Timber Rattlesnake
(*Crotalus horridus*)

A Species Conservation Assessment
for
The Nebraska Natural Legacy Project

Prepared by Melissa J. Panella,[1] Daniel D. Fogell,[2] and Colleen Rothe-Groleau[1]
[1]Nebraska Game and Parks Commission, Wildlife Division
[2] Southeast Community College, Department of Arts and Sciences
2022

Suggested citation: Panella, M.J., D.D. Fogell, and C. Rothe-Groleau. 2022. Timber Rattlesnake (*Crotalus horridus*): a species conservation assessment for the Nebraska Natural Legacy Project. Nebraska Game and Parks Commission, Lincoln, Nebraska.

The mission of the Nebraska Natural Legacy Project is to implement a blueprint for conserving Nebraska's flora, fauna, and natural habitats through the proactive, voluntary conservation actions of partners, communities, and individuals.

Purpose

The primary goal in the development of at-risk species conservation assessments is to compile biological and ecological information that may assist conservation practitioners in making decisions regarding the conservation of species of interest. The Nebraska Natural Legacy Project recognizes the timber rattlesnake (*Crotalus horridus*) as a Tier 1 at-risk species. Provided here are general management recommendations regarding timber rattlesnakes. Conservation practitioners will need to use their professional judgment for management decisions based on objectives, location, and site-specific conditions. Based on the body of literature and available data, this species conservation assessment provides an overview of our current knowledge of timber rattlesnakes and may aid in decision-making for their conservation or in identifying research needs for the benefit of the species. Species conservation assessments will need to be updated as new scientific information becomes available. The Nebraska Natural Legacy Project focuses efforts in the state's Biologically Unique Landscapes (BULs), but it is also recommended that whenever possible, practitioners make considerations for a species throughout its range in order to increase the success of conservation efforts.

Common Name	Timber Rattlesnake
Scientific Name	*Crotalus horridus*
Order	Squamata
Family	Viperidae
G-Rank	G4
S-Rank	S1
Goal	1
Distribution	Peripheral
Criteria for selection as Tier I	State listed Threatened, G4S1, Declining species: ranked as imperiled or vulnerable in nearly all states in its range
Trends since 2005 in NE	Declining
Range in NE	Very southeast portion of the state
Habitat	Deciduous and riparian woodlands, often associated with prairie uplands, in conjunction with rock outcrops or talus slopes; grasslands; occasionally agricultural fields as migratory corridors between woodlands
Threats	Woody encroachment/overshading by eastern red cedar at den sites; destruction of den sites for agriculture and/or mining; Snake Fungal Disease; vehicle mortality; intentional harm or killing by humans Climate Change Vulnerability Index: Highly Vulnerable (NatureServe 2016)
Research/Inventory	Continue surveys to assess distribution and abundance; continue population monitoring and population viability assessment; identify and protect possible den sites
Landscapes	Sandstone Prairies, Southeast Prairies, Missouri River, Indian Cave Bluffs, Rulo Bluffs

Status

Timber rattlesnakes in Nebraska are listed as a Tier 1 at-risk species (Schneider et al. 2011, Schneider et al. 2018) and are protected at the state level as a Threatened species under the Nebraska Non-game and Endangered Species Conservation Act. According to the latest review in 2021 (NatureServe 2021), the subnational conservation status rank for the timber rattlesnake is S1 ('Critically Imperiled'), indicating that the species is "at very high risk of extirpation in the jurisdiction due to very restricted range, very few populations or occurrences, very steep declines, very severe threats or other factors." The global conservation rank, which uses the world rather than the state as a geographic reference, is G4 ('Apparently Secure') which means the species is "at fairly low risk of extinction or collapse due to an extensive range and/or many populations or occurrences, but with possible cause for some concern as a result of local recent declines, threats, or other factors."

The Nebraska Natural Legacy Science Team, consisting of members representing numerous agencies, was tasked with setting a quantitative conservation goal for target species so that multiple populations could be conserved. According to Schneider et al. (2011), species that are found mainly in other regions, where generally less than 10% of the range is within Nebraska, are considered Peripheral. Therefore, it is considered a Peripheral species in Nebraska. The current goal for timber rattlesnake population conservation in Nebraska is one population. The quantitative goals are an approximation and are subject to change as new information becomes available. (Schneider et al. 2011)

In December 2020, the Nebraska Administrative Code 163 §4-004.02 was approved, designating timber rattlesnakes as Threatened in Nebraska, making it illegal "for any person to take, export, possess, process, sell or offer for sale, deliver, carry, transport, or ship by any means whatsoever any threatened species except as specifically provided by state or federal law. Taking of a timber rattlesnake will not be considered unlawful if it is done for the immediate protection of the health of humans, livestock or pets" (NAC 163 §4-004.03A2).

Principal Risk Factors

1. Loss of Habitat

The present or threatened destruction, modification, or curtailment of its habitat or range is the primary risk factor affecting timber rattlesnake survival. While timber rattlesnakes are known to use grassland and agricultural habitats during their active seasons, they are predominantly a woodland species that is adapted to forested and savanna-like environments (Panella and Fogell 2018). Woodlands are rare in Nebraska, and woodlands associated with suitable hibernation habitat, also called hibernacula, are even more scarce. Timber rattlesnakes are found, as the common name implies, in deciduous woodlands with exposed rocky outcrops (Fogell 2010) that provide access into fissures in the bedrock. These fissures offer protection from the elements and are used as hibernacula, also called dens or den sites. The need for these habitat features limits further distribution in Nebraska (Fogell and Fawcett 2005).

The continued persistence of timber rattlesnakes in Nebraska depends on the availability of suitable hibernacula. Encroaching woody vegetation, predominantly eastern redcedar (*Juniperus virginiana*), has caused significant shading over of den sites, which depend on solar exposure during

winter months (Breisch et al. 2021). Many of these den sites have been abandoned over the past 30–40 years (per landowner discussions), likely because of "shading over."

In the species' range, rock outcroppings in some locations are being quarried for rock. In Nebraska, timber rattlesnakes once occurred from Plattsmouth to Rulo along the limestone bluffs of the Missouri River. Channelization construction during the 1930s and 1940s quarried those bluffs for stabilization rock, which ultimately reduced the distribution of the population to a small part of Richardson County. Some old quarries in areas where denning sites were historically known are once again being mined, thus destroying potential denning sites, and removing the possibility of repatriation of the species in those areas.

2. Over-Utilization

Over-utilization from commercial, sporting, educational, and/or other purposes have caused declines across the species range. Timber rattlesnakes have been victims of illegal collecting and the pet trade in some states such as Connecticut (Connecticut Department of Energy and Environmental Protection 2016), New York (New York State Department of Environmental Conservation 2018), and New Jersey (Conserve Wildlife Foundation for New Jersey 2018). It is unknown if this is a significant contributing factor to the species' decline in Nebraska.

3. Disease

Additionally, a relatively new and potentially devastating risk factor is a disease known as *Ophidiomyces ophiodiicola*, also known as Snake Fungal Disease (SFD). Preliminary evidence of this disease in Nebraska's timber rattlesnakes has been recorded as far back as 1998 (Fogell 2000). Other than several observational notes in the past 20 years, its prevalence, mortality rate, and continued presence in Nebraska are currently unknown. Populations in Massachusetts (McBride et al. 2015) and New Hampshire (Clark et al. 2011) have experienced high mortality rates and severe population declines directly attributable to SFD. Other states have reported occurrences – in timber rattlesnakes and other species – but without any observable population declines (Lorch et al. 2016). While the effects of SFD on Nebraska's timber rattlesnakes are unknown, the effects could potentially be disastrous based on reports from other areas.

4. Climate Change

Climate change alters ecological processes like fire and precipitation, as well as exacerbating non-climate aspects such as habitat loss and fragmentation (Wilhite and Morrow 2016). The need for rocky outcrops, with very specific characteristics, such as access to shelter below the frost line, limits the likelihood that timber rattlesnakes will survive extreme winter conditions in Nebraska. While timber rattlesnakes in more southern regions of their range can survive by hibernating in tree root systems and mammal burrows, extended time periods with sub-freezing temperatures preclude this behavior in Nebraska. Some species are able to shift their distribution; however, timber rattlesnakes have such specific overwintering needs in Nebraska that such adaptation is unlikely.

5. Human Interactions

The greatest contribution to mortality of timber rattlesnakes in Nebraska has been the result of human interactions. In the past 20–25 years, residents of Gage County have reported an estimated average of 6–8 large adult timber rattlesnakes killed on roads, either accidentally by traffic or maliciously (Dan Fogell, personal communication), each year. Additionally, in the past 5 years, a total of at least six have been killed by vehicle traffic on roads in Richardson County. Additional malicious killings

of timber rattlesnakes have also occurred at locations other than roads (Nebraska Natural Heritage database), such as directly on den sites or during random encounters. Since timber rattlesnakes in Nebraska frequently occupy grasslands, such as pastures and hay fields, there is the potential they could be killed during hay cutting and baling activities. Loss of individual timber rattlesnakes is of greater concern due to the small size of the remaining populations.

With the recent conversion of railroad lines to bicycling/hiking trails along the Big Blue River in Gage County, trail users will now pass directly in front of den sites where timber rattlesnakes hibernate communally. These areas were previously protected by railroad "no trespassing" regulations, which have since been removed; therefore, negative interactions with timber rattlesnakes could increase in these areas.

Species Description

Timber rattlesnakes can have variable ground colors, but there are always dark crossbands present (except when all black), and a black tail that looks similar to velvet. The western variant (found in Nebraska) is generally gray, brown, or tan with an orange-red middorsal stripe, dark markings often edged in white, and reddish-brown lines behind the eyes (Figure 1). A golden colored stripe extends along the cheeks. Timber rattlesnakes are the largest of Nebraska's rattlesnakes and grow to an average size of 111.8–127 cm (44–50 in) long. (Powell et al. 2016)

Timber rattlesnakes are distinctive in appearance and are not easily mistaken for other species; however, the northern water snake (*Nerodia sipedon*) is another heavy-bodied snake that can be found in riparian areas in southeastern Nebraska (Fogell 2010). Prairie rattlesnakes can be found in Nebraska as well, though their range does not overlap that of the timber rattlesnake in the state.

FIGURE 1. A female timber rattlesnake, *Crotalus horridus*, in southeastern Nebraska (Photo by Dan Fogell).

Habitat and Range

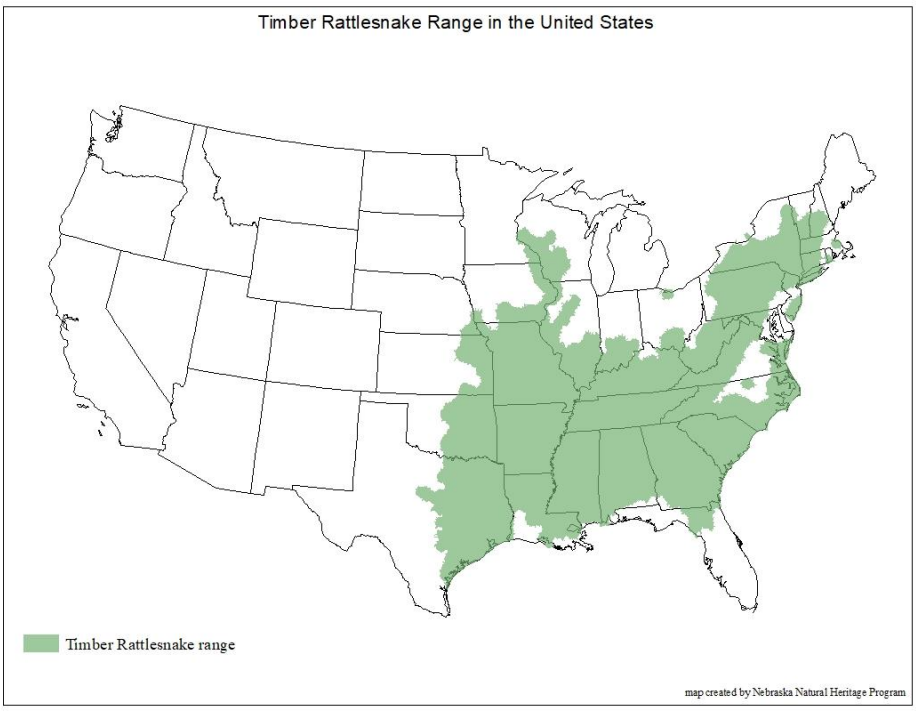

FIGURE 2. Map illustrating the distributional range of the timber rattlesnake, *Crotalus horridus*, in the United States.

Timber rattlesnakes have a wide distribution across most of the eastern half of the United States. NatureServe (2017) describes their range as extending south from the states of central New England to northern Florida, and west to southeastern Minnesota, southern and eastern Iowa, eastern Texas, central Oklahoma, eastern Kansas, and southeastern Nebraska. Timber rattlesnakes have a patchy distribution on the northern and western portions of their range. (NatureServe 2017; Figure 2).

In the northeastern portion of the range, timber rattlesnakes have likely been extirpated from Ontario, Canada, Maine, and Rhode Island. Two populations remain in Vermont, but only one persists in New Hampshire. In Massachusetts, there are five known viable population clusters. In New York, 26% of known historic den sites are now extirpated, another 5% are nearly extirpated, and the state's entire population is estimated to have declined by 50–75% since colonial settlement. Populations have declined significantly in New Jersey and the mid-Atlantic region. (NatureServe 2017)

Precise data on range decline at the global level are not readily available; however, the consensus among researchers is that timber rattlesnake distribution is shrinking everywhere they occur. The most notable distribution declines are in the New England states, New York, New Jersey, Minnesota, Wisconsin, and Indiana. There is no place where their distributions are increasing, though in several Appalachian states, they are somewhat stable. In Nebraska, they once occurred from Plattsmouth to Rulo along the Missouri River's limestone bluffs; however, channelization construction quarried these bluffs for stabilization rock, which ultimately reduced their distribution to a small part of Richardson County near the town of Barada. The distribution of timber rattlesnakes in Gage County has been moderately reduced as a result of quarrying and land conversion for agriculture, but several stronghold den sites still persist.

In Nebraska, timber rattlesnakes live in the very southeast portion of the state (Figure 3). There is suitable habitat in the Sandstone Prairies, Southeast Prairies, Missouri River, Indian Cave Bluffs, and Rulo Bluffs Biologically Unique Landscapes, although records are scarce. Nebraska's population is at the northwestern periphery of the species' range.

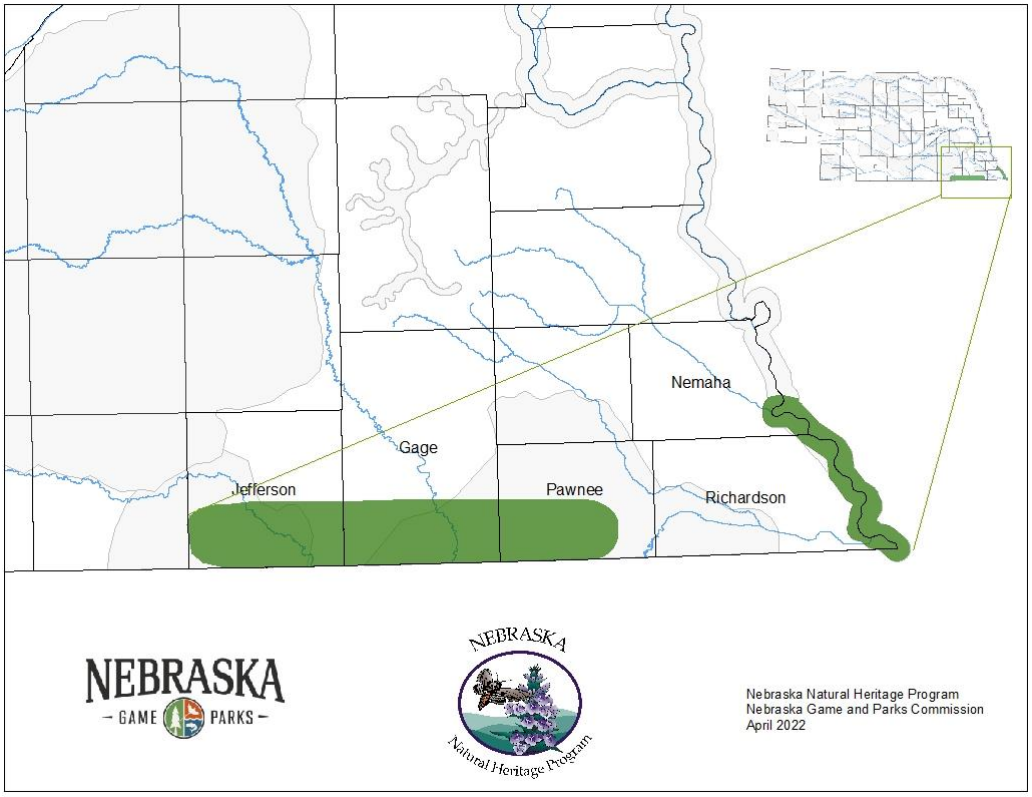

FIGURE 3. Within the state of Nebraska, the current estimated range of the timber rattlesnake, *Crotalus horridus*, is limited to the southeastern area of the state.

The only known extant occurrences of timber rattlesnakes in Nebraska are in southern Gage County and in northeastern Richardson County (Figure 3). In southern Gage County, there are multiple (10–12) small den sites which collectively form a single population in which gene flow can regularly occur (Fogell 2016). In northeastern Richardson County in the Barada Hills, there is a single known den site, but evidence supports at least 1–2 additional den sites that collectively compose a single, interbreeding population (Fogell 2016). Additional den sites may occur in southeastern Richardson County; however, presently there are no known sites. Specimens from Pawnee and Jefferson counties exist, but extant populations have never been identified for those locales. Populations in Cass County were extirpated by the end of the 1970s, and it is believed that any Otoe and Nemaha County populations also perished during that time. Population studies and surveys have been ongoing in Gage County since 1997, and evidence strongly shows a decline in both number and distribution in Gage County. In Richardson County where timber rattlesnakes were once reported to be fairly common, fewer than 20 individuals have been sighted within the past 40 years, and seven of those were within the last 3 years as a result of intense survey efforts. Two of the largest den site populations in Nebraska have less than 100 timber rattlesnakes each, based on a long-term mark and recapture study from Gage County. Given that there

are 10–12 known den sites in Gage County and one in Richardson County, the total number of timber rattlesnakes in the state is estimated to be less than 1,000 individuals.

Dispersal, Migration, and Den Site Fidelity

The active season of timber rattlesnakes lasts an average of 179 days (Fogell and Fawcett 2005) and begins in early April. Fogell (2010) documented timber rattlesnakes using deciduous and riparian woodlands in conjunction with rock outcrops or talus slopes that provide winter denning hibernacula. Woodlands that timber rattlesnakes inhabit often are associated with prairie uplands. Grasslands, and sometimes agricultural fields, provide the snakes with a migratory corridor between woodlands. During migration, they are known to use houses of eastern woodrats (*Neotoma floridana*) for cover (Fogell 2010).

Several studies at locations within the population core, including Lenexa, Kansas (Walker et al. 2009), the Sauratown Mountains area, North Carolina (Sealy 2002), and eastern Pennsylvania (Reinert and Rupert 1999), have looked at translocation as a conservation method with some mixed success, likely because of the strong den site fidelity exhibited by this species (Panella and Fogell 2018). In Nebraska, den site fidelity occurs most commonly, but is not 100% (Fogell ongoing surveys, unpublished results), thus re-establishing den sites here would likely be more successful than at the core of the species' distribution.

The natural history of timber rattlesnakes will not afford for a successful recovery within a short amount of time (i.e., 10 years or less). Habitat connectivity in both Gage and Richardson counties is so poor that natural recolonization of extirpated den sites would take substantially more time. Additionally, genetic diversity among populations is significantly lower in populations isolated by fragmentation, than in populations in contiguous habitat (Clark et al. 2010).

Diet and Foraging

Timber rattlesnakes are ambush predators, meaning they deploy a sit-and-wait technique for obtaining prey (Greene 1986). The foraging ecology of timber rattlesnakes can vary geographically, and they will hunt a variety of prey (Reinert et al. 2011). Clark (2002) synthesized the known feeding ecology of timber rattlesnakes with published records and information about stomach contents from museum specimens. Their diet consists primarily of small mammals (>90%) such as mice, chipmunks, ground squirrels, and voles (Clark 2002). Occasionally, they will eat birds, amphibians, or reptiles (Clark 2002). Gravid females may fast or feed less, relying on their fat reserves, because they must spend more time basking and seeking warmth of rocks to support development of their young (Keenlyne 1972).

Reproduction and Life History

Timber rattlesnakes are a slow-growing and long-lived species. Sexual maturity is not reached until males are approximately 5 years old (New York State Department of Environmental Conservation 2018), and females are 5–11 years old (i.e., most females are 7–10 years at first reproduction; Brown 1991, Martin 1993). The females ovulate 4–6 weeks after their spring emergence from their hibernacula (Martin 1993). A female may migrate around 3.2 km (2 mi) in search of a mate (Fogell 2010). Anderson (2010) and Mohr (2012) found that males traveled farther than females in search of mates. Birthing occurs in late summer (August–September) (Martin 1993, Fogell 2010). Litter sizes range from 4–15,

with an average of 9 young (Center for Reptile and Amphibian Conservation and Management 2003, New York State Department of Environmental Conservation 2018).

The largest females can be expected to have the greatest overall fecundity (i.e., number and size of neonates) (Martin 1993). Females reproduce at 2–4-year intervals (Brown 1991, Martin 1993), so they may only produce 3-4 litters within their lifetime. Frequency of reproduction and litter size can vary based on environmental conditions and food availability (Martin 1993).

Lifespan is 16–22 years with a maximum life expectancy of approximately 30 years (New York State Department of Environmental Conservation 2018). Survival rates among adult timber rattlesnakes (≥ 5 years old), stabilize and may even increase slightly with age (Brown et al. 2007).

The young remain close to their mother for at least the first week of life (Cobb et al. 2005). Snake mortality during the first year of life is high, estimated at 75–90% because of predation on neonates, not enough small prey, lack of suitable dens (Greene 1997), and risks during dispersal (Bonnet et al. 1999).

Survival

While Nebraska's population represents a significantly small proportion of the global population, its placement in distribution is notable and significant in terms of the species' biogeography, global genetic diversity, and conservation value. Several studies have shown that as species become rare and start to decline in population size and distribution, they do not collapse at the periphery of their range but rather at the center, and the peripheral populations remain intact (Crowley 2011; Channell and Lomolino 2000). In a review of numerous studies, more than 90% of declining distributions remained intact at the western periphery of their global distribution – which is precisely where Nebraska's timber rattlesnakes reside. One reason for this is the more diverse set of adaptability "tools" present within these populations. Individuals at peripheries are more prone to adapt and survive under suboptimal conditions, thus those "survival" alleles become prevalent in peripheral populations. Those at the core of the range are rarely presented with the extreme conditions present at the periphery, thus those same "survival" alleles are not nearly as prevalent (Lesica and Allendorf 1995). From a conservation genetics standpoint, timber rattlesnakes at their extreme periphery contain valuable genetic diversity that will allow both for survival in an already extreme environment and the potential to provide founding stock for reintroduction efforts elsewhere in the range as populations begin to collapse and become extirpated. While Nebraska's timber rattlesnakes are an extreme peripheral population, the Richardson County population is also disjunct from the rest of the distribution, with the nearest known population occurring ~45 mi (~72 km) to the southeast near Atchison, Kansas. Populations in Gage County are somewhat continuous with populations in Kansas to the south.

Declining population densities reduce the probability of encounters with other timber rattlesnakes, and therefore reduce the probability for mating, reproduction, and recruitment. This exacerbates the continued decline of populations.

Research and Conservation Strategies

A multitude of factors should be considered before implementing any conservation actions. Within the guidelines of state and federal law, the Nebraska Natural Legacy Project recommends: 1)

consider, but do not limit options to, scenarios that benefit not only the species of interest but also property owners, 2) consider species dispersal and landscape context, 3) plan for multiple years, and 4) do no harm.

While take of timber rattlesnakes is prohibited, state laws and regulations do not protect against habitat loss and alteration that threatens timber rattlesnakes. The Nongame and Endangered Species Conservation Act could offer the possibility for additional protection of this species on state and private lands through Section 37-807 involving conservation programs and state agency consultation (Panella and Fogell 2018). For example, Breisch et al. (2021) recommends that state protections should include the purchase of areas where hibernacula are known to occur, along with adjacent forested bluff lands, which is a known habitat preference for the species' summer range.

In Nebraska, there are five BULs where conservation considerations for timber rattlesnakes can be made: Sandstone Prairies, Southeast Prairies, Missouri River, Indian Cave Bluffs, and Rulo Bluffs. The Nebraska Natural Legacy Project identified these landscapes as places that offer the best opportunities for conservation of timber rattlesnakes in the state based on current knowledge. Given the principal threats identified, research and conservation efforts (summarized in Table 2) for timber rattlesnakes may want to employ the following conservation and management actions, as well as the research topics listed below, many of which come from Breisch et al. 2021:

1. State protection against the destruction or large-scale alteration of remaining timber rattlesnake habitat and hibernacula. This includes requiring comprehensive field surveys to determine whether potential quarry sites are part of a hibernacula-complex prior to quarrying. This protects critical overwintering habitat for a number of species, including the timber rattlesnake.
2. Habitat maintenance around known den sites to prevent over-shading by encroaching woody vegetation should be performed regularly using a combination of prescribed fire and pruning. These methods will reduce the cooling effect caused by over-shading and woody encroachment as well as open additional habitat for small mammals that make up the majority of the diet of the timber rattlesnake. Prescribed fire should be conducted during the winter months (typically November 1 – March 31) when timber rattlesnakes are not active and are safely ensconced in hibernacula. If burning needs to occur during the spring, summer, or fall, den sites should be surveyed by a qualified biologist prior to burning. Additionally, abandoned den sites should be cleared of understory growth and over-shading eastern redcedars to encourage expanding populations from neighboring dens to recolonize these vacant sites.
3. Investigate public perceptions and create an educational campaign to inform landowners and the public of the habits and requirements of timber rattlesnakes and how to live and work safely in the same areas. This fosters a sense of empathy and connection that is necessary for recovering and protecting species that may be perceived as less charismatic than others, such as the timber rattlesnake.
4. Gain and maintain relationships with private landowners to increase awareness, interest, and facilitate habitat conservation. Facilitate partnerships and cooperative efforts to protect, restore, and enhance suitable habitat and conduct research, with federal (U.S. Army Corps of Engineers, U.S. Fish and Wildlife Service, U.S Department of Agriculture (USDA), etc.) and state (Nebraska Department of Transportation, Nebraska Forest Service, Natural Resource Districts,

Universities, etc.) agencies, conservation organizations, and tribal partners (specifically Ponca Tribe, Sac and Fox Nation, and Iowa Tribe).

5. Ongoing periodic field surveys should continue in Gage, Richardson, Pawnee, and Jefferson counties to determine distribution, population size, and status in these counties. Additionally, these surveys should identify structures useful to timber rattlesnakes during summer foraging/migration activities, such as large wooden snags, debris piles, and/or eastern woodrat middens.
6. Surveys and mark/recapture studies at known den sites should be continued to observe population trends, habitat changes, and to continuously assess landowner empathy.
7. More research regarding the occurrence, severity, and spread of SFD and/or other zoonotic diseases affecting snake species in Nebraska is necessary.
8. Numerous USDA-Natural Resources Conservation Service Farm Bill programs might be used to benefit timber rattlesnakes, but each management practice should be scientifically evaluated before it is widely implemented for this purpose. Availability of programs may vary in any given year.

   Consider the following examples of practices and programs that may provide benefits for timber rattlesnakes:

   CRP – CP 2 (Native Grasses), 4D (Permanent Wildlife Habitat), 10 (Existing Grasses and Legumes), 21 (Filter Strip-grass), 25 (Rare and Declining Habitat), 33 (Upland Bird Habitat Buffer), 38 (State Acres for Wildlife Enhancement), 42 (Permanent Wildflowers and Legumes)

   EQIP- 528 – Prescribed Grazing, 314 – Brush Management, 645 – Upland Wildlife Habitat Management, 391 – Riparian Forest Buffer, 666 – Forest Stand Improvement

   Conservation Stewardship Program – Numerous enhancements

   Forest Restoration Partnership Regional Conservation Partnership Program – This program is slated for 5 years
9. Funding for conservation actions may also be available from other potential NGPC programs listed below:

   Nebraska Natural Legacy Project Implementation Grants

   State Wildlife Grants

   WILD Nebraska

   The Nebraska Environmental Trust
10. Continually update location data with incidental observations and research study findings and share with conservation partners.

Information Gaps

The distribution of timber rattlesnake populations throughout Nebraska could be better understood through continued systematic survey efforts. In particular, surveys should occur in Jefferson County where there are vast areas of likely suitable habitat. To what extent conservation practices (i.e., Farm Bill programs) could benefit timber rattlesnakes has not been evaluated in detail. We do not have a clear understanding how timber rattlesnakes could survive using refugia during the haying process

(i.e., how big should un-mowed patches be, how long should patches be left, and how should locations of patches shift over time?).

There is a distinct lack of information regarding the prevalence of SFD in Nebraska, as well as the effects of recurring and/or severe infections with SFD on affected species, such as the timber rattlesnake, western massasauga, and other snake species. Climate change has been identified as a driver of range shifts for several species (Chen et al. 2011). How climate change could contribute to the alteration of the timber rattlesnake's range spread and severity of SFD in Nebraska remains to be seen.

Considerations for Additional Species

At-risk species which share habitat with timber rattlesnakes should be considered when forming management plans for this and other species. On-the-ground conservation for timber rattlesnakes may affect or be influenced by species that can be found in the same BULs. Actions to conserve these sympatric species should also integrate conservation for timber rattlesnakes where appropriate. Associated species that may benefit from conservation of timber rattlesnakes are listed below (Schneider et al. 2011). This list will not apply to all sites of occupancy of timber rattlesnakes nor is the list all-inclusive.

TABLE 1. *Associated species that may benefit from conservation actions for timber rattlesnakes.*
***** *Species conservation assessment exists for NGPC*
^ *State threatened or endangered species in Nebraska*

Birds	**Insects**
Greater Prairie-Chicken (*Tympanuchus cupido*)	Iowa Skipper (*Atrytone aragos iowa*)
Henslow's Sparrow (*Ammodramus henslowii*)	Ottoe Skipper (*Hesperia ottoe*)
Loggerhead Shrike (*Lanius ludovicianus*)	Regal Fritillary (*Argynnis idalia*)
Wood Thrush (*Hylocichla mustelina*)	Married Underwing (*Catocala nuptialis*)
Buff-Breasted Sandpiper (*Calidris subruficollis*)	Whitney Underwing (*Catocala whitneyi*)
Short-eared Owl (*Asio flammeus*)	Monarch (*Danaus plexippus*)
Summer Tanager (*Piranga rubra*)	
Reptiles	**Mammals**
Massasauga (*Sistrurus tergeminus*) *** ^**	Southern Flying Squirrel (*Glaucomys volans*) *** ^**
Copperhead (*Agkistrodon contortrix*)	Tricolored Bat (*Perimyotis subflavus*)
Prairie Kingsnake (*Lampropeltis calligaster*)	Little Brown Myotis (*Myotis lucifugus*)
Five-Lined Skink (*Plestiodon fasciatus*)	Northern Long-eared Myotis (*Myotis septentrionalis*)**^**
	Plants
	Missouri Sedge (*Carex missouriensis*)
	American Ginseng (*Panax quinquefolius*) *** ^**
	Nodding Pogonia (*Triphora trianthophora var. trianthophora*)

TABLE 2. Summary of suggested management strategies and considerations, in order of priority, for timber rattlesnakes in Nebraska. The following are general guidelines based on the best available knowledge at the time of this publication. See Research and Conservation Strategies section of this document for more detail and the Literature Cited section for sources of additional information.

FOCUS	STRATEGIES	CONSIDERATIONS
Timing and extent of prescribed fires	Perform prescribed fires prior to spring emergence (~March; transmitters on some individuals can help to determine if snakes have emerged) on cool days early in the day to avoid unintentional mortality of timber rattlesnakes. Fires could be used to create a patchwork of habitat to maintain retreat and foraging opportunities.	Prescribed fires may make timber rattlesnakes more visible to predators in the short term and reduce abundance of small mammal prey in burned areas for at least one full season. Days post-fire are a good time to locate timber rattlesnakes and conduct surveys.
Maintain habitat and hibernacula	Monitor hibernation areas for encroachment of woody vegetation and remove via burning or pruning. Develop monitoring plans or site-specific recommendations. Address changes through low-impact management actions. Survey sites of new quarry activities to assess hibernacula potential.	Maintenance should occur outside of the March-late October active season to reduce conflict with timber rattlesnakes.
Reduce road mortality	Consider developing wildlife crossing structures and directed reptile fencing at highways which bisect travel corridors or are located near known occupied den sites. Consider closing county or minimum maintenance roads that timber rattlesnakes are known to frequent during spring or fall migration times.	Construction activities on roads may disrupt timber rattlesnakes migrating through or otherwise occupying roadside ditches. Road construction projects should use net-free or “snake-friendly” erosion control on bare soil and leave overlapping gaps in silt fence to allow snake passage.
Increase public outreach	Informational signs or kiosks could notify visitors about presence of timber rattlesnakes and current conservation strategies. Public outreach campaigns via social media, classroom and extension education programs, and Master Naturalist programs could aid in increasing general public awareness of the snakes.	As necessary, signage should include positive statements in place of warnings to keep visitors from feeling defensive or fearful during their time at a property. Do not put signage directly at den sites to try to minimize poaching risk.

Monitor and inventory populations	Known populations of timber rattlesnakes should continue to be regularly monitored to record their status and observe possible declines. Survey efforts should be used to locate any additional populations in the state.	Radio transmitters or PIT tags may be used for monitoring. Efforts to locate additional populations could include informing landowners on how to report possible sightings.
Monitor health and disease in populations	Document any clinical signs of disease during inventory work. Diseased timber rattlesnakes should not be exposed to healthy snakes.	Various assays can be used to analyze blood samples for infection but be wary of cross-contamination and false positives.

Acknowledgments

The authors would like to thank Shaun Dunn, Caroline Jezierski, Melissa Marinovich, Sarah Nevison, and Jonathan Tejeda for their helpful comments and thoughtful suggestions in previous versions of this manuscript.

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