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Blanding's Turtle
(Emydoidea blandingii)

A Species Conservation Assessment
for
The Nebraska Natural Legacy Project



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Nebraska Game and Parks Commission
Wildlife Division
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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 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 Blanding's turtle (*Emydoidea blandingii*) as a Tier I at-risk species. Some general management recommendations are made here regarding Blanding's turtles; however, conservation practitioners will need to use professional judgment to make specific management decisions based on objectives, location, and a multitude of variables. This resource was designed to share available knowledge of this at-risk turtle that will aid in the decision-making process or in identifying research needs to benefit the species. Species conservation assessments will need to be updated as relevant scientific information becomes available and/or conditions change. The Nebraska Natural Legacy Project focuses efforts in the state's Biologically Unique Landscapes, but it is recommended that whenever possible, practitioners make considerations for a species throughout its range in order to increase the outcome of successful conservation efforts.

<u>Common Name</u>	Blanding's Turtle	<u>Scientific Name</u>	<i>Emydoidea blandingii</i>
<u>Order</u>	Testudines	<u>Family</u>	Emydidae
<u>G-Rank</u> G4	<u>S-Rank</u> S4	<u>Goal</u> 4	<u>Distribution</u> Limited
<u>Criteria for selection as Tier I</u>	Ranked as imperiled or vulnerable in all but one state in its range		
<u>Trends since 2005 in NE</u>	Stable		
<u>Range in NE</u>	Primarily Sandhills marshes, very locally in eastern portion of state		
<u>Habitat in NE</u>	Requires proximity to water; Sandhills fens, Sandhills freshwater marsh, northern cordgrass wet prairie, small tributaries, Sandhills prairies (upland habitat), marshes and oxbows in eastern portion of state		
<u>Threats in NE</u>	Habitat fragmentation and loss of wetlands in eastern part of range in the state; vehicle mortality; collection for pet trade		
	Climate Change Vulnerability Index: Not Vulnerable; presumed stable		
<u>Research/Inventory</u>	Continue surveys along eastern edge of range within the state as populations recover from extreme weather events of 2019; Continue population monitoring in the Sandhills region and areas further south and west in the state; Collect DNA samples for population research		
<u>Landscapes</u>	Cherry County Wetlands, Dismal River Headwaters, Elkhorn Confluence, Elkhorn River Headwaters, Lower Loup Rivers, Lower Platte River, Middle Niobrara, Upper Loup Rivers and Tributaries		

Status

According to the last review in 2020, Blanding's turtle Subnational Heritage status rank is S4, indicating that the species is apparently secure at the state level. U.S. national status is N4, and global conservation rank is G4 (NatureServe 2020), all of which indicate the species is apparently secure throughout the species range, however, the species is listed as vulnerable or imperiled in all but one state in the species range in the United States. This parity of rank at the state, national and global levels has led to a review of the methodology used by NatureServe to determine ranking at different regional levels.

“Comparison of Global and National/Subnational Rank Information: Useful when assigning conservation status, especially when the national/subnational information is more current or detailed than the global information or vice versa. Historically, a subnational rank that implied that a species or ecosystem was more secure at the state/province level than it was nationally or globally was not acceptable (e.g., a rank of G1S3 was invalid), and similarly, a national rank that implied that an element was more secure at the national level than it was globally was not acceptable. This rule is under review, because current methods provide a more explicit role for Threats and Trends, which may indicate low levels of risk at national/subnational scales as compared to global scales, and a one-rank difference may be permissible (e.g., G1S2).” (Faber-Langendoen, et al. 2012)

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. A target goal of maintaining at least four populations of Blanding's turtles within the state was set due to the widespread range of the species throughout the United States and Canada. The quantitative goals set by the Science Team are an approximation and are subject to change as new information becomes available. (Schneider et al. 2011).

Principal Threats

Approximately one-third of all aquatic and semi-aquatic turtle species in the United States are in need of some type of conservation action (Lovich 1995, Gibbs and Shriver 2002). Because of delayed sexual maturity in turtles, populations are less able to sustain significant disturbances and increased mortality threats (Wilbur and Morin 1988, Congdon et al 1993, Gibbs and Shriver 2002).

Blanding's turtles, like other freshwater turtles, have multi-faceted habitat needs including aquatic habitats for feeding and hibernation, as well as upland terrestrial habitats for nesting (Reid et al 2015). Loss of any of these habitat types due to wetland conversion to agriculture, industry, urban development, etc. can be detrimental to the population. Wetlands that are overrun by cattails are avoided by Blanding's turtles (Henning and Hinz Jr. 2016). Upland habitats used for nesting are often lost to woody encroachment which can lead to bare soil elimination, changes in incubation temperatures, and increased predation rates (Henning and Hinz Jr. 2016). Additionally, the introduction of trees to a nesting environment may reduce hatchling Blanding's turtles' ability to locate water (Pappas et al. 2009).

Road mortality is a significant threat to adult Blanding's turtles as they frequently tend to move long distances to find mates and to get to nesting areas. As such, they are quite vulnerable to road mortality, especially where roads bisect prime aquatic and/or terrestrial habitats (Reid et al. 2015). Individual Blanding's turtles have been observed to use multiple wetlands throughout their active season by moving among wetlands and thereby increasing their risk of road mortality (Beaudry et al. 2009, Joyal, et al. 2001). Gibbs and Shriver found that land areas covered with more than 1 km of roads/km² and that support travel for 100 or more cars/day are most likely to negatively impact Blanding's turtles (2002). Grgurovic and Sievert analyzed that the probability of road-related turtle mortality can decrease when the mean traffic density is 550 vehicles or less per day (2005). Also, heavy use of all-terrain vehicles near turtle nests can be damaging (MassWildlife 2007).

Nest predation poses another threat to the most vulnerable life stage of Blanding's turtles: the egg. Medium-sized mammals such as raccoons (*Procyon lotor*), red (*Vulpes fulva*) and gray foxes (*Urocyon cinereoargenteus*), and striped skunks (*Mephitis mephitis*) are common nest predators (Congdon et al. 1983, Henning and Hinz Jr. 2016). Nest predation occurs throughout the nesting period, not just at oviposition, and is associated with a variety of environmental cues (Riley and Litzgus 2014, McCurdy-Adams 2016).

Loss of genetic diversity can have detrimental effects on species. As habitat becomes increasingly fragmented throughout the species range, small populations are at greater risk of becoming isolated from the species range and eventually become extirpated. Adults in small, isolated populations may end up breeding with offspring, resulting in an inbreeding depression. This can also increase genetic drift, making it necessary in the long term to manage for the exchange of genetic material (Henning and Hinz Jr. 2016).

Other threats to turtles include collection for the pet trade that reduce wild populations (Salzberg 1995, Conant and Collins 1998, Gibbons et al. 2000). In some areas, concern is growing that the harvest of turtles for commercial trade is not sustainable (Ceballos and Fitzgerald 2004). In Nebraska, from 2010–2020, there have been no seizures of Blanding's turtles reported by/to the U.S. Fish and Wildlife Service (USFWS) or Nebraska Game and Parks Commission (NGPC) (S. M. Dunn, NGPC Zoologist, pers. comm.), though collections by hobbyists and visitors have been documented in other populations (Henning and Hinz Jr. 2016).

Description

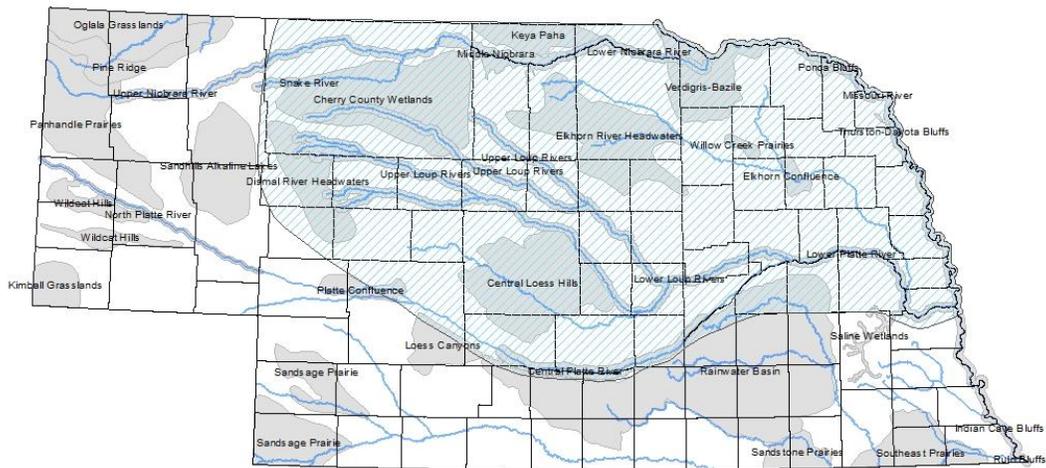
Blanding's turtles are 12.7–20.3 cm long. Females are larger than males. The turtles have a bright yellow chin and throat. The black carapace has a smooth helmet shape with yellow spots. The upper jaw has a center notch visible at the front of the mouth. The mostly yellow plastron is hinged, and it is slightly concave on males. The neck is long and head somewhat flattened with protruding eyes. Similar to Blanding's turtles, ornate box turtles also have hinged plastrons but lack the bright yellow chin and throat. See Figure 1.



FIGURE 1. The Blanding's Turtle has a distinctive bright yellow chin and throat (Photo courtesy of NEBRASKAland Magazine).

Habitat and Range

A mosaic of connected habitats may be necessary to support the shifting needs of Blanding's turtles by season and age-class. Blanding's turtles are semi-aquatic. They prefer wetland habitats rather than fast-moving water and typically utilize upland sites when nesting. (Edge et al. 2010). They inhabit lake shallows, ponds, marshes, and slow-moving streams with soft bottoms and dense aquatic vegetation. Marshes and small ponds appear to be particularly important to juvenile Blanding's turtles because they offer waters less likely to be inhabited by large predators (Bury and Germano 2003). Studies indicate they prefer forested wetlands in spring, wetlands with morning sun and abundant egg masses for feeding in early summer, and deeper pools that stay cooler in late summer and fall (Hartwig and Kiviat 2007, Beaudry et al. 2009). Blanding's turtles are tolerant of cold temperatures in moist, terrestrial hibernacula (Dinkelacker et al. 2004), but extreme lows in dry winters could be problematic for turtles in the Sandhills (Costanzo et al. 2004). In Nebraska, Blanding's turtles have been found in Cherry County Wetlands, Dismal River Headwaters, Elkhorn Confluence, Elkhorn River Headwaters, Lower Loup Rivers, Lower Platte River, Middle Niobrara, Upper Loup Rivers and Tributaries Biologically Unique Landscapes.



Nebraska Natural Heritage Program,
Nebraska Game and Parks Commission
September 2016

FIGURE 2. Current range of Blanding's turtles in Nebraska based on field observations, museum specimens, and expert knowledge. Map courtesy of Nebraska Natural Heritage Program, Nebraska Game and Parks Commission.

Area Requirements

Blanding's turtle dispersal varies seasonally, with long distances traversed in the spring as turtles move to ephemeral wetlands. Females, in particular, may also move long distances during the nesting season (Piepgras and Lang 2000). For both sexes, Grgurovic and Sievert found a mean annual home range size of 22 ha and a mean home range length (i.e., distance between two farthest sites used by an individual, Pluto and Bellis 1988) of 856 m in Massachusetts (2005). However, research suggests that the landscape complex needed for a Blanding's turtle during the course of its lifetime encompasses a much greater area than indicated here (Grgurovic and Sievert 2005). Piepgras and Lang indicated a home range size of 63 ha (2000), and Grgurovic and Sievert found a maximum home range length of 3.2 km traveled over 46 days (2005).

Diet

Blanding's turtles are omnivorous and will feed from the land and water. They prefer to prey or scavenge on crayfish, frogs, fish, earthworms, snails, and occasionally carrion, but they also consume berries and other vegetation.

Reproduction

Blanding's turtles mate in early spring and nest May to July. Nesting occurs almost exclusively during evening hours (Congdon et al. 1983). The female lays 8–12 oval, dull-white, leathery 3.8-cm eggs. Hatchlings appear August to September (Fogell 2010, Panella 2010). The sex of the hatchlings is determined by the incubation temperature; higher temperatures (i.e., >30° C; 86°F) result in production of females (Ewert and Nelson 1991). Males do not attain breeding age until approximately 12 years and females not until 18 years of age (MassWildlife 2007), though younger gravid females (11–14 years) in Nebraska populations have been observed (Ruane et al, 2008). A healthy individual may live 75+ years (Congdon et al, 2008).

Research and Conservation Strategies

A multitude of factors should be considered before implementing any conservation actions for species. 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 both the species of interest and property owners, 2) consider species dispersal and landscape context, 3) plan for multiple years, and 4) do no harm.

In Nebraska, conservation considerations should be made for Blanding's turtles in eight Biologically Unique Landscapes: Cherry County Wetlands, Dismal River Headwaters, Elkhorn Confluence, Elkhorn River Headwaters, Lower Loup Rivers, Lower Platte River, Middle Niobrara, Upper Loup Rivers and Tributaries. These landscapes offer the best opportunities for conservation of the species within Nebraska based on current knowledge. Given the principal threats identified, conservation efforts for Blanding's turtles (summarized in Table 2) may want to employ the following management strategies:

1. Wetland conservation can provide habitat for Blanding's turtles. Blanding's turtles use wetlands of mean size 1.5 ha and shoreline length of approximately 600 m (Attum et al. 2008). Blanding's turtles tend to occupy wetlands near stands of deciduous trees and that are spaced at least 450 m from roads (Attum et al. 2008). Protect and restore wetland complexes with some deciduous tree cover, especially in eastern Nebraska habitats, while ensuring connectivity and minimizing impacts from roads (Attum et al. 2008). A distance less than 50 m between patches connected by high-quality corridors is important to Blanding's turtles (Ricketts 2001, Fleishman et al. 2002, Attum et al. 2008). A 250-m buffer zone may be appropriate for rare species (Attum et al. 2008). Natural or mitigated habitats should offer "abundant, emergent vegetation...basking areas, muck, floating plant material, and submerged aquatic vegetation" (Hartwig and Kiviat 2007). However, Blanding's turtles will avoid using wetlands where cattails are abundant (Henning and Hinz Jr. 2016). Mitigating cattail and Phragmites invasion should be a priority in wetland habitat conservation with Blanding's turtles in mind.

2. Ensure turtle access to upland areas for nesting; nests farther from water are less likely to be depredated (Congdon et al 1983). Consider exclosures for highly vulnerable populations (D. D. Fogell, pers. comm.). Because Blanding's turtles may use grassy upland sites for nesting, discourage conversion to agriculture in sites utilized heavily by the turtles. Limit mowing and chemical exposure impacts to juveniles.
3. Consider installment of seasonal signage alerting motorists to highly sensitive turtle areas to encourage drivers to travel slower, more cautiously in select locations. High risk areas may also be equipped with turtle passageways of various designs. During the nesting season, discourage ATV use where Blanding's turtles nest.
4. Prioritize reducing mortality of sexually mature individuals. Turtle species, in general, have long life-spans and low fecundity. The loss of adults is more detrimental to this strongly k-selected (i.e. long life expectancy, late maturity, few offspring) species than loss of eggs or juveniles (Congdon et al. 1993, Heppel 1998).
5. In Nebraska, it is illegal to take, possess, transport, export, process, sell or offer for sale, or ship [Blanding's turtle] (NGPC 2006). Regulations should be enforced.
6. Several studies have isolated and characterized microsatellite loci from Blanding's turtles that may be useful in making decisions regarding the conservation of genetic diversity of the species (Osentoski et al. 2002, Anthonysamy et al. 2017, Jordan et al. 2019). This is especially important when considering the feasibility of supplementing a small population with individuals from a large population in order to avoid inbreeding depressions.
7. Numerous USDA-NRCS Farm Bill programs might be used to benefit Blanding's turtles, but each management practice should be scientifically evaluated before it is widely implemented for this purpose. Consider:

CRP – CP 2 (Native Grasses), 4D (Permanent Wildlife Habitat), 9 (Shallow Water Areas for Wildlife), 21 (Filter Strips-grass), 22 (Riparian Buffers), 23 (Wetland Restoration-floodplain), 23A (Wetland Restoration- non-floodplain), 25 (Rare and Declining Habitat), 29 (Wildlife Habitat Buffer), 33 (Upland Bird Habitat Buffer), 38 (State Acres for Wildlife Enhancement), 42 (Pollinator Habitat), 43 (Prairie Strips)

EQIP- 528 – Prescribed Grazing, 314 – Brush Management, 390 – Riparian Herbaceous Cover, 420 (Wildlife Habitat Planting), 644 – Wetland Wildlife Habitat Management, 645 – Upland Wildlife Habitat Management, 657 – Wetland Restoration, 659 – Wetland Enhancement

Agricultural Conservation Easement Program (Agricultural Land Easements and Wetland Reserve Easements)

Regional Conservation Partnership Program

WILD Nebraska

Please note that the availability of programs may vary in any given year.

Information Gaps

Breeding and overwintering locations, as well as travel corridors, for Blanding's turtles are not well known, particularly along the eastern edge of the species' range in Nebraska (Schneider et al 2011). Our knowledge of *E. blandingii* intrapopulation and interpopulation genetic diversity is also lacking (D. D. Fogell, pers. comm.). It is important to continue to conduct surveys for Blanding's turtles and monitor populations. Radio transmitters and PIT tags may be used to track individuals. Grgurovic and Sievert (2005) provide an overview of previously used methods for safe capture and marking.

Considerations for Additional Species

At-risk species that share habitat with Blanding's turtles should be considered in management plans for the turtle. Conservation of Blanding's turtles may affect or be influenced by at-risk species that can be found in the same Biologically Unique Landscapes as the turtles. Table 1 lists a sample of at-risk species you may want to consider while planning for Blanding's turtle habitat. This list will not apply to all sites of occupancy of *E. blandingii* nor is the list all-inclusive.

TABLE 1. Tier 1 at-risk species identified in the Nebraska Natural Legacy Project that inhabit biologically unique landscapes with Blanding's turtles (Schneider et al. 2018) may necessitate consideration in habitat management plans.

Animals

Plains Pocket Mouse (*Perognathus flavescens perniger*)
Henslow's Sparrow (*Ammodramus henslowii*)
Interior Least Tern (*Sternula antillarum athalassos*)
Loggerhead Shrike (*Lanius ludovicianus*)
Long-billed Curlew (*Numenius americanus*)
Piping Plover (*Charadrius melodus*)
Short-eared Owl (*Asio flammeus*)
Whooping Crane (*Grus americana*)
American Burying Beetle (*Nicrophorus americanus*)
Blacknose Shiner (*Notropis heterolepis*)
Finescale Dace (*Chrosomus neogaeus*)
Northern Redbelly Dace (*Chrosomus eos*)
Plains Topminnow (*Fundulus sciadicus*)
Topeka Shiner (*Notropis topeka*)
Iowa Skipper (*Atrytone arogos iowa*)
Ottoe Skipper (*Hesperia ottoe*)
Mottled Duskywing (*Erynnis martialis*)
Whitney Underwing (*Catocala whitneyi*)
Platte River Caddisfly (*Ironoquia plattensis*)
Regal Fritillary (*Speyeria idalia*)
Pimpleback (*Quadrula pustulosa*)
Plain Pocketbook (*Lampsilis cardium*)

Plants

Hall's Bulrush (*Schoenoplectus hallii*)
Small White Lady's-slipper (*Cypripedium candidum*)
Western Prairie Fringed Orchid (*Platanthera praeclara*)
Wolf Spikerush (*Eleocharis wolfii*)

TABLE 2. Suggested management for Blanding’s turtles in Nebraska is summarized. The following should be interpreted as general guidelines based on the best available knowledge at the time of this publication. See Research and Conservation section of this document for more detail and Reference section for sources of additional information.

FOCUS	STRATEGIES	CONSERVATION CONSIDERATIONS
Inventory of Blanding’s turtles	Document locations used by Blanding’s turtles in Nebraska	Radio transmitters (short-term) and/or PIT tagging (long-term) may be used
Keep high ratio of sexually-mature adults in the population	While we do not recommend completely neglecting nest and juvenile survivorship, efforts are better invested in reducing adult mortality and maintaining habitat	Turtles have long life-spans, late sexual maturity, and low fecundity
Wetland Conservation	Preserve wetlands used by Blanding’s turtles, and create wetlands in an interconnected complex. Protect wetlands from chemical run-off by maintaining at least a 50’ buffer in native vegetation.	Mitigation wetlands of at least 1.5 ha should be designed to provide adequate vegetation and forest cover
Maintain upland habitat	Discourage further loss of nesting sites and conversion of open, grassy/brushy uplands to agriculture through various programs. Protect Blanding’s upland sites of occupancy from chemical exposure and mowing when eggs and hatchlings are present.	Blanding’s turtles have nested in farm fields to evade nest predation. These nests could be marked for avoidance and protected from predators by exclosures. Screens must be removed just before hatching (approx. Aug. 1).
Halt increases in turtle mortalities on roads	Place constructed wetlands at least 450 m from road. Construct turtle passages (e.g., funnels) in high-risk locations. Install signage to alert motorists to periods of increased turtle movement (e.g., May to October).	Roads with traffic of more than 100 vehicles/day are most likely to impact Blanding’s turtles
Document and maintain genetic diversity in populations	Facilitate movement of turtles between populations by maintaining adequate habitat corridors. Consider translocations of individuals into appropriate habitats.	Continued review of genetic research on Blanding’s turtles may influence decisions

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References

- Anthonyamy, W. J. B., M. J. Dreslik, M. R. Douglas, D. Thompson, G. M. Klut, A. R. Kuhns, D. Mauger, D. Kirk, G. A. Glowacki, M. E. Douglas, C. A. Phillips. 2017. Population genetic evaluations within a co-distributed taxonomic group: a multi-species approach to conservation planning. *Animal Conservation* 21:137–147 doi:10.1111/acv.12365
- Attum, O., Y. M. Lee, J. H. Roe, and B. A. Kingsbury. 2008. Wetland complexes and upland-wetland linkages: landscape effects on the distribution of rare and common wetland reptiles. *Journal of Zoology* 275:245–251.
- Beaudry, F., P. G. DeMaynadier, and M. L. Hunter, Jr. 2009. Seasonally dynamic habitat use by spotted (*Clemmys guttata*) and Blanding's turtles (*Emydoidea blandingii*) in Maine. *Journal of Herpetology* 43(4) 636–645.
- Beaudry, F., P. G. DeMaynadier, and M. L. Hunter, Jr. 2009. Nesting Movements and the Use of Anthropogenic Nesting Sites by Spotted Turtles (*Clemmys guttata*) and Blanding's Turtles (*Emydoidea blandingii*). *Herpetological Conservation and Biology* 5(1):1–8.
- Bury, R. B. and D. J. Germano. 2003. Differences in habitat use by Blanding's turtles, *Emydoidea blandingii*, and Painted Turtles, *Chrysemys picta*, in the Nebraska Sandhills. *The American Midland Naturalist* 149:241–244.
- Ceballos, C. P. and L. A. Fitzgerald. 2004. The trade in native and exotic turtles in Texas. *Wildlife Society Bulletin* 32(3):881–892.
- Conant, R. and J.T. Collins. 1998. *Petersen Field Guides-Reptiles and Amphibians East/Central North America*. Third Edition, Expanded. Houghton Mifflin Company. Boston, New York, USA
- Congdon, J. D., D. W. Tinkle, G. L. Breitenbach, and R. C. van Loben Sels. 1983. Nesting ecology and hatching success in the turtle *Emydoidea blandingii*. *Herpetologica* 39(4):417–429.
- Congdon, J. D., A. E. Dunham, and R. C. van Loben Sels. 1993. Delayed sexual maturity and demographics of Blanding's turtles (*Emydoidea blandingii*): implications for conservation and management of long-lived organisms. *Conservation Biology* 7:826–833.
- Congdon, J. D., T. E. Graham, T. B. Herman, J. W. Lang, M. J. Pappas, B. J. Brecke. 2008. *Emydoidea blandingii* (Holbrook 1838)-Blanding's Turtle. *Conservation Biology of Freshwater Turtles and Tortoises: A Compilation Project of the IUCN/SSC Tortoise and Freshwater Turtle Specialist Group*, edited by A. G. J. Rhodin, P. C. H. Pritchard, P. P. van Dijk, R. A. Saumure, K. A. Buhlmann, J. B. Iverson, Chelonian Research Monographs (ISSN 1088-7105) No. 5, doi:10.3854/crm.5.015.blandingii.v1.2008
- Costanzo, J. P., S. A. Dinkelacker, J. B. Iverson, and R. E. Lee. 2004. Physiological ecology of overwintering in the hatchling painted turtle: multiple scale variation in response to environmental stress. *Physiological and Biochemical Zoology* 77(1):74–99.
- Dinkelacker, S. A., J. P. Costanzo, J. B. Iverson, and R. E. Lee Jr. 2004. Cold-hardiness and dehydration resistance of hatchling Blanding's turtles (*Emydoidea blandingii*): implications for overwintering in a terrestrial habitat. *Canadian Journal of Zoology* 82:594–600.
- Edge, C. B., B. D. Steinberg, R. J. Brooks, and J. D. Litzgus. 2010. Habitat selection by Blanding's turtles (*Emydoidea blandingii*) in a relatively pristine landscape. *Ecoscience* 17(1):90–99.
- Ewert, M. A. and C. E. Nelson. 1991. Sex determination in turtles: diverse patterns and some possible adaptive values. *Copeia* 1991:50–69.
- Faber-Langendoen, D., J. Nichols, L. Master, K. Snow, A. Tomaino, R. Bittman, G. Hammerson, B. Heidel, L. Ramsay, A. Teucher, and B. Young. 2012. *NatureServe Conservation Status Assessments: Methodology for Assigning Ranks*. NatureServe, Arlington, VA.

- Fleishman, E., C. Ray, P. Sjorgren-Gulve, C. L. Boggs and D. D. Murphy. 2002. Assessing the roles of patch quality, area, and isolation in predicting metapopulation dynamics. *Conservation Biology* 16: 706–716.
- Fogell, D. D. 2010. A field guide to the amphibians and reptiles of Nebraska. University of Nebraska, Lincoln, NE, USA.
- Gibbons, J. W., D. E. Scott, T. J. Ryan, K. A. Buhlmann, T. D. Tuberville, B. S. Metts, J. L. Greene, T. Mills, Y. Leiden, s. poppy, and C. T. Winne. 2000. The global decline of reptiles, déjà vu amphibians. *BioScience* 50:653–666.
- Gibbs, J. P. and W. G. Shriver. 2002. Estimating the effects of road mortality on turtle populations. *Conservation Biology* 16(6):1647–1652.
- Grgurovic, M. and P. R. Sievert. 2005. Movement patterns of Blanding’s turtles (*Emydoidea blandingii*) in the suburban landscape of eastern Massachusetts. *Urban Ecosystems* 8:203–213.
- Hartwig, T. S. and E. Kiviat. 2007. Microhabitat association of Blanding’s turtle in natural and constructed wetlands in southeastern New York. *Journal of Wildlife Management* 71(2):576–582.
- Henning, B. M. and L.C. Hinz Jr. 2016. Conservation Guidance for Blanding’s Turtle (*Emydoidea blandingii*). INHS Technical Report 2016. 21 pps.
- Heppel, S. S. 1998. Application of life-history theory and population model analysis to turtle conservation. *Copeia* 2:367–375.
- Jordan, M. A., V. Mumaw, N. Millspaw, S. W. Mockford, F. J. Janzen. 2019. Range-wide phylogeography of Blanding’s Turtle [*Emys* (= *Emydoidea*) *blandingii*]. *Ecology, Evolution and Organismal Biology Publications*. 323. https://lib.dr.iastate.edu/eeob_ag_pubs/323
- Joyal, L. A., M. McCollough, M. L. Hunter Jr. Landscape Ecology Approaches to Wetland Species Conservation: A Case Study of Two Turtle Species in Southern Maine. *Conservation Biology* 15(6):1755–1762.
- Lovich, J. E. 1995. Turtles. Pages 118–121 in E. T. Laroe, C. E. Puckett, P. D. Doran, and M. J. Mac, editors. *Our living resources: a report to the nation on the distribution, abundance and health of the U.S. plants, animals and ecosystems*. National Biological Service, Washington, D.C., USA.
- Massachusetts Division of Fish and Wildlife (MassWildlife). 2007. Blanding’s turtle (*Emydoidea blandingii*). Natural Heritage and Endangered Species Program, Westborough, MA, USA.
- McCurdy-Adams, H. L. 2016. Anthropogenic effects on chronic stress and nest predation patterns in freshwater turtles. Graduate thesis. Laurentian University Sudbury, Ontario, Canada, 128 pps.
- Minnesota Department of Natural Resources (MNDNR). 2008. Endangered, threatened, and special concern species of Minnesota: Blanding’s turtle (*Emydoidea blandingii*). Environmental Review Fact Sheet Series. St. Paul, MN, USA.
- NatureServe. 2020. NatureServe Explorer [web application]. NatureServe, Arlington, Virginia. Available <https://explorer.natureserve.org/> (accessed 31 Dec. 2020).
- Nebraska Game and Parks Commission (NGPC). 2006. Chapter 4 – Wildlife regulations. Pages 4-010-2 to 4-010-3 in *Nebraska Administrative Code*. Lincoln, NE, USA.
- Osentoski, M. F., S. Mockford, J. M. Wright, M. Snyder, T. B. Herman and C. R. Hughes. 2002. Isolation and characterization of microsatellite loci from the Blanding’s turtle, *Emydoidea blandingii*. *Molecular Ecology Notes* 2:147–149.
- Panella, M. J. 2010. Nebraska’s at-risk wildlife: conserving species and their habitats. Nebraska Game and Parks Commission. Mennonite Press, Inc., Newton, KS, USA. 196 pps.

- Pappas, M. J., J. D. Congdon, B. J. Brecke, J. D. Capps. 2009. Orientation and dispersal of hatchling Blanding's turtles (*Emydoidea blandingii*) from experimental nests. *Canadian Journal of Zoology*, 87: 755–766
- Piepgas, S. A. and J. W. Lang. 2000. Spatial ecology of Blanding's turtle in central Minnesota. *Chelonian Conservation and Biology* 3:589–601.
- Pluto, T. G. and E. D. Bellis. 1988. Seasonal and annual movements of riverine map turtle, *Graptemys geographica*. *Journal of Herpetology* 22:152–158.
- Reid, B. N., R. P. Theil, M. Z. Peery. 2015. Population Dynamics of Endangered Blanding's Turtles in a Restored Area. *The Journal of Wildlife Management* 80: 553–562. <https://doi.org/10.1002/jwmq.1024>
- Riley, J. L., and J. D. Litzgus. 2014. Cues used by predators to detect freshwater turtle nests may persist late into incubation. *Canadian Field-Naturalist* 128(2): 179–188.
- Ricketts, T. H. 2001. The matrix matters: effective isolation in fragmented landscapes. *The American Naturalist* 158:87–99.
- Ruane, S., S. A. Dinkelacker, J. B. Iverson. 2008. Demographic and Reproductive Traits of Blanding's Turtles, *Emydoidea blandingii*, at the Western Edge of the Species' Range. *Copeia*. 2008(4):771–779.
- Salzberg, A. 1995. Report on import/export turtle trade in the United States. Pages 314-322 in *Proceedings of the International Congress of Chelonian Conservation*. Gonafron, France.
- Schneider, R., K. Stoner, G. Steinauer, M. Panella, and M. Humpert. 2011. The Nebraska Natural Legacy Project: State Wildlife Action Plan. 2nd ed. The Nebraska Game and Parks Commission, Lincoln, NE, USA, 344 pps.
- Schneider, R. M. Fritz, J. Jorgensen, S. Schainost, R. Simpson, G. Steinauer, C. Rothe-Groleau. 2018. Revision of the Tier 1 and 2 Lists of Species of Greatest Conservation Need: A Supplement to the Nebraska Natural Legacy Project State Wildlife Action Plan. The Nebraska Game and Parks Commission, Lincoln, NE, USA, 101 pps.
- Wilbur, H. M., and P. J. Morin. 1988. Pages 396-447 in C. Gans and R. Huey, editors. Life history evolution in turtles. *Biology of the Reptilia*. Volume 16b. Alan R. Liss, New York, USA.