-Federal entities on threatened and endangered species and their critical habitat that are reasonably certain to occur within the action area (U.S. Fish and Wildlife Service and National Marine Fisheries Service, 1998). Future Federal actions unrelated to the proposed action are not included as cumulative effects because they are subject to consultation pursuant to section 7 of the act.

The summary of cumulative effects on the ABB was based on chapter 4 of the species status assessment (U.S. Fish and Wildlife Service, 2019e). Within the EOR, actions with potential for adverse effects on the ABB include oil and gas wells, pipelines, commercial and residential development, and agriculture (cultivated croplands, managed timber plantations, and pastures that are intensively managed, grazed, or mowed). Agricultural croplands and urban development likely have contributed to the greatest loss of ABB habitat in the EOR. Surface disturbance from oil and gas development is relatively low compared to agricultural development in the EOR and reaches a high density only in localized areas (U.S. Fish and Wildlife Service, 2019e). Almost 3 million acres are protected within the Southern Plains. Most ABB populations, however, are located on private lands lacking long-term protection (U.S. Fish and Wildlife Service, 2019e). An industry conservation plan for ABBs in the Southern Plains set aside 1,800 acres for permanent mitigation, while 400 acres of occupied or potential ABB habitat were permanently converted and 600 acres were altered but remain suitable for ABBs in the Southern Plains (U.S. Fish and Wildlife Service, 2019e). Resiliency of the ABB populations within the EOR (based on the Flint Hills and the Arkansas River analysis areas in the Southern Plains) is moderate to high (U.S. Fish and Wildlife Service, 2019e). Past, current, and future actions are not expected to significantly affect the continued viability of ABB populations in the Southern Plains (U.S. Fish and Wildlife Service, 2019e).

Conclusions for American Burying Beetle

A determination of "may affect and is likely to adversely affect" is made for the American burying beetle (ABB). Most of the proposed treatments, however, are expected to have beneficial long-term effects by restoring the structure and dynamics of ABB habitat. This includes increasing forest heterogeneity and resilience primarily by reducing eastern redcedar expansion and reducing the risk of high-severity fire. Although some proposed treatments could cause short-term habitat degradation and, in some cases, permanent loss of habitat that may result in incidental take of the beetles, it is anticipated that the long-term benefits will greatly exceed the short-term adverse effects. Consequently, it was concluded that the proposed vegetation management program will not negatively affect the viability of ABB populations in the Eastern Oklahoma Region.

Minimization of Treatment Effects Using Best Management Practices

The use of BMPs for aquatic and terrestrial systems can help to minimize the risk of adverse effects of treatments on threatened and endangered species. For aquatic species, the use of BMPs recommended by the FWS for projects that may affect streams (tables 2.1 and 2.2) can be effective in preventing or reducing negative effects on soils and water quality, and minimize the potential for indirect adverse effects to aquatic species (Aust and Blinn, 2004; U.S. Fish and Wildlife Service, 2007; Cristan and others, 2016; Warrington and others, 2017). Likewise, recommended forestry practices (Oklahoma Forestry Services, 2016), and BMPs specifically designed for the red-cockaded woodpecker (table 2.3), bats (table 2.4), and American burying beetle (table 2.5) can also minimize adverse effects of terrestrial treatments.

Summary

The proposed vegetation management program will include a variety of projects within the 21,316,045 acres of the Eastern Oklahoma Region. Annual vegetation treatments will total approximately 47,315 acres. Over the 5-year program duration, the maximum action area is estimated to be 236,575 acres. Treatments could include prescribed burning, timber removal, and management for species composition and stand density, depending on project objectives identified by the Tribes and the Bureau of Indian Affairs. These projects will provide benefits to Tribes in the Eastern Oklahoma Region by enhancing their use of cultural and natural resources and improving opportunities for agricultural activities.

This biological assessment addresses the potential effects of the proposed vegetation management program on 22 federally threatened, endangered, and candidate species that may be present within the EOR. Because treatments will be conducted in terrestrial systems and adhere to forestry best management practices, there are no anticipated adverse effects on the 15 species

associated with aquatic systems. Likewise, use of best management practices and avoidance of critical habitats are expected to minimize the likelihood of adverse effects for six terrestrial species, resulting in a determination of "may affect but unlikely to adversely affect." The American burying beetle is the only threatened or endangered species within the Eastern Oklahoma Region that is expected to experience adverse effects due to short-term (less than 5 years) disturbance to soil and vegetation in potential American burying beetle habitat. It is estimated, however, that 91 percent of the total action area will be primarily beneficial to the American burying beetle over the 5-year project duration by reducing risk of high-severity fires and eastern redcedar expansion within the action area and for the surrounding landscape. Less than 1 percent of the action area is expected to have lasting adverse effects from the proposed treatments. Based on the limited adverse effects relative to the beneficial effects of the treatments, the proposed vegetation management program will not adversely affect the viability of American burying beetle populations in the Eastern Oklahoma Region.

References Cited

Abbott, I.M., Harrison, S., and Butler, F., 2012, Clutter adaptation of bat species predicts their use of under-motorway passageways of contrasting sizes—A natural experiment: Journal of Zoology, v. 287, no. 2, p. 124–132. [Also available at https://doi.org/10.1111/j.1469-7998.2011.00894.x.]

Aldridge, H.D.J.N., and Rautenbach, I.L., 1987, Morphology, echolocation and resource partitioning in insectivorous bats: Journal of Animal Ecology, v. 56, no. 3, p. 763–778. [Also available at https://doi.org/10.2307/4947.]

Angwin, P.A., Cluck, D.R., Zambino, P.J., Oblinger, B.W., Woodruff, W.C., 2012, Hazard tree guidelines for Forest Service facilities and roads in the Pacific Southwest region: U.S. Forest Service Report No. RO-12-01, accessed January 17, 2020, at https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5332560.pdf.

Aust, W.M., and Blinn, C.R., 2004, Forestry best management practices for timber harvesting and site preparation in the eastern United States—An overview of water quality and productivity research during the past 20 years (1982–2002): Water Air and Soil Pollution Focus, v. 4, no. 1, p. 5–36. [Also available at https://doi.org/10.1023/B:WAFO.0000012828.33069.f6.]

Bakker, D., Davies, S., and Isbister, B., 2017, Deep ripping for soil compaction: [Western Australia] Department of Primary Industries and Regional Development web page, accessed July 30, 2019, at https://agric.wa.gov.au/n/105.

Barnhart, M.C., 2001, Fish hosts and culture of mussel species of special concern—Annual report for 2000: U.S. Fish and Wildlife Service and Missouri Department of Conservation, prepared by Southwest Missouri State University, 38 p.

Barnhart, M.C., 2003, Culture and restoration of mussel species of concern—Final report: Missouri Department of Conservation and U.S. Fish and Wildlife Service, prepared by Southwest Missouri State University, 56 p., accessed May 13, 2019, at https://bearworks.missouristate.edu/cgi/viewcontent.cgi?article=1090&context=articles-cnas.

Barnhart, M.C., 2010, Final Report—Reproduction and fish hosts of the Ouachita rock pocketbook, *Arkansia wheeleri*: Arkansas Game and Fish Commission, prepared by Missouri State University, 19 p., accessed May 13, 2019, at https://bearworks.missouristate.edu/cgi/viewcontent.cgi?article=1097&context=articles-cnas.

Barnhart, M.C., and Roberts, A., 1997, Reproduction and fish hosts of unionids from the Ozark uplifts, *in* Cummings, K.S., Buchanan, A.C., Mayer, C.A., and Naimo, T.J., eds., 1997, Conservation and management of freshwater mussels II—Initiatives for the future: Rock Island, Ill., Upper Mississippi River Conservation Committee, 293 p.

Bedick, J.C., Ratcliffe, B.C., Hoback, W.W., and Higley, L.G., 1999, Distribution, ecology and population dynamics of the American burying beetle [*Nicrophorus americanus* Olivier (Coleoptera, Silphidae)] in south–central Nebraska, USA: Journal of Insect Conservation, v. 3, no. 3, p. 171–181. [Also available at https://doi.org/10.1023/A:1009684926873.]

Bencin, H.L., Harms, B.R., and Carr, N.B., 2020, Estimated habitat suitability for the American burying beetle using land cover classes in the Southern Plains (ver. 1.1, June 2020): U.S. Geological Survey data release, accessed June 26, 2020, at https://doi.org/10.5066/P95LDGHX.

Bestgen, K.R., Platania, S.P., Brooks, J.E., and Propst, D.L., 1989, Dispersal and life history traits of *Notropis girardi* (Cypriniformes—Cyprinidae), introduced into the Pecos River, New Mexico: The American Midland Naturalist, v. 122, no. 2, p. 228–235. [Also available at https://doi.org/10.2307/2425907.]

Betz, R.F., Lootens, R.J., and Becker, M.K., 1997, Two decades of prairie restoration at Fermilab Batavia, Illinois *in* Warwick, C., ed., 1997, Fifteenth North American Prairie Conference Proceedings, North American Prairie Conference, 15th, October 23–25, 1996, St. Charles, Ill: Natural Areas Association, p. 20–30.

Bey, M., 2005, Glossary of terms: Ashland, Oreg., Lomakatsi Restoration Project, accessed July 30, 2019, at https://lomakatsi.org/wp-content/uploads/LRPGlossary.pdf.

Bixler, A., and Gittleman, J.L., 2000, Variation in home range and use of habitat in the striped skunk (*Mephitis mephitis*): Journal of Zoology, v. 251, no. 4, p. 525–533. [Also available at https://doi.org/10.1111/j.1469-7998.2000.tb00808.x.]

Blakey, R.V., Webb, E.B., Kesler, D.C., Siegel, R.B., Corcoran, D., and Johnson, M., 2019, Bats in a changing landscape—Linking occupancy and traits of a diverse montane bat community to fire regime: Ecology and Evolution, v. 9, no. 9, p. 5324–5337. [Also available at https://doi.org/10.1002/ece3.5121.]

Boggs, J., Sun, G., and McNulty, S., 2016, Effects of timber harvest on water quantity and quality in small watersheds in the Piedmont of North Carolina: Journal of Forestry, v. 114, no. 1, p. 27–40. [Also available at https://doi.org/10.5849/jof.14-102.]

Boyd, R.L., 1991, First nesting record for the piping plover in Oklahoma: The Wilson Bulletin, v. 103, no. 2, p. 305–308.

Briggs, J.M., Hoch, G.A., and Johnson, L.C., 2002, Assessing the rate, mechanisms, and consequences of the conversion of tallgrass prairie to *Juniperus virginiana* forest: Ecosystems (New York, N.Y.), v. 5, no. 6, p. 578–586. [Also available at https://doi.org/10.1007/s10021-002-0187-4.]

Briggs, J.M., Knapp, A.K., Blair, J.M., Heisler, J.L., Hoch, G.A., Lett, M.S., and McCarron, J.K., 2005, An ecosystem in transition—Causes and consequences of the conversion of mesic grassland to shrubland: Bioscience, v. 55, no. 3, p. 243–254. [Also available at https://doi.org/10.1641/0006-3568(2005)055[0243:AEITCA]2.0.CO;2.]

British Columbia Ministry of Forests, 1993, Site preparation implements, chap. 7 *of* Silviculture manual: British Columbia Ministry of Forests website, accessed January 17, 2020, at https://www.for.gov.bc.ca/hfp/publications/00099/siteprep/2-Mech-06.htm.

Brockway, D.G., and Lewis, C.E., 1997, Long-term effects of dormant-season prescribed fire on plant community diversity, structure and productivity in a longleaf pine wiregrass ecosystem: Forest Ecology and Management, v. 96, no. 1–2, p. 167–183. [Also available at https://doi.org/10.1016/S0378-1127(96)03939-4.]

Brown, J.K., and Smith, J.K., 2000, Wildland fire in ecosystems—Effects of fire on flora: U.S. Department of Agriculture and U.S. Forest Service General Technical Report RMRS-GTR-42, v. 2, 257 p. [Also available at https://doi.org/10.2737/RMRS-GTR-42-V2.]

Bryan, J.L., Wildhaber, M.L., and Noltie, D.B., 2006, Influence of water flow on Neosho madtom (*Noturus placidus*) reproductive behavior: The American Midland Naturalist, v. 156, no. 2, p. 305–318. [Also available at https://doi.org/10.1674/0003-0031(2006)156[305:IOWFON]2.0.CO;2.]

Buehler, D.M., Baker, A.J., and Piersma, T., 2006, Reconstructing palaeoflyways of the late Pleistocene and early Holocene red knot *Calidris canutus*: Ardea, v. 94, no. 3, p. 485–498.

Bulger, A.G., and Edds, D.R., 2001, Population structure and habitat use in Neosho madtom (*Noturus placidus*): The Southwestern Naturalist, v. 46, no. 1, p. 8–15. [Also available at https://doi.org/10.2307/3672368.]

Bünemann, E.K., Schwenke, G.D., and Van Zwieten, L., 2006, Impact of agricultural inputs on soil organisms—A review: Australian Journal of Soil Research, v. 44, no. 4, p. 379–406. [Also available at https://doi.org/10.1071/SR05125.]

Bureau of Indian Affairs, 2009, Indian forest management handbook: Bureau of Indian Affairs Manual 53 IAM 2–H, 57 p., accessed January 21, 2020, at https://www.bia.gov/policy-forms/handbooks [Supersedes Manual 53 IAM Supplement 2].

Buthod, A.K., and Hoagland, B.W., 2013, Oklahoma: Castanea, v. 78, no. 3, p. 213–215. [Also available at https://doi.org/10.2179/13-010.]

Butler, R.S., 2005, Status assessment report for the rabbitsfoot, *Quadrula cylindrica cylindrica*, a freshwater mussel occurring in the Mississippi River and Great Lakes Basins: Asheville, N.C., U.S. Fish and Wildlife Service, accessed May 2019, at https://doi.org/10.13140/RG.2.1.3065.4883.

Caceres, M.C., and Barclay, R.M., 2000, *Myotis septentrionalis*: Mammalian species, no. 634, p. 1–4. [Also available at https://doi.org/10.2307/0.634.1.]

Caire, W., Tyler, J.D., Glass, B.P., and Mares, M.A., 1989, Mammals of Oklahoma: Norman, Oklahoma, University of Oklahoma Press, 567 p.

Carter, M.C., and Foster, C.D., 2004, Prescribed burning and productivity in southern pine forests—A review: Forest Ecology and Management, v. 191, no. 1–3, p. 93–109. [Also available at https://doi.org/10.1016/j.foreco.2003.11.006.]

Certini, G., 2005, Effects of fire on properties of forest soils—A review: Oecologia, v. 143, no. 1, p. 1–10. [Also available at https://doi.org/10.1007/s00442-004-1788-8.]

Clark, S.L., Hallgren, S.W., Engle, D.M., and Stahle, D.W., 2007, The historic fire regime on the edge of the prairie—A case study from the cross timbers of Oklahoma, *in* Masters, R.E., and Galley, K.E.M., eds., Proceedings of the 23rd Tall Timbers Fire Ecology Conference—Fire in Grassland and Shrubland Ecosystems: Tallahassee, Fla., Tall Timbers Research Station and Land Conservancy, p. 40–49, accessed May 2019 at https://talltimbers.org/wp-content/uploads/2018/09/40-Clark2007_op.pdf.

Clark, D.R., 1988, How sensitive are bats to insecticides?: Wildlife Society Bulletin, v. 16, no. 4, p. 399–403.

Clark, D.R., LaVal, R.K., and Swineford, D.M., 1978, Dieldrin-induced mortality in an endangered species, the gray bat (*Myotis grisescens*): Science, v. 199, no. 4335, p. 1357–1359. [Also available at https://doi.org/10.1126/science.564550.]

Clinnick, P., McCormack, B., and Connell, M., 2008, Management guidelines for private native forests: Kingston, Australian Capital Territory, Rural Industries Research and Development Corporation, accessed July 30, 2019, at https://www.agrifutures.com.au/wp-content/uploads/publications/08-160.pdf.

Conant, R., and Collins, J.T., 1991, A field guide to reptiles and amphibians—Eastern and central North America: Boston, Mass., Houghton Mifflin Co, 450 p.

Creighton, J.C., Vaughn, C.C., and Chapman, B.R., 1993, Habitat preference of the endangered American burying beetle (*Nicrophorus americanus*) in Oklahoma: The Southwestern Naturalist, v. 38, no. 3, p. 275–277. [Also available at https://doi.org/10.2307/3671432.]

Creighton, J.C., and Schnell, G., 1998, Short-term movement patterns of the endangered American burying beetle (*Nicrophorus americanus*): Biological Conservation, v. 86, no. 3, p. 281–287. [Also available at https://doi.org/10.1016/S0006-3207(98)00035-4.]

Creighton, J.C., Bastarache, R., Lomolino, M.V., and Belk, M.C., 2009, Effect of forest removal on the abundance of the endangered American burying beetle, *Nicrophorus americanus* (Coleoptera—Silphidae): Journal of Insect Conservation, v. 13, no. 1, p. 37–43. [Also available at https://doi.org/10.1007/s10841-007-9115-4.]

Cristan, R., Aust, W.M., Bolding, M.C., Barrett, S.M., Munsell, J.F., and Schilling, E., 2016, Effectiveness of forestry best management practices in the United States—Literature review: Forest Ecology and Management, v. 360, p. 133–151. [Also available at https://doi.org/10.1016/j.foreco.2015.10.025.]

DeBano, L.F., 1991. The effect of fire on soil properties, *in* Harvey, A.E.; Neuenschwander, L.F., eds., Proceedings—Management and productivity of western-montane forest soils, Boise, Idaho, April 10–12, 1990, U.S. Department of Agriculture, Forest Service, Intermountain Research Station, p. 151–156.

Decher, J., and Choate, J.R., 1995, *Myotis grisescens*: Mammalian Species, no. 510, p. 1–7. [Also available at https://doi.org/10.2307/3504084.]

DeVault, T.L., Rhodes, O.E.J., Jr., and Shivik, J.A., 2003, Scavenging by vertebrates—Behavioral, ecological and evolutionary perspectives on an important energy transfer pathway in terrestrial ecosystems: Oikos, v. 102, no. 2, p. 225–234. [Also available at https://doi.org/10.1034/j.1600-0706.2003.12378.x.]

Dijak, W.D., and Thompson, F.R., 2000, Landscape and edge effects on the distribution of mammalian predators in Missouri: The Journal of Wildlife Management, v. 64, no. 1, p. 209–216. [Also available at https://doi.org/10.2307/3802992.]

Dillon, G.K., 2018, Wildlife hazard potential for the conterminous United States (270-m GRID) (2d edition): Fort Collins, CO, Forest Service Research Data Archive, accessed June 25, 2019, at https://www.firelab.org/project/wildfire-hazard-potential.

Faure, P.A., Fullard, J.H., and Dawson, J.W., 1993, The gleaning attacks of the northern long-eared bat, *Myotis septentrionalis*, are relatively inaudible to moths: The Journal of Experimental Biology, v. 178, p. 173–189.

Fenton, M.B., Merriam, H.G., and Holroyd, G.L., 1983, Bats of Kootenay, Glacier and Mount Revelstoke national parks in Canada—Identification by echolocation calls, distribution and biology: Canadian Journal of Zoology, v. 61, no. 11, p. 2503–2508. [Also available at https://doi.org/10.1139/z83-332.]

Fobian, T.B., 2007, Reproductive biology of the rabbitsfoot mussel (*Quadrula cylindrica*) (Say, 1817) in the upper Arkansas River system, White River system, and the Red River system: Springfield, Missouri State University, Master's thesis, 105 p.

Frye, C.T., and Tessel, S.M., 2012, Multivariate analysis of stream substrates in subpopulations of harperella *(Ptilimnium nodosum* (Rose) Mathias—Apiaceae) at Sideling Hill Creek, Maryland, USA: Castanea, v. 77, no. 1, p. 2–10. [Also available at https://doi.org/10.2179/11-023.]

Fuselier, L., and Edds, D.R., 1994, Seasonal variation in habitat use by the Neosho madtom (Teleostei—Ictaluridae—*Noturus placidus*): The Southwestern Naturalist, v. 39, no. 3, p. 217–223. [Also available at https://doi.org/10.2307/3671585.]

Galbraith, H., Jones, R., Park, R., Clough, J., Herrod-Julius, S., Harrington, B., and Page, G., 2002, Global climate change and sea level rise—Potential losses of intertidal habitat for shorebirds: Waterbirds, v. 25, no. 2, p. 173–183. [Also available at https://doi.org/10.1675/1524-4695(2002)025[0173:GCCASL]2.0.CO;2.]

Galbraith, H.S., Spooner, D.E., and Vaughn, C.C., 2008, Status of rare and endangered freshwater mussels in southeastern Oklahoma: The Southwestern Naturalist, v. 53, no. 1, p. 45–50. [Also available at https://doi.org/10.1894/0038-4909(2008)53[45:SORAEF]2.0.CO;2.]

Gibbs, J.P., and Stanton, E.J., 2001, Habitat fragmentation and arthropod community change—Carrion beetles, phoretic mites, and flies: Ecological Applications, v. 11, no. 1, p. 79–85. [Also available at https://doi.org/10.1890/1051-0761(2001)011[0079:HFAACC]2.0.CO;2.]

Graening, G.O., and Brown, A.V., 1999, Cavefish population status and environmental quality in Cave Springs Cave, Arkansas: Arkansas Natural Heritage Commission, prepared by University of Arkansas [publication 276], 36 p.

Graening, G.O., Fenolio, D.B., Niemiller, M.L., Brown, A.V., and Beard, J.B., 2010, The 30-year recovery effort for the Ozark cavefish (*Amblyopsis rosae*)—Analysis of current distribution, population trends, and conservation status of this threatened species: Environmental Biology of Fishes, v. 87, no. 1, p. 55–88. [Also available at https://doi.org/10.1007/s10641-009-9568-2.]

Graening, G.O., Harvey, M.J., Puckette, W.L., Stark, R.C., Sasse, D.B., Hensley, S.L., and Redman, R.K., 2011, Conservation status of the endangered Ozark big-eared bat (*Corynorhinus townsendii ingens*)—A 34-year assessment: Oklahoma Biological Survey, v. 11, no. 1, p. 1–16.

Gromicko, N., 2019, Slash piles: International Association of Certified Home Inspectors web page, accessed July 30, 2019, at https://www.nachi.org/slash-piles.htm.

Hall, J.S., Cloutier, R.J., and Griffin, D.R., 1957, Longevity records and notes on tooth wear of bats: Journal of Mammalogy, v. 38, no. 3, p. 407–409. [Also available at https://doi.org/10.2307/1376240.]

Han, H.S., Page-Dumroese, D., Han, S.K., and Tirocke, J., 2006, Effects of slash, machine passes, and soil moisture on penetration resistance in a cut-to-length harvesting: International Journal of Forest Engineering, v. 17, no. 2, p. 11–24.

Harvey, M.J., 1992, Bats of the eastern United States: Little Rock, Ark., Arkansas Game and Fish Commission, 46 p.

Harvey, M.J., Altenbach, J.S., and Best, T.L., 2011, Bats of the United States and Canada: Baltimore, Mass., John Hopkins University Press, 224 p.

Hoagland, B., 2000, The vegetation of Oklahoma—A classification for landscape mapping and conservation planning: The Southwestern Naturalist, v. 45, no. 4, p. 385–420. [Also available at https://doi.org/10.2307/3672589.]

Hoback, W.W., 2016, Effects of compaction and soil moisture on American burying beetles—A report on research sponsored by Nebraska Department of Roads: Lincoln, Nebr., Federal Highway Administration, 55 p.

Hoff, D.L., Will, R.E., Zou, C.B., Weir, J.R., Gregory, M.S., and Lillie, N.D., 2018, Estimating increased fuel loading within the cross timbers forest matrix of Oklahoma, USA due to an encroaching conifer, *Juniperus virginiana*, using leaf-off satellite imagery: Forest Ecology and Management, v. 409, p. 215–224. [Also available at https://doi.org/10.1016/j.foreco.2017.11.003.]

Holloway, A.K., and Schnell, G.D., 1997, Relationship between numbers of the endangered American burying beetle *Nicrophorus americanus* Olivier (Coleoptera—Silphidae) and available food resources: Biological Conservation, v. 81, no. 1–2, p. 145–152. [Also available at https://doi.org/10.1016/S0006-3207(96)00158-9.]

Hoops, J.N., 2017, Biotic and abiotic factors affecting abundance of the American burying beetle, *Nicrophorus americanus*: Norman, Oklahoma State University, Master's thesis, 45 p.

Horncastle, V.J., Hellgren, E.C., Mayer, P.M., Ganguli, A.C., Engle, D.M., and Leslie, D.J., Jr., 2005, Implications of invasion by *Juniperus virginiana* on small mammals of the southern Great Plains: Journal of Mammalogy, v. 86, no. 6, p. 1144–1155. [Also available at https://doi.org/10.1644/05-MAMM-A-015R1.1.]

Hove, M.C., Steingraeber, M.T., Newton, T.J., Heath, D.J., Nelson, C.L., Bury, J.A., Kurth, J.E., Bartsch, M.R., Thorpe, W.S., McGill, M.R., and Hornbach, D.J., 2012, Early life history of the winged mapleleaf mussel (*Quadrula fragosa*): American Malacological Bulletin, v. 30, no. 1, p. 47–57. [Also available at https://doi.org/10.4003/006.030.0104.]

Howard, D., 2017, Distribution, population estimate, and response to prescribed fire in the rattlesnake-master borer moth at the Nature Conservancy's Tallgrass Prairie Preserve in Osage County, Oklahoma: Oklahoma Department of Wildlife Conservation, prepared by University of New Hampshire, Durham, N.H., under grant no. F12AF01228, 19 p.

Howard, D.R., Cook, V., Smith, A.D.F., Howard, J.M., and Clifford, C., 2007, The effect of fire history and post-burn interval on population dynamics in the American burying beetle, *Nicrophorus americanus* (Coleoptera—Silphidae): 2007 Entomological Society of America Annual Meeting, San Diego, Calif., December 9–12, 2007, accessed November 08, 2019, at https://esa.confex.com/esa/2007/techprogram/paper_30690.htm.

Humphrey, S.R., 1978, Status, winter habitat, and management of the endangered Indiana bat, *Myotis sodalis*: Florida Scientist, v. 41, no. 2, p. 65–76.

International Whooping Crane Recovery Team, 2007 International recovery plan for the whooping crane (*Grus americana*) (third edition): Canadian Wildlife Service and U.S. Fish and Wildlife Service, 91 p., accessed May 13, 2019, at https://ecos.fws.gov/docs/recovery_plan/070604_v4.pdf.

Iverson, L.R., and Hutchinson, T.F., 2002, Soil temperature and moisture fluctuations during and after prescribed fire in mixed-oak forests, USA: Natural Areas Journal, v. 22, no. 4, p. 296–304.

International Union for the Conservation of Nature, 2019, The IUCN red list of threatened species: International Union for the Conservation of Nature website, accessed May 22, 2019, at https://www.iucnredlist.org/.

International Union of Pure and Applied Chemistry, 2007, Pesticide properties database: International Union of Pure and Applied Chemistry website, accessed May 13, 2019, at http://sitem.herts.ac.uk/aeru/iupac/index.htm.

Jain, T., Sikkink, P., Keefe, R., and Byrne, J., 2018, To masticate or not—Useful tips for treating forest, woodland, and shrubland vegetation: U.S. Forest Service General Technical Report RMRS-GTR-381, 55 p.

James, P.W., and Collins, K.D., 1993, Leopard darter revised recovery plan: U.S. Fish and Wildlife Service, prepared by Central Washington University and U.S. Fish and Wildlife Service, 53 p., accessed June 27, 2019, at https://ecos.fws.gov/docs/recovery_plan/930503b.pdf.

Johnson, C.M., and King, R.A., 2018, Beneficial forest management practices for WNS-affected bats—Voluntary guidance for land managers and woodland owners in the eastern United States: White-nose Syndrome Conservation and Recovery Working Group, 39 p.

Johnson, S.A., Brack, V., Jr., and Rolley, R.E., 1998, Overwinter weight loss of Indiana bats (*Myotis sodalis*) from hibernacula subject to human visitation: The American Midland Naturalist, v. 139, no. 2, p. 255–261. [Also available at https://doi.org/10.1674/0003-0031(1998)139[0255:OWLOIB]2.0.CO;2.]

Johnson, S.A., and Chambers, C.L., 2017, Effects of ponderosa pine forest restoration on habitat for bats: Western North American Naturalist, v. 77, no. 3, p. 355–369. [Also available at https://doi.org/10.3398/064.077.0308.]

Jurzenski, J., 2012, Factors affecting the distribution and survival of endangered American burying beetles, *Nicrophorus americanus* Olivier: Lincoln, Nebr., University of Nebraska, Master's thesis, 266 p.

Jurzenski, J., Snethen, D.G., Brust, M.L., and Hoback, W.W., 2011, New records of carrion beetles in Nebraska reveal increased presence of the American burying beetle, *Nicrophorus americanus* Olivier (Coleoptera—Silphidae): Great Plains Research, v. 21, no. 2, p. 131–143.

Kozol, A.J., 1995, Ecology and population genetics of the endangered American burying beetle, *Nicrophorus americanus*: Boston, Mass., Boston University, Ph.D dissertation.

Kozol, A.J., Scott, M.P., and Traniello, J.F.A., 1988, The American burying beetle, *Nicrophorus americanus*—Studies on the natural history of a declining species: Psyche [Cambridge, Mass.], v. 95, no. 3–4, p. 167–176. [Also available at https://doi.org/10.1155/1988/79403.]

Kral, K.C., Limb, R.F., Harmon, J.P., and Hovick, T.J., 2017, Arthropods and fire—Previous research shaping future conservation: Rangeland Ecology and Management, v. 70, no. 5, p. 589–598. [Also available at https://doi.org/10.1016/j.rama.2017.03.006.]

Kress, W.J., Maddox, G.D., and Roesel, C.S., 1994, Genetic variation and protection priorities in *Ptilimnium nodosum* (Apiaceae), an endangered plant of the eastern United States: Conservation Biology, v. 8, no. 1, p. 271–276. [Also available at https://doi.org/10.1046/j.1523-1739.1994.08010271.x.]

LANDFIRE, 2016, Existing Vegetation Type (ver. 1.4.0): U.S. Forest Service and U.S. Department of the Interior, accessed May 15, 2019, at https://www.landfire.gov/evt.php.

Langwig, K.E., Frick, W.F., Bried, J.T., Hicks, A.C., Kunz, T.H., and Kilpatrick, A.M., 2012, Sociality, density-dependence and microclimates determine the persistence of populations suffering from a novel fungal disease, white-nose syndrome: Ecology Letters, v. 15, no. 9, p. 1050–1057. [Also available at https://doi.org/10.1111/j.1461-0248.2012.01829.x.]

Law, B., Park, K.J., and Lacki, M.J., 2016, Insectivorous bats and silviculture—Balancing timber production and bat conservation, chap. 5 *of* Voigt, C.C., and Kingston, T., eds., Bats in the anthropocene—Conservation of bats in a changing world: Basel, Switzerland, Springer Science, p. 105–150.

Leasure, D.R., and Garner, K.A., [2009], Endangered *Nicrophorus americanus* prefer disturbed successional communities at military installation in western Arkansas: Ecological Knowledge and a Global Sustainable Society—94th Ecological Society of America Annual Meeting, Albuquerque, N. Mex., August 2–7, 2009, proceedings, [n.p.].

Leasure, D.R., and Hoback, W.W., 2017, Distribution and habitat of endangered American burying beetle in northern and southern regions: Journal of Insect Conservation, v. 21, no. 1, p. 75–86. [Also available at https://doi.org/10.1007/s10841-017-9955-5.]

Leslie, D.M., Jr., and Clark, B.S., 2002, Feeding habits of the endangered Ozark big-eared bat (*Corynorhinus townsendii ingens*) relative to prey abundance: Acta Chiropterologica, v. 4, no. 2, p. 173–182. [Also available at https://doi.org/10.3161/001.004.0206.]

Loeb, S.C., Lacki, M.J., and Miller, D.A., 2011, Conservation and management of eastern big-eared bats—An introduction, *in* Conservation and management of eastern big-eared bats—A symposium, Athens, Ga., March 2010: Asheville, N.C., U.S. Forest Service General Technical Report SRS–145, p. 1–11.

Loeb, S.C., and O'Keefe, J.M., 2011, Bats and gaps—The role of early successional patches in the roosting and foraging ecology of bats, *in* Greenberg, C., Collins, B., and Thompson, F., III, eds., 2011, Sustaining young forest communities—Ecology and management of early successional habits in the central hardwood region, USA, v. 21 *of* von Gadow, K., Pukkala, T., and Tomé, M., eds., Managing forest ecosystems: Dordrecht, Springer, p. 167–189, at https://doi.org/10.1007/978-94-007-1620-9_10.

Loeb, S.C., and O'Keefe, J.M., 2014, Indiana bats, northern long-eared bats, and prescribed fire in the Appalachians—Challenges and considerations, *in* Proceedings of wildland fire in the Appalachians—Discussions among managers and scientists, Roanoke, Va., October 8–10, 2013: Asheville, N.C., U.S. Forest Service General Technical Report SRS–199, p. 73–81.

Lomolino, M.V., and Creighton, J.C., 1996, Habitat selection, breeding success and conservation of the endangered American burying beetle *Nicrophorus americanus*: Biological Conservation, v. 77, no. 2–3, p. 235–241. [Also available at https://doi.org/10.1016/0006-3207(96)00003-1.]

Lomolino, M.V., Creighton, J.C., Schnell, G.D., and Certain, D.L., 1995, Ecology and conservation of the endangered American burying beetle (*Nicrophorus americanus*): Conservation Biology, v. 9, no. 3, p. 605–614. [Also available at https://doi.org/10.1046/j.1523-1739.1995.09030605.x.]

Lott, C.A., Wiley, R.L., Fischer, R.A., Hartfield, P.D., and Scott, J.M., 2013, Interior least tern (*Sternula antillarum*) breeding distribution and ecology—Implications for population-level studies and the evaluation of alternative management strategies on large, regulated rivers: Ecology and Evolution, v. 3, no. 10, p. 3613–3627. [Also available at https://doi.org/10.1002/ece3.726.]

Maddox, D., and Bartgis, R., 1990, Harperella (*Ptilimnium nodosum*) recovery plan: U.S. Fish and Wildlife Service, prepared by Maryland Natural Heritage, 60 p., accessed May 13, 2019, at https://ecos.fws.gov/docs/recovery_plan/910305b.pdf.

Martinez, A.D., 2004, Ouachita rock pocketbook (*Arkansia wheeleri*) recovery plan: U.S. Fish and Wildlife Service, 83 p., accessed May 20, 2019, at https://ecos.fws.gov/docs/recovery_plan/040602.pdf.

Maryland Department of Natural Resources, 2019, Glossary of fire terms: Maryland Department of Natural Resources web page, accessed July 30, 2019, at https://dnr.maryland.gov/forests/Pages/gloss.aspx.

Mather, C.M., 2005, The freshwater mussels of Oklahoma: Oklahoma City, Oklahoma Department of Wildlife Conservation, prepared by University of Science and Arts of Oklahoma [grant number T-14-P], accessed May 20, 2019, at https://www.wildlifedepartment.com/sites/default/files/T14P1.PDF.

Mckenna-Foster, A., Perrotti, L., Blyth, J., LoPresti, E., and Kennedy, R.S., 2016, Measuring success of a reintroduced population of the American burying beetle (*Nicrophorus americanus* Olivier) to Nantucket Island, MA: Journal of Insect Conservation, v. 20, no. 5, p. 895–904. [Also available at https://doi.org/10.1007/s10841-016-9926-2.]

McPherron, M.M., Jurzenski, J., Albrecht, M.C., Farnsworth, K.M., Walker, T.L., and Hoback, W.W., 2012, Model of habitat suitability for American burying beetles in Nebraska's Loess Canyons ecosystem: Trends in Entomology, v. 8, p. 27–36.

Meltofte, H., Piersma, T., Boyd, H., McCaffery, B., Ganter, B., Golovnyuk, V.V., Graham, K., Gratto-Trevor, C.L., Morrison, R.I.G., Nol, E., Rösner, H.U., Schamel, D., Schekkerman, H., Soloviev, M.Y., Tomkovich, P.S., Tracy, D.M., Tulp, I., and Wennerberg, L., 2007, Effects of climate variation on the breeding ecology of Arctic shorebirds: Copenhagen, Denmark, Danish Polar Center, 48 p.

Menzel, M.A., Menzel, J.M., Carter, T.C., Ford, W.M., and Edwards, J.W., 2001, Review of the forest habitat relationships of the Indiana bat (*Myotis sodalis*): U.S. Forest Service General Technical Report NE–284, 21 p.

Miller, R.E., 1939, The reproductive cycle in male bats of the species *Myotis lucifungus lucifugus* and *Myotis grisescens*: Journal of Morphology, v. 64, no. 2, p. 267–295. [Also available at https://doi.org/10.1002/jmor.1050640205.]

Monitoring Trends in Burn Severity, 2019, Fire occurrence dataset: Monitoring Trends in Burn Severity web page, accessed July 17, 2019, at https://www.mtbs.gov/index.php/direct-download.

Moore, G.A., 1944, Notes on the early life history of *Notropis girardi*: Copeia, v. 1944, no. 4, p. 209–214.

National Park Service, 2017, Wildland fire—What is hazard fuel reduction?: National Park Service website, accessed July 30, 2019, at https://www.nps.gov/articles/what-is-hazard-fuel-reduction.htm.

Natural Resources Conservation Service, 2002, Plant fact sheet—Rattlesnake master: U.S. Department of Agriculture, accessed June 27, 2019, at https://plants.usda.gov/factsheet/pdf/fs_eryu.pdf.

NatureServe, 2016, LANDFIRE/GAP land cover map unit descriptions (ver. 1.13): NatureServe, accessed January 22, 2020, at https://www.landfire.gov/documents/LF-GAPMapUnitDescriptions.pdf.

Neal, J.C., and Montague, W.G., 1991, Past and present distribution of the red-cockaded woodpecker *Picoides borealis* and its habitat in the Ouachita Mountains, Arkansas: Journal of the Arkansas Academy of Science, v. 45, article 22, p. 71–75.

Neosho Mucket Recovery Team, 2018, Species biological report Neosho mucket (*Lampsilis rafinesqueana*): U.S. Fish and Wildlife Service, 37 p., accessed May 20, 2019, at https://ecos.fws.gov/docs/recovery_plan/Neosho%20Mucket%20Species%20Biological%20Report.pdf.

Niles, L.J., Sitters, H.P., Dey, A.D., Atkinson, P.W., Baker, A.J., Bennett, K.A., Carmona, R., Clark, K.E., Clark, N.A., Espoz, C., González, P.M., Harrington, B.A., Hernández, D.E., Kalasz, K.S., Lathrop, R.G., Matus, R.N., Minton, C.D.T., Guy Morrison, R.I., Peck, M.K., Pitts, W., Robinson, R.A., and Serrano, I.L., 2008, Status of the red knot (*Calidris canutus rufa*) in the western hemisphere: Studies in Avian Biology, no. 36, 185 p.

Norberg, U.M., and Rayner, J.M.V., 1987, Ecological morphology and flight in bats (Mammalia; Chiroptera)—Wing adaptations, flight performance, foraging strategy and echolocation: Philosophical Transactions of the Royal Society of London: Series B, Biological Sciences, v. 316, no. 1179, p. 335–427. [Also available at https://doi.org/10.1098/rstb.1987.0030.]

Northern Great Plains Piping Plover Recovery Team, 2016, Recovery plan for the northern Great Plains piping plover (*Charadrius melodus*) March 2016—First revision: U.S. Fish and Wildlife Service, 131 p., accessed July 18, 2019, at https://ecos.fws.gov/docs/recovery_plan/Vol%20I%20NGP%20Draft%20Revised%20Breeding%20Rec%20Plan%20(JR%20Edits)%20(kk)%2020160224_1.pdf.

Oklahoma Department of Wildlife Conservation, 2018, Oklahoma wildlife field guide: Oklahoma Department of Wildlife Conservation website, accessed May 13, 2019, at https://www.wildlifedepartment.com/wildlife/field-guide.

Oklahoma Forestry Services, 2016, Forestry best management practice guidelines for water quality management in Oklahoma: Oklahoma City, Oklahoma Department of Agriculture, Food, and Forestry, 62 p.

O'Shea, T.J., and Clark, D.R., Jr., 2002, An overview of contaminants and bats, with special reference to insecticides and the Indiana bat *in* Kurta, A., and Kennedy, J., 2002, The Indiana bat—Biology and management of an endangered species [proceedings], Lexington, Ky., 2001: Austin, Tex., Bat Conservation International, p. 237–253.

O'Shea, T.J., Cryan, P.M., Hayman, D.T., Plowright, R.K., and Streicker, D.G., 2016, Multiple mortality events in bats—A global review: Mammal Review, v. 46, no. 3, p. 175–190. [Also available at https://doi.org/10.1111/mam.12064.]

Omernik, J.M., 1987, Ecoregions of the conterminous United States: Annals of the Association of American Geographers, v. 77, no. 1, p. 118–125.

Owen, S.F., Menzel, M.A., Edwards, J.W., Ford, W.M., Menzel, J.M., Chapman, B.R., Wood, P.B., and Miller, K.V., 2004, Bat activity in harvested and intact forest stands in the Allegheny Mountains: Northern Journal of Applied Forestry, v. 21, no. 3, p. 154–159. [Also available at https://doi.org/10.1093/njaf/21.3.154.]

Panzer, R., 2002, Compatibility of prescribed burning with the conservation of insects in small, isolated prairie reserves: Conservation Biology, v. 16, no. 5, p. 1296–1307. [Also available at https://doi.org/10.1046/j.1523-1739.2002.01077.x.]

Patriquin, K.J., and Barclay, R.M., 2003, Foraging by bats in cleared, thinned and unharvested boreal forest: Journal of Applied Ecology, v. 40, no. 4, p. 646–657. [Also available at https://doi.org/10.1046/j.1365-2664.2003.00831.x.]

Perry, R.W., and Thill, R.E., 2007, Roost selection by male and female northern long-eared bats in a pine-dominated landscape: Forest Ecology and Management, v. 247, no. 1–3, p. 220–226. [Also available at https://doi.org/10.1016/j.foreco.2007.04.041.]

Piersma, T., and Davidson, N.C., 1992, The migrations and annual cycles of five subspecies of knots in perspective: Wader Study Group Bulletin, v. 64, p. 187–197.

Polivka, K.M., 1999, The microhabitat distribution of the Arkansas River shiner, *Notropis girardi*—A habitat-mosaic approach: Environmental Biology of Fishes, v. 55, no. 3, p. 265–278. [Also available at https://doi.org/10.1023/A:1007577411279.]

Poulson, T.L., 1963, Cave adaptation in amblyopsid fishes: The American Midland Naturalist, v. 70, no. 2, p. 257–290. [Also available at https://doi.org/10.2307/2423056.]

Pruitt, L., and TeWinkel, L., 2007, Indiana bat (*Myotis sodalis*) draft recovery plan—First revision: U.S. Fish and Wildlife Service, 221 p., accessed May 22, 2019, at https://www.fws.gov/midwest/Endangered/mammals/inba/pdf/inba_fnldrftrecpln_apr07.pdf.

Raison, R.J., Woods, P.V., Jakobsen, B.F., and Bary, G.A.V., 1986, Soil temperatures during and following low-intensity prescribed burning in a *Eucalyptus pauciflora* forest: Australian Journal of Soil Research, v. 24, no. 1, p. 33–47. [Also available at https://doi.org/10.1071/SR9860033.]

Raithel, C., 1991, American burying beetle (*Nicrophorus americanus*) recovery plan: U.S. Fish and Wildlife Service, 80 p., accessed May 13, 2019, at https://ecos.fws.gov/docs/recovery_plan/910927.pdf.

Ratcliffe, B.C., 1996, The carrion beetles (Coleoptera—Silphidae) of Nebraska: Bulletin of the University of Nebraska State Museum, v. 13, 100 p.

Red-Cockaded Woodpecker Recovery Team, 2003, Recovery plan for the red-cockaded woodpecker (*Picoides borealis*)—Second revision: U.S. Fish and Wildlife Service, 296 p., accessed May 13, 2019, at https://ecos.fws.gov/docs/recovery_plan/030320_2.pdf.

Reisinger, T.W., Simmons, G.L., and Pope, P.E., 1988, The impact of timber harvesting on soil properties and seedling growth in the south: Southern Journal of Applied Forestry, v. 12, no. 1, p. 58–67. [Also available at https://doi.org/10.1093/sjaf/12.1.58.]

Roberts, A.D., 2010, Scaleshell mussel (*Leptodea leptodon*) recovery plan: Fort Snelling, Minn., U.S. Fish and Wildlife Service, 76 p., accessed May 13, 2019, at https://ecos.fws.gov/docs/recovery_plan/100407_v2.pdf.

Roe, K.J., and Boyer, S.L., 2015, A comparison of genetic diversity between sympatric populations of the endangered winged-mapleleaf (*Quadrula fragosa*) and the pimpleback (*Amphinaias pustulosa*) in the St. Croix River, USA: American Malacological Bulletin, v. 33, no. 1, p. 52–60. [Also available at https://doi.org/10.4003/006.033.0109.]

Russo, D., and Ancillotto, L., 2015, Sensitivity of bats to urbanization—A review: Mammalian Biology, v. 80, no. 3, p. 205–212. [Also available at https://doi.org/10.1016/j.mambio.2014.10.003.]

Sasse, D.B., Clawson, R.L., Harvey, M.J., and Hensley, S.L., 2007, Status of populations of the endangered gray bat in the western portion of its range: Southeastern Naturalist, v. 6, no. 1, p. 165–172. [Also available at https://doi.org/10.1656/1528-7092(2007)6[165:SOPOTE]2.0.CO;2.]

Schnell, G.D., Goetzinger, J.C., Hiott, A.E., Estevez, B.D.N., and Brennan, S.P., 2014, Effects of available food resources on numbers of the endangered American burying beetle (*Nicrophorus americanus*): The Southwestern Naturalist, v. 59, no. 2, p. 173–180. [Also available at https://doi.org/10.1894/F03-JC-74.1.]

Shiver, M.A., 2002, Reproduction and propagation of the Neosho mucket, *Lampsilis rafinesqueana*: Springfield, Southwest Missouri State University, Master's thesis, 65 p.

Sikes, D.S., and Raithel, C.J., 2002, A review of hypotheses of decline of the endangered American burying beetle (Silphidae—*Nicrophorus americanus* Olivier): Journal of Insect Conservation, v. 6, no. 2, p. 103–113. [Also available at https://doi.org/10.1023/A:1020947610028.]

Silvis, A., Perry, R., and Ford, W.M., 2016, Relationships of three species of bats impacted by white-nose syndrome to forest condition and management: U.S. Forest Service General Technical Report SRS–214, 48 p.

Stark, R., 2008, Ozark big-eared bat (*Corynorhinus townsendii ingens*) 5-year review—Summary and evaluation: U.S. Fish and Wildlife Service, 40 p., accessed September 17, 2019, at https://ecos.fws.gov/docs/five_year_review/doc1912.pdf.

Taylor, D.A., 2006, Forest management and bats: Bat Conservation International, 14 p., accessed July, 2019, at http://www.batcon.org/pdfs/ForestMgmtandBats.pdf.

Thogmartin, W.E., Sanders-Reed, C.A., Szymanski, J.A., McKann, P.C., Pruitt, L., King, R.A., Runge, M.C., and Russell, R.E., 2013, White-nose syndrome is likely to extirpate the endangered Indiana bat over large parts of its range: Biological Conservation, v. 160, p. 162–172. [Also available at https://doi.org/10.1016/j.biocon.2013.01.010.]

Trumbo, S.T., 1990, Reproductive success, phenology and biogeography of burying beetles (Silphidae, *Nicrophorus*): The American Midland Naturalist, v. 124, no. 1, p. 1–11. [Also available at https://doi.org/10.2307/2426074.]

Trumbo, S.T., 1992, Monogamy to communal breeding—Exploitation of a broad resource base by burying beetles *Nicrophorus*: Ecological Entomology, v. 17, no. 3, p. 289–298. [Also available at https://doi.org/10.1111/j.1365-2311.1992.tb01060.x.]

Trumbo, S.T., 1994, Interspecific competition, brood parasitism, and the evolution of biparental cooperation in burying beetles: Oikos, v. 69, no. 2, p. 241–249. [Also available at https://www.jstor.org/stable/3546144?seq=1#metadata_info_tab_contents.]

Trumbo, S.T., and Bloch, P.L., 2000, Habitat fragmentation and burying beetle abundance and success: Journal of Insect Conservation, v. 4, p. 245–252. [Also available at https://doi.org/10.1023/A:1011390215088.]

Turton, D.J., Stebler, E., and Smolen, M.D., 2009, Effectiveness of BMPS in reducing sediment from unpaved roads in the Stillwater Creek, Oklahoma Watershed: Journal of the American Water Resources Association, v. 45, no. 6, p. 1343–1351. [Also available at https://doi.org/10.1111/j.1752-1688.2009.00367.x.]

Tuttle, M.D., 1979, Status, causes of decline, and management of endangered gray bats: The Journal of Wildlife Management, v. 43, no. 1, p. 1–17. [Also available at https://doi.org/10.2307/3800631.]

Tuttle, M.D., and Kennedy, J., 2005, Field guide to eastern cave bats: Austin, Tex., Bat Conservation International, Inc., 41 p.

U.S. Department of Agriculture, 2017, The ARS pesticide properties database: U.S. Department of Agriculture website, accessed May 13, 2019, at https://www.ars.usda.gov/northeast-area/beltsville-md-barc/beltsville-agricultural-research-center/adaptive-cropping-systems-laboratory/docs/ppd/pesticide-properties-database/.

U.S. Environmental Protection Agency, 2015, Bottomland hardwoods: U.S. Environmental Protection Agency web page, accessed July 30, 2019, at https://www.epa.gov/wetlands/bottomland-hardwoods.

U.S. Fish and Wildlife Service, 1987, Endangered and threatened wildlife and plants—Reclassification of the American alligator to threatened due to similarity of appearance throughout the remainder of its range: Federal Register, v. 52, no. 107, p. 21059–21064.

U.S. Fish and Wildlife Service, 1998, Endangered and threatened wildlife and plants—Final rule to list the Arkansas River Basin population of the Arkansas River shiner (*Notropis Girardi*) as threatened: Federal Register, v. 63, no. 225, p. 64772–64799.

U.S. Fish and Wildlife Service, 2002, Endangered and threatened wildlife and plants—Designation of critical habitat for the northern great plains breeding population of the piping plover: Federal Register, v. 67, no. 176, p. 57638–57717.

U.S. Fish and Wildlife Service, 2007, Best management practices for projects affecting rivers, streams and tributaries: U.S. Fish and Wildlife Service, 2 p., accessed May 13, 2019, at https://www.fws.gov/southwest/es/TexasCoastal/docs/BMPs_For_Freshwater_Mussels.pdf.

U.S. Fish and Wildlife Service, 2009, Gray bat (*Myotis grisescens*) 5-year review—Summary and evaluation: Columbia, Mo., U.S. Fish and Wildlife Service, 34 p., accessed September 17, 2019, at https://ecos.fws.gov/docs/five_year_review/doc2625.pdf.

U.S. Fish and Wildlife Service, 2011a, Gray bat—*Myotis grisescens*: U.S. Fish and Wildlife Service fact sheet, 1 p., accessed May 17, 2019, at https://www.fws.gov/southwest/es/oklahoma/Documents/TE_Species/Species%20Profiles/Gray%20Bat.pdf.

U.S. Fish and Wildlife Service, 2011b, Ozark cavefish (*Amblyopsis rosae* Eigenmann 1898) 5-year review—Summary and evaluation: U.S. Fish and Wildlife Service Southeast Region, Arkansas Ecological Services Field Office, 25 p., accessed May 13, 2019, at https://ecos.fws.gov/docs/five_year_review/doc3850.pdf.

U.S. Fish and Wildlife Service, 2012a, Endangered and threatened wildlife and plants—Proposed endangered status for the Neosho mucket, threatened status for the rabbitsfoot, and designation of critical habitat for both species: Federal Register, v. 77, no. 200, p. 63440–63536.

U.S. Fish and Wildlife Service, 2012b, North American bat death toll exceeds 5.5 million from white-nose syndrome: U.S. Fish and Wildlife Service news release, January 17, 2012, 2 p., accessed September 17, 2019, at https://www.batcon.org/pdfs/USFWS_WNS_Mortality_2012_NR_FINAL.pdf.

U.S. Fish and Wildlife Service, 2013a, Endangered and threatened wildlife and plants—12-month finding on a petition to list the rattlesnake-master borer moth (*Papaipema eryngii*) as an endangered or threatened species: Federal Register, v. 78, no. 157, p. 49422–49440.

U.S. Fish and Wildlife Service, 2013b, Endangered and threatened wildlife and plants—Endangered status for the Neosho mucket and threatened status for the rabbitsfoot: Federal Register, v. 78, no. 180, p. 57076–57097.

U.S. Fish and Wildlife Service, 2013c, Least tern (*Sternula antillarum*) 5-year review—Summary and evaluation: U.S. Fish and Wildlife Service Mississippi Ecological Services Field Office, Jackson, Miss., 71 p., accessed May 13, 2019, at https://ecos.fws.gov/docs/five_year_review/doc4294.pdf.

U.S. Fish and Wildlife Service, 2013d, Neosho madtom (*Noturus placidus*) 5-year review—Summary and evaluation: U.S. Fish and Wildlife Service, 38 p., accessed September 17, 2019, at https://ecos.fws.gov/docs/five_year_review/doc4140.pdf.

U.S. Fish and Wildlife Service, 2014, Rufa red knot background information and threats assessment—Supplement to endangered and threatened wildlife and plants; final threatened status for the Rufa red knot (*Calidris canutus rufa*): U.S. Fish and Wildlife Service, 376 p., accessed June 27, 2019, at https://www.fws.gov/northeast/redknot/pdf/20141125_REKN_FL_supplemental_doc_FINAL.pdf.

U.S. Fish and Wildlife Service, 2015a, Northern long-eared bat—*Myotis septentrionalis*: U.S. Fish and Wildlife Service fact sheet, 2 p., accessed May 24, 2019, at https://www.fws.gov/Midwest/endangered/mammals/nleb/pdf/NLEBFactSheet01April2015.pdf.

U.S. Fish and Wildlife Service, 2015b, Status of the species—Red knot (*Calidris canutus rufa*): U.S. Fish and Wildlife Service, 48 p., accessed May 13, 2019, at https://www.fws.gov/verobeach/StatusoftheSpecies/20151104_SOS_RedKnot.pdf.

U.S. Fish and Wildlife Service, 2016a, Endangered and threatened wildlife and plants—4(d) rule for the northern long-eared bat: Federal Register, v. 81, no. 9, p. 1900–1922.

U.S. Fish and Wildlife Service, 2016b, Endangered and threatened wildlife and plants—Review of native species that are candidates for listing as endangered or threatened: Federal Register, v. 81, no. 232, p. 87246–87272. [Annual description of progress on listing actions].

U.S. Fish and Wildlife Service, 2019a, IPaC information for planning and consultation: U.S. Fish and Wildlife Service website, accessed October 1, 2018, at https://ecos.fws.gov/ipac/.

U.S. Fish and Wildlife Service, 2019b, [ECOS species] Data explorer: U.S. Fish and Wildlife Service website, accessed May 6, 2019, at https://ecos.fws.gov/ecp/report/ad-hoc-creator?catalogId=species&reportId=species&columns=%2Fspecies@cn,sn,status,desc,listing_date.

U.S. Fish and Wildlife Service, 2019c. Range-wide Indiana bat survey guidelines: U.S. Fish and Wildlife Service, 63 p., accessed October 1, 2019, at https://www.fws.gov/midwest/endangered/mammals/inba/inbasummersurveyguidance.html.

U.S. Fish and Wildlife Service, 2019d, Endangered and threatened wildlife and plants—Reclassifying the American burying beetle from endangered to threatened on the federal list of endangered and threatened wildlife with a 4(d) rule: Federal Register, v. 84, no. 86, p. 19013–19029.

U.S. Fish and Wildlife Service, 2019e, Species status assessment report for the American burying beetle (*Nicrophorus americanus*): U.S. Fish and Wildlife Service, 174 p., accessed July 17, 2019, at https://www.fws.gov/southwest/es/oklahoma/Documents/ABB/Listing/ABBSSA_Final_V1.0_Feb2019.pdf.

U.S. Fish and Wildlife Service, and Costa, R., 2002, Red-cockaded woodpecker: Stephen F. Austin State University Faculty Publications, article 426, accessed January 10, 2020 at https://scholarworks.sfasu.edu/forestry/426.

U.S. Fish and Wildlife Service, and National Marine Fisheries Service, 1998, Consultation handbook—Procedures for conducting consultation and conference activities under section 7 of the Endangered Species Act: U.S. Fish and Wildlife Service and National Marine Fisheries Service, 315 p., accessed July 30, 2019, at https://www.fws.gov/endangered/esa-library/pdf/esa_section7_handbook.pdf.

U.S. Forest Service, 2019a, Fire effects information system: U.S. Forest Service, accessed July 30, 2019, at https://www.fs.fed.us/database/feis/glossary.html.

U.S. Forest Service, 2019b, Felling heads: U.S. Forest Service web page, accessed on July 30, 2019, at https://www.fs.fed.us/forestmanagement/equipment-catalog/fellingheads.shtml.

U.S. Forest Service, 2019c, Glossary of forest engineering terms: U.S. Forest Service web page, accessed July 30, 2019, at https://www.srs.fs.usda.gov/forestops/glossary/.

U.S. Geological Survey, 2018, Download species range and predicted habitat data, *in* Gap analysis project species range and predicted habitat maps CONUS_2001: U.S. Geological Survey data release, accessed June 5, 2019, at https://doi.org/10.5066/F7V122T2. [Download data directly accessible at https://gapanalysis.usgs.gov/apps/species-data-download/.]

Vaughn, C.C., Mather, C.M., Pyron, M., Mehlhop, P., and Miller, E.K., 1996, The current and historical mussel fauna of the Kiamichi River, Oklahoma: The Southwestern Naturalist, v. 41, no. 3, p. 325–328.

Vaughn, C.C., and Pyron, M., 1995, Population ecology of the endangered Ouachita rock pocketbook mussel, *Arkansia wheeleri* (Bivalvia—Unionidae), in the Kiamichi River, Oklahoma: American Malacological Bulletin, v. 11, no. 2, p. 145–151.

Verschuyl, J., Riffell, S., Miller, D., and Wigley, T.B., 2011, Biodiversity response to intensive biomass production from forest thinning in North American forests—A meta-analysis: Forest Ecology and Management, v. 261, no. 2, p. 221–232. [Also available at https://doi.org/10.1016/j.foreco.2010.10.010.]

Walker, T.L., Jr., and Hoback, W.W., 2007, Effects of invasive eastern redcedar on capture rates of *Nicrophorus americanus* and other Silphidae: Environmental Entomology, v. 36, no. 2, p. 297–307. [Also available at https://doi.org/10.1093/ee/36.2.297]

Warrington, B.M., Aust, W.M., Barrett, S.M., Ford, W.M., Dolloff, C.A., Schilling, E.B., Wigley, T.B., and Bolding, M.C., 2017, Forestry best management practices relationships with aquatic and riparian fauna—A review: Forests, v. 8, no. 9, article 331, p. 1–16. [Also available at https://doi.org/10.3390/f8090331.]

Weaver, W.E., Weppner, E.M., and Hagans, D.K., 2015, Handbook for forest, ranch, and rural roads—A guide for planning, designing, constructing, reconstructing, upgrading, maintaining, and closing wildland roads: Ukiah, Calif., Mendocino County Resource Conservation District, 420 p., accessed July 30, 2019, at http://www.pacificwatershed.com/sites/default/files/roadsenglishbookapril2015b_0.pdf.

Willemssens, K.A., 2015, Soil preferences of *Nicrophorus* beetles and the effects of compaction on burying behavior: Lincoln, University of Nebraska, Master's thesis, 102 p.

Willis, L.D., Jr., 1986, Ozark cavefish (*Amblyopsis rosae*) recovery plan: U.S. Fish and Wildlife Service, 42 p., accessed May 13, 2019, at https://ecos.fws.gov/docs/recovery_plan/891114b.pdf.

Wilson, B.T., Lister, A.J., Riemann, R.I., and Griffith, D.M., 2013, Live tree species basal area of the contiguous United States (2000-2009): U.S. Forest Service, accessed June 28, 2019, at https://data.nal.usda.gov/dataset/live-tree-species-basal-area-contiguous-united-states-2000-2009.

Winged Mapleleaf Mussel Recovery Team, 1997, Winged mapleleaf mussel (*Quadrula fragosa*) recovery plan: U.S. Fish and Wildlife Service, 69 p., accessed May 13, 2019, at https://ecos.fws.gov/docs/recovery_plan/970625.pdf.

Witt, E.L., Barton, C.D., Stringer, J.W., Kolka, R.K., and Cherry, M.A., 2016, Influence of variable streamside management zone configurations on water quality after forest harvest: Journal of Forestry, v. 114, no. 1, p. 41–51. [Also available at https://doi.org/10.5849/jof.14-099.]

Zou, C.B., Turton, D.J., Will, R.E., Engle, D.M., and Fuhlendorf, S.D., 2014, Alteration of hydrological processes and streamflow with juniper (*Juniperus virginiana*) encroachment in a mesic grassland catchment: Hydrological Processes, v. 28, no. 26, p. 6173–6182. [Also available at https://doi.org/10.1002/hyp.10102.]

Glossary[1]

[Glossary definitions were compiled from Omernik (1987), Raithel (1991), British Columbia Ministry of Forests (1993), U.S. Fish and Wildlife Service and National Marine Fisheries Service (1998), Bey (2005), Clinnick and others (2008), Abbott and others (2012), Angwin and others (2012), U.S. Forest Service (2019a, b, c), U.S. Environmental Protection Agency (2015), Weaver and others (2015), Bakker and others (2017), National Park Service (2017), Jain and others (2018), Gromicko (2019), and Maryland Department of Natural Resources (2019).]

action area Total area treated for the five-year duration of the vegetation management program.

bare root or container tree Tree seedlings from garden nurseries used for restoration (also referred to as containerized trees).

basal area Cross sectional area (square feet) of trees (measured at breast height) used to quantify the density of a timber stand.

best management practice Methods to minimize or avoid adverse effects of treatments on ecologically sensitive natural resources.

bio log An erosion control device consisting of a mesh tube filled with soil or other material.

broadcast burning Prescribed fire used to reduce fuels and achieve other silvicultural objectives.

bucking The process of cutting felled and limbed trees into logs.

chip van A vehicle used for transporting wood chips.

clearcut Cutting and removing all merchantable trees larger than a minimum diameter (such as four inches) within a treatment area.

clutter adapted Bat species with morphological adaptations to allow for movement and foraging in dense foliage.

discountable Adverse effects that are extremely unlikely to occur.

eclosure Emergence of an adult arthropod after it has pupated.

ecoregion Ecologically similar areas within a given geographic region corresponding to biotic and abiotic patterns and processes, including geology, topography, soils, hydrology, climate, disturbance regimes, vegetation, wildlife, and land use.

feller buncher A self-propelled machine used to cut and process trees into bunches.

felling The process of cutting or uprooting standing trees.

fire line An area of bare mineral soil that has been cleared of vegetation and other organic material to prevent fires from spreading beyond the desired burn perimeter.

fire return interval The average number of years between two successive fires for a specified area.

forest canopy Generally refers to the upper layer of a forest formed by tree crowns.

forest understory Vegetation below the forest canopy.

fuel connectivity The amount of continuous fuels that can promote the spread of flames horizontally or vertically (also referred to as fuel continuity).

glochidia (*Singular glochidium*) the parasitic larval stage of unionid freshwater mussels that attach to fish host species.

hardened ford A shallow stream crossing strengthened with hardened materials such as rocks or concrete.

hazardous fuel Fuel loads including surface or ladder fuels and standing trees that can increase the risk of high-severity fire.

hazard tree Dead, dying, or unstable live trees, and parts of such trees, that could strike people or property if they were to fall.

[1]Glossary terms appear in boldface type where first used in the text.

hibernacula (*Singular hibernaculum*) a shelter that an organism occupies for refuge during hibernation.

high-severity fire Predominantly active crown fires that kill more than 75 percent of the upper canopy, consume most of the understory and litter, and reduce organic material in the soils.

incidental take The harm, harassment, collection, or killing of an organism that is unintentional, but not unexpected.

ladder fuels Understory vegetation and lower branches of trees providing fuel continuity from the surface to the forest canopy.

low-severity fire Predominantly surface fires and passive crown fires that generally only consume fine fuels and litter, kill aboveground portions of understory plants, but kill less than 26 percent of the upper canopy.

masticating The grinding of trees or shrubs into smaller pieces onsite or at nearby processing areas.

mechanical ripping A method for breaking up soils compacted by heavy machinery.

mounted hydraulic shear A machine or an attachment head on a feller buncher that uses hydraulic force to fell trees.

precommercial thinning Removal of young trees to promote growth of remaining trees.

prescribed fire Fires intentionally ignited to achieve specific management objectives.

primary treatment Activities to achieve a management objective, including prescribed fire, timber removal, and activities to manage species composition and stand density.

pronotum A plate-like structure on some insect species that covers the dorsal surface of the thorax.

pruning The removal of lower branches or multiple leaders from standing trees.

secondary treatment Activities that support the implementation of primary treatments, including site preparation and processing, creation of road infrastructure, and restoration.

seed tree A preferred species of tree left standing to produce seeds for reforestation of a cut stand.

shelterwood Selected trees that remain standing after removing timber to provide seeds for regeneration and shelter for seedlings.

skid steer A small engine-powered machine that can be used in conjunction with a variety of tools or attachments for multiple management activities.

skidder A self-propelled machine used for trailing or dragging (also referred to as skidding) trees or portions of trees to a processing area.

slash pile Isolated piles of vegetative debris including woody material and leaves that are burned on site.

species composition The species present in a given area.

snag A standing dead or dying tree, often missing a top or most of the smaller branches.

stand condition The health of a group of trees that reflects tree characteristics relative to the site potential.

stand density A quantitative measure of tree stocking, such as the number of trees, basal area, or volume per unit area.

surface fuels Vegetative materials within six feet of the ground, including litter or shrubs, that provide fuels for surface fires.

teneral A freshly molted or immature adult arthropod that has recently pupated.

thinning Selective removal of trees, which can stimulate tree growth and reduce hazardous fuels.

thinning from above Removal of the larger and preferred trees from a stand, which can enhance growth of remaining trees.

thinning from below Removal of smaller trees to promote an increased growth rate of larger trees.

timber landing A cleared area where harvested material is processed and loaded for transport off site for processing.

volant The ability of an animal to fly or glide.

Appendix 1. Section 7 Requirements of the Endangered Species Act

Consultation Guidance

A biological assessment was required for the Bureau of Indian Affairs' proposed vegetation management program to determine if the proposed action will affect federally threatened, endangered, or candidate species. The biological assessment is prepared in accordance with section 7 of the Endangered Species Act, summarized as follows (U.S. Fish and Wildlife Service, 2011):

> "The purposes of the Endangered Species Act (ESA) are to provide a means for conserving the ecosystems upon which endangered and threatened species depend and a program for the conservation of such species. The ESA directs all Federal agencies to participate in conserving these species. Specifically, section 7 (a)(1) of the ESA charges Federal agencies to aid in the conservation of listed species, and section 7 (a)(2) requires the agencies to ensure that their activities are not likely to jeopardize the continued existence of listed species or adversely modify designated critical habitats."
>
> "The U.S. Fish and Wildlife Service uses section 7 tools in partnership with *** other Federal agencies to collaboratively solve conservation challenges, as well as create opportunities, using section 7 consultations, to recover the ecosystems of listed species. It requires Federal agencies to consult with the Service to ensure that actions they fund, authorize, permit, or otherwise carry out will not jeopardize the continued existence of any listed species or adversely modify designated critical habitats. *** Federal agencies *** and the Service engage in early coordination to develop methods of integrating proposed activities with the conservation needs of listed resources before the proposed actions are fully designed."
>
> "If the Federal agency determines that a project is likely to adversely affect a listed species or designated critical habitat, the agency initiates formal consultation by providing [a biological assessment documenting] the anticipated effects." [The biological assessment is used by the U.S. Fish and Wildlife Service to prepare a biological opinion]. "The analysis of whether or not the proposed action is likely to jeopardize the continued existence of the species or adversely modify designated critical habitat is contained in a biological opinion [prepared by the U.S. Fish and Wildlife Service within 135 days of receiving the biological assessment]. "The Service must anticipate any incidental take that may result from the proposed project and, provided that such take will not jeopardize the continued existence of the listed species, authorize that take in an incidental take statement. The latter contains clear terms and conditions designed to reduce the impact of the anticipated take to the species involved."
>
> Additional explanation text by the report authors is shown in brackets.

Consultation History

Conference calls among the Bureau of Indian Affairs, U.S. Fish and Wildlife Service, and the U.S. Geological Survey in preparation of the biological assessment occurred on the following dates:

- 2018: 19 November, 4 December.
- 2019: 12 February, 14 March, 24 April, 8 May, 9 June, 11 July, 31 July, 5 September, 1 October, 7 November, and 3 December.

References Cited

U.S. Fish and Wildlife Service, 2011, Consultations with Federal agencies—Section 7 of the Endangered Species Act: U.S. Fish and Wildlife fact sheet, 2 p., accessed April 27, 2020, at https://www.fws.gov/endangered/esa-library/pdf/consultations.pdf.

Appendix 2. Best Management Practices to Reduce Adverse Effects of Treatments on Ecologically Sensitive Natural Resources

Aquatic Systems

The following best management practices (BMPs) for the threatened and endangered species associated with aquatic systems including plants, freshwater mussels, fishes, birds, and bats (tables 2.1 and 2.2; U.S. Fish and Wildlife Service, 2007) will help to avoid or minimize the negative effects of treatments on aquatic habitats near treatment areas.

Table 2.1. Best management practices for management activities in aquatic systems.

Treatment	Best management practice
All treatments	Disturb riparian and floodplain vegetation only when necessary.
	Move equipment over streams within a single confined location over an existing bridge, equipment pad, clean temporary native rock fill, or a temporary portable bridge.
	Do not store hazardous materials, chemicals, fuels, lubricating oils, and other such substances within 300 feet of streambanks.
	Refuel heavy machinery at least 300 feet from streambanks.
	Revegetate all disturbed areas as soon as possible after construction to prevent unnecessary soil erosion. Use only native riparian plants to help prevent the spread of exotics.
	Maintain sediment filters at the base of all slopes located adjacent to the streams until right-of-way vegetation becomes established.
	Maintain a vegetative filtration strip adjacent to streams and wetlands that is an appropriate size for the stream width and bank slope (table 2.2).
	Direct water runoff into vegetated areas.
Roads, bridges, and culverts	Construct stream crossings during a period of low streamflow (typically July through September).
	Cross streams, stream banks, and riparian zones at right angles and in areas of gentle bank slopes.
	When feasible, directionally bore under stream channels.
	Deposit trench spoil greater than 25 feet from the stream channel and banks.
	Use sediment filter devices to prevent movement of spoil outside of the right-of-way when standing or flowing water is present.
	Conduct trench dewatering to prevent discharge of silty water into stream channels.
	Maintain the existing contours of the stream bank and channel bottom.

The widths of stream management zones are determined from watershed characteristics, risk of erosion, soil type and stream width (table 2.2; U.S. Fish and Wildlife Service, 2007). Erosion risk is increased with sandy soil, steep slopes, large water sheds, and increasing stream widths.

Table 2.2. Width of primary and secondary stream management zones.

[Primary stream management zones apply to ephemeral streams. Secondary stream management zones apply to intermittent, braided, and perennial streams as well as ponds and lakes. <, less than; >, greater than; ≤, less than or equal to]

Stream width (feet)	Stream slope (percent)	Stream management zone width (feet)[1]	
		Primary	Secondary
<20	<7	35	0
	7 to 20	35	50
	>20	Top of slope or 150	75
20 to 50	<7	50	0
	7 to 20	50	50
	>20	Top of slope or 150	75
>50	<7	Width of stream or ≤100	0
	7 to 20	Width of stream or ≤100	50
	>20	Top of slope or 150	75

[1]See U.S. Fish and Wildlife Service (2007) for additional details on stream management zones.

Terrestrial Species

The Bureau of Indian Affairs will use the BMPs recommended by the U.S. Fish and Wildlife Service for the terrestrial threatened and endangered species including *Picoides borealis* (red-cockaded woodpecker) (table 2.3; Red-Cockaded Woodpecker Recovery Team, 2003), bats (table 2.4; Taylor, 2006; Johnson and King, 2018), and *Nicrophorus americanus* (American burying beetle) (table 2.5; U.S. Fish and Wildlife Service, 2019) to minimize the adverse effects on these species.

Red-Cockaded Woodpecker

Table 2.3. Best management practices for red-cockaded woodpecker habitat.

[RCW, red-cockaded woodpecker]

Treatment	Best management practice
All treatments	Monitor cavity nest resources and retain existing cavity trees.
	Maintain at least four suitable cavities in each cluster of cavities.
	Use tree cavity restrictors to control tree cavity enlargement.
	Retain large and old pines to serve as potential cavity trees.
Clearcut	Maintain management objectives of restoring native pine species.
	Limit treatment size to less than 40 acres.
Shelterwood or seedtree	Use long rotations based on the following guidelines: 1) at least 120 years for *Pinus palustris* (longleaf pine) and *P. echinata* (shortleaf pine); 2) at least 100 years for *P. taeda* (loblolly pine), *P. elliottii*, (slash pine), and *P. serotina* (pond pine).
	Retain all flat-top, turpentine-scarred, and other relict pine trees.
	Leave a minimum of 6 to 10 pines on each acre.
Thinning	Minimize entries into a stand where feasible.
	Preferentially remove deciduous trees where possible.
	Retain 12 or more of the oldest pine trees on each hectare (5 or more on each acre).
Prescribed burns	Conduct a program of frequent (every 5 years) prescribed burning that mimics the frequency, intensity, seasonality, and variability of the natural fire regime. This will help control midstory, exclude deciduous trees, encourage groundcover, and allow for reproduction of loblolly and shortleaf pine.
	Where feasible, conduct burns during the early to middle growing season to maximize forest understory regeneration.
	Protect active and inactive *Picoides borealis* (red-cockaded woodpecker; RCW) cavity trees from fire by raking, mowing, or hand-backburning to a distance of at least 20 feet. Do not use plow lines around the cavity trees because this can cause tree mortality.
	Ensure that all members of the burn crew have maps detailing the location and status of all cavity trees within and in close proximity to the burn unit.
	Give first priority to maintaining active RCW clusters that support healthy herbaceous understory.
	Give second priority to restoring herbaceous understory in active RCW clusters with excessive deciduous midstory.
	Give third priority to recently inactive RCW clusters with excessive midstory.
	Where feasible, use prescribed fire as the only site preparation treatment to promote understory regeneration and longleaf pine reproduction.
	Where prescribed burning is not feasible, use site preparation treatments that minimize ground disturbance to inhibit invasive species colonization.

Bats

Table 2.4. Best management practices for threatened and endangered bat habitat.

[BMP, best management practices; OHWM, ordinary high-water mark; FWS, U.S. Fish and Wildlife Service]

Treatment	Best management practice
All treatments	Within potential bat habitat, FWS will be contacted during project planning to determine if known caves, karst features, or roost trees are present within proposed treatment areas.
	Timing stipulations (table 9) will be followed to avoid disturbance to maternity sites (trees and caves) during pup-rearing season and winter hibernation (caves).
	If an occupied bat roost tree is discovered during site visits, the tree will be marked and protected by a 100-foot wide buffer.
	In areas with karst topography, surveys for potential unknown karst features will be conducted before all project activities. If karst features are observed, a 300-foot wide buffer will be placed around the feature, and FWS will be contacted for further consultation.
	Aerial or broadcast spraying of herbicides and pesticides will avoid known hibernacula, maternity sites, riparian areas, and surface karst features.
	Refueling of heavy machinery and storage of all hazardous materials, chemicals, fuels, and oils will be at least 300 feet from the OHWM.
	BMPs for aquatic habitats (table 2.1) will be followed to minimize negative impacts on water quality that may affect prey species.
Timber removal	Snags and live trees with roost tree characteristics (for example, loose bark, large crevices, cracks, cavities) will be retained when feasible. If snags must be removed, replacement snags can be created by girdling trees to mitigate the loss of roosting sites.
	Before felling a hazard tree, an emergence survey will be conducted during appropriate conditions to determine if bats are roosting in the tree. If no bats are observed, the hazard tree may be removed on the following day. If bats are observed or surveys are too hazardous, FWS will be contacted for further consultation.
	Groups of trees will be retained around snags to provide partial shade and protection as feasible.
	In stands greater than 20 acres where timber removal reduces basal area to less than 30 square feet per acre, 5 percent of the removal area will be retained in patches.
	During forest thinning, at least 16 live trees greater than or equal to 9 inches diameter at breast height will be maintained per acre, six of which preferably will include the largest available species favored by roosting bats.
	During forest thinning, average canopy closure will be maintained at or above 60 percent on a stand or compartment level.
Prescribed burns	FWS will be contacted during project planning to determine if known caves or karst features are present within proposed treatment areas.
	For burning near karst features that are only occupied seasonally, burning will be planned to take place when bats are not present, or during the inactive season.
	If prescribed burning must take place near a karst feature where bats are present year round, it will take place in March when daytime high temperatures are 45 to 70 degrees Fahrenheit (when air movement into the cave is minimal). Ignition of the fire must take place at least 50 feet from the cave entrance.
	Excess fuels such as leaf litter will be removed from the cave entrance with leaf blowers or by hand.
	Plan burns in accordance with wind direction, wind speed, air mixing height, and transport winds to reduce influence of smoke on caves. Fires will be ignited so that a perimeter fire draws the interior fire away from the cave entrance, and smoke is not drawn into the cave.
	A truck will be kept on site and fire crew will monitor the fire near the cave entrance.
	Weather conditions where air mixing heights are between 300 and 650 feet will be included as a prescription so that smoke will move upward.

American Burying Beetle

General forestry BMPs (Oklahoma Forestry Services, 2016), and BMPs specific to the (American burying beetle) will be used to avoid or minimize disturbance to American burying beetle populations and habitat whenever feasible (table 2.5), as recommended by the U.S. Fish and Wildlife Service (2016).

Table 2.5. Best management practices for the American burying beetle.

[ABB, American burying beetle; ROW, right of way]

Treatment	Best management practice
All treatments	Minimize clearing of temporary work areas and use small equipment or hand cutting techniques that leave the root zone intact and reduce soil compaction from heavy machinery.
	In areas where *Nicrophorus americanus* (American burying beetle; ABB) are present (determined by valid surveys) or where ABB presence is assumed (when no ABB surveys were completed), return surface soils to approximate pretreatment conditions.
	Restore areas in native range using approved native seed mixes developed for the applicable ecozone.
	Educate all workers operating in the treatment areas about ABB habitat, biology, reasons for ABB decline, and the responsibility of all workers to protect the ABB. Require all workers to report any ABB sightings to the project manager or environmental inspector.
	Provide each worker a full-color endangered species card with a picture of the ABB and summarized species information before conducting soil disturbing activities. Post signs at all access points to the treatment area highlighting the areas as ABB habitat and reminding workers to follow special restrictions in the area.
	Remove all food wastes from the ROW each day, and prohibit dogs or cats on the ROW.
	Implement Pollution Prevention Requirements as required in §3.3.3 of the Oklahoma Department of Environmental Quality general permit OKR10 for stormwater discharges.
	Fuel all equipment outside of ABB habitat (undisturbed native vegetation), and store all fuel and motor vehicle oil outside of ABB habitat.
Roads, bridges, and culverts	Minimize use of artificial lighting, such as lighting needed during night construction. In situations where artificial lighting is necessary, shield direct light to the work area, and prevent light from projecting upwards.
	Install appropriate erosion controls, including such items as straw bales, **bio logs**, silt fence, and similar materials.
Timber removal	Prior to the topsoil replacement, rip (mechanically turn soil with a plow or ripping device) the impacted area to reduce soil compaction. Rip and disk at a time when the soil is sufficiently dry to allow normal tillage operations in adjacent farmlands.

References Cited

Johnson, C.M., and King, R.A., 2018, Beneficial forest management practices for WNS-affected bats—Voluntary guidance for land managers and woodland owners in the eastern United States: White-Nose Syndrome Conservation and Recovery Working Group, 39 p.

Oklahoma Forestry Services, 2016, Forestry best management practice guidelines for water quality management in Oklahoma: Oklahoma City, Oklahoma Department of Agriculture, Food, and Forestry, 62 p.

Red-Cockaded Woodpecker Recovery Team, 2003, Recovery plan for the red-cockaded woodpecker (*Picoides borealis*)—Second revision: U.S. Fish and Wildlife Service, 296 p., accessed May 13, 2019, at https://ecos.fws.gov/docs/recovery_plan/030320_2.pdf.

Taylor, D.A., 2006, Forest management and bats: Bat Conservation International, 14 p., accessed July, 2019, at http://www.batcon.org/pdfs/ForestMgmtandBats.pdf.

U.S. Fish and Wildlife Service, 2007, Best management practices for projects affecting rivers, streams and tributaries: U.S. Fish and Wildlife Service, 2 p., accessed May 13, 2019, at https://www.fws.gov/southwest/es/TexasCoastal/docs/BMPs_For_Freshwater_Mussels.pdf.

U.S. Fish and Wildlife Service, 2016, American burying beetle impact assessment for project reviews: U.S. Fish and Wildlife Service, 20 p., accessed May 13, 2019, at https://www.fws.gov/southwest/es/Oklahoma/documents/abb/surveying%20final/abb%20impact%20assessment%20for%20project%20reviews_30march2016_final.pdf.

U.S. Fish and Wildlife Service, 2019, Species status assessment report for the American burying beetle (*Nicrophorus americanus*): U.S. Fish and Wildlife Service, 174 p., accessed July 17, 2019, at https://www.fws.gov/southwest/es/oklahoma/Documents/ABB/Listing/ABBSSA_Final_V1.0_Feb2019.pdf.

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