South Dakota Bat Management Plan

2025

Management Plan Prepared by

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Acknowledgements

Bat Management Plan Development

The development of this plan builds upon the foundational work established in the 2004 South Dakota Bat Management Plan for the South Dakota Game, Fish and Parks. The 2004 plan was created by original members of the South Dakota Bat Working Group including Alyssa Kiesow, Barb Muenchau, Brad Phillips, Chad Tussing, Cheryl Schmidt, Doug Backlund, Eileen Dowd-Stukel, Joel Tigner, Lon Kightlinger, Linda Schaefer, Natalie Gates, Sara Reindl, Scott Pedersen, Stephanie Middlebrooks, and Vicki Swier. We extend our sincere gratitude to the authors and contributors of the prior plan, whose efforts provided critical guidance for bat conservation, research, and management. Their dedication laid the groundwork for ongoing and future conservation initiatives, provided invaluable educational outreach opportunities for the community, and their contributions continue to inform best practices in bat stewardship today.

We would also like to acknowledge the many individuals who made contributions and provided feedback in the development of the 2025 South Dakota Bat Management Plan, including South Dakota Game, Fish and Parks wildlife biologists: Mandy Pearson, Andrew Norton, Eileen Dowd-Stukel, J. M. Weidler, Jessica Speiser, and Ryan Wendinger and current members of the South Dakota Bat Working Group: Silka Kempema, Alexis McEwan, Amy Hammesfahr, Scott Pedersen, Brad Phillips, Phillip Dobesh, and Renee Lile. We thank this team for their valuable input and dedication to bat conservation.

Bat Conservation Partners

This plan would like to acknowledge the many conservation partners whose collaboration is essential to the management and protection of South Dakota's bats. First, we recognize and acknowledge the management authority and jurisdiction of the nine Native Nations of South Dakota including Cheyenne River, Standing Rock, Oglala, Rosebud, Lower Brule, Crow Creek, Yankton, Sisseton Wahpeton Oyate, and Flandreau Santee. Additionally, we recognize the management efforts of the various state and federal agencies, as well as private landowners. Together, state, federal, tribal, and private stakeholders play a crucial role in advancing bat research, implementing conservation measures, and ensuring the long-term viability of bat species and their habitats. An expanded list of partners and collaborators in South Dakota bat conservation can be found in Appendix B.

Finally, we extend our appreciation to the researchers, land managers, conservation organizations, and community stakeholders whose dedication to bat conservation continues to shape and refine management strategies. Their expertise and commitment to bat conservation through research, land stewardship, and regulatory oversight is fundamental to the success of this plan and to the continued protection of bat populations.

Participants

The South Dakota Bat Management Plan is a cooperative effort between local, state, and federal entities. The South Dakota Game, Fish and Parks contracted several members of the Cheeseman Lab at South Dakota State University Department of Natural Resource Management to revise the 2004 SDBWG Bat Management Plan. The following participants provided invaluable feedback during the outlining, drafting, and editing portions of the plan revision, and provided valuable comments and suggestions. The making of this plan could not have been possible without input and work from the following partners:

Maya Pendleton (Co-Lead), South Dakota State University, Department of Natural Resource Management

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Silka Kempema, U. S. Fish and Wildlife Service

Alexis McEwan, Montana Natural Heritage Program

Renee Lile, University of Wyoming

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1. Introduction

Many wildlife populations across the globe are in decline, leaving resource managers with the difficult task of managing populations in the face of uncertainty in a changing environment (Nichols et al. 2011). Due to the complex nature of many conservation issues facing wildlife populations, paired with limited resources and knowledge, implementing best management practices (BMPs) within a management plan framework is a common and effective way to prioritize conservation efforts to maximize benefits for multiple species (Peltola et al. 2023). This management plan seeks to highlight relevant BMPs for bats in priority habitats across South Dakota.

Bats play a vital role in ecosystems by occupying unique ecological niches and providing essential ecosystem services, contributing billions of dollars to economies worldwide (Boyles et al. 2011, Russo et al. 2018, Maslo et al. 2022). However, bat populations have been declining globally due to factors such as disease (e.g., white-nose syndrome), wind turbine collisions, habitat loss, climate change, and human interference (Frick et al. 2020, Adams et al. 2024).

Given their ecological and economic importance, bat population declines have spurred increased conservation efforts and research and monitoring initiatives to better understand bat habitat needs and population dynamics (Drake et al. 2020, Udell et al. 2022, Adams et al. 2024). Many studies have focused on assessing species occupancy and abundance (Udell et al. 2022), and understanding the specific requirements needed across species for summer and maternity roosts, hibernacula, and migration corridors to facilitate protection of these key areas (Weller et al. 2018, Cortes and Gillam 2020, Drake et al. 2020). Other studies evaluate the impacts of varying conservation challenges on bats (Frick et al., 2015). These studies provide critical insights into bat demographics, allowing for the creation of species and habitat specific guidelines and BMPs to aid population management. Although significant progress has been made, many knowledge gaps remain, particularly in regions with limited bat research. These data gaps are problematic, as understanding important habitats, resources, and life history traits is critical for effective bat conservation (Frick et al. 2020).

To address these challenges, various bat working groups, such as the South Dakota Bat Working Group, have been established. The South Dakota Bat Working Group developed South Dakota's first edition of the Bat Management Plan in 2004 to guide bat conservation and management. This 2025 edition of South Dakota's Bat Management Plan does not seek to repeat information from the 2004 edition but strives to incorporate the breadth of new information pertaining to bat conservation issues and management strategies since the 2004 edition. Similar to the 2004 edition, this 2025 edition seeks to unite partners, increase educational outreach and awareness, and provide a reference for bat management and conservation efforts in South Dakota. This plan will also integrate into the 2025 South Dakota Wildlife Action Plan which has added six new bat species since the 2022 revision.

Purpose

The South Dakota Bat Management Plan serves as a concise reference for land and resource management agencies, biologists, researchers, and stakeholders looking to enhance bat conservation and management in South Dakota. This document details the ecological importance of bats and provides an overview of species' status and habitat associations in South Dakota. It identifies key conservation issues facing bat populations and outlines strategies to address and mitigate these challenges. This plan describes primary habitat types in South Dakota, including associated bat species, important characteristics benefiting bats, conservation concerns, and tailored BMPs for each habitat type. Additionally, it addresses collaboration and education outreach approaches, highlights current research efforts and future research needs, and provides an overview of bat survey methods and their applications to offer practical direction for implementing conservation measures. Importantly, this document also includes a synthesis of past and current monitoring efforts, research projects, publications, and technical reports compiled since 2004 to provide an overview of current knowledge on South Dakota bat populations. In addition, summary species accounts and county-level species distribution maps are provided for reference.

Knowledge gaps regarding bat species' distributions and habitat associations in South Dakota constrain the development of regionally specific guidance. As a result, many conservation strategies and BMPs herein are informed by research conducted outside the state. Continued research and monitoring are essential to improve understanding of South Dakota's bat populations and to support more locally tailored conservation efforts. To foster collaboration among agencies, land managers, tribes, the public, and other stakeholders and enhance the efficiency of conservation actions, a list of active participants in bat conservation and management are included.

The 2004 South Dakota Bat Management Plan

The original South Dakota Bat Management Plan, published in 2004, was initiated and developed by the South Dakota Bat Working Group comprised of 16 agencies, organizations, and partners. The overarching goal of the 2004 edition was to provide guidance for individuals and agencies to promote long-term conservation of South Dakota bat species through research, management, and education.

The 2004 edition introduced the ecological value of bats and outlined the conservation concerns recognized at that time. It provided a comprehensive natural history overview of bats in South Dakota, including physical characteristics, physiology, reproduction, key habitats, food habits, seasonal behavior, and causes of mortality. Specific threats to bat populations included habitat loss, inadequate protection and policy enforcement, limited funding and outreach, lack of standardized survey methods, insufficient data, few collaborative networks, and lack of public awareness and knowledge. To address these threats, the plan outlined targeted objectives and strategies aligned with key areas of management, research, and education. Management needs focused on habitat associations, regulatory considerations, and interagency collaboration. Research needs emphasized standardized survey protocols, data management and analysis, and science-based recommendations. Education needs centered on public outreach and awareness efforts to promote bat conservation. A progress evaluation detailing annual and five-year reviews of the plan and a list of potential cooperators were also included.

The Appendices provided valuable information recommended for reference:

- *Appendix A*: Taxonomy
- *Appendix B*: Species accounts
  - Organized by roosting associations (tree-, multi-habitat-, and cave-roosting species) detailing morphology, distribution and status, natural history, and management note
- *Appendix C*: Dichotomous key
  - Included a secondary key focused on measurements to assist with more challenging identifications
- *Appendix D*: Management recommendations for habitat associations
  - Covered underground roosting habitat, water sources, riparian/cottonwood areas, forestry practices, and buildings
- *Appendix E–F:* Federal laws and regulations
- *Appendix G:* Proper house exclusion methods
- *Appendix H:* Rabies information
- *Appendix I:* Conservation Digest articles – published by South Dakota Game, Fish and Parks
  - Townsend's big-eared bat
  - South Dakota's tree bats

2. Ecological Value and Conservation Concerns

Bats fill a unique ecological niche and play a vital role in ecosystems. They provide billions of dollars of ecosystem services worldwide (Ramírez-Fráncel et al. 2022) as highly adept nocturnal insect predators in both agricultural and natural settings, as pollinators and seed dispersers for important cash crops and wildflowers, in fertilizer production, as disease vector controllers, and even as bioindicators (Kunz 1982*a*). Furthermore, due to their high mobility and cryptic behavior, the ecological impacts of bats are likely to extend beyond what is currently understood (Kerth 2008, Russo et al. 2018).

Crop Protection

Bats are highly efficient insectivores (Riccucci and Lanza 2014, Russo et al. 2018), consuming a diverse range of nocturnal invertebrates such as moths and beetles (Boyles et al. 2011, Maslo et al. 2022). They can eat up to half their body weight in insects each night, while pregnant and lactating females may consume their entire body weight (Anthony and Kunz 1977, Kurta et al. 1989, Kunz et al. 1995). Many species feed on agricultural pests, including corn rootworms (*Diabrotica* spp.), clover worms (*Hypena* spp.), and armyworms (*Spodoptera* spp.) (McCracken et al. 2012, Whitby et al. 2020). A study in the southern U.S. found that three bat species ate 23 crop pests, with at least one pest species present in 61% of fecal samples, indicating frequent predation on pests (Hughes et al. 2021). Notably, the Seminole bat (*Lasiurus seminolis*), a southern migratory tree bat, similar to the northern hoary bat (*L. cinereus*) and eastern red bat (*L. borealis*) in South Dakota, consumed three times more pest species than other bats studied. A bat dietary analysis study conducted in the Black Hills of South Dakota found that bats ate multiple species of significant agricultural pests including the crucifer flea beetle (*Phyllotreta cruciferae*), two species of tarnished plant bug (*Lygus hesperus* and *L. lineolaris*), the seedcorn maggot (*Delia platura*), and the cabbage moth (*Plutella xylostella*) (Lile et al. 2025), indicating their potential importance as pest predators in the region. Together, pest consumption by bats in the contiguous United States provides an estimated 23 billion USD annually in pest control services as bats decrease the abundance of crop-damaging insects, reducing crop losses and pesticide use (Boyles et al. 2011).

Human, Livestock, and Ecosystem Services

Bats contribute to human and animal health and wellbeing by controlling disease vectors like mosquitoes, which carry malaria and West Nile virus pathogens (Puig-Montserrat et al. 2020), and by reducing the need for chemical pesticides in agricultural production (Frank 2024). Studies have linked bat population declines with increased pesticide application and subsequent economic and human health consequences (Frank 2024). While mosquitoes were once thought to be an insignificant part of bat diets, multiple studies have confirmed their frequent consumption (Reiskind and Wund 2009, Wray et al. 2018, Puig-Montserrat et al. 2020), including seven distinct species of mosquitos in the Black Hills of South Dakota (Lile et al. 2025). Bats also help manage parasites and pests affecting livestock (Ancillotto et al. 2017, 2021, 2024, Russo et al. 2018) such as dipterans (flies, midges, and mosquitoes) which negatively affect cattle (Byford et al. 1992). One study found that bats had higher foraging activity over herds of cattle (Ancillotto et al. 2017) and another found that two bat species had feces composed of over 50% of two dipteran species known to be cattle pests (Vescera et al. 2024). Finally, bats can serve as bioindicators of ecosystem health (Russo et al. 2021) as fluctuations in their populations may signal changes in water quality, forest fragmentation, pesticide use, and climate conditions (Jones et al. 2009) and may be indicators of environmental heavy metal contamination, which could potentially be tested for in guano (Zukal et al. 2015).

Additional Ecosystem Services

Beyond food crop protection, North American bats contribute to forest and tree plantation pest control, pollination, seed dispersal, and fertilizer production. Bats will eat spruce budworm moths and oak moths (Pierson 1998, Lloyd et al. 2006, Charbonnier et al. 2016) and can protect forests and agroforestry by eating defoliating and fruit eating insects (Ancillotto et al. 2022, Tuneu-Corral et al. 2023), as well as orchard and ornamental plant pests (Riccucci and Lanza 2014, Ancillotto et al. 2024). Some North American bats are primary pollinators of cacti and agave, including the agave species used to make tequila (Ramírez-Fráncel et al. 2022). Seed dispersal by fruit eating bats has been found to not only improve plant species richness and soil fertility but also promoted growth of plants used by humans for food, medicine, and animal feed (Enríquez-Acevedo et al. 2020). Bat guano serves as a valuable nitrogen and phosphate rich fertilizer and remains commercially harvested (Pierson 1998, Sakoui et al. 2020) and used worldwide (Ramírez-Fráncel et al. 2022).

Conservation Concerns

Despite their ecological importance, many bat populations are in steep decline due to disease, wind energy, habitat loss, climate change, and human disturbance (Frick et al. 2020). Over 50% of North American bat species face a moderate to severe risk of extinction within the next 50 years (Adams et al. 2024). South Dakota bat species are no exception, with the northern myotis (*Myotis septentrionalis,* federally endangered 2022), little brown myotis (*M. lucifugus,* under review for federal listing), and tricolored bat (*Perimyotis subflavus,* proposed for federal listing 2025), all of which have experienced losses as high as 97% across their ranges (Cheng et al. 2021, Udell et al. 2022). Other South Dakota species of concern include the northern hoary bat (*L. cinereus,* scheduled for federal review in 2028 (M. McGrath, USFWS, pers. comm.) which may see population declines of 90% by 2060 if impacts from wind turbines are not mitigated (Frick et al. 2017).

A major challenge in bat conservation in South Dakota is our limited understanding of their habitat needs. Most North American bat research has focused on eastern forests, largely in response to white-nose syndrome, but these findings may not be applicable to other, less-studied ecosystems like grasslands. Such knowledge gaps hinder conservation efforts in the region, making it difficult to guide land management and implement effective protections. Expanding research and monitoring to better understand these species in a grassland system is crucial for their long-term survival.

3. Bats of South Dakota

South Dakota is home to 13 bat species (Table 1), although bat species richness varies across the state (Jones and Genoways 1967, Swier 2003, Tigner and Stukel 2003). Current records indicate that eastern South Dakota hosts six species: northern myotis (*Myotis septentrionalis*), little brown myotis (*M. lucifugus*), northern hoary bat (*Lasiurus cinereus*), *eastern* red bat (*L. borealis*), silver-haired bat (*Lasionycteris noctivagans*), big brown bat (*Eptesicus fuscus*), and evening bat (*Nycticeius humeralis*) (Swier 2006, Bales 2007, Kiesow and Kiesow 2010). The tricolored bat (*Perimyotis subflavus*) may also be present in eastern South Dakota due to its expanding range (Geluso et al. 2005), although this has yet to be confirmed. However, there are several records of tricolored bats in nearby counties in Minnesota, Nebraska, and Iowa (U.S. Fish and Wildlife Service 2024*a*). In central South Dakota, along the Missouri River corridor, bat species richness increases, with western small-footed bat (*M. ciliolabrum*) and possibly tricolored bat reported alongside all the eastern species, although the evening bat has not been confirmed in central South Dakota (Swier 2006, Bales 2007). All 13 bat species occur in western South Dakota (Tigner and Stukel 2003). See Table 2 for bat habitat associations in South Dakota. Appendix A offers brief species accounts and known distributions in the state.

All 13 South Dakota bat species can be found roosting in the state during the summer months. During the winter, bats either move to hibernacula to initiate torpor or they migrate south to warmer climates. Several species, including the northern myotis, little brown myotis, western small-footed bat, fringe-tailed myotis (*M. thysanodes pahasapensis*), long-eared myotis (*M. evotis*), long-legged myotis (*M. volans*), tricolored bat, big brown bat, and Townsend's big-eared bat (*Corynorhinus townsendii*) are known hibernating species and have been recorded hibernating in the Black Hills National Forest (Tigner and Stukel 2003, Geluso et al. 2005). However, the overwintering habitats of *Myotis spp*. along the Missouri River and in eastern South Dakota remain unknown. It has been speculated these bats travel from the Missouri River to the Black Hills National Forest via other riparian corridors to hibernate. Alternatively, a recent study documented several northern myotis overwintering in bluffs along the Missouri River in northeastern Nebraska (White et al. 2020). Migratory bats in South Dakota include the northern hoary bat, eastern red bat, and silver-haired bat, all of which are tree-dwelling species. These species typically travel south during fall, although the silver-haired bat has been observed hibernating in South Dakota (S. Kempema, USFWS, pers. comm.; Tigner 2004) and Colorado (Bonewell et al. 2017). The big brown bat commonly hibernates across the state, using buildings and human-made structures as well as caves and mines (Tigner and Stukel 2003). The winter status of the evening bat and its overall distribution in South Dakota remains poorly understood (Lane et al. 2003).

Species Status

Table 1. Conservation status as of 2025 for bat species known to occur in South Dakota. **Federal Status** refers to designations under the U.S. Endangered Species Act (U.S. Fish and Wildlife Service, 2025). **State Status** and **SD SGCN Criterion** reflect state status and criteria as designated by South Dakota Game, Fish and Parks (2025). **Midwest RSGCN Concern Levels** indicate concern levels for Regional Species of Greatest Conservation Need from the Midwest Landscape Initiative (2025). **Global Rank** and **State Rank** follow NatureServe's conservation status rankings (NatureServe, 2025).

Common Name	Scientific Name	Federal Status[a]	SD SGCN Criterion[b]	Midwest RSGCN Concern Levels[c]	Global Rank[d]	State Rank[d]
Townsend's big-eared bat	*Corynorhinus townsendii*		3e		G4	S2
Big brown bat	*Eptesicus fuscus*				G5	S5
Eastern red bat	*Lasiurus borealis*		3e	High	G3	S3
Northern hoary bat	*Lasiurus cinereus*		3e	High	G3	S3
Silver-haired bat	*Lasionycteris noctivagans*		3e	Moderate	G3	S3
Western small-footed myotis	*Myotis ciliolabrum*				G5	S5
Long-eared myotis	*Myotis evotis*		2b		G5	S1
Little brown myotis	*Myotis lucifugus*	UR	3e	Very High	G3	S3
Northern myotis*	*Myotis septentrionalis*	E	1	Very High	G2	S2
Fringe-tailed myotis**	*Myotis thysanodes pahasapensis*		2a	High	G4T3	S2
Long-legged myotis	*Myotis volans*		3e		G4	S4
Evening bat	*Nycticeius humeralis*				G5	S1
Tricolored bat	*Perimyotis subflavus*	PE	3e	Very High	G3	SNR

*Also commonly called northern long-eared bat (Integrated Taxonomic Information System 2025).
**The common name for the species-level taxon (*Myotis thysanodes*) is fringed myotis (Integrated Taxonomic Information System 2025). Authors reference the species-level taxon throughout the rest of this document.
[a]**Federal Status:** federal listing as designated by the U.S. Fish and Wildlife Service (2025*a*).
E = Endangered, a species in danger of extinction throughout all or a significant portion of its range; T = Threatened, a species likely to become endangered in the foreseeable future throughout all or a significant portion of its range; C = Candidate for federal listing; PE = Proposed Endangered; UR = Under Review.
[b]**SD SGCN Criterion:** criteria informing state listing as defined by South Dakota Game, Fish and Parks (2025) in the Species of greatest conservation need list for South Dakota Wildlife Action Plan Revision of 2025.
1 = State or federally listed species for which the state has a mandate for recovery (listed as threatened or endangered)
2a = Species that are regionally or globally imperiled*** and for which South Dakota represents an important portion of their remaining range
2b = Species that are regionally or globally secure*** and for which South Dakota represents an important portion of their remaining range; or
3a-3h = Species with characteristics that make them vulnerable, including any of the following:
- 3a = are indicative of or depend on a unique or declining habitat or resource in South Dakota
- 3b = require large home ranges/use multiple habitat
- 3c = depend on large habitat patch sizes
- 3d = depend on an ecological process (such as fire) that no longer operates within the historical range of variation

3e = are limited in their ability to recover on their own due to low dispersal ability or low reproductive rates
3f = have a highly localized or restricted distribution (endemics)
3g = concentrate their populations during some time of the year
3h = have significant information or data needs

***Based, in part, on NatureServe conservation status ranking

[c]**Midwest RSGCN Concern Levels:** regional concern levels as designated in the Midwest Regional Species of Greatest Conservation Need Airtable (Midwest Landscape Initiative 2025), definitions provided by Terwilliger Consulting, Inc., and Midwest Landscape Initiative (2021).

Very High Concern = Highly imperiled and urgent conservation action is required to recover populations to sustainable levels. Species must have had at least one of the following: a G-Rank of G1, an average S-Rank less than or equal to S1, be federally listed as endangered, or listed as Critically Endangered on the IUCN Red List.

High Concern = Species has clearly documented declines and that would benefit from coordinated conservation action. Species must have at least one of the following: a G-Rank of G2, an average S-Rank in the region between 1 and 2, be federally listed as threatened, or listed as Endangered on the IUCN Red List.

Moderate Concern = Species would benefit from region-wide monitoring and coordination. Species must have at least one of the following: an average S-Rank in the region between 2 and 3, be state-listed in any Midwest Association of Fish and Wildlife Agencies (MAFWA) state, or listed as Vulnerable on the IUCN Red List.

[d]**Global/State Rank:** conservation statuses applied range wide for global rank (NatureServe 2025) and statewide for state rank (South Dakota Game, Fish and Parks 2025).

G1 S1 = Critically imperiled because of extreme rarity (5 or fewer occurrences or very few remaining individuals or acres) or because of some factor(s) making it especially vulnerable to extinction.

G2 S2 = Imperiled because of rarity (6 to 20 occurrences or few remaining individuals or acres) or because of some factor(s) making it very vulnerable to extinction throughout its range.

G3 S3 = Either very rare and local throughout its range or found locally (even abundantly at some of its locations) in a restricted range, or vulnerable to extinction throughout its range because of other factors; in the range of 21 of 100 occurrences.

G4 S4 = Apparently secure, though it may be quite rare in parts of its range, especially at the periphery. Cause for long term concern.

G5 S5 = Demonstrably secure, though it may be quite rare in parts of its range, especially at the periphery.

GNR SNR = Unranked - National or subnational conservation status not yet assessed.

T# = Infraspecific Taxon (trinomial) - the status of infraspecific taxa (subspecies or varieties) are indicated by a T-rank following the species' global rank. Rules for assigning T-ranks follow the same principles as G- and S-ranks.

Habitat Associations

Table 2. Bat species known to occur in South Dakota as of 2025 and their respective residency, habitat associations, and seasonal roost types as currently understood for South Dakota. **Natural Habitats** and **Anthropogenic Habitats** classify habitat types as either naturally occurring or heavily influenced by humans, respectively. Bats use a variety of roosts that shift seasonally to support different activities, including maternity roosting, daily use, and hibernation. **Roosts – Summer** and **Roosts – Winter** indicate seasonal use of different roost structures by South Dakota bat species.

Common Name	Scientific Name	Residency	Natural Habitats[a]				Anthropogenic Habitats[b]			Roosts – Summer[c]						Roosts – Winter[c]	
			Forest	Riparian	Caves and Karst	Grassland	Mines	Developed	Silviculture or Orchard	Caves and Mines	Human-made Structures	Foliage	Bark	Cavities	Crevices	Caves and Mines	Human-made Structures
Townsend's big-eared bat	*Corynorhinus townsendii*	Year-Round	X	X	X		X			X	X[d]			X[d]		X	
Big brown bat	*Eptesicus fuscus*	Year-Round	X	X	X	X	X	X	X	X	X		X	X	X	X	X
Eastern red bat	*Lasiurus borealis*	Summer	X	X		X		X	X		X[d]	X	X				
Northern hoary bat	*Lasiurus cinereus*	Summer	X	X		X		X	X		X[d]	X	X				
Silver-haired bat	*Lasionycteris noctivagans*	Summer	X	X	X	X	X	X	X	X	X		X	X	X	X	X[d]
Western small-footed myotis	*Myotis ciliolabrum*	Year-Round	X	X	X	X	X	X[d]	X	X	X		X	X	X	X	
Long-eared myotis	*Myotis evotis*	Year-Round	X	X	X		X	X[d]		X	X[d]		X	X	X	X	
Little brown myotis	*Myotis lucifugus*	Year-Round	X	X	X	X	X	X	X	X	X		X	X	X	X	X[d]
Northern myotis	*Myotis septentrionalis*	Year-Round	X	X	X	X	X	X[d]	X[d]		X[d]		X	X	X	X	X[d]
Fringed myotis	*Myotis thysanodes*	Year-Round	X	X	X		X	X[d]		X	X[d]		X	X	X	X	X[d]
Long-legged myotis	*Myotis volans*	Year-Round	X	X	X	X[d]	X	X[d]			X[d]		X	X	X	X	
Evening bat	*Nycticeius humeralis*	Summer	X	X				X	X		X[d]		X	X	X		
Tricolored bat	*Perimyotis subflavus*	Year-Round	X	X	X		X	X[d]	X[d]	X	X[d]	X	X		X	X	

[a]**Natural Habitats**: habitats where species naturally occur that are not created or heavily influenced by human activities (Terwilliger Consulting, Inc., and Midwest Landscape Initiative 2021).
Forest = areas dominated by woody vegetation greater than five meters in height, generally with distinct canopy (generally at least 25% closed) and understory layers.
Riparian = areas with a narrow zone of vegetation directly associated with streams, rivers, ponds, lakes, and other aquatic features.

Caves and Karst = Karst is a distinctive subterrain topography formed by a soluble bedrock, such as limestone, slowly dissolved over time by the movement of water. This process can result in the formation of sinkholes, springs, and caves. A cave is any large, naturally occurring cavity formed underground or in the face of a cliff or hillside.
Grasslands = areas dominated by grasses, sedges, and other herbaceous vegetation, usually more than 80% of the total land cover.
[b]**Anthropogenic Habitats**: habitats created or heavily influenced by human activities (Terwilliger Consulting, Inc., and Midwest Landscape Initiative 2021).
Mines = locations where humans extract minerals or other geological materials from deposits in the ground.
Developed = areas heavily used and impacted by human activity; may contain some vegetation. These areas are generally dominated by constructed materials such as buildings or roads. Impervious surfaces account for more than 20% of the total area.
Silviculture or Orchard = agricultural features comprised of a majority of woody vegetation, including orchards, vineyards, and tree plantations.
[c]**Roosts – Summer/Winter:** Known seasonal use (summer and winter) of different roost structures for bat species in South Dakota.
Caves = any large, naturally occurring cavity formed underground or in the face of a cliff or hillside.
Mines = locations where humans extract valuable minerals or other geological materials from deposits in the ground.
Human-made Structures = Structures created by humans that provide roosting habitat for bats. These structures include buildings, bridges, dams, culverts, and artificial roosts such as bat boxes.
Foliage = the leaves, stems, and branches of trees that form the tree canopy.
Bark = the outermost layer of a tree trunk that is sloughing or exfoliating.
Cavities = small openings in tree trunks.
Crevices = small openings or cracks in rocky outcrops, steep banks, or cliff faces.
[d]Based on observations from other regions. South Dakota specific information is lacking.

4. Conservation Challenges for South Dakota Bats

4.1 White-Nose Syndrome

The rapidly spreading fungal pathogen *Pseudogymnoascus destructans* (*Pd*) poses a significant threat to bat populations in North America as the causative agent of white-nose syndrome, a disease that is decimating many hibernating species (Cheng et al. 2021). In contrast to Eurasian bats that have co-evolved with *Pd*, North American bats, particularly those in the genus *Myotis*, are highly susceptible to infection (Wibbelt et al. 2010). The spread of *Pd* has resulted in mass die-off events and the collapse of entire bat colonies in Indiana, Missouri, Kentucky, Michigan, and Wisconsin. It has caused over 95% population declines in northern myotis (*Myotis septentrionalis*), little brown myotis (*M. lucifugus*), and the tricolored bat (*Perimyotis subflavus*) (Cheng et al. 2021, Udell et al. 2022). Indiana bat (*M. sodalis*) hibernacula study sites have also documented localized declines due to white-nose syndrome symptoms (Pettit and O'Keefe 2017). Although white-nose syndrome primarily affects *Myotis* species, several other bats including big brown bat (*Eptesicus fuscus*) and silver-haired bat (*Lasionycteris noctivagans*), have tested positive for *Pd* but exhibit milder symptoms or remain asymptomatic (Bachen et al. 2018). Townsend's big-eared bats (*Corynorhinus townsendii*) have also tested positive but typically show no apparent symptoms of white-nose syndrome yet may still serve as a vector for the fungal pathogen (Bachen et al. 2018).

First detected in upstate New York near Albany in 2006 (Frick et al. 2010*a*, Lorch et al. 2016), the fungus spread westward and was identified in Jewel Cave National Monument and Badlands National Park, South Dakota in May 2018 (Abernathy and Whittle 2024). Since then, white-nose syndrome has also been documented in bat species which roost and travel along the Missouri River corridor in South Dakota (Kiesow and Kiesow 2010, White et al. 2020). The fungus thrives on the cool bodies of hibernating bats, penetrating the epidermis and dermis and causing sores and open wounds. This fungal growth awakens hibernating bats, leading to the depletion of energy reserves and contributing to increased mortality (Powers 2016). The rapid spread and high mortality rate make it one of the most severe wildlife diseases in recent history (Cryan et al. 2010). By 2012, it was estimated that roughly 5.7 to 6.7 million bats had died due to white-nose syndrome (U.S. Fish and Wildlife Service 2012), though current mortality numbers are likely much higher (Fuller et al. 2020). Monitoring known bat populations for signs of white-nose syndrome and mitigating the spread of *Pd* is crucial for preserving bat biodiversity and ensuring continued persistence of impacted bats in South Dakota.

Management Strategies

While experimental treatments, such as fungicides, vaccines, and investigations into beneficial cave-dwelling bacteria are being explored as potential mitigation strategies for white-nose syndrome (Cheng et al. 2021, Hoyt et al. 2021), preventative measures remain the most effective method for limiting the spread of white-nose syndrome and reducing its impact on South Dakota bat populations (White-Nose Syndrome Disease Management Working Group 2024).

- **Strategy 4.1.1 – Decontaminate all equipment in between study sites that is in direct contact with bats including survey, measurement, and personal equipment.** See the National White-Nose Syndrome Decontamination Protocol for specific methods**.** Before sanitizing, **remove dirt, mud, and other debris** as physical debris reduces the efficacy of decontamination methods (White-Nose Syndrome Disease Management Working Group 2024).
- **Strategy 4.1.2 – Restrict human excursions year-round into known hibernacula to prevent the introduction or transmission of *Pd*.** Implementing caving restrictions on unaffected cave or mine sites can mitigate the spread of *Pd* and protect bat hibernation sites. Posting informative signage at publicly known caves and mines to raise awareness about the severity of white-nose syndrome and its impact on North American bat populations to encourage voluntary compliance with access restrictions (Perry 2013, U.S. Fish and Wildlife Service 2025*b*). Additionally, the gating of hibernation sites may also discourage the spread of *Pd* to unaffected areas (White-Nose Syndrome Disease Management Working Group 2024).
- **Strategy 4.1.3 – Monitor for *Pd* in known hibernation sites** to track white-nose syndrome presence and help inform status of resident bat populations (Janicki et al. 2015, White-Nose Syndrome Disease Management Working Group 2024). Winter hibernacula surveys should be conducted cautiously to minimize disturbance and avoid stressing hibernating bats (Whiting et al. 2024). See section 7.3 for Monitoring Guidelines and Applications for more information.
- **Strategy 4.1.4 – Conduct early-spring monitoring on bats coming out of torpor to monitor for white-nose syndrome. During summer surveillance, check bats for signs of current or past *Pd*** by checking for scarring on the wings, flaking of the skin, abrasions, or using UV lights (Maxell et al. 2015, U.S. Geological Sciences National Wildlife Health Center 2023). See section 7.3 for Monitoring Guidelines and Applications for more information.
- **Strategy 4.1.5 – Use passive monitoring to detect the presence of *Pd*.** DNA analysis of guano samples, and environmental swabs (outside of the hibernation season) can be used to detect the presence of *Pd* (Urbina et al. 2020). Winter acoustic surveillance near known hibernacula can be used to monitor for arousal events which may be an indication of white-nose syndrome (Maxell et al. 2015, U.S. Geological Sciences National Wildlife Health Center 2023).
- **Strategy 4.1.6 – Monitor cave microclimates to understand the stable temperature and humidity conditions that support bat species with specific roosting requirements.** Bat species will select caves with specific microclimate conditions that help minimize energy expenditure and water loss during hibernation (Perry 2013). Understanding these microclimates allows researchers and land management agencies to identify vital hibernation locations and ensure they are preserved to meet the ecological needs of bat populations. Studies examining the environmental conditions of hibernation sites have demonstrated that these microclimates factor

significantly in both virulence and severity of white-nose syndrome outbreaks (Verant et al. 2012).

- **Strategy 4.1.7 – Improve foraging and drinking habitat quality surrounding known and potential hibernacula areas.** Bats in better body condition and with higher fat stores entering into torpor are more likely to survive hibernation if infected with *Pd*. (Jonasson and Willis 2011, Reeder et al. 2012, Cheng et al. 2021).
- **Strategy 4.1.8 – Provide resources to educate the public about white-nose syndrome and the ecological importance of bats** to encourage voluntary protection of hibernacula (Hoffmaster et al. 2016). Extend outreach and survey efforts to local landowners as some hibernacula and/or roosts may be located on private lands.
- **Strategy 4.1.9 – Explore the role and increase understanding of resistance traits in increasing bat resilience to white-nose syndrome**. Recent studies have identified genetic factors and skin microbiome compositions that may confer resilience to white-nose syndrome in certain bat species (Ange-Stark et al. 2023).
- **Strategy 4.1.10 – Explore experimental efforts to mitigate the impacts of white-nose syndrome in afflicted species** (Rocke et al. 2019). In controlled studies, the little brown myotis immunized with a vaccine demonstrated lower fungal loads and higher survival rates compared to the unvaccinated controls (Rocke et al. 2019). Trials in the field have also demonstrated that vaccination may be reducing levels of white-nose syndrome infections (U.S. Fish and Wildlife Service 2024). Vaccinations could be a viable tool to mitigate the impact that white-nose syndrome has on vulnerable bat species.

4.2 Wind Energy

In South Dakota, wind energy plays a major role in power generation, producing 55% of the state's energy (U.S. Energy Information Administration 2024). As of 2022, South Dakota wind energy facilities generated 3,462 megawatts (MW) of energy, with an additional 454 MW planned for construction, primarily concentrated east of the Missouri River (U.S. Energy Information Administration 2024). While wind energy is a rapidly growing industry alternative to combat greenhouse gas emissions from other energy sources, it presents a "green on green dilemma" with negative impacts on volant species and is an unsustainable additive source of mortality for some bat populations, contributing to population declines (Frick et al. 2017, Voigt et al. 2024). Wind turbines impact bat populations directly through mortality due to collisions with turbines and barotrauma (i.e., internal organ damage, particularly the lungs and other air-filled organs, caused by a rapid change in air pressure) (Baerwald et al. 2008). Barotrauma has been observed in bats flying near operating wind turbines, where sudden pressure drops around the moving blades leads to fatal internal hemorrhage without any external signs of trauma (Baerwald et al. 2008). The direct effects of wind energy development are compounded by indirect impacts such as habitat loss, fragmentation, and the disturbance of tree roosts (Lacki 2018, Allison et al. 2019).

While many bat species are susceptible to negative impacts from wind turbines, the eastern red bat (*Lasiurus borealis*), northern hoary bat (*L. cinereus*), and silver-haired bat (*Lasionycteris noctivagans*) appear the most impacted (Allison et al. 2019). It is thought that migratory bat species are particularly impacted as they traverse long distances between summer and winter habitats, bringing them into increased contact with wind turbines (Wieringa et al. 2024). Mortalities for migratory species primarily occur during spring and fall migration, although mortalities are greatest in the fall for unknown reasons (Arnett et al. 2016).

Wind energy development also alters habitat quality, affecting the availability of vegetation for roosting and foraging resources on the landscape (Fernández-Bellon et al. 2019). This can negatively impact migratory species during their intensive migration windows by removing and altering the quality of stopover resources (Peste et al. 2015, Bennett and Hale 2018). Wind energy development can result in the removal of tree roosts or alter forested areas that are used by maternity colonies and can disrupt caves and mine roosts by altering the temperature and humidity within the cave sites (National Research Council 2007). Furthermore, wind development near riparian corridors can cause fragmentation and disrupt movement patterns (Fargione et al. 2012). Wind energy development may compound threats to already imperiled species such as the northern myotis which faces additional threats from white-nose syndrome (Udell et al. 2022, Adams et al. 2024). The installation of wind turbines near a known hibernacula or maternity roost, especially for *Myotis* spp., would elicit added pressure to already threatened and endangered species (Gaultier et al. 2023), further complicating conservation and management actions targeting its recovery.

Management Strategies

Wind energy development can negatively affect bats through both direct mortality and habitat loss. The following mitigation strategies, including careful turbine sitting, deployment of deterrent technologies, and operational curtailment methods, can help reduce these negative impacts on declining bat populations.

- **Strategy 4.2.1 – Conduct pre-construction bat surveys at wind energy sites** to assess activity levels, identify roost presence, minimize mortality, conduct clearance surveys for threatened and endangered species, and inform project siting. Scouting of wind farm sites is also vital, with priority attention given to avoiding areas near forests, forested ridges, water sources, or known bat roosts (Arnett et al. 2008, U.S. Fish and Wildlife Service 2012).
- **Strategy 4.2.2 – Monitor post-construction bat mortality at wind energy sites** to evaluate species-specific impacts and ensure compliance with the Endangered Species Act. Implement standardized monitoring protocols to quantify bat mortality, identify species affected, and evaluate the effectiveness of mitigation strategies (Arnett et al. 2008, U.S. Fish and Wildlife Service 2012).
- **Strategy 4.2.3 – Incorporate prior data to identify habitat features to help guide turbine siting and protect critical habitat.** Given the limited availability of detailed migratory data, focusing on habitat features offers a more practical strategy when data

is lacking. Early integration of bat habitat use data in turbine site planning to identify and avoid sitting turbines in areas of potential importance to bat populations can help mitigate negative impacts to bat populations (Arnett et al. 2008, Cryan and Barclay 2009).

- **Strategy 4.2.4 – Evaluate and implement deterrent technologies to reduce bat collisions.** Acoustic and ultrasonic deterrents interfere with echolocation to discourage bats from approaching turbines (Arnett et al. 2013, Weaver et al. 2020), ultraviolet lighting and blade patterning or decals may increase turbine visibility and disrupt attraction (Gorresen et al., 2015; Weaver et al., 2020).
- **Strategy 4.2.5 – Implement operational curtailment at low wind speeds** to reduce bat fatalities during high-risk periods. Temporarily shutting down turbines at low wind speeds (typically ≤ 6.5 m/s) and establishing cut-in speeds (the wind speed at which turbine blades begin to spin) between 5–6.9 m/s can significantly reduce bat fatalities by 40-91% (Hayes et al. 2019).
- **Strategy 4.2.6 – Adjust turbine operations to keep blades idle or reduce blade rotation speeds at night** to mitigate bat mortality. Fatalities occur most frequently at night under low wind conditions and moderate temperatures (Arnett et al. 2008, Cryan and Barclay 2009).
- **Strategy 4.2.7 – Apply curtailment during high-risk weather conditions and peak bat migration seasons to reduce fatalities when bats are most active.** Curtailment strategies focused on high-risk conditions during peak migration between late summer and early fall have been shown to reduce fatalities in some cases by over 50% (Whitby et al. 2024).
- **Strategy 4.2.8 – Implement "smart curtailment" systems using acoustic detectors and artificial intelligence** to reduce bat fatalities while maintaining energy production. Smart curtailment strategies combine idle mode settings with temporal and environmental settings such as wind speed and temperature to optimize turbine operation with site-specific, adaptive curtailment measures (Hayes et al. 2019, Whitby et al. 2024). Acoustic detectors directly installed onto the turbines can shut off or slow turbines if a bat is detected in real time (Hayes et al. 2019) and the use of machine learning and artificial intelligence can analyze patterns in bat activity across temporal and environmental variables to predict periods of elevated risk and improve curtailment protocols for turbines (National Renewable Energy Laboratory 2024).
- **Strategy 4.2.9 – Install bat boxes or other artificial roost structures in previously disturbed roosting habitats to mitigate for natural roost displacement** (Mering and Chambers 2014)**.** Care should be taken when choosing roost box placement to avoid attracting bats to potential hazard areas (Russo et al. 2024). See Appendix E for more information on bat box installations.
- **Strategy 4.2.10 – Minimize habitat impacts during wind energy installations and restore natural habitats affected during construction** including forests, grasslands, and wetlands to improve foraging conditions, roosting opportunities, and mitigate for development impacts (Cowden et al. 2014, Lacki 2018).

4.3 Habitat Loss, Degradation, and Fragmentation

Habitat loss, fragmentation, and degradation are the leading cause of wildlife population declines globally, and bat populations are no exception (Frick et al., 2020). Bats rely on a diversity of ecosystems and resources throughout the year and at different stages of their life cycle. Losses of any one necessary component (e.g., roosting, breeding, foraging, drinking, migrating, or hibernating sites) can have detrimental impacts on bat populations (Frick et al., 2020; Kunz, 2013). Anthropogenic activities such as deforestation, urban development and expansion, agricultural conversion, wetland draining, riparian alteration and damming, resource extraction, energy production, intensive grazing, fire suppression, and the introduction of invasive species can all affect critical resource availability (Frick et al., 2020). These activities all reduce native vegetation and thus, habitat quality as native vegetation acts as an important environmental buffer (i.e., improves water quality and soil health, sequesters carbon, etc.) as well as providing critical habitat for wildlife.

Other human activities contributing to habitat degradation and potentially impacting bat populations, include water pollution (Korine et al. 2016), the use of pesticides and herbicides (Oliveira et al. 2020), light pollution (Stone et al. 2015), cave vandalism (Furey and Racey 2016), improper mine closures (Sherwin et al. 2009), and improper exclusion of bats from structures (Voigt et al. 2016) (see Appendix E for details). Many actions that contribute to habitat loss and degradation can indirectly impact bats further by altering insect prey community composition and abundance. In turn, this may limit bats' ability to build suitable fat stores prior to hibernation or migration, impacting survival of these bats (McGuire et al. 2012, 2013, Frick et al. 2016). Where bats also face threats from white-nose syndrome, access to high quality habitat and forage resources may be critical as bats entering hibernation in better body condition have better chances of surviving white-nose syndrome through the winter (Frick et al., 2016).

Fragmentation can exacerbate the impacts of habitat loss and degradation by increasing travel distances among foraging grounds and other critical resources. Such fragmentation can, in turn, result in increased energy expenditures, exposure to risk, or otherwise constrain bats to small habitat patches where they may face limited resource availability, quality, or increased competition for resources (Fuentes-Montemayor et al. 2013, Segers and Broders 2014). Migratory bats appear to be particularly impacted by fragmentation along their long-distance migratory corridors as they often use linear features, such as forest edges and river corridors, to navigate the landscape (Kunz 1982*a*, Campbell et al. 2024). Many species exhibit strong roost site fidelity, and the loss of these navigational aids and the presence of barriers can lead to reduced orientation efficiency, elevated energetic costs, and increased mortality during migration (Claireau et al. 2019, Lagerveld et al. 2024). Fragmentation may limit access to critical foraging habitats and freshwater sources (Segers and Broders 2014), resulting in poorer body condition. Because migratory bats depend on stopover sites to rest, feed, and rehydrate, the loss of such habitats exacerbates the physiological demands of migration. Furthermore, both migratory and non-migratory bats face collision risks with human-made structures such as buildings and wind turbines, which not only serve as physical barriers but also represent a significant and direct source of bat mortality (Frick et al., 2017).

Management Strategies

Land development and resource management will continue to take place across bat habitats. However, natural resource management and bat conservation can work in tandem by identifying and managing critical resources and landscapes and implementing BMPs, such as preserving buffers of vegetation around roosting, hibernating, and foraging sites (discussed in section 5 – Priority Habitats). The following recommendations provide broad guidance for facilitating human-bat coexistence under different landscape contexts.

- **Strategy 4.3.1 – Conduct surveys prior to implementing larger-scale projects** that could alter the availability of important resources for bats (e.g., roosting trees, hibernacula, water) (Kunz and Fenton 2006, Katzner et al. 2016). Avoid removing or degrading important features for bats (i.e., old-growth trees and snags, riparian corridors, wetlands, rocky features, caves, and mines). This is particularly critical where sensitive bat species may be present (U.S. Fish and Wildlife Service 2024*b*).
- **Strategy 4.3.2 – Manage foraging and roosting areas by maintaining heterogeneous landscapes and landscape connectivity**, particularly along migratory corridors and where wide-ranging or sensitive species are present (Frey-Ehrenbold et al. 2013, Fuentes-Montemayor et al. 2013, Heim et al. 2015).
- **Strategy 4.3.3 – Manage for and restore native plant diversity including a diversity of forbs and grasses** to sustain an abundant and diverse insect prey community (Mata et al. 2021). Manage for diverse, native tree assemblages of mixed ages and species to promote a diversity of roosting features for different bat species (Drake et al. 2020).
- **Strategy 4.3.4 – Restore natural hydrology** by removing or modifying human-made barriers such as dams and diversions, reduce stream channelization, promote natural flow regimes (i.e. periods of flooding and drawback) and remove invasive species (Scott et al. 1997, Hester and Grenier 2005, Ober and Hayes 2008*a*, South Dakota Department of Game, Fish and Parks 2014).
- **Strategy 4.3.5 – Reduce point and non-point source pollution into the environment** to improve drinking resources, insect populations, and overall ecosystem and watershed health (Korine et al. 2016, Adams and Hayes 2021)**.** Limit herbicide and pesticide use to avoid harmful chemical buildup in bats (Hester and Grenier 2005, Radcliffe et al. 2009, Oliveira et al. 2020).
- **Strategy 4.3.6 – Restrict disturbance in tiered buffers around summer roosts, maternity colonies, hibernacula, and critical habitats** such as riparian corridors, caves, mature forests, and wetlands to minimize disturbance to bat populations (Pierson 1998, Hester and Grenier 2005, Clark and Reeder 2007, Taylor et al. 2020, U.S. Fish and Wildlife Service 2024*b*). Specific species and habitat features require varying buffer sizes, see section 5 – Priority Habitats for more details.

- **Strategy 4.3.7 – Install artificial roosting features such as properly installed bat houses and bridge boxes (see Appendix E)** on managed and urban lands to provide a diversity of roosting options for bats (Arias et al. 2020, Crawford and O'Keefe 2024).
- **Strategy 4.3.8 – Work with land managers, agencies, and the public to raise bat conservation awareness and improve and restore habitat features** that are important for bat populations such as limiting pesticide use, promoting native plants that attract nocturnal insects, and providing stable water sources such as livestock tanks with escape ladders (Hester and Grenier 2005, Taylor and Tuttle 2012, Hoffmaster et al. 2016).
- **Strategy 4.3.9 – Work with land managers to time development or resource extraction projects** (i.e. avoid the maternity or hibernation season) to limit impacts on bat populations (U.S. Fish and Wildlife Service 2012, 2024*b*).

4.4 Climate Change

In South Dakota, climate change is driving environmental shifts, including an increase in drought, heat waves, flooding, and milder winters (Adams 2010, South Dakota Department of Game, Fish and Parks 2014, Timberlake et al. 2021). Such changes are altering species distributions and the availability and timing of critical resources (Frick et al. 2012, Adams et al. 2018, Festa et al. 2023). However, many of the long-term impacts of climate change on South Dakota's wildlife and habitats remain uncertain (South Dakota Department of Game, Fish and Parks 2014). While advancements in data collection, inter-agency collaboration, and ecological modeling have improved our understanding and predictive capabilities surrounding the impacts of climate change, considerable knowledge gaps persist, particularly for lesser-studied and sensitive taxa such as bats (South Dakota Department of Game, Fish and Parks 2014). Continued monitoring of bat populations is essential to detect trends and assess their responses to changing climatic variables. Strengthening communication and collaboration across agencies will also be critical to integrating diverse data sources and effectively managing bat populations in a changing climate.

Certain changes to South Dakota's climate are more likely to adversely affect bat populations. Prolonged, high-severity droughts and increasing temperatures threaten the quality and persistence of naturally occurring streamways and river run offs (Barth and Sando 2024) and overall soil moisture (Morgan et al. 2008). Severe droughts have also been known to affect the timing of nightly bat emergence with bats emerging earlier in years with less moisture (Frick et al. 2012). Water features are particularly important to several bat species, including the little brown myotis (*Myotis lucifugus*) and northern myotis (*M. septentrionalis*), which often select roosting sites near water sources like open wetlands and flooded forested areas (Nelson and Gillam 2017, Burrell and Bergeson 2022). Bat prey, such as aquatic insects and macroinvertebrates, can be highly sensitive to changes in air and water temperature, water quality, and water availability (Stone et al. 2005). The decline of insects like mayflies, caddisflies, and midges can significantly affect bat populations that depend on the seasonal emergence of these insect species (Buchler 1976, Jacobus et al. 2019).

Climate change also impacts plant communities that bats and their invertebrate prey depend on. Oak (*Quercus* spp.), box elder (*Acer negundo*), green ash (*Fraxinus pennsylvanica*), cottonwood (*Populus deltoides*), aspen (*Populus* spp.), and ponderosa pine (*Pinus ponderosa*) provide critical roost resources for bats yet are threatened by drought, changing precipitation patterns, and altered hydrology associated with climatic change (Swanston et al. 2018). Increasing frequency in extreme weather events such as flooding can alter plant communities and could disturb native floodplain species such as cottonwoods (Conant et al. 2018, Barth and Sando 2024). Decreased snowpack and associated drought can increase wildfire risk in coniferous forests of western South Dakota and may result in future species composition shifts (South Dakota Department of Game, Fish and Parks 2014, Timberlake et al. 2021). Increasing temperatures will also impact the distribution of warm and cool season mixedgrass prairies across the Great Plains (South Dakota Department of Game, Fish and Parks 2014). These rising temperatures have also favored several invasive plant species that alter South Dakota habitats including smooth brome (*Bromus inermis*), Kentucky bluegrass (*Poa pratensis*), and yellow sweet clover (*Melilotus officinalis*) (Amberg et al. 2012, Palit et al. 2021, Palit and DeKeyser 2022). Habitat shifts towards monocultures of invasive species can alter insect assemblages (Palit and DeKeyser 2022) and impact bat foraging habitat. Climatic warming can also increase the frequency of plant pest outbreaks, such as bark beetles, which further increase fuel loads and degrade forest habitat (Jenkins et al. 2008). However, snags created from beetle outbreaks could potentially provide habitat for several bat species (Mehr et al. 2012, Kortmann et al. 2018).

Shifting environmental conditions can affect both migratory and hibernating bat species (Adams et al. 2024). For migratory species, climate change may shift the timing of migration events (Haest et al. 2021). Habitat shifts may impact the stop-over foraging and roosting sites used during migration which may change migration paths (Festa et al. 2023). For hibernating species, earlier spring warming results in earlier arousal from hibernation (Czenze and Willis 2015), which may lead to phenological mismatches between bat activity and insect nymph emergences (Damien and Tougeron 2019). Increased exposure to adverse weather events, such as droughts, can also impact the availability of insect prey and reduce bat foraging success (Meyer et al. 2016). *Myotis* spp., being smaller-bodied, face increased mortality from shorter hibernation bouts, as frequent arousals deplete fat and water stores (Reeder et al. 2012, Moore et al. 2013). For example, little brown myotis affected by white-nose syndrome show accelerated fat loss during hibernation, resulting in higher mortality (Reeder et al. 2012). Warmer temperatures also impact roosts and hibernacula in cave ecosystems, particularly through disruption of temperature traps where temperatures in certain cave areas remain relatively stable compared to the entrance and surface environment (Perry 2013). These areas can either retain warm or cool air depending on their location, airflow, and cave structure (Medina et al. 2023) and provide important microclimate variation for bat species during different stages of their life history.

Rising temperatures can lead to increased degradation of delicate areas within caves and mines (Pryor et al. 2014).

Management Strategies

Climate change has been identified as one of the biggest threats to North American bat species (Adams et al. 2024). Climatic conditions in South Dakota have also been shifting including decreased annual snowpack, increased precipitation, and increased extreme weather events (Timberlake et al. 2021). The following strategies can mitigate the impacts of a changing and uncertain climate on bat populations in South Dakota. More detailed and targeted management practices are outlined in section 5 – Priority Habitats.

- **Strategy 4.4.1 – Improve cross agency collaboration and communication to leverage information sources regarding impacts of climate on factors likely to impact bat species**. Use data to improve modeling efforts and better predict the impacts of future climate change on bat populations and their critical habitats (South Dakota Department of Game, Fish and Parks 2014, Marolla et al. 2021, Festa et al. 2023).
- **Strategy 4.4.2 – Regularly monitor bat colonies to detect shifts in species distribution, abundance, and composition**. Long-term datasets are important for monitoring and detecting shifts in bat populations to assess conservation needs and evaluate the effects of climate change (Meyer 2015, Festa et al. 2023). See section 7.3 for Monitoring Guidelines and Applications for more information.
- **Strategy 4.4.3 – Monitor suitable habitats and watersheds to assess how bat populations respond to environmental change**. These areas can provide critical resources, particularly during disturbances such as droughts or habitat fragmentation. The implementation of a systematic monitoring plan in these areas will allow for better habitat quality assessment (Rowland and Vojta 2013).
- **Strategy 4.4.4 – Protect and restore natural habitats to improve roosting and foraging habitat for bats.** Plant native species that are resilient and adaptable to a variety of environmental and climactic conditions. Maintaining suitable foraging and roosting habitat is critical for bat survival (Jonasson and Willis 2011, Reeder et al. 2012).
- **Strategy 4.4.5 – Enhance and monitor the quality, quantity, and persistence of natural and human-made water sources on the landscape** to improve drinking and foraging opportunities for bats (Hester and Grenier 2005, Navo et al. 2018). Ensure that human-made water features, such as stock tanks and ponds, are usable to bats and devoid of hazards, particularly in arid areas where bat activity may be concentrated around water features. Install wildlife friendly-guzzlers to increase water resources where applicable (Taylor and Tuttle 2012).
- **Strategy 4.4.6 – Restore natural hydrological processes through practicing coexistence with beavers and/or installing beaver dam analogs (BDAs), to improve water retention and enhance bat habitat.** Beaver dams and BDAs help raise water tables, create wetlands, and increase insect populations, thereby increasing foraging

areas for bats. These restoration efforts can contribute to ecosystem resiliency during periods of drought or extreme weather conditions (Pollock et al. 2014).

- **Strategy 4.4.7 – Monitor emergence timing of bats and their prey** to understand the effects of climate change on foraging success, reproductive timing, and phenological mismatches to inform land management and conservation actions that support insect availability (Jones and Cresswell 2010, Festa et al. 2023).
- **Strategy 4.4.8 – Enhance cross-agency and multi-stakeholder collaboration in conservation programs that support climate resiliency and wildlife and habitat conservation.** Work collaboratively to assess the projected impacts of climate change on bat species and their critical habitats, identify regional conservation priorities, and support projects across jurisdictional boundaries to meet species and habitat needs (Reichert et al. 2021, Adams et al. 2024).

4.5 Human Interference (Anthropogenic and Natural Structures)

Human interference is present in anthropogenic structures, which can harm bats through improper exclusion techniques, increased persecution near human activity, and removal of buildings that serve as roosting sites (Chenger 2017). Poorly executed exclusion efforts in barns, attics, or bridges can entrap or displace bats, resulting in mortality events. Sealing entry points during maternity season or without prior inspection can lead to the death of non-volant young (Howard 2009). Similarly, the dismantling or renovation of a building's infrastructure without conducting bat assessment surveys poses a serious threat to roosting colonies (Geiser and Drury 2003, Voigt et al. 2016) and can result in the loss of important roosting habitat (Lausen and Barclay 2006, Howard 2009). Buildings such as barns, attics, abandoned houses, warehouses, and churches can offer suitable shelters due to their stable temperature and distance to nearby foraging areas (Voigt et al. 2016). Yet roosts in these structures often go unnoticed by routine maintenance and are easily overlooked. As a result, well-intentioned repairs and renovations may unintentionally disturb or displace bat colonies, especially during sensitive periods such as maternity season or hibernation.

Trespassing into caves poses serious risk to bats by causing disturbance that leads to energy depletion, roost abandonment, and increased mortality, particularly during hibernation and maternity periods (Moore et al. 2013, Powers 2016, Hoyt et al. 2021). Recreational caving can also increase the spread of white-nose syndrome through the unintentional transport of *Pd* spores on caving equipment, further threatening vulnerable bat populations (Reynolds and Barton 2013). Proper signage on cave gates or perimeter fencing can help reduce these risks by informing the public of ecological sensitivities and white-nose syndrome threats. Explicitly identifying critical sites (e.g., maternity colonies or migratory stopovers) may inadvertently increase vulnerability to disturbance by attracting public attention but increasing signage at publicly known caves can be used to emphasize the importance of the cave ecosystem can raise public awareness without exposing sensitive roost locations (Sheffield et al. 1992, Navo et al. 2018).

Improper exclusions, vandalism, and inadequate regulations for protection can lead to declines in negatively impacted bat colonies, resulting in bat population declines (Ludlow and Gore 2000, Tuttle 2017). Many caves and mines experience external contamination due to littering and graffiti, which can degrade the hibernacula sites (Olson 2017). In caves that are open to the public and shared with roosting bats, common issues include corrosion of copper wiring of cave infrastructure and the accumulation of outside dust and bacteria, which alters the caves internal ecosystem. Additional concerns over human interference are harmful paints used for graffiti tagging on the walls, the creation of holes drilled into the walls for climbing bolts, and the potential for introduction of harmful pollutants such as food wrappers or discarded plastics (Olson 2017). Installing iron gates at commonly used entrances can discourage human disturbance and restrict unauthorized access. These gates are specially designed to protect roosting bats while allowing them to enter and exit freely (White and Seginak 1987). While iron gating has proven effective in protecting cave-reliant species (Tuttle 1977), they should be designed to avoid obstructing bat flight paths (Spanjer and Fenton 2005).

Management Strategies

Human interference can negatively impact bat populations, particularly during sensitive time periods. Through proactive planning, it is possible to support necessary development while conserving natural and anthropogenic structures that bats depend on. The following strategies can mitigate these interferences and protect bats in areas of high human activity. More detailed and targeted management practices are outlined in section 5 – Priority Habitats.

- **Strategy 4.5.1 – Implement outreach and education programs that discuss the ecological roles of bats and the threats they may face.** Public education efforts can reduce negative perceptions and promote interest for bats and other wildlife too. Effective and informative communication will help in generating positive attitudes towards bats that may roost near humans (Knight 2008).
- **Strategy 4.5.2 – Increase citizen science efforts through community bat monitoring programs** (Lundberg et al. 2021). Promote and provide resources for the creation of nocturnal pollinator gardens to increase foraging opportunities for bats in urban areas (Bat Conservation International 2025*a*).
- **Strategy 4.5.3 – Enforce seasonal access restrictions that limit access to critical bat habitats by installing bat-friendly gates at cave and mine entrances where feasible.** Limiting human disturbance, particularly during sensitive periods such as hibernation and maternity season, helps minimize disturbances that can lead to population declines (Thomas 1995, White-Nose Syndrome Disease Management Working Group 2024).
- **Strategy 4.5.4 – Place educational signs at the entrance of publicly known caves and mines to inform visitors about the presence of sensitive bat colonies and the importance of minimizing disturbances.** This form of signage has been demonstrated to enhance public awareness and encourage responsible behavior (Hoffmaster et al. 2016).

- **Strategy 4.5.5 – Promote habitat conservation and restoration to ensure bats have safe roosting and foraging areas.** This includes guidelines for building renovations that protect roosting bats and reduce the risk of improper exclusions from human structures (Vasko et al. 2024).
- **Strategy 4.5.6 – Increase awareness surrounding humane methods and correct timing to exclude bat from houses.** Provide publicly available information, resources, and options for exclusionary methods (South Dakota Bat Working Group 2004)**.** Installation of one-way exit devices allow bats to leave buildings yet prevent them from re-entering and should only implemented outside of the maternity season (Kern 1995, Voigt et al. 2016). See Appendix E on Proper House Exclusion of Bats for more information.

5. Priority Habitats

5.1 Riparian and Aquatic

Habitat Characteristics

South Dakota hosts a diverse hydrological landscape, with an increasingly arid climate in the west transitioning to higher precipitation alongside a dense network of depressional wetlands that characterize the Prairie Pothole region in eastern South Dakota (Conant et al. 2018, Zou et al. 2018). The Missouri River runs North to South, bisecting South Dakota, and is a major riparian corridor connecting multiple watersheds across several states. Several other rivers and streams connect into the Missouri River watershed, with more ephemeral features and flows in the west and more persistent features in the east. Annual cycles of drought and flood add to the dynamic nature of South Dakota's water features, making land and wildlife management challenging (Barth and Sando 2024).

Riparian and other aquatic habitats, including wetlands, lakes, and ponds, are critical for bats and have been found to support higher levels of activity and species diversity compared to upland habitats (Table 3) (Carter 2006, Fukui et al. 2006, Blakey et al. 2017). Water resources are necessary to bats for drinking, foraging, mineral acquisition, and can provide important movement pathways across the landscape as well as roosting opportunities in surrounding habitat (Holloway and Barclay 2000, Adams et al. 2003, Adams and Hayes 2021). Even bats that do not directly roost in or near riparian and aquatic habitats, still use these areas for drinking or foraging (Korine et al. 2016). Riparian vegetation around water resources helps improve water quality (Johnson and Buffler 2022) and provides roosting and foraging resources for bats (Holloway and Barclay 2000).

Riparian and aquatic vegetation vary widely from the montane landscape of the Black Hills National Forest to riparian corridors in the grasslands and prairie potholes (Hoffman 1987, Barth and Sando 2024). However, some species, such as cottonwood (*Populus deltoides*), willow (*Salix* spp.), box elder maple (*Acer negundo*), green ash (*Fraxinus pennsylvanica*), bur oak (*Quercus macrocarpa*), eastern redcedar (*Juniperus virginiana*), dogwood (*Cornus* spp.), chokecherry (*Prunus* spp.), hackberry (*Celtis* spp.), bulrushes (*Scirpus* spp., *Schoenoplectus* spp., *Bolboschoenus* spp.), cattails (*Typha* spp.), sedges (*Carex* spp.), and milkweeds (*Asclepias* spp.), are generally found throughout the state. As are certain invasive species, such as Russian olive (*Elaeagnus angustifolia*), purple loosestrife (*Lythrum salicaria*), salt cedar (*Tamarix ramosissima*), common buckthorn (*Rhamnus cathartica*), smooth brome (*Bromus inermis*), and Canada thistle (*Cirsium arvense*). Higher-elevation species include quaking aspen (*Populus tremuloides*), paper birch (*Betula papyrifera*), and maples (*Acer* spp.) (Hoffman 1987) while low elevation species include a higher diversity of willows, deciduous trees that are largely restricted to riparian corridors, and prairie adapted grasses and forbs.

Riparian Habitat in South Dakota

Healthy riparian areas are structurally diverse, with streams and rivers forming riffles, pools, oxbows, meanders, side channels, undercut banks, and sandbars. This provides diverse niches and vegetation for aquatic insects (Vinson and Hawkins 1998) and foraging opportunities for bats (Ober and Hayes 2008*a*). Beavers may also dam riparian areas, creating wetland complexes with deep pools, further increasing bat foraging and drinking resources (Hooker et al. 2024). In South Dakota, multiple bat species have been caught over beaver constructed ponds, including the endangered northern myotis (*Myotis septentrionalis*) (M. Pendleton, SDSU, pers. comm.). Vertical and horizontal structural diversity of vegetation around riparian areas, wetlands, lakes, and ponds have been shown to be important for bat habitat use (Lundy and Montgomery 2010). Vertical structural diversity can provide roosting opportunities for bats, particularly where advanced-age woodlands and snags persist. Horizontal vegetation structure surrounding riparian areas can increase insect breeding habitat and therefore bat foraging habitat, as well as provide filtration of ground and surface water (Lacki et al. 2007).

The Missouri River Corridor

The Missouri River is an important corridor for bat diversity (Swier 2006, Bales 2007, Kiesow and Kiesow 2010). Retained patches of old-growth floodplain forests and river bluffs along the Missouri provide suitable roosting and foraging habitat for a variety of bat species including sensitive species like northern myotis and little brown myotis (Swier 2006, Bales 2007, Fabianek et al. 2015, Nelson et al. 2015, White et al. 2020).

Other Major Riparian Corridors

Several rivers from western South Dakota, including the White, Cheyenne, Bad, Moreau, Little Missouri, and Grand Rivers, flow eastward, down an elevational gradient, into the Missouri River Basin. In eastern South Dakota, the James, Vermillion, and Big Sioux Rivers flow south, joining the Missouri River near the southeastern corner of South Dakota. Multiple smaller tributaries connect the watersheds across the state and many of the riparian areas are privately owned (Dakota Water Science Center 2017, Conant et al. 2018).

Aquatic Habitats in South Dakota

Other water sources in South Dakota include the depressional wetlands and lakes of the prairie pothole region, montane wetlands, springs, and human-made reservoirs, wetlands, stock ponds, and irrigation canals and ditches (Barth and Sando 2024). Wetlands and lakes comprise a large portion of eastern South Dakota and vary greatly in size, depth, and surrounding vegetation with some water features being surrounded by grasslands and lacking tree cover while others have adjacent shelterbelts or deciduous forests (Doherty et al. 2018).

East River

The Prairie Pothole Region spans 800,000 km^2 of North America and encompasses much of eastern South Dakota. This region is characterized as a grassland landscape with a mosaic of depressional wetlands and lakes that originated from the Glacial Period (Doherty et al. 2018). These water features can be ephemeral or permanent, being fed by the season's snowmelt, precipitation, and ground water. Many of the water features throughout the Prairie Pothole Region are managed by state and federal partners as waterfowl and game production areas, and many are privately owned or enrolled in Conservation or Wetland Reserve Programs (Prairie Pothole Joint Venture 2017).

West River

West of the Missouri River, annual precipitation and the abundance of natural water features decrease. Many of the water features across western South Dakota are ephemeral or human-made and maintained. Stock ponds, tanks, and guzzlers are used to supply water to livestock in arid areas but provide critical water to wildlife as well (Taylor and Tuttle 2012). However, persistent natural wetlands and ponds exist in the high altitudes of the Black Hills National Forest and are scattered across the landscape (Conant et al. 2018).

Human-Made

While human alteration of prairie landscapes has decreased or degraded many natural water sources, state-wide human-made water sources, such as dugout ponds, irrigation ditches, canals, stock ponds and tanks, and even water-filled road ruts, provide water sources for bats in otherwise dry environments (Austin and Buhl 2009, Marshall et al. 2022). While many of these artificial water sources lack vegetative and structural diversity, they may still provide important drinking and foraging opportunities for bats across the landscape (Chung-MacCoubrey 1996). Additionally, human-made structures like beaver dam analogs, which mimic the ecological functions of natural beaver ponds, may enhance habitat quality and support foraging bats (Hooker et al. 2024). Agricultural ditches and open canals are common throughout the state to support agricultural practices. However, these water sources often lack plant and insect diversity, and water quality may be impaired due to proximity to agricultural runoff.

Associated Species

Table 3. South Dakota bat species that use various water features in the state, including: the Missouri River Corridor, the Prairie Pothole Region, West River water resources (riparian corridors, springs, and lakes), and human-made water resources (guzzlers, stock-tanks, stock reservoirs).

		Water Resources			
Common Name	**Scientific Name**	Missouri River	East River	West River	Human-made
Townsend's big-eared bat	*Corynorhinus townsendii*	X		X	X
Big brown bat	*Eptesicus fuscus*	X	X	X	X
Eastern red bat	*Lasiurus borealis*	X	X	X	X
Northern hoary bat	*Lasiurus cinereus*	X	X	X	X
Silver-haired bat	*Lasionycteris noctivagans*	X	X	X	X
Western small-footed myotis	*Myotis ciliolabrum*	X		X	X
Long-eared myotis	*Myotis evotis*			X	X
Little brown myotis	*Myotis lucifugus*	X	X	X	X
Northern myotis	*Myotis septentrionalis*	X	X	X	X
Fringed myotis	*Myotis thysanodes*			X	X
Long-legged myotis	*Myotis volans*			X	X
Evening bat	*Nycticeius humeralis*	X			X
Tricolored bat	*Perimyotis subflavus*	X		X	X

Important Characteristics for Bats

Drinking and Mineral Acquisition

Water features provide essential drinking resources for bats, which have high metabolic rates and lose water through flight, an energetically costly process, and evaporation from their wing membranes (Thomas and Suthers 1972, Kunz 1982*a*, Adams and Hayes 2021). Pregnant and lactating bats may also require more water to meet their energetic demands (Kurta et al. 1989, Nelson and Gillam 2017, Adams and Hayes 2021). In addition to hydration, certain water sources that have high mineral content (referred to as "mineral licks") can provide important calcium and sodium supplementation (Adams et al. 2003). While insects likely provide many of these nutrients for insectivorous bats, individuals with increased energy demands, such as lactating females and developing juveniles, have been shown to seek out mineral licks with these key elements (Adams et al. 2003, Bravo et al. 2010).

Foraging

Water sources provide critical foraging grounds for bats as many insects reproduce in or near water (Kunz 1982*a*). Certain species, such as little brown myotis, tricolored bat, and northern hoary bat frequently forage over open water (Brooks and Ford 2005, Reimer et al. 2010, Nelson and Gillam 2017, Taylor et al. 2020). The presence of upland vegetation surrounding riparian areas can also increase insect abundance and diversity, increasing foraging opportunities for bats (Vinson and Hawkins 1998, Lundy and Montgomery 2010).

However, while vegetative complexity improves habitat quality, some bat species require open spaces for maneuvering while drinking. Excessive overhanging vegetation, algal growth, or other obstructions can limit access to water for some species. Many bats also tend to prefer foraging over slower, calmer waters, possibly to minimize echolocation interference or reduce predation risks (Rydell et al. 1999, Lundy and Montgomery 2010).

Roosting

River bluffs, old-growth trees along floodplains, and upland vegetation around riparian and aquatic habitats provide critical roosting habitat for a variety of bat species (Swier 2006, Bales 2007, Fabianek et al. 2015). Planted shelterbelts around waterbodies provide windbreaks for foraging bats and can provide roosting habitat once trees are appropriately mature (Boughey et al. 2011, Lacoeuilhe et al. 2018). Large snags with cavities or old trees with sloughing bark provide important resources for many species including the northern myotis (Caceres and Barclay 2000, Owen et al. 2003). Thick foliage is attractive to tree-roosting species like the northern hoary bat and eastern red bat (Klug et al. 2012, Beilke et al. 2023) and can provide protection from predators.

Movement

Riparian corridors provide important movement pathways for many species of wildlife, including bats, due to the availability of drinking water and foraging opportunities for migrating and dispersing bats (Henderson and Broders 2008, Russo and Ancillotto 2015, Cortes and Gillam 2020, Bernard and Minckley 2024). In addition to riparian corridors, maintaining water sources such as wetlands, ponds, and lakes, and even stock-tanks across the landscape are important for a bat's survival (Kunz and Fenton 2005, Vindigni et al. 2009, Korine et al. 2016).

Conservation Concerns

Riparian and aquatic habitats are among the most altered ecosystems in South Dakota, facing significant degradation from various land management practices. Approximately 78% of streams in the state are designated as impaired (South Dakota Department of Agriculture and Natural Resources 2024). Habitat loss, fragmentation, and water quality degradation stem from activities such as streamflow alteration, fire suppression, intensive grazing, large-scale farming, irrigation, pesticide application, mining, and construction (South Dakota Department of Agriculture and Natural Resources 2024).

Water Quality

Water quality is a growing concern in South Dakota (Menendez III et al. 2020) for humans and wildlife. Bats can die from drinking contaminated water and prolonged exposure to poor-quality water can impact overall bat health and survival (Clark and Hothem 1991, Vaughan et al. 1996). Additionally, the loss of riparian vegetation disrupts critical microhabitats along riverbanks, reducing the filtering services of riparian vegetation, and potentially degrading habitat quality for bats. Additionally, invasive species alter communities, reducing structural and habitat diversity in riparian and aquatic ecosystems (Grant et al. 2009, 2020, Ellis-Felege et al. 2013). Widespread use of herbicides and pesticides, including mosquito fogging, has further diminished insect populations and water quality, reducing the prey base for insectivorous bats while also exposing them to chemical bioaccumulation and associated risks (Oliveira et al. 2020, Tuneu-Corral et al. 2023).

Habitat Loss

The transformation of the Missouri River corridor throughout South Dakota compounds riparian conservation. Historically, this area was dominated by cottonwood floodplains, exposed river bluffs, and sandbars. However, the construction of large reservoirs in the 1960s has fundamentally altered river dynamics (Erickson et al. 2008, Barth and Sando 2024). Controlled flows have led to a decline in old-growth cottonwood forests by decreasing natural flooding, necessary for seed germination and recruitment (Scott et al. 1997). This has led to the decline of old-growth cottonwood forests and a subsequent loss of critical roosting habitat for bats and other wildlife.

Land Conversion

Beyond the Missouri River, most riparian areas in South Dakota are privately owned and heavily modified for agriculture or development (South Dakota Department of Agriculture and Natural Resources 2024). Wetlands and lakes in the Prairie Pothole Region have also been significantly impacted by agricultural and grazing practices that reduce water quality (South Dakota Department of Agriculture and Natural Resources 2024). Furthermore, many wetlands have been drained for cropland and urban expansion (Prairie Pothole Joint Venture 2017), while environmental shifts driven by climate change including reduced snowpack and increased variability in precipitation patterns, generate uncertainty around future water resources (Timberlake et al. 2021) although the Great Plains are predicted to experience increased temperatures and drought in the future (Morgan et al. 2008)

Best Management Practices

The following BMPs are designed to enhance habitat conditions for bats but may also benefit a variety of other wildlife species. These recommendations incorporate guidance from multiple sources and state bat management plans, but their applicability may vary depending on site conditions and history.

- **BMP 5.1.1 – Restore natural floodplains and stream dynamics** by reducing channelization and promoting meanders, oxbows, pools, and riffles to increase habitat complexity and diversity (Ober and Hayes 2008*a*). Restore drained wetlands, lakes, and other non-flowing waterbodies to provide increased foraging and drinking opportunities for bats.
- **BMP 5.1.2 – Maintain and restore diverse riparian and shoreline vegetation** with native species to enhance structural and habitat diversity for bats (Ober and Hayes 2008*a*, Bernard and Minckley 2024). Key species include cottonwoods, willows, dogwoods, cattails, sedges, grasses, and forbs, with fir and quaking aspen present at higher elevations.
- **BMP 5.1.3 – Protect and promote native roost trees near waterbodies.** Ideal roosts are older trees with crevices, holes, or sloughing bark. Large snags provide high-quality habitat and may be selected for increased solar exposure (Fabianek et al. 2015).

- **BMP 5.1.4 – Promote a mosaic of habitat structure** to provide resources for a diversity of bats. Enhance vertical habitat structure by maintaining trees of varying ages and promoting a mix of canopy, understory, and ground cover (Ober and Hayes 2008*b*, Lundy and Montgomery 2010).
- **BMP 5.1.5 – Diversify horizontal habitat structure by preserving buffer zones of natural riparian vegetation of at least 90 m (300 ft)**. These buffers support habitat connectivity, improve water filtration, and stabilize shorelines (Johnson and Buffler 2022).
- **BMP 5.1.6 – Restore and protect upland habitat adjacent to waterbodies** by promoting native grasses, forbs, and native deciduous and coniferous forests in areas where they naturally occur (Lacki et al. 2007).
- **BMP 5.1.7 – Remove invasive species like Russian olive and salt cedar that alter and degrade native aquatic habitats** (South Dakota Department of Game, Fish and Parks 2014). Control encroaching cattails to provide bats access to open water areas. Avoid herbicide contamination when managing vegetation near water and implement an Integrated Pest Management Plan (IPM) that limits chemical use (Hester and Grenier 2005)
- **BMP 5.1.8 – Limit the use of pesticides and herbicides near waterbodies** as these chemicals can degrade water quality, negatively impact insect communities, and bioaccumulate in bats (Hester and Grenier 2005, Oliveira et al. 2020).
- **BMP 5.1.9 – Maintain river bluffs, rocky surfaces, or incised edges that may offer roosting crevices for bats** (Schorr et al. 2025)**.** Northern myotis have been found over-wintering in the bluffs of the Missouri River in Nebraska (White et al. 2020).
- **BMP 5.1.10 – Manage human-made shelterbelts near water sources** by encouraging a diversity of tree species, preferably native, with understory cover (Boughey et al. 2011). Allow trees to reach advanced decay stages and retain snags when possible.
- **BMP 5.1.11 – Manage land use practices to support riparian habitat.** To maintain ecosystem functions, practices such as development, farming, grazing, and drilling should be avoided in riparian habitat (Warrington et al. 2017). Avoid major disturbances during the summer maternity season as bats have been shown to have increased foraging activity in riparian areas during the breeding season (Gorman et al. 2022).
- **BMP 5.1.12 – Minimize recreational disturbances (e.g., UTV use) and limit new road construction near waterbodies** to prevent erosion, sedimentation, and water degradation (Warrington et al. 2017).
- **BMP 5.1.13 – Maintain bat-accessible water features** by ensuring open water for drinking and foraging. Remove excessive obstructions that may hinder bat access (Hester and Grenier 2005).
- **BMP 5.1.14 – Retain some decaying woody debris and plant material in waterbodies** as decomposing organic matter supports insect populations (Lemly and Hilderbrand 2000).
- **BMP 5.1.15 – Manage livestock access to water sources with exclusion fencing or off-site stock tanks** to limit water contamination and riparian zone degradation. Use rotational grazing to minimize impacts if livestock must access riparian areas (Sovell et

al. 2000, Hulvey et al. 2021). Manage stock tanks and ponds for bat access, particularly in arid systems (Chung-MacCoubrey 1996). Ensure safe water access by removing hazards (e.g., barbed wire) and installing escape ladders in stock ponds (Taylor and Tuttle 2012).

- **BMP 5.1.16 – Maintain water availability throughout summer** (i.e., wildlife guzzlers and troughs that collect rainwater), especially in arid regions near known bat colonies (Taylor and Tuttle 2012, Rich et al. 2019).
- **BMP 5.1.17 – Encourage beaver populations or install beaver dam analogs** to improve water retention, enhance water quality, and create slow-moving pools beneficial for bats (Hooker et al. 2024).
- **BMP 5.1.18 – Reduce water pollution** including sediment, agricultural runoff, heavy metals, oil, and trash, as contaminated water can be fatal to bats (Clark and Hothem 1991).

5.2 Grasslands

Habitat Characteristics

Grasslands and associated shrub systems were historically the most abundant terrestrial ecosystem in South Dakota, covering approximately 40.5 million acres and spanning 82% of the state (South Dakota Department of Game, Fish and Parks 2014). These vast landscapes extended from the glaciated shallow wetlands of the Prairie Pothole Region in the east to the rolling hills and buttes of the Northern Great Plains west of the Missouri River. However, many grasslands have since been converted to agriculture and other land uses, with a 10-year average of approximately 630,000 acres of grassland converted to cropland each year across the Northern Great Plains (World Wildlife Fund 2024). These ecosystems historically supported a diverse vegetation community dominated by short, tall, and mixed grasses with forbs, scattered shrubs, and minimal tree presence, except in shelterbelts and along riparian corridors. South Dakota's grasslands are currently known to support at least seven bat species (Table 4), though more research is needed to understand species use, distribution, and ecological relationships. Grassland communities in heterogeneous landscapes, especially those interspersed with wetlands and other open water sources, promote higher insect abundance and biodiversity beneficial to supporting bat populations (Kunz et al. 2011, Ghanem and Voigt 2012, Riccucci and Lanza 2014).

The Missouri River flows south through the center of the state, dividing the grasslands into eastern (East River) and western (West River) sections, each characterized by unique geological structures and distinct biological communities. Farming and ranching practices are widespread across the grasslands, with agricultural fields and urban development prevalent in East River systems, while livestock production dominates resource use west of the Missouri (U.S. Department of Agriculture, Natural Resources Conservation Service 2022).

East River

The Prairie Pothole Region is a rich and diverse wetland-grassland ecosystem east of the Missouri River. Here, grasslands are interspersed with depressional wetlands created by glacial retreat at the end of the Pleistocene (Doherty et al. 2013). Tallgrass prairies span the eastern edge of the state, with big bluestem (*Andropogon gerardii*), little bluestem (*Schizachyrium scoparium*), indiangrass (*Sorghastrum nutans*), porcupine grass (*Miscanthus sinensis*), and green needlegrass (*Nassella viridula*) as the dominate grass species (U.S. Department of Agriculture, Natural Resources Conservation Service 2022). The tallgrass prairies east of the Vermillion and Big Sioux Rivers are the wettest of South Dakota's prairies (Hays 1994), supporting cattails (*Typha* spp.), prairie cordgrass (*Spartina pectinata*), bulrush (*Schoenoplectus* spp.), and reed canary grass (*Phalaris arundinacea*) within the abundant wetland and riparian areas (U.S. Department of Agriculture, Natural Resources Conservation Service 2022).

As grasslands extend west, the vegetation communities transition into mixedgrass prairie and shrubs that span across eastern and central South Dakota on either side of the Missouri River (Hays 1994). The dominant grasses of the east-central plains include western wheatgrass (*Pascopyrum smithii*), green needlegrass, needle and thread (*Hesperostipa comata*), porcupine grass, big bluestem, little bluestem, and blue grama (*Bouteloua gracilis*). Common shrubs include Western snowberry (*Symphoricarpos occidentalis*), leadplant (*Amorpha canescens*), and prairie rose (*Rosa arkansana*) (U.S. Department of Agriculture, Natural Resources Conservation Service 2022). Invasive species are also prevalent in these grasslands systems including Canada thistle (*Cirsium arvense*), smooth brome (*Bromus inermis*), Kentucky bluegrass (*Poa pratensis*), and sweet clover (*Melilotus officinalis*). Though native to South Dakota, eastern redcedar (*Juniperus virginiana*), encroaches on grasslands due to fire suppression and human plantations, and functions ecologically as an invasive species (Zou et al. 2018). These invasive species can critically alter natural habitat, potentially degrading quality and altering native insect assemblages (Grant et al. 2009, 2020, Larson and Larson 2010).

West River

Mixedgrass prairies form a transitional zone between tallgrass and shortgrass prairies across central South Dakota, extending west of the Missouri River (Hays 1994). Mostly comprised of unglaciated shale plains, the West River grasslands are dryer with old plateaus, eroded terraces, and rolling hills. In northern South Dakota, mixedgrass prairie transitions westward into shortgrass prairie and gray sagebrush (*Artemisia* spp.) along the state's dry western edge, where annual precipitation rarely exceeds 14 in. (Blann et al. 2017). The tablelands and Badlands of southwestern South Dakota are characterized by dramatic escarpments of eroded sandstone and siltstone bedrock that supports a mix of short-, mid-, and tallgrasses interspersed with ponderosa pine (*Pinus ponderosa*), eastern redcedar, and a variety of shrubs.

Dominant West River grasses include bluestems, western wheatgrass, green needlegrass, needle and thread, porcupine grass, blue grama (*Bouteloua gracilis*), buffalograss (*B. dactyloides*), and sideoats grama (*B. curtipendula*). A diverse array of forbs occurs within

West River grasslands, including various asters (Asteraceae), legumes (Fabaceae), and mallows (Malvaceae). Riparian corridors and floodplains extend throughout these grasslands, supporting prairie cottonwood (*Populus deltoides* var. *occidentalis*), bur oak (*Quercus macrocarpa*), green ash (*Fraxinus pennsylvanica*), boxelder (*Acer negundo*), hackberry (*Celtis occidentalis*), and willow species (*Salix* spp.) (U.S. Department of Agriculture, Natural Resources Conservation Service 2022). Invasive species present in West River systems include smooth brome and sweet clover along with more xeric species such as cheat grass (*Bromus tectorum*) and Japanese brome (*Bromus japonicus*) (Grant et al. 2009, 2020, Larson and Larson 2010).

Associated Species

Table 4. Bat species known to occur in South Dakota grasslands as of 2025.

		Grasslands	
Common Name	**Scientific Name**	East River	West River
Big brown bat	*Eptesicus fuscus*	X	X
Eastern red bat	*Lasiurus borealis*	X	X
Northern hoary bat	*Lasiurus cinereus*	X	X
Silver-haired bat	*Lasionycteris noctivagans*	X	X
Little brown myotis	*Myotis lucifugus*	X	X
Northern myotis	*Myotis septentrionalis*	X	X
Western small-footed myotis	*Myotis ciliolabrum*		X
Long-legged myotis	*Myotis volans*		X[a]
Fringed myotis	*Myotis thyasanodes*		X[a]

[a]Species have been captured and recorded in the Buffalo Gap National Grasslands, which consist of increased geological structures compared to other South Dakota grasslands.

Important Characteristics for Bats

Foraging

Heterogenous grassland communities support insect production and biodiversity, a significant food resource for South Dakota bat species. All insectivorous bats capture insects in flight, and several species are adept at gleaning insects from the ground and vegetation (Saunders and Barclay 1992, Adams 2003). Native prairies and grasslands with high plant diversity and structural heterogeneity support higher insect diversity beneficial for foraging bats, particularly for larger-bodied bats that are adapted to maneuvering in more open environments (Adams 2003, Hinman and Snow 2003, Hester and Grenier 2005). Management practices such as rotational grazing and prescribed fire can reduce vegetative clutter and create structural open areas that are more accessible to less maneuverable bat species, while also enhancing insect diversity and abundance that supports bat foraging (Heim et al. 2015, Blakey et al. 2016).

Roosting

Grasslands typically lack suitable roosting habitat, such as trees, except around riparian and aquatic features. However, grasslands may offer roosting opportunities in the form of rock, slabs, or boulders on the ground or potentially abandoned wildlife burrows, such as prairie dog burrows (McEwan and Bachen 2017, Adams 2021). More research is needed to determine if South Dakota bats use these similar features in grasslands habitats.

Conservation Concerns

Habitat Loss and Land Conversion

Habitat loss due to land conversion for agriculture, ranching, natural resource extraction, and urban development are of conservation concern for bats occurring in grassland ecosystems. A substantial portion of South Dakota's grasslands have been converted for agricultural practices, with 18,488,619 acres of cropland comprising approximately 38% of total land across the state (Le 2024, U.S. Department of Agriculture, Economic Research Service 2025). Bauman et al. (2016) reported that only 24.2% of eastern South Dakota's land remains potentially undisturbed, with only 4.3% under permanent conservation protection amid widespread and prevalent urban development across the region (Conzen 2010). West River, livestock production accounts for more than 60% of land use in almost all of the Major Land Resource Areas designated by the Natural Resource Conservation Service, with additional land converted for cash-grain crops. Such widespread conversion and fragmentation of native grasslands can reduce foraging opportunities and roost availability for insectivorous bats, particularly species that rely on heterogeneous vegetation structure or riparian corridors (Heim et al. 2015, O’Shea et al. 2016). These simplified agricultural landscapes are often associated with lower insect abundance and diversity, which can directly limit bat prey availability and reduce reproductive success of bats (Wickramasinghe et al. 2004, Park 2015).

Soil Degradation and Invasive Species

Soil degradation on cropland and overgrazed grasslands lowers biodiversity and facilitates the spread of invasive and noxious species such as smooth brome, Kentucky bluegrass, leafy spurge (*Euphorbia esula*), non-native thistles, and absinth wormwood (*Artemisia absinthium*) (Grant et al. 2009, 2020). Soil degradation and the resulting spread of invasive plant species alter vegetation structure and composition, reducing the availability of native foraging habitat and negatively impacting insect prey availability (Trubitt et al. 2018).

Overgrazing

Overgrazing of pastures can increase surface runoff and soil erosion, reducing soil productivity, degrading water quality, and disrupting hydrologic regimes (Giuliano and Homyack 2004, U.S. Department of Agriculture, Natural Resources Conservation Service 2022). While low-intensity, rotational grazing can help reduce woody encroachment and promote a heterogenous vegetation structure, these benefits steadily decline under sustained high-grazing pressure (Olff and Ritchie 1998, DiTomaso 2000, van Klink et al. 2015). Prolonged disturbance in intensely grazed systems can allow for invasive species to outcompete native vegetation and dominate the landscape, reducing overall plant diversity (DiTomaso 2000, van Klink et al. 2015). A decline in native plant diversity can in turn diminish insect diversity and abundance (van Klink et al. 2015), which may negatively impact bats dependent on these ecosystems (Trubitt et al. 2018).

Best Management Practices

Preserving and promoting intact, heterogeneous landscapes within South Dakota's grasslands is essential for sustaining healthy bat populations. The following BMPs offer concrete strategies to reduce the negative impacts of habitat loss and degradation in these heavily modified ecosystems. Several organizations provide support and resources for these efforts, including the Conservation Reserve Program (CRP), the Conservation Reserve Enhancement Program (CREP), the Environmental Quality Incentives Program (EQIP), the South Dakota Grassland Coalition, the Central Grasslands Roadmap Initiative, and Integrated Pest Management (IPM).

- **BMP 5.2.1 – Preserve and promote corridor features** such as grassland/woodland edge, riparian corridors, hedgerows, ditches, and shelterbelts that connect habitat patches and support high densities of foraging bats (Entwistle et al. 2001, Hinman and Snow 2003, Racey and Entwistle 2003, Hester and Grenier 2005, Boughey et al. 2011, Finch et al. 2020).
- **BMP 5.2.2 – Improve cultivated farmland by employing conservation forward practices near grasslands** (Fenton 1997, Hester and Grenier 2005), such as expanding field margins, implementing no-till or conservation tillage and contour farming practices, diversifying crop rotations, planting cover crops, retaining crop residue, and preserving natural areas between fields (Entwistle et al. 2001, Hinman and Snow 2003, Hester and Grenier 2005, U.S. Department of Agriculture, Natural Resources Conservation Service 2022, World Wildlife Fund 2024).
- **BMP 5.2.3 – Establish early- and late-season pastures to supplement forage production and reduce grazing pressure** on rangelands during critical vegetative growth periods (U.S. Department of Agriculture, Natural Resources Conservation Service 2022).
- **BMP 5.2.4 – Incorporate and maintain large, deciduous trees in livestock pastures and establish low-intensity grazing practices** to enhance bat habitat. Silvopastoral systems with mature broadleaf trees and low-intensity grazing livestock attract insect prey and support higher bat activity and species richness compared to more open pastures (Ancillotto et al. 2017, 2021, Edo et al. 2025).
- **BMP 5.2.5 – Manage for a mosaic of grassland successional stages through strategic rotations of livestock grazing, prescribed fires, and mowing** (Entwistle et al. 2001, Hinman and Snow 2003, Hester and Grenier 2005). Management practices that mimic nature disturbance regimes in grassland systems can increase plant and landscape heterogeneity and promote bat species richness (Blakey et al. 2019, Steel et al. 2019).
- **BMP 5.2.6 – Encourage participation in native prairie restoration initiatives and programs** such as the CRP and CREP, which provides practitioners with an annual rental payment to remove environmentally sensitive land from agricultural production and plant species that promote environmental quality (U.S. Department of Agriculture, Farm Service Agency 2021, 2025).
- **BMP 5.2.7 – Protect, restore, and maintain water features in and near grasslands** such as ponds, wildlife tanks, streams and tributaries, and wetland

areas to provide water sources for bats and promote insect production (Chung-MacCoubrey 1996, Entwistle et al. 2001, Hester and Grenier 2005).

- **BMP 5.2.8 – Limit herbicide and insecticide use and follow the IPM principles** for sustainable pest management practices that avoid loss of non-target species and minimize environmental exposure to harmful chemicals (Entwistle et al. 2001, Hester and Grenier 2005, Radcliffe et al. 2009).

5.3 Forests and Woodlands

Habitat Characteristics

Forest and woodland systems, characterized by trees and other woody vegetation, are essential to the survival of almost all North American bats, with more than half of bat species relying on trees for roosting at some point during their life cycle (Taylor et al. 2020). Yet in South Dakota, forests and woodlands, including trees along riparian corridors and shelterbelts, only cover approximately 4% of total land area (1.95 million acres) based on Forest Inventory and Analysis (FIA) estimates (Bechtold and Patterson 2015, Meneguzzo and Paulson 2019), making these limited forest systems especially critical for bat populations in the Northern Great Plains. South Dakota's forests and woodlands vary in composition, structure, and function across the state, with the Black Hills National Forest located in the southwest section of the state, floodplain forests surrounding the Missouri River and its tributaries, and upland forests along the eastern border (Ball and Erickson 1992). Shelterbelts comprising both native and non-native species have been planted throughout South Dakota but are particularly prevalent near row-crop agriculture and human structures (Ball 1992, South Dakota Department of Agriculture and Natural Resources, Division of Resource Conservation and Forestry 2006, 2008). Together these forests and woodlands support all 13 bat species in South Dakota (Table 5) with a range of tree species including ponderosa pine (*Pinus ponderosa*), bur oak (*Quercus macrocarpa*), eastern cottonwood (*Populus deltoides*), white spruce (*Picea glauca*), green ash (*Fraxinus pennsylvanica*), Rocky Mountain juniper (*Juniperus scopulorum*), boxelder (*Acer negundo*), American elm (*Ulmus americana*), eastern redcedar (*J. virginiana*), and Siberian elm (*U. pumila*) (Meneguzzo and Paulson 2019).

Black Hills National Forest

The Black Hills National Forest, hereafter referred to as the Black Hills, accounts for approximately 90% of South Dakota's forested habitats, featuring a heterogeneous landscape ranging from gentle slopes of meandering streams to high plateaus, rugged granite peaks, and crags of slate, schist, and limestone (Meneguzzo and Paulson 2019, U.S. Department of Agriculture, Natural Resources Conservation Service 2022). Located in the southwest region of the state, this forest is part of an isolated mountain range with an elevation range of around 3,000 to over 7,000 feet, supporting a rich diversity of flora and fauna, including over 300 wildlife and fish species (U.S. Forest Service 2022*a*). The dominate tree species is ponderosa pine, with white spruce occurring along drainages and at higher elevations. Paper birch (*Betula papyrifera*), bur oak, and quaking aspen (*P. tremuloides*) can be found in areas disturbed by wildfire and silvicultural treatments (U.S.

Department of Agriculture, Natural Resources Conservation Service 2022). The Black Hills are a key region for timber production, with forest management activities primarily focused on timber harvest and fuels reduction to maintain forest health and reduce wildfire risk (U.S. Department of Agriculture, Natural Resources Conservation Service 2022).

Custer Gallatin National Forest

The Custer-Gallatin National Forest lies primarily in southeastern Montana but extends into the northwest corner of South Dakota in isolated patches. In South Dakota, the Custer-Gallatin National Forest receives little rainfall and is dominated by ponderosa pine surrounded by mixed grasslands (Hays 1994, Gartner and Sieg 1996). Trees grow on large sandstone buttes in contrast to the granite and limestone of the Black Hills. Forests here are patchy and less dense and connected than the Black Hills (U.S. Forest Service 2022*b*).

Floodplain Woodlands and Upland Forests

Floodplain woodlands naturally develop in areas with water retention and drainage, supporting woody vegetation along both perennial and ephemeral watercourses and waterbodies within South Dakota's grass-dominated landscapes (Ball and Erickson 1992). These floodplains play a vital role in stabilizing fragile riparian banks, providing essential wildlife habitat, and supporting recreational opportunities. Trees are primarily deciduous hardwood species and vary in species composition with soil moisture levels. Willows (*Salix* spp.) and cottonwoods are common along more frequently flooded areas and those with high soil moisture content (Ball and Erickson 1992). As soil moisture content declines (often as elevation and distance from the bank increase), green ash, American elm, and boxelder appear among mature cottonwoods. On the higher terraces, bur oaks become more prevalent, gradually giving way to prairie habitats (Ball and Erickson 1992). Along the Missouri River in the southeastern corner of the state, the elevated edges of floodplains support additional species such as silver maple (*Acer saccharinum*), black walnut (*Juglans nigra*), honey locust (*Gleditsia triacanthos*), basswood (*Tilia americana*), and hackberry (*Celtis occidentalis*) (Ball and Erickson 1992). Farther north on the eastern edge of South Dakota, basswood and sugar maple (*A. saccharum*) occur in scattered upland forests such as Sica Hollow State Park (Ball and Erickson 1992).

Shelterbelts

Shelterbelts, also known as windbreaks or hedgerows, are linear plantings of woody vegetation established along cropland edges and near human-made structures to reduce wind impacts, improve water retention, and enhance crop yields (Mize et al. 2008). Often located in open landscapes, shelterbelts provide numerous benefits to bats and other wildlife. These linear tree breaks offer protection from predators and harsh environmental conditions and serve as valuable commuting and foraging corridors that increase habitat connectivity and insect prey availability for bats (Boughey et al. 2011, Heim et al. 2015, Finch et al. 2020).

Associated Species

Table 5. All of South Dakota's bat species are associated with forest and woodland habitat, with 12 of the 13 South Dakota bat species known to occur in the **Black Hills National Forest,** and all species are associated with **Floodplain Woodlands and/or Upland Forests** in South Dakota as currently understood.

		Forest/Woodland Type	
Common Name	**Scientific Name**	Western Ponderosa and Mixed-conifer Forests	Floodplain Woodlands, Shelterbelts, and/or Upland Forests
Townsend's big-eared bat	*Corynorhinus townsendii*	X	X
Big brown bat	*Eptesicus fuscus*	X	X
Eastern red bat	*Lasiurus borealis*	X	X
Northern hoary bat	*Lasiurus cinereus*	X	X
Silver-haired bat	*Lasionycteris noctivagans*	X	X
Western small-footed myotis	*Myotis ciliolabrum*	X	X
Long-eared myotis	*Myotis evotis*	X	X
Little brown myotis	*Myotis lucifugus*	X	X
Northern myotis	*Myotis septentrionalis*	X	X
Fringed myotis	*Myotis thysanodes*	X	X
Long-legged myotis	*Myotis volans*	X	X
Evening bat	*Nycticeius humeralis*		X
Tricolored bat	*Perimyotis subflavus*	X	X

Important Characteristics for Bats

Roosting

Several bat species rely exclusively on trees for summer roosting sites with specific roost requirements and preferred tree characteristics varying by bat species (Cryan et al. 2014, Taylor et al. 2020). Forests and woodlands provide a variety of roosting options that are essential for bat survival, offering protection from predators and environmental conditions, sites for raising young, distinct day and night roosts, and shelter for hibernation during the winter (Cryan et al. 2014). Common tree roost sites include cavities, exfoliating bark, and crevices in live, older-growth trees, snags and dense foliage of both deciduous and coniferous trees (Hester and Grenier 2005, Navo et al. 2018, Taylor et al. 2020). Many bat species are known to roost beneath loose, exfoliating bark and tree cavities, while tree-roosting specialists such as the northern hoary bat (*Lasiurus cinereus*) and eastern red bat (*L. borealis*) primarily roost within the thick canopies of living trees (Klug et al. 2012, Beilke et al. 2023).

Roost selection is influenced by thermoregulatory needs that may vary by season, time of day, species, sex, reproductive status, and age class (Navo et al. 2018). These needs are shaped by microsite conditions such as ambient temperature, humidity, solar and wind exposure, forest structure, and vegetation composition (Neubaum et al. 2007). Bats may switch roosts daily or throughout the season, especially when using ephemeral structures like trees and snags, but are also known to return to high-quality roost sites throughout a season or across multiple years (Navo et al. 2018).

Various parts of trees offer different roosting opportunities: cavities in live trees and snags provide thermal stability, while exfoliating bark offers temporary yet secure crevices that provide concealment (Hester and Grenier 2005). Trees with greater diameter and height typically offer a higher density of well-insulated cavities that help maintain stable microclimates essential for bat thermoregulation (Kunz and Lumsden 2003). Once dead, larger trees are more likely to become structurally stable snags and persist on the landscape longer than small trees (Hester and Grenier 2005, Navo et al. 2018). The decay stage of snags also influences roost suitability, as early-, mid-, and late-decay snags are used by different bat species, each offering varying degrees of sloughing bark and cavity availability (Cryan et al. 2001, Navo et al. 2018, Taylor et al. 2020). Additionally, a high density of clustered snags offers increased roosting opportunities for colonies, supports a variety of microsite conditions, and ensures the availability of replacement roosts as individual snags deteriorate (Pierson 1998). Small canopy openings within forests can also serve as important microsites, offering increased sun exposure to roost trees that can aid in thermoregulation (Vonhof and Gwilliam 2007, Law et al. 2018).

Protection and Movement

Tree foliage provides protective cover and can reduce commuting or migration distances due to its abundance in forested landscapes (Adams et al. 2009). Smaller, more agile species such as the long-legged myotis (*Myotis volans*), fringed myotis (*Myotis thysanodes)*, and Townsend's big-eared bat (*Corynorhinus townsendii*) are well adapted to navigate dense forest environments (Adams 2003). Conversely, larger-bodied species like the big brown bat (*Eptesicus fuscus*) have reduced maneuverability in cluttered environments and may benefit from older stands and wider spacing between trees to facilitate movement and foraging (Cryan et al. 2001). Forest edges typically have reduced vegetation clutter, making them easier to navigate and useful as commuting corridors and can provide valuable shelter from wind and predators (Adams 2003, Hester and Grenier 2005). Bats have been shown to travel and forage along linear features such as forest edges and shelterbelts with some studies reporting higher bat activity and diversity along forest edges compared to inner forest and open field habitats (Morris et al. 2010, Kalcounis- Rueppell et al. 2013).

Foraging

Differences in bat morphology and foraging strategies enable species to exploit distinct ecological niches across vertical canopy layers, varying degrees of forest clutter, open areas, and habitat edges (Adams 2003, Adams et al. 2009). Larger bats with long, narrow wings are well-suited for fast, efficient flight in open spaces, while smaller bats with shorter, broader wings are more maneuverable and better adapted to navigating cluttered forest interiors (Adams 2003). Both vertical and horizontal forest structure can influence bat species composition and habitat use. Dense vegetation, or structural clutter, can hinder the echolocation abilities of species adapted to open or edge-space environments, and increased foraging activity in open areas with high insect abundance has been documented among both open- and edge-space bat guilds (Adams et al. 2009). The presence of deciduous trees within conifer-dominated forests can support more diverse insect communities and increase foraging opportunities for bats (Hester and Grenier 2005, Charbonnier et al. 2016).

Forest and woodland edges create transitional ecotones that offer valuable foraging habitat for bats (Morris et al. 2010, Jantzen and Fenton 2013). Shelterbelts and other linear features with diverse species composition and vertical structure, including the presence of tall trees, have been shown to increase bat activity, especially in open landscapes with limited woodland cover (Wickramasinghe et al. 2004, Froidevaux et al. 2021). Frick et al. (2020) found that shelterbelts and hedgerows managed with strategic tree cutting every three years, while retaining tall trees, supported greater bat activity than those cut annually. This less frequent cutting also enhanced shrub and forb diversity and abundance, resulting in 2.1 times more flowers and 3.4 times greater berry mass over five years (Finch et al. 2020). Open areas in canopy with a variety of shrubs and herbaceous plant species may also support greater insect biodiversity (Achury et al. 2023) and decrease clutter, both of which are beneficial for bat foraging. Studies assessing the effects of mild disturbances such as prescribed fire and understory thinning projects in hardwood forests often found a positive relationship between decreased clutter and bat activity, even in clutter-adapted species (Cox et al. 2016, Ford et al. 2016).

Breeding

Breeding success is closely tied to the availability of suitable roosting structures and stable microclimates provided by forested environments. Warm, thermally stable roosts such as tree cavities, crevices, and exfoliating bark can provide critical conditions for pup development during the breeding season (Taylor et al. 2020). Warmer roosts can also reduce the energetic costs for thermal regulation of breeding females and young. Forest heterogeneity with diversity among tree species and age structure of trees and habitat patches can support higher-quality roosts (Hester and Grenier 2005, Navo et al. 2018, Taylor et al. 2020).

Conservation Concerns

Timber Harvest

Timber harvesting can have varied impacts on bats depending on species' needs, landscape and habitat characteristics, and harvesting prescriptions (Caldwell et al. 2019). Timber harvest practices with short rotation periods may limit regeneration of new growth, leading to uniform-aged stands and reduced vertical heterogeneity important for bat species (Vonhof and Gwilliam 2007). Dense, homogenous stands of similar-age trees are more vulnerable to infestations by defoliating insects, bark beetles (Curculionidae: Scolytinae), and wood borers (Coleoptera and Lepidoptera) that can cause widespread tree mortality and increase the risk of severe, stand-replacing wildfires. Extensive tree damage and mortality can negatively affect bats that rely on a diversity and abundance of tree roost types (Crampton and Barclay 1998, Hester and Grenier 2005). Even-aged stands also reduce insect abundance and diversity, limiting key prey resources for many bats (Hester and Grenier 2005, Charbonnier et al. 2016). Additionally, the removal of snags and mature trees further decreases the availability of critical roosting habitat for bats while short rotation intervals may not allow for recruitment of older age-class trees frequently selected for roosting (Hester and Grenier 2005, Vonhof and Gwilliam 2007, Navo et al. 2018).

Tree Pests and Pathogens

Tree pest infestations and pathogens pose complex threats with varying ecological trade-offs affecting habitat suitability for bats. While pests and pathogens that weaken, defoliate, or kill trees can reduce roost availability, pest-driven mortality may also create snags and cavities that provide roosting habitat for several bat species (Mehr et al. 2012, Kortmann et al. 2018). For example, the mountain pine beetle (*Dendroctonus ponderosae*) has caused extensive tree die-offs in the Black Hills, with an estimated loss of over 8.6 million ponderosa pine trees in the most recent mountain pine beetle epidemic from 2000 to 2017, leading to cascading ecological impacts (Graham et al. 2021). Other notable pests include pine engraver beetles (*Ips* spp.), which attack weakened or recently felled pines (Ball and Seidl 2020), and the invasive emerald ash borer (*Agrilus planipennis*), which has caused widespread mortality in ash trees across North America, including South Dakota (South Dakota Division of Resource Conservation and Forestry 2021*a*). Furthermore, pathogens such as the fungus *Ophiostoma novo-ulmi*, which causes Dutch elm disease and is spread by elm bark beetles (*Scolytus* spp.), can infect any of South Dakota's elm trees (South Dakota Department of Agriculture and Natural Resources 2025).

Notably, bats may influence tree pest dynamics through predation (Ancillotto et al. 2022, 2024, Beilke and O'Keefe 2023), reducing, but not fully mitigating, insect defoliation of trees in forested landscapes (Beilke and O'Keefe 2023). Several nocturnal, volant tree pests in South Dakota, including pine tip moths (*Rhyacionia* spp.), Zimmerman pine moths (*Dioryctria zimmermani*), and bagworms (*Thyridopteryx ephemeraeformis*) (South Dakota Division of Resource Conservation and Forestry 2021*b*, *a*, *c*) may serve as potential prey resources. Bats can consume a significant number of insects including beetles, moths, treehoppers, and other tree pests, providing valuable biological control of insects. Estimates suggest that a single colony of 150 big brown bats can consume nearly 1.3 million pest insects annually (Boyles et al. 2013). While bats can act as important top-down regulators of forest pests, bat population size and diet variability play an important role in pest control effectiveness (Gong et al. 2025). As bat populations decline, their ability to be effective predators may also decrease.

Land Conversion

Land conversion and woodland modification can significantly transform ecological function and composition of forest systems (Ghazoul et al. 2015). Such alterations can decrease water retention, increase soil erosion, and reduce the vegetative diversity needed to maintain healthy woodlands (Ghazoul et al. 2015). This is particularly relevant for floodplain woodlands in South Dakota, where extensive damming of the Missouri River and its tributaries has led to significant reduction of cottonwood habitat and recruitment

(Johnson and Knight 2022), resulting in fewer critical roosting sites and declines in insect diversity vital to bat populations.

Overgrazing

Certain grazing practices present an additional disturbance altering community dynamics in forest and woodlands. When done in excess without allowing for vegetation recovery, overgrazing can lead to increased soil compaction, streambank erosion, impaired water quality, and channel degradation (Giuliano and Homyack 2004, Alkemade et al. 2013). These factors can reduce insect abundance and diversity is essential for bat foraging. Habitat degradation from overgrazing, particularly in riparian zones along these corridors, can lead to the loss of roosting trees, disrupt migratory movements, and decrease survival rates. These impacts are especially significant in areas with limited vertical structure and for species that depend on stopover habitats during long-distance migration. Overgrazing can also affect horizontal habitat structure, decreasing grass and forb diversity, and thereby further impacting insect and bat communities (Giuliano and Homyack 2004, Alkemade et al. 2013). Notably, when conducted sustainably, grazing practices can provide a useful management tool to increase grass and forb diversity, horizontal structural complexity, and overall landscape diversity (Zhang et al. 2021, Campbell and King 2022) which may have positive impacts on insect prey species and bat populations.

Best Management Practices

South Dakota's forest and woodland systems represent a valuable and scarce resource vital to the survival of almost all North American bat species (Taylor et al. 2020). The following BMPs provide guidance for managing tree-dominated systems in South Dakota to preserve and enhance habitat for bats.

- **BMP 5.3.1 – Promote vertical and horizontal structural complexity** within forest stands by maintaining a diversity of plant species, sizes, and age classes in both the canopy and understory (Patriquin and Barclay 2003, Adams et al. 2009). Forest stands with multiple vegetation layers and a mix of age classes support greater insect biodiversity and provide a wider range of roosting opportunities for bats (Hutchinson and Lacki 2000, Waldien et al. 2000, Hester and Grenier 2005, Lacki et al. 2007, Adams et al. 2009, Navo et al. 2018).
- **BMP 5.3.2 – Manage for a mosaic of habitat patches** within extensive areas of continuous forest, including meadows, aspen groves, and open areas that support shrub and forb diversity, and linear features such as trails, forest roads, and riparian corridors (Krusic et al. 1996, Entwistle et al. 2001, Hester and Grenier 2005, Navo et al. 2018, Froidevaux et al. 2021), while avoiding significant forest fragmentation, partially within old-growth stands (Keinath 2004, Hester and Grenier 2005).
- **BMP 5.3.3 – Maintain small canopy openings within forest and woodland habitats to improve foraging conditions for bats** (Grindal and Brigham 1998, Hester and Grenier 2005, Navo et al. 2018, Froidevaux et al. 2021). Given that many bat species rely on forest edges for both foraging and navigation, these openings should be designed to maximize the edge-to-area ratio (Fenton 1997, Crampton and Barclay 1998, Froidevaux et al. 2021). Clearings should remain relatively small to minimize the

risk of habitat fragmentation and preserve forest continuity (Krusic et al. 1996). The retention of large trees, snags, and patches of mature forest within and adjacent to these openings is important to ensure the availability of critical roosting habitat (Krusic et al. 1996, Hester and Grenier 2005, Navo et al. 2018, Froidevaux et al. 2021).

- **BMP 5.3.4 – Support the restoration and regeneration of aspen within conifer-dominated forests to enhance habitat diversity** (Hester and Grenier 2005). Aspen trees provide unique ecological benefits, including distinct insect communities and a greater abundance of tree cavities compared to conifers. Large aspen stands are especially valuable, as they are frequently selected by both bats and primary cavity-nesting bird species (Kalcounis and Brigham 1998, Vonhof and Gwilliam 2007).
- **BMP 5.3.5 – Design and maintain shelterbelts with a mix of tall trees and diverse shrubs and adopt longer, strategic tree-cutting intervals while retaining tall trees** within shelterbelts to enhance bat foraging activity and roost availability. Reduced cutting frequency of woody vegetation within shelterbelts promotes structural complexity and biodiversity, resulting in greater bat use (Finch et al. 2020). Similarly, shelterbelts and hedgerows that incorporate trees (rather than shrubs solely) are associated with higher bat activity (Boughey et al. 2011). Support and resources for planting shelterbelts and managing woodlands to benefit wildlife are available to private landowners through programs such as The South Dakota Game, Fish and Parks Woody Habitat Program and The Environmental Quality Incentives Program (EQIP).
- **BMP 5.3.6 – Perform bat surveys prior to timber harvesting projects or other vegetation modification measures to identify active roosts and foraging areas within project boundaries** (Hester and Grenier 2005). See section 7.2 for Monitoring Guidelines and Applications.
- **BMP 5.3.7 – Implement a 0.4 km (0.25 mile) radius buffer around known bat roosts, within which the removal of other known or suitable tree roosts do not occur**, particularly for threatened and endangered species (U.S. Fish and Wildlife Service 2024*c*). If activities within this zone are unavoidable, even when the roost is temporarily unoccupied, maintain at least a 150 m (500 ft) buffer of undisturbed forest surrounding the roost (Pierson 1998, Keinath 2004). This intact vegetation helps preserve the natural airflow and thermal conditions essential for roost suitability (Pierson 1998, Keinath 2004, Hester and Grenier 2005).
- **BMP 5.3.8 – Establish a 0.4 km (0.25 mile) radius buffer around the entrance(s) to known bat hibernacula**, **within which the removal of known or suitable roost trees do not occur**, particularly for threatened or endangered species. These measures protect essential microclimate conditions, underground features, and unconfirmed entrances that may not be reflected in known location data (U.S. Fish and Wildlife Service 2024*c*).
- **BMP 5.3.9 – Implement a 2.4 km (1.5 mile) radius buffer around capture or acoustic locations of threatened or endangered bat species, within which removal of known or suitable roost trees does not occur**. These buffer zones are particularly important during the pup season (June 1st – August 31st) and winter torpor (December 15th –

February 15th) when bat species have increased vulnerability to disturbance (U.S. Fish and Wildlife Service 2024*c*).

- **BMP 5.3.10 – Prioritize the retention and recruitment of large snags**, as they offer longer-lasting structural integrity, more extensive bark cover, and a higher number and diversity of cavities. Concentrate on preserving snags in clusters that are easily accessible to flying bats and positioned in areas with moderate to high sun exposure to support suitable thermal conditions (Waldien et al. 2000, Kunz and Lumsden 2003, Hester and Grenier 2005).
- **BMP 5.3.11 – Preserve trees that have been documented as bat roosts.** The repeated and selective use of certain roosts by bat colonies indicates that some species exhibit site fidelity, especially to trees that are more likely to persist on the landscape over time (Chung-MacCoubrey 2003, Hester and Grenier 2005).
- **BMP 5.3.12 – Maintain a diverse range of age classes and tree species among stands to ensure a diversity of roost sites and a continuous supply of future snags as older trees die and decay.** This approach supports long-term snag availability and helps sustain essential habitat features required for different bat species and their varied life stages (Mattson et al. 1996, Waldien et al. 2000, Keinath 2004, Hester and Grenier 2005, Navo et al. 2018).
- **BMP 5.3.13 – Extend harvest rotation intervals when possible to retain large, mature trees on the landscape** (Jung et al. 1999, Hester and Grenier 2005). Intensive forest management and short rotation cycles limit the presence of large, mature trees, reducing the availability of suitable roosting habitat for bats (Hester and Grenier 2005, Vonhof and Gwilliam 2007).
- **BMP 5.3.14 – Conduct periodic, low-intensity prescribed fires** in forest and woodland systems to help sustain open habitat conditions and mimic the natural disturbance patterns historically present in these ecosystems (Krusic et al. 1996, Hester and Grenier 2005, Armitage and Ober 2012, Cox et al. 2016, Steel et al. 2019). Controlled burns can also reduce hazardous fuel accumulation, lowering the risk of severe wildfire events (Hinman and Snow 2003), while enhancing habitat diversity across the landscape (Keinath 2004). When possible, prescribed fires should result in the creation of new snags at a rate equal to or greater than the number lost during burning (Keinath 2004, Hester and Grenier 2005).
- **BMP 5.3.15 – Minimize pesticide use in forested landscapes** to protect insect populations and reduce ecological disruption. When pest control is necessary, prioritize silvicultural practices that lower the prevalence of susceptible host species. Use targeted, species-specific control methods, such as pheromone disruptors or sterile male release, over broad-spectrum pesticides. When chemicals must be used, incorporate them into a comprehensive Integrated Pest Management (IPM) strategy to minimize unintended impacts on non-target species (Pierson 1998, Hester and Grenier 2005, Radcliffe et al. 2009).

5.4 Caves, Mines, and Geological Structures

Habitat Characteristics

Caves, mines, and geological structures can all provide important roosting and hibernating habitat for many North American bat species (Perry 2013), offering more stable microclimates, higher landscape permanence, higher humidity, and better protection from many predators compared to tree roosts (Furey and Racey 2016). Several species are reliant on caves, mines, or rock faces while some species may use them opportunistically (Table 6) (Moran et al. 2023). Furthermore, different species may select for varying conditions within these features (Leivers et al. 2019). Regardless, maintaining a healthy, connective habitat for optimal foraging opportunities around these areas is critical for bat conservation.

Caves

Caves are primarily concentrated in western South Dakota, and their presence contributes to greater bat species richness in this region compared to eastern South Dakota. South Dakota's caves are primarily limestone and dolomite karst formations, though some are composed of gypsum and salt (Palmer 2016). While eastern South Dakota also contains karst features, they are deeply buried beneath the soil and inaccessible to bats (Artz 2011). The state's unique karst systems in the west form some of the most expansive cave networks in the country, with over 100 explored caves and many more yet to be surveyed (Palmer 2016). South Dakota caves can range from narrow tunnels and holes that are inaccessible to humans, to shallow chambers, deep crevices, cavernous rooms, and large, interconnected tunnels and chambers, with more complex cave systems generally hosting higher bat species richness (Furey and Racey 2016, Palmer 2016). Furthermore, caves such as Jewel Cave and Wind Cave in South Dakota are some of the longest cave networks in the world and provide valuable habitat to bats in the Black Hills.

Mines

Mining has played a significant role in South Dakota's economy, both historically and in present day (Norton 1974, U.S. Geological Services National Minerals Information Center 2019). Although many historical mines have closed, active mining continues throughout South Dakota (U.S. Geological Services National Minerals Information Center 2019). Abandoned mines, which are remnants of operations extracting minerals such as gold, silver, tin, mica, feldspar, gypsum, and various rock types (granite, limestone, quartzite), often provide critical bat habitat (Tigner and Stukel 2003). While active mines are typically unsuitable due to ongoing disturbance, closed and abandoned mines create valuable roosting opportunities (Sherwin et al. 2009). Many closed mines have large entrances and are relatively intact, while some mines have collapsed with openings too small for human access. Abandoned mines often have remaining adits, which are horizontal tunnels that were created to enter the mine, improve airflow, or release water from mining sites. Like caves, increasing depth and complexity in mines can support a greater variety of bats (Sherwin et al. 2009).

Geological Structures

South Dakota's geological diversity includes hard rock formations such as the granite and limestone of the Black Hills, as well as softer rock features like the sandstone, siltstone, claystone, and shale of the Badlands formations and the buttes of the Custer-Gallatin National Forest (Jarrett 1974). Other formations in the state, notably river bluffs composed of chalkstone, shale, and clay, as well as rocky alcoves and boulder fields provide important roosting resources for bats (Bogan et al. 1996, White et al. 2020). These different geological structures form crevices, cracks, tunnels, and sinkholes that may be used by bats which have been shown to use rocky, talus slopes, badlands formations, and river bluffs for roosting and hibernating (Bogan et al. 1996, Barnhart and Gillam 2017, McEwan and Bachen 2017, White et al. 2020).

Associated Species

Table 6. South Dakota bat species that have been found using cave, mine, and other geological structures either during the summer active season or for hibernacula.

		Roost Type		
Common Name	**Scientific Name**	Caves	Mines	Geologic Structures
Townsend's big-eared bat	*Corynorhinus townsendii*	X	X	X
Big brown bat	*Eptesicus fuscus*	X	X	X
Silver-haired bat	*Lasionycteris noctivagans*	X	X	
Northern myotis	*Myotis septentrionalis*	X	X	X
Little brown myotis	*Myotis lucifugus*	X	X	X
Long-legged myotis	*Myotis volans*	X	X	X
Long-eared myotis	*Myotis evotis*	X	X	X
Fringed myotis	*Myotis thysanodes*	X	X	X
Western small-footed myotis	*Myotis ciliolabrum*	X	X	X
Tricolored bat	*Perimyotis subflavus*	X	X	

Important Characteristics for Bats

Roosting and Hibernating

Caves, mines, and geologic structures provide stable temperatures, increased humidity, and predator protection, which are attractive roosting features for bats (Furey and Racey 2016). Different bat species may select different features within these structures including cavern height and depth, cave entrance size, crevice density, number and complexity of passages and tunnels, airflow, water sources, and specific microclimates depending on species morphology, time of year, and stage of their lifecycle (Perry 2013, Furey and Racey 2016). Some species, such as the Townsend's big eared bat, spend most of their life cycle in these spaces, while other species, such as the tricolored bat, may only use these habitats for hibernation and will disperse into nearby forests for summer roosting and pup rearing (Sherwin et al. 2000, McCoshum et al. 2023). Other species use these spaces opportunistically. Notably, cave-dwelling bats have some of the highest rates of roost fidelity, presumably because caves provide a stable, more permanent state on the landscape compared to trees and even mines which may collapse over time (Sherwin et al. 2009, Furey and Racey 2016). The unique conditions of caves provide critical habitat for multiple bat species throughout the year and may also be important for bats seeking refugia from outside habitat disturbances (Chambers et al. 2024).

Temperature plays a crucial role in the selection of caves, mines, and other geologic structures. Bats select structures with warmer environments to support reproduction and pup growth but structures with cooler conditions during hibernation to aid in metabolic regulation and to minimize water losses (Kunz and Fenton 2005, Furey and Racey 2016). Humidity is also a key factor because it indicates stable airflow, which ensures a proper circulation system to avoid disrupting delicate microclimates inside the bats roosting site. Humid, stable air also helps to reduce bats' moisture loss to the environment (Perry 2013). For hibernating bats, finding optimal microhabitats with suitable temperatures (~2–10 degrees Celsius), humidity, proper airflow, and lack of disturbance is crucial for winter survival (Furey and Racey 2016). Bats enter a state of torpor and although they may occasionally naturally rouse several times during the winter (to drink, urinate, change positions or roosts), every arousal uses critical energy, fat, and water reserves (Whiting et al. 2024). Bats that wake too frequently due to improper microhabitats, disturbance, or disease risk starving to death before the end of winter (Whiting et al. 2024).

Rock crevices, cracks, talus slopes, and rocky outcrops offer important stable roosting conditions for bats, especially in the absence of cave and mine features or adequate tree roosts (McEwan and Bachen 2017, Navo et al. 2018, Bat Rock Habitat Key 2021, Schorr et al. 2025). Although some of these features may not extend deeply or possess the complexities of caves and mines, many rock features are suitable roosts as they also offer tight crevices and may extend deeply into the rock face, providing shelter from the elements and predators while providing cooler, more stable temperatures compared to tree roosts (Bat Rock Habitat Key 2021, Schorr et al. 2022). However, some rocky features, especially those that make up the Badlands formations or river bluffs, often erode, making these roosting features less stable than cave and mine features (Barnhart and Gillam 2017).

Drinking

Karst formations account for approximately 12% of global landcover, and their aquifers provide 40% of the drinking water for the United States and 25% worldwide (Kalhor et al. 2019). The aquifers supply important drinking opportunities for many species of wildlife, including bats. Caves and mines may feature springs, seeps, and sinkholes that provide water and potentially minerals for cave wildlife (Furey and Racey 2016, Vanderwolf et al. 2017). These water sources may be especially important in times of drought when water on the landscape is scarce. In the Pryor Mountains of Montana, bats were observed entering caves just to drink when water was scarce on the landscape (A. McEwan, Montana Natural Heritage Program, pers. comm.). Water availability in cave systems may be particularly important for white-nose syndrome infected habitats where bats struggle to maintain their water balance and control evaporative losses (Willis et al. 2011).

Breeding

Caves, mines, and geologic structures offer important breeding habitat (Furey and Racey 2016). During the summer, Townsend's big-eared bats exclusively use caves as maternity roosts to rear their pups in stable temperatures and away from disturbance and predation (Sherwin et al. 2000). While most species do not commonly form large maternity colonies in caves, many species including fringed myotis, western long-eared bat, and little brown myotis choose rocky crevices for maternity roosts (Rancourt et al. 2005, Hayes and Adams 2015, Canadian Bat Maternity Roost Protection Working Group 2024). Beyond maternity roosts, caves and mines have been shown to be important sites for "fall swarming events," which is when large groups of bats, particularly males, will aggregate near known hibernacula. Although the exact reasons are unknown, it is thought that fall swarming is related to mating, where males prepare to court females and may also be used to show the young of year hibernacula sites (Lowe 2012, Fraser and McGuire 2023).

Conservation Concerns

White-nose Syndrome

Caves, mines, and geological structures provide optimal microclimates for bats but also provide optimal conditions for the invasive fungus that causes white-nose syndrome (Frick et al. 2016). Once white-nose syndrome is established in these systems, it can quickly affect the entire bat population and cause high mortality rates for several hibernating bat species (Cheng et al. 2021). It can be extremely difficult to eradicate the fungus using traditional fungicides without disrupting the delicate cave ecosystem (Hoyt et al. 2021). Furthermore, because these features are used by a variety of bats for a multitude of purposes, bats can spread the fungus to new roosts and structures (Hoyt et al. 2021). Additionally, humans entering caves and mines recreationally can spread fungal spores to new areas if equipment is not properly decontaminated (Reynolds et al. 2025). Finally, equipment used to survey bats can spread the fungus to other survey areas unless great care is taken with decontamination protocols (White-Nose Syndrome Disease Management Working Group 2024).

Anthropogenic Disturbance

Beyond white-nose syndrome, the main threat to these systems is human interference, disturbance, and degradation (Pierson 1998, Furey and Racey 2016). Irresponsible caving practices, repeated surveys, disturbances within caves and near openings (e.g. parties, fireworks, intensive land modification), and physical alterations to caves, including structural damage to the walls, cave roofs, mine gates, and rocky crevice structures, may force bats to relocate (Furey and Racey 2016, Boyles et al. 2023, Whiting et al. 2024). Additionally, structural modifications can disrupt airflow and microclimates that are necessary for survival (Meierhofer et al. 2024). Vandalism, litter, and direct aggression toward roosting bats can lead to bats awakening early from hibernation or stress mothers and pups, potentially threatening populations and resulting in pup abandonment (Kunz et al. 2011, Furey and Racey 2016). Even well-meaning surveys conducted by bat biologists may cause effects that negatively impact bat populations (Whiting et al. 2024). For example, when conducting hibernacula surveys, even slight disturbances such as whispering, gear clattering, and sampling (e.g., swabbing and band number checks) can cause bats to rouse from torpor, often after the surveyor is gone and has no knowledge of the arousal (Thomas 1995, Whiting et al. 2024). Roused bats may in turn rouse other hibernating bats, causing a cascading effect in the roost (Thomas 1995, Verant et al. 2014, Frick et al. 2016). If surveys are conducted frequently, this may have substantial impacts on hibernating bats and negatively impact their fat stores that are used during each arousal event.

Improper Closures

Mines, although often important roosting and hibernating habitat for many bats, are often considered dangerous to humans who may wish to explore these historic features (Sherwin et al. 2009). There have been hundreds of reports of humans becoming trapped or injured while exploring closed mines (Sherwin et al. 2009). Furthermore, many mines may still contain toxic or radioactive elements, such as uranium, or emit gases that can kill humans with prolonged exposure (Clark and Hothem 1991, Bennett 2016). Because of their threat to human health, many mines have been closed and blocked off (McCullough et al. 2016). Completely sealing mine entrances can be detrimental to bat populations, not only through the loss of available roosting habitat, but if mines are sealed when bats are inside, there may be no way for bats to escape, resulting in mortality (Sherwin et al. 2009). Furthermore, complete closures can alter airflow and microclimate conditions in mines, reducing habitat suitability (Sherwin et al. 2009).

Best Management Practices

Caves, mines, and geological structures are valuable habitats that serve as critical sites for hibernation, breeding, and roosting for many bat species in South Dakota (Tigner and Stukel 2003). These habitats are particularly delicate and are susceptible to degradation and alteration. As such, these habitats and bat populations that rely on them require protection from disturbance. The following BMPs provide guidance for minimizing risks to bats during sensitive periods and protecting the populations that rely on these resources.

- **BMP 5.4.1 – Conduct annual surveys for white-nose syndrome** near known hibernacula. Surveys include winter hibernacula inspections, winter acoustics to detect unusual periods of activity, and spring emergence captures and wing swabs to determine the prevalence and distribution of the fungus in bat populations (Foley et al. 2011, White et al. 2020, U.S. Geological Sciences National Wildlife Health Center 2023). Winter hibernacula surveys should be conducted between January and March and no more than once per year to minimize disturbance to bats (Loeb et al. 2015).
- **BMP 5.4.2 – Conduct environmental sampling of cave, mine, and geological structures** (e.g., swabs of walls and ceilings, soil and guano collection) to detect and monitor the spread of white-nose syndrome (Foley et al. 2011, Verant et al. 2014)
- **BMP 5.4.3 – Follow all white-nose syndrome decontamination protocols** for any gear that was used during sampling or surveying efforts to limit the spread of white-nose syndrome to new areas (White-Nose Syndrome Disease Management Working Group 2024). Install decontamination stations in areas that are frequently visited by the public (e.g., boot scrub and boot wash stations) (Smith and Paylor 2017).

- **BMP 5.4.4 – Adopt a landscape-level management approach. Protect and restore native habitats around caves, mines, and geologic features** (Meierhofer et al. 2024). Promote a diversity of plant species to increase foraging habitat quality, protect watershed health and connectivity, and limit the use of pesticides or other sources of pollution around known roosts to prevent bioaccumulation in foraging bats (Frick et al. 2020, Oliveira et al. 2020).
- **BMP 5.4.5 – Implement a buffer of at least 0.4 km (0.25 mile) around known bat roosts and hibernacula** and limit habitat disturbance and land management, including resource extraction, logging, thinning, and prescribed fire within the buffer (Hester and Grenier 2005, Navo et al. 2018, Johnson and Buffler 2022). Certain species including the federally endangered northern myotis, the tricolored bat, and the Townsend's big-eared bat require at least a 1.5 km buffer around known roosts (Pierson 1998, U.S. Fish and Wildlife Service 2024*b*).
- **BMP 5.4.6 – Limit all forms of disturbance to these systems**, including noise, light, and touching or modifying of cave, mine, and rocky features (Furey and Racey 2016). This includes survey work such as hibernacula counts (Whiting et al. 2024).
- **BMP 5.4.7 – Conduct surveys of caves, mines, and rocky crevices at appropriate times** to determine the presence of bat species to aid in targeted conservation efforts (Weller et al. 2018, U.S. Geological Sciences National Wildlife Health Center 2023). Due to the limited availability of these features in South Dakota, assume all provide suitable bat habitat (Hester and Grenier 2005).
- **BMP 5.4.8 – Identify and map cave, mine, and rocky habitats**-tools such as GIS and LiDAR may aid in the identification of unknown structures on the landscape (Idrees and Pradhan 2016, Frausto Martinez et al. 2019).
- **BMP 5.4.9 – Inactive mines should be closed in a manner that increases human safety while maintaining safe access for bats** (Sherwin et al. 2009). Monitor and retrofit existing mine closures and work with land managers when new mines are closed to ensure closures meet bat use standards (Sherwin et al. 2009, Tobin et al. 2018).
- **BMP 5.4.10 – Install gates at caves and mines that have known bat populations** (Hester and Grenier 2005, Navo et al. 2018). Choose an appropriate gate type dependent on the specific characteristics and criteria fitting for each entrance and species that may be present (Pugh and Altringham 2005, Elliott 2006, Tobin et al. 2018). Ensure bar spacing on gates is adequate for bat passage depending on species (Tobin et al. 2018). Monitor gates for signs of damage and vandalism on a yearly basis and repair structures as necessary (Sherwin et al. 2009).
- **BMP 5.4.11 – Limit the erosion of rocky faces, crevices, and river bluffs** that may occur from recreational practices (e.g., climbing, hiking, UTV use) or during development projects (Pierson 1998, Hester and Grenier 2005, Bat Rock Habitat Key 2021).
- **BMP 5.4.12 – Keep cave and mine locations confidential** and do not list locations on maps or websites (Federal Cave Resources Protection Act of 1988). Limit or restrict public access to caves with known bat hibernacula or maternity roosts.

- **BMP 5.4.13 – Do not place roads within 0.4 km (0.25 mile) from caves, mines**, or other known bat roosts to avoid drawing attention to these features and to limit disturbance from construction and passing vehicles (Hester and Grenier 2005, Navo et al. 2018).
- **BMP 5.4.14 – Install educational signage** where appropriate (e.g., heavily visited areas where feature locations are already known) to spread awareness about the importance of cave, mine, and geological ecosystems and threats to bat populations in these systems (Shapiro et al. 2022).
- **BMP 5.4.15 – Develop educational outreach materials** to inform land managers and the public about the importance of bats on the landscape, their reliance on cave, mine, and geologic features, the threats of white-nose syndrome, and actions that can be taken to limit population disturbance (South Dakota Bat Working Group 2004, Hester and Grenier 2005, Hoffmaster et al. 2016, Shapiro et al. 2022). Promote collaboration among conservation partners to support these efforts (Kading and Kingston 2020).
- **BMP 5.4.16 – Work with qualified caving and climbing groups** to identify occupied caves and mines and incorporate citizen science into conservation efforts (Bat Rock Habitat Key 2021, Schorr et al. 2022, Gross et al. 2023).

5.5 Human-made Structures

Habitat Characteristics

The relationship between bats and human-made structures is complex and shaped by species-specific ecology and the characteristics of altered environments. Various anthropogenic structures such as buildings, bridges, culverts, and dams can provide novel roosting opportunities for some bat species (Table 7). Big brown bats (*Eptesicus fuscus*) and little brown myotis (*Myotis lucifugus*) in particular are known to roost in the crevices and cavities of buildings and bridges, especially in areas where natural roosts are scarce (Neubaum et al. 2007, Coleman and Barclay 2013). In open landscapes, these structures may add vertical complexity and mimic natural roost features. However, the introduction of these structures and corresponding modifications of natural landscapes can involve trade-offs, including increased exposure to light, noise, and human disturbance, as well as habitat fragmentation and homogenization of the landscape (Navo et al. 2018). These dynamics highlight the complexity of human-made structures and the need for such structures to be evaluated within broader ecological and species-specific contexts (Ree and McCarthy 2005).

Buildings

More than half of the bat species found in the United States use buildings such as barns, outbuildings, houses, businesses, schools, and apartment buildings at some point during their annual cycle (Adams 2003, Kunz and Reynolds 2003, Neubaum et al. 2007). Bats occupy a variety of structural elements within buildings, including eaves, attics beneath floorboards and shingles, and within crevices in stone or brick walls (Kunz and Reynolds 2003). Buildings serve a wide range of roosting functions, including maternity roosts, night roosts, bachelor roosts, and transitional day roosts, especially in areas where natural roosts are limited (Kunz and Reynolds 2003, Neubaum et al. 2007).

Bridges, Culverts, and Dams

Bridges, culverts, and dams provide elevated, stable roosting environments, while the associated riprap mimics rock and talus slopes and provides roosting opportunities for bats (McEwan and Bachen 2017). These features may be especially valuable in fragmented landscapes where natural roosts such as snags, trees, and other vertical features are limited or absent (Hinman and Snow 2003, Hester and Grenier 2005, Navo et al. 2018). Bridge surveys have demonstrated significant use of these structures by bats (Bachen et al. 2018).

Artificial Roosts

Artificial roosts can serve as a refuge that may help sustain bat colonies, particularly in extensive agricultural areas with minimal woodlands and other vertical structures (Tuttle et al. 2013). A variety of artificial structures are designed to support roosting bats, including bat houses and condos, bridge-mounted boxes, fake bark, artificial trees, and human-constructed caves. More information on artificial roosts, including proper placement and design (as well as drawbacks), can be found in Appendix E.

Associated Species

Table 7. Bat species known to use human-made structures as of 2025.

		Roost Type		
Common Name	**Scientific Name**	Buildings	Bridges and Culverts	Dams
Townsend's big-eared bat	*Corynorhinus townsendii*	X		
Big brown bat	*Eptesicus fuscus*	X	X	
Long-eared myotis	*Myotis evotis*	X		
Little brown myotis	*Myotis lucifugus*	X	X	X
Northern myotis	*Myotis septentrionalis*	X	X	
Fringed myotis	*Myotis thysanodes*	X		
Long-legged myotis	*Myotis volans*	X		
Evening bat	*Nycticeius humeralis*	X	X	
Tricolored bat	*Perimyotis subflavus*		X	

Important Characteristics for Bats

Roosting

Buildings provide roosting opportunities for both day and night use, and are commonly used as maternity roosts, for bachelor colonies, and as temporary stop-over sites during migration (Kunz and Reynolds 2003). The use of buildings as roosting sites is most common in the warmer, active season, as low temperatures and humidity often prohibit the use of buildings for many species in the winter (Adams 2003, Kunz and Reynolds 2003), although several species are known to overwinter in buildings as well. Buildings with accessible features such as attics, eaves, and structural crevices facilitate bat movement throughout the structure and provide favorable roosting opportunities (Kunz and Reynolds 2003). Where buildings have broad thermal gradients, the ability to move more freely also facilitates access to multiple microclimates, allowing bats to shift locations and thermoregulate as needed (Neubaum et al. 2007). While older buildings often offer more entry points, newer constructions may provide better insulation, suggesting that design and materials of a building may be more important indicators of its suitability as bat roosting habitat than the age of buildings. Proximity of buildings to water sources and quality foraging habitat can enhance the value of building roosts and serve multiple life needs of bats (Kunz and Reynolds 2003, Neubaum et al. 2007).

Bridges, culverts, and dams made of concrete materials can absorb and retain heat more efficiently than other building materials, and surrounding riprap can provide microsites that reduce energy expenditure. Such structures may be particularly beneficial in higher elevation regions with wide-ranging diel temperature fluctuations. The presence of cavities and crevices in these structures offers valuable roost options. Crevices between 1.2 and 3.2 cm (0.5 to 1.25 in) wide, at least 30 cm (12 in) deep, and covered at the top are ideal for many bat species (Keeley and Tuttle 1999, U.S. Fish and Wildlife Service 2024*b*). Older concrete structures with rough textures and irregular surfaces often provide more crevice and cavity options than smoother, sleeker structures (Keeley and Tuttle 1999, Detweiler and Bernard 2023). Bats have been documented roosting in swallow nests located under bridges, culverts, and building overhangs, demonstrating the value of retaining these nests for bat use (South Dakota Bat Working Group 2004, California Bat Working Group 2022). Additionally, covered bridges provide better protection for bats than more open designs (Keeley and Tuttle 1999).

Large dams with internal crevices and compartments provide roosting sites and during sensitive periods such as breeding and hibernation (Berthinussen et al. 2021). In some cases, these roosts are in areas that may become seasonally inundated during water releases, requiring surveys for roost identification and safe exclusion as necessary to prevent flooding-related mortality (Berthinussen et al. 2021).

Artificial roosts are often used to mitigate roost loss from building renovations, tree removals, or exclusion and may also facilitate colony monitoring or research on bat behavior. However, the effectiveness of these structures varies by species, climate, and microhabitat conditions, and their success depends on proper design, placement, and maintenance (Rueegger 2016). With effective design and placement, artificial roosts can provide valuable refuge for maternity colonies, offering warm, stable microclimates needed for pup development and maternal thermoregulation (Rueegger 2016).

Foraging and Drinking

Bridges, culverts, and dams are typically situated near water sources, which are essential for bats to meet their daily water intake and foraging needs. Bats often forage over riparian zones, ponds, and reservoirs, where emerging aquatic insects and increased humidity provide beneficial foraging conditions. Many bats rely on waterbodies as both foraging grounds and navigation corridors, making human-made structures near water especially important in modified landscapes (Voigt and Kingston 2016).

Breeding

Well-insulated buildings that offer a variety of warm, dark spaces are highly attractive to bats, particularly as maternity roosts. The energetic demands of reproduction make warm roosting sites especially valuable for females, as they help reduce energy expenditure during the critical period of pup growth and development (Kunz and Reynolds 2003, Voigt et al. 2016). Bridges also provide important artificial roosting habitat for bats, with structural features such as crevices, joints, and hollow chambers that offer favorable microclimates and protection from predators, making them suitable for day and night roosts and in cases even maternity colonies (Meierhofer et al. 2024). Bats may also swarm near bridges when looking for a mate or searching for potential hibernacula (Bernard et al. 2022). With effective design and placement, artificial roosts can also provide valuable refuge for maternity colonies, offering warm, stable microclimates needed for pup development and maternal thermoregulation (Rueegger 2016).

Protection

The elevated height of many anthropogenic structures provides additional protection from terrestrial predators (Hester and Grenier 2005, Navo et al. 2018). Studies have documented bats selecting bridges at least 3 m (10 ft) above the ground and culverts ranging from 1.5–3 m (5–10 ft) in height (Keeley and Tuttle 1999). Higher culverts that are not susceptible or prone to flooding offer greater roosting benefits (Keeley and Tuttle 1999, Detweiler and Bernard 2023).

Conservation Concerns

Urbanization

The impact of urbanization on bat populations is of growing concern as natural landscapes are rapidly modified across the West. This issue is particularly relevant in South Dakota, where the Northern Great Plains have experienced the fastest and most extensive urban expansion in the shortest time frame of any other biome in the United States (Cromartie 1998, Coleman and Barclay 2013). The effects of urbanization on bats are complex and multi-faceted, as different species may respond to and interact with human-altered environments in varied ways (Navo et al. 2018, Tanalgo et al. 2025). In forested areas, urban development can lead to deforestation, fragmentation, and habitat simplification (Ree and McCarthy 2005), resulting in the loss of critical roosting and foraging sites. Anthropogenic features introduced into more open landscapes such as buildings, bridges, and urban trees can add vertical structure and increase roost options for generalist species such as big brown bats (Neubaum et al. 2007) and little brown myotis (Neubaum et al. 2007, Coleman and Barclay 2013). However, these benefits may be limited to more adaptable, synanthropic species (Coleman and Barclay 2013), and the overall impact of such features likely depends on whether they enhance or reduce landscape heterogeneity and the potential for human conflict when using such features (Gehrt and Chelsvig 2003, Coleman and Barclay 2013).

Persecution and Inadequate Control Measures

Negative public perception or misconceptions of bats can lead to human conflict and attempts to exclude or exterminate bats roosting in buildings (Kunz and Reynolds 2003, Hester and Grenier 2005, Detweiler and Bernard 2023). Improper bat exclusions used to deter bats from roosting in buildings have been associated with bat mortality and reduced reproductive success (Brittingham and Williams 2000, Racey and Entwistle 2003, Hester and Grenier 2005).

Disturbance

Older buildings and bridges that serve as roosts may be demolished for new development or to comply with human safety regulations (Hickman et al. 1999). Modern structures erected to replace demolished buildings and bridges may lack the textured crevices and compartments characteristic of older designs and materials (Kunz 1982*a*, Hinman and Snow 2003, Hester and Grenier 2005), resulting in reduced roost habitat can negatively impact bat populations (Keeley and Tuttle 1999).

Bats that use urban areas with a higher density of bridges and buildings may face an increased risk of vehicle collisions, which can be a significant source of mortality in urban or high-traffic environments (Bennett and Zurcher 2013, Tanalgo et al. 2025). Noise pollution may also negatively impact bats, with one study documenting bats avoiding roads with noise levels exceeding 88 dB (Bennett and Zurcher 2013) and evidence that noise pollution at oil and gas development decreased bat activity in those areas (Warner 2016). The effects of light pollution vary, as some species show reduced activity in artificially lit areas, while others have demonstrated positive associations with artificial lighting (Berthinussen and Altringham 2012, Lewanzik and Voigt 2014).

Ecological Traps

While artificial roosts such as bat houses can support conservation goals, under certain conditions they can also pose unintended ecological risks. If improperly designed or placed, these structures can function as ecological traps that may reduce individual fitness or survival (Crawford and O'Keefe 2021, 2024, Pschonny et al. 2022). For example, bat houses that are too small, poorly ventilated, or exposed to excessive heat may lead to thermal stress, dehydration, or abandonment (Rueegger 2016, Crawford and O'Keefe 2024). Attempting to attract bats to areas with sub-optimal or fragmented foraging habitats or areas with heavy pesticide use via artificial housing may negatively affect bat populations. In urban and suburban environments, artificial roosts may also increase exposure to predators such as domestic cats or birds of prey (Russo and Ancillotto 2015, Tanalgo et al. 2025). Compared to more ephemeral, natural roosts such as snags and tree cavities, artificial roosts may facilitate greater disease transmission as they often persist long on the landscape and concentrate bat use (Crawford and O'Keefe 2024). Without proper cleaning and maintenance, artificial roosts that support high densities or repeated use of the same structure may increase contact among individuals, perpetuating the spread of pathogens and ectoparasites (Rueegger 2016, Pschonny et al. 2022, Crawford and O'Keefe 2024). Additionally, human activity around artificial roosts may cause disturbance that can negatively impact bat behavior, roost fidelity, and energy reserves (Speakman et al. 1991).

Best Management Practices

Human-made structures present ecological trade-offs that can have varied effects on bat populations. The following BMPs offer practical guidance for protecting these resources while minimizing potential negative impacts on bats.

- **BMP 5.5.1 – Conduct surveys of human-made structures prior to modification or demolition** to assess roost suitability and use (Hester and Grenier 2005). If evidence of bat use is observed, consider building the replacement structure nearby and retaining the original structure to preserve the roost habitat (Keeley and Tuttle 1999, Hinman and Snow 2003, Hester and Grenier 2005).
- **BMP 5.5.2 – Avoid excluding bats from occupied structures whenever feasible.** Bats roosting on or near building exteriors do not typically pose a threat to human inhabitants (Hinman and Snow 2003, Hester and Grenier 2005).
- **BMP 5.5.3 – Promote public education on humane bat exclusions**, emphasizing proper timing (e.g., outside maternity season), safe installation methods, and alternatives such as one-way exclusion devices to reduce harm to bats and prevent roost abandonment (Kunz and Reynolds 2003, Hester and Grenier 2005).
- **BMP 5.5.4 – Schedule any unavoidable/necessary demolition of human-made structures or exclusion installment between October 1st – April 1st** to minimize roost loss and bat mortality during the active season (Tigner 2002, Hester and Grenier 2005). Conduct surveys prior to exclusion or demolition for projects at any time of year (BMP 5.5.1), as bats may also use human-made structures as hibernacula during the winter and early spring. If exclusion work must be conducted when bats are actively using the roost, use human devices such as mesh netting or one-way doors that allow bats to exit but not enter the roost (Navo et al. 2018).
- **BMP 5.5.5 – Encourage installation of artificial roosts such as bat houses when exclusions occur, and provide public resources on species-specific design, placement, and habitat considerations.** Well-designed and appropriately sited bat houses can support displaced bats and promote coexistence with humans (Keeley and Tuttle 1999, Hester and Grenier 2005, Keinath 2005). See Appendix E for further information and instructions on bat house designs and proper placement.
- **BMP 5.5.6 – Preserve and protect foraging habitat and water sources within 1.5 km (1 mile) of human-made roost structures**, as access to nearby foraging and drinking sites is critical for bat survival and reproductive success (Pierson et al. 1999, Hester and Grenier 2005, O’Shea et al. 2016, Crawford and O’Keefe 2024).
- **BMP 5.5.7 – Collaborate with state and local transportation departments and land management agencies to survey for bats under bridges and in culverts** to provide more detailed guidance on detecting bats and address specific questions pertaining to bat management and monitoring (Bachen et al. 2018). Survey methods may include swabbing for white-nose syndrome, guano sampling and eDNA swabs, and visual

inspections to confirm use (Clare et al. 2022). See section 7.3 on Monitoring Guidelines and Applications for more information.

- **BMP 5.5.8 – Work with state and local transportation departments to raise awareness of the importance of bridges and culverts** for bat conservation and the value of conserving these roosts (Navo et al. 2018).
- **BMP 5.5.9 – Consider roost suitability when designing and constructing new bridges and culverts as feasible** (Hester and Grenier 2005). Strategies include constructing bridges with expansion joints or other crevices and cavities to enhance roost options (Wetzel and Roby 2023) and constructing modified box culverts (termed bat-domed culverts) that are specially designed to accommodate bat colonies (Keeley and Tuttle 1999). Provide state and local transportation departments with bat-friendly bridge designs and modifications (Navo et al. 2018).

6. Collaboration and Educational Outreach

6.1 Collaboration

Enhancing communication among partners at national, regional, state-wide, and local levels on bat projects can build efficiencies and enhance partnerships through various channels (Taylor et al. 2017, Reichert et al. 2021, Schorr et al. 2025). Numerous potential collaborators across local, state, and federal agencies, tribes, non-profit organizations, consulting agencies, universities, and the public will ultimately aid bat conservation and management across the state (for a full list of potential collaborators see Appendix B) (Kading and Kingston 2020). Local, regional, and national working groups such as the South Dakota Bat Working Group, the Western Bat Working Group, the Midwest Bat Working Group, and the North American Bat Monitoring Program provide opportunities for networking and cross-agency and cross-regional collaboration. These group driven initiatives not only support consistent data collection and protocol development but provide means of reporting critical findings to a multitude of outlets. An organized effort to have various groups collaborating on bat conservation is a vital step in opening the dialogue between federal agencies, local governments, and on-the-ground researchers (South Dakota Bat Working Group 2004). Strengthening these partnerships across a multitude of levels will be invaluable in the effort of bat conservation and long-term action plans to protect wildlife.

6.2 Educational Outreach

Educational actions can help build a broader base of understanding for the public surrounding bat ecology, conservation, and their importance. Cave-specific education could be expanded through the development and sharing of grey literature such as public-friendly books, educational videos covering cave ecosystems and white-nose syndrome, and potential workshops hosted for early career scientists (Shapiro et al. 2022). Working groups may play a role by hosting workshops that bring together private landowners, forest managing agencies, and other parties that are interested in discussing bat conservation, bat ecology, and general conservation issues (Western Bat Working Group 2025). Particular attention should be given to identifying and contacting private landowners who may unknowingly be hosting hibernacula on their properties (Debby and Dick 2012). An effort to contact private landowners will also encourage citizen scientists who are interested in bat conservation. Citizen scientists may help in reporting bat roosts or areas of high foraging activity along with potentially collecting observation data that could be shared with university or governmental personnel (Gross et al. 2023). Agencies and universities may coordinate to facilitate events like a bio-blitz; where experts on bats, insects, and birds engage with the public in a hands-on conservation experience while systematically surveying an area of interest (Graeter et al. 2015). Organizations such as the South Dakota State University Student Chapter of The Wildlife Society can play a key role in public outreach by visiting schools, building on prior wildlife education initiatives.

The South Dakota Bat Working Group has consistently prioritized educational outreach as a key component of bat conservation. Over the years, the group has implemented a range of educational initiatives and developed resources such as educational bat kits (including presentations, videos, activities, and displays) and posters distributed to school systems across South Dakota (South Dakota Bat Working Group 2018). Furthermore, they created a series of free educational bat books that they distributed to schools and libraries across the state (South Dakota Bat Working Group 2018). Continuing and expanding educational outreach should remain a priority for bat conservation partners. Efforts should focus on engaging the public to increase awareness and understanding of bats and their habitats, dispel common myths, provide educational materials, conflict mitigation resources, promote bat habitat enhancements, and host public bat nights for the public. Researchers can help bring attention to local bat species by taking flattering photographs of bats for presentations or outreach events (White-Nose Syndrome Communications and Outreach Group 2023). By collaborating across jurisdictions and organizational boundaries, and by pooling resources and expertise, partners can significantly advance long-term conservation outcomes for bat populations in South Dakota.

7. Research Highlights and Monitoring Guidelines

7.1 Research Highlights

Ongoing and Previous Research and Monitoring

A comprehensive literature review of ongoing and previous South Dakota bat research and monitoring has been compiled in Appendix C, synthesizing all relevant literature and reports since the 2004 edition; this review includes:

- Ongoing research and monitoring efforts (at time of preparation)
- Peer-reviewed research
- Theses/Dissertations
- Agency survey reports
- Wind-farm survey reports
- Notes/Occasional papers

Each reviewed source of information is accompanied by proper citations and a brief description of the research conducted. By consolidating this information, the literature review serves as a valuable resource for understanding past and current bat research and monitoring efforts in South Dakota. This approach of collecting information helps identify research trends, highlight knowledge gaps, and informs future efforts for bat conservation and management in South Dakota.

7.2 Research and Monitoring Needs

While many research and monitoring (R&M) efforts are ongoing, there has been relatively little focus on South Dakota bats, leaving multiple knowledge gaps that hinder effective management and conservation. Below we have listed several identified gaps impacting bat management and conservation in the state and across the Great Plains. While this list highlights priority research needs, it is not exhaustive, and work should be done in collaboration with conservation partners to identify additional knowledge gaps.

- **R&M 7.2.1 –** Information on species distributions and abundance, high-value habitats, roosting requirements, and the location and characteristics of maternity colonies and hibernacula.
- **R&M 7.2.2 –** Information on migration and seasonal movement corridors across the state for both migratory and hibernating species (e.g., hotspots for migratory species during spring and fall migration or potential for bats to move to and from the Black Hills National Forest via riparian corridors).
- **R&M 7.2.3 –** The effects of land management practices such as prescribed burns, resource extraction, forest thinning, and wind farm installations, participation in Conservation Reserve and Conservation Reserve Enhancement Programs, and activities on state managed Game Production Areas, and federally managed Waterfowl Production Areas and National Wildlife Refuges.
- **R&M 7.2.4 –** Use of urban areas and human-made structures by sensitive bat species.

- **R&M 7.2.5 –** The effects of contaminants that may be directly or indirectly affect bats including herbicides, pesticides, heavy metals, and other sources of point and non-point source pollution.
- **R&M 7.2.6 –** Information on the distribution, prevalence, and impact of white-nose syndrome on South Dakota bats.
- **R&M 7.2.7 –** The impacts of climate change, including unpredictable weather patterns and drought, on South Dakota bat populations and associated foraging habitat.
- **R&M 7.2.8 –** The impacts of invasive plant and animal species (e.g., impacts of monocultures like smooth brome on foraging habitat quality and the extent and impact of cat predation on bats).
- **R&M 7.2.9 –** The impacts of human-bat conflict and roost disturbance within the state, use of improper removal practices by companies and property owners, and expanding educational outreach in effective, audience-specific ways.
- **R&M 7.2.10 –** Evaluate the sensitivity and elasticity of key vital rates, assess metapopulation dynamics, and analyze interspecific relationships to guide resource allocation and inform management actions that enhance bat population growth and diversity.

7.3 Monitoring Guidelines and Applications

Monitoring and research employ a wide range of methodologies; different methods have trade-offs depending on the research questions or project goals. Several methods have distinct advantages and disadvantages, and often multiple methods are used simultaneously to help address data uncertainties and gaps. Each method requires varying levels of effort, staff-time, and equipment costs, and addresses different metrics. The following methods form a robust toolkit for understanding and conserving bat populations.

Acoustic Surveillance

Acoustic surveys are a widely used, non-invasive approach to record and identify the ultrasonic calls emitted by echolocating bats (Loeb et al. 2015). Such surveys are most useful for collecting species level detection/non-detection data and activity data. Acoustic surveys may be stationary where detectors are placed at fixed locations and programmed to record for prolonged timeframes or mobile where detectors are carried or mounted and moved through an area along specified routes (Loeb et al. 2015, Fraser et al. 2020). Each method has distinct strengths and limitations and may be selected based on specific project goals or site conditions (Table 8). For example, stationary acoustic surveys cannot provide true abundance estimates, as recordings cannot distinguish whether calls originate from one individual or multiple bats. However, they can be used to assess general activity levels and are valuable for collecting long-term data to evaluate temporal variation in bat presence and behavior. In contrast, mobile acoustic surveys can offer estimates of relative abundance based on the assumption that each bat is only detected once along the survey route. However, this method captures only a brief snapshot in time and may miss temporal fluctuations. While these methods can be used independently of one another, these approaches can complement one another by providing both robust long-term occupancy data and relative abundance estimates for bat populations (Loeb et al. 2015).

Acoustic deployments may result in large datasets that make processing time consuming. Several programs (e.g., Kaleidoscope Pro, SonoBat) are useful for automatically processing acoustic data, although not all software and classification packages are approved by the U.S. Fish and Wildlife Service to identify rare and endangered species (U.S. Fish and Wildlife Service 2024*b*). Acoustic processing software struggles to distinguish some species or calls (Table 9), resulting in ambiguous results or false-positive and false-negative detections (Loeb et al. 2015). False-negative and false-positive rates may be reduced by manually vetting calls; however, this process can be time consuming and requires substantial training to ensure accuracy (Russo and Voigt 2016, Hopp et al. 2025).

Acoustic detectors may record in full-spectrum, which records the entire range of frequencies and amplitudes present in a bat's call, providing a detailed representation of the complete waveform, or zero-crossing, which records only the points at which the waveform crosses the baseline (zero amplitude) (Loeb et al. 2015). Full-spectrum recordings retain more call information but generate larger files, requiring significant storage space compared to zero-crossing recordings (Agranat 2013). Most acoustic detectors on the market record in full-spectrum or allow the user to select from full-spectrum or zero-crossing. Several detector microphones also exist, including omnidirectional and directional. Directional microphones are used for recording calls at a greater distance and for noise reduction, but do not cover as broad of an area as omnidirectional microphones (Loeb et al. 2015, 2020). When acoustic detectors are placed near known or suspected hibernacula, care must be taken to follow appropriate decontamination protocols to avoid the spread of white-nose syndrome (White-Nose Syndrome Disease Management Working Group 2024).

Table 8. Different uses and factors for stationary and mobile acoustic surveys.

Aspect	Stationary Detection	Mobile Detection
Deployment	Fixed location	Transect or survey route
Spatial Coverage	Limited; fixed radius (~20 m) around detector	Broad; extensive area coverage
Temporal Coverage	Continuous; long-term (days–months)	Short duration; continuous movement, brief at each location
Primary Use	Monitoring temporal activity patterns	Broad-scale spatial inventory and estimating abundance
Analysis Complexity	Moderate (focused and consistent location)	High (variable conditions, brief samples)
Logistics	Requires periodic visits, battery exchanges	Single or repeated routes required

Table 9. Specific call characteristics of South Dakota bat species. Call sequences data comes from Bachen et al. (2018). A full detail of call characteristics of bat species in South Dakota can be found in the Bachen et al. 2018 report. Table describes whether species can confidently be identified using auto-ID software (High/Medium/Low), the minimum frequency range (Fmin) for each species, whether the species is considered broadband, narrowband, and whether it has a characteristic frequency (Fc) >40k (Y – yes, N – no), and information on species with similar call characteristics.

Common Name	Scientific Name	Auto ID Confidence	Fmin	Bandwidth (>40k Fc)	Similar Species
Townsend's big-eared bat	*Corynorhinus townsendii*	Medium[a]	17–25	Broad (N)	Northern hoary bat, fringed myotis
Big brown bat	*Eptesicus fuscus*	High	24–30	Narrow (N)	Eastern red bat, silver-haired bat
Eastern red bat	*Lasiurus borealis*	High	34–46	Narrow (Y)	Big brown bat, evening bat, tricolored bat
Northern hoary bat	*Lasiurus cinereus*	High	16–24	Narrow (N)	Silver-haired bat
Silver-haired bat	*Lasionycteris noctivagans*	Medium	22–29	Narrow (N)	Big brown bat, northern hoary bat
Western small-footed myotis	*Myotis ciliolabrum*	Low[b]	37–43	Broad (Y)	Little brown myotis, northern myotis, long-legged myotis
Long-eared myotis	*Myotis evotis*	Low[b]	24–34	Broad (N)	Northern myotis, fringed myotis, long-legged myotis
Little brown myotis	*Myotis lucifugus*	Low[b]	34–42	Broad (Y)	Western small-footed myotis, little brown myotis, northern myotis, long-legged myotis
Northern myotis	*Myotis septentrionalis*	Low[b]	27–47	Broad (Y)	Western small-footed myotis, little brown myotis, long-eared myotis, long-legged myotis
Fringed myotis	*Myotis thysanodes*	Low[b]	14–24	Broad (N)	Northern myotis, long-eared myotis, long-legged myotis
Long-legged myotis	*Myotis volans*	Low[b]	31–43	Broad (Y)	Western small-footed myotis, little brown myotis, northern myotis, long-eared myotis
Evening bat	*Nycticeius humeralis*	Medium	28–43	Narrow (N)	Eastern red bat, tricolored bat
Tricolored bat	*Perimyotis subflavus*	Medium[a]	34–46	Both	Eastern red bat, evening bat

[a]Have diagnostic calls that can help distinguish from other species but call sequences may not be present in all recordings.

[b]Requires manual vetting and high quality calls to distinguish from other *Myotis* species.

Mist-netting

Mist-netting is a widely-used physical capture method for surveying bats (Loeb et al. 2015). This method can be used to gather species detection/non-detection data and individuals may be uniquely marked, facilitating abundance estimation (Loeb et al. 2015). Other data can be collected on bat capture including reproductive status, age, sex, health, morphometric data (forearm length, mass, presence of a keeled calcar, tail length, and tragus length), and various biological samples for disease sampling, dietary analyses, and genetic analyses. Voucher photographs of distinguishing morphological characteristics can also be collected while bats are in hand, which can be particularly important when handling species that may be visually similar to federally endangered species (i.e., little brown myotis and northern myotis). Mist-netting also facilitates the tagging of bats with transmitters or arm bands, which can be used to monitor individuals longer term (see below) (Ellison 2008, O'Mara et al. 2014, Loeb et al. 2015). While certain bat species can still be challenging to identify in hand (see dichotomous key in Appendix C of 2004 South Dakota Bat Management Plan and the dichotomous key from the Montana Natural Heritage Program), particularly some members of the genus *Myotis*, this method is generally thought to result in fewer false-positive and false negative identifications than acoustic sampling when researchers are properly trained (Loeb et al. 2015). As such, mist-netting is recommended and commonly employed to supplement and verify acoustic data records, particularly for sensitive and otherwise hard to identify species (U.S. Fish and Wildlife Service 2024*b*).

Mist-netting involves the positioning of a thin, near invisible nylon net in areas used by target species; frequently canopy flyways, foraging areas, and near/over water sources (Loeb et al. 2015, U.S. Fish and Wildlife Service 2024*b*). Nets are generally opened prior to emergence and around sunset to avoid non-target bird captures. They are then checked by survey personnel at frequent intervals (i.e., every 10 to 15 minutes) for several hours (Ellison et al. 2013). When conducted properly mist netting is considered a relatively safe survey method but can result in stress, injury, or mortality to bats and care should be taken to follow proper protocols and have properly trained individuals extracting and handling bats to minimize risk (Ellison et al. 2013). Care must be taken to follow appropriate decontamination protocols to avoid the spread of white-nose syndrome (White-Nose Syndrome Disease Management Working Group 2024).

Harp Trapping

Similar to mist-netting, harp trapping is a specialized capture method that can be used to gather species detection/non-detection data, uniquely mark individuals, and collect physiological and morphological data and biological samples (See Mist-netting above for a more complete description of samples) (Ellison et al. 2013, Loeb et al. 2015). Harp traps are less commonly employed than mist nets, although their use is increasing (Tanshi and Kingston 2021). They are most effective on bats that are known to avoid mist-nets or in areas where a large volume of bats are expected to be captured, such as during fall swarming events (Ellison et al. 2013, Tanshi and Kingston 2021). They are generally placed near pinch points that are frequented by bats such as cave or mine entrances, and heavily used flyways (Tanshi and Kingston 2021). Harp traps consist of vertical rows of fine wires stretched across a frame, with a collecting bag, positioned below the frame. When the bats fly into the wires, their flight is interrupted, and they slide down into the collecting bag where the researchers can collect them (Ellison et al. 2013). Similar to mist-netting, harp trapping is generally considered to be a safe capture method, but like other capture methods can result in stress, injury, and even death to bats and care should be taken to follow proper protocols and have properly trained individual handling bats to minimize risk (Ellison et al. 2013). Care must be taken to follow appropriate decontamination protocols to avoid the spread of white-nose syndrome (White-Nose Syndrome Disease Management Working Group 2024).

Radio, GPS, and PIT Tagging

Radio-telemetry is frequently employed to assess bat movement, behavior, habitat use, and to locate important sites such roosts, maternity colonies, migratory stop-over sites, and hibernacula (Ellison et al. 2013, U.S. Fish and Wildlife Service 2024*b*). Typically, a small radio transmitter, less than 5% of the body weight (Aldridge and Brigham 1988) is temporarily affixed using specialized surgical glue between the scapula and allowed to dry briefly prior to release. Tagged bats can then be tracked via very high frequency (VHF) radio-telemetry using handheld or stationary mounted antennas and receivers until the transmitter becomes detached or the battery dies (~2–4 weeks, depending on the transmitter and the activity of the bat) (Ellison et al. 2013, O'Mara et al. 2014). VHF radio-tracking, while commonly used to study important life history traits of bats, can be time-intensive and often unsuccessful (O'Mara et al. 2014).

Global Positioning System (GPS) tags are an emerging avenue to study bat movements, although their use for bats has largely been limited due to improper device weights for small insectivorous bats (O'Mara et al. 2014). However, recent technological advances have allowed for the use of GPS tags for certain species (Gonsalves et al. 2024, Stidsholt et al. 2024). At the time of this publication, GPS transmitters are not commonly used in North America due to weight limitations; however, GPS loggers and some GPS transmitter options, including solar options, may be viable for tree roosting and other larger bat species. Recently, a study conducted in Zion National Park, Utah used GPS transmitters on several *Myotis* to identify hibernacula and track winter movements in the park, but these data are yet to be published (Z. Warren, BCI, pers. comm.). As technology advances, GPS transmitters may become more accessible for bat studies.

Passive Integrated Transponder (PIT) tags are a valuable tool for acquiring population estimates and understanding population dynamics, including survival, movement, activity, and abundance over time (Sedgeley et al. 2012, Ellison et al. 2013). PIT tags are small, permanent microchips that are implanted subcutaneously, typically between the scapulae. They emit a unique signal when they pass near an electronic reader, which are often placed in areas of high bat traffic, such as roost entrances or flyways (Ellison et al. 2013, van Harten et al. 2019). Unlike radio telemetry, PIT tags do not readily enable active tracking but allow for long-term, non-invasive stationary monitoring of individual movements and can yield more precise population estimates than other survey methods

(Ellison et al. 2013). PIT tag data have been used to estimate parturition timing and reproductive success in some species (Ellison et al. 2013, Fontaine et al. 2024). However, PIT tag effectiveness depends on strategic reader placement; they are less useful in roosts where bats do not pass in close proximity to the receiver (Ellison et al. 2013).

Motus Wildlife Tracking Systems

Motus is an international collaborative network that uses radio telemetry to track transmitted organisms, including bats, from stationary receivers (i.e., Motus stations) (Taylor et al. 2017). When a tagged animal is detected, the tower receiver logs the date, time, signal direction, and transmitter ID for the event. Both fine and large-scale monitoring set-ups may be deployed depending on project goals, assessing movement, migration, habitat use, and survival of individuals (Taylor et al. 2017). There are several types of Motus station set-ups including stand-alone towers that generally require their own power and internet connection, or antennas and receivers can be added to existing structures such as buildings or other revieing towers, to use existing power (Motus Station Types). Two types of transmitters currently exist for the Motus network (Lotek and Cellular Tracking Technologies (CTT) radio-tags) and each tag works differently depending on the station receiver (Motus – How Tags Work). When building stations, working with surrounding conservation partners to ensure the widest coverage for all tags deployed in the area will greatly improve conservation efforts for bats and other aerial animals (Taylor et al. 2017). South Dakota currently lacks sufficient Motus stations to be considered useful for research and monitoring of bat populations. However, future efforts to install stations across the state may greatly improve our knowledge of bat movements.

Arm Banding

Arm banding, also called wing banding, is a long-term method to mark individual bats, facilitating longer-term mark recapture surveys to assess abundance, movement, survival, and migration patterns (Ellison 2008). The band is a small, lightweight, “c-shaped” piece of metal that is placed on the forearm of the bat. Different styles of arm bands are available, although a recent study suggests that several styles may cause injury, though recovery rates were considered high (Reynolds et al. 2025). Plastic bands and larger-sized metal bands were shown to have the highest rate of injury, while smaller (2.9 mm) aluminum flanged bands had the lowest impact on recaptured bats. While arm bands are useful tools, careful consideration should be used when determining which band to use and in developing banding protocols to minimize potential risks (Ellison 2008, Reynolds et al. 2025).

Genetic Sampling

Genetic sampling is important to accurately confirm species ID. This is especially true for the genus *Myotis*, which is often difficult to distinguish, even in hand (U.S. Fish and Wildlife Service 2025*b*). Accurately identifying species is not only important for conservation, but for compliance under the Endangered Species Act. Genetic samples can be collected via fecal collection, wing or oral swabs, and wing punches (tissue collection) (U.S. Fish and Wildlife Service 2025*b*). Depending on the goal of the study, different approaches may be preferred/used. The USFWS guidelines recommend wing swabs and fecal collection for low-level genetic studies (U.S. Fish and Wildlife Service 2025*b*). For more robust genetic analysis (e.g., metapopulation dynamics, hybridization, genome sampling, etc.), tissue samples are needed (Sedgeley et al. 2012, Corthals et al. 2015, Jebb et al. 2020, Moreno Santillán et al. 2021).

Environmental DNA Sampling

Advancements in environmental DNA (eDNA) sampling can now facilitate the non-invasive collection of detection/non-detection data for bat species and their pathogens, including white-nose syndrome (Vanderwolf et al. 2017, Clare et al. 2022). Many types of environmental samples may be useful for these purposes but swabbing any surfaces bats may have encountered (roost walls, openings, etc.), collecting soil samples, and guano collection have been successfully employed for surveys of bats and their pathogens (Walker et al. 2016, Clare et al. 2022, U.S. Fish and Wildlife Service 2025*b*).

Hibernacula, Colony, and Emergence Counts

Visual surveys, including hibernacula and colony counts, are commonly used, cost-effective methods to estimate bat abundance by directly observing, counting, and recording individuals at a site (Loeb et al. 2015). These techniques can be enhanced using thermal and wildlife cameras, which provide non-invasive options for monitoring bats in hibernacula or maternity colonies. Automated image analysis software is being developed to improve the accuracy and efficiency of colony size estimates (Hayman et al. 2017, Bentley et al. 2023, Krivek et al. 2023). Measuring microclimates (temperature, wind, humidity, etc.) at survey sites can further inform habitat selection and patterns of bat activity.

Hibernacula typically offer stable microclimates, and many bat species exhibit strong site fidelity to these locations. As a result, repeated hibernacula surveys can be a valuable tool for tracking changes in population size over time (Loeb et al. 2015). This approach is especially effective for species that form large, visible aggregations. White-nose syndrome surveillance can be incorporated into hibernacula surveys, with wing swabs collected during mid- to late-hibernation periods to test for the presence of the causative fungus (Coleman et al. 2011). Because hibernating bats are highly sensitive to disturbance, such surveys should be carefully timed, minimally invasive, and limited to essential visits to avoid disrupting torpor and depleting energy reserves (Speakman et al. 1991, Whiting et al. 2024).

Emergence counts are another widely used method, conducted at dusk as bats exit known roosts such as caves, mines, snags, bridges, or bat boxes (Loeb et al. 2015). These counts are useful for monitoring seasonal colony activity and long-term health. Alternatively, some counts are conducted during the day when bats are roosting in structures like bat boxes, which may reduce errors associated with tracking individual bats in flight during emergence (Sedgeley et al. 2012). Daytime counts carry a greater risk of disturbing resting bats and should be done cautiously.

Regardless of the method used, appropriate decontamination protocols must always be followed when entering roost sites to prevent the spread of white-nose syndrome (White-Nose Syndrome Disease Management Working Group 2024).

Monitoring Resources

Protocols and Guidelines

- A Plan for the North American Bat Monitoring Program
- Range-wide Indiana Bat and Northern Long-eared Bat Survey Guidelines
- U.S. Fish and Wildlife Service Cave and Mine Survey Protocol
- U.S. Fish and Wildlife Service Recommended DNA Sampling Methods for Bat Species Identification
- U.S. Geological Service Environmental Sampling for White-Nose Syndrome
- U.S. Geological Service – Collecting a Skin Swab for White-Nose Syndrome Surveillance
- North American Bat Monitoring Program- Hibernacula and Roost Count Surveys
- U.S. Fish and Wildlife Emergence Survey Protocol
- Standard Operating Procedure for the Study of Bats in the Field

Additional Resources

- Bat Conservation International: Bat Detector Guide
- Capture Methods and Holding Devices
- Transmitter Attachment for Small Insectivorous Bats
- Application of Transmitters in Small Insectivorous Bats
- Biomark Terrestrial Monitoring Systems – PIT tags
- Motus Webpage
- USFWS Motus Stations
- Summary and Analysis of the U.S. Government Bat Banding Program
- Northern Arizona University Bat Ecology and Genetics Lab
- USDA Developing Tools to Detect Bats in Soil, Water, and Air
- Bat Workers' Manual
- How to Conduct Summer Bat Colony Counts
- Guidance for Conducting Bat Emergence Surveys at Structures
- White-Nose Syndrome Response Team- Effective Bat Imagery

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Appendices

Appendix A – Species Accounts

Species Accounts Forward

The following species accounts are abbreviated descriptions detailing important characteristics for these species in South Dakota and their current threats. Full species accounts can be found in the 2004 South Dakota Bat Management Plan. Distribution maps created for each species included data from the South Dakota Natural Heritage Database, the Montana Natural Heritage Program, the Wyoming Natural Diversity Database, the Global Biodiversity Information Facility (excluding iNaturalist observations), published literature, unpublished manuscripts, and survey reports. Each distribution map is broken into two categories: acoustic records only, and observational data which includes net captures, hibernacula surveys, and museum records and may also include acoustic records where another observational method is also present. Each map also includes the International Union for Conservation of Nature (IUCN) distribution maps for reference.

Townsend's Big-eared Bat: *Corynorhinus townsendii*

Description

The Townsend's big-eared bat (*Corynorhinus townsendii*) is a relatively large bat that has the longest ears of any species in South Dakota (South Dakota Bat Working Group 2004). They exclusively use caves and mines within western desert scrublands and coniferous forests for both summer roosting and for hibernation (Sherwin et al. 2000), limiting their range to western portions of South Dakota. They are frequently found roosting and hibernating in the Black Hills National Forest in South Dakota (see Tigner survey reports in Appendix C). The Townsend's big-eared bat is considered a "whispering" bat and as such is often difficult to detect using acoustics (Fraser and McGuire 2023) and is more often encountered during mist-net/harp-trap surveys and winter hibernacula counts, where they can be found in groups of up to 100 individuals (Sherwin et al. 2000).

Threats

The Townsend's big-eared bat is considered one of the most sensitive bat species in North America (Gruver and Keinath 2006). They are highly sensitive to cave and mine disturbances including vandalism, heavy land use near known roosts and hibernacula, and improper mine closures (Gruver and Keinath 2006). These disturbances can result in direct mortality or roost abandonment. Townsend's big-eared bats have tested positive for the fungus that causes white-nose syndrome yet these bats do not exhibit symptoms of the disease, despite their cave obligate life-history (Bachen et al. 2018, Frank 2021).

Distribution

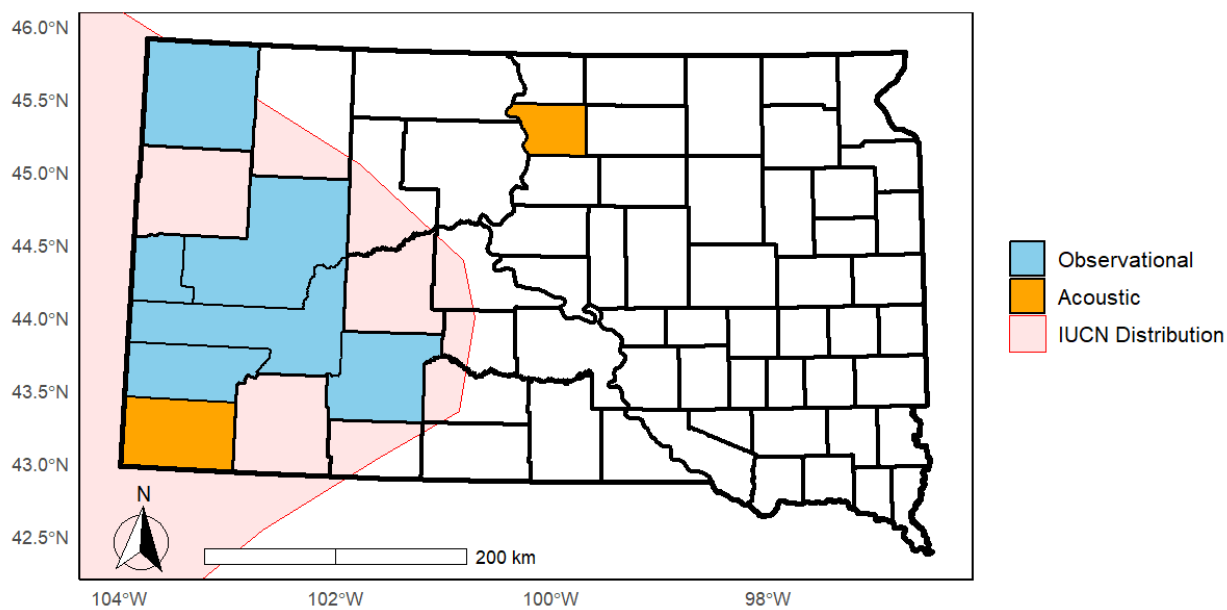

Figure 1. County level observational (blue; including net captures, hibernacula surveys, museum records and may also include acoustic records where another observational method is also present) and acoustic only records (orange) for Townsend's big-eared bat (*Corynorhinus townsendii*). The International Union for Conservation of Nature (IUCN) distribution map for the species is shown in red.

Big Brown Bat: *Eptesicus fuscus*

Description

Big brown bats (*Eptesicus fuscus*) are large-bodied bats with pale brown fur, a broad head, and short, broad wings. As habitat generalists, big brown bats are found across the United States and occupy a wide variety of environments from high-elevation meadows to lowland deserts in both natural and anthropogenic landscapes (Bachen et al. 2018). In South Dakota, big brown bats occur year-round and are common across all habitats in the state including a variety of human-made structures such as mines and buildings (Tigner and Stukel 2003, South Dakota Bat Working Group 2004). They have been found hibernating in buildings and the Black Hills National Forest (Tigner and Stukel 2003; see Tigner survey reports in Appendix C). As insectivores, big brown bats provide valuable pest control services by preying on a variety of agricultural and forest pests, including beetles, stink bugs, leafhoppers, and moths (Bat Conservation International 2025*b*).

Threats

Encroaching development and habitat loss can force big-brown bats to occupy areas with high human activity, increasing the likelihood of human contact and persecution as they roost in human-made structures. Declines in insect abundance and the use of pesticides in both urban areas and agricultural settings can also negatively impact big brown bat populations (Bat Conservation International 2025*b*). White-nose syndrome has been detected on this species but overall impacts on populations are unknown.

Distribution

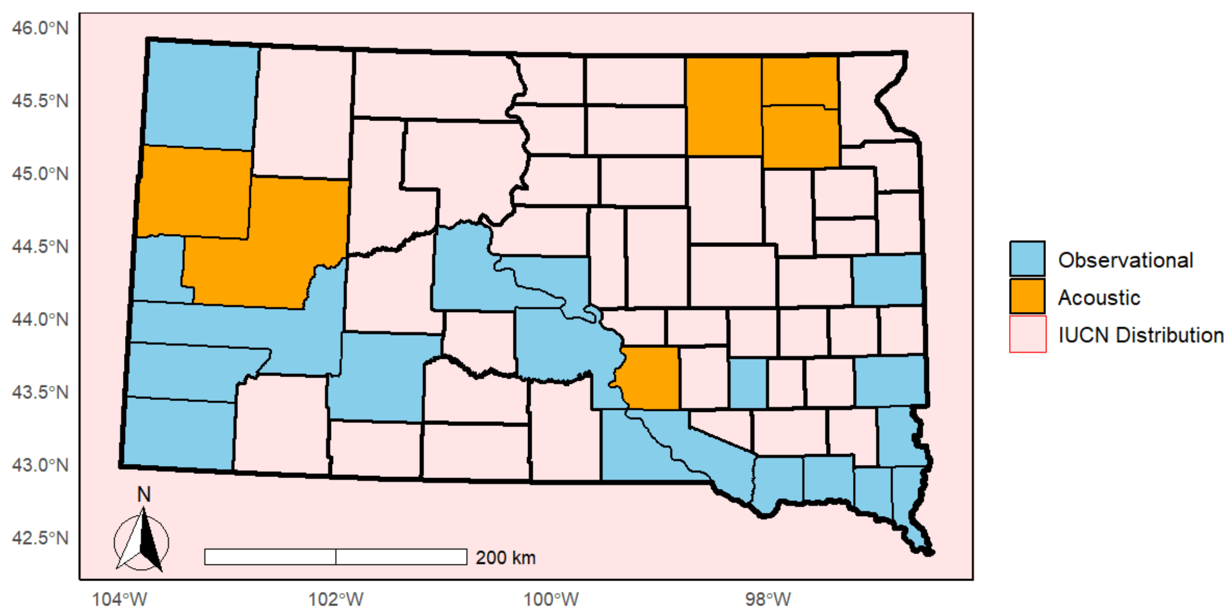

Figure 2. County level observational (blue; including net captures, hibernacula surveys, museum records and may also include acoustic records where another observational method is also present) and acoustic only records (orange) for big brown bat (*Eptesicus fuscus*). The International Union for Conservation of Nature (IUCN) distribution map for the species is shown in red.

Eastern Red Bat: *Lasiurus borealis*

Description

Eastern red bats (*Lasiurus borealis*) are migratory tree bats with orange to reddish fur, with males having darker red fur than the females (Beilke et al. 2023). Eastern red bats have contrastingly dark membranes with fur on their wing and tail membranes (South Dakota Bat Working Group 2004). They can be found in both deciduous and coniferous forested environments and prefer to roost in the foliage of trees rather than in bark or cavities (NatureServe 2025). They are generally solitary outside of pup-rearing season where the mothers often have one to five young (South Dakota Bat Working Group 2004). Eastern red bats can be found statewide during the summer months and migrate south during the fall (Jones and Genoways 1967, South Dakota Bat Working Group 2004).

Threats

The most pressing threat to eastern red bats is wind turbine related mortality, particularly during fall migration (Kunz et al. 2007). Habitat loss due to logging and land conversion also reduces roosting and foraging opportunities for these tree-dependent bats (Cryan and Barclay 2009). Climate change may further disrupt migratory behavior, alter prey availability, and reduce vegetation cover (Frick et al. 2010*b*). Additionally, the use of pesticides to lower insect abundance may expose the eastern red bat to toxins that can accumulate and become fatal (Wickramasinghe et al. 2004).

Distribution

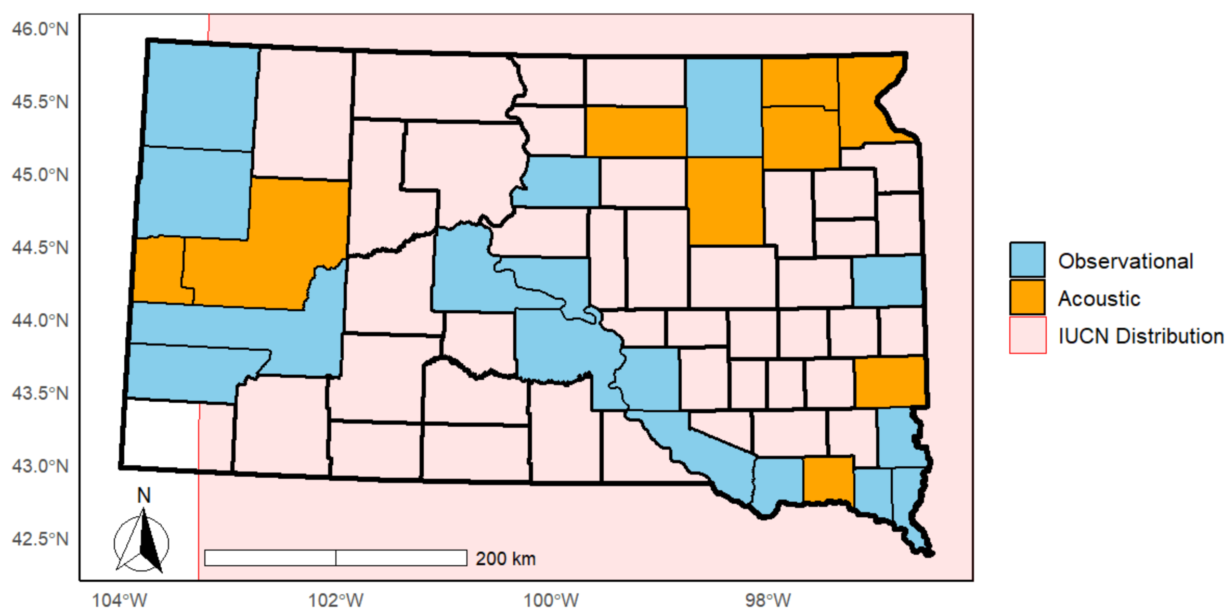

Figure 3. County level observational (blue; including net captures, hibernacula surveys, museum records and may also include acoustic records where another observational method is also present) and acoustic only records (orange) for eastern red bat (*Lasiurus borealis*). The International Union for Conservation of Nature (IUCN) distribution map for the species is shown in red.

Northern Hoary Bat: *Lasiurus cinereus*

Description

The northern hoary bat (*Lasiurus cinereus*) has a thick coat of salt-and-pepper fur giving it a frosted appearance, with a caramel-colored face and black-tipped ears. A tree-roosting specialist, these bats are known to wrap their fur-covered tail membrane around themselves, providing effective camouflage that resembles a dead leaf among thick foliage (Shump 1982, Bat Conservation International 2025*b*). Northern hoary bats are found throughout much of the state during the summer months, foraging over water sources and above tree canopies. Northern hoary bats migrate southward out of the state during the colder winter months (Shump 1982, Tigner and Stukel 2003).

Threats

Wind turbines pose a significant threat to the northern hoary bat. Northern hoary bats account for the highest proportion of bat fatalities at wind energy facilities, estimated at 38% of total mortalities caused by wind energy development (Arnett et al. 2013, 2016). Based on current estimates of population size, growth rate, and wind turbine-related mortality, northern hoary bat populations are projected to decline by as much as 90% by 2060 (Arnett and Baerwald 2013, Frick et al. 2017). Due to their reliance on tree roosts, northern hoary bats are also threatened by deforestation, large-scale logging, and the loss of forested habitat (Bat Conservation International 2025*b*).

Distribution

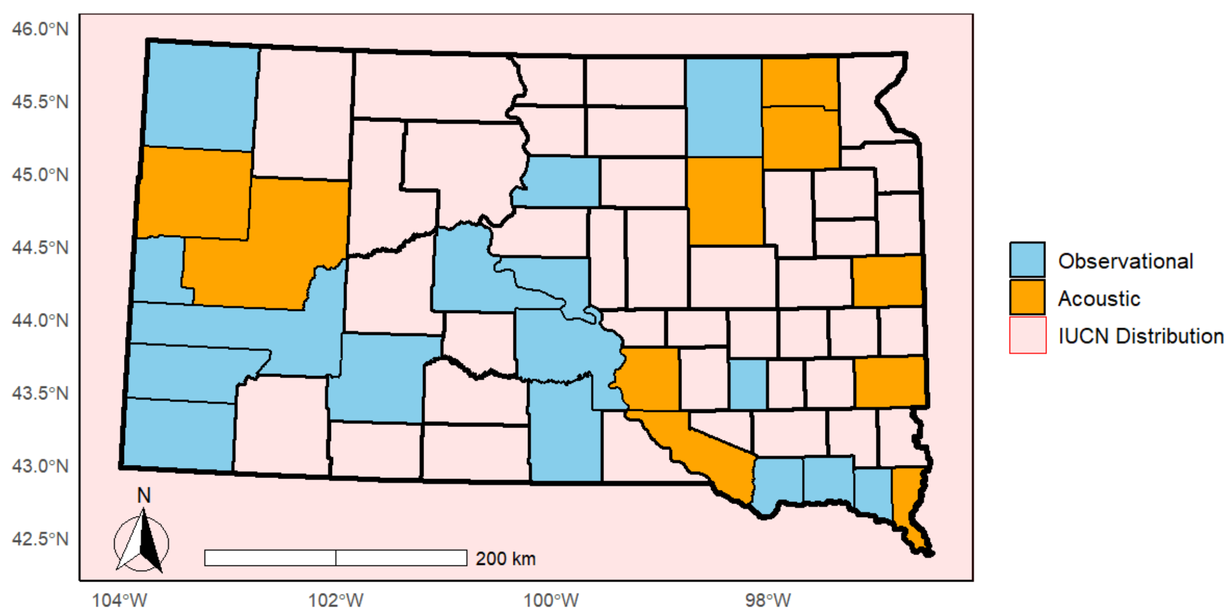

Figure 4. County level observational (blue; including net captures, hibernacula surveys, museum records and may also include acoustic records where another observational method is also present) and acoustic only records (orange) for northern hoary bat (*Lasiurus cinereus*). The International Union for Conservation of Nature (IUCN) distribution map for the species is shown in red.

Silver-haired Bat: *Lasionycteris noctivagans*

Description

Silver-haired bats (*Lasionycteris noctivagans*) are named for their distinctive dark brown to black fur tipped with silver (Kunz 1982*b*). A tree-roosting specialist, the silver-haired bat is associated with coniferous, deciduous, and old-growth forests. With a reliance on mature stands and high snag densities, these bats benefit from heterogeneous forest mosaics that support a variety of age classes (South Dakota Bat Working Group 2004). While they typically roost and forage in forested habitats, they also use open clearings and disturbed areas such as roadways and water courses for foraging (Bat Conservation International 2025*b*). Silver-haired bats are one of the few bat species known to hibernate primarily in forested areas, where they camouflage themselves beneath exfoliating bark, within small tree cavities, and in rocky crevices (Bat Conservation International 2025*b*). In South Dakota, silver-haired bats are found statewide during the summer and have been found hibernating in the Black Hills National Forest (Tigner 2004). They have also been reported in the middle of the state in January (S. Kempema, USFWS, pers. comm.).

Threats

Extensive logging and the selective removal of old-growth forests and snags can negatively impact this tree-roosting species (Colorado Natural Heritage Program 2025). They also face significant risks from wind turbines (Colorado Natural Heritage Program 2025). Additionally, high pesticide use, and declining insect abundance further threaten their populations (Bat Conservation International 2025*b*).

Distribution

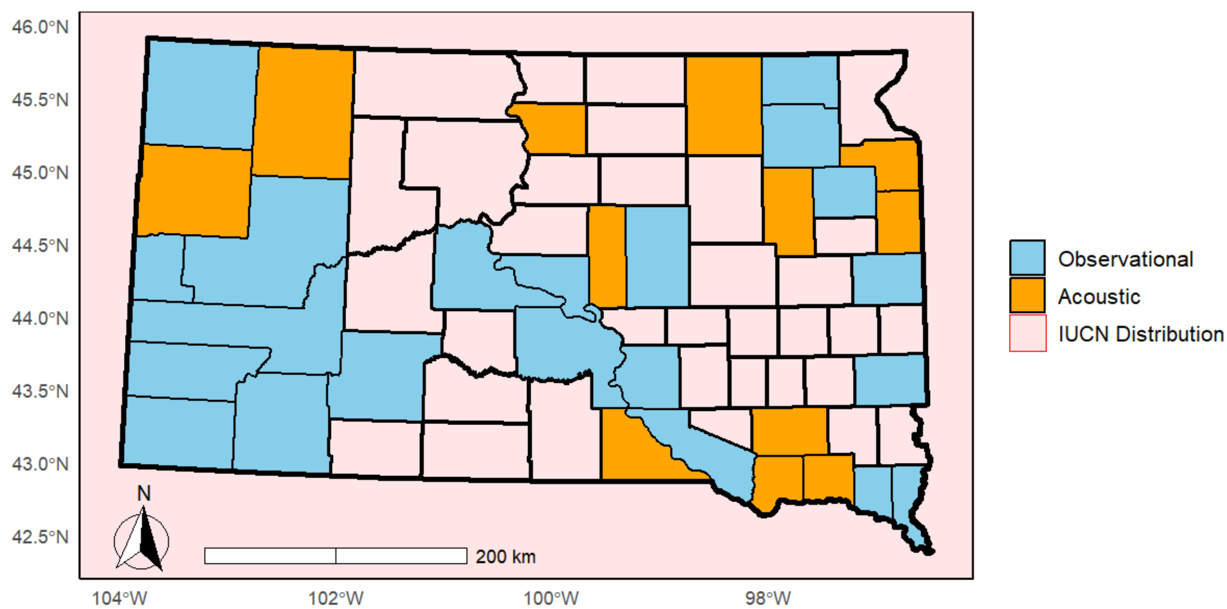

Figure 5. County level observational (blue; including net captures, hibernacula surveys, museum records and may also include acoustic records where another observational method is also present) and acoustic only records (orange) for silver-haired bat (*Lasionycteris noctivagans*). The International Union for Conservation of Nature (IUCN) distribution map for the species is shown in red.

Western Small-footed Myotis: *Myotis ciliolabrum*

Description

Western small-footed myotis (*Myotis ciliolabrum*) is one of the smallest bats in South Dakota next to the tricolored bat (South Dakota Bat Working Group 2004). It has notably small feet relative to its body size along with a keeled calcar (South Dakota Bat Working Group 2004). The western small-footed bat has cream colored fur and dark pigmented ears, face and wing membranes (Holloway and Barclay 2001). Because of its small size and agility, this species can use very small roost features (South Dakota Bat Working Group 2004). This species is associated with multiple habitat types and can be found roosting in crevices and spaces in between rocks and clay. It can be found across western South Dakota in the summer months and is known to hibernate in the Black Hills National Forest (see Tigner survey reports in Appendix C).

Threats

As a hibernating *Myotis*, this species is at risk from white-nose syndrome (Frick et al. 2016). Some evidence suggests this species may not be as severely affected compared to other *Myotis* due to lower rates of evaporative water loss. However, recent studies have found no difference between survival rates of *Myotis* with white-nose syndrome (Haase et al. 2020). Other threats that further impact this species include wind energy and habitat loss, particularly of rocky features, caves, and riparian corridors where this species is known to occur (Colorado Natural Heritage Program 2025, NatureServe 2025).

Distribution

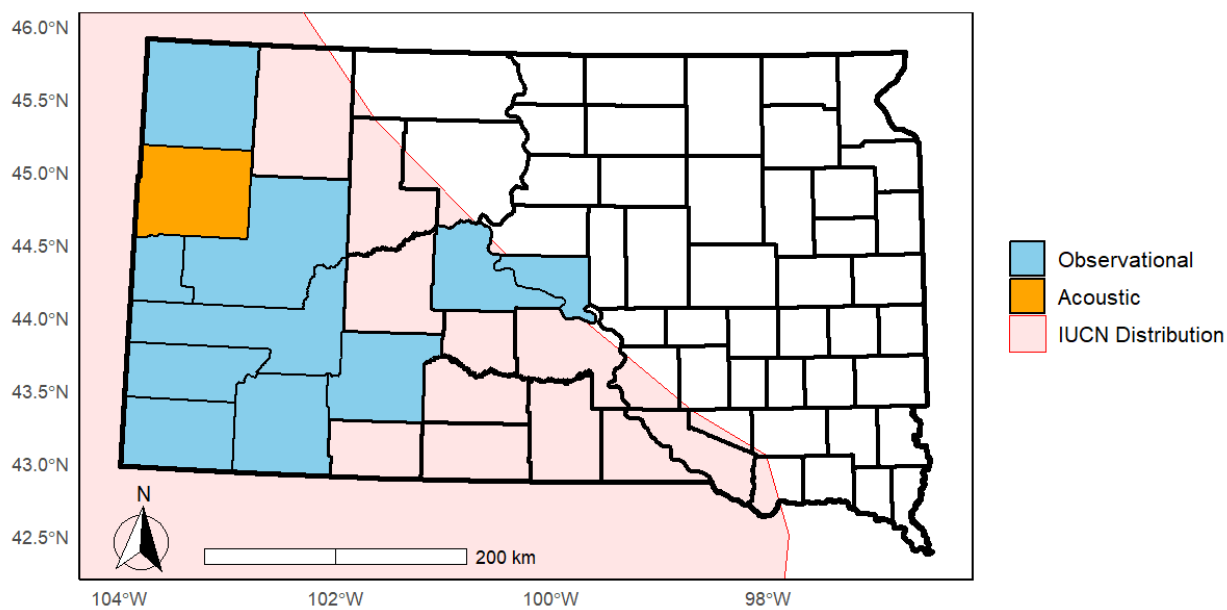

Figure 6. County level observational (blue; including net captures, hibernacula surveys, museum records and may also include acoustic records where another observational method is also present) and acoustic only records (orange) for western small-footed myotis (*Myotis ciliolabrum*). The International Union for Conservation of Nature (IUCN) distribution map for the species is shown in red.

Long-eared Myotis: *Myotis evotis*

Description

The long-eared myotis (*Myotis evotis*) has the largest ears of any *Myotis* in North America (Manning 1989). Their ears and face are generally dark/black, creating a masked appearance (Manning 1989). The long-eared myotis is considered a western species with a limited distribution in South Dakota (Tigner and Stukel 2003). Captures and acoustic recordings of this species are relatively rare in the state and occur primarily within Custer-Gallatin and Black Hills National Forests where it has also been found hibernating (Tigner and Stukel 2003; see Tigner survey reports in Appendix C). The long-eared myotis may use various roosts such as trees, rocky crevices, human-made structures, mines, and caves (Manning 1989). Notably, they have been documented several times roosting in rocky crevices (Chruszcz and Barclay 2002, Snider et al. 2013, Anthony and Sanchez 2019) including maternity roosts (Rancourt et al. 2005).

Threats

As a hibernating bat species, the long-eared myotis is at risk of white-nose syndrome (U.S. Geological Sciences National Wildlife Health Center 2023), particularly in areas like the Black Hills National Forest, where white-nose syndrome has been detected (Abernathy and Whittle 2024). Cave and mine degradation and disturbance may impact this species during hibernation. Other threats that further impact this species include resource extraction, wind energy, and habitat loss, particularly of old growth forests which are used for roosting (Colorado Natural Heritage Program 2025, NatureServe 2025).

Distribution

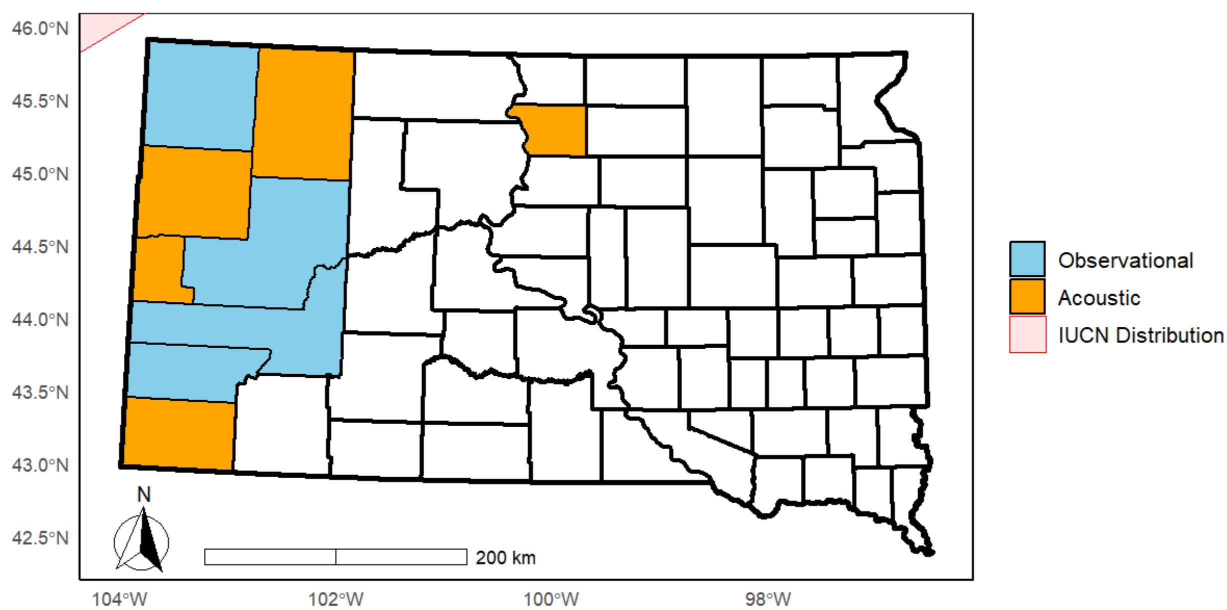

Figure 7. County level observational (blue; including net captures, hibernacula surveys, museum records and may also include acoustic records where another observational method is also present) and acoustic only records (orange) for long-eared myotis (*Myotis evotis*). The International Union for Conservation of Nature (IUCN) distribution map for the species is shown in red.

Little Brown Myotis: *Myotis lucifugus*

Description

The little brown myotis (*Myotis lucifugus*) is aptly named for its small size and soft brown fur. It is widely distributed across forested landscapes of the United States and Canada, ranging from tree-lined scrub to mountainous aspen meadows and coniferous rainforests (Bat Conservation International 2025*b*). Little brown myotis can also be found in human-dominated areas and are known to form large roosting colonies in buildings and other human-made structures (Slough and Jung 2020). Like many other bat species, the little brown myotis commonly forages near water sources, as well as open meadows, farmland, and along cliff faces. Its varied diet of aquatic insects, beetles, and moths make it a valuable asset for the biological control of insect pests (Bat Conservation International 2025*b*). It was historically found throughout the state during the summer and has been found hibernating in the Black Hills (see Tigner survey reports in Appendix C).

Threats

White-nose syndrome has caused precipitous declines in little brown myotis populations, with the most severe impacts observed in the eastern United States (Udell et al. 2022). Other threats that further impact this species include resource extraction, wind energy, and habitat loss, particularly of old growth forests which are used for roosting (Colorado Natural Heritage Program 2025, NatureServe 2025). Additional threats include persecution, as little brown myotis frequently roost in buildings, increasing their risk of conflict with people (South Dakota Bat Working Group 2004).

Distribution

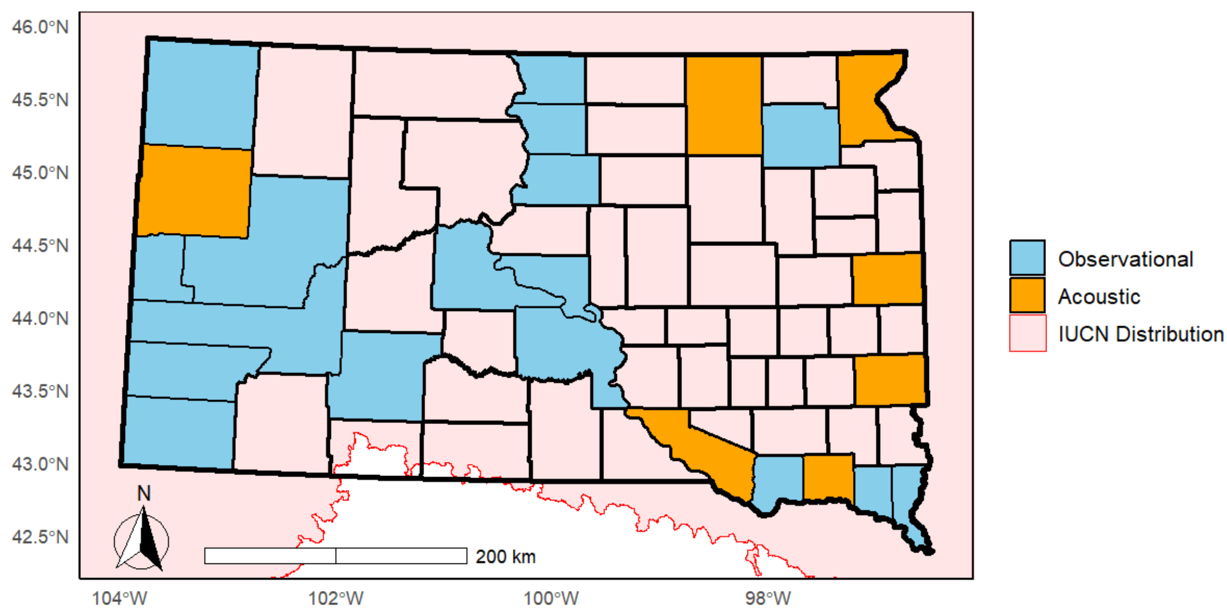

Figure 8. County level observational (blue; including net captures, hibernacula surveys, museum records and may also include acoustic records where another observational method is also present) and acoustic only records (orange) for little brown myotis (*Myotis lucifugus)*. The International Union for Conservation of Nature (IUCN) distribution map for the species is shown in red.

Northern Myotis: *Myotis septentrionalis*

Description

The federally endangered northern myotis (*Myotis septentrionalis*) has long ears that extend beyond the nose and slightly lighter colored ears and face resulting in a less dark mask than other long-eared myotis (U.S. Fish and Wildlife Service 2022). In the Great Plains region, this species can be confused with the little brown myotis; however, a long, sharply pointed tragus and lack of toe hairs on the northern myotis can help distinguish the two species (U.S. Fish and Wildlife Service 2022). Northern myotis can be difficult to detect and differentiate from other *Myotis* spp. using acoustics (Bachen et al. 2018). They are associated with patches of old-growth forest and woodland habitat including cottonwood floodplains, oak, and mixed coniferous forests (Burrell and Bergeson 2022, U.S. Fish and Wildlife Service 2022). Populations in western South Dakota are known to hibernate in the Black Hills National Forest (see Tigner survey reports in Appendix C).

Threats

As a hibernating bat species, the long-eared myotis is at risk of white-nose syndrome (U.S. Geological Sciences National Wildlife Health Center 2023), particularly in areas like the Black Hills National Forest, where white-nose syndrome has been detected (Abernathy and Whittle 2024). Cave and mine degradation and disturbance may impact this species during hibernation. Other threats that further impact this species include resource extraction, wind energy, and habitat loss, particularly of old growth forests which are used for roosting (U.S. Fish and Wildlife Service 2022).

Distribution

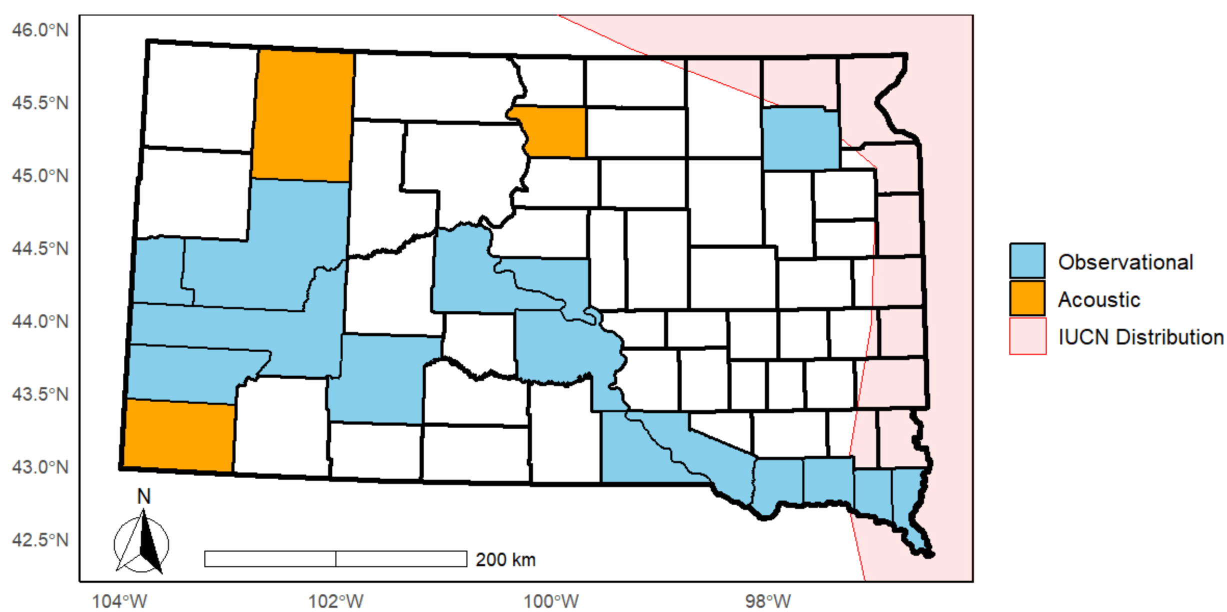

Figure 9. County level observational (blue; including net captures, hibernacula surveys, museum records and may also include acoustic records where another observational method is also present) and acoustic only records (orange) for northern myotis (*Myotis septentrionalis*). The International Union for Conservation of Nature (IUCN) distribution map for the species is shown in red.

Fringe-tailed Myotis: *Myotis thysanodes pahasapensis*

Description

The fringe-tailed myotis (*Myotis thysanodes pahasapensis*) is a western sub-species of the fringed myotis (*M. thysanodes*) with a limited distribution in South Dakota (Jones and Genoways 1967, Tigner and Stukel 2003, Keinath 2004). The sub-species has longer ears and shorter forearms making them difficult to differentiate from the long-eared myotis in this region (Bachen et al. 2018, Geluso and Bogan 2018). However, the fringed myotis is generally slightly larger than the other two species and can be distinguished by a characteristic fringe of hairs on the bottom edge of the uropatagium (Bachen et al. 2018). The fringed myotis may use various roosts such as trees, rocky crevices, human-made structures, mines, and caves (South Dakota Bat Working Group 2004) and hibernates in the Black Hills National Forest (see Tigner survey reports in Appendix C).

Threats

As a hibernating bat species, the fringed myotis is at risk of white-nose syndrome (U.S. Geological Sciences National Wildlife Health Center 2023), particularly in areas like the Black Hills National Forest, where white-nose syndrome has been detected (Abernathy and Whittle 2024). Cave and mine degradation and disturbance may impact this species during hibernation. Other threats that further impact this species include resource extraction, wind energy, and habitat loss, particularly of old growth forests which are used for roosting (Colorado Natural Heritage Program 2025, NatureServe 2025).

Distribution

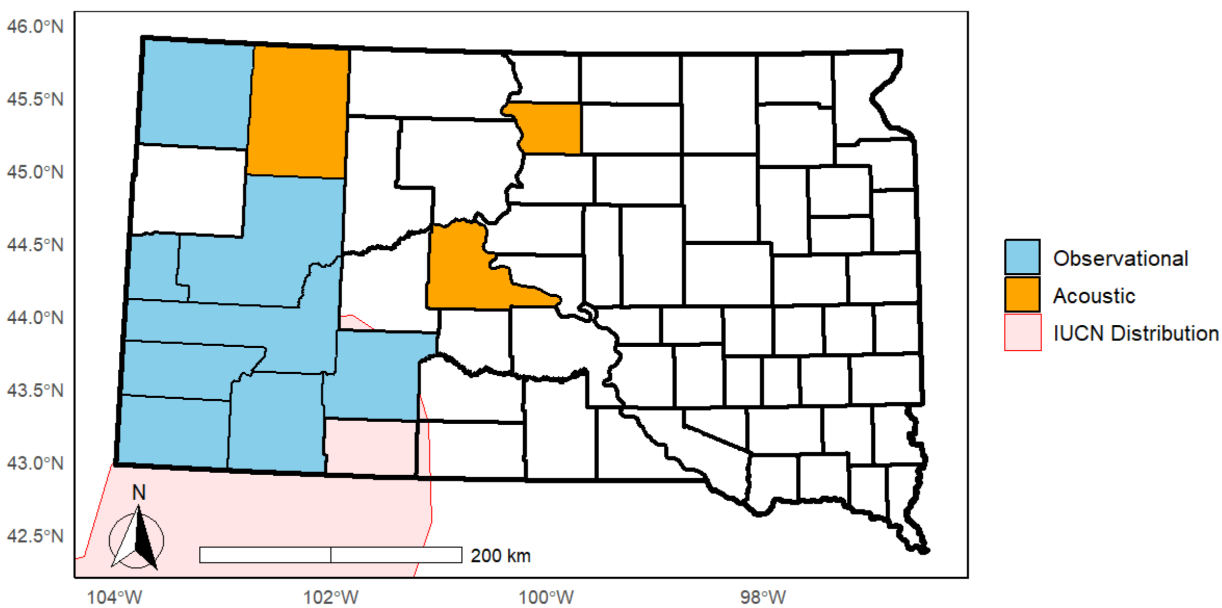

Figure 10. County level observational (blue; including net captures, hibernacula surveys, museum records and may also include acoustic records where another observational method is also present) and acoustic only records (orange) for fringe-tailed myotis (*Myotis thysanodes pahasapensis*). The International Union for Conservation of Nature (IUCN) distribution map for the species is shown in red.

Long-legged Myotis: *Myotis volans*

Description

The long-legged myotis (*Myotis volans*) is a relatively large *Myotis* species that can be distinguished from other *Myotis* by patches of fur on the wings that extend to the elbow and the presence of a keeled calcar (Bachen et al. 2018). The long-legged myotis is considered a western species with a limited distribution in South Dakota, although it may be slightly more common than the long-eared myotis and fringed myotis (Tigner and Stukel 2003). This species has also been found hibernating in the Black Hills (see Tigner survey reports in Appendix C). Long-legged myotis may use various roosts such as trees, rocky crevices, human-made structures, mines, and caves (Warner and Czaplewskit 1984).

Threats

As a hibernating bat species, the long-legged myotis is at risk of white-nose syndrome (U.S. Geological Sciences National Wildlife Health Center 2023), particularly in areas like the Black Hills National Forest, where white-nose syndrome has been detected (Abernathy and Whittle 2024). Cave and mine degradation and disturbance may impact this species during hibernation. Other threats that further impact this species include resource extraction, wind energy, and habitat loss, particularly of old growth forests which are used for roosting (Colorado Natural Heritage Program 2025, NatureServe 2025).

Distribution

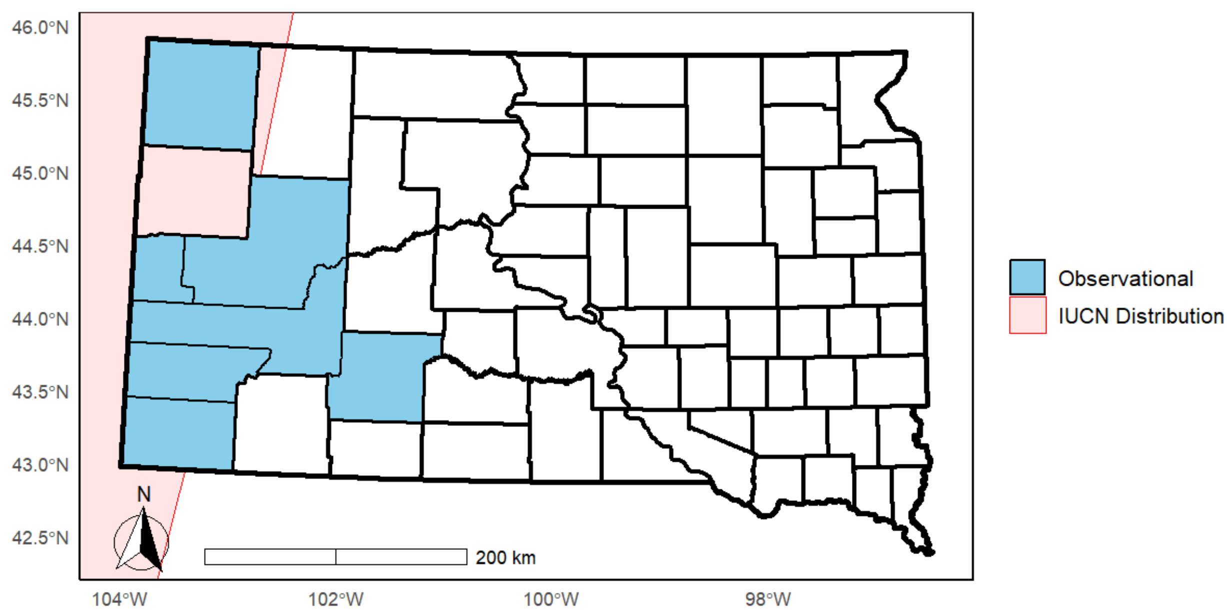

Figure 11. County level observational (blue; including net captures, hibernacula surveys, museum records and may also include acoustic records where another observational method is also present) for long-legged myotis (*Myotis volans*). The International Union for Conservation of Nature (IUCN) distribution map for the species is shown in red.

Evening Bat: *Nycticeius humeralis*

Description

The evening bat (*Nycticeius humeralis*) is a dark brown to reddish brown bat with a dark pigmented face and wing membrane (Watkins 1972). Evening bats have a blunt tragus and short ears, with no distinctive facial markings. They resemble the big brown bat (*Eptesicus fuscus*) but with a noticeably smaller body size and smaller wingspan (Watkins 1972). This species can most commonly be found using forests and human-made structures as roosts and it is thought that they migrate to more suitable habitat in the fall rather than hibernate and they are rarely observed using caves (Watkins 1972, NatureServe 2025). This species has only been captured three times over two summer survey seasons in one county in South Dakota (Lane et al. 2003). This species has been expanding its range (Andersen et al. 2017) and their current distribution in South Dakota is unknown.

Threats

Evening bat populations may be impacted by habitat loss due to urban development, tree removal, and agricultural expansion, which can reduce availability of daytime roosting and maternity colonies (Boyles and Robbins 2006). Pesticide use and declining insect abundance may further threaten their populations (Oliveira et al. 2020). While not yet heavily impacted by white-nose syndrome, the disease remains a potential threat to this species if an individual roosts within a cave or mine (Frick et al. 2016).

Distribution

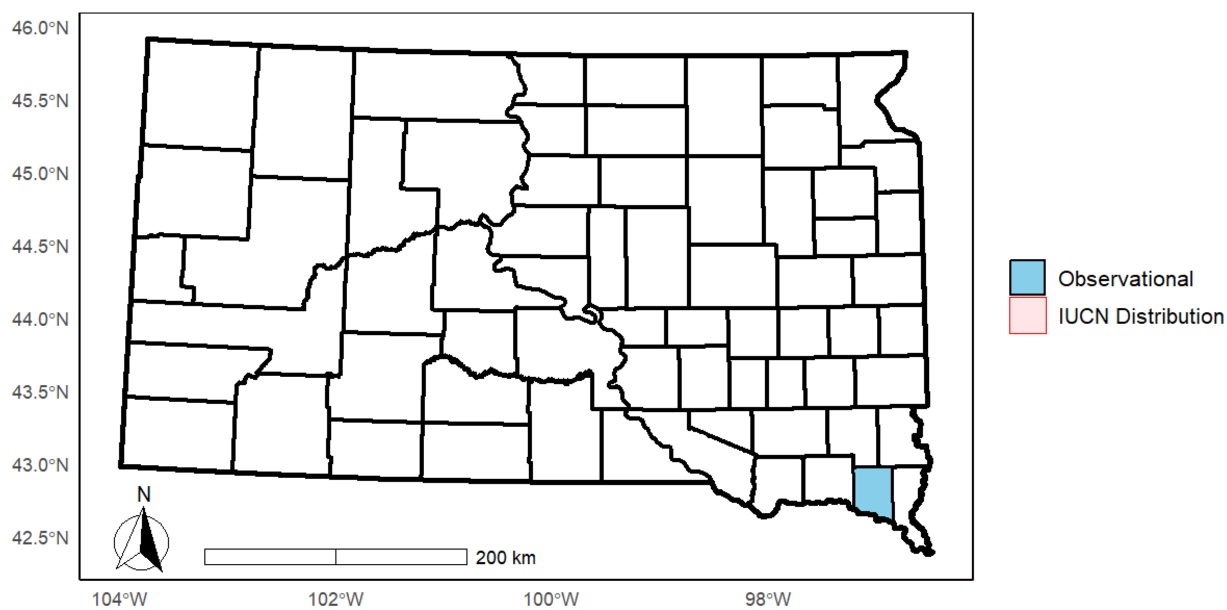

Figure 12. County level observational (blue; including net captures, hibernacula surveys, museum records and may also include acoustic records where another observational method) for evening bat (*Nycticeius humeralis*). The International Union for Conservation of Nature (IUCN) distribution map for the species is shown in red.

Tricolored Bat: *Perimyotis subflavus*

Description

The tricolored bat (*Perimyotis subflavus*) is currently proposed for listing on the Endangered Species Act due to severe population declines (Table 1) (Udell et al. 2022). One of the smallest bat species in eastern North America, their common name refers to the coloration of their dorsal fur, which has three distinct color bands on each hair follicle: dark base, pale middle, and dark tip (McCoshum et al. 2023). Their wings are relatively large for their body size, aiding in fluttering flight through forest understories and along waterways (McCoshum et al. 2023). This species roosts in forested habitats during the summer, and will use tree cavities, bark, and foliage (McCoshum et al. 2023). This species was first documented expanding its range into South Dakota in 2004 and has only been observed during hibernacula counts (see Tigner survey reports in Appendix C). Its current distribution and summer habitat use in the state are unknown.

Threats

Tricolored bats are vulnerable to white-nose syndrome, which has caused drastic population declines across their range (Frick et al. 2015). The tricolored bat is now a rare species and a conservation concern due to white-nose syndrome mortalities and habitat-related threats (Reeder et al. 2012). Habitat loss, particularly of roosting and hibernating habitats, negatively impact this bat as well as resource extraction and wind energy expansion (Colorado Natural Heritage Program 2025, NatureServe 2025).

Distribution

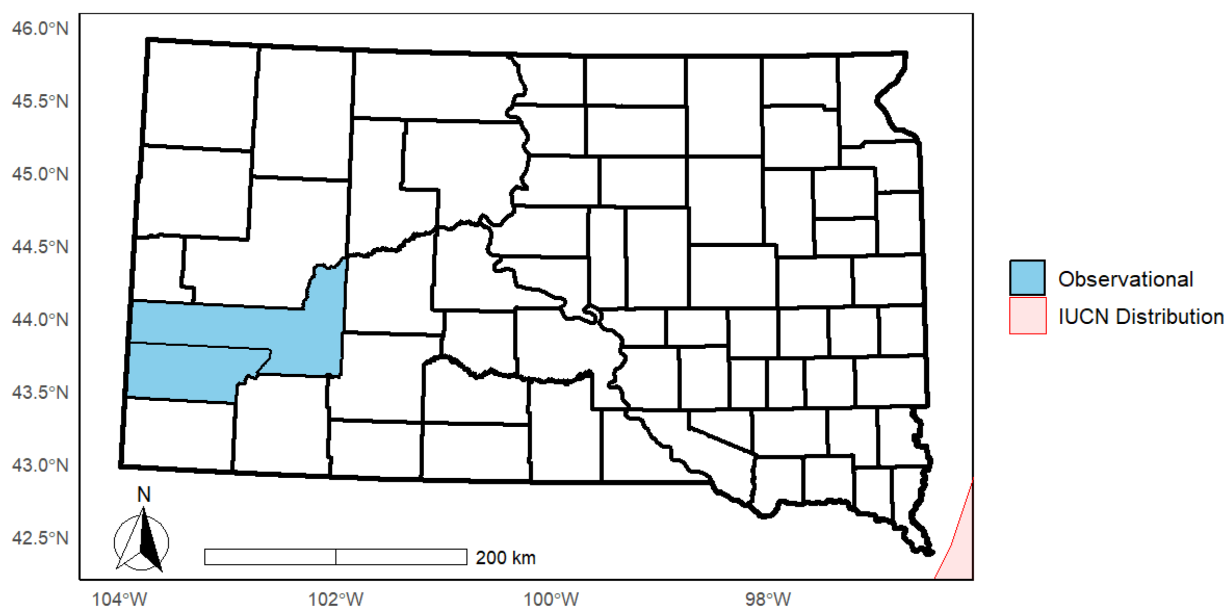

Figure 13. County level observational (blue; including net captures, hibernacula surveys, museum records and may also include acoustic records where another observational method is also present) for tricolored bat (*Perimyotis subflavus*). The International Union for Conservation of Nature (IUCN) distribution map for the species is shown in red.

Appendix B – List of Potential Collaborators

Organization	Website
Badlands National Park	https://www.nps.gov/badl/index.htm
Bat Conservation International	http://www.batcon.org/
Black Hills State University	http://www.bhsu.edu/
Cheyenne River Sioux Tribe	https://www.cheyenneriversioux.com/
Crow Creek Sioux Tribe	https://hunkpatioyate.org/
Dakota Prairie Grasslands	https://www.fs.usda.gov/dpg
Flandreau Santee Sioux Tribe	https://fsst-nsn.gov/
Jewel Cave National Park	https://www.nps.gov/jeca/index.htm
Lower Brule Sioux Tribe	https://www.lowerbrulesiouxtribe.com/
Midwest Bat Working Group	https://mwbwg.org/
Missouri National Recreational Area	https://www.nps.gov/mnrr/index.htm
Montana Natural Heritage Program	https://mtnhp.org/
North American Bat Monitoring Program	https://www.nabatmonitoring.org/
Oglala Sioux Tribe	https://www.oglala.gov/
Rosebud Sioux Tribe	https://www.rosebudsiouxtribe-nsn.gov/
Sisseton Wahpeton Oyate Sioux Tribe	https://swo-nsn.gov/
South Dakota Bat Working Group	http://sdbwg.org/
South Dakota Department of Game Fish and Parks	https://gfp.sd.gov/
South Dakota Department of Health	https://doh.sd.gov/
South Dakota Office of School and Public Lands	https://sdpubliclands.sd.gov/
South Dakota Department of Transportation	https://dot.sd.gov/
South Dakota National Refuges	http://mountain-prairie.fws.gov/refuges/sd
South Dakota State University	http://www.sdstate.edu
Standing Rock Sioux Tribe	https://standingrock.org/
The Nature Conservancy	https://www.nature.org/en-us
University of Nebraska at Kearney	https://www.unk.edu/
University of Nebraska at Omaha	https://www.unomaha.edu/
University of South Dakota	http://www.usd.edu/
University of Wyoming	https://www.uwyo.edu/index.html
US Army Corp of Engineers	http://www.usace.army.mil/
US Army National Guard	http://www.arng.army.mil/
US Bureau of Land Management	https://www.blm.gov/
US Fish and Wildlife Service	http://www.fws.gov/
US Geological Survey	http://www.usgs.gov/
US Forest Service Rocky Mountain Research Station	https://research.fs.usda.gov/rmrs
US Forest Service, Black Hills National Forest	https://www.fs.usda.gov/blackhills
US Forest Service, Custer-Gallatin National Forest	https://www.fs.usda.gov/r01/custergallatin
US Forest Service, Nebraska National Forest	https://www.fs.usda.gov/nebraska

Western Bat Working Group	https://wbwg.org/
Wind Cave National Park	https://www.nps.gov/wica/index.htm
Wyoming Natural Diversity Database	https://www.uwyo.edu/wyndd/index.html
Yankton Sioux Tribe	https://www.yanktonsiouxtribe.net/

Appendix C – Summary of Past and Ongoing Research and Monitoring for South Dakota Bats

Summary of past and ongoing bat research and monitoring efforts in South Dakota. Ongoing research summary reflects a description of unpublished efforts at the time this plan was prepared. Summary of past research includes a literature review of bat research and monitoring reports published since the 2004 edition of the South Dakota Bat Management Plan.

Ongoing Research (at time of preparation)

Bat research efforts in South Dakota have increased recently with research and monitoring projects being conducted by multiple entities across the state:

- Research is conducted on a yearly basis in the Black Hills National Forest with the U.S. Forest Service, the Bureau of Land Management, the University of Wyoming, South Dakota State University, and others.
- Mobile and stationary acoustic information is collected by the Buffalo Gap National Grasslands.
- South Dakota Game, Fish and Parks is conducting a two-year acoustic survey across 10 historical locations in the state and deploying two additional detectors in the Black Hills with the goal of establishing annual acoustic monitoring.
- White-nose syndrome is conducted within the Badlands National Park by the Wyoming Natural Diversity Database.
- Bat Conservation International has been collaborating with the U.S. Forest Service and Bureau of Land Management to use LiDAR to map caves in the Black Hills National Forest.
- South Dakota State University is conducting research to map the distribution and occupancy of bat species across South Dakota, assess critical roosting structures for sensitive species, assess the effects of prescribed fire on bat communities, and examine their response to conservation focused agriculture practices.

Published Articles

Bales, B. (2007). Records of western small-footed myotis in Central South Dakota. The Prairie Naturalist, 39(3/4), 159–162.

Study confirmed a historical museum specimen of *M. ciliolabrum* from Farm Island R.A., South Dakota and discussed the two recordings of *M. ciliolabrum* that were detected by Swier 2003 at Farm Island. Bales captured one non-scrotal adult male at Oahe Downstream and tracked it to a cottonwood tree. These occurrences represented the most eastern records of *M. ciliolabrum* at the time.

Geluso, K., Mollhagen, T. R., Tigner, J. M., and Bogan, M. A. (2005). Westward expansion of the eastern pipistrelle (*Pipistrellus subflavus*) in the United States, including new records from New Mexico, South Dakota, and Texas. Western North American Naturalist, 65(3), 405–409.

Article discussed the range expansion of *P. subflavus* into new states, including South Dakota. Joel Tigner confirmed four *P. subflavus* in three different abandoned mines in Pennington County, South Dakota (2003–2004) during winter hibernacula surveys. Article also shows a historical record of a *P. subflavus* in north-west Minnesota, near the south-east corner of South Dakota.

Geluso, K., and Bogan, M. A. (2018). Bats in the Bear Lodge Mountains and surrounding areas in northeastern Wyoming. Museum of Texas Tech University Occasional Papers, 355, 17 pp.

Study included a discussion of how the subspecies of *Myotis thysanodes* (*Myotis thysanodes pahasapensis*) that is thought to occupy the Black Hills in South Dakota may be *M. evotis*, based on both museum records and captures. Study was conducted in the Bear Lodge District of the Black Hills National Forest. Most commonly captured species were *M. lucifugus*, *M. septentrionalis*, *M. volans*, and *L. noctivagans*. Reported first *M. ciliolabrum* reproductive data from Wyoming.

Ke, W., and Bales, B. (2007). Estimation of sampling effort for catching enough bats. Significance, 4(1), 19–21. https://doi.org/10.1111/j.1740-9713.2007.00214.x

Authors discuss using species accumulation models to model species diversity at sites where every species may not be captured even though they occur. Mist-netted species but provide no capture or species data.

Kiesow, A., and Kiesow, J. (2010). Bat survey along the Missouri River in central South Dakota. The Prairie Naturalist, 42(1/2), 65–66. https://digitalcommons.unl.edu/tpn/230.

Study was conducted from 2003–2005 using both mist-nets and acoustic detectors. Surveyed along the Missouri River: Farm Island R.A., La Framboise R.A., and Oahe Downstream R.A. Found same seven species as Swier 2003 and Bales 2007, including *M. septentrionalis* and *L. noctivagans*. Noted that volant young *M. septentrionalis* first appeared in mid-September. In 2005 they recaptured a banded bat from Swier 2003 at Farm Island R.A.

Lane, J., Loren Buck, C., and Brigham, B. (2003). The bat fauna of eastern South Dakota. The Prairie Naturalist, 35(4), 246–256.

Study was conducted using mist-nets in Clay and Union Counties, South Dakota (2000–2001). They sampled eight locations and did not find *M. septentrionalis* but did catch three *N. humeralis* across both years (including one post-lactating female) which were the first records in South Dakota. *E. fuscus* and *M. lucifugus* were the most common species and Myron Grove R.A. was the most successful capture site. Most individuals were captured in Clay County.

Swier, V. (2003). Food habits of big brown bats (*Eptesicus fuscus*) in Sioux Falls, South Dakota. Proceedings of the South Dakota Academy of Science, 82, 73–77.

Study described the food habits of *E. fuscus* in Sioux Falls, South Dakota. 620 bats were collected from the Department of Health in 2000–2001 and stomach contents were analyzed. Four orders of insects were identified: Coleoptera, Hemiptera, Diptera, and Lepidoptera. Carabidae occurred at an occurrence frequency of 29.1%, followed by unidentifiable insects (18.2%), Lepidoptera (12.2 %), unidentified Coleoptera (7.3%), Pentatomidae (stinkbugs) (7.3%), Diptera (1.8%), and hairballs (5.3%). Determined *E. fuscus* does not feed in the winter, stopping around late October. This study was part of the Swier 2003 master's thesis.

Swier, Vicki J. (2006). Recent distribution and life history information for bats of Eastern South Dakota. Texas Tech University Natural Science Research Laboratory Occasional Papers, 264, 21 pp. https://www.biodiversitylibrary.org/part/281454

Based on master's thesis work at South Dakota State University summarizing mist-netting and acoustic work conducted across 35 sites in 2000–2002. Focused on discriminant function analysis for species-specific calls, testing acoustic files against reference call libraries. Provides detailed species accounts for the State. Refer to the full thesis below for the entire project's information.

Thesis/Dissertations

Swier, V. J. (2003). Distribution, roost site selection, and food habits of bats in eastern South Dakota. Master's thesis, South Dakota State University.

This study monitored bats in eastern South Dakota and along the Missouri River using acoustic surveys and mist-netting. *M. septentrionalis* and *M. lucifugus* were found at multiple locations, with *M. septentrionalis* primarily along the Missouri River at Farm Island R.A., La Framboise R.A., and Oahe Downstream R.A. Radio tracking was conducted for *M. septentrionalis*, *M. lucifugus*, *E. fuscus*, and *L. noctivagans*. In the summer of 2002, *M. septentrionalis* (*n*=3), *M. lucifugus* (*n*=2), *L. noctivagans* (*n*=1), and *E. fuscus* (*n*=6) were tracked at five locations: Karl Mundt N.W.R., Lewis and Clark R.A., West Bend R.A., La Framboise R.A., and Farm Island R.A. *M. septentrionalis* (at Karl Mundt and Farm Island) and *L. noctivagans* roosted exclusively in eastern cottonwood trees (*Populus deltoides*), while *M. lucifugus* and *E. fuscus* roosted in bridges, houses, a picnic shelter, eastern cottonwoods, and bur oaks (*Quercus macrocarpa*). Roost swapping was observed.

Bales, B. (2007). Regional distribution and monitoring of bats along the Lower Missouri River in South Dakota. Master's thesis, South Dakota State University.

Bats were monitored using acoustics, mist-netting, and radio tagging along the Missouri River from Oahe Downstream R.A. to Yankton. *M. septentrionalis*, *M. lucifugus*, and other species were captured, with 90 *M. septentrionalis* recorded during 2005–2006. The study summarized the reproductive timing of different species and raised questions about the residency status of *L. noctivagans* and *L. cinereus* in eastern South Dakota. Radio tracking of *M. septentrionalis* (*n*=27) revealed species-specific habitat preferences, with *M. septentrionalis* selecting plains cottonwoods at sites including Arikara G.P.A., Fort Randall Spillway L.U.A., Byre Bottom G.P.A., and Oahe Downstream R.A. Roost swapping was observed.

Karevold, H. M. (2021). Foraging strategies and morphometric characteristics of bats in North and South Dakota. Master's thesis, North Dakota State University.

This multistate study assessed diet preferences, foraging strategies, and morphological differences among *E. fuscus*, *M. lucifugus*, and *M. septentrionalis* in South Dakota (Black Hills National Forest) and across North Dakota. It contains an in-depth dietary analysis of multiple species and found Lepidoptera in the diets of all species sampled. *M. lucifugus*, *M. septentrionalis*, *M. volans*, and *E. fuscus* had arachnids in their diets. Study also identifies agricultural pests in bat diets. *M. septentrionalis* were captured in the Black Hills. The study also compared ear and forearm length of *M. lucifugus*, *M. septentrionalis*, and *E. fuscus* in North and South Dakota and found that *M. lucifugus* in South Dakota have longer ears than those in North Dakota.

Reports

Abernethy, I., and Whittle, E. (2024). White-nose syndrome surveillance across Northern Great Plains National Park Units: 2024 Final Report. Report to the National Park Service, Northern Great Plains Inventory and Monitoring Network. Wyoming Natural Diversity Database, University of Wyoming. 16 pp.

White-nose syndrome sampling was conducted at 13 parks in the Northern Great Plains Network, including four National Parks/Monuments in South Dakota (Badlands, Jewel Cave, Mount Rushmore, and Wind Cave). Mist-netting, wing swabs, and visual inspections were used. At Badlands (surveyed in 2018, 2019, 2022, and 2023), white-nose syndrome was detected in 2018 on five bats (four *E. fuscus* and one *M. ciliolabrum*) but not in later years. Jewel Cave (surveyed in 2018, 2019, and 2023) detected white-nose syndrome one *M. volans* in 2018, but no testing occurred in 2019–2021, though capture rates declined. Mount Rushmore was surveyed in 2018 and 2019 with no white-nose syndrome detected, though the disease was confirmed in Pennington County in 2020–2021. Wind Cave was surveyed in 2018 and 2019, with no positive white-nose syndrome tests, though one *M. septentrionalis* had a faint fluorescent orange glow on its wing (the individual later tested negative). White-nose syndrome was confirmed at Wind Cave later in 2019.

Bachen, D. A., Maxell, B., and Whittle, E. (2017). Measurements, body condition, and reproductive status of bats captured in Montana, Northern Idaho, and Western South Dakota. Montana Natural Heritage Program, Helena, Montana, USA. 13 pp.

This report provides detailed measurements of bat species in western South Dakota, synthesizing data from 3,201 bats across 14 species captured between 1994 and 2016. It also models body condition for certain species across seasons.

Bachen, D. A., McEwan, A., Burkholder, B., Hilty, S., Blum, S., and Maxell, B. (2018). Bats of Montana: Identification and natural history. Report to Montana Department of Environmental Quality. Montana Natural Heritage Program, Helena, Montana, USA. 110 pp.

This report details the biology and status of bat species in Montana, including species found in northwestern South Dakota. It includes seasonal activity patterns, species identification keys, measurement ranges, echolocation characteristics, and sonogram examples.

Bachen, D. A., McEwan, A., Burkholder, B., Hilty, S., Blum, S., and Maxell, B. (2020). Long-term acoustic assessment of bats at Battle Creek, South Dakota for 2013–2015. Report to the Bureau of Land Management. Montana Natural Heritage Program, Helena, Montana, USA. 19 pp.

A long-term acoustic station was run October 2013–June 2015 at Battle Creek in Butte County, South Dakota on BLM land. They also collected weather, solar, and lunar data. The species detected in the active season were *L. noctivagans*, *L. borealis*, *L. cinereus*, *M. evotis*, and *M. lucifugus*. They also assessed temporal activity across seasons and years and analyzed weather data with activity. *L. noctivagans* had the most months confirmed (*n*=5) of any species.

Bachen, D. A., McEwan, A., Burkholder, B., Hilty, S., Blum, S., and Maxell, B. (2020). Long-term acoustic assessment of bats at Battle Creek, South Dakota for 2015. Report to the Bureau of Land Management. Montana Natural Heritage Program, Helena, Montana, USA. 19 pp.

A long-term acoustic station was run June 2015-November 2015 at Battle Creek in Butte County, South Dakota on BLM land. They also collected weather, solar, and lunar data. The species detected in the active season were *L. noctivagans*, *L. borealis*, *L. cinereus*, *M. evotis*, and *M. lucifugus*. They also assessed temporal activity across seasons and years and analyzed weather data with activity. *L. noctivagans* had the most months confirmed (*n*=5) of any species.

Bachen, D. A., McEwan, A., Burkholder, B., Hilty, S., Blum, S., and Maxell, B. (2020). Long-term acoustic assessment of bats at Bismark Bridge, South Dakota for 2013–2015. Report to the Bureau of Land Management. Montana Natural Heritage Program, Helena, Montana, USA. 19 pp.

A long-term acoustic station was run October 2013-Jun 2015 at Bismark Bridge in Butte County, South Dakota. They also collected weather, solar, and lunar data. The species detected in the active season were *L. borealis*, *L. cinereus*, and *M. lucifugus*. They also assessed temporal activity across seasons and years and analyzed weather data with activity. *L. cinereus* had the most confirmed months (*n*=3) of any species.

Bachen, D. A., McEwan, A., Burkholder, B., Hilty, S., Blum, S., and Maxell, B. (2020). Long-term acoustic assessment of bats at Bismark Bridge, South Dakota for 2015. Report

to the Bureau of Land Management. Montana Natural Heritage Program, Helena, Montana, USA. 19 pp.

A long-term acoustic station was run June 2015–November 2015 at Bismark Bridge in Butte County, South Dakota. They also collected weather, solar, and lunar data. The species detected in the active season were *L. noctivagans*, *L. borealis*, *L. cinereus*, *M. ciliolabrum*, and *M. lucifugus*. They also assessed temporal activity across seasons and years and analyzed weather data with activity. *L. noctivagans* and *L. cinereus* had the most confirmed months (*n*=5) of any species.

Bachen, D. A., McEwan, A., Burkholder, B., Hilty, S., Blum, S., and Maxell, B. (2020). Long-term acoustic assessment of bats at South Moreau Bridge, South Dakota for 2013–2015. Report to the Bureau of Land Management. Montana Natural Heritage Program, Helena, Montana, USA. 20 pp.

A long-term acoustic station was run October 2013–June 2015 at South Moreau Bridge in Harding County, South Dakota. They also collected weather, solar, and lunar data. The species detected in the active season were *C. townsendii*, *L. noctivagans*, *L. borealis*, *L. cinereus*, *M. ciliolabrum*, *M. evotis*, and *M. lucifugus*. They also assessed temporal activity across seasons and years and analyzed weather data with activity. *L. noctivagans* and *M. lucifugus* had the most months confirmed (*n*=5) of any species. Species captured within 50 km of site include *E. fuscus* and *M. evotis* and species detected acoustically within 50 km include *C. townsendii*, *E. fuscus*, *L. noctivagans*, and *M. evotis*. Active season roosts included *M. evotis* and *M. volans*.

Bachen, D. A., McEwan, A., Burkholder, B., Hilty, S., Blum, S., and Maxell, B. (2020). Long-term acoustic assessment of bats at South Moreau Bridge, South Dakota for 2015. Report to the Bureau of Land Management. Montana Natural Heritage Program, Helena, Montana, USA. 20 pp.

A long-term acoustic station was run June 2015–November 2015 at South Moreau Bridge in Harding County, South Dakota. They also collected weather, solar, and lunar data. The species detected in the active season were *C. townsendii*, *L. noctivagans*, *L. borealis*, *L. cinereus*, *M. ciliolabrum*, *M. evotis*, and *M. lucifugus*. They also assessed temporal activity across seasons and years and analyzed weather data with activity. *L. noctivagans* and *M. lucifugus* had the most months confirmed (*n*=5) of any species. Species captured within 50 km of site include *E. fuscus* and *M. evotis* and species detected acoustically within 50 km include *M. evotis* and *C. townsendii*, *E. fuscus*, *L. noctivagans*, and *M. evotis*. Active season roosts included *M. evotis* and *M. volans*.

Bachen, D. A., Burkholder, B. O., and Maxell, B. (2020). Long-term acoustic assessment of bats at Deer Draw Reservoir, South Dakota for 2015–2016. Report to United States Forest Service. Montana Natural Heritage Program, Helena, Montana, USA. 20 pp.

A long-term acoustic station was run June 2015–June 2016 at Deer Draw Reservoir in Harding County, South Dakota on USFS lands. They also collected weather, solar, and lunar data. The species detected in the active season were *C. townsendii*, *E. fuscus*, *L.*

noctivagans, *L. borealis*, *L. cinereus*, *M. ciliolabrum*, *M. evotis*, and *M. lucifugus*. They also assessed temporal activity across seasons and years and analyzed weather data with activity. *L. cinereus* and *M. ciliolabrum* had the most confirmed months (*n*=5) of any species. Species captured within 50 km of site include *C. townsendii*, *E. fuscus*, *L. cinereus*, *M. ciliolabrum*, *M. evotis*, *M. lucifugus*, *M. thysanodes*, and *M. volans* and species detected acoustically within 50 km include *C. townsendii*, *E. fuscus*, *L. noctivagans*, and *M. thysanodes*. Active season roosts included *M. lucifugus*.

Bachen, D. A., McEwan, A., Burkholder, B., Hilty, S., Blum, S., and Maxell, B. (2020). Long-term acoustic assessment of bats at Browns Pond Slough, South Dakota for 2015–2016. Report to United States Forest Service. Montana Natural Heritage Program, Helena, Montana, USA. 20 pp.

A long-term acoustic station was run June 2015–June 2016 at Browns Pond Slough in Harding County, South Dakota on USFS land. They also collected weather, solar, and lunar data. The species detected in the active season were *E. fuscus*, *L. noctivagans*, *L. cinereus*, *M. ciliolabrum*, *M. evotis*, and *M. lucifugus*. They also assessed temporal activity across seasons and years and analyzed weather data with activity. *L. cinereus* and *M. ciliolabrum* had the most confirmed months (*n*=5) of any species. Species captured within 50 km of site include *E. fuscus*, *L. cinereus*, *M. ciliolabrum*, *M. evotis*, *M. lucifugus*, *M. thysanodes*, and *M. volans*. Species detected acoustically within 50 km include *C. townsendii*, *E. fuscus*, *L. noctivagans*, *L. cinereus*, *M. evotis*, *M. lucifugus*, and *M. thysanodes*. Active season roosts within 50 km include *C. townsendii*, *M. evotis*, *M. lucifugus*, and *M. volans*.

Bachen, D. A., McEwan, A., Burkholder, B., Hilty, S., Blum, S., and Maxell, B. (2020). Long-term acoustic assessment of bats at East Short Pines, South Dakota for 2015-2016. Report to United States Forest Service. Montana Natural Heritage Program, Helena, Montana, USA. 20 pp.

A long-term acoustic station was run June 2015–June 2016 at East Short Pines in Harding County, South Dakota on USFS land. They also collected weather, solar, and lunar data. The species detected in the active season were *C. townsendii*, *E. fuscus*, *L. noctivagans*, *L. cinereus*, *M. ciliolabrum*, *M. evotis*, and *M. lucifugus*. They also assessed temporal activity across seasons and years and analyzed weather data with activity. *M. ciliolabrum* had the most months confirmed (*n*=8) of any species. Species captured within 50 km of site include *C. townsendii*, *E. fuscus*, *L. cinereus*, *M. ciliolabrum*, *M. evotis*, *M. lucifugus*, *M. thysanodes*, and *M. volans*. Species detected acoustically within 50 km include *C. townsendii*, *E. fuscus*, *L. noctivagans*, *L. cinereus*, *M. ciliolabrum*, *M. evotis*, *M. lucifugus*, and *M. thysanodes*. Active season roosts within 50 km include *M. evotis* and *M. volans*.

Bachen, D. A., McEwan, A., Burkholder, B., Hilty, S., Blum, S., and Maxell, B. (2020). Long-term acoustic assessment of bats at Fort Meade Reservoir, South Dakota for 2013–2015. Report to the Bureau of Land Management. Montana Natural Heritage Program, Helena, Montana, USA. 19 pp.

A long-term acoustic station was run Fall 2013–Summer 2015 at Fort Meade Reservoir in Meade County, South Dakota on BLM land. They also collected weather, solar, and lunar data. The species detected in the active season were *E. fuscus*, *L. noctivagans*, *L. borealis*, *L. cinereus*, *M. ciliolabrum*, and *M. lucifugus*. They also assessed temporal activity across seasons and years and analyzed weather data with activity. *E. fuscus* had the most confirmed months (*n*=9) of any species

Bachen, D. A., McEwan, A., Burkholder, B., Hilty, S., Blum, S., and Maxell, B. (2020). Long-term acoustic assessment of bats at Fort Meade Reservoir, South Dakota for 2015. Report to the Bureau of Land Management. Montana Natural Heritage Program, Helena, Montana, USA. 19 pp.

A long-term acoustic station was run June 2015–November 2015 at Fort Meade Reservoir in Meade County, South Dakota on BLM land. They also collected weather, solar, and lunar data. The species detected in the active season were *E. fuscus*, *L. noctivagans*, *L. borealis*, *L. cinereus*, *M. ciliolabrum*, *M. lucifugus*, and *M. thysanodes*. They also assessed temporal activity across seasons and years and analyzed weather data with activity. *L. noctivagans*, *L. cinereus*, and *M. lucifugus* had the most confirmed months (*n*=5) of any species

Bachen, D. A., Burkholder, B. O., and Maxell, B. (2020). Long-term acoustic assessment of bats at Powderhouse, South Dakota for 2015–2017. Report to the Bureau of Land Management. Montana Natural Heritage Program, Helena, Montana, USA. 19 pp.

A long-term acoustic station was run June 2015–November 2017 at Powderhouse in Lawrence County, South Dakota on BLM land. They also collected weather, solar, and lunar data. The species detected in the active season were *C. townsendii*, *L. noctivagans*, *L. borealis*, *L. cinereus*, *M. ciliolabrum*, *M. evotis*, *M. lucifugus*, and *M. thysanodes*. They also assessed temporal activity across seasons and years and analyzed weather data with activity. *L. cinereus* had the most confirmed months (*n*=9) of any species.

Bachen, D. A., McEwan, A., Burkholder, B., Hilty, S., Blum, S., and Maxell, B. (2020). Long-term acoustic assessment of bats at Horse Camp, South Dakota for 2015–2017. Report to the Bureau of Land Management. Montana Natural Heritage Program, Helena, Montana, USA. 19 pp.

A long-term acoustic station was run June 2015–August 2017 at Horse Camp in Meade County, South Dakota on BLM land. They also collected weather, solar, and lunar data. The species detected in the active season were *C. townsendii*, *E. fuscus*, *L. noctivagans*, *L. borealis*, *L. cinereus*, *M. ciliolabrum*, *M. evotis*, *M. lucifugus*, and *M. thysanodes*. They also assessed temporal activity across seasons and years and analyzed weather data with activity. *L. cinereus* had the most confirmed months (*n*=12) of any species.

Bachen, D. A., McEwan, A., Burkholder, B., Hilty, S., Blum, S., and Maxell, B. (2020). Long-term acoustic assessment of bats at Jug Creek, South Dakota for 2013–2015.

Report to the Bureau of Land Management. Montana Natural Heritage Program, Helena, Montana, USA. 19 pp.

A long-term acoustic station was run October 2013–June 2015 at Jug Creek in Butte County, South Dakota on BLM land. They also collected weather, solar, and lunar data. The species detected in the active season were *E. fuscus*, *L. noctivagans*, *L. borealis*, *L. cinereus*, *M. ciliolabrum*, and *M. lucifugus*. They also assessed temporal activity across seasons and years and analyzed weather data with activity. *M. lucifugus* had the most confirmed months (*n*=4) of any species.

Bachen, D. A., McEwan, A., Burkholder, B., Hilty, S., Blum, S., and Maxell, B. (2020). Long-term acoustic assessment of bats at Jug Creek, South Dakota for 2015. Report to the Bureau of Land Management. Montana Natural Heritage Program, Helena, Montana, USA. 19 pp.

A long-term acoustic station was run June 2015–November 2015 at Jug Creek in Butte County, South Dakota on BLM land. They also collected weather, solar, and lunar data. The species detected in the active season were *L. noctivagans*, *L. borealis*, *L. cinereus*, *M. ciliolabrum*, and *M. lucifugus*. They also assessed temporal activity across seasons and years and analyzed weather data with activity. *L. noctivagans*, *L. cinereus*, and *M. lucifugus* had the most months confirmed (*n*=4) of any species.

Bachen, D. A., Burkholder, B. O., McEwan, A. L., Hilty, S. L., Blum, S. A., and Maxell, B. (2020). Long-term acoustic assessment of bats at North Cave Hills, South Dakota for 2012–2015. Report to United States Forest Service. Montana Natural Heritage Program, Helena, Montana, USA. 20 pp.

A long-term acoustic station was run June 2012–June 2015 at North Cave Hills in Harding County, South Dakota on USFS land. They also collected weather, solar, and lunar data. The species detected in the active season were *E. fuscus*, *L. noctivagans*, *L. borealis*, *L. cinereus*, *M. ciliolabrum*, *M. evotis*, *M. lucifugus*, *M. thysanodes*, and *M. volans*. They also assessed temporal activity across seasons and years and analyzed weather data with activity. *E. fuscus* had the most months confirmed (*n*=10) of any species. Species captured within 50 km of site include *E. fuscus*, *L. cinereus*, *M. ciliolabrum*, *M. evotis*, *M. lucifugus*, *M. thysanodes*, and *M. volans*. Species detected acoustically within 50 km include *C. townsendii*, *E. fuscus*, *L. noctivagans*, *L. cinereus*, and *M. evotis*. Active season roosts within 50 km include *C. townsendii*, *M. evotis*, *M. lucifugus*, and *M. volans*.

Chodachek, K., Suehring, A., and Wilson, T. (2022). Post-construction bird and bat fatality monitoring at Crowned Ridge II Wind Farm, South Dakota (2021). Report to Northern States Power. Western EcoSystems Technology, Inc., Bismarck, North Dakota, USA. 81 pp.

This study estimated fatality rates of birds and bats at the Crowned Ridge II Wind Farm, with a focus on sensitive species. Over multiple turbines, 16 bird and seven bat carcasses (notably *L. noctivagans*) were found. Estimated bird and bat fatality rates were 0.41 and 0.74 fatalities per megawatt per study period, respectively.

South Dakota Department of Game, Fish and Parks (2018). Initial analysis of migratory bat data from South Dakota Department of Game, Fish and Parks, Pierre, South Dakota, USA. 81 pp.

Long-term acoustic surveys were conducted at 13 sites across South Dakota in 2011 and 2012, with 11 sites surveyed both years. The study examined migratory bat timing and pathways, detecting *L. cinereus*, *L. borealis*, and *L. noctivagans*. Activity peaked in July and August, with 2012 showing 63% less bat activity than in 2011. *M. septentrionalis* was found at multiple sites but in low numbers.

Kiesow, A. (2005). Bat data collected at proposed wind power site near St. Francis, South Dakota. Report to the Rosebud Sioux Tribe and DisGen, Inc. 4 pp.

Mist-netting and acoustic surveys (stationary and mobile) were conducted near St. Francis, South Dakota, from August 2004 to August 2005. The study, a collaboration between the Rosebud Sioux Tribe and DisGen, suggested the area could be an important wildlife corridor. One *L. cinereus* was captured, and acoustically-recorded species included *E. fuscus*, *L. cinereus*, *L. noctivagans*, *M. lucifugus*, and *Myotis* spp.

Licht, D. S. (2018). Acoustic surveys of bats at Northern Great Plains Parks (2014–2016). Report to the National Park Service, Fort Collins, Colorado, USA. 157 pp.

Acoustic surveys were conducted across 12 parks, including nine in South Dakota. A total of 55 NABat and 62 non-NABat sites were surveyed, along with 14 mobile routes twice per year. 14 bat species were identified, though community structure varied across parks. *M. septentrionalis* was detected but was not common. The study also found evidence of *P. subflavus* expanding westward.

Licht, D. S. (2018). Badlands draft chapter for the acoustic surveys of bats at Northern Great Plains Parks (2014–2016). Report to the National Park Service, Fort Collins, Colorado, USA. 29-40 pp.

NABat cells were surveyed acoustically through stationary and mobile routes from 2014 to 2016. Calls were analyzed using Kaleidoscope Pro and SonoBat software, with both programs identifying *E. fuscus*, *L. borealis*, *L. cinereus*, *L. noctivagans*, *M. ciliolabrum*, and *M. lucifugus*. SonoBat detected *M. thysanodes*, while Kaleidoscope identified *M. volans*. Neither program confirmed *C. townsendii*, *M. septentrionalis*, or *P. subflavus*. The study found no significant year-to-year changes in bat activity and suggested white-nose syndrome was not yet present.

Pickle, J., Bishop-Boros, L., and Solick, D. I. (2017). Bat acoustic survey report for the Crocker Wind Farm, South Dakota (2016). Report to Crocker Wind Farm, LLC. Western EcoSystems Technology, Inc. (WEST), Laramie, Wyoming, USA. 43 pp.

Acoustic surveys were conducted at the Crocker Wind Farm in Clark County, South Dakota, using paired stations in spring, summer, and fall. Low-frequency bats (*L. cinereus*) comprised 67% of detected calls, while high-frequency bats (*Myotis* spp.) made up 33%. Activity increased in the fall.

Schmidt, C. A. (2003). Conservation assessment for the northern myotis in the Black Hills National Forest, South Dakota and Wyoming. USDA Forest Service, Rocky Mountain Region, Custer, South Dakota, USA. 19 pp.

This literature review summarizes robust *M. septentrionalis* research in the Black Hills. It documents *M. septentrionalis* presence in Custer, Lawrence, Meade, and Pennington counties (SD) and Crook and Weston counties (WY). It includes *M. septentrionalis* natural history, roosting and hibernacula preferences, foraging habitats, community ecology, and risk factors.

SWCA, Inc. (2019). Bat habitat assessment for the proposed Crowned Ridge Wind II Facility, South Dakota. Report to Crowned Ridge Wind II, LLC. 15 pp.

A habitat assessment identified potential bat habitat requiring follow-up surveys. A post-construction fatality survey, conducted in 2017 by Western EcoSystems, is referenced in this report. The study provided habitat suitability maps.

Tigner, J. (2004a). Winter bat hibernacula surveys 2003/04. Report to South Dakota Game, Fish and Parks. BATWORKS, LLC, Rapid City, South Dakota, USA. 20 pp.

Winter bat hibernacula visual surveys were conducted at selected caves and 24 abandoned mine sites across the Black Hills National Forest and surrounding region (nine Northern Hills, 14 Mystic, five Hell Canyon, one Custer State Park, and four private/unidentified) during the winter of 2003–2004. Most of the surveys represent the initial survey following protective bat gate installation. Species found within hibernacula include *C. townsendii*, *E. fuscus*, *L. noctivagans*, *M. evotis*, *M. lucifugus*/*M. volans*, *M. septentrionalis*, *M. thysanodes*, *M. volans*, *Myotis* spp., *P. subflavus*, and Unknown. The *P. subflavus* observations (*n*=2) were from two different mines and represent the 2nd and 3rd known observations in SD. The *M. evotis* (*n*=1) is the 1st known observation of this species hibernating in the Black Hills.

Tigner, J. (2004b). Bat surveys – 2004 Buffalo Gap National Grasslands. Report to South Dakota Game, Fish and Parks. BATWORKS, LLC, Rapid City, South Dakota, USA.70 pp.

Mist net surveys were conducted at 15 sites across the Buffalo Gap National Grasslands between Oct. 6–Sept. 5, 2004. Sites surveyed included surface water and riparian corridors, isolated wooded draws, human-made structures, open prairie, and badlands features. Data collected included species, sex, age, forearm length, weight, and reproductive condition. Species found include *C. townsendii*, *E. fuscus*, *L. borealis*, *L. cinereus*, *M. ciliolabrum*, *M. septentrionalis*, *M. volans*, and *Myotis* spp.

Tigner, J. (2005a). Buffalo Gap National Grasslands bat surveys – 2005. Report to South Dakota Game, Fish and Parks. BATWORKS, LLC, Rapid City, South Dakota, USA.36 pp.

Mist net surveys, supplemented with acoustic data, were conducted at 13 sites across the Buffalo Gap National Grasslands from July–October of 2005. The purpose was to compare bat presence within and between years. Data collected included species for both mist-netted and acoustic detections, with age, sex, forearm length, and weight recorded as well for mist-netted individuals. Species found include *E. fuscus*, *L. cinereus*, *L. noctivagans*, *M. ciliolabrum*, *M. septentrionalis*, and *M. thysanodes*. Notably, *L. borealis* were not detected in 2005 during the Buffalo Gap National Grasslands surveys but was observed in 2004.

Tigner, J. (2005b). Bat surveys – 2005 report to Bureau of Land Management, Belle Fourche, South Dakota. Report to Bureau of Land Management. BATWORKS, LLC, Rapid City, South Dakota, USA.11 pp.

Hibernacula surveys conducted in winter of 2004–2005 in the Black Hills consisted of visual surveys of observed bats for four abandoned mines (three mines had been previously surveyed, and one new abandoned mine). Three of these mines were gated, two of which were not fully surveyed for safety reasons; therefore, count surveys were not conducted at the two inaccessible locations. Additionally, acoustic data was collected at each site during the active season, which ranged from August to October 2005. Species found during winter mine counts include *C. townsendii*, *E. fuscus*, *M. ciliolabrum*, *M. thysanodes*, *Myotis spp*., and a tentative *M. evotis*. Species found during active season acoustic surveys include *C. townsendii*, *E. fuscus*, *L. cinereus*, *L. noctivagans*, *L. borealis*, *M. ciliolabrum*, *M. evotis*, *M. septentrionalis*, *M. thysanodes*, and *M. volans*.

Tigner, J. (2006a). Black Hills bat hibernacula survey 2005–2006. Report to South Dakota Game, Fish and Parks, Pierre, South Dakota, USA. BATWORKS, LLC, Rapid City, South Dakota, USA.21 pp.

Winter bat hibernacula visual surveys were conducted at six gated caves and 14 gated abandoned mine sites across the Black Hills National Forest and surrounding region, along with eight additional mines termed "Other Sites". Surveys were conducted between December 2004 to March 2005. Species found within hibernacula include *C. townsendii*, *E. fuscus*, *M. lucifugus/M. volans*, *M. ciliolabrum*, *M. septentrionalis*, *M. thysanodes*, *M. volans*, *Myotis* spp., and *P. subflavus*.

Tigner, J. (2006b). Gating report July 2005–June 2006. Report to South Dakota Game, Fish and Parks. BATWORKS, LLC, Rapid City, South Dakota, USA.11 pp.

Hibernacula surveys were conducted at 14 different mines sites, eight are privately owned and six are in the Black Hills National Forest (BHNF). Gave general descriptions of sites and methods for repairing site entrances that were vandalized. Additionally, Tigner reported to have found *C. townsendii*, *M. ciliolabrum*, *E. fuscus* as year-round

residents for a mine in the BHNF. Tigner also went on to give descriptions of the private mines and usage of acoustic detectors.

Tigner, J. (2007). Bat surveys Buffalo Gap National Grasslands 2007. Report to South Dakota Game, Fish and Parks. BATWORKS, LLC, Rapid City, South Dakota, USA.42 pp.

Bat surveys were conducted in the southern section of the Buffalo Gap National Grasslands at 11 sites consisting of mixedgrass prairies, woody draws, riparian flight corridors, and scattered water sources. The survey tactics were three methods: mist-netting suspected flyways, heterodyne ultrasonic detectors for measuring bat activity, and full-spectrum echolocation detectors for species identification. Species reported were *M. ciliolabrum, E. fuscus, L. noctivagans, M. septentrionalis, L. cinereus, M. thysanodes, M. lucifugus,* and *Myotis* spp. *M. ciliolabrum was* the most common species recorded.

Tigner, J. (2008). Bat hibernacula survey winter 2007–2008: *Black Hills Region, SD*. Report to South Dakota Game, Fish and Parks. BATWORKS, LLC, Rapid City, South Dakota, USA.21 pp.

Tigner visited 20 mines and five caves. Site descriptions provided along with species counts of and details of necessary gate repairs for both cave and mine entrances. Species reported were *C. Townsendii, E. fuscus, M, ciliolabrum, M. septentrionalis, Myotis* spp., *P. subflavus, M. lucifugus,* and *M. volans*.

Tigner, J. (2009a). Acoustic bat survey – Zimmerman Property. Report to South Dakota Game, Fish and Parks. BATWORKS, LLC, Rapid City, South Dakota, USA.12 pp.

The report details three acoustic surveys at a privately owned barn near Jim Creek and Erskine Cave, located about three miles from the barn. Detected species included *M. lucifugus, M. evotis, M. septentrionalis, M. thysanodes, L. cinereus, L. noctivagans,* and *E. fuscus*.

Tigner, J. (2009b). Bat hibernacula survey winter 2008–2009 and newly identified abandoned mine sites, Black Hills Region, SD. Report to South Dakota Game, Fish and Parks. BATWORKS, LLC, Rapid City, South Dakota, USA. 33 pp.

Report describes surveys conducted at 16 known mines, five known caves, and four newly discovered sites. The hibernacula surveys consisted of visual searches for roosting bats. Lists summaries of recommended methods for repairing gates and mentions lock replacements for the bat gates. Species reported included *C. townsendii, E. fuscus, M. ciliolabrum, Myotis spp., P. subflavus, M. evotis, M. lucifugus, M. thysanodes,* and *M. volans*.

Tigner, J. (2011). Acoustic bat surveys: West Camp Rapid, 2011, Rapid City, South Dakota, USA. Report to the South Dakota Army National Guard. BATWORKS, LLC, Rapid City, SD. 9 pp.

Surveys were conducted at the SD Army National Guard's West Camp Rapid City Training Area which is roughly 800 acres. Acoustic detectors were deployed from September to October 2011 and captured calls from *M. ciliolabrum*, *L. noctivagans*, and *E. fuscus*. Noted that the property may be serving as a corridor for movement from lower elevations into sites in the Black Hills.

Tigner, J. (2012). Bat hibernacula surveys 2011–2012: Black Hills National Forest, SD. Report to Black Hills National Forest, USDA Forest Service. BATWORKS, LLC, Rapid City, South Dakota, USA. 11 pp.

Winter bat hibernacula visual surveys were conducted at seven caves and abandoned mine sites across the Black Hills National Forest (four Northern Hills, two Mystic, and one Hell Canyon) during the winter of 2011–2012. Most of the sites surveyed had installed bat gates, all of which were found locked and secure at the time of survey and there were no signs of white-nose syndrome. Species found within hibernacula included: *C. townsendii*, *E. fuscus M. septentrionalis*, *M. ciliolabrum*, *M. volans*, *M. lucifugus/M. volans*, and *Myotis* spp. Count data sheets are provided.

Tigner, J. (2014). Bat surveys: Wind Cave National Park, Custer County, SD, 2014 Interim Report. Report to the National Park Service, Wind Cave National Park. BATWORKS, LLC, Rapid City, South Dakota, USA. 22 pp.

Six surveys were conducted during the active season of 2014 within the boundaries of Wind Cave National Park. Surveys consisted of mist-netting in likely foraging sites with simultaneous supplemental acoustic surveying. The study reports information on age, sex, reproductive condition, length of forearm, and weight of captured individuals. No evidence of white-nose syndrome was found. Captured bats included: *L. borealis*, *L. cinereus*, *L. noctivagans*, *E. fuscus*, *M. septentrionalis*, *M. ciliolabrum*, and *M. thysanodes*. Acoustically recorded species included: *C. townsendii*, *E. fuscus*, *L. borealis*, *L. cinereus*, *L. noctivagans*, *M. ciliolabrum*, *M. lucifugus*, *M. thysanodes*, *M. volans,* and potentially *M. septentrionalis* although these calls could not be confirmed. Detailed site maps are provided.

Tigner, J. (2015). Bat Surveys: Wind Cave National Park, Custer County, SD, 2015 Final Survey Report. Report to the National Park Service, Wind Cave NP. BATWORKS, LLC, Rapid City, South Dakota, USA. 33 pp.

Study included nine mist-netting surveys and seven acoustic surveys during the active season of 2015 within the Wind Cave National Park boundary. Captured species included: *M. septentrionalis*, *M. ciliolabrum*, *M. thysanodes*, *M. lucifugus*, *E. fuscus*, *L. borealis*, *L. noctivagans*, *L. cinereus*, and *C. townsendii*. Acoustically-recorded species included: *M. septentrionalis*, *M. ciliolabrum*, *M. evotis*, *M. lucifugus*, *M. thysanodes*, *M. volans*, *C. townsendii*, *E. fuscus*, *L. borealis*, *L. cinereus*, and *L. noctivagans*. The only SD species that were not captured were *M. evotis* and *P. subflavus*. *P. subflavus* was also not detected acoustically. Study provides detailed site maps and tables of species

captures by site as well as reproductive status of captured individuals. Herp Hole is mentioned as a productive site every year.

Tigner, J. (2016). Bat surveys 2016: Buffalo Gap National Grasslands, USFS, Wall, SD. Report to Buffalo Gap National Grasslands, USDA Forest Service. BATWORKS, LLC, Rapid City, South Dakota, USA. 45 pp.

Study included five sites where both mist-netting and acoustic surveys were conducted and an additional eight acoustic survey sites during the active season of 2016 within the Buffalo Gap National Grasslands (Wall and Fall Districts). Captured species included: *L. borealis*, *L. cinereus*, *E. fuscus*, *M. septentrionalis*, *M. ciliolabrum*, and *Myotis* spp. (escaped). Acoustically recorded species included: *M. septentrionalis*, *M. ciliolabrum*, *M. evotis*, *M. lucifugus*, *M. thysanodes*, *M. volans*, *E. fuscus*, *L. borealis*, *L. cinereus*, *L. noctivagans*, and *C. townsendii*. Fiddlecreek Dam, near Edgemont, SD had 88 *M. septentrionalis* captures with adults and juveniles of both sexes on 8/28/2016. Potentially recorded *Antrozous pallidus* at Brush Creek but only had 5 call files. Study provides detailed site maps and tables of species captures by site as well as reproductive status of captured individuals. Noted that there were no visible signs of white-nose syndrome on any captured bats.

Tigner, J. (2017a). Black Hills Regional Bat Hibernacula Surveys: Winter 2016-2017, Black Hills National Forest, SD. Report to Black Hills National Forest, USDA Forest Service. BATWORKS, LLC, Rapid City, South Dakota, USA. 50 pp.

Winter bat hibernacula visual surveys were conducted at 23 selected caves and abandoned mine sites across all three districts in the Black Hills National Forest during the winter of 2016–2017. Most of the sites surveyed had installed bat gates, all of which were found locked and secure at the time of survey. Species found within hibernacula included: *C. townsendii*, *E. fuscus*, *M. septentrionalis*, *M. ciliolabrum*, *M. thysanodes*, *M. volans*, *Myotis* spp., and *P. subflavus*. Six *P. subflavus* were found at White Elephant Mine and nine were found at Joe Dollar Mine, along with nine *M. septentrionalis*. Hibernacula soil samples were collected at two caves and two mines to test for white-nose syndrome, all samples came back negative. Count data are provided as well as pictures of cave/mine openings and gates. Additional mines beyond the 23 surveyed were described but due to lack of access, were not surveyed.

Tigner, J. (2017b). Bat Surveys: Wind Cave National Park, Custer County, SD, 2017 Survey Report. Report to the National Park Service, Wind Cave NP. BATWORKS, LLC, Rapid City, South Dakota, USA. 36 pp.

Study included eight locations (five historical sites and three new sites). Both mist-netting and acoustic detectors were used at each site in August of 2017 within the Wind Cave National Park boundary. Captured species included: *M. septentrionalis*, *M. ciliolabrum*, *M. thysanodes*, *M. volans*, *L. borealis*, *L. noctivagans*, *L. cinereus*, *M. lucifugus*, *E. fuscus*, and *C. townsendii*. Acoustically recorded species included: *M. septentrionalis*, *M. ciliolabrum*, *M. evotis*, *M. lucifugus*, *M. thysanodes*, *M. volans*, *Myotis* spp., *C. townsendii*, *E. fuscus*, *L. borealis*, *L. cinereus*, and *L. noctivagans*. The only SD species that were not captured were *M. evotis* and *P. subflavus*. *P. subflavus* was also not detected acoustically. Elk Mountain Spring was particularly productive and diverse. Study provides detailed site maps and tables of species captured with sex, age, reproductive status, forearm length, and weight reported. No mention of tests for white-nose syndrome.

Appendix D –Rabies Information

Rabies is a viral disease that is nearly 100% fatal if left untreated. It is primarily transmitted through the saliva of infected animals including bats, skunks, raccoons, and canids (Center for Disease Control 2024); airborne transmission of the virus has been reported but is extremely rare (Gibbons 2002, Johnson et al. 2006). Globally, over 95% of human rabies cases are from domestic and feral dogs (World Health Organization 2024). In the United States, 4,000 human rabies infections are reported each year although fewer than 10 deaths occur. Out of these cases, 70% are from exposure to infected bats as feral canine populations are low in the United States (Center for Disease Control 2024). Several steps can be taken to reduce exposure risks (see below), and post-exposure treatments are nearly 100% effective when administered prior to the development of symptoms — as such, it is recommended to receive treatment immediately following exposure. For general information on rabies, consult the Centers for Disease Control and Prevention (CDC) website: CDC Rabies Overview.

State-specific resources provided by the South Dakota Department of Health include: a Disease Fact Sheet, Human Rabies Prevention Guidelines, a Rabies Survey Summary, and instructions for Submitting a Rabies Specimen for Testing. Additional information is also provided on South Dakota statues for rabies control (SDCL 40-12) and taking and holding animal suspected of being dangerous (SDCL 7-12-29).

Appendix H of the 2004 South Dakota Bat Management Plan offers additional details, including how the rabies virus affects humans, how bats may contract or transmit the disease, steps to minimize exposure risk, and guidance on safe bat removal from structures such as houses. Most bats do not carry rabies. Surveys of wild populations as well as rabies testing conducted on submitted bats suggest less than 1% of wild bats have rabies (Pape et al. 1999, Krebs et al. 2003, Klug et al. 2012). However, if a situation occurs where a bat bites a human or a bat comes into direct contact with a human, post-exposure measures should be taken immediately. CDC guidelines on post-exposure rabies prophylaxis are available here: CDC Post-Exposure Prophylaxis Recommendations.

All individuals conducting bat research or handling bats must receive a series of pre-exposure rabies vaccinations. This typically consists of two or three doses administered over several days. The most up-to-date CDC guidelines on pre-exposure rabies prophylaxis are available here: CDC Pre-Exposure Prophylaxis Recommendations. Personnel who handle bats should undergo a rabies titer check or receive a booster vaccination at least every two years to maintain adequate immunity.

Appendix E – Proper House Exclusion of Bats

Bat Use of Structures and Management Strategies

Human-made structures such as houses, barns, and bridges are commonly used by multiple bat species for summer roosting and, in some regions, for hibernation (Voigt et al., 2016). This is especially true in areas like the Great Plains, where natural roosting options such as mature trees, caves, and rock crevices, are limited (Kunz and Reynolds 2003). While this use of buildings can benefit bats, it often leads to human-wildlife conflict, particularly when property owners seek to evict bats due to concerns over noise, odor, or guano accumulation (Pfeiffer 2019). Although bats are protected by law in many jurisdictions, property owners are generally allowed to remove them from buildings, provided the removal is conducted in a humane and legally compliant manner (Pfeiffer 2019). Exclusion is the most widely recommended method for evicting bats from structures, particularly if there is a colony (Voigt et al. 2016). This involves sealing all but one or two known exit points, then installing one-way exclusion devices that allow bats to exit but prevent re-entry.

The timing of exclusions is critical. Exclusion should never occur during the maternity season (typically May through August), when flightless pups are present as removing adult females during this time can orphan pups, resulting in their death (Voigt et al. 2016, Pfeiffer 2019). Exclusions are best performed in the early fall, after juveniles are volant and bats begin to migrate or move to hibernacula (Bat Conservation International, 2025). Although many bat species do not hibernate in buildings, certain species like the big brown bat have been found hibernating in buildings in South Dakota and the Midwest (South Dakota Bat Working Group 2004). Exclusion of these species during winter months should also be avoided, as disturbing hibernating bats can lead to mortality due to their limited fat reserves and lack of suitable foraging habitats in the winter (Speakman et al. 1991).

For detailed guidance on exclusion techniques and humane bat removal, consult resources such as: the 2004 South Dakota Bat Management Plan (Appendix G), the Colorado Bat Working Group, Bat Conservation International, and Merlin Tuttle's Bat Conservation website.

If professional bat exclusion services are used, it is essential to select a company that is appropriately trained, accredited, and adheres to science-based, humane exclusion practices in accordance with state and federal wildlife regulations.

Artificial Roosting Structures

Many bat species exhibit high roost fidelity, returning to the same roosting area year after year (Lewis 1995, Slough and Jung 2020). Simply excluding bats from a structure does not guarantee they will not return the following season. An increasingly popular and conservation-minded approach is to install artificial bat houses near exclusion sites to offer alternative roosting habitat (Pfeiffer 2019).

Bat houses come in a variety of forms and configurations, and their effectiveness depends on species-specific needs, local habitat conditions, and proper installation (Crawford and O'Keefe 2024). Among the most successful artificial roosts are rocket boxes, which provide access to multiple sides for optimal temperature regulation and microclimate (South Dakota Bat Working Group, 2025). Other designs include traditional single- or multi-chamber bat boxes, artificial bark mounted on telephone poles, artificial roost trees with internal cavities, and temperature-controlled artificial caves.

For design specifications and installation recommendations, refer to: Bat Conservation International, Copperhead Environmental Consulting, Merlin Tuttle's Bat Conservation, South Dakota Bat Working Group, and the University of Illinois Urbana-Champaign Human-Wildlife Interactions websites.

Best Practices for Installation

When installing artificial roosts, consider the following key factors:

- **Target species:** Different species have varying roost preferences that influence box dimensions and internal structure (Mering and Chambers 2014, Willemsens et al. 2025).
- **Location and Microclimate:** Ensure access to a range of temperatures (a thermal gradient), especially warm, stable conditions preferred by maternity colonies (Mering and Chambers 2014, Pschonny et al. 2022). Avoid placing artificial roosts in locations that could result in overheating (Griffiths 2021). Place near suitable foraging habitats.
- **Predator protection:** Avoid installation near overhanging branches and consider using predator guards to deter climbing animals (Pschonny et al., 2022; Threlfall et al., 2013; Wildlife Conservation Society, 2025).

It is important to note that artificial roosts can pose ecological risks if not carefully planned (Pschonny et al. 2022, Crawford and O'Keefe 2024, Russo et al. 2024). Communal roosts where bats come into frequent contact with each other in large numbers may increase the spread of ectoparasites and diseases (Crawford and O'Keefe 2024). Furthermore, attracting bats to unsuitable locations, such as pesticide-treated agricultural areas or areas lacking foraging habitat, can create ecological traps that negatively impact bat survival and reproduction (Russo et al. 2024).

Proper site assessment, species-specific planning, and long-term monitoring are essential for ensuring that artificial roosts serve as effective conservation tools rather than unintentional hazards.

Appendix F – Laws and Regulations

There are multiple federal laws that protect bats and bat habitat. The 2004 edition of the South Dakota Bat Management Plan identified two pieces of federal legislature that protect Bat habitat including the Federal Cave Resources Protection Act of 1988 and the National Cave and Karst Research Institute Act of 1998, which prohibit the destruction, modification, and public announcement of cave habitats. The 2004 plan also identifies conservation-based management strategies of the National Park Service and U.S. Fish and Wildlife Service in South Dakota to protect cave and riparian habitats (South Dakota Bat Working Group 2004).

Other federal laws concerning bats have come into effect in South Dakota over the last decade, including the Endangered Species Act of 1973. This is due to the federal designation of the northern myotis (*Myotis septentrionalis*) as an endangered species in 2022 (U.S. Fish and Wildlife Service 2022): https://www.regulations.gov/; Docket No. FWS-R3-ES-2021-0140.

Other federal regulations could play an important role in protecting important bat habitat such as the Clean Water Act, the North American Wetlands Conservation Act, the National Environmental Policy Act, and the Fish and Wildlife Coordination Act.

The state of South Dakota also offers protection for bats under their legislature for threatened, endangered, and non-game species: Chapter 34A-8 Endangered and Threatened Species. South Dakota also has a state level Environmental Policy Act, SDEPA, and additional regulations that protect water and air (see Environmental Protections in South Dakota Codified Laws, 34A).

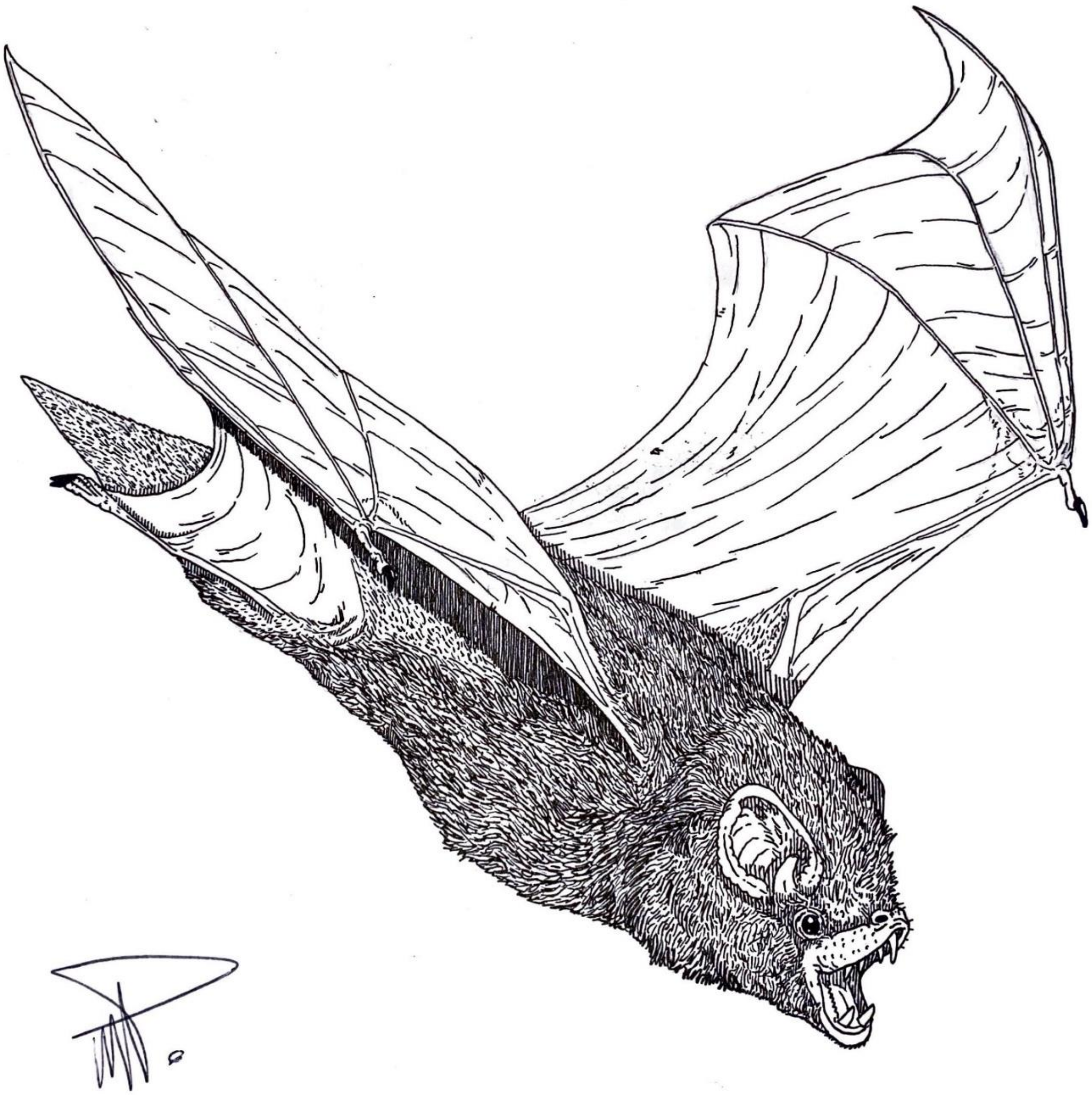

Figure 2: Illustration of a northern hoary bat, Lasiurus cinereus. Cover and end illustrations were done by Victor A. Piñeiro.