Conservation Guidance for

Blanding's Turtle

Emydoidea blandingii (Holbrook,1838)

IL status:
Endangered

US status:
Under review

Global rank:
Apparently secure[1]
Endangered[2]

Trend:
Declining

Family:
Emydidae

Habitat:
Permanent and temporary wetlands and waterbodies; well drained uplands near or between wetlands

Similar species:
Box turtles, Spotted turtle

Seasonal cycle:

Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec

Overwintering in wetlands
Active on land and water
Survey period

Species information

Characteristics

Adult Blanding's turtle.
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Blanding's Turtle is a medium-sized turtle (up to 10 inches in upper shell length) with a dark, lightly speckled, domed shell and a **bright yellow chin and throat**[3]. It has a **notched upper jaw** with an up-curved mouth giving the impression of a smile[4]. The upper shell or carapace usually has 12 scales (scutes) along each edge, and the lower shell or plastron has six pairs of scutes and a **crosswise hinge**[3]. Males and females appear similar with slight differences in size and shape. Males are often larger and heavier and the lower shell is concave[5]. Hatchlings are 1.2 to 1.4 inches long and dark brown to black or gray, usually with faint speckling[4], and the underside hinge is not always apparent[6].

Habitat

Blanding's Turtles inhabit mosaic landscapes, which include both permanent and temporary water bodies and upland habitat[7]. Occupied wetlands are often shallow with soft organic substrates, open water, and emergent vegetation, such as cattails and sedge tussocks[8–11], but Blanding's Turtles have been found using all wetland types in their home range and utilize multiple wetlands within a year[9,12,13]. Individual Blanding's Turtles used 6.5 different wetlands per year on average and as many as 20 different wetlands in one year in Maine[14]. Although regional variation is apparent, marshes, ponds, shrub swamps and sloughs are favored over lakes, rivers and other open waters, yet these habitats are also used, especially in the case of drought when marshes may dry up[9,14–20]. Isolated wetlands (more than 0.3 mi from another wetland) are less likely to be used by Blanding's turtles[13]. Sun exposure and basking sites are also important habitat characteristics, especially during the spring and early

Blanding's Turtle wetland habitat. Photo by Gary Glowacki

summer[21]. Although adults and juveniles use similar habitat types[10], younger turtles have a stronger preference for wetlands with more abundant emergent vegetation[16,22]. Adult and juvenile Blanding's Turtles typically overwinter in permanent wetlands with organic substrates and at least a few inches of unfrozen water[10,23,24].

Blanding's Turtles make more use of upland sites than many other aquatic turtle species. Upland habitats associated with wetlands are used as nesting sites and as overland travel corridors among permanent and temporary water bodies. Nesting areas are typically within 0.1 miles of a wetland, but may be as far as 1.2 miles away[11,12,25–28]. Nests sites are typically in well-drained, loose soil (e.g., sand, sandy loam) with exposure to sunlight and little to no vegetation cover[10,11,17,29,30]. Sites with disturbed soil, such as gardens, road and trail margins, borrow pits, railroad embankments, and agricultural lands, are often used as nest sites[10,12,19,25,30–34]. Nest sites adjacent to vegetation can become "root bound" with hatchlings unable to dig out of the nest[7].

Taxonomy

Blanding's Turtle is the only species in its genus *(Emydoidea)* and there are no described subspecies[7,35,36]. However, two recent alternative taxonomic schemes have been suggested, one maintaining Blanding's Turtle in its own genus and the other including Blanding's Turtle in the genus *Emys*[35]. The Illinois List of Endangered and Threatened Fauna uses *Emydoidea blandingii*[37].

Distribution

Global distribution of Blanding's Turtle centers on the Great Lakes Region, extending to west-central Nebraska in the west, central Illinois in the south, and eastern Ontario in the northeast with a few separated populations in eastern New England and Nova Scotia[1]. The northern distribution of Blanding's Turtle is likely limited by the failure of eggs to develop at cool incubation temperatures but the southern limitation may be due to interactions with other species[34,38].

In Illinois, Blanding's Turtle observations are most common in the northern quarter of the state, but spotty observations have occurred along the Illinois River valley down to Cass County and across the eastern

Blanding's Turtle nesting habitat with sparse vegetation.
Photo by Gary Glowacki

side of the state. It is estimated that Blanding's Turtles occur in just 22% of their historic range in Illinois[27].

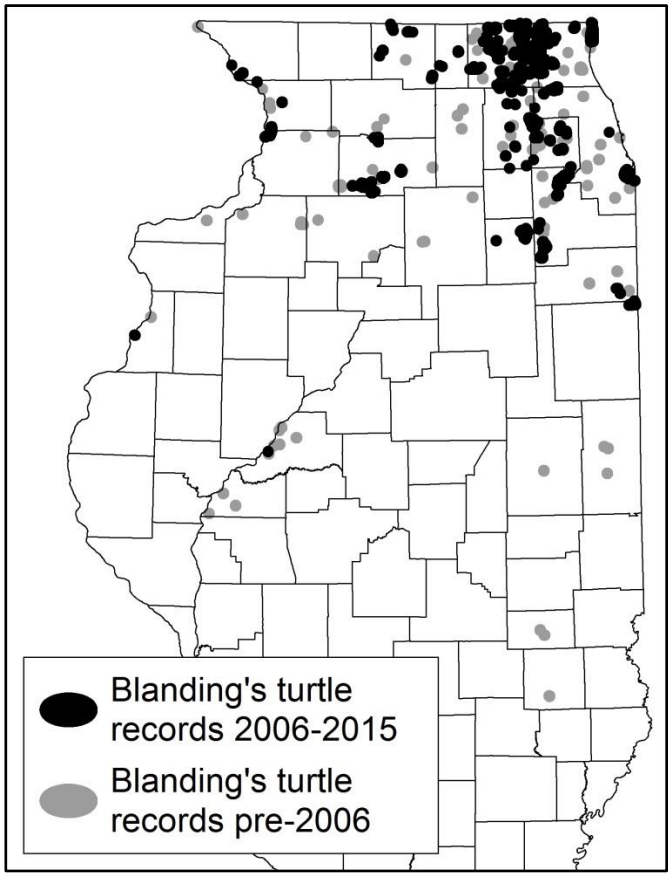
Status

Although populations in Nebraska and Minnesota are estimated to be very large with thousands of individuals, most populations are small and isolated[5,39]. Blanding's Turtle is listed as endangered, threatened, or species of concern in all of the states in which it occurs[39]. The International Union for Conservation of Nature has ranked Blanding's Turtle as globally Endangered[2], while NatureServe has ranked it as Apparently Secure meaning it is "uncommon but not rare" and there is "some cause for long-term concern due to declines or other factors"[1,2]. Blanding's Turtle was first listed as Threatened in Illinois in 1999 due to its sensitive life history characteristics, and elevated to Endangered in 2009 due to threats and declining populations[37,40].

There are 162 Blanding's Turtle occurrence records in the Illinois Natural Heritage Database, 91 of which

have been observed in the last ten years (see map). The number of Blanding's Turtle records can be deceiving because the longevity of the species results in continued presence, of perhaps only a single individual, long after a population has become unviable, or incapable of reproducing itself[41] (see population dynamics section). For example, of the 17 Lake County locations with Blanding's Turtle records only one has adequate population size and habitat area to be deemed potentially viable[42].

Experts estimate that most Illinois populations have less than 25 individuals, at least four populations have 25–50 individuals, two populations have 50–100 individuals, and three populations have 100–500 individuals[39]. More precise estimates of adult population size have been made for five sites in Illinois based on mark-recapture surveys with estimates ranging from 25 to135 adults [27,43–54]. The minimum number of individuals for six other populations are between 8 and 56 adults[17,54–56]. A population viability analysis shows that the largest known population in Illinois has a 95% chance of going extinct in the next 50 years without active management[53].



Blanding's Turtle records from the Illinois Natural Heritage Database[148]

Natural History

Blanding's Turtles spend most of their time in wetlands and often have a few small centers of activity around 5 acres in size, where individuals spend the majority of their time and return to year after year[57,58]. However, upland areas do not form a barrier to their movement and Blanding's Turtles will frequently move between wetland complexes or to upland nesting sites, sometimes moving more than 0.6 miles in a day[7,11,12,28,29,55,59]. Blanding's Turtles may move between wetlands to locate seasonally abundant food, mating partners, nesting sites, or overwintering sites, and will often move outside natural areas[5,20,32,48,60,61]. Peaks in terrestrial movements occur during the nesting season (late May through early July) and in the spring and fall when individuals move to and from overwintering sites[5]. Blanding's Turtle home ranges vary considerably from tens of acres, to more than 200 acres and individuals have been found to move as much as 17 miles[15,26,28,49,55,62]. Blanding's Turtles move much farther than other aquatic turtle species.

Individual Blanding's Turtle home ranges commonly overlap[11,19] and they do not show antagonistic behavior towards other individuals [9]. Density of individuals varies considerably from site to site with fewer than 1 turtle/acre to as many as 23 adults/acre[7,10,62]. Three populations in northeast Illinois had 0.3, 0.1, and 0.4 turtles/acre[45,48].

Blanding's Turtles are opportunistic omnivores that feed on both land and water. Their diet varies by season and has been found to include snails, crayfish, tadpoles, earthworms, leaches, insects, fish, frogs, and plant material[5,10,32,63]. Blanding's Turtles prefer prey items at least 0.4 inches in size over more abundant smaller prey items[32].

Turtle growth, activity, and productivity are dependent on body temperature, which is dependent on sunlight, air and water temperatures, and thermoregulation behavior[10,64]. Blanding's Turtles prefer a body temperature of 71–77°F, which is lower than many other turtle species[65], but are active across a wide range of body temperatures (37–94°F)[10]. Overwinter body temperatures range between 32–36°F[10]. Blanding's Turtles typically emerge from hibernation in March to April, some as early as February, when their body temperature is still less than 38°F [5,56,58,66]. Early in the spring Blanding's

Turtles seek areas with more sun exposure for basking[8,67,68]. Blanding's Turtles have been observed to become inactive on land or in water during the summer for a few days to weeks[11,48,58,60].

Blanding's Turtles mate throughout the active season, but most commonly in early spring and fall when adults are moving around and come into contact with mates[5,10,59,61,64]. Courtship and mating takes place in the water and lasts around 30–60 minutes [5,69]. Males and females both mate with multiple partners[59,61,70]. It is fairly common (11–56%) for a single clutch to have multiple fathers, and repeated paternity is common (70–83%) due to either repeated mating or female sperm storage over multiple years[59,61,70,71]. Larger females reproduce more often and produce a slightly larger clutch than do smaller females[10,30,61,72,73].

The onset of annual nesting activity varies between populations and may be related to ambient temperature[5]. Nesting in Illinois has been observed between late May and early July, with an air temperature around 75°F and ground temperature around 72°F [23,47,53]. The nesting period lasts from 13 to 28 days[29,58,74]. Timing of nesting, nest site selection, and nest building play an important role in sex

Female Blanding's Turtle laying eggs in a nest.
Photo by Gary Glowacki.

Hatchling Blanding's Turtle emerging from nest.
Photo by Gary Glowacki.

determination because turtles eggs that develop at a temperature below 78°F become male while those that develop above 86°F become female[38,75]. Eggs incubated below 71°F will not survive[38]. Pregnant females will make long, multiple day, meandering migrations to nesting sites, often temporarily stopping in smaller wetlands for refuge along the way[5,10–12,14,25,29,43,58,64]. Turtles commonly cross roads during these migrations[19]. Females have been observed using the same nesting site year after year[26,29,64], but may use newly available nesting habitat [25]. Females have also been observed using shared nesting areas[10,64].

Most often nesting begins in the evening from 7–11 p.m. and lasts eight hours[10,29,30,32]. The female will dig a depression about 5 inches deep with her hind legs, lay eggs in the nest, replace and compact the excavated material with her hind feet, and move away from the nest[10]. The nesting attempt may be abandoned and attempted another night, especially if an immovable object is encountered while digging[10,12,29,30,32].

Nest predation can be very high at 15–100%, especially in developed areas that support high populations of predators, such as raccoons[11,27,53,54,76–78]. Protected nests in northeast Illinois had a much higher hatching rates, around 78%[54].

Eggs incubate 49–128 days depending on the temperature and emerge late August to October in mid-morning to afternoon[5,10,29,38,53,79]. A single clutch will typically hatch within 1–2 days, but hatching can span as many as 11 days[29]. Upon emergence hatchlings visually orient towards dark horizons, such as the wooded edges of a wetland as far as 0.2 miles

away[80,81]. Hatchlings will often use temporary wetlands, terrestrial depressions, and terrestrial cover for a few hours to days before moving to permanent wetlands[5,10,79,82–84].

Blanding's Turtles typically enter winter dormancy between mid-September and October, sometimes as late as December, when water temperatures drop to 50–55°F[10,11,56,58,66]. Typically, they will spend winter partially buried in wetlands, below ice if present[11,85]. Blanding's Turtles exhibit high fidelity to wintering sites and multiple turtles often overwinter in the same wetland[11,19,23,85]. They are capable of enduring freezing and oxygen depletion[66]. Occasionally Blanding's Turtles, especially hatchlings, have been observed to overwinter on land[6,58,83,84].

Population dynamics

Blanding's Turtles are long-lived (>70 years) with delayed maturity (at 14–20 years old) and have low reproductive output (4 female eggs per year)[1,5,7,53,72,74,77,86]. Nesting frequency is variable with females reproducing in 33–80% of years[29,30,61,74,77]. Females produce a maximum of one clutch per year typically with 10–14 eggs, but as many as 18 eggs[10,29,30,54,61]. In addition, survival from egg to one year tends to be low (7–26%) and variable[53,74,77].

The Blanding's turtle's life history strategy requires high juvenile survival rates (around 78%) and very high adult survival rates (around 94%) to maintain a viable population[77]. Slightly lower adult survival (<90%), common in many populations, causes populations to decline[53,62,73]. Population models have demonstrated that in terms of population growth rates the importance of a single mature female is equivalent to more than 90 female eggs[87].

Population age structure can indicate population growth patterns[88], and population models have shown that a stable Blanding's Turtle population will have a 3.5:1 ratio of juveniles to reproductive adults[87] Many Blanding's Turtle surveys have found populations with lower numbers of juveniles[10,30,45,53,73]. This may indicate low nest and juvenile survival or it may be the result of biased survey efforts[22,88,89].

Populations with more of one sex relative to the other can be a conservation concern as sex bias reduces the effective population size and may lead to inbreeding and fewer offspring[90]. Male-biased populations may be due to the higher risk of road mortality to females on long distance nesting forays, while female-biased populations may be due to warmer nesting environments increasing the number of female offspring[91]. Non-biased, male-biased, and female-biased Blanding's Turtle populations have all been documented [45,53,62,72,83,88].

Community associations

Community associations include marsh, pond, sedge meadow, wet prairie, prairie, grassland, savanna, and woodland assemblages. The species composition of these assemblage varies across Blanding's Turtle range[7]. Predators of Blanding's turtles include raccoons, skunks, opossums, foxes, mink, and coyotes[78].

Other Species in Greatest Conservation Need (SGCN) that are found in marshes include: spotted turtle (*Clemmys guttata)*, Kirtland's snake (*Clonophis kirtlandii*), smooth greensnake (*Opheodrys vernalis*), eastern massasauga (*Sistrurus catenatus)*, buff-breasted sandpiper *(Tryngites subruficollis*), Wilson's phalarope (*Phalaropus tricolor)*, American bittern (*Botaurus lentiginosus)*, least bittern (*Ixobrychus exilis)*, Wilson's snipe (*Gallinago delicatata)*, common gallinule (*Gallinula chloropus)*, yellow rail (*Coturnicops noveboracensis)*, king rail (*Rallus elegans)*, black rail (*Laterallus jamaicensis)*, sandhill crane (*Grus canadensis)*, whooping crane (*Grus americana)*, black tern (*Chlidonias niger)*, Forster's tern (*Sterna forsteri)*, pied-billed grebe (*Podilymbus podiceps)*, marsh wren (*Cistothorus palustris)*, and yellow-headed blackbird (*Xanthocephalus xanthocephalus)*[92].

Conservation and Management

Threats

The greatest threat to Blanding's Turtle populations is habitat loss and fragmentation, and the associated increase in road mortality and predation. Additional threats, such as collection, disease, climate change, invasive species, and pollution are lesser concerns. Between 2003 and 2014, the State of Illinois authorized the "taking" of Blanding's Turtle 14 times for residential, recreational, and commercial development, road construction, bridge replacement, wind farm construction, and electric transmission line maintenance (see Regulations section).

Habitat loss

Blanding's Turtle habitat loss and fragmentation has been extensive. In Illinois between the 1780s and 1980s, 85% of wetland acreage and 99% of prairie acreage was lost, primarily for agricultural production[93]. Among the 32 Illinois counties with verifiable Blanding's Turtle records, the human population increased 325% between 1900 and 2000, from 3 million to 9.8 million[27]. Increasing human populations and expanding urban development are reducing Blanding's Turtle habitat.

Only 7% of the area where Blanding's turtles have been observed is protected in the Illinois Nature Preserve system, and 37% is within "conservation lands"[56,94]. "Conservation lands" are those recognized by federal, state and local government and private land holders as having a conservation purpose, but may include areas such as baseball diamonds[94].

Although numerous protected areas include Blanding's Turtle wetland habitat, the full extent of their habitat, such as upland nesting areas and travel corridors, often is not protected. An analysis of the 28 most frequently observed Illinois Blanding's Turtle populations revealed that only 13% of the wetlands and adjacent land (650 ft wetland buffer), where most nesting occurs, were protected in the Illinois Nature Preserve system, and only 3% of the area encompassing all adult activity (1.25 mi wetland buffer) was protected[27].

Roads and Rails

One of the largest concerns for Blanding's Turtle populations is road mortality, which is considered to be the largest source of adult mortality. Blanding's Turtles are more susceptible to road mortality than other turtle species due to their long distance movements. An unsustainable annual rate of 5% road mortality has been estimated for the Great Lakes-Big Rivers Region, including Illinois[95]. In one northeast Illinois population, road/rail mortality was responsible for loss of 11% of the population from 2002 to 2006[96]. Injuries from vehicles are the most common injury treated by wildlife rehabilitation facilities in northeast Illinois.

Blanding's Turtles frequently cross roads and railways to access wetlands or nesting areas and may be drawn to roadsides as nesting areas[10,19,25,97,98]. Although there is some evidence that Blanding's Turtles avoid crossing roads[99], the probability they will cross a road is higher the closer a road is to the center of its home range[100]. Of turtles with home range centers within 0.12 miles of a road, 70–80% of turtles will cross a road, but less than 5% attempt to cross when the road is 0.6 miles away from the center of their home range[100]. Unfortunately, in Illinois wetlands occupied by Blanding's Turtle and the adjacent land (0.12 mi buffer) contain on average 4.3 miles of road and 1.2 miles of railway, and the larger habitat area (0.6 mi buffer) that covers 87% of adult movements has on average 21 miles of roadway and 3 miles of railway[27]. Furthermore, the likelihood of mortality increases with traffic volume, with more than 40% mortality per crossing attempt at traffic volumes ≥ 10,000 vehicles per day[100]. Road mortality may lead to population declines, but the full effect on the population may not be seen for decades due to Blanding's Turtle longevity[41].

Predators

Another major concern is predation, especially of nests. Nest predation rates of 15–100% have been

Turtle killed while crossing railway. Photo by Gary Glowacki

Skunk predating a Blanding's Turtle nest. Photo by Gary Glowacki

observed[11,27,53,54,76,77]. Raccoons and other meso-predators (medium-sized predators from the middle of the food chain) are especially abundant in developed areas where human sources of food and shelter are readily available and their natural predators are absent[101–104]. In addition, higher nest predation rates have been observed when fur trapper harvest rates are low[77]. Raccoon removal has temporarily reduced predation rates, but not eliminated predation from other predators[78]. Domestic dogs may also contribute to predation[78]. Most nest predation events occur within a few days after laying[74,76]. Nests are detected by smell and the appearance of soil disturbance, and the concentration of nests due to habitat loss may further increase the chance of detection[74,105]. Although infrequent, hatchling and adult turtles can also be predated and have been observed with missing limbs and shell injuries[10,29,106].

Habitat Degradation

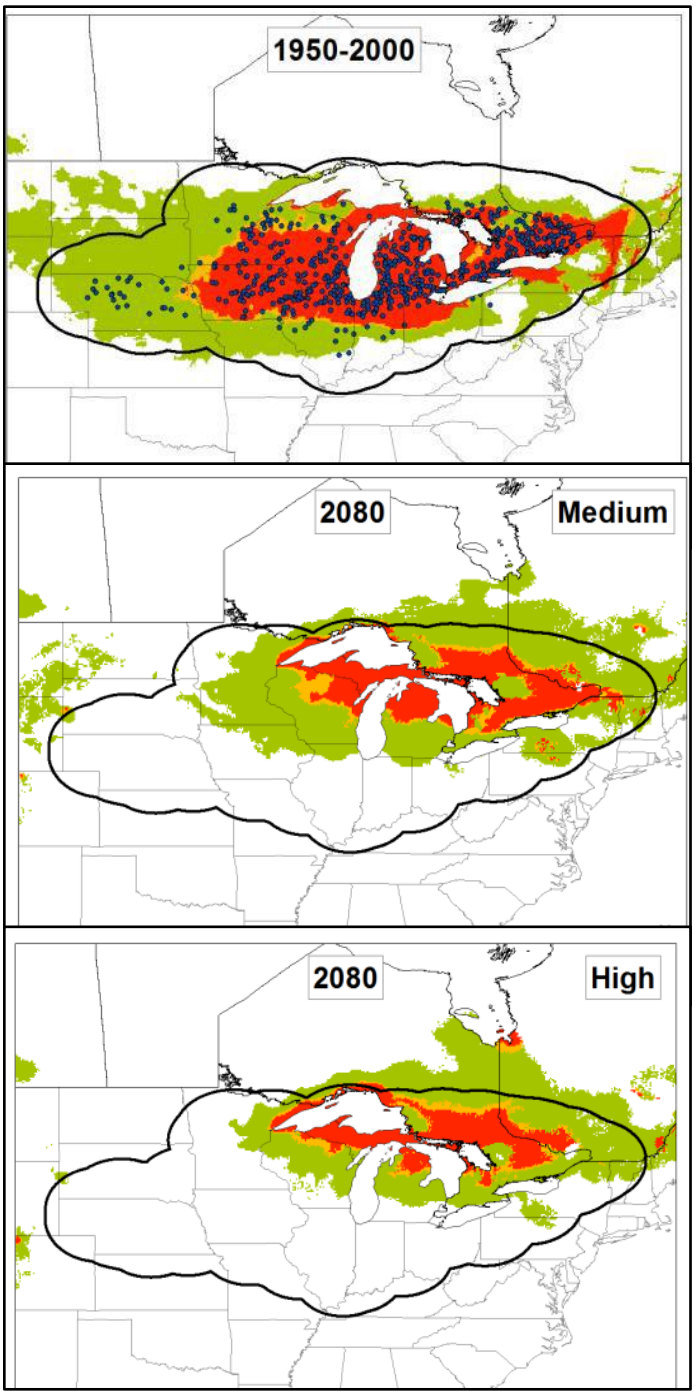
Habitat degradation is also a threat to Blanding's Turtle populations. Forest succession and invasive species can increase vegetation cover that reduces heat input and basking opportunities in wetlands. Blanding's Turtles avoid wetlands that are filled in with cattails[17]. Agriculture, transportation infrastructure, urbanization, and storm-water management influence the quantity and quality of water flowing into and out of wetlands. Lowering the water level in a wetland during winter can be a threat to overwintering turtles[107]. Dumping of garbage in Blanding's Turtle habitat has caused adult mortality[53].

Nesting sites can also be degraded by vegetation encroachment, which eliminates bare soil, alters the incubation temperature, increases predation rates, and prevents hatchling emergence when nests become "root bound"[5,76]. Altered landscape composition may reduce hatchling survival, as upon emergence they cue to dark horizons, which may no longer indicate suitable habitat, and put them at greater risk of mortality[80]. Nests in disturbed areas are at risk of additional disturbance by garden tools, farm machinery, road graders, and other motor vehicles. Turtle mortalities can result from the flooding of nesting sites[29]. Mowers and farm equipment can kill adult turtles[108].

Although collection of Blanding's Turtles is prohibited, it is a common concern of land managers in Illinois[27], and collection by hobbyists or visitors has occurred in northeast Illinois populations[53].

Climate Change

The sensitivity of Blanding's Turtle to climate change is not clear. It has been described as both moderately vulnerable and highly sensitive to climate change depending on the scale of analysis and risk factor considered[109–111]. One study described Blanding's Turtle as physiologically vulnerable to climate



Current (top) and projected 2080 (middle and bottom) climatic suitability for Blanding's Turtle based on a current records and medium (middle) and high (bottom) emission levels. Black dots are occurrence records, red indicates maximum evidence for suitability, and green indicates minimal evidence for suitability[109].

change[111]. Another study found that as little as 15% of Blanding's Turtle current range is projected to remain climatically suitable over the next several decades, mostly due to changes in mean annual temperature and annual precipitation[109]. The already highly fragmented nature of Blanding's Turtle habitat reduces the potential for climate related migration should current habitats become unsuitable[110]. Altered wetland hydrology may change habitat suitability and lead to increased movement and risk of road mortality[20,27]. As rainfall events are projected to become more extreme, there may be an increased risk of nest flooding. Warmer nest temperatures result in development of female turtles, which could lead to sex-bias populations [91].

Loss of Genetic Diversity

Loss of genetic variation can be a conservation concern, especially for small, isolated populations. Long lived species, such as Blanding's Turtles, may breed with offspring causing inbreeding depression, and small population sizes can cause genetic drift. Indeed, the high number (48%) of inviable eggs found in one Illinois population may be the result of inbreeding[112], and the infrequent occurrence of multiple paternity and highly skewed reproductive success among males in another Illinois population[59] may indicate critically low population density. The long-generation time of Blanding's Turtle is expected to buffer against rapid loss of genetic variability and available data show that genetic variation in Illinois populations (0.57 average heterozygosity) is similar to the overall population (0.59 average heterozygosity), but long term projections show declining genetic diversity[27,113]. Some Illinois Blanding's Turtle populations are genetically differentiated from each other (Lake vs Grundy Counties), indicating limited migration and exchange of genes between populations[112–114]. To prevent the loss of genetic diversity and maintain fitness in the long term, it may be necessary to manage for the exchange of genetic material.

Pollution

Although not specific to Blanding's Turtle, there is concern about the impacts of chemical, light, and sound pollution on turtles. Chemical contaminants, such as PCBs, organochlorine pesticides and dioxins, are known to accumulate in turtles[115–117]. The proximity of rails, roads, and pipelines to Blanding's Turtle habitats makes hazardous material spills an ongoing threat. Artificial lighting may interfere with turtle orientation and sound may inhibit hatchling movements[118].

Disease

Although evidence for emerging infectious disease among Blanding's Turtles in Illinois is lacking, this is a potential risk[119].

Regulations

In Illinois, it is illegal to "take" any threatened or endangered animal, such as Blanding's Turtle. "Take" of listed species, defined as "to harm, hunt, shoot, pursue, lure, wound, kill, destroy, harass, gig, spear, ensnare, trap, capture, collect, or attempt to engage in such conduct", is prohibited by the Illinois Endangered Species Protection Act: http://ilga.gov/legislation/ilcs/ilcs3.asp?ActID=1730&ChapterID=43

The IDNR Impact Assessment Section reviews proposed actions to assess potential impacts to listed species, using their online tool EcoCAT: http://dnr.illinois.gov/ecopublic/

IDNR can authorize the taking of listed species that is incidental to otherwise lawful activities. To receive Incidental Take Authorization, one must prepare a conservation plan and notify the public of the impact. See: http://www.dnr.illinois.gov/conservation/NaturalHeritage/Pages/IncidentalTakeAuthorization.aspx

Research, handling, possession, and management of listed species require IDNR permits, including a Scientific Collector Permit and an Endangered and Threatened Species Possession Permit, as well as additional site permits if activities take place on IDNR land or a protected Illinois Nature Preserve Commision site: http://www.dnr.illinois.gov/conservation/NaturalHeritage/Pages/ResearchPermits.aspx. Risks and impacts of methods on the species survival must be weighed against the benefits to justify the activity.

Species Conservation Goal

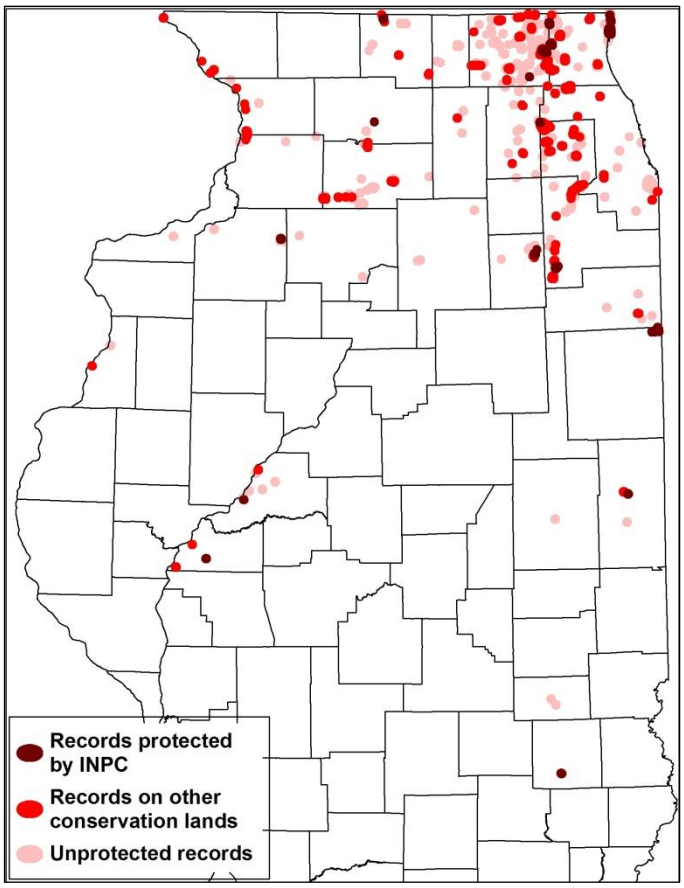
The "Illinois Conservation Assessment for the Blanding's Turtle" recommended a state-wide goal for the Blanding's Turtle population of at least 1500 adults over 40 years[27]. The population should include at least ten populations each exceeding 50 adults at

protected sites, and together total at least 750 adults distributed across at least 3 geographic units and exhibit natural recruitment[27].

Conservation Efforts

The longevity of Blanding's Turtle enables individuals to persist long after populations are no longer viable. This longevity and delayed maturity provide time for conservation actions but means that recovery efforts may take decades or centuries. The "Illinois Conservation Assessment for the Blanding's Turtle" has identified actions necessary for recovery including monitoring, habitat protection and enhancement, and reduction of road mortality and predation rates[27]

The Illinois Nature Preserve Commission has dedicated 56 nature preserves and land and water reserves that protect Blanding's Turtle habitat[56]. Blanding's turtle habitat conservation is also achieved through other types of conservation land such as federal wildlife refuges and county conservation districts[94] (see map). Although not specifically targeting Blanding's Turtles, there are a number of



Blanding's Turtle records from the Illinois Natural Heritage Database found on INPC sites (dedicated Nature Preserves and Land and Water Reserves), other "conservation lands" as identified by Ducks Unlimited, and non-conservation lands[94,148].

government-supported wetland conservation programs to assist private landowners in conservation (See http://dnr.state.il.us/wetlands/ch5a.htm).

Forest preserve districts are conducting on-site protection of nests with wire mesh and off-site protection of eggs collected from pregnant females to increase hatching rates (67% and 78% hatching rate respectively, compared to unprotected nests 23%)[53,54]. In Lake County, control of predators through trapping has reduced nest predation[54,78]. The Forest Preserve Districts of DuPage and Lake Counties, and the McHenry County Conservation District have experimented with head-starting(rearing of hatchlings to improve survival rates), which has demonstrated an annual juvenile survival rate of 66%[53]. However, there is some concern about the possibility of creating a sex-bias population, the potential to alter behavior, and the effects of repeated use of oxytocin to induce egg laying in pregnant females[31,120]. Vegetation management has also been used to maintain and improve Blanding's Turtle habitat.

Population modeling has revealed the relative importance of adult survival[87]. Although protection of nests or head-starting may delay the loss of populations, the population will continue to decline unless adult survival is also improved[53].

Survey Guidelines

Monitoring for trends

A long term monitoring program is needed to identify population trends. A mark recapture approach should be used to enable estimation of population size and survival and recruitment rates. A standardized monitoring protocol has been developed for Blanding's turtle in the Northeast region of the USA and may serve as a model.

Surveys for presence

Surveys to determine presence or absence should include hoop traps and visual surveys. Baited hoop trap surveys should be conducted in mid-May to July by a permitted biologist. Traps should be set in the best habitat available. Trapping success is highest when water temperature is warmer and on days with cloud cover less than 60%[53,121]. Capture rates vary between 0.02 and 0.1 captures per trap night and affect the amount of survey effort necessary to conclude absence to any degree of certainty (see table)[54,121]. Detection rate varies with habitat and

population, and will be lowest at locations with fewer individuals.

The number of trap-nights necessary to determine presence or absence to various degrees of certainty depends on the detection rate.

	Low detection rate	Average detection rate	High detection rate
Trap-nights	*0.02*	*0.05*	*0.1*
27	42%	**75%**	94%
45	60%	**90%**	99%
100	87%	**99%**	99%
Note: Trap-night recommendations should be applied to 0.6 miles of linear shoreline habitat or 15 acres of wetland habitat.			

Visual surveys for basking turtles should also be conducted to increase detection. Surveys should take place in March and April after ice-off when air temperatures reach at least 50°F[122]. While walking the shorelines of potential overwintering sites, surveyors should use binoculars to scan basking sites within 20 feet of the shoreline. At a minimum, 6 hours of surveying should be conducted per site, on at least 3 different days (3 days at 2 hours each), while it is sunny with calm to moderate winds. Additional methods, such as basking traps, funnel traps, dip nets, seines, and drift fences, may increase the chance of detection. Alternatively, new methods are being developed to use environmental DNA to detect Blanding's Turtles presence in a wetland, which may prove more cost effective than field surveys[123].

Monitoring for impacts

Surveys to monitor impacts of habitat alterations, such as habitat restoration and Incidental Take Authorization, should assess changes in population size, survival, and recruitment. Monitoring should follow a before-after-control-impact design [124,125]. A variety of trap sizes and types should be used across different habitats to capture adults, juveniles, and hatchlings[53,126]. Each captured turtle should be marked with identifying notches along the edge of its shell or PIT tagged (Passive Integrated Transponder) to identify recaptures. Methods, such as radio telemetry, camera traps, nest monitoring or road mortality monitoring, may be useful for identifying specific impacts and may strengthen the conclusions of monitoring.

Stewardship recommendations

Areas known or suspected of supporting Blanding's Turtle populations should be managed to maintain suitable habitat[127]. Wetland management for Blanding's Turtles should focus on maintaining, enhancing and restoring habitat features such as emergent and submerged vegetation, open water areas, basking areas, such as logs in or around the wetland, and deep muck substrates[8]. Management should include monitoring site hydrology and preventing alteration of natural water level fluctuation and drainage patterns. Water quality should also be monitored to ensure pollution, such as from road, lawn, or agriculture run-off, does not impose a threat. Natural shorelines should be maintained, and garbage that has accumulated should be removed. Aquatic invasive species should be controlled to prevent the loss of open water habitat.

Upland habitat management should focus on providing large nesting areas and travel corridors between wetlands. Nesting areas may need to be created or maintained to provide open areas with well-drained, friable soil near wetlands[25]. If maintenance is necessary to maintain open, friable soil conditions, tilling is preferred to mowing or weeding[33]. Restoration of upland nesting habitat that increased the distance to forest edge resulted in increased population growth and decreased nest predation in Wisconsin[76]. Turtle nesting mounds can be built but they may require nest protection to prevent predation[128]. Upland habitat may require woody or invasive species control to maintain suitable, open areas[127]. Burning, mowing, or tilling to maintain suitable conditions should occur between November and March[129]. Mechanical and chemical removal of vegetation should follow INPC stewardship guidelines (http://www.dnr.illinois.gov/INPC/Pages/INPCManagementGuidelines.aspx). To increase adult survival managers should identify travel corridors among wetlands and nesting sites and mitigate barriers and threats. Fencing or curbing can be used to prevent turtles from entering hazardous areas.

To reduce nest predation managers can protect nests and/or reduce predator abundance. To protect nests on-site, female Blanding's Turtles should be monitored for nesting movements (e.g., via

radiotelemetry) to locate nests; then following deposition, nests should be covered by wire mesh (2 ft diameter) and uncovered at the beginning of August[32,34,53,79]. Electric fencing has also been used to protect nests on-site[130]. On-site nest protection has been shown to decrease predation rates[34]. In addition, meso-predator populations should be monitored and managed, and efforts should be made to eliminate human sources of food and shelter for them[78,131]. Trapping may be necessary, especially before and during the nesting season. Three years of raccoon removal increased nest success from 8% to 69% in one Illinois population[54,78]. However, meso-predator populations tend to rebound quickly, so control efforts need to be recurrent and cover a large area to have an impact on meso-predator abundance[132].

Because some reptile populations may harbor infectious diseases, it is important to decontaminate prior to moving between wetland sites[133]. Decontamination requires washing and disinfecting all equipment, boots, and waders with a bleach solution or other disinfectant. Anyone working with this species should follow the decontamination guidelines of NEPARC[134]:
http://www.northeastparc.org/products/pdfs/NEPARC_Pub_2014-02_Disinfection_Protocol.pdf

Adjacent land owners and local residents should be informed of the presence and sensitivity of Blanding's Turtles and of practices that they can perform to support Blanding's Turtle survival, such as nest site creation/protection, elimination of meso-predator resources, conscientious driving, and confining pets.

Nest protection cage placed after egg deposition to prevent predation. Photo by Gary Glowacki

Avoidance, Minimization, Mitigation

Avoidance measures
It is difficult to ensure complete avoidance of Blanding's Turtles due to their use of all habitat types and long distance movements. To avoid all potential impacts work should occur more than 1.2 miles from an occupied wetland [57].

Minimization measures
Spatial and temporal efforts
The farther an impact occurs from occupied wetlands, the lower the impact will be. Development that occurs more than 0.6 mi from an occupied wetland may avoid nearly all nesting sites and most of adult turtle activity[57]. Development more than 0.2 mi away may avoid impact to most nest sites (around 90%) but may still have an impact on adult activity[57]. Development siting should avoid bisecting wetland complexes and travel corridors.

Wetlands should not be drained, dredged, deepened, or filled, but, if necessary, these activities are best conducted during between April and September when turtles can emigrate[107]. Replacement wetlands should be made available to emigrating turtles with fencing to guide them prior to these activities. Upland work should be conducted during the overwintering period (November to March). Impacts to nesting areas should never occur from June to September.

Compatible design
Development designs should be compatible with continued Blanding's Turtle occupation and survival by incorporating natural landcover and Blanding's Turtle's habitat needs. Wetland impoundments should be designed to be suitable Blanding's Turtle habitat including natural shorelines and no use of riprap or retaining walls (see habitat section above)[79]. Water control structures should be designed to allow for turtle movement and to prevent trapping of turtles. Artificial nesting areas that receive regular management should be included in designs (see stewardship section)[33]. Wetlands and adjacent areas should remain un-mowed March to October[108]. Artificial lighting should be minimized, reduced in intensity, and directed away from habitat[135].

Turtle travel corridors should be created to allow for movement among wetlands and nesting areas. Curbing

Reptile exclusion fencing. Photo credit Baxter-Gilbert 2015[140].

and barriers may prevent turtles from entering hazardous areas but allow them to leave. One-way "turtle curbs," which are gradual on the road side to allow turtles to leave roadways but are steep barriers on the other side, can discourage turtles from entering busy roadways[136].

New and existing roads and railways, especially those bisecting habitat, should be designed or retrofitted with safe passage systems[137]. Turtles have been observed using safe passage ways and will follow barriers/fencing that direct them to these crossings[97,138,139]. Although there is limited information on the effectiveness of passage systems, one safe passage system was found to greatly reduce road mortalities, while another failed to reduce road mortalities after numerous gaps developed in the barrier fencing, highlighting the importance of design and maintenance[140,141].

General safe passage system guidelines have been developed[142]. Barrier fencing should extend half a foot underground and at least two feet aboveground with an overhang to prevent some species from climbing over and entering the roadway[138,139]. Although wire mesh or plastic fencing may be used, it will require considerable amounts of maintenance to be effective; a concrete wall or steel barrier will be longer lasting and may be more effective[140].

Spotted turtle using a railroad crossing structure in Massachusetts. Photo credit Pelletier et al. 2006[146]

In general, the effectiveness of passageways depends on their openness and light permeability[143,144]. Openness is defined as (height x width)/length of the culvert or passage. An openness of at least 0.82 should be maintained[143,145]. Bridges are preferred to culverts due to their natural open conditions[124]. Flat-bottomed or elliptical culverts are ideal, and "skylights" can be used to increase light permeability. Blanding's Turtles have used culverts with variable bottom substrates, but logs and natural materials in the culvert may encourage use[138]. Railroad passages can be made by allowing for gaps between adjacent rail ties (see photo)[146]. Passageways should be located in the best travel corridor, often low-lying areas between wetlands[138,139]. Costs of passageways vary widely, from $3,000 to $375,000[142]. Slower speed limits and rerouting of heavy traffic may also reduce road mortality rates. Turtle crossing signs have been used to inform motorists of crossing turtles, but the benefits are questionable[147].

<u>Construction practices</u>

Construction and maintenance practices should be sensitive to impacts to turtles and their habitats. Clearing of native vegetation should be limited. Staging areas should be located far from sensitive areas. The area impacted should be reduced as much as possible, and areas that are not to be disturbed should be flagged or fenced to alert construction personnel. Debris and excess materials should be removed and properly disposed. Erosion and sediment controls should be strictly implemented, monitored, and maintained for the duration of the project. Erosion control measures should be turtle safe, such as loosely woven, natural-fiber erosion control matting and native vegetation. Avoid using erosion control products that are made with welded plastic mesh or webbing. All project personnel should be informed of the sensitive nature of the project and notified of the proper procedures to follow if a turtle is found.

Silt fencing should be used to keep Blanding's Turtles from entering active construction sites. Trenches should be checked for turtles prior to being backfilled and the sites should be returned to original grade.

Relocating adult turtles should be avoided whenever possible, but when necessary to move them out of dangerous areas, they should be moved by an IDNR authorized person to the closest safe location in the direction that they are moving.

Mitigation and Conservation Opportunities
Mitigation opportunities include protection, stewardship, and restoration of Blanding's Turtle habitat and research to inform conservation. Mitigation practices have included: habitat protection through conservation easement, wetland and upland habitat restoration, habitat stewardship through vegetation management, prescribed burning, native plantings, creation of nesting areas, predator control, public outreach, and compensatory payment to IDNR to support species conservation.

Protection
Unprotected and inadequately protected Blanding's Turtle populations should be first priority for habitat protection. Nine of the 28 most frequently observed populations have no protection in the Illinois Nature Preserve Commission system[27], and only three of these occur on other types of conservation land[94,148]. Site protection should consist of both wetland habitat and surrounding 1.2 mi of upland habitat[57]. In addition, protection of sites that are adjacent to occupied habitat and corridors will improve connectivity and increase the long term survival of those populations.

Land protection may consist of acquisition or conservation easement. Acquired land could be donated to a conservation agency or local conservation organization. Conservation easements may provide a level of protection without acquisition. Illinois Nature Preserves Commission permanently protects high quality areas and habitat for listed species on both private and public lands in the Illinois Nature Preserve System. Conservation easements on agricultural land can also protect habitat through retirement of farmed and previously converted wetlands. Conservation organizations that are active in the Blanding's Turtle Illinois range may be interested in partnering on conservation efforts and may be identified through the Prairie State Conservation Coalition (http://www.prairiestateconservation.org).

Stewardship
Beyond protection of Blanding's Turtle habitat, there is considerable stewardship work that could be done as mitigation to maintain habitat that is already protected, reduce adult mortality, and increase hatching rates (See stewardship recommendations section). Blanding's Turtle habitat stewardship opportunities exist on state-owned property, various forest preserve/conservation districts, and private properties.

Restoration
Upland and wetland habitats can be restored on undeveloped and agricultural land. It is expected that because Blanding's Turtles use a diversity of wetlands in habitat complexes, the addition of constructed wetlands and upland habitat will further increase the diversity and availability of resources and potentially reduce the distances they move across the landscape[8]. Blanding's Turtles have been observed using constructed wetlands seasonally for basking and foraging[8]. Constructed wetlands should aim to mimic suitable habitat conditions (see habitat section). Unfortunately, constructed wetlands tend to be warmer, drier, and have less cover and muck than Blanding's Turtle suitable habitat[8]. If habitat destruction will be followed by restoration, sediment and vegetation can be saved from the original wetland to produce comparable conditions[136]. The "Illinois Wetland Restoration and Creation Guide" may provide guidance for restoring the wetland portion of Blanding's Turtle habitat[149].

The Natural Resource Conservation Service (NRCS) provides practice standards and estimated costs on various conservation practices that may be of benefit to Blanding's Turtles. Restoration of wetlands by removing or disabling drainage tiles (NRCS practice 657 and 649) costs an estimated $600/ac. Creating wetlands (NRCS practice 643 and 658) costs an estimated $1800–4500/ac. Maintaining suitable open nesting habitat (NCRS practice 647) costs an estimated $100/ac.

Research needs

How viable are Blanding's Turtle populations across Illinois?

- Determine occupancy, survival, and recruitment rates for various populations across Illinois, especially northwestern and central populations.

How much suitable habitat is available to Illinois populations and what are the habitat limitations?

- Conduct a GIS analysis of Blanding's turtle records, land cover, roadway, and railway layers to identify habitats that are most likely to sustain populations in the long term and identify key barriers to connectivity that may be modified.

How do habitat needs and threats differ between juvenile and adult Blanding's Turtles?

- Assess habitat use, survival rates, and sampling bias between adults and juveniles.

How beneficial are safe passage systems to Blanding's Turtle?

- Compare movement, survival rates, and genetic exchange among various travel corridors.

What are the effects of light and noise pollution on Blanding's Turtle?

- Determine if hatchling or nesting turtles are attracted to artificial light and if certain lighting characteristics are more important than others.

What are the long-term effects of ex situ nest protection and head-starting?

- Compare the fitness of wild born and head-started Blanding's turtles.

How can genetic diversity be maintained across Illinois Blanding's Turtle populations?

- Assess population genetic structure in central and northwestern Illinois, identify gene flow limitations, and develop a genetic management plan.

Additional information

Species profiles

- http://explorer.natureserve.org/servlet/NatureServe?searchName=Emys+blandingii
- http://wwx.inhs.illinois.edu/collections/herps/data/ilspecies/em_blandin/

Conservation assessments

- http://niu.edu/biology/_pdfs/rking/Illinois-Blandings-Turtle-Conservation-Assessment-FINAL-25-Feb2013.pdf
- http://www.mwparc.org/products/blandings/Blandings_Turtle_Conservation_Assessment_2010_FINAL.pdf

Habitat management

- http://www.mwparc.org/products/habitat/MWHMG-Full.pdf

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