

Status Assessment for the Blanding's Turtle (*Emydoidea blandingii*) in the Northeast



Photo: B. Compton

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Summary

Blanding's turtles (*Emydoidea blandingii*) occur in the northern U.S. and southeastern Canada. Populations are found throughout the northern Midwest, with several disjunct populations in the Northeast (eastern New York, eastern Massachusetts, southern New Hampshire, southern Maine, and southern Nova Scotia). These eastern populations have been effectively isolated from the main range for several millennia, are genetically distinct, and may qualify for federal listing as a Distinct Population Segment under the U.S. Endangered Species Act.

These relatively small, scattered populations occur in areas with large human populations, where suburban sprawl is increasing development and road traffic rates are increasing. Blanding's turtles typically move long distances between wetlands throughout the summer, and nest far from the wetlands where they overwinter. These movements often lead individuals to cross roads, where they face a high likelihood of being killed by traffic.

The life history strategy of Blanding's turtles is extreme: adults live and reproduce for many decades, balancing high rates of nest and hatchling mortality. As a result, populations are vulnerable to increases in adult mortality, such as that caused by vehicles road mortality. In addition, human-commensal nest and hatchling predators may be depressing reproduction and recruitment at many sites. Increasing development within the Blanding's turtle range \ is thought to be causing population declines.

Because Blanding's turtles have a generation time of nearly 40 years and population increases take place slowly, recoveries from declines may take many decades or centuries. Therefore, to be effective, conservation efforts must take place well in advance of severe declines. State and federal agencies and researchers in the four states with northeastern Blanding's turtle populations have recently begun coordinating conservation efforts. As the first product of this multi-state cooperation, this assessment of the status of Blanding's turtle populations in the Northeast is intended to be a comprehensive summary of the species ecology and conservation needs.

Introduction

Blanding's turtles (*Emydoidea blandingii*) occur primarily in the northern Midwest of the U.S., and southeastern Ontario (as well as a small area of adjacent Québec; Fig. 1). In addition, several disjunct populations occur in the northeastern U.S. and Nova Scotia (Fig. 2). These disjunct populations are scattered, generally small, and are found in areas where human population increases and development associated with suburban sprawl are likely to lead to severe declines. Recent DNA analysis shows that these disjunct eastern populations are genetically distinct from those in the main range. Blanding's turtles are listed as either Threatened or Endangered in nine of 15 states where they occur, including three of the four states in the Northeast. The species was a federal Category 2 candidate before the elimination of this status, and is considered as a high risk species warranting consideration for federal listing by the Northeast Endangered Species and Wildlife Diversity Technical Committee (Therres 1999, p. 97).

In February, 2004, the New Hampshire Nongame and Endangered Wildlife Program hosted a meeting of state, federal, university, and non-governmental organizations to share information, assess the status of the Blanding's turtle in the Northeast, foster state and federal cooperation, identify common priorities, and develop a plan for the conservation of this species. Based on the status information presented and the level and degree of threats, the "Northeast Blanding's Turtle Working Group" recommended that a formal status assessment should be prepared to assemble the results of the last 15 years of surveys and research, assess current habitat and its status, document and analyze threats, and identify areas to target for future conservation efforts. We also agreed to work in partnership to pool available resources, identify common priorities, work together on conservation problems, and develop a coordinated multi-state conservation plan for the Blanding's turtle. A grant to further this work was awarded through the Science Support Partnership Program of the U. S. Geological Survey Biological Resources Division (USGS-BRD) and U. S. Fish and Wildlife Service (USFWS). This status assessment is one of the products of this grant.

The objectives of this status assessment are to summarize the current state of knowledge of the species in the Northeast and provide background for conservation efforts, as well as to provide information to support a decision by the USFWS on listing under the federal Endangered Species Act. This assessment is a review of the scientific literature on Blanding's turtles, with a focus on the ecology and status of populations in the Northeast. In addition, unpublished results from recent field studies in the Northeast have been incorporated, as well as a summary of Element Occurrence records from state Natural Heritage programs and analysis based on a regional expert survey and discussions with members of the Northeast Blanding's Turtle Working Group.

**U.S. FISH AND WILDLIFE SERVICE
SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM**

SCIENTIFIC NAME: *Emydoidea Blandingii*

COMMON NAME: Blanding's turtle

LEAD REGION: Region 5

INFORMATION CURRENT AS OF: January 11, 2007

STATUS/ACTION

Species assessment - determined we do not have sufficient information on file to support a proposal to list the species and, therefore, it was not elevated to Candidate status

New candidate

Continuing candidate

Non-petitioned

Petitioned - Date petition received:

90-day positive - FR date:

12-month warranted but precluded - FR date:

Did the petition request a reclassification of a listed species?

FOR PETITIONED CANDIDATE SPECIES:

a. Is listing warranted (if yes, see summary of threats below)?

b. To date, has publication of a proposal to list been precluded by other higher priority listing actions?

c. If the answer to a. and b. is "yes", provide an explanation of why the action is precluded.

Listing priority change

Former LP:

New LP:

Date when the species first became a Candidate (as currently defined):

Candidate removal: Former LPN:

A – Taxon is more abundant or widespread than previously believed or not subject to the degree of threats sufficient to warrant issuance of a proposed listing or continuance of candidate status.

U – Taxon not subject to the degree of threats sufficient to warrant issuance of a proposed listing or continuance of candidate status due, in part or totally, to conservation efforts that remove or reduce the threats to the species.

F – Range is no longer a U.S. territory.

I – Insufficient information exists on biological vulnerability and threats to support listing.

M – Taxon mistakenly included in past notice of review.

- N – Taxon does not meet the Act’s definition of “species.”
- X – Taxon believed to be extinct.

ANIMAL/PLANT GROUP AND FAMILY: Reptiles, Emydidae (Pond turtles)

HISTORICAL STATES/TERRITORIES/COUNTRIES OF OCCURRENCE:

Northeastern DPS: eastern New York, Massachusetts, New Hampshire, Maine, and Nova Scotia.

Main range: South Dakota, Nebraska, Minnesota, Iowa, Missouri, Wisconsin, Illinois, Michigan, Indiana, Ohio, Pennsylvania, west/central New York, Ontario, and Québec.

CURRENT STATES/COUNTIES/TERRITORIES/COUNTRIES OF OCCURRENCE:

Northeastern DPS: eastern New York, Massachusetts, New Hampshire, Maine, and Nova Scotia.

Main range: Nebraska, Minnesota, Iowa, Missouri, Wisconsin, Illinois, Michigan, Indiana, Ohio, west/central New York, Ontario, and Québec. Extirpated in South Dakota and Pennsylvania.

LAND OWNERSHIP

Blanding’s turtle is found on a mix of Federal, State and private land. The majority of known occurrences in the Northeast are on private land, although the largest known population is on Federal land.

LEAD REGION CONTACT: -----

LEAD FIELD OFFICE CONTACT: -----

Biological Information

Species Description

The Blanding's turtle is a medium-sized turtle with a high-domed carapace. The carapace is black, and in most individuals, flecked with yellow spots and lines (although the carapace of older individuals is often entirely dark). The most obvious distinguishing character (often discernable from a distance in basking and floating individuals) is the bright yellow unmarked chin and throat. The scales are mostly black, with some yellow; the top of the head may have yellow flecks. The upper jaw is notched.

Blanding's turtles have a kinetic plastron, hinged between the pectoral and abdominal scutes. The plastron may be yellow with dark blotches at the outer rear of each scute, or may be completely dark. In males, the plastron is concave, and the cloaca reaches beyond the posterior rim of the carapace, and the upper jaws are dark. In females, the plastron is flat and there are faint yellow stripes on the upper jaws (although upper jaws may be dark in older females).

In Massachusetts, adult Blanding's turtles ranged from 13.5 to 25.5 cm straight-line carapace length, with a mean of 20.9 cm and an interquartile range of 19.7-22.3 cm (n = 92, B. Compton, University of Massachusetts, unpublished data). In two sites in New Hampshire, males had a mean carapace length of 21.0 cm (n = 20) and females of 20.2 cm (n = 17; Babbitt and Jenkins 2003, p. 18). Adults in Maine ranged in carapace length from 17.1 to 22.9 cm, with a median of 20.8 cm for females and 21.8 cm for males (Joyal 1996, p. 100; and J. Haskins, unpublished data as cited in Hunter et al. 1999, pp. 144-145). Another study in Maine found carapace lengths of males ranged from 19.3-24.3 cm (mean = 22.0, n = 48), and those for females ranged from 16.8-22.9 cm (mean = 20.6, n = 53; F. Beaudry, University of Maine, unpublished data). In New York, males ranged from about 21 to 25 cm (n = 12), and females ranged from about 18 to 23 cm (n = 16; Kiviat et al. 2004, p. 96). Table 1 summarizes carapace lengths.

Table 1. Straight-line carapace lengths (cm) of adult Blanding's turtles.

State	Sex	Mean	Range	n	Citation
Massachusetts	combined	20.9	13.5-25.5	92	B. Compton, unpublished data
New Hampshire	males	21.0		20	Babbitt and Jenkins (2003)
	females	20.2		17	
Maine	combined		17.1-22.9		J. Haskins, unpublished data and Joyal (1996)
Maine	males	22.0	19.3-24.3	48	F. Beaudry, unpublished data
	females	20.6	16.8-22.9	53	
New York	males		21-25	12	Kiviat et al. (2004)
	females		18-23	16	

Taxonomy

Blanding's turtle (*Emydoidea blandingii*, Holbrook 1838) is the sole member of a monotypic genus in the *Clemmys* complex (Emydinae) of Emydidae (Ernst et al. 1994, pp. 203-204; Stephens and Wiens 2003, p. 584). It was once included in *Deirochelys* based on features that Bramble (1974, p. 714) later suggested were convergent (Ernst et al. 1994, p. 249). Feldman and Parham (2002, p. 391) argued that molecular data support merging *E. blandingii*, *Clemmys* (now *Actinemys*) *marmorata* and *Emys obicularis* into *Emys*. Interestingly, these three closely related species are widely separated geographically (eastern North America, western North America, and Europe through northern Africa and western Asia, respectively). Stephens and Wiens (2003, p. 584) provided further molecular evidence supporting the monophyly of these three species, and argued against lumping them into *Emys*. NatureServe (2006, pp. 1-2) has adopted this change to *Emys*, based on Feldman and Parham (2002). This change was rejected by the Committee on Standard English and Scientific Names (SSAR, ASIH, HL; Crother et al. 2003, p. 203), which supported Holman and Fritz's (2001, p. 323) argument in favor of moving *Clemmys marmorata* to the monotypic genus *Actinemys*. Following Crother et al. (2003, p. 203), we retain the name *Emydoidea blandingii*. No subspecies are recognized (McCoy 1973, p. 1).

Habitat

Wetland habitat requirements

Habitat use by Blanding's turtles varies somewhat across its range and among sites, presumably in response to differing availability and configuration of wetlands. Blanding's turtles typically require wetland complexes, and move among different wetlands throughout the season. Wetlands used by Blanding's turtles are usually stagnant or slow-moving, relatively shallow (<2 m), with abundant aquatic vegetation (Ross and Anderson 1990, pp. 6-8; Joyal et al. 2001, pp. 1757-1759; B. Compton, unpublished data). Blanding's turtles have been reported to use shrub swamps, marshes, vernal pools, bogs, ponds, lakes, wet prairies, forested wetlands, and low-gradient streams and rivers. In Minnesota, Blanding's turtles spent more time in shrub swamps than other wetlands, and stayed in shrub swamps for a longer time than they did in marshes or ponds (Piegras and Lang 2000, p. 595). In Wisconsin, Blanding's turtles selected ponds most strongly; in early summer they used marshes heavily (Ross and Anderson 1990, p. 8). In Massachusetts, turtles were found at a median depth of 0.5 m (interquartile range = 0.25-0.7 m, n = 3987 locations; B. Compton, unpublished data).

In Maine, Blanding's turtles were located most often in permanent pools (>50% of locations for most individuals), but used vernal pools about 25-30% of the time (Joyal et al. 2001, p. 1758). Wetlands used by turtles were less isolated than random wetlands within a 500 m radius. In the Hudson Valley of New York, Blanding's turtles selected summer wetlands with significantly more buttonbush (*Cephalanthus occidentalis*) and common duckweed (*Lemna minor*) than random plots (Kiviat et al. 2004, p. 96). Wetlands used in the spring were often dominated by shrubs, were 0.1-7.2 ha, and had hydroperiods of 8-12 months and water depths of 0.5-1.2 m (Kiviat 1997, p. 378). Habitat selection in Massachusetts (based on resource selection

functions of use ÷ availability of active season wetland habitat of 3,459 locations of 52 turtles using photo-interpreted GIS wetland data) indicate that bogs¹ were most highly selected (i.e., used more often than available), followed by marshes and vernal pools², but that shrub swamps were used most often, followed by marshes (Table 2; B. Compton, unpublished data). Note that seldom-used types may be highly selected if they have low availability.

Table 2. Habitat selection (use ÷ availability) by Blanding's turtles in Massachusetts (B. Compton, unpublished data). Generalized wetland types are based on GIS data; animals are pooled across years, sites, sex, and season. Resource selection functions represent the expected proportional use if all types were equally available.

Wetland type	Resource Selection Function	Number of locations	Percent of locations
Bog	0.43	69	2
Marsh	0.21	970	28
Vernal pool	0.20	317	9
Shrub swamp	0.10	1,696	49
Stream	0.05	407	12
Total	1.00	3,459	100

Upland habitat requirements

Blanding's turtles use uplands for several parts of their life cycle: for nesting, moving among wetlands, basking, aestivation, and possibly feeding (page 25). In Maine, where a number of turtles aestivated in one summer, Blanding's turtles were found in uplands 38% of the time (Joyal et al. 2001, p. 1759). In Massachusetts, where aestivation was uncommon, animals were located in uplands about 8% of the time (B. Compton, unpublished data). Although individuals may spend a relatively small amount of time in uplands throughout the season, turtles typically travel considerable distances overland during interwetland and nesting movements.

Upland habitat for nesting generally consists of unvegetated or sparsely vegetated areas, typically with a mixed gravel and sand substrate. These sites are often in areas disturbed by humans, such as gravel pits, power lines, and residential landscaping (page 20).

Juvenile habitat requirements

Few studies have documented habitat use by juvenile Blanding's turtles. McMaster and Herman (2000, pp. 602-610) used radiotelemetry to examine micro-habitat use by 22 juveniles (19 individuals ranging from 2-13 years) and three subadults (17-18 years). Juveniles selected

¹ These photo-interpreted bogs may include acidic fens and other similar wetlands.

² Vernal pools are defined based on photo-interpreted the Massachusetts potential vernal pool data layer. These include small seasonal wetlands of varying cover types, as well as some permanent wetlands.

cover of mixed *Sphagnum* and sweet gale (*Myrica gale*), and were found in wetlands with sedge and pure stands of *Sphagnum* or sweet gale to a lesser extent. In Minnesota, smaller juveniles were found most often in sedge (*Carex comosa*) and alder (*Alnus rugosa*) hummocks, medium-sized juveniles in alder and at edges between sedge and open water, and larger juveniles in open water dominated by pondweed (*Potamogeton pectinatus*) and duckweed (*Lemna minor*; Pappas and Brecke 1992, p. 233).

Landscape considerations

It is important to note that, in the Northeast, very few Blanding's turtles have been observed to spend the entire season in one wetland (exceptions have been observed, e.g. 1 out of 50 turtle/seasons in Maine, F. Beaudry, pers. comm. and New York, A. Breisch, New York State Department of Environmental Conservation, pers. comm.). Most individuals move overland among multiple wetlands throughout the season. In addition, females often move long distances to nesting sites. Habitat, therefore, must be considered in the context of its landscape setting (Joyal et al. 2001, p. 1761).

Movements

Blanding's turtles usually occupy complexes of wetlands, moving overland among wetlands throughout the season. Typically, a turtle will spend several days to a few weeks moving within in a wetland, then travel overland to another wetland, repeating this pattern several times during the active season (usually from mid-April through late October). In addition to inter-wetland movements, Blanding's turtles often nest far from wetlands where they overwintered. These overland movements often lead turtles to cross roads, where they have a high risk of being killed by traffic. For instance, in Massachusetts in 2001-2002, 11 successful road crossings were made by seven turtles during interwetland movements, while 13 crossings were made by five females on nesting forays (Grgurovic and Sievert 2005, pp. 207-208; B. Compton, unpublished data). In the same study, a male Blanding's turtle with a home range length of 3.2 km was killed while attempting to cross a road. Of 14 road-killed Blanding's turtles found in Massachusetts from 2001-2003, four were females, two were males, five were juveniles, and the sex was unknown for three (B. Compton, unpublished data). In Maine, 50 radio-tracked adult turtles crossed paved roads 40 times, and unpaved roads 34 times, for an average of 1.54 road crossings (any type) per turtle, per year. Females crossed roads more often than males ($U = 429.5$, $P = 0.011$) (F. Beaudry, unpublished data).

Inter-wetland movements

Maximum overland movements have been reported as 1400 m in Illinois (Rowe and Moll 1991, p. 182), 1928 m in Massachusetts (B. Compton, unpublished data), 2050 m in Maine (Joyal et al. 2001, p. 1760), 3670 from another Maine study (Beaudry et al. 2006, p. 17 and unpublished data), and 2900 m in Minnesota (Piepgras and Lang 2000, p. 592). In Massachusetts, the median interwetland movement was 55 m (75th percentile = 198 m, 95 percentile = 599 m, 99th percentile = 1091, maximum = 1928 m, n = 1240 movements by 69 animals over 3 years; B.

Compton, unpublished data). Males moved farther between wetlands than females (geometric mean of male movements = 98 m vs. 63 m for females, log-transformed t -test, $P < 0.01$, d.f. = 1213). Maximum interwetland movements by each animal had a median of 418 m (75th percentile = 769 m, 95th percentile = 1272 m, 99th percentile = 1848 m, maximum = 1928 m, $n = 69$ animals). There was no difference between males and females in maximum interwetland movement (log-transformed t -test, $P = 0.3$, d.f. = 63). Blanding's turtles at Great Meadows National Wildlife Refuge (NWR), on the other hand, are relatively sedentary, rarely moving from the refuge impoundments to other wetlands (Windmiller 2004, p. 1; Windmiller and Ives 2005, p. 1). This may be a result of the size and quality of the impoundment wetlands, or a result of past losses of more mobile adults to road mortality on busy roads bordering the refuge to the east and west (Windmiller and Ives 2005, p. 1). Overland movements are summarized in Table 3.

Table 3. Interwetland movements (m) of Blanding's turtles.

State	95th percentile	Maximum	n ^a	Citation
Illinois		1400		Rowe and Moll (1991)
Massachusetts	599	1928	1240/69	B. Compton, unpublished data
Maine		2050		Joyal et al. (2001)
Maine	935	3670	397/49	(Beaudry et al. 2006 and unpublished data)
Minnesota		2900		Piepgas and Lang (2000)

^a Number of movements / number of animals

Movements to nesting sites

In Maine, distances from nests to the nearest wetland ranged from 70-410 m (mean = 242 m, $n = 6$). The distance from each nest to the wetland most recently used by the nesting female ranged from 100-1620 m (mean = 633 m, $n = 6$; Joyal et al. 2000, p. 583). In Massachusetts, the distance from each nest to the most-recently used wetland ranged from 7-974 m (median = 208 m, $n = 34$ nests of 22 individuals; B. Compton, unpublished data). Note that females may move several hundred meters to nest over several days, stopping in wetlands (often vernal pools) along the way and near the nest site. Depending on how often a female is located, nesting distances may represent the entire nesting movement, or just the movement from a nearby staging wetland. In Michigan, distances from each nest to the nearest water body ranged from 2-1115 m (mean = 135 m; Congdon et al. 1983, p. 421); a later report from the same site notes that 99% of nests were within 400 m of water ($n = 263$; Congdon et al. 2000, p. 571). In Minnesota, the straight-line distance from a female's wetland to her nest ranged from 100-1609 m (mean = 426 m, $n = 13$; Piepgas and Lang 2000, p. 592). In Dutchess County, New York, the greatest movement from overwintering wetland to nest site was 950 m (A. Breisch, unpublished data) and in Saratoga County it was 1300 m (M. Kallaji, New York State Department of Environmental Conservation, unpublished data). These typically long-distance nesting movements may be partially driven by higher rates of turtle nest predation that occur near wetlands (Marchand and Litvaitis 2004b, pp. 247-248). Notably, these long-distance movements can put nesting females

(the most demographically-important sex, and life stage) at great risk of road mortality in heavily-developed areas. Distances from wetlands to nest sites are summarized in Table 4.

Table 4. Distance (m) from wetlands to nesting sites for female Blanding's turtles.

State	Wetland	Mean	Median	Range	n	Citation
Maine	Nearest	242		70-410	6	Joyal et al. (2000)
Maine	Most recent	633		100-1620	6	Joyal et al. (2000)
Massachusetts	Most recent		208	7-974	34/ 22 ^a	B. Compton, unpublished data
Michigan	Nearest	135		2-1115	10 5	Congdon et al. (1983)
Minnesota	"Turtle's wetland"	426		100-1609	13	Piepgras and Lang (2000)
New York	Overwintering			950 ^b 1300 ^c		A. Breisch, unpublished data

^a Number of nests / number of females

^b Maximum, Dutchess County

^c Maximum, Saratoga County

Nest site fidelity

Nest site fidelity is generally high in Blanding's turtles. Of eleven females whose nests were located in multiple years in Michigan, eight of these used the same general nesting area across years; those that did not show fidelity nested 258 m, 700 m, and 1300 m apart in different years (Congdon et al. 1983, p. 421). In Massachusetts, nest site fidelity was similarly high. Of females that nested in known locations over multiple years, most nested in approximately the same location. The mean distance between nests across years was less than 130 m for ten of eleven females (median = 63 m, interquartile range = 12-116 m, maximum = 598 m, n = 25 nests of 11 females across three years; B. Compton, unpublished data). Some individuals, however, moved quickly to newly-disturbed sites, such as clearings for house construction. At another site in Massachusetts, the median distance between successive nests was 88 m (n = 49 turtles; S. Smyers, Oxbow Associates, unpublished data). In New York, while nest site fidelity also appears high, female Blanding's turtles responded to newly created disturbed areas and changed nesting sites (A. Breisch, pers. comm.).

Home range sizes

Home ranges have been measured using a number of different methods, including home range length, minimum convex polygon (MCP), MCP of "activity centers," kernel and adaptive kernel estimators, and grid summation. In general, these techniques give results that are not comparable, thereby making regional comparisons across different studies problematic. Some of these techniques are inappropriate for Blanding's turtles: MCP includes large areas of non-habitat and is highly sensitive to the configuration of wetlands used by turtles; grid summation is

sensitive to an arbitrarily-chosen cell size. Note also that home range lengths (the longest distance between locations in a year) are often distributed log-normally (as are interwetland movements), thus a geometric mean or median are more appropriate measures of central tendency than an untransformed mean.

In Minnesota, home range lengths ranged from 243-2987 m, with a mean of 906 m (Piepgras and Lang 2000, p. 598). In Massachusetts, annual home range lengths for 44 animals tracked for at least 20 weeks in a year had a median of 1001 m (range = 316-2559 m, interquartile range = 698-1353 m, 95th percentile = 2253 m, 99th percentile = 2503 m; B. Compton, unpublished data). These home range lengths were distributed log-normally (Shapiro-Wilk test, $P = 0.46$), with a geometric mean of 972.2 m (95% CI = 395-2391 m). During the first two years of this Massachusetts study, there was no significant difference by site, year, or sex; movements were significantly longer between April 15 and May 31 than other seasons, primarily due to long-distance movements from overwintering sites to vernal pools (Grgurovic and Sievert 2005, p. 209). In Maine, 50 Blanding's turtles had a median annual home range length of 1272.5 m, with a range of 453 - 8927 m (F. Beaudry, unpublished data). Home range lengths are summarized in Table 5.

Table 5. Home range lengths (m) of Blanding's turtles.

State	Mean	Median	Range	Inter-quartile range	95th percentile	n	Citation
Minnesota	906		243-2987			25	Piepgras and Lang (2000)
Massachusetts		1001	316-2559	698-1353	2253	44	B. Compton, unpublished data
Maine		1272.5	453-8927			50	F. Beaudry, unpublished data

Estimates of home range area in Massachusetts using the fixed kernel estimator with least-squares cross-validation had 95% contours of 19.9 ha for 27 females and 27.4 ha for 14 males, with considerable variation among individuals and years (Grgurovic and Sievert 2005, p. 207). Fifty turtles in Maine had a mean home range of 134.2 ha, with no difference between sexes ($U = 282$, $P = 0.579$), using a 95% fixed kernel estimator. When a 75% fixed kernel estimator was used, mean home range size was 63.0 ha; the 50% fixed kernel was 26.6 ha; all used least square cross validation (F. Beaudry, unpublished data). In New Hampshire, mean home range estimates using adaptive kernels (reported by site) were 14.9 ha, 11.6 ha, and 14.1 ha for males, and 2.8 ha, 24.8 ha, and 2.6 ha for females (Babbitt and Jenkins 2003, pp. 19-20). In Minnesota, mean adaptive kernel home ranges were 53.4 ha for six males, 63.0 ha for 13 females, and 15.1 ha for six juveniles (Piepgras and Lang 2000, p. 598). Piepgras and Lang (2000, p. 598) also reported

mean home ranges using grid summation with a 20 m grid as 7.8 ha both males and females and 5.9 ha for juveniles.

Several studies reported home ranges as MCPs of activity areas. In Wisconsin, mean MCP of activity areas were 0.76 ha for two males and 0.64 ha for four females (Ross and Anderson 1990, p. 10). In Illinois, the MCP of activity areas was 0.6 ha (range = 0.1-1.2 ha, n = 26; Rowe and Moll 1991, p. 181). In Minnesota, mean MCP of activity areas was 1.7 ha for six males, 4.8 ha for 13 females, and 1.2 ha for six juveniles (Piegras and Lang 2000, p. 598). In Maine, the mean MCP for 50 Blanding's was 74.17 ha, with no difference between sexes ($U = 282$, $P = 0.579$; F. Beaudry, unpublished data). Home range areas are summarized in Table 6. Another Maine study reported total area of activity wetlands (rather than MCP): the mean total area of activity wetlands (defined as areas used by turtles for a minimum of five days) was 0.91 ha (range = 0.3-1.5 ha, n = 12; Joyal 1996, p. 86).

Table 6. Mean home range areas (ha) of Blanding's turtles. Note that areas reported by different methods are not comparable.

State	all	females	males	juveniles	n	Citation
Fixed kernel						
Massachusetts		19.9	27.5		27/14	Grgurovic and Sievert (2005)
Maine	134.2				50	F. Beaudry, unpublished data
Adaptive kernel						
New Hampshire		2.8, 24.8,	14.9, 11.6,		15	Babbitt and Jenkins (2003)
Minnesota		2.6, 63.0	14.1, 53.4	15.1	6/13/6	Piegras and Lang (2000)
Grid summation (20 m grid)						
Minnesota		7.8	7.8	5.9	6/13/6	Piegras and Lang (2000)
Minimum convex polygon, activity areas						
Wisconsin		0.64	0.76		4/2	Ross and Anderson (1990)
Illinois	0.6				26	Rowe and Moll (1991)
Minnesota		4.8	1.7	1.2	6/13/6	Piegras and Lang (2000)
Total area of activity wetlands						
Maine	0.91				12	Joyal (1996)
Minimum convex polygon						
Maine	74.2				50	F. Beaudry, unpublished data

The duration of residence in a wetland increases with wetland size ($r^2 = 0.51$ for shrub swamps), presumably because larger wetlands offer greater resources and are typically more diverse (Piegras and Lang 2000, p. 596). Likewise, during July and August 2001 in Massachusetts, the rate of overland movements was related to wetland size ($r^2 = 0.28$, $P =$

0.002), with turtles in smaller wetlands moving more often than those in larger wetlands (B. DeGregorio, University of Massachusetts, unpublished data).

Fidelity to wetlands across years has not been addressed quantitatively in Blanding's turtles. In general, most animals appear to show a fairly high degree of fidelity to a set of wetlands across years, often using a different subset of wetlands in different years. In Minnesota, 12 of 20 turtles used some of the same activity areas across two years (Piepgras and Lang 2000, p. 592). Because radiotelemetry studies have been short-term (1-3 years), habitat fidelity over longer periods has not been addressed. This is an important conservation issue, both because of the importance of dispersal to long-term spatial population dynamics, and because in areas with high road and development rates (such as the Northeast), animals that drift across the landscape over years are more likely to encounter high-traffic roads during their lifetime, thus elevating adult mortality rates. If fidelity were to turn out to be relatively low, this would also greatly complicate site planning.

Hatchling orientation and movements

Three studies have tracked hatchlings using florescent powder as they left the nest; two in Massachusetts (Butler and Graham 1995; Jones 2002) and one in Nova Scotia (Standing et al. 1997); an additional experimental study assessed hatchling movements to water (McNeil et al. 2000). Standing et al. (1997, p. 1391) found that hatchlings' trails were relatively convoluted and often changed direction, while Butler and Graham (1995, p. 189) found that most trails maintained a fairly consistent heading. In general, hatchlings from each nest disperse in multiple directions (hatchlings from one nest in Massachusetts moved to four separate wetlands; Jones 2002, p. 11). Hatchlings do not move immediately to wetlands, and sometimes appear to avoid water (Standing et al. 1997, p. 1391), but spend several days in the uplands before entering wetlands (median = 2 days, n = 9; Butler and Graham 1995, p. 192; median = 6.4 days, n = 18; Jones 2002, p. 11). In a manipulative experiment with 36 hatchlings from four natural nests, McNeil et al. (2000, pp. 613-614) confirmed that hatchlings do not orient toward water in the first few days after emergence, and found that proximity to water does not affect the probability that a turtle will enter water. Some hatchlings moved long distances to wetlands (up to 457 m straight-line distance, 572 m total distance; Jones 2002, p. 11). Hatchlings move during daylight hours (avoiding mid-day; Butler and Graham 1995, p. 191), resting in excavated forms between movement bouts. Butler and Graham (1995, pp. 190-191) noted that several hatchlings moved to dry vernal pools, where they remained in forms beneath *Sphagnum* for up to 24 days.

Butler and Graham (1995, pp. 191-192) noted that several hatchlings followed coincident trails (despite a lack of obvious cues such as wheel ruts), suggesting an olfactory component of orientation, but Standing et al. (1997, p. 1392) and Jones (2002, pp. 18-19) did not observe coincident trails, although hatchlings often crossed paths. The orientation mechanisms used by hatchling Blanding's turtles are still unknown, with conflicting evidence for olfaction (Butler and Graham 1995, pp. 191-192; Standing et al. 1997, pp. 1392-1394), and evidence suggesting that hatchlings do not follow slope, compass bearing, or gross visual cues (Standing et al. 1997, pp. 1392-1394). Standing et al. (1997, p. 1391) observed more convoluted paths in the open than under canopy.

Jones (2002, p. 11) observed seven hatchlings that crossed roads. Crossings appeared to be in random directions rather than perpendicularly, thus increasing exposure to road mortality (two of these hatchlings were killed by cars). Jones (2002, pp. 14-15) also found evidence that eight hatchlings were killed by eastern chipmunks (*Tamias striatus*); other sources of mortality included predation by an unidentified rodent, predation by a bird, and one hatchling that was crushed by a horse. Standing et al. (2000, p. 658) reported predation of hatchlings by short-tailed shrews (*Blarina brevicauda*) while still in screened nest enclosures.

Dispersal

True dispersal distances (the distance from an individual's natal site to sites where it reproduces) have not been measured in Blanding's turtles. Dispersal is extremely difficult to measure in the field, as a large number of hatchlings would have to be marked and followed throughout their reproductive lives—a many decades-long undertaking. The relationship between home range and median dispersal distance has been estimated for mammals (Bowman et al. 2002, p. 2052) and birds (Bowman 2003, p. 198) at 7 and 12 times the square-root of the home range area, respectively. Similar analyses have not been carried out for reptiles, but the value for mammals (given similar vagility) can be used as a rough estimate. Mean home range sizes of Blanding's turtles in the Northeast (using fixed kernel and minimum convex polygon of full home range, Table 6) range from 20-134 ha, suggesting median dispersal distances on the order of 3-8 km.

Reproduction

Nesting frequency

Female Blanding's turtles produce no more than one clutch per year, and not all females nest every year. In Michigan, 48% of reproductive females nest in any one year (Congdon et al. 1983, p. 424). In Massachusetts, of 15 females tracked in May (to avoid bias of capturing females while nesting) for more than one year, only 3 animals skipped a year (for a mean of 91% nesting in any year; B. Compton unpublished data). In 2001, 7 of 8 females nested; in 2002, 19 of 24 nested; and in 2003, 18 of 23 nested; for an overall annual nesting rate of 80% (B. Compton unpublished data). In Maine, 90.5% of tracked females nested in a single year (n = 21; F. Beaudry, unpublished data).

Nest sites

Nest sites are usually unvegetated or sparsely vegetated areas, typically with a mixed gravel and sand substrate. In Massachusetts, most nests were in anthropogenic sites, including gravel pits, power lines, residential yards (gardens, forest edges, and bark mulch landscaping), agricultural fields (such as corn fields), construction sites, and industrial areas (B. Compton, unpublished data). In Maine, 21 of 26 nests were in human-altered sites, while natural nesting sites consisted in rocky outcrops with sparse or absent tree cover (Joyal et al. 2000, pp. 585; F. Beaudry, unpublished data). Butler (1997, p. 60) attributed one relatively large population to

abundant nesting habitat created as a byproduct of military training. Presumably appropriate nesting sites (such as bedrock fissures, forest disturbance gaps, and glacial gravel deposits) were rare in the pre-settlement northeastern landscape, which may have led Blanding's turtles to evolve a strategy of moving long distances in search of nesting sites. Currently, most early-successional nesting habitat is due to human disturbance. It is possible that nests in some human-altered sites may face higher rates of predation due to the concentration of subsidized predators (page 54).

Clutch sizes

In Massachusetts, the mean clutch size (based on captured hatchlings + unhatched eggs) was 11.4 (S.D. = 2.9, range = 4-17, interquartile range = 9-13, n = 42 nests; B. Compton, unpublished data). Eleven nests failed completely (four of these due to predation, either before or despite nest protection); of those that produced at least one live hatchling, the median egg success rate was 69%, with an interquartile range of 41-92% (B. Compton, unpublished data). Also in Massachusetts, Butler and Graham (1995, p. 189) found a mean clutch size of 10.6 (range 8-13, n = 14); with an overall egg hatching success rate of 87% (n = 149 hatchlings). A third Massachusetts study found that ten nests produced 77 hatchlings (Windmiller 2004, p. 1). In Maine, mean clutch size was 8.5 (S.D. = 2.1, range = 5-11, n = 6; Joyal et al. 2000, p. 585). Of these six nests, five produced at least one hatchling, of which 47% successfully emerged (n = 51 eggs). In another Maine study, mean clutch size (by X-ray) was 11.7 (median = 11.0, range = 8-17, interquartile range = 10-13, n = 8 nests; F. Beaudry, unpublished data). In Ontario, mean clutch size from nests excavated immediately after deposition was 8.0 (range = 6-11, n = 12; MacCulloch and Weller 1988, p. 2318). In Michigan, mean clutch size (by X-ray) was 10.0 (range = 3-15, n = 90; Congdon et al. 1983, p. 423). Congdon et al. (2000, p. 573) found that nest clutch size measured from nest inspection counted 2.0 fewer eggs (S.E. = 0.34) than radiographs. Clutch sizes are summarized in Table 7.

Table 7. Clutch sizes for Blanding's turtles in the Northeast.

State	Mean	S.D.	Range	Interquartile range	n	Citation
Massachusetts	11.4	2.9	4-17	9-13	42	B. Compton, unpublished data
Massachusetts	10.6		8-13		14	Butler and Graham (1995)
Maine	8.5	2.1	5-11		6	Joyal et al. (2000)
Maine	11.7		8-17	10-13	8	F. Beaudry, unpublished data
Ontario	8.0		6-11		12	MacCulloch and Weller (1988)
Michigan	10.0		3-15		90	Congdon et al. (1983)

Egg mortality and nest predation

A number of sources of egg mortality and nest destruction have been identified, including nest predation by mammals and ants, vandalism by humans, destruction of eggs by roots, possible infertility, parasitism by Sarcophagid flies, death of embryos from high temperatures, and death

of embryos or failure of eggs to hatch before winter because of cool incubation temperatures. Over a 23-year study in Michigan, the overall nest predation rate was 78.2% (range = 40-100%, n = 182 nests; Congdon et al. 2000, p. 572). Predation rates were not constant over time; in one ten-year period, 100% of observed nests were destroyed by predators in 9 years (Congdon et al. 2000, p. 572). The primary nest predators were raccoons (*Procyon lotor*), while other predators included red foxes (*Vulpes vulpes*) and less commonly gray foxes (*Urocyon cinereoargenteus*), as well as an unknown species of ant (Congdon et al. 1983, p. 422). Predation risk was highest in the first days following nesting with about 50% of nests were predated the first night, and 80% were predated within the first five days (n = 182; Congdon et al. 2000, p. 571). An additional 19.5% of nests failed to produce any hatchlings due to egg infertility or embryo death (Congdon et al. 2000, p. 572). The majority (85%) of these failures were due to low incubation temperatures in nests with excessive shading. Other failures were due to desiccation, egg breaking, flooding, erosion, and encapsulation by roots. In 2002 in Massachusetts, a particularly warm summer, 3 nests failed completely and 3 failed partially because embryos were apparently killed by high incubation temperatures, which reached 35-40° C on 17 days in one nest (B. Compton, unpublished data). In addition, eggs and emerged hatchlings were predated by raccoons, skunks (*Mephitis mephitis*), fly larvae, and red ants. Because nests were protected with screens an attempt to prevent predation, mammalian predation rates (four of 48 nests) were presumably greatly reduced (B. Compton, unpublished data). In Massachusetts in 1990, 94% of 35 unprotected nests were destroyed by predators (Butler and Graham 1995, p. 189). Joyal et al. (2000, p. 585) screened nests and did not observe any mammalian nest predation, but did observe invertebrate predation in 27% of 51 eggs in five nests, and another 24% failed during development for unknown reasons. At a nest site in Townsend, Massachusetts, skunks are the primary nest predator (M. Grgurovic, Swampwalkers Wetland Ecosystem Specialists, pers. comm.). Vandals have destroyed caged nests in at least two sites in Massachusetts (B. Butler, Oxbow Associates, pers. comm., and M. Grgurovic, pers. comm.), although nests that have not been marked by researchers are unlikely to be found by vandals. A more prevalent form of human nest destruction may be due to off-road vehicle use, although rates of destruction are unknown. Nest predation rates vary with predator (especially raccoon) populations across time and space. Congdon et al. (1993, pp. 830-831) note that a decline in nest survival from 44% during 1976-1984 to 3% from 1985-1991 coincided with a collapse in the fur market, which may have resulted in an increase in raccoon and fox populations. Likewise, the arrival of raccoon rabies in Massachusetts in 1992 (Centers for Disease Control and Prevention 1994, p. 1) may have reduced predation rates on Blanding's turtle nests, although data to demonstrate this are unavailable. Due to of this spatial and temporal variation, attempts to use empirically-determined mean nest predation rates in population viability modeling are likely to misrepresent the dynamics of nest predation. Because Blanding's turtles are so long-lived, occasional banner years of reproduction might be adequate to sustain populations over the long term, but chronic high levels of nest predation could also drive declines.

Incubation

Like most turtles, Blanding's turtles exhibit temperature-sensitive sex determination (TSD). In Blanding's turtles, males are produced at cool incubation temperatures and females at warm temperatures (known as "Pattern Ia"), with an incubation temperature threshold somewhere

between 26.5 and 30° C (Gutzke and Packard 1987, p. 162; Ewert and Nelson 1991, p. 53). Incubation rate is a function of nest temperature. In a laboratory study of eggs from Blanding's turtles in Nebraska, Gutzke and Packard (1987, p. 162) found that eggs incubated at 31° C hatched in 49 days, while those incubated at 26.5° C hatched in 62-63 days. Hatching success was also affected by temperature: hatching rate was 0% at 22.0° C, 95.2% at 26.5° C, and 77.3% at 31.0° C. In Massachusetts, the first hatchling in each nest emerged after 60-96 days (median = 74.5 days, interquartile range = 69-83 days, n = 36 nests; B. Compton, unpublished data). Also in Massachusetts, incubation periods varied from 58-112 days (median = 74 days, n = 148 nests; S. Smyers, unpublished data). Nest success data over seven years from this study suggest that although incubation time is shorter in warmer years, in warmer years survival decreases, and rates of abnormal hatchlings increase, especially in dry years (S. Smyers, unpublished data). In Maine, the first hatchling emerged after 67-118 days (median = 106.5, interquartile range = 77-112 days, n = 10 nests; Joyal et al. 2000, p. 585). Unlike some turtle species, Blanding's turtles seldom overwinter in the nest (Packard et al. 2000, pp. 367-374).

Demographics

Blanding's turtles share a life history strategy with many turtle species that consists of low nest and juvenile survival and delayed sexual maturity (to 14-20 years, Congdon and van Loben Sels 1993, p. 551). These traits are compensated for by high adult survival and iteroparity over a long lifespan (up to 77 years, Brecke and Moriarty 1989, p. 53; at least 66 years, Congdon et al. 2001, p. 816). Low nesting success and low juvenile survival are compensated by occasional years of high nesting success (Wilbur 1975, pp. 74-75; Cunnington and Brooks 1996, pp. 294-295). This suite of traits buffers populations against multi-year nesting failures, and allows them to withstand relatively high rates of nest loss. Although this life history strategy has been effective over evolutionary time, it leaves populations vulnerable to anthropogenically induced increases in adult mortality. These demographic characteristics result in slow population growth, and thus slow recovery from declines. The extreme longevity of turtles can result in nonviable "ghost" populations consisting of dwindling numbers of adults persisting for decades.

Age at first reproduction varies among populations, and is not precisely known in most populations. In Michigan, where the best data are available, females nested at a minimum age of 14 years and the smallest nesting female had a 16.3 cm carapace length (Congdon and van Loben Sels 1993, p. 551). In New Hampshire, nesting females had estimated ages of at least 19 years (Babbitt and Jenkins 2003, p. 27). In Massachusetts, the youngest nesting female had 14 annuli and the smallest nesting female (an older individual with a worn shell) had a carapace length of 18.1 cm (B. Compton, unpublished data). In a Maine study all breeding females were at least 26 years old, and two radio-tracked females that did not breed were 15 and 17 years old (F. Beaudry, unpublished data). Because determining age in turtles from annuli is subject to error and generally limited to pre-reproductive individuals (Germano and Bury 1998, pp. 127-128), precise determination of age at maturity requires long-term marking efforts that begin with hatchlings. Note also that secondary sexual characteristics may appear in animals that are not yet reproductively active, thus estimates of age at maturity based on secondary sexual characteristics may not be reliable.

Nest survival tends to vary in time and space in response to nest predation and other factors (page 21). Although nest survival is the demographic variable that can be most easily influenced by management, it has low demographic leverage (Galbraith et al. 1997, p. 193), and even extreme increases in first-year survival are unable to compensate for increased adult mortality (Heppell et al. 1996, p. 563). This suggests that nest protection and headstarting efforts will be ineffective unless anthropogenic sources of adult mortality are eliminated, (or at least greatly reduced) first.

The survival rate of juvenile life stages is poorly known in Blanding's turtles. Congdon et al. (1993, p. 829) found that juvenile survival (from 1 to 13 years) must be 78% annually to maintain a stable population. Windmiller and Ives (2005, p. 9) provide limited results on the survival of 12 headstarted hatchlings tracked with radiotelemetry: four were found dead, perhaps due to asphyxiation under a thick, late ice cover; one was predated; four could not be relocated; and one survived at least one year. In New York, 59 headstarted hatchlings (grown to the size of four-year-olds) were released between 1995 and 2000; 26 of these survived at least two winters, and headstarted juveniles were observed after as many as eight winters (A. Breisch, pers. comm.).

Blanding's turtles have one of the highest adult survival rates of any freshwater turtles (Congdon et al. 1993, p. 830). Estimates of minimum adult survival over eight periods in a 31-year study in Michigan ranged from 91.5-94.7% (Congdon et al. 1993, p. 829). Blanding's turtles continue to be reproductively active for many decades. In Michigan, females with known minimum ages of at least 75 years continued to reproduce, and females in the oldest age group nested at a significantly higher frequency than younger females (Congdon et al. 2001, p. 819).

Congdon et al. (1993, pp. 828-830) built a life table based on 27 years of data from a population of Blanding's turtles on protected land with no roads in southeastern Michigan. They estimated an intrinsic rate of population increase of $r = 0.0001$, based on an annual adult survival rate of 0.96, and a generation time of 37.5 years. They state that "Effective management and conservation programs...will recognize the limitation that the evolution of longevity has placed on the ability of populations of long-lived organisms to withstand and respond to increased mortality or reduced fecundity of any life-history stage." The extreme life history strategy of Blanding's turtles complicates management by introducing a considerable time lag of population response to management actions, thus current status is the result of past events, and responses to current management efforts will not be evident for years (Mockford et al. 2007, p. 210).

Congdon et al. (1993, pp. 831-832) point out that federally-listed desert tortoises (*Gopherus agassizii*) and sea turtles share demographic constraints with Blanding's turtles. As a result, populations these long-lived species are "severely limited in their ability to respond to chronic increases in mortality of neonates and even less so to increased mortality of juveniles or adults."

Heppell (1998, pp. 369-373) compared the demographics of several turtle species, including Blanding's turtles, desert tortoises, and loggerhead sea turtles (*Caretta caretta*). Her results supports this hypothesis of Congdon et al. (1993). She found that populations of freshwater turtles (including Blanding's turtles) are relatively more sensitive to changes in adult survival

rates than desert tortoises and even more so than loggerhead turtles, leaving freshwater turtles even more vulnerable to increases in adult mortality.

Feeding ecology

Blanding's turtles are diet generalists, eating a wide variety of aquatic invertebrates and vertebrates, as well as leaves, seeds, and fruit (Ernst et al. 1994, p. 248). Blanding's turtles primarily feed in water, although they sometimes feed on land (Harding 1990, p. 4). Although terrestrial feeding by Blanding's turtles has not been widely reported, Ditmars (1907, p. 57) describes wild turtles foraging in uplands for shoots, berries, and insect larvae, and observed captives eating lettuce. Ernst and Barbour (1972; as cited in Ernst et al. 1994, p. 248) observed captives eating dog food from a dry dish. Bramble (1973, p. 1342) described the primary feeding mechanism of Blanding's turtles, which involves creating negative pressure by rapid expansion of the buccopharyngeal cavity with the strongly developed hyoid apparatus, which is combined with rapid head thrusts to draw prey into the mouth. Prey of Blanding's turtles includes larval dragonflies, and damselflies, caddisflies, beetles, and flies, as well as adult beetles and Orthopterans, crayfish, snails and slugs, leeches, earthworms, small fish, fish eggs, carrion, and amphibians in all life stages, as well as leaves, grasses, seeds, and berries (Ditmars 1907; Lagler 1943, p. 289; Graham and Doyle 1977, p. 413; Kofron and Schreiber 1985, p. 34). Crayfish were reported as the dominant prey by Lagler (1943, p. 289) who found that crustaceans (almost entirely crayfish) made up more than 50% of the stomach volume of 66 Blanding's turtles in Michigan. Crayfish were also the dominant prey reported from stomach contents of 15 Missouri Blanding's turtles by Kofron and Schreiber (1985, p. 34). Lagler (1943, p. 289) reported that insects were then second most-common food item (stomach contents 21% by volume). In Massachusetts, food items included pondweed (*Potamogeton*), seeds, and fish including golden shiners (*Notemigonus crysoleucas*) and brown bullheads (*Ameiurus nebulosus*; Graham and Doyle 1977, p. 413).

Seasonal and daily activity patterns

Active season

Blanding's turtles become active in late March or early April and begin overwintering in late September, October, or early November (Gibbons 1968, p. 289; Kofron and Schreiber 1985, pp. 33-34; Ross and Anderson 1990, pp. 9; B. Compton, unpublished data; Rowe and Moll 1991, p. 180). In Missouri, feeding begins in early April about two weeks after water temperatures reach 18° C, then ceases from mid-July until water temperatures fall to 21° C in the fall (Kofron and Schreiber 1985, p. 33). Rowe and Moll (1991, p. 179) observed Blanding's turtles active in water as cold as 10° C.

Mating

According to Ernst et al. (1994, p. 244), Blanding's turtles across their range mate most often from March to July. In Massachusetts, however, most matings were observed in September

(37%) and October (22%), with a secondary peak in April (19%; $n = 27$) and sporadic matings occurred throughout the rest of the active season (B. Compton, unpublished data). In Maine, copulation was observed once in April and May, twice during June and three times in July, and courtship was observed once in September (Joyal et al. 2000, pp. 582; and F. Beaudry, unpublished data).

Nesting

Nesting generally occurs in June, typically in the evening, although turtles may nest throughout the day, often associated with rain. Nesting dates over three years in Massachusetts ranged from June 4 to July 1, and the median nesting date was June 18, with an interquartile range of June 11-June 21 ($n = 55$ nests of 34 individuals; B. Compton, unpublished data). Also in Massachusetts, Butler and Graham (1995, p. 188) located 14 nests from June 12-17. In Maine, nesting dates ranged from June 13-June 20 with a median of June 17 ($n = 6$ nests of 4 individuals over 2 years; Joyal et al. 2000, p. 582). In a second Maine study, nesting dates ranged from June 15-June 30, with a median date of June 22 ($n = 20$ nests of 20 individuals over 3 years; F. Beaudry, unpublished data). In New Hampshire, two radio-tracked females were believed to have nested on June 27 and July 4-6 (Curtis 2003, p. 3). In Michigan, nesting dates over 23 years ranged from May 15-July 9 ($n = 451$; Congdon et al. 2000, p. 571), with the wide range of dates likely due to the large sample size.

Aestivation

Like many turtle species, Blanding's turtles often aestivate for a period of days or weeks during hot, dry periods. Aestivating turtles become dormant for extended periods, typically burying themselves in leaves in upland forests. In Wisconsin, aestivation (from 0.5 to 5 days) was observed in July and August when water temperatures ranged from 18-28.5° C (Ross and Anderson 1990, p. 8). In Maine, one turtle (of 7 tracked) aestivated for 9 days in 1992, and 4 of 5 turtles aestivated for 9-21 days in 1993 (Joyal et al. 2001, p. 1760). Aestivation sites were from 30-110 m from the nearest wetland (mean = 78, s.d. = 36, $n = 7$). In Massachusetts, 13 individuals (6 males and 7 females, of 59 tracked) were observed aestivating (defined as being observed in a terrestrial form at or near the same location for three or more days; B. Compton, unpublished data). These aestivation episodes ($n = 15$) were initiated primarily in August (6) and September (5), with three in April and one in October. Aestivation lasted from 3 to 33 days (median = 9, interquartile distance = 7-22 days). In several of these episodes, animals moved several meters to a new form during this aestivation period; most animals aestivated fairly close to wetlands (usually within 20-30 m). One male aestivated for at least 55 days in one of the three seasons he was tracked, and he was not observed to aestivate in the other two years. Note that because animals were located by telemetry (typically every 2-6 days), animals may have returned to wetlands during these periods, some short aestivation episodes were likely missed, and aestivation periods were likely longer than measured. These observations suggest that upland aestivation is not as prevalent in northeastern Blanding's turtles as in some turtle species such as spotted turtles (*Clemmys guttata*), that most animals do not aestivate in most years, and there is considerable individual and annual variation.

Overwintering

Blanding's turtles often overwinter in the same wetlands that are used during the active season (Joyal et al. 2001, pp. 1760; B. Compton, unpublished data), but will sometimes move long distances overland to overwintering wetlands (up to 870 m; Piepgras and Lang 2000, p. 593). Ross and Anderson (1990, p. 8) observed Wisconsin Blanding's turtles overwintering in ponds and creeks, and found that turtles overwintered partially buried in organic substrate in the deepest location at the site. Most of these turtles (5 of 6) overwintered within summer activity centers. During weekly overwintering checks of two overwintering Blanding's turtles in Missouri, the turtles changed locations frequently (up to 13 m) when water temperatures were above about 6° C, while at 2-3° C, movements were only 1-2 m (Kofron and Schreiber 1985, p. 34). In Nova Scotia, Blanding's turtles often overwinter communally, with up to 12 individuals in close proximity (E. Newton, Acadia University, unpublished data). Massachusetts Blanding's turtles overwintered in a variety of wetland types, including shrub swamps, marshes, under bog mats, stream backwaters, and buried in saturated substrate in nearly-dry vernal pools. In Massachusetts, Blanding's turtles show weak fidelity to overwintering sites, with a mean distance between hibernacula across years of 112 m (D. Hastings, University of Massachusetts, unpublished data).

Daily activity patterns

In an experimental study under artificial light, the daily activity patterns of Blanding's turtles were bimodal, with peaks around 7 a.m. and 4 p.m. at 25° C, and unimodal with a peak around noon at 15° C (Graham 1979, pp. 365-366). In Illinois, Blanding's turtles were primarily diurnal, and were most active during the morning (Rowe and Moll 1991, p. 180).

Thermoregulation

According to Hutchison et al. (1966, p. 35), Blanding's turtles have a relatively low critical thermal maximum (mean = 39.6° C, range = 38.2-40.6° C). It is unclear whether this is a partial determinant or an evolutionary response to their northerly distribution. In a laboratory experiment, Blanding's turtles selected a significantly lower mean preferred temperature than wood turtles (*Glyptemys insculpta*), common map turtles (*Graptemys geographica*), red-bellied cooters (*Pseudemys rubriventris*), and red-eared sliders (*Trachemys scripta*; Nutting and Graham 1993, p. 244). In a Minnesota study using surgically implanted temperature loggers and temperature-sensitive telemetry, Sajwaj and Lang (2000, pp. 629-632) found that Blanding's turtles actively thermoregulate throughout the season, basking when necessary to maintain body temperatures at higher than ambient temperatures. Active thermoregulation rates were high early in the season, with >80% of animals basking on sunny days in April and May, falling to 40%-60% of animals basking in June through August. Interestingly, although male basking rates continued to fall in September and October (<20%), females began basking at significantly higher rates (ca. 80% in September, and ca. 60% in October). In Massachusetts, the proportion of telemetry-located animals in which basking was observed also peaked in April and May and declined throughout the season, but there was no difference between males and females in autumn (B. Compton, unpublished data).

Historical Range/Distribution

Historical distribution

Unlike many turtle species, historical records of eastern Blanding's turtles are sparse, likely because populations have been small and scattered throughout the past two centuries, and individuals are cryptic and occupy difficult-to-access wetlands. Survey efforts have been irregular at best until recent years. In Massachusetts, for instance, 90% of Element Occurrences were first located in 1988 or later. Region-wide, 90% of EOs were first located after 1975. Blanding's turtles in the Northeast are first mentioned in the literature by Storer (1839, pp. 215-216), a year after they were described by Holbrook (1838, pp. 39-42). Throughout the literature, eastern Blanding's turtles are described as rare, e.g., "vary rarely found in New England, though abundant in its regular habitat, the prairies of Illinois and Wisconsin" (Bumpus 1884-1886, p. 5); "eastward of the Central States it is a comparatively rare species" (Ditmars 1907); "this turtle is nowhere common in New England" (Babcock 1919, p. 83). Blanding's turtles were first recorded in Massachusetts in 1839 (Storer 1839, pp. 215-216), in New Hampshire in 1901 (Huse 1901, pp. 50-51), in eastern New York in 1943 (Hecht 1943, pp. 196-197), in Nova Scotia in 1953 (Bleakney 1958; as cited in Bleakney 1963, pp. 67-69), and not until 1960 in Maine (Packard 1960, p. 86).

Several historical records refer to populations that no longer appear to exist. Some of these records are likely in error, but it is unclear whether others refer to extirpated populations, escaped captives (Blanding's turtles were once commonly used in comparative anatomy classes; Netting 1932, p. 174), or are the result of misidentification. Records of eastern Blanding's turtles from Long Island (Schoonhoven 1911, p. 917; Murphy 1916, pp. 59-60), central New Jersey (Abbott 1884, p. 253), and eastern Pennsylvania (Stewart 1928, p. 24; Pawling 1939, p. 168) have all been discounted (Netting 1939; Pope 1939, p. 110; McCoy 1973, p. 1). A number of authors include Rhode Island in the range of Blanding's turtles (Henshaw 1904, p. 3; Drowne 1905, pp. 5-6; Ditmars 1907) without reporting specific records. Pope (1939, p. 110) mentions "an old indefinite record for Rhode Island" but gives no details. Bumpus (1884-1886, p. 5) mentions a record from Seekonk, Massachusetts, which is on the Rhode Island border. The case for Blanding's turtles in Connecticut is somewhat stronger. Babbitt (1932, p. 26) says he took a specimen in Canton in 1925, and Finneran (1948, p. 126) collected a male from Branford in 1940. Linsey (1844, pp. 40-41) reports an equivocal sight record from Darien in 1843. According to Lamson (1935, p. 32), "Connecticut records appear to be confined to westerly portions of the state, and are not common." Klemens (1993, p. 151) expressed skepticism about these Connecticut records, while allowing that it is conceivable that these records represent extirpated populations. Although such skepticism is likely warranted, the recent discoveries of a apparent disjunct populations in Erie County in 2001 and Saratoga County in 2003, New York (A. Breisch, pers. comm.) recall Pope's (1939, p. 110) words: "It is possible that some of these peripheral records are based on escaped specimens; on the other hand the fact that this turtle has a habit of turning up rarely in widely separated places argues against such an explanation."

An annotated bibliography of historical records of Blanding's turtles in the Northeast can be found in Appendix D.

Fossil and archeological records

Pliocene and Pleistocene fossil records of Blanding's turtle have been reported from Oklahoma, Kansas, Nebraska, Missouri, Mississippi, and South Carolina (Preston and McCoy 1971, p. 28; McCoy 1973, p. 2; Van Devender and King 1975, p. 209; Bentley and Knight 1998, pp. 4-5; Mockford et al. 1999, p. 324). Archeological sites from the mid-western portion of the Blanding's turtle range have been discovered in Illinois, Wisconsin, Michigan, Ontario, Québec, and western New York (McCoy 1973, p. 2; Van Devender and King 1975, p. 209; Mockford et al. 1999, p. 324).

Three archeological sites have been discovered in the northeastern range. French (1986, p. 40) reported a Blanding's turtle from an Indian shell midden on Hog Island, Muscongus Bay, Maine, dated to between 2500 and 500 years old. This record is more than 50 km northeast of the nearest recent record, in Durham. Rhodin (1992, p. 27) reported Blanding's turtle bones from a midden in Concord, Massachusetts, dated to 4660 years old (Spiess and Sobolik 1997, p. 25). Bones from Blanding's turtles were found at the Turner Farm Archeological Site, a midden in North Haven, in Maine's Penobscot Bay, dating to ca. 4000 years old (Spiess and Sobolik 1997, p. 25). Spiess and Sobolik (1997, p. 25) note that Blanding's turtle is the second-most common turtle at this site, after the snapping turtle (*Chelydra serpentina*). They suggest that these archeological sites support the hypothesis that Blanding's turtles were harvested, perhaps more or less sustainably, by Native Americans for several thousand years (although this conjecture is based on relatively thin data).

Current Range/Distribution

The main (midwestern) range of Blanding's turtles stretches from central Nebraska through the Midwest into Ontario and southern Québec and western and northern New York (Fig. 1). Populations of Blanding's turtles are localized throughout the range, especially in peripheral areas (McCoy 1973, p. 1).

The disjunct eastern range of the Blanding's turtle is restricted to eastern New York, eastern Massachusetts, southeastern New Hampshire, southern Maine, and southern Nova Scotia (Fig. 2). In New York, populations are found in Dutchess County, with a recently-discovered isolated and apparently small population in Saratoga County. In Massachusetts, populations are found in the northeastern part of the state, primarily in Worcester, Middlesex, and Essex Counties, with scattered populations in Norfolk, Bristol, and Plymouth Counties. In New Hampshire, populations are in Hillsborough, Rockingham, Merrimack, and Strafford Counties, the edges of Belknap, Cheshire, and Carroll Counties, with an isolated record in Grafton County. In Maine, populations are found primarily in York County, with scattered records throughout Cumberland County, and in the southern edges of Oxford and Androscoggin County. Finally, three populations are known from southern Nova Scotia, in the vicinity of Kejimikujik National Park. Details on historical distribution and questionable records from other states in the Northeast are discussed under Historical distribution (page 28) and detailed in Appendix D.

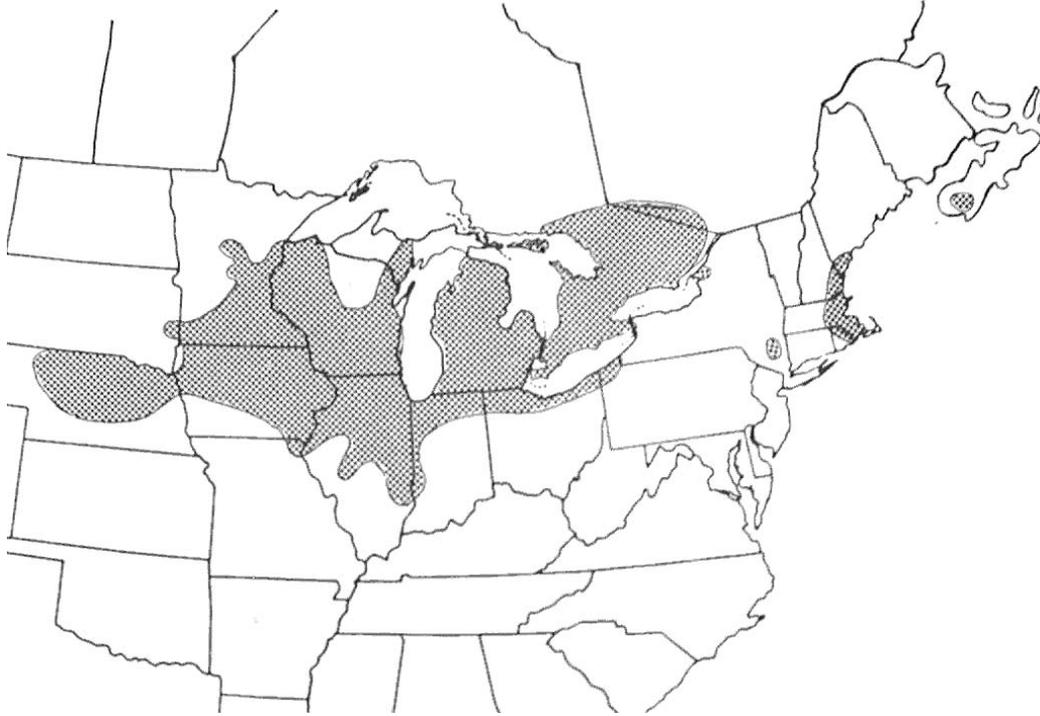


Fig. 1. Generalized range of Blanding's turtle (Ernst et al. 1994).

Population Estimates and Status

Population status and trends

Empirically determining the status and trends of Blanding's turtles in the Northeast is difficult. Most sites in the Northeast were discovered relatively recently (i.e., within the past 30 years), and the historical record is sparse. Given the long generation time of Blanding's turtles (estimated at 37.5 years by Congdon et al. 1993, p. 829), quantitative determination of population trends from available data is essentially impossible. In general, trends must be inferred based upon an understanding of the species' life history, knowledge of the general condition and trends of habitat in the range of Blanding's turtles in the Northeast, anecdotal reports, and upon knowledge gained from intensive studies at a few sites.

Northeast occurrence data

To help assess the current distribution and status of Blanding's turtles in the Northeast, Element Occurrence (EO) data were collected and summarized. These data have been collected by each state's natural resources agency under the Natural Heritage Program, coordinated by NatureServe. Data for each recorded observation of Blanding's turtles generally consist of location, first and last date observed, number of animals, and a text description of population and

habitat status. Most EOs are incidental observations (e.g., animals crossing roads), and these EOs are biased toward areas near roads and with high human populations. In addition, each state has conducted at least some surveys for Blanding's turtles. There is some inconsistency among states



Fig. 2. Generalized range of Blanding's turtle in northeastern United States.

as to what information is included in each record, and especially in how single observations are combined into an EO. In theory, rules published by NatureServe (2006, pp. 17-18) guide the collection and integration of observations, but in practice, the level of integration varies from Maine, where each wetland with a Blanding's turtle observation is recorded separately, to Massachusetts, where observations have sometimes been combined across many kilometers and several major roads. For this status assessment, EOs were processed in a uniform fashion to provide consistency across the Northeast range (see below for details).

EO data were obtained from eastern New York (New York Natural Heritage Program, September 13, 2005), Massachusetts (Natural Heritage and Endangered Species Program, December 20, 2005 and September 29, 2006), New Hampshire (New Hampshire Fish and Game, Nongame and Endangered Species Program, August 25, 2005), and Maine (Department of Inland Fisheries and Wildlife and University of Maine, September 11, 2006). In a few instances, EO data were supplemented with information from intensive studies (e.g., numbers of marked animals at study sites). For each record, the following information was extracted:

- EOid.** An internal number used by each state to identify an Element Occurrence.
- First-obs.** The year a turtle was first observed at a site.
- Last-obs.** The year a turtle was most recently observed at a site.
- Number.** The number of turtles observed in each sex and age class (M = male, F = female, U = unknown sex, J = juvenile, H = hatchling, and modifier X = dead).
- Min-turtles.** The minimum number of live adult turtles represented by the EO.
- N-roadkills.** The total number of road-killed adults recorded in the EO.
- Source.** The source of data represented in the EO (I = incidental, V = visual survey, T = trapping, R = radiotelemetry).

The number of turtles represented by each EO was assessed conservatively to represent the minimum number of turtles observed that are still potentially alive. For example, a male observed in 2000, two females observed together in 2001, a road-killed female observed in 2002, and a turtle of unknown sex and two juveniles observed in 2003 would be recorded as 1M, 1F, 1FX, 2J = 2 live adult turtles (the road-killed animal could have been one of the females from 2001; the turtle of unknown sex could have been the male from 2000 or the remaining live female from 2001). Animals that were reported as marked or radio-tracked were assumed to be separate individuals, and animals reported in one year were assumed to be separate unless the report implied incidental observations on different dates (e.g., one female observed June 20, one female observed July 19 = one female).

NatureServe's mapping criteria (reprinted in Appendix C) provide for combining neighboring observations into an Element Occurrence. This is usually done manually, with regard to the extent of wetlands, amount of development, and locations of busy roads. This process has been followed inconsistently by states, and none of the states have combined EOs to the extent suggested by NatureServe. For this assessment, EOs were combined with an automatic procedure based on the NatureServe criteria. EOs/observations that were within the "separation distance" of each other were combined, unless they were separated by a major road. The separation distance used was 5 km, for "continuous, undeveloped upland habitat lacking aquatic or wetland habitat." Although much of the Northeast range of Blanding's turtles might better match "upland habitat with significant but not intense development (e.g., scattered buildings in otherwise 'natural' habitat)" (2 km), this coarser lumping made more sense for a regional analysis. EOs were separated by major roads, defined as limited-access highways, primary highways, and secondary highways from USGS TIGER roads data (2002, http://www.bts.gov/gis/download_sites/ntad02/maindownload.html). All EOs within the separation distance and within the same block defined by major roads were combined into a single EO polygon, and are depicted as a point at the centroid of the source EO points. First-obs

is the earliest year recorded among source EOs, and last-obs is the last date. The minimum number of turtles and the total number of roadkills were calculated from the source EOs.

Errors and idiosyncrasies in the EO databases from each state required some hand editing. Some EOs traverse major roads, and some points within single EOs are separated by more than the 5 km separation distance. These were corrected by either editing a break into a major road when it was impossible to assign data to one side of the road, or by moving points representing a single animal (often an observation on a road) across a road so it would merge with the rest of the data from its EO. Two such errors were corrected for New York, and seventeen for Massachusetts. In addition, separate EOs for Massachusetts were sometimes interdigitated, leaving no choice but to lump these EOs.

Other errors and issues include the following: first-obs was not recorded for older wetland locations from Maine; for these points, first-obs was set to last-obs, and it may be later than the true date. The second-largest known population in Massachusetts is reported as having 92 marked animals (and an estimated population of 135), the number marked during the 1970's (Graham and Doyle 1977, p. 413). Recent work, however, suggests that this population has declined to 33 marked animals (and an estimated population of 54). Other old records may be masking such declines; on the other hand, minimum estimates at sites where little work has been done may represent larger populations.

This procedure has resulted in 180 combined EOs: 14 in New York, 59 in Massachusetts, 62 in New Hampshire, and 45 in Maine. Fig. 3 shows all EOs and the minimum number of live adults recorded at each site. Fig. 4 shows all EOs with the network of major highways, and Fig. 5 shows all roadkills recorded in EOs. Finally, Fig. 6 shows last-obs for each EO, indicating sites where populations may have been extirpated. A listing of EOs and summary EO data by county is included in Appendix C.

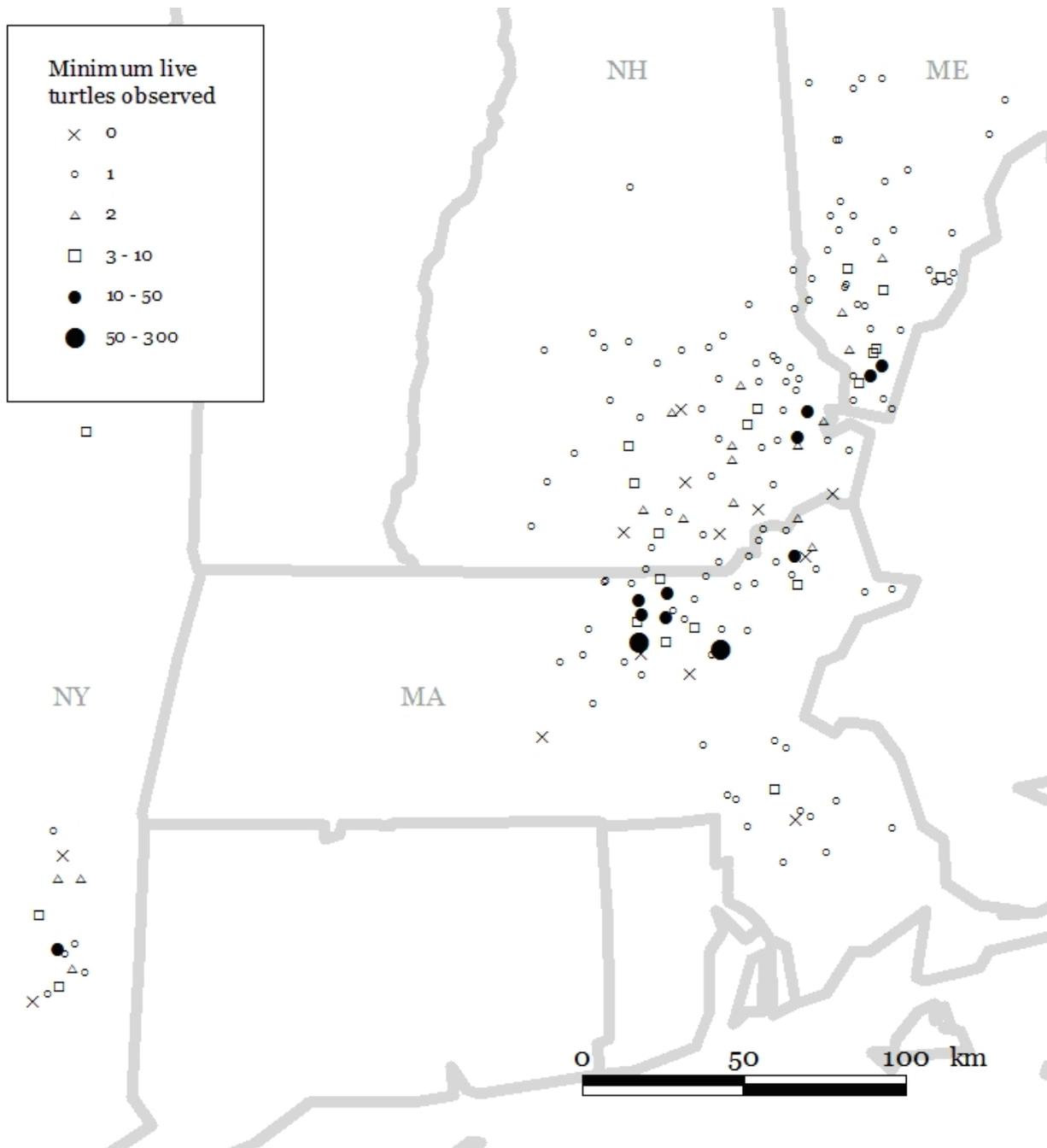


Fig. 3. Blanding's turtle Element Occurrences in the Northeast. Symbols indicate the minimum number of live adult turtles observed at each site. Sites with zero turtles are records of juveniles, or of road-killed turtles or other animals known to be dead.

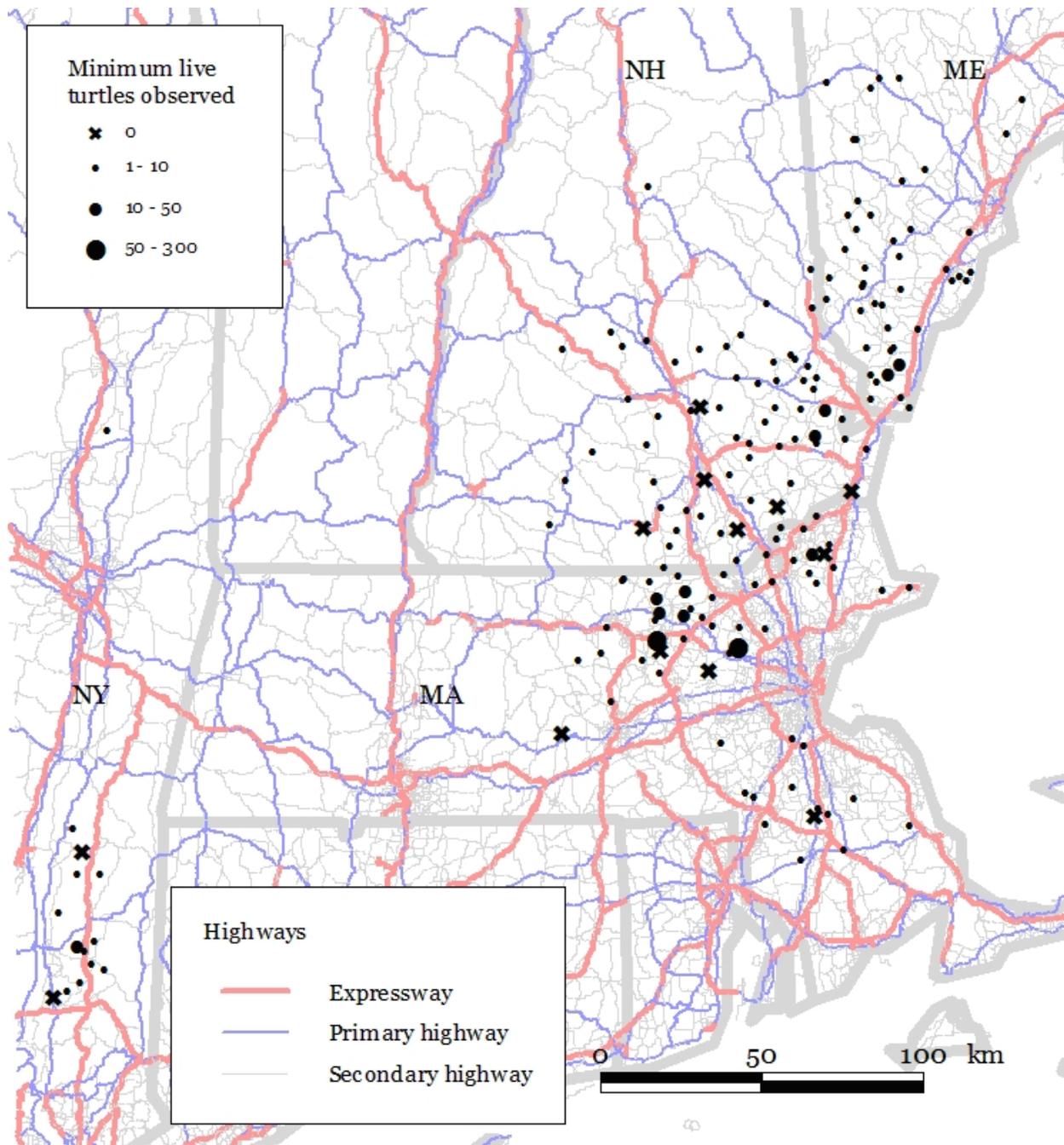


Fig. 4. Blanding's turtle Element Occurrences and major roads.

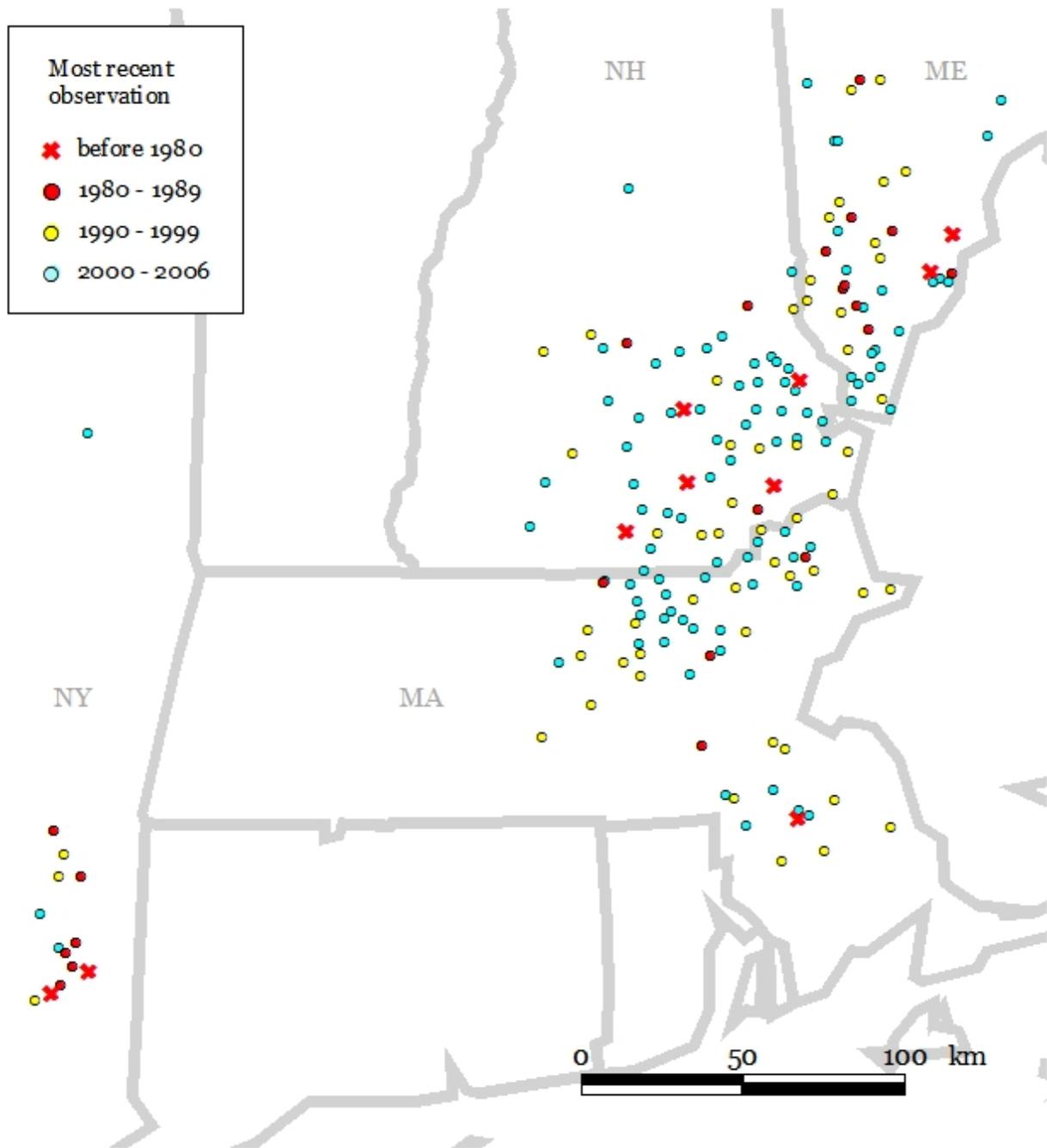


Fig. 6. Blanding's turtle Element Occurrences in the Northeast, with most recent observation at each site.

Population densities and status

Although population sizes have been estimated at very few sites, in general, populations in the Northeast seem to be extremely small, with the largest known population hosting an estimated population of >450 adults with about 200 marked females (B. Butler, pers. comm.). At a nearby site, 85 adults have been marked, with an estimated population of 101-194 (B. Butler, pers. comm.). Butler (1997, p. 60) suggests that one relatively large population is the result of abundant nesting habitat created and maintained as a side effect of military training activities.

In the 1970's, Great Meadows National Wildlife Refuge supported an estimated 135 animals of >110 mm plastron length (Graham and Doyle 1977, p. 413), but this population appears to have declined dramatically since then to an estimated population of 54 adults and juveniles >110 mm carapace length (Windmiller and Ives 2005, p. 1). This represents a 60% decline over 30 years. Windmiller and Ives (2005, p. 5) believe that this decline is primarily due to recruitment failure, because most animals in the population are very old (12 of 13 adult females captured from 2003-2005 were marked prior to 1986). This population now has an estimated sex ratio of 1.54 M:F, although it was slightly female biased in the 1970's (Graham and Doyle 1977, pp. 413-414), presumably as the result of increased mortality of nesting females, possibly due to road mortality (as has been noted for many turtle species; Steen et al. 2006, pp. 271-272).

Population sizes have not been formally estimated elsewhere in the Northeast, but all populations are believed to be far smaller than these largest known populations. All of other known populations in the Northeast have fewer than 50 marked adults (see Fig 4; note that some of these records span major roads and may be composites of multiple populations). Typically, numbers of individuals captured at a site are quite low, for example, in three years of intensive trapping and radiotelemetry at nine sites across northeastern Massachusetts 5-26 adults were captured per site (median = 15; ≥ 20 adults were marked at three sites; B. Compton, unpublished data). Sites in all four states have been the subject of several years of intensive trapping and radiotelemetry. With the exception of the three sites mentioned above, all of these sites have leveled out at no more than a few dozen marked adults. Because all studies in the Northeast have been short-term in comparison to the lifespan of Blanding's turtles, little is as yet known about lifetime dispersal, and thus the spatial extent of individual populations. In general, populations are considered to be bounded by major roads (e.g., those with >1000 cars/day). Although occasional dispersal across busy roads may occur often enough to be important from a population genetics perspective, it is unlikely that such dispersal is demographically important, as road-crossing mortality likely far outweighs immigration. Thus, it is safe to say that across the Northeast, populations (in a demographic sense) are small and isolated, typically with fewer than 50 adults.

Population viability

The only formal population viability analysis (PVA) to date in the Northeast is a non-spatial PVA for Blanding's turtles in Maine (Hayes 2000). Projections matrices were based on four life stages (egg, juvenile, subadult, and adult). As strong estimates of most demographic parameters for Blanding's turtles in Maine were not available, this analysis combined demographic

parameter estimates from (Joyal 1996) with those reported rangewide for Blanding's and for other freshwater turtle species, while acknowledging the uncertainty this introduces in model results. Model results suggest that the annual rate of change for the Mt. Agamenticus population in Maine is between -2% and +1%. The model used a quasi-extinction threshold (a predetermined size at which a population is considered effectively extinct) of 50 adult females, and projected minimum viable populations (<10% chance of quasi-extinction over 50 years) of 100-500 adult females under various scenarios. By this criterion of quasi-extinction, most Northeast populations would currently be considered quasi-extinct. Although a quasi-extinction threshold of 50 adult females is considered relatively low, for many endangered species the prevalence of small existing populations is often used to justify a lower quasi-extinction threshold (Morris and Doak 2002, pp. 43-44). In addition, a lower threshold may be justified for turtles since they are longer-lived and high adult survival buffers against extreme population fluctuations.

Dave McDonald and Takeshi Ise present a life history model based on the long-term data from a Michigan population presented by Congdon et al. (1993) as an appendix to Congdon and Keinath (2006, pp. 44-53). This analysis used a stage-based post-breeding census female-only model. Stages included egg, juvenile (years 2-13), early breeding adult (years 14-16, with increasing fertilities), and adult (years 17 and up). All breeding stages shared the same survival rate. Sensitivity and elasticity analyses showed strong agreement with the most important demographic parameter being survival of breeding adults, followed by survival of juveniles, then survival of eggs. Fertility rates showed very low sensitivity. These results support past work on turtle demography (e.g., Congdon et al. 1993, p. 832; Heppell et al. 1996, p. 563; Galbraith et al. 1997, p. 193; Heppell 1998, p. 369), which has found that adult survival rates are the demographic parameter with by far the most leverage. The stable age distribution at the end of reproduction (e.g., late June) should consist of 46% eggs, 42% juveniles, and 12% adults. The reproductive value of adults is 95.9, indicating that removal of one breeding female is the demographic equivalent of removing nearly 100 eggs. In a number of varying stochastic runs, McDonald and Ise found that populations were tolerant to high variation in fertility, but that variance in adult survival is detrimental to populations, often resulting in extinction.

A deterministic matrix population model based the model and data presented by McDonald and Ise (Congdon and Keinath 2006, pp. 44-45) shows the effects of various rates of additional adult mortality (Fig. 7). Note that even small rates of additional adult mortality cause severe population declines. Note also that populations crash to low levels over a few decades (e.g., at 3% mortality, the population has fallen to 35 individuals in 50 years, and 12 animals in 100 years), but the last animals can persist for a long time—at 3% mortality, the last animal in a starting population of 100 dies at year 227. Various annual adult mortality rates may be assessed by the number of years or generations it would take to reach a 90% reduction in population (Table 8). To the extent that real populations follow this pattern, population surveys must be quite sensitive to detect declines.

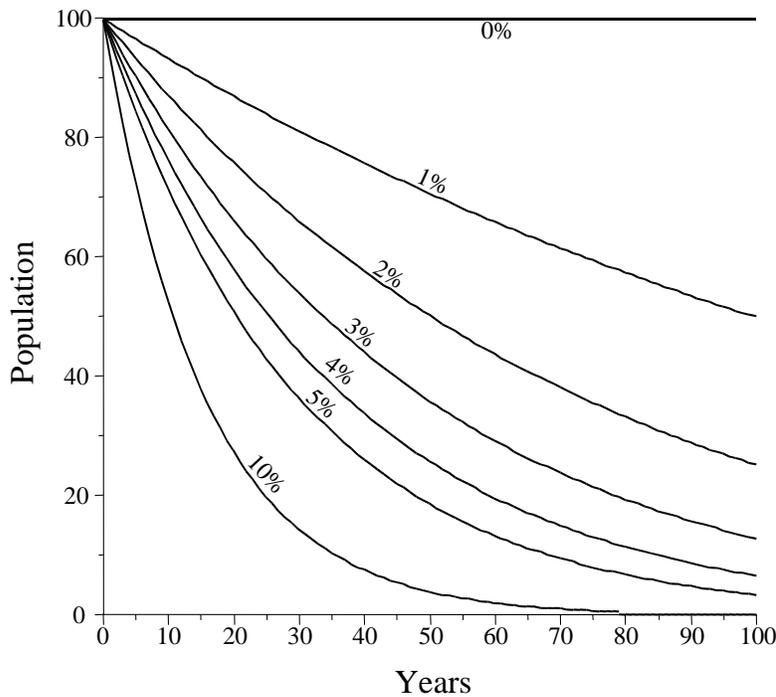


Fig. 7. Population trajectories from a deterministic population model of a population of 100 Blanding's turtles, given various rates of additional adult mortality.

Table 8. Time to 90% reduction of populations at given annual adult mortality rates from deterministic population model. Generation time is assumed to be 37 years (Congdon et al. 1993, p. 829).

Annual mortality (percent)	Time to 90% reduction	
	Years	Generations
1	334	9.0
2	169	4.6
3	114	3.1
4	87	2.4
5	70	1.9
10	37	1.0
50	10	0.3

Such static, non-spatial PVAs are useful for understanding the relative effect of demographic factors, but do not consider local sources of mortality and thus cannot predict local population sizes. Another modeling approach is to take spatial pattern into account since road mortality resulting from movement between wetlands is an important source of mortality in Blanding's

turtles. Two efforts to produce spatially-explicit PVAs for Blanding's turtles are ongoing (F. Beaudry, pers. comm. and B. Compton, unpublished data). These spatial PVAs will provide guidance on which populations are most likely to persist, and help assess the importance of various demographic factors for population persistence. Results of these PVAs, including sensitivity analyses, will help estimate the likely population trends of Blanding's turtle populations in various landscape settings.

Direct evidence for population declines

A recent study in Maine sheds light on population trends over a relatively short timeframe with regard to one of the major threats, road mortality (P. deMaynadier and J. Haskins, unpublished data). Eighty-eight wetlands where Blanding's and spotted turtles had been sighted between 1975 and 1993 were resurveyed in 2002-2003. These wetlands included smaller vernal pools and open pocket swamps, where turtles are relatively easy to find. Each wetland was visited up to three times, and surveyed (by the same observer) for 30-180 minutes with binoculars and by wading. Forty-five Blanding's turtles were located. Wetlands where more than one turtle was sighted were significantly farther from major roads (901.3 ± 190.9 m) than those where one (337.4 ± 111.7 m) or zero (403.8 ± 91.7 m) turtles were sighted (Kruskal-Wallis $H = 5.94$, $P < 0.10$). The implication is that even over this short time span of 10-30 years, populations closer to roads have declined relative to those farther from roads, presumably due to road mortality or secondary effects of roads and associated development.

Few extirpations have been recorded, primarily because of the paucity of historical data. Most older records specify the location no more precisely than town, making it impossible to determine if the population has been extirpated (unless all populations occurring in the town have been extirpated). Most surveys have merely recorded presence/absence or a simple count of animals observed, and most of these have taken place in the past twenty years. Thus, it is generally impossible to record declines, and extirpations would only be observed if they took place in an extremely short time frame for such a long-lived species. Because individuals can live so long, functionally extinct "ghost" populations of a single or small handful of animals can persist for decades, confounding surveys.

A 1984 record of Blanding's turtles at Fairy Beach, in Saco, Maine refers to a population that no longer exists (M. McCollough, U.S. Fish and Wildlife Service, pers. comm.). An archeological record dated to between 2500 and 500 years ago (French 1986, p. 40) is at a site more than 50 km from the nearest current or historical record. This suggests either a range retraction in recent centuries, or possibly transportation of the specimen by Native Americans. The clearest recorded decline is at Great Meadows National Wildlife Refuge, where the population declined 60% between the mid-1970's and 2004 (Graham and Doyle 1977, p. 413; Windmiller and Ives 2005, p. 2).

Legal status in the U. S. and Canada

Blanding's turtles are listed as Threatened or Endangered in nine of 13 states where they occur, and all three Canadian provinces (Table 9). Blanding's turtles were listed as Category 2

candidates in the U.S. before the elimination of this status (U.S. Fish and Wildlife Service 1994, p. 8), and they are listed as Threatened (Great Lakes) and Endangered (Nova Scotia) by both COSEWIC and under the Species at Risk Act (SARA) in Canada (Canadian Wildlife Service 2006, p. 1). The Northeast Endangered Species and Wildlife Diversity Technical Committee (Therres 1999, p. 97) included Blanding's turtles as a high risk species warranting consideration for federal listing. NatureServe has assigned a global (rangewide) rank of G4 (apparently secure), yet in the Northeast, state ranks are S2 (imperiled) in Massachusetts and Maine, S2S3 (imperiled/vulnerable) in New York, and S3 (vulnerable) in New Hampshire (NatureServe 2006, p. 2).

Table 9. Status of Blanding's turtle across its range.

Region/organization	Listing status	Source	State Heritage rank¹
Northeast Endangered Species and Wildlife Diversity Technical Committee	High risk/warrants federal endangered or threatened species listing consideration	(Therres 1999, p. 97)	
IUCN Red List	LR/nt (lower risk/near threatened)	Tortoise & Freshwater Turtle Specialist Group (1996, p. 1)	
CITES	Not listed	UNEP-WCMN (2006, p. 1)	
United States (federal)	Not listed (formerly Category 2)	U.S. Fish and Wildlife Service (1994, p. 8)	
Canada (federal)	Great Lakes/ St. Lawrence populations: Threatened (COSEWIC)/ Threatened, Schedule 1 (SARA) Nova Scotia population: Endangered (COSEWIC)/ Endangered, Schedule 1 (SARA)	Canadian Wildlife Service (2006, p. 1)	
United States, northeastern range			
New York	Threatened	New York Natural Heritage Program (2007, p. 1)	S2S3

¹ Source: NatureServe (2006, p. 2).

Region/organization	Listing status	Source	State Heritage rank¹
Massachusetts	Threatened	Massachusetts Natural Heritage and Endangered Species Program (2002, p. 3)	S2
New Hampshire	Special Concern ¹	New Hampshire Fish and Game Department (2005, pp. A-164)	S3
Maine	Endangered	Maine Endangered Species Program (2005, p. 1)	S2
United States, main range			
South Dakota	Not listed (extirpated)	South Dakota Department of Game, Fish, and Parks (2006), E. Dowd Stukel, South Dakota Department of Game, Fish, and Parks, pers. comm.	S1
Nebraska	Not listed	Nebraska Nongame and Endangered Species Program (2006)	S4
Minnesota	Threatened	Minnesota Natural Heritage and Nongame Research Program (2006, p. 1)	S2
Iowa	Threatened	Iowa Department of Natural Resources (2002, p. 3)	S3
Missouri	Endangered	Missouri Natural Heritage Program (2007, p. 14)	S1
Wisconsin	Threatened	Wisconsin Department of Natural Resources (2006, p. 1)	S3
Illinois	Threatened	Illinois Endangered Species Protection Board (2006, p. 10)	S3

¹ NHFG Department is currently reviewing its list of Endangered and Threatened wildlife and Blanding's turtles are a high priority for inclusion within these categories (M. Marchand, New Hampshire Fish and Game, pers. comm.).

Region/organization	Listing status	Source	State Heritage rank¹
Michigan	Special Concern	Michigan Endangered Species Program (1999, p. 11)	S3
Indiana	Endangered	Indiana Department of Natural Resources (2004, p. 1)	S2
Ohio	Not listed (collection prohibited)	Ohio Division of Wildlife (2005, p. 1)	S2
Pennsylvania	Candidate species for Special Concern, "likely extirpated"	Pennsylvania Fish & Boat Commission (2006, p. 5) and Pennsylvania Game Commission (2007, p. 3)	S1
Canadian provinces			
Ontario	Threatened	Ontario Ministry of Natural Resources (2006, p. 7)	S3
Québec	"Likely to be designated Threatened or Vulnerable"	Ministère des Ressources Naturelles et de la Faune Québec (2006, p. 3)	S1
Nova Scotia	Endangered	Parks Canada (2006, p. 2)	S1

Distinct Population Segment (DPS)

U.S. Fish and Wildlife Service policy (U.S. Fish and Wildlife Service and National Marine Fisheries Service 1996, p. 7) requires the following three elements to be considered in assessing a Distinct Population Segment (DPS): (1) Discreteness of the population segment in relation to the remainder of the taxon; (2) the significance of the population segment to the taxon to which it belongs; and (3) the population segment's conservation status in relation to the Act's standards for listing (i.e., is the population segment, when treated as if it were a species, endangered or threatened?)

Discreteness

A population segment of a vertebrate species may be considered discrete if it satisfies either one of the following conditions:

1. It is markedly separated from other populations of the same taxon as a consequence of physical, physiological, ecological, or behavioral factors. Quantitative measures of genetic or morphological discontinuity may provide evidence of this separation.
2. It is delimited by international governmental boundaries within which differences in control of exploitation, management of habitat, conservation status, or regulatory mechanisms exist that are significant in light of section 4(a)(1)(D) of the Act.

The eastern populations of Blanding's turtle occur in several discrete geographic areas, separated by stretches of more than 100 km in which no populations are known to occur. All distances among populations along the St. Lawrence (in the main range), the Hudson Valley, the newly discovered Saratoga population, the group of populations ranging from Massachusetts through New Hampshire to Maine, and the Nova Scotia populations are much greater than any conceivable individual dispersal distance of this species (Fig. 8). Thus, the eastern populations consist of at least four discrete units, completely separated from the main range (which includes populations in northern and western New York, western Pennsylvania, Québec and Ontario, and the Midwest) and from each other.

Significance

If a population segment is considered discrete under one or more of the above conditions, its biological and ecological significance will then be considered in light of Congressional guidance (see Senate Report 151, 96th Congress, 1st Session) that the authority to list DPS's be used "...sparingly" while encouraging the conservation of genetic diversity. In carrying out this examination, the Services will consider available scientific evidence of the discrete population segment's importance to the taxon to which it belongs. This consideration may include, but is not limited to, the following:

1. Persistence of the discrete population segment in an ecological setting unusual or unique for the taxon,
2. Evidence that loss of the discrete population segment would result in a significant gap in the range of a taxon,
3. Evidence that the discrete population segment represents the only surviving natural occurrence of a taxon that may be more abundant elsewhere as an introduced population outside its historic range, or
4. Evidence that the discrete population segment differs markedly from other populations of the species in its genetic characteristics.

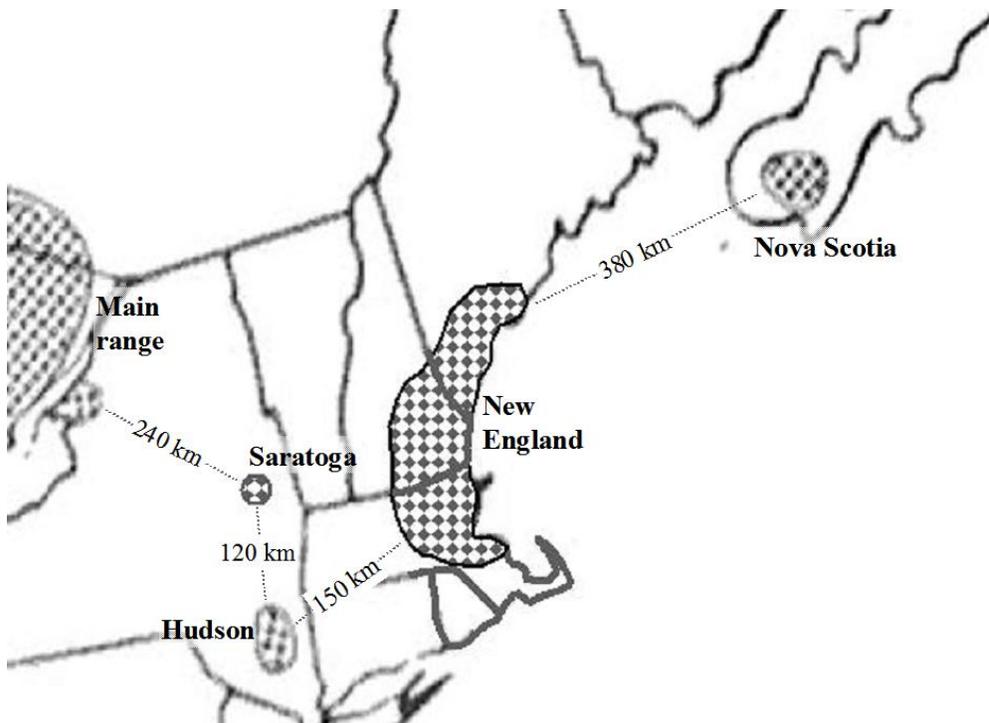


Fig. 8. Approximate distances among populations in the northeastern DPS of Blanding's turtle, and distance to the main range. Map modified from Ernst et al. (1994, p. 242).

A loss of all eastern populations of Blanding's turtles would result in a significant gap in the range of the species. Such a loss would result in a longitudinal range reduction of some 900 km (500 km excluding Nova Scotia). Many of the easternmost populations in the main range are considered vulnerable or imperiled and face the same threats faced by the eastern populations. Thus a loss of eastern populations would likely coincide with an additional significant reduction of the main range.

Furthermore, eastern Blanding's turtle populations are genetically distinct from those in the main range. The best direct information on the structure of Blanding's turtle populations comes from a recent study of microsatellites of 300 individuals in 12 populations across the range (Mockford et al. 2007, pp. 209-219). They found that the major barrier among populations follows the Appalachian Mountains, while a secondary barrier follows the Hudson River. They argue that populations to the east and west of the Appalachians represent evolutionarily significant units (ESUs). The correct placement of the Hudson Valley population (in Dutchess County, New York) and a population sampled in Ontario (St. Lawrence Islands National Park) are less clear than the separation between western populations and those in New England and Nova Scotia. They further suggest that the Nova Scotia populations merit recognition as a third ESU, because of the lack of current gene flow between Nova Scotia and any other populations.

Summary of Discreteness and Significance Evaluations

The above considerations of discreteness and significance of the eastern populations of Blanding's turtle provide strong support for a distinct population segment. These populations are discrete due to geographic separation from other populations in the main range, and genetic differences between the eastern and main ranges provide evidence of this separation. Although geographic separation could support the further subdividing of the eastern DPS into at least four segments, genetic research has not yet been performed at such a fine scale. Because the status of the eastern populations are similar, they should be considered for listing as a single unit.

Conservation Status

Pursuant to the Act, U.S. Fish and Wildlife Service must consider for listing any species, subspecies, or, for vertebrates, any distinct population segment of these taxa, if there is sufficient information to indicate that such action may be warranted. For an evaluation of the conservation status of the eastern DPS of Blanding's turtle, see Threats (below). This evaluation will allow the Service to make a determination of whether the eastern DPS of Blanding's turtle meets the Act's standards for listing the DPS as endangered or threatened. Based on the definitions provided in section 3 of the Act, endangered means the DPS is in danger of extinction throughout all or a significant portion of its range, and threatened means the DPS is likely to become endangered within the foreseeable future throughout all or a significant portion of its range.

Threats

Summary of Factors Affecting the Species

Section 4 of the Act and regulations (50 CFR part 424) promulgated to implement the listing provisions of the Act set forth the procedures for adding species to the Federal list. As defined in section 3 of the Act, the term “species” includes any subspecies of fish or wildlife or plants, and any distinct population segment of any species or vertebrate fish or wildlife which interbreeds when mature. The U. S. Fish and Wildlife Service may determine a species to be an endangered or threatened species due to one or more of the five factors described in section 4(a)(1) of the Act. These factors, and their application to the eastern DPS of the Blanding’s turtle, are as follows:

A. The present or threatened destruction, modification, or curtailment of its habitat or range

Wetland habitat

An important component in past, and to some extent, current declines of Blanding’s turtles is the loss of wetland habitat. From the 1780’s to 1980’s, the conterminous United States lost an estimated 53% of its wetlands; New York lost 60%, Massachusetts lost 28%, New Hampshire lost 9%, and Maine lost 20% (Dahl 1990, p. 6). These are likely underestimates of the loss of wetlands most used by Blanding’s turtles, as the National Wetland Inventory used for these estimates often fails to map small wetlands such as vernal pools, which are a preferred habitat. Loss of wetlands not only removes habitat used by turtles, thus potentially extirpating local populations, but wetland losses can increase the functional distance between populations, fragmenting and isolating formerly connected populations.

Wetland habitat is protected to some degree by Section 404 of the Federal Clean Water Act, and by state wetlands protection legislation. Neither Section 404 nor most state wetlands protection regulations adequately protect small isolated wetlands such as vernal pools, which are an important component of Blanding’s turtle habitat in the Northeast. Thus, although the direct loss of larger wetlands in the Northeast to agriculture and development has diminished, important seasonal wetlands continue to be lost to development at an unknown rate.

Because vernal pools and the uplands surrounding them are poorly protected, populations of pool-breeding amphibians (ambystomatid salamanders and wood frogs, *Rana sylvatica*) are at risk. Even when pools themselves and the modest regulated buffer areas are left intact, vernal pool amphibian populations are likely to be extirpated if upland forests in the unregulated “life zone” are removed (Semlitsch 1998, p. 1115). Furthermore, because these amphibians sometimes operate in metapopulations, populations may be extirpated by the loss of connections among vernal pools due to roads and development (Compton et al. 2007, pp. 789-790). These amphibians provide an important seasonal food resource for Blanding’s turtles. Loss of

amphibian populations in pools where Blanding's turtles feed is likely to have negative effects of unknown severity.

Upland habitat

Upland habitat for Blanding's turtles (for nesting, aestivation, and movement among wetlands) is partially protected by state wetlands protection laws (e.g., the relatively strong Wetlands Protection Act of Massachusetts only protects a 30.5 m buffer around wetlands, as does the Freshwater Wetland Act in New York). State endangered species laws provide modest protection of upland habitat via environmental review of development projects in sites where Blanding's turtles are known to exist. In practice, the large complexes of wetlands and intervening upland habitat used by Blanding's turtles are poorly protected from development, despite state endangered species legislation.

The scale of Blanding's turtle movements (a kilometer or more) is much greater than the scale of regulatory protection (often less than 100 m; see Appendix A). These upland movements are idiosyncratic among individuals (and even across years), thus it is not always clear which upland areas should be the highest priority for protection, even where resources and regulatory tools are present.

The fragmentation of habitat resulting from roads and development in the uplands divides Blanding's turtle populations into smaller functional units. These small populations have increased risks of extirpation due to demographic stochasticity. Upland fragmentation also separates wetlands used by individuals throughout the season, resulting in increased mortality rates. This is especially an issue when roads fragment upland habitat (see Vehicle mortality, page 56).

Landscape and population changes in the Northeast

Blanding's turtle populations in the Northeast coincide with some of the areas of highest human population density in North America (Fig. 9). Projections by the U. S. Census Bureau predict that the human population in the four northeastern states with Blanding's turtle populations will increase by nearly 2.5 million from 2005 to 2025, an overall increase of 9.1% (Campbell 1997, p. 3). New York is expected to increase by 1.6 million (8.7%), Massachusetts by 592,000 (9.4%), New Hampshire by 158,000 (12.3%), and Maine by 138,000 (10.7%).

County-level projections for each of the four states paint a more detailed picture (Table 10). In Maine, York County, with the majority of Blanding's turtle populations, has a projected 1990-2020 population increase of 46% (Maine State Planning Office 2005, p. 3). The four counties in New Hampshire with most of the Blanding's turtle populations have projected 1990-2020 increases of 29-41%, with a projected increase of 35% in Rockingham County, where many populations are concentrated (New Hampshire Office of Energy and Planning 2006, p. 9). In Massachusetts, projected population growth in the three counties with most of the Blanding's turtle populations ranges from essentially stable to 13% (Massachusetts State Data Center undated, pp. 1-7). Middlesex and Essex Counties, where most of the larger known Blanding's

turtle populations occur, contain both urban and suburban towns surrounding Boston, and more rural towns farther from urban centers. Population trends are generally declining or steady on the urban areas, where Blanding's turtles are largely absent. Most Blanding's turtle populations instead occur in rapidly suburbanizing areas where human population growth is the greatest. Dutchess County, New York, where most New York Blanding's turtles in the eastern DPS occur,

Table 10. Projected human population size of counties in the range of Blanding's turtles in the Northeast, in thousands (Maine State Planning Office 2005, p. 3; New Hampshire Office of Energy and Planning 2006, p. 9; Cornell Institute for Social and Economic Research 2007, p. 1; Massachusetts State Data Center undated, pp. 1-7). In each state, counties with the greatest number of Blanding's turtle populations are in bold.

County	1980	1990	2000	2010	2020	2030	Projected increase (%)	
							1990-2020	2000-2020
Maine								
Androscoggin		105	104	109	111		5.6	7.1
Cumberland		244	266	285	300		23.0	12.8
Oxford		53	55	59	61		15.2	10.9
York		165	188	217	241		46.0	28.3
New Hampshire								
Belknap		49	56	65	70	74	42.2	24.2
Carroll		35	44	50	57	62	61.1	30.6
Cheshire		70	74	79	85	90	20.8	14.7
Grafton		75	82	89	95	101	26.9	16.4
Hillsborough		336	381	417	447	474	32.9	17.3
Merrimack		120	136	154	169	182	40.9	24.1
Rockingham		246	277	308	331	352	34.7	19.4
Strafford		104	112	124	134	143	28.8	19.6
Massachusetts								
Bristol	475	506	535	554	577		13.9	7.9
Essex	634	670	723	755	787		17.5	8.8
Middlesex	1,367	1,398	1,466	1,475	1,469		5.1	0.2
Norfolk	607	616	650	654	652		5.9	0.3
Plymouth	405	435	473	496	518		18.9	9.5
Suffolk	650	664	690	731	777		17.0	12.6
Worcester	646	710	750	793	844		18.9	12.5
New York								
Dutchess			280	294	305	312	n/a	8.8
Saratoga			201	213	223	229	n/a	11.3

shows a 9% population increase from 2000-2020 (Cornell Institute for Social and Economic Research 2007, p. 1).

A predominant component of recent human population trends is migration from urban to suburban or rural areas, known as “sprawl,” and typified by the development of large lots on the suburban fringe. This results in rates of land development much higher than rates of population increase (Heimlich and Anderson 2001, pp. 9-14). Much of the remaining Blanding’s turtle habitat is in rural or recently rural areas of northeastern Massachusetts, southeastern New Hampshire, southern Maine, and the lower Hudson River Valley of New York where suburban sprawl from neighboring metropolitan areas is advancing most rapidly. In Massachusetts between 1985 and 1999, about 40 acres of forest and agricultural land per day were lost to development; 65% of this development was low-density residential construction (Breunig 2003, p. 4). An additional element of sprawl is an increase in the size of houses and residential lots, despite declining numbers of residents per household. In Massachusetts, the mean size of new single-family houses increased from 1572 ft² to 2260 ft² from 1970-2001, while lot sizes increased 47% (Breunig 2003, pp. 8-9). Specific threats resulting from sprawl include road mortality from

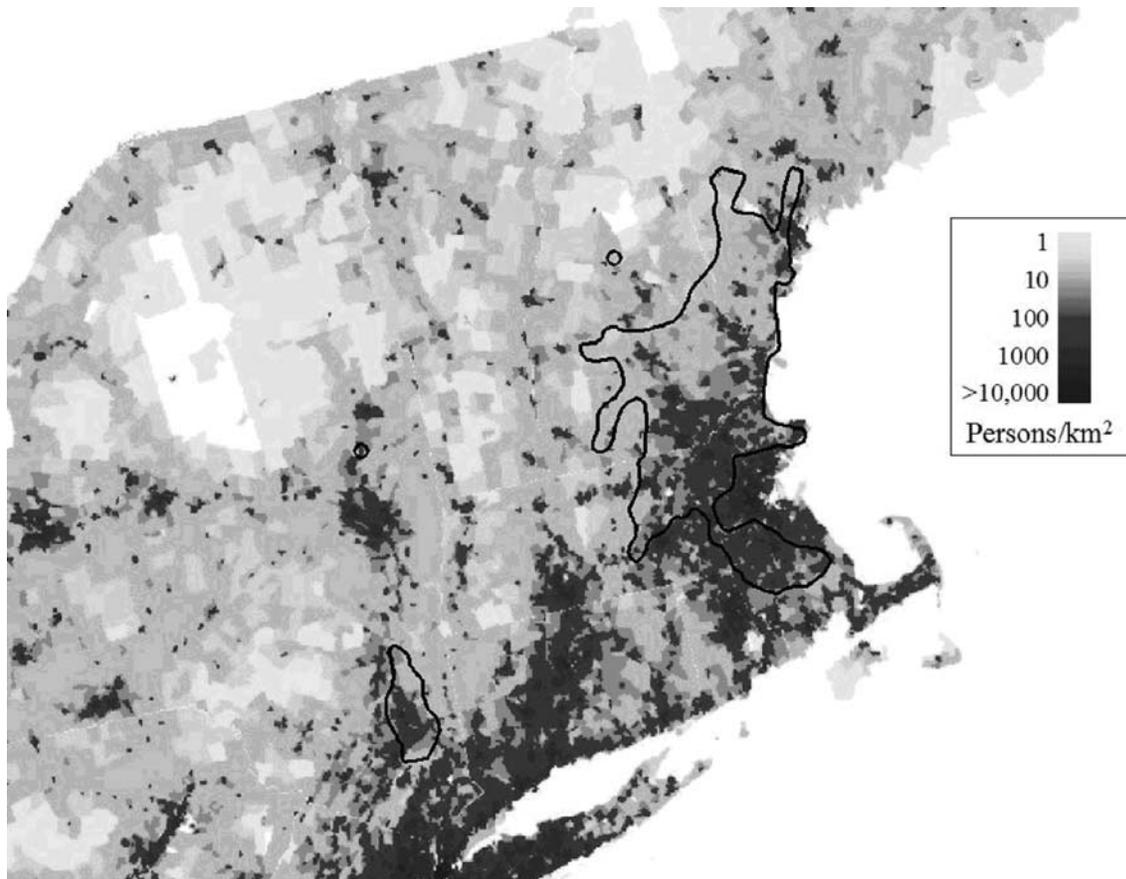


Fig. 9. Eastern Blanding’s turtles and human population density. Outlines show generalized range of Blanding’s turtles in New York and New England.

increased traffic rates and increased road density, increased predation on nests, hatchlings, and juveniles by subsidized predators, direct loss of wetland (especially vernal pools) and upland habitat from development, and increased fragmentation of populations.

B. Overutilization for commercial, recreational, scientific, or educational purposes

Although the pet trade has been implicated in the decline of other turtle species such as the bog turtle (*Glyptemys muhlenbergii*), box turtle (*Terrapene carolina*), and wood turtle (*Glyptemys insculpta*; Harding 1991, p. 8; Thorbjarnarson et al. 2000, pp. 56-58), collection for the pet trade is not currently believed to be a major problem for Blanding's turtles, which are not popular as pets (Levell 2000, pp. 666-670; J. Harding, Michigan State University, pers. comm.). None of the respondents to the Blanding's Turtle Status Questionnaire (Appendix A) were aware of commercial collection or trade in their states. Casual collection, however, does exist at a low level (e.g., about 15 known cases in Massachusetts in the past 22 years; L. Erb, Massachusetts Natural Heritage and Endangered Species Program, pers. comm.), and may in some cases contribute to declines in local populations. Because Blanding's turtles are state-listed throughout their eastern range, they are presumably seldom or never collected for scientific or educational purposes.

C. Disease or predation

Disease

There are no known incidences of diseases presenting a threat to Blanding's turtle populations. In extreme circumstances, the introduction of an exotic disease can devastate local populations of turtles, as did the introduction of upper respiratory tract disease into desert tortoise populations by released pet desert tortoises (Flanagan 2000, p. 89). Reduced and fragmented populations (such as most Blanding's turtle populations in the Northeast) may be unable to rebound from severe disease outbreaks. Ongoing releases of native and exotic pet turtles including box turtles (*Terrapene* sp.) and red-eared sliders (*Trachemys scripta elegans*) throughout the range of Blanding's turtles could provide effective disease vectors. The 2006 death of a female box turtle from Mattapoisett, Massachusetts, from an iridovirus infection (C. Innis, VMD, New England Aquarium, pers. comm.), the first reported in the state, could signal a future epidemic. Disease is a potential future threat, but is not known to be a current problem.

Predation of adults

Mortality of adult Blanding's turtles due to predation is apparently rare. Given their large size and hinged plastron, Blanding's turtles are relatively predator-proof. However, in Michigan, a few observations (in 5 of 28 years) have been made of females that were injured or killed by

raccoons or other predators during nesting forays (Congdon and Keinath 2006, p. 24). In 2003-2006 in New Hampshire, two Blanding's turtle carapaces were found in the forest next to wetlands used by Blanding's turtles. The cause of death was not known but predation was considered likely (S. Najjar, New Boston Air Force Station, unpublished data). Predation by aquatic mammals such as the river otter (*Lutra canadensis*) could occur on overwintering animals, as has been observed in snapping turtles (*Chelydra serpentina*; Brooks et al. 1991, p. 1316), but this has not been observed in Blanding's turtles, which are probably less vulnerable due to their more protective plastron. Extensive predation by otters has also been observed in the European pond turtle (*Emys obicularis*), a close relative of Blanding's turtles (Lanszki et al. 2006, p. 221). In some populations, adults have injuries that are consistent with predation attempts. In a Missouri population, 31% of captured individuals had previous injuries, including 13 animals with injuries to the feet, three with cracked shells, and eight with chipped shells, and five with missing tail tips (Kofron and Schreiber 1985, p. 34). In Maine, of 115 turtles captured, 29% showed signs of injury: 11% had shell damage, 10% were missing either a foot or a leg, and one turtle was missing two feet (F. Beaudry, unpublished data). In Massachusetts, only three of 155 Blanding's turtles captured had tail injuries and four had missing toes; none were missing limbs (B. Compton, unpublished data). It is unlikely that predation on adults plays an important role in natural population dynamics of Blanding's turtles.

Predation of nests, hatchlings, and juveniles

Predation upon nests, hatchlings, and young juveniles is naturally high in Blanding's turtles. Like most turtles, Blanding's turtles are adapted to withstand high sustained rates of predation on nests and young age classes. A typical female may produce 200 or more eggs over her lifetime; this suggests that expected survival from egg to recruitment is on the order of 1%. Thus, high predation rates *per se* should not be considered to be a threat to Blanding's turtles. However, artificially elevated rates of nest and hatchling predators can be an important threat.

Unfortunately, populations of certain nest predators are often high in human-dominated areas, as ample habitat and food supplies (e.g., garbage) are available. These "subsidized" predators include raccoons (*Procyon lotor*), red foxes (*Vulpes vulpes*), striped skunks (*Mephitis mephitis*), and crows (*Corvus brachyrhynchos*; Mitchell and Klemens 2000, pp. 26-29). Nest predation can essentially shut down reproduction for many years. In a ten-year period in Michigan, 100% of Blanding's turtle nests were destroyed in nine years (Congdon et al. 2000, p. 572). Congdon (1993, p. 831) noted that a decline in nest survival in Michigan coincided with a collapse in the fur market, which presumably allows the populations of nest predators (especially raccoons and foxes) to increase. The 1996 referendum banning trapping in Massachusetts may further contribute to increases in nest predator populations.

Predators upon hatchlings include all of the above, as well as eastern chipmunks (*Tamias striatus*; Jones 2002, pp. 14-15), short-tailed shrews (*Blarina brevicauda*; Standing et al. 2000, pp. 658-659), bullfrogs (*Rana catesbiana*; B. Butler pers. comm; C. McDonough, New England Environmental, pers. comm.), and likely several other species. Because hatchlings are difficult to track, the identity of predators and rates of predation are less well-known than those on nests.

Because of the life history strategy of Blanding's turtles, increases in egg, hatchling, or juvenile mortality have relatively low demographic leverage. Thus, predation of younger life stages is not likely to represent as great a threat as sources of additional adult mortality, at least in the near-term. However, chronic increases in nest and hatchling mortality can contribute to population declines, and the high rates of nest and hatchling predation associated with subsidized predators can lead to nearly complete collapse of reproduction (e.g., Congdon et al. 2000, p. 572). Such chronic reproductive failure has not been detected in northeastern populations, although detecting such failures would require long-term intensive studies.

D. The inadequacy of existing regulatory mechanisms

Inadequacy of existing regulatory mechanisms

Although the Blanding's turtle is listed by the four states in its Northeast range (Special Concern in New Hampshire¹, Threatened in New York and Massachusetts, and Endangered in Maine) and thus protected from direct take, protection provided to habitat is weak and variable. Because Blanding's turtles move overland among widely separated wetlands, upland habitat is rarely adequately protected. Perhaps most importantly, adult mortality from road traffic on existing roads is completely unregulated. The ephemeral wetlands strongly selected by Blanding's turtles often lack a surface hydrological connection to other waters and, therefore, are not strongly protected by Section 404 of the Clean Water Act or most state wetlands protection regulations (Massachusetts does provide protection for some vernal pools, as will Maine beginning September 2007). Incremental threats related to "off-site" development, such as increased populations of nest predators, increased traffic, pollution, and wetland degradation are also unregulated to a great extent. Blanding's turtles are not believed to share habitat with any federally-listed species. These factors suggest that protection of existing populations in the Northeast will require a coordinated, long-term commitment to proactive conservation, rather than the existing piecemeal, mostly reactive efforts.

E. Other natural or manmade factors affecting its continued existence

Demographic vulnerability

The life history strategy of Blanding's turtles presents two difficulties for conservation, both involving the long timeframe of population dynamics. The first problem is that because of delayed maturity, the potential growth rate of Blanding's turtle populations is low. This means recovery from declines is likely to take many decades or even centuries. The generation time of Blanding's turtles has been estimated at 37 years (Congdon et al. 1993, p. 829), suggesting that the effects of management actions will generally take longer than the careers of conservation practitioners.

¹ Currently under review for possible uplisting.

The second problem is that because individuals live so long, declining populations can persist for decades. Although populations may disappear quickly from catastrophic declines (e.g., wetland destruction at a site), populations may also be lost from chronic declines, in which mortality cannot be compensated by reproduction. Such chronic declines may take place over many decades. For instance, the demographic model on page 39 shows an initial population of 100 adult females with 3% annual rate of additional adult mortality. This population declines to 12 adult females after 100 years, but takes 227 years to decline to extirpation. Therefore, presence/absence surveys or imprecise abundance estimates are unlikely to detect all but the most severe declines until late in the process. Estimating population sizes generally takes intensive work, which has not been carried out at most sites in the Northeast.

The result is a dilemma: population declines are unlikely to be detected in their early stages, but to be effective, conservation actions must take place before populations have severely declined. This demographic vulnerability is, in a sense, an intrinsic threat to Blanding's turtles, as it exacerbates other threats. One consequence is that conservation decisions about Blanding's turtles must be made in regard to an appropriate timeframe: turtle generations, rather than years. Rather than considering the "near future" to be the next 10, 20, or 30 years, we might think in terms of one, two, or three Blanding's turtle generations (37, 74, or 110 years).

Vehicle mortality

In many parts of the Northeast, road mortality is likely the most important threat to Blanding's turtle populations. The life history strategy of Blanding's turtles requires approximately 95% annual adult survival to maintain a stationary population (Congdon et al. 1993, p. 831), thus additional adult mortality can lead to rapid population declines. Blanding's turtles make long overland movements between wetlands (sometimes greater than 2 km, with typical maximum overland movements of several hundred meters; page 14); in addition, females often nest more than a kilometer from home wetlands (page 15). Because Blanding's turtles occur in some of the areas of the Northeast with the highest road density, many adults cross roads on at least an annual basis.

In addition, road mortality rates of hatchlings (although a less demographically important segment of the population) may be a threat. Reports of hatchling road mortality includes two of seven hatchlings killed crossing roads in Massachusetts (Jones 2002, p. 15), and 5-10 road-killed hatchlings at the New Boston Air Force Station (S. Najjar, unpublished data).

Road mortality rates in Blanding's turtles have been poorly quantified. Because of their life history strategy, mortality rates as low as 2-3% annually can lead to severe population declines (page 39). Detecting such roadkill rates with an adequate degree of precision using radio telemetry would require tracking hundreds of animals (e.g., a power analysis reveals that distinguishing a 1% rate of roadkill from a 3% rate at $P \leq 0.05$ would require tracking 800 animals for a year). Another approach would be to carefully estimate source populations over an area large enough to contain hundreds of turtles, and survey all roads in the study area daily for dead turtles. In addition to being expensive, such efforts would have limited utility, because road density, traffic rates, and turtle populations vary over space, thus point estimates of road

mortality cannot be applied statewide or rangewide. In this section, we present an alternative to these problematic empirical approaches. We estimated population-level threats from GIS traffic rate data, turtle movement patterns, and a model of road-crossing mortality. The result is an estimate of the “footprint” of roads on Blanding’s turtle populations across the landscape.

Estimates of road crossing rates by Blanding’s turtles come from two sources: observed road crossing rates from empirical studies in Massachusetts and Maine, and inference from known movement patterns of turtles. Radiotelemetry projects in Massachusetts (B. Compton, unpublished data) and Maine (Beaudry et al. 2006, pp. 12-13) recorded road crossings at several sites (Table 11) and from 35%-46% of turtles crossed at least one road during these studies. The overall road crossing rate was 0.52 roads crossed per turtle per year in Massachusetts, and 1.63 roads crossed per turtle per year in Maine. Neither of these studies were biased toward sites with high road density—sites were selected in part because their landscape settings were thought to support strong populations, thus they are more likely biased toward areas with lower road density.

Table 11. Road crossing rates by radio-tracked Blanding’s turtles in Massachusetts (B. Compton, unpublished data) and Maine (Beaudry et al. 2006, pp. 12-13).

State	Year	Turtles tracked	Total crossings (rate/animal/yr)	Turtles crossing roads (percent)
Massachusetts ¹	2001	17	8 (0.47)	6 (35%)
	2002	33	17 (0.52)	8 (24%)
	2003	38	21 (0.55)	10 (26%)
	Total	46	46 (0.52)	16² (35%)
Maine ³	2004	16	28 (1.75)	9 (56%)
	2005	21	21 (1.00)	8 (38%)
	2006	13	28 (2.15)	6 (46%)
	Total	50	77 (1.63)	23 (46%)

As noted above, road mortality rates are difficult to measure empirically. Of the 59 Blanding’s turtles tracked in eastern Massachusetts from 2001-2003, one adult (male M302) was killed while crossing a road (Grgurovic and Sievert 2005, p. 207). During this study 13 additional road-killed adult and juvenile Blanding’s turtles were found on roads in the study area. During a three-year radiotelemetry study in Maine, none of the 50 tracked Blanding’s turtles were killed, but two road-killed turtles (an older male and a 7-year-old juvenile) were found (F. Beaudry, unpublished data). It is not possible to estimate mortality rates from these opportunistic observations of road-killed turtles, because source population sizes are unknown.

¹ Turtles were tracked at least 18 weeks. Lightly-traveled roads (< ca. 10 trips/day) were excluded.

² Total number of individuals that crossed roads. Some animals crossed roads in more than one year.

³ Roads without traffic were excluded.

Several authors have presented variations on a model of road crossing mortality given traffic rates (Hels and Buchwald 2001, p. 339; Gibbs and Shriver 2002, pp. 1648-1649; van Langevelde and Jaarsma 2004, pp. 898-899):

$$P(\text{killed}) = 1 - e^{\frac{-\text{traffic} \cdot (2 \cdot \text{tirewidth} + 2 \cdot \text{turtlelength})}{\text{velocity}}}$$

We applied Gibbs and Shriver's (2002) model, assuming that 80% of traffic occurs during daylight hours, when Blanding's turtles make most of their movements (Gibbs and Shriver 2002, p. 1648), tire widths of 25 cm, turtle lengths of 210 mm and a turtle velocity of 10 m/min (Fig. 10). This model assumes that cars arrive following a Poisson distribution (this is likely a good assumption at low to moderate traffic rates), that turtles cross perpendicularly to roads, that turtles move at a constant rate, and that drivers do not react to turtles by trying to miss them, hit them, or move them off of the road. Although these assumptions are problematic (e.g., turtles often retract into their shells in response to danger), this model gives a reasonable approximation of the probability a turtle is killed given it crosses a road having a particular traffic rate.

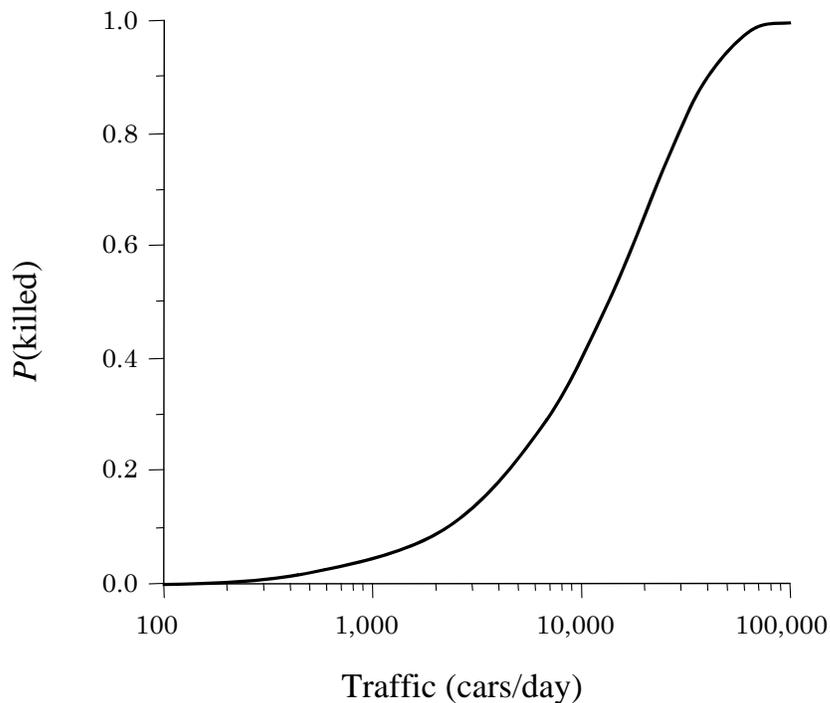


Fig. 10. Roadkill model relating traffic rate to the probability of a Blanding's turtle crossing that road being killed by traffic.

We validated the roadkill model by applying it to traffic rates of roads crossed by turtles in the Maine and Massachusetts telemetry studies (Fig. 11). This validation, based on a small sample size, is not definitive, but it does highlight the expense of empirically determining traffic

mortality rates. In Massachusetts, 16 turtles made 46 crossings, with an expected mortality rate of 1.83 (95% CI = 0,4); the observed mortality rate was one turtle ($P = 0.41$). In Maine, 42 turtles made 73 crossings, with an expected mortality rate of 1.39 (95% CI = 0, 3); the observed mortality rate was zero ($P = 0.24$). For the two states combined the 95% CI was (1, 6), and $P = 0.14$. Thus, the observed number of roadkills from each study (and both studies combined) are consistent with the predictions of the road mortality model.

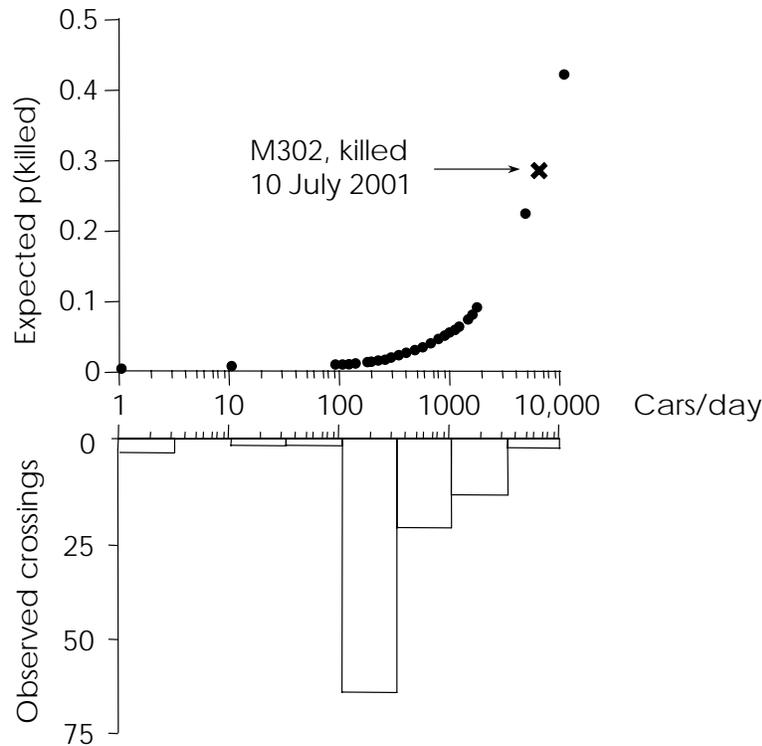


Fig. 11. Estimated probability of turtle mortality, by traffic rate, for observed road crossings in Massachusetts and Maine during 2001-2006 (top), and number of observed crossings by traffic rate (bottom).

Given their life history strategy, even small increases in adult mortality rates can have profound effects on turtle populations. For example, demographic modeling suggests that a population of 100 animals with additional adult mortality of 3% would be reduced to 12 animals after 100 years (page 39). An analysis of surveys of Blanding's turtles in Maine provides evidence for reductions in Blanding's turtle populations near major roads (page 41). Recent research has shown that populations of several turtle species are becoming increasingly male-biased due to higher road mortality in females, presumably associated with nesting forays (Marchand and Litvaitis 2004a, p. 763; Steen and Gibbs 2004, p. 1145; Gibbs and Steen 2005, pp. 553-554; Steen et al. 2006, pp. 270-271).

Observed crossing rates can be estimated from observed movement patterns of Blanding's turtles. This allows making inferences about movement distances from radiotelemetry studies, and relating these to GIS road and traffic data. Our goal was to estimate the "ecological footprint" of roads in Massachusetts and Maine (where GIS road traffic rates are available) on Blanding's turtle populations. We used the roadkill model to estimate the expected road mortality rate for a turtle crossing each road segment, given the daily traffic rate. We estimated the probability of a turtle crossing a road at a specified distance from its home range centroid by counting the proportion of radio-tracked turtles that would cross a straight road tangent to the home range in various orientations (100 random orientations at each 10 m distance interval, analyzed separately for each state). We fit these empirically generated curves to a logistic curve

$$P(\text{cross}) = \left(1 - \frac{1}{1 + e^{-\frac{\text{distance} - d_i}{d_s}}} \right) \times d_y$$

where *distance* = distance to road, d_i = inflection point of logistic curve, d_s = logistic scaling factor, and d_y = vertical scaling factor (for Massachusetts, $d_i = 198.0$, $d_s = 181.7$, $d_y = 1.428$, $r^2 = 0.999$, $P < 0.001$; for Maine, $d_i = 350.6$, $d_s = 201.8$, $d_y = 1.242$, $r^2 = 0.999$, $P < 0.001$). This curve estimates the probability that a turtle with its homerange center at a given distance from a road would cross that road (Fig. 12). We assumed that any road crossings were made twice in a season (assuming a there-and-back movement).

Given a selected annual roadkill mortality rate due to traffic (e.g., 1%), we then used this road crossing curve and the roadkill model applied to the traffic rate of each road segment to estimate the distance from each road segment that a turtle's homerange center would have to be to face less than the given mortality rate. Thus, the 1% footprint map shows all areas where turtles (assuming their homerange center is within the footprint) have a $\geq 1\%$ chance of road mortality. Likewise, the 2% footprint shows (smaller) zones where mortality is likely to be at least 2%, and so on. We report these footprints as the percent of the total area of the generalized Blanding's turtle range in each county where Blanding's turtles occur in Massachusetts and Maine, as well as graphically.

Although lack of digitized road traffic data precludes applying this model to New Hampshire or New York, the road threat in these states is likely to be roughly similar. Note that this approach underestimates road mortality in areas close to two or more roads (such as intersections), because it counts only the road with highest probability of roadkill at each point, rather than the cumulative probability from all roads. Note also that this model uses only roads and road traffic data from GIS, and ignores the arrangement of wetlands. Thus, the model assumes that wetlands are arranged randomly with respect to roads. This assumption is fairly well met at the landscape scale, although not necessarily at local scales. In some places, linear riparian wetland complexes running parallel to major highways may support Blanding's turtle populations moving normally without crossing roads. Likewise, turtles may be less likely to repeatedly cross roads without wetlands on the other side. Note also that this simple model makes no provision for barriers to turtle travel (e.g., ocean), and thus may give nonsensical

results for coastal islands and peninsulas. Over larger areas (towns, counties, and states) however, this model gives a good approximation of the threat of road mortality.

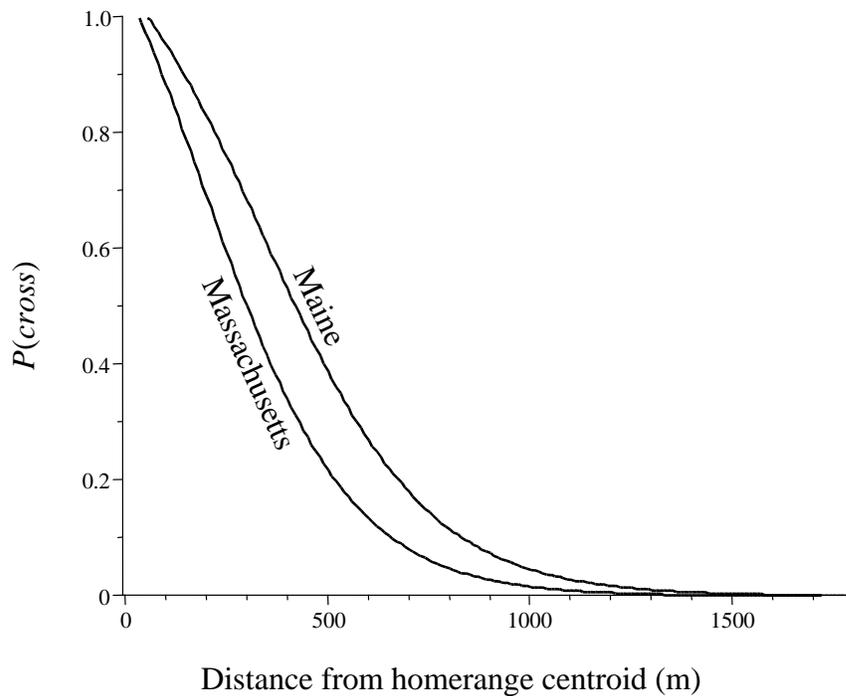


Fig. 12. Road crossing curves for Massachusetts and Maine, giving the probability a turtle will cross a road at a given distance from its home range centroid.

The ecological footprint of roads in Massachusetts and Maine (Table 12, Fig. 13-Fig. 16) is extensive. Of the four counties with the bulk of known Blanding's turtle populations in these two states (Essex, Middlesex, and Worcester in Massachusetts, and York in Maine), at least 84% of land is within the 1% footprint, and at least 55% is within the 5% footprint (Table 12). This suggests that most Blanding's turtle populations in Massachusetts and Maine are facing at least 1% additional mortality from traffic, and many face much higher unsustainable rates of road mortality. The pattern of the higher-mortality footprints (10% and 50%, Fig. 13 and Fig. 15) suggest a significant fragmentation effect of roads. Most known populations are separated from one another by areas of at least 10% mortality. Compare these results with the time to 90% reduction (Table 8): a 5% rate of annual mortality, for instance, corresponds to a 90% reduction in population in less than two generations. This expected rate of decline from road mortality corresponds to at least 55% of the area of York County, Maine, and 67-81% of the three counties in Massachusetts with the majority of Blanding's turtle records.

The extent of road footprints is greater in Massachusetts than in Maine, as one would expect from the high road density and traffic rates in eastern Massachusetts. In Massachusetts, element occurrences typically coincide with areas where the road footprint is smaller, suggesting that the

current population distribution may partially reflect the effect of past road mortality. In particular, note the extensive footprints in eastern and southern Middlesex County (Fig. 15, Fig. 16), corresponding to heavy development along Rt. 95 and the Massachusetts Turnpike. These areas also have fewer element occurrences (Fig. 15), possibly because populations have already been extirpated.

Evidence in this section suggests that road mortality is a threat to Blanding's turtles, contributing to the decline and extirpation of populations across the Northeast. Although a few sites may be isolated from major roads, most Blanding's turtle populations are affected by road mortality, and this threat is expected to increase in the future as traffic rates continue to increase. Furthermore, areas of high road mortality fragment and isolate populations. Because road mortality contributes to incremental declines, as opposed to wholesale population extirpation, the effects are difficult to detect empirically. Nonetheless, road mortality is a significant and growing threat to Blanding's turtles, and no simple solutions are available.

Table 12. Ecological footprint of roads on Blanding's turtles in Massachusetts and Maine, by county. Values are the percent of the total land in each county with an expected annual road mortality rate for adult Blanding's turtles greater than or equal to the specified percent. Counties with most of the Blanding's turtle populations in each state are in bold.

County	Percent with annual mortality at least						
	1%	2%	3%	4%	5%	10%	50%
Massachusetts							
Bristol	97	94	89	85	79	65	17
Essex	93	87	83	80	76	65	20
Middlesex	97	91	87	84	81	69	22
Norfolk	98	94	91	89	87	76	28
Plymouth	95	87	82	78	74	59	16
Suffolk	97	96	96	96	95	94	69
Worcester	87	80	75	71	67	52	14
Maine							
Cumberland	85	76	69	64	59	45	11
Oxford	54	40	32	27	23	13	0
York	84	74	66	60	55	38	7

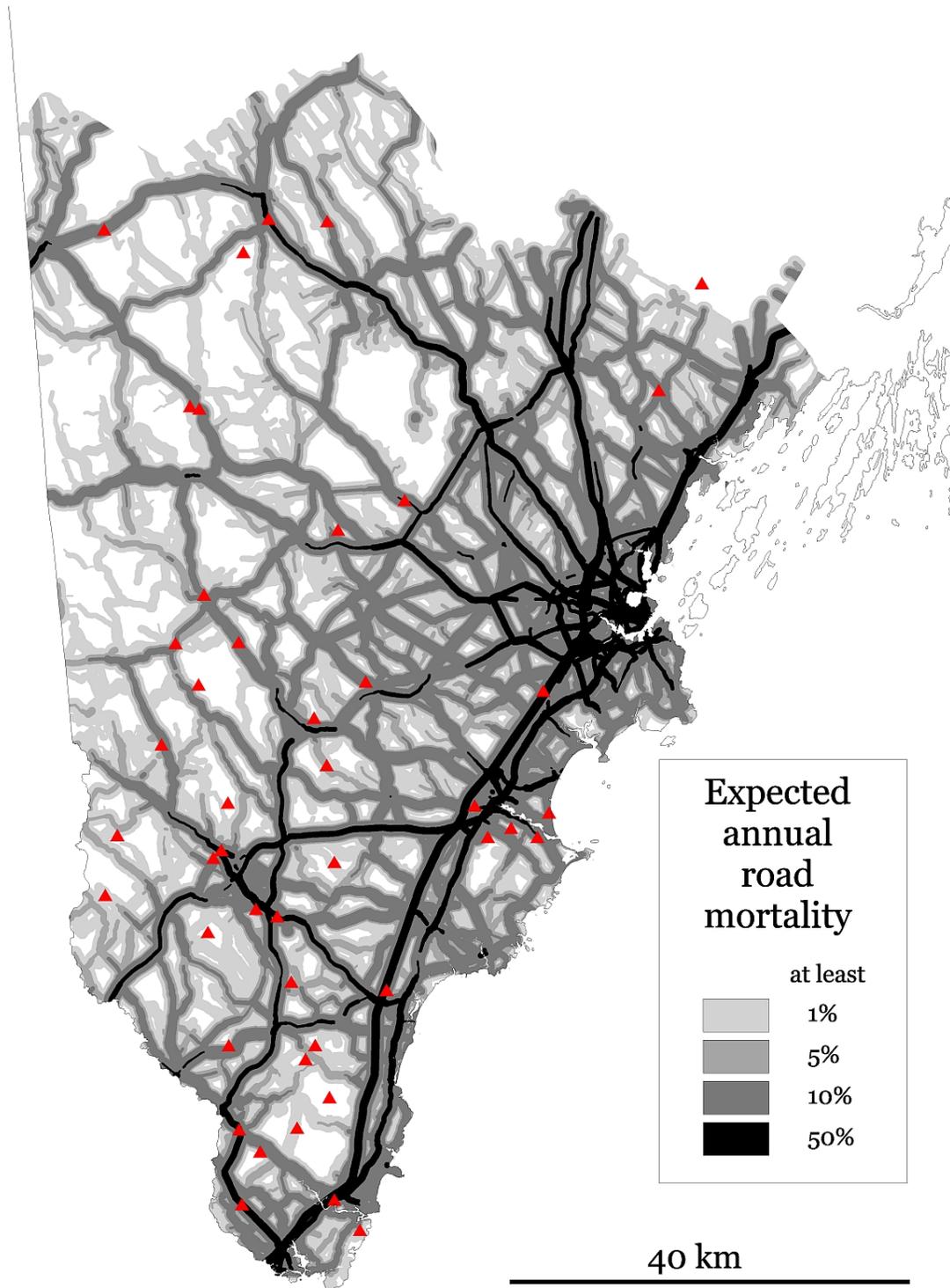


Fig. 13. Road footprints for the range of Blanding's turtles in Maine, at the 1%, 5%, 10%, and 50% levels of expected annual road mortality. Triangles denote element occurrences of Blanding's turtles (see page 30). Turtles with homorange centers within each footprint are expected to face at least the specified percent additional annual mortality from traffic.

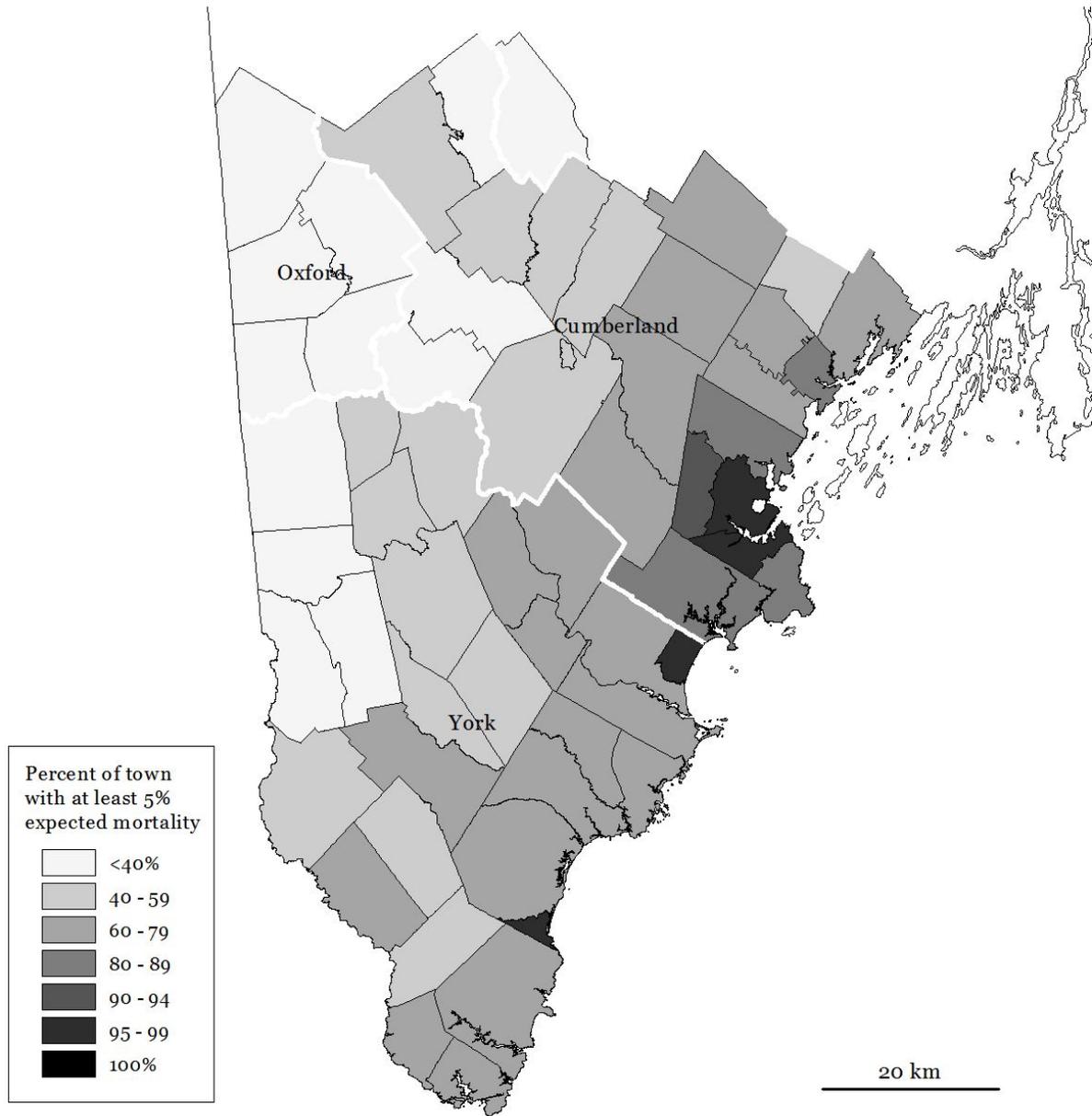


Fig. 14. Percent of each Maine town within the 5% road footprint for Blanding's turtles.

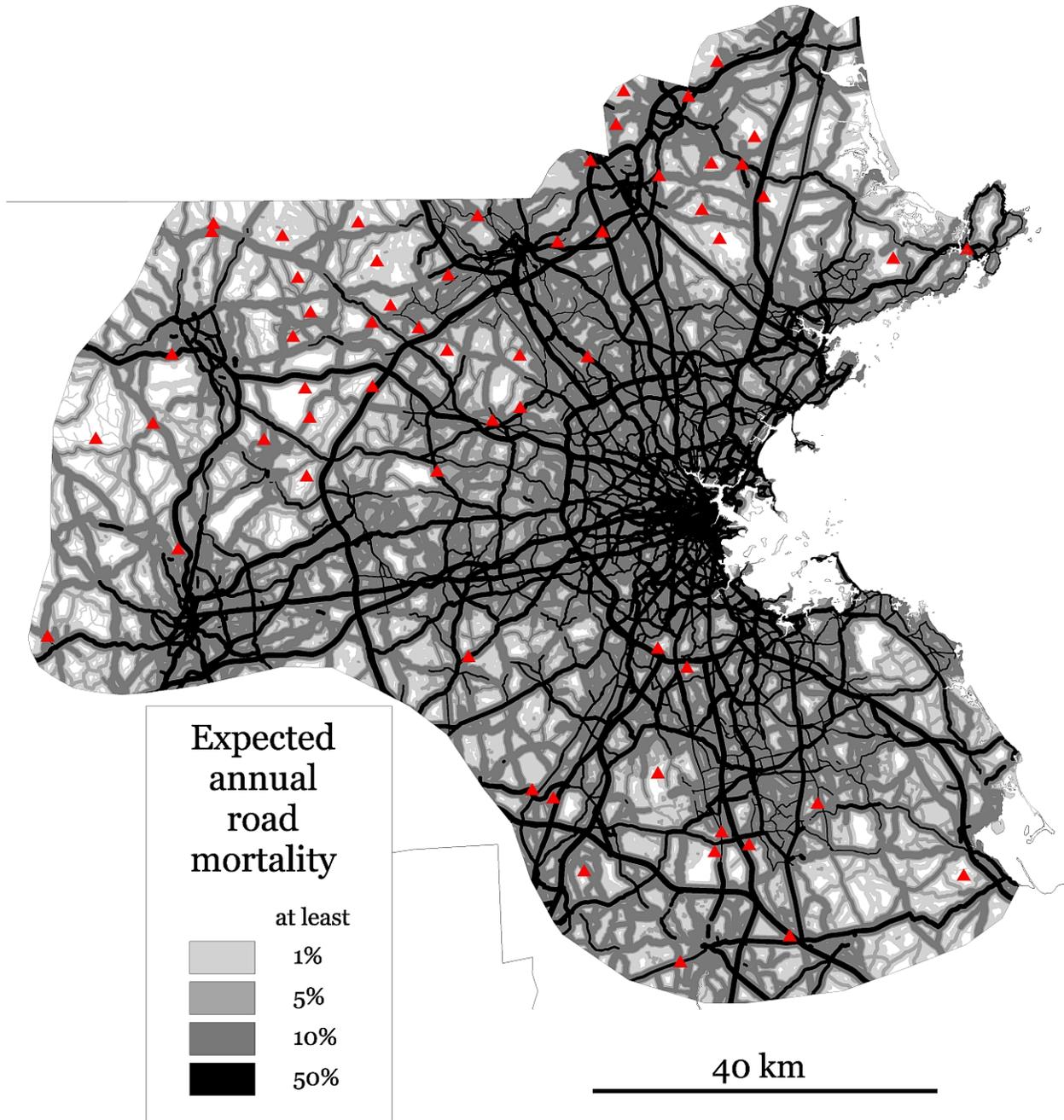


Fig. 15. Road footprints for the range of Blanding's turtles in Massachusetts, at the 1%, 5%, 10%, and 50% levels of expected annual road mortality. Triangles denote element occurrences of Blanding's turtles (see page 30). Turtles with homerange centers within each footprint are expected to face at least the specified percent additional annual mortality from traffic.

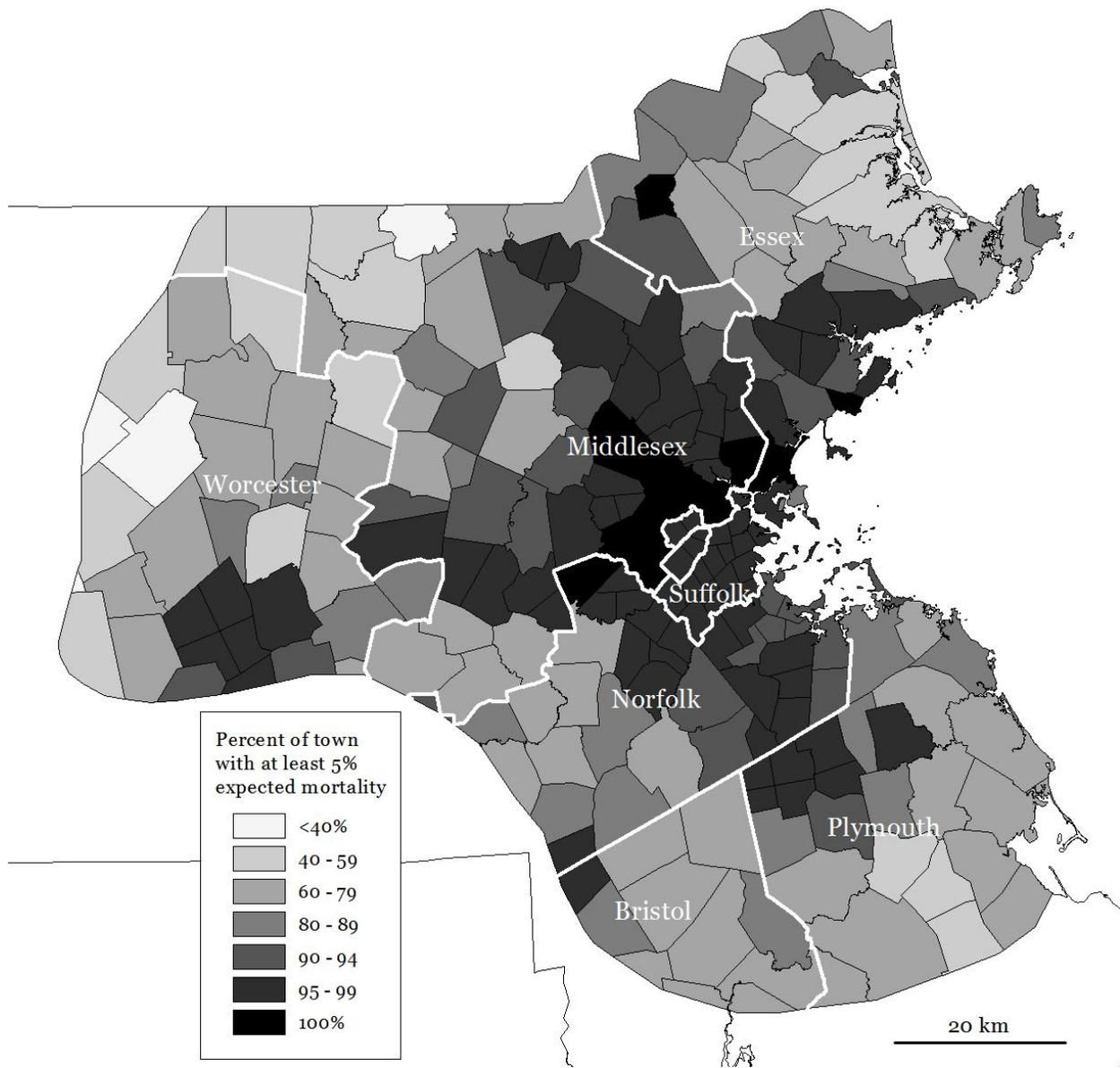


Fig. 16. Percent of each Massachusetts town within the 5% road footprint for Blanding's turtles.

Forestry, agriculture, and water impoundment management

The Northeast is one of the most forested regions in the US, and at the same time the majority of land is in private ownership, thus timber management is one of the region's most widespread land use practices. Forestry poses two threats: first, harvesting equipment can potentially crush animals when operated during the turtle's surface active periods. Secondly, logging can degrade habitat for vernal pool amphibians that are closely associated with relatively intact, closed-canopy forest conditions in the upland life zone surrounding their breeding pools. These amphibians, in turn, serve as an important prey base for Blanding's turtles (deMaynadier and Houlahan 2007).

The main threats from agriculture are nonpoint source pollution run-off that degrades wetland quality for Blanding's turtles and their prey, and the potential crushing and injury of nesting and migrating upland turtles. Dutchess County, New York has a significant number of agricultural fields within the Blanding's turtles range. The females make their nesting migration during the period that farmers are usually making their first cutting of hay and are vulnerable to being crushed by tractor wheels or mowers. Some turtles nest in crop fields, such as corn, which may appear to turtles to be good nesting habitat in late May to mid June but is very shaded by mid summer and may not allow eggs to incubate properly.

Although most Blanding's turtles in the Northeast are found in wetlands where water levels are not artificially manipulated, some populations occur in managed impoundments (e.g., (Windmiller 2004, p. 11). Management of impoundments for purposes such as waterfowl habitat improvement or invasive species control could threaten Blanding's turtle populations, depending upon the time of year and specific situation. Winter draw-downs could, for example, expose overwintering adults to freezing temperatures, and drawdowns during the active season could force turtles to move to other wetlands, possibly leading to road mortality.

Climate change

Blanding's turtles have the most latitudinally compressed range of any turtle found in the northern United States, ranging less than 900 km from north to south (Ernst et al. 1994, p. 242). In the Northeast, the latitudinal range stretches only about 350 km from southern Maine and Nova Scotia to the lower Hudson Valley. The reasons for this narrow range are poorly understood. The southern limit of the range may be related to the species' relatively low critical thermal maximum (Hutchison et al. 1966, p. 35) and low preferred body temperatures (Nutting and Graham 1993, pp. 244-245), or perhaps competition with other species. At the northern edge of the range, low incubation temperatures may result in a sex ratio skewed too heavily to males (it is worth noting that wood turtles, the species with the most northerly range in North America, is one of the few species to exhibit genetic sex determination; Ewert and Nelson 1991, p. 53). Although the effects of projected global warming on Blanding's turtles are purely speculative at this point, the narrow latitudinal range of this species, combined with a long generation time may leave it especially vulnerable to climate change.

Conservation Measures Planned or Implemented

New York

Blanding's turtles were listed as Threatened in New York in 1983. Fragmentation by roads and loss of habitat to suburban sprawl and second home development were the most significant threats identified at that time and continue to be the greatest threats. Several Blanding's turtle populations are at least partially protected in southeastern New York. In Dutchess County populations are found in a state park which is managed primarily as a golf course, at a Nature Conservancy preserve, and at a park operated by the National Park Service. In Saratoga County the only known population was found on land within the Wilton Wildlife Preserve and Park, a co-operative effort between the Town of Wilton, The Nature Conservancy and the NYS Department of Environmental Conservation. Although these preserves serve as overwintering and/or nesting habitats, none are large enough to adequately protect the populations with some turtles migrating to wetlands or nest sites off of the protected land which results in frequently crossing public or private roadways, agricultural fields or housing developments.

Management efforts in New York include creation of alternative nesting habitat (Emrich 1991), headstarting (A. Breisch, unpublished data) and creation of wetlands and nest sites adjacent to a high school parking lot (Kiviat et al. 2000, pp. 650-656; Kiviat et al. 2004, pp. 93-99). Other initiatives include habitat modeling by the NY Natural Heritage Program linked with field surveys and a study funded by NYS DOT to design tunnels (ecopassages) under roadways that will be used by turtles (J. Gibbs, State University of New York, unpublished data). A yearly effort is made to trap known and potential Blanding's turtle ponds. This has led to the discovery of nest sites in recent year in Dutchess County but for an unknown reason trapping in Saratoga County has not produced a single turtle. A Master's student has begun research in Saratoga County with one of the objectives being to develop a survey protocol for sites where traditional trapping does not work.

The New York Natural Heritage Program (NYNHP) has developed a GIS buffer for extant Blanding's turtle occurrences to help municipalities in the Hudson River Valley identify areas that may be important to this species. Currently, the NYNHP depicts occurrences of Blanding's turtles as occupied wetlands, areas of known use as determined through radio-telemetry or other methods, or road-crossing records. Since Blanding's turtles are known to make extensive overland movements between wetlands, a method that captures upland habitat within 1 kilometer of known occurrences and buffers contiguous wetlands that intersect the 1 kilometer upland buffer is being used. In addition, an online Conservation Guide for Blanding's turtle has also been written (see NYNHP.org). The maps and Conservation Guides resulting from this effort, which also include additional rare species (animals and plants) and ecological communities, are designed to help inform land use decisions and conservation efforts in the towns where Blanding's turtles occur.

In 2005, the NYNHP began the process of creating predictive distribution maps by utilizing precise locational data from the NYNHP database for each species or ecological community of

interest and multiple environmental characteristics that may influence their distributions (J. Jaycox, New York Natural Heritage Program, unpublished data). Two statistical modeling approaches, Random Forests and MaxEnt, and currently being used by NYNHP and the outputs of both models are combined to produce a single map. The final map depicts the distribution of the environments that are suitable for occupation. As part of this process, predictive distribution maps were created for the Blanding's turtle, mainly to help prioritize where future field surveys for this species should take place. As NYNHP uses this predictive map to guide future survey efforts, they hope to gather additional data that can then be used to re-run the model in order to create more refined predictive maps. NYNHP has not yet conducted a full evaluation of the Blanding's turtle predictive distribution map to determine its accuracy, but plans to conduct these evaluations through various NYNHP projects. Additional future research efforts by the New York State Department of Environmental Conservation and others will also aid with this validation process.

Although the wetland act only protects the wetland and the 100 ft adjacent area surrounding the wetland, a recent court case (Amato and Rosenthal 2001, pp. 117-118) involving timber rattlesnakes determined that the state's endangered species law could be interpreted to extend protection to an species' habitat if the disturbance to the habitat was sufficient to result in a "taking." This decision has not yet been applied to the upland habitat of Blanding's turtles but may have the potential to help in mitigating losses to nesting or migration habitat.

New York is the site of the most intensive habitat mitigation project for Blanding's turtles to date. A public school expansion in Dutchess County, New York, involved the filling of a 0.7 ha shrub swamp that was known to be used by Blanding's turtles. Because of their threatened status in New York, the New York State Department of Environmental Conservation required the creation of replacement wetlands constructed to high standards. Creating three replacement wetlands involved transporting intact 1.2 × 3 m tiles of wetland substrate 38 cm deep, including herbaceous and woody plants that included trees up to 6 m tall. The project also involved construction of nesting areas and a 1.5 km fence. The project cost was \$1.6 million, with expected final costs expected to run much higher (Kiviat et al. 2000, pp. 650-656; Klemens 2000, pp. 245-247; Kiviat et al. 2004, pp. 93-99).

Massachusetts

Blanding's turtle distribution is restricted to eastern Massachusetts and there are no records from Cape Cod. The greatest numbers of observations are from the northeastern part of the state. Relatively few areas of significant size have been identified as "truly" protected roadless areas throughout the state. Human land use pressures, particularly in the eastern part of Massachusetts, and the lack of protected habitat in these projected development hotspots leave the Blanding's turtle vulnerable to continued habitat degradation, fragmentation and loss and increases in adult mortality due to increased traffic volume, and predation.

A Blanding's turtle habitat model developed at the University of Massachusetts (Compton et al. 2006) will be used in conjunction with Massachusetts Natural Heritage records to assess and prioritize Blanding's turtle habitat patches for land acquisition. Prioritization will be based on

the extent, quality, and juxtaposition of habitats and their predicted ability to support relatively large and self-sustaining populations of Blanding's turtles. Sites will also be prioritized based on the relative size and lack of fragmentation of both wetland and upland habitats and their proximity and connectivity to other areas of relatively unfragmented habitats, especially within existing protected open space. Given limited conservation funds, due to high land values, alternatives to outright purchase of conservation land is an important component to the conservation strategy. These can include conservation easements such as Conservation Restrictions (CR's) and Agricultural Preservation Restrictions (APR's). One method of protecting large blocks of land is allowing the building of small or clustered roadside developments in conjunction with protecting large areas of unimpacted land.

Alternative wildlife corridor structures should be considered at strategic sites on existing roads. In particular, appropriate wildlife corridor structures should be considered for bridge and culvert upgrade and road-widening projects within Blanding's Turtle Habitat Polygons. Efforts should be made by the Natural Heritage and Endangered Species Program to inform local regulatory agencies of the new wildlife corridor section in the Massachusetts Highway design guidance document, and to provide them with key locations where these measures would be most effective for turtle conservation.

Habitat management and restoration guidelines should be developed and implemented in order to create and/or maintain consistent access to nesting habitat within core habitat areas. This is most practical on state-owned conservation lands (i.e. DFW, DCR). However, educational materials should be made available to guide private land-owners on the best management practices for Blanding's turtle habitat.

Forestry restrictions should be implemented on state lands to avoid direct mortality of turtles. Operation of motorized vehicles at harvest sites that coincide with habitat of Blanding's turtle should be restricted to periods when the Blanding's turtle is inactive (i.e., during the winter). Although seasonal restrictions should be applied throughout Blanding's turtle habitat, particularly strong emphasis should be placed on restricting operation of heavy equipment in stands that contain or are located within 600 feet (183 m) of wetlands, vernal pools, or other water bodies. To maintain the structural integrity of wintering sites, wetland harvesting by hand-felling is required and crossing wetlands with standing water must be done with temporary bridges or only occur under completely frozen conditions. New landings and skid roads must be located as far away as possible and at least 100 feet (30 m) from vernal pools and wetlands.

New Hampshire

The status of Blanding's turtle populations in New Hampshire is currently unknown, but it is believed that numbers are declining due to habitat loss and road mortality. To determine habitat use of Blanding's turtles in the state, a cooperative project was initiated in 2001 by the Nongame and Endangered Wildlife Program, the University of New Hampshire, and the Audubon Society of New Hampshire, with funding from the Department of Environmental Services. During this three-year study, 20 Blanding's turtles were tracked using radio telemetry. Results from the study indicate that turtles are traveling great distances and show the importance of protecting

large unbroken tracts of land that include both wetlands and uplands. Almost as many turtles were found dead on roads as were captured alive. An ongoing telemetry study of Blanding's turtles was initiated at the New Boston Air Force Station in 2004 (Najjar and Drake 2004; Kostrzewski et al. 2005). The Blanding's turtle was identified as a species in greatest need of conservation in the NH Wildlife Action Plan. A Blanding's turtle profile was completed (Marchand 2005), which included a condition and threat assessment and identified a series of high priority conservation actions. An analysis of element occurrences found that 16% percent of areas occupied by Blanding's turtles were in conservation land, and only four occupied areas were more than 70% protected. The Nongame and Endangered Wildlife Program uses Blanding's turtle occurrences to help prioritize local land conservation efforts. Conservation focus area maps produced for the NH Wildlife Action Plan included rare species data and large unfragmented landscapes and high quality wetlands. Rare species records, such as Blanding's turtles, are being incorporated into grant applications (NRCS Farm Bill Programs, Landowner Incentive Program) to prioritize funding in New Hampshire. Existing programs such as the Great Bay Partnership and Land Conservation and Heritage Investment Program (LCHIP) have protected large parcels of land where Blanding's turtles are likely or known to occur. Blanding's turtles are currently under review for a listing status change, from special concern to endangered.

Maine

Blanding's turtles in Maine were listed as Threatened in 1986, and then upgraded to Endangered in 1997 following extensive surveys showing that the population size was likely under 1000 and available habitat was highly fragmented. Existing conservation efforts include surveys, research, the Mount Agamenticus Land Conservation Initiative, environmental review, land trust and municipal data-sharing, and public outreach/education.

MDIFW has been actively surveying for spotted and Blanding's turtles for over 15 years with financial support from USFWS and USEPA. While some Blanding's turtle records are a product of incidental reports by the general public, most of the state's observations come from contractual surveys of over 3,000 wetlands using binocular, wading, trapping, and telemetry methods. Currently, MDIFW is cooperating with University of Maine to sponsor a 4-year doctorate research project (Frederic Beaudry) using radio-telemetry to investigate the extent and frequency of overland movements made by Blanding's turtles, the road mortality risk associated with these movements, and the consequences of road mortality on population viability. Furthermore, a GIS-based spatially explicit movement model, supported by habitat selection data, will help with conservation efforts such as road mitigation, land protection, and regulatory review recommendations.

Southern Maine's landscape is rapidly developing, and some of the best remaining populations of Blanding's turtles are found on a 35,000 acre area surrounding Mount Agamenticus in York County. MDIFW is working closely with a coalition of partners, including TNC, Maine Natural Areas Program, local land trusts, local water districts, and relevant municipalities, to protect habitat for rare turtles and other wildlife in this area. To date, approximately 11,000 acres have been protected through fee acquisition or conservation easement.

Regarding environmental review, all wetlands hosting Blanding's turtles are scrutinized for direct and indirect population impacts, as directed by Maine's Endangered Species Act (MESA). While this regulatory vehicle is limited in its ability to extend large scale habitat protections, MDIFW is vigilant in applying MESA's Take and Harassment provisions to strictly enforce wetland and upland buffer protections.

Land trust and municipal data-sharing occurs through the program "Beginning With Habitat" (<http://www.beginningwithhabitat.org/>), in which MDIFW shares information on rare, threatened, and endangered species habitat and biodiversity focus areas. Municipalities and landtrusts are encouraged to use the information to inform comprehensive planning and land protection efforts. More general public outreach and education on rare turtles has also been a priority for MDIFW. Some recent outreach projects most relevant to Blanding's turtles include the publishing and distribution of endangered Blanding's turtle fact sheets (McCollough et al. 2003), a new Turtles of Maine poster, Best Development Practices for Conserving Vernal Pools in Residential and Commercial Developments in the Northeastern United States (Calhoun and Klemens 2004), and Forestry Habitat Management Guidelines for Vernal Pool Wildlife in Maine (Calhoun and deMaynadier 2004). Finally, a new road crossing signage project was launched in 2006 whereby MDIFW deploys cautionary turtle signs, seasonally, along strategic high-use Blanding's and spotted turtle road segments throughout the Mt. Agamenticus area.

Summary of Threats

To be added by USFWS.

Recommended Conservation Measures

Priorities for research and conservation

The top priority for Blanding's turtle conservation is the protection of high-quality wetlands, wetland complexes and surrounding uplands that contain viable populations. These essential habitat areas are compatible with low-impact human uses, but they must preclude ungated roads unless they are equipped with effective barrier and passage systems. Without protected areas of sufficient size, efforts at Blanding's turtle conservation can achieve little more than the delay of extirpation. Any such work must be done in the context of protecting entire ecosystems and associated communities of wetland and upland species (Klemens 2000, pp. 253-258). Due to their need for such large protected areas, Blanding's turtles may act as an umbrella for other wetland dependent species, which would benefit from any reserves created for Blanding's turtles.

The causes behind declines in Blanding's turtle populations are believed to be a combination of habitat loss and fragmentation, increased adult mortality, and increased predation on nests and juveniles. These are the result of draining and filling of wetlands, development in intervening uplands, and increasing road traffic. Because of their long-lived life history strategy, increases in adult mortality (such as those caused by automobile traffic) can lead to severe population declines. Blanding's turtles tend to move long distances overland among wetlands and to nesting sites, thus they are exposed to many roads in highly developed areas. Finally, populations of a number of nest and juvenile predators (especially raccoons) are often artificially increased in areas with human development.

The most immediate threats to Blanding's turtles in the Northeast are the continued loss of upland habitat that connects wetland complexes, and associated adult mortality from road traffic. Increased development in the vicinity of Blanding's turtle wetlands may also contribute to increases in populations of subsidized nest and juvenile predators, and illegal collection. Even if development in Blanding's turtle habitat were to be halted at current levels, in many areas the continued loss of adults to mortality on existing roads is unsustainable. Regulatory protection mechanisms at the state level are insufficient to protect the few large remaining roadless complexes of wetland and upland habitat required to sustain Blanding's turtle populations.

Respondents to the Blanding's Turtle Status Questionnaire (Appendix A) ranked direct adult mortality as the highest general threat (mean = 1.2¹, range = 1-2), followed closely by habitat loss and modification (mean = 1.3, range = 1-3), and reproduction and recruitment failure (mean = 1.7, range = 1-3). Within adult mortality, road traffic mortality was ranked by far the highest, with a mean of 1.1 (range = 1-2). Within habitat loss, loss of connectivity was ranked the highest (mean = 1.2, range = 1-2), followed by changes in habitat quality and loss of vernal pools. Reproductive failure was mostly attributed to nest predation by subsidized predators

¹ Where 1 = high, 2 = medium, 3 = low, and 4 = not a threat.

(mean = 1.6, range = 1-3), as well as road mortality of hatchlings and juveniles, predation of hatchlings and juveniles, and loss of nesting habitat.

Management needs and issues

Respondents to the Blanding's Turtle Status Questionnaire (Appendix A), all of whom have experience studying or managing Blanding's turtles in the Northeast identified site protection as the highest overall conservation priority (all 13 respondents scored this category as high priority). The second highest priority was research (mean = 1.5¹, range = 1-2), which was nearly tied with education, outreach, and law enforcement (mean = 1.6, range = 1-3). The third priority was habitat and population management (mean = 2.2, range = 1-3).

Within site protection, all 13 respondents scored "protect known sites through land acquisition and conservation restrictions" as a high priority. "Protect sites from development through environmental review" and "identify, protect, and/or establish habitat corridors" were tied, with a mean of 1.4 (range = 1-2). A more specific approach, protecting connectivity between wetlands with passage structures such as tunnels was next, with a mean of 2.2 (range = 1-3).

Within research, the highest priorities were identifying viable populations/strategic conservation (mean = 1.1, range = 1-2), and surveys to assess known sites or identify new populations (mean = 1.4, range = 1-3).

All of the highest-ranked categories within education, outreach, and law enforcement focused on education, including education and outreach on land protection needs and conservation restriction options for landowners (all gave this high priority), outreach on turtles crossing roads (mean = 1.3, range = 1-2), on turtles as pets (mean = 1.6, range = 1-2), on life history strategy (mean = 1.6, range = 1-3), and on nesting turtles (mean = 1.7, range = 1-3).

Most of the categories within habitat and population management (itself a medium to low priority) were ranked as medium to low priority; the highest categories were related to nest site management (creating/maintaining nest sites, protecting nests from predators, and predator control). Interestingly, none of the respondents considered more intensive strategies (headstarting, captive breeding, or population reintroduction) as a high priority.

In summary, comprehensive site protection is seen as the highest priority. This involves (1) identifying potentially viable populations; (2) proactively protecting the complexes of wetlands and uplands used by these populations and surrounding land via outright purchase, conservation restrictions, and other approaches; (3) using regulatory review in a supporting role during the protection process; (4) managing sites with measures such as road mitigation, nest site management, and nest predator control; and (5) including a strong education/outreach component.

¹ Where 1 = high priority, 2 = medium priority, 3 = low priority, and 4 = useless or detrimental.

Recent research, surveys, and monitoring

A number of recent studies have been carried out on Blanding's turtles in the Northeast (Appendix B). These studies have had three primary focuses: (1) radiotelemetry studies of habitat, movements, and basic ecology; (2) extensive surveys to identify populations; and (3) modeling efforts intended to inform conservation.

Radiotelemetry studies have been carried out in eastern New York (Kiviat 1997; Kiviat et al. 2000; Kiviat et al. 2004; A. Breisch pers. comm.), Massachusetts (Compton and Sievert 2004; Windmiller 2004; Grgurovic and Sievert 2005; Windmiller and Ives 2005), New Hampshire (Babbitt and Jenkins 2003; Najjar and Drake 2004), and Maine (Joyal 1996; Joyal et al. 2000, 2001; Beaudry et al. 2005; Haskins et al. 2005). The most comprehensive surveys have been carried out in Maine (e.g. Haskins and deMaynadier 2001, 2003), but some surveys have taken place in Massachusetts (Fowle 2001; M. Grgurovic, unpublished data) and New Hampshire (Babbitt and Jenkins 2003) and New York (A. Breisch and J. Jaycox, unpublished data). Modeling efforts include a population viability analysis for Maine Blanding's turtles (Hayes 2000), species-occurrence modeling based on environmental variables in New York (J. Jaycox, unpublished data), a regional model of potential Blanding's turtle habitat (Compton et al. 2007a), and ongoing efforts to build spatially-explicit population viability models in Maine (Beaudry et al. 2005) and Massachusetts (B. Compton, unpublished data).

These recent studies have greatly increased our knowledge about many aspects of Blanding's turtle ecology. In particular, we now have a good handle on habitat use and movement patterns across their eastern range, as well as certain demographic parameters such as clutch size, nesting frequency, and (to some extent) nesting success. Our knowledge of the extent of populations is relatively good, based on Element Occurrences and surveys, but we still have a very poor sense of the size and status of populations. Studies in the Northeast have all been short-term relative to the lifetime and population dynamics of Blanding's turtles, thus we still have poor knowledge about the dynamics of populations, as well as key issues such as long-term fidelity and dispersal.

Future research priorities

Future research falls into three categories: (1) intensive study; (2) extensive surveys; and (3) modeling. Several important questions remain that can only be answered by further intensive work. Extensive surveys for the presence and population sizes of Blanding's turtles will be necessary to help guide site-specific conservation decisions. Ideally, modeling and surveys will be done in concert, with results from modeling guiding surveys, which in turn provide refinements in modeling.

Intensive research

Although many aspects of Blanding's turtle ecology in the Northeast are by now well-understood (e.g., clutch size, nesting frequency, movement patterns), several questions important to conservation remain for future intensive studies. Examples include:

- **Protecting nests from predation.** Better knowledge of methods to protect turtle nests from common nest predators could prove to be important in managing sites. The currently used approach, screening nests, works well but is extremely labor intensive. Approaches that could provide some protection to entire nest sites would be preferable. Research on possible methods using surrogate species such as painted turtles, or using artificial nests (e.g., Marchand et al. 2002) would be relatively inexpensive and yield potentially useful results.
- **Rates and sources of mortality of hatchlings and juveniles.** The life history of hatchling and juvenile turtles is still mostly unknown. Although several researchers have followed hatchlings for their first few weeks (Butler and Graham 1995; Standing et al. 1997; McNeil et al. 2000; Jones 2002), no systematic study of mortality sources has been done. Although adult survival is a more important demographic parameter, decreased survival of hatchlings due to predation can also limit population growth.
- **Movements and habitat selection by hatchlings and juveniles.** Likewise, the movements and habitat selection of hatchlings and young juveniles are not well known.
- **Mitigation structures.** A viable design for turtle tunnel and barrier systems is needed for road reconstruction and mitigation at sensitive sites. Rather than perform uncontrolled “experiments” on rare species as is now sometimes done, we need controlled experiments with Blanding’s turtles or surrogate species (such as painted turtles) to determine the elements of an effective tunnel and barrier system.
- **Road-crossing behavior.** The behavior of turtles crossing roads, factors that influence where and whether they cross roads of different types, and expected mortality rates given traffic rates are all poorly understood. For instance, it is currently unknown whether turtles avoid roads to some extent. A better sense of the levels of road mortality that currently exist, and approaches to reducing road mortality are critical to conservation of Blanding’s turtles.
- **Interwetland movement behavior.** Although several intensive studies have adequately described the frequency of interwetland movements and distances moved, the behavior of turtles during the hours or days spent moving overland are more poorly known (but see Beaudry et al. 2005, pp. 9-10). Do turtles make straight-line movements, regardless of land cover? Do they avoid certain cover types, such as open fields or development? What land cover and topographic features affect movement? Answering such questions will be important to better designing road mitigation structures, managing sites, and more effectively modeling movement-related mortality.
- **Fidelity.** The level of fidelity of individual turtles to home ranges, nest sites, and overwintering sites over their lifetime are poorly known. Fidelity is an important conservation issue, because turtles with strong fidelity might be able to survive in heavily-developed areas for a long time because their individual movement patterns do not bring them into harm’s way, while animals with low fidelity will sample much more of the landscape over their lifetime, eventually crossing busy roads.

Extensive surveys

Field surveys are needed to verify the existence of Blanding's turtle populations in areas that seem to provide habitat for viable populations (e.g., areas ranked high by modeling or identified in the field). Surveys would be most useful if based on modeling—there is little reason, for instance, to document “ghost populations” that are not viable, while ignoring sites more likely to support populations. Modeling can help direct surveys to areas most likely to contain viable populations of Blanding's turtles. A consistent survey protocol for the Northeast would be helpful.

Surveys can take two forms: visual walk-throughs and hand-capturing, or intensive trapping. Visual surveys are most effective during a few weeks in early spring. In April and early May, water temperatures are still cold enough that turtles must bask extensively, thus increasing their visibility. At the same time, vegetation has not yet leafed-out to obscure the turtles. Use of binoculars during slow walks through likely habitat often leads to observations of basking Blanding's turtles. These turtles can sometimes be hand-captured, but not at a frequency high enough to allow population estimation by mark-recapture techniques. Animals that are not captured obviously cannot be marked. Additionally, visual records from a distance may be subject to questions of observer reliability. Once vegetation has leafed-out, visual encounters and hand-captures of Blanding's turtles are rare. Blanding's turtles usually spend most of the summer in large, relatively deep wetlands often with high vegetative cover. They are among our most alert and easily-alarmed turtles, thus are difficult to approach. During the nesting season, chance encounters with females on nesting forays are relatively more common, but still rare. Identification of females at nesting sites provides little insight into the wetlands they are using. Visual surveys are best suited to quickly determining presence/not-detected status in large numbers of wetlands.

Intensive trapping is a more effective way to survey wetlands for Blanding's turtles, although it is far from efficient. Trapability drops considerably as nesting season arrives, and trapping is generally less effective during summer months. Traps (e.g., hoop nets baited with sardines) are most effective during April and May. Trapping provides the advantage of being able to mark, sex, and measure animals. Individuals vary in their susceptibility to trapping. Some are extremely shy of traps, while others will reenter traps repeatedly. Given the difficulty of trapping Blanding's turtles, their varying responses to traps, their long-distance movements, and their rarity on the landscape, surveys with the goal of determining population size or density are generally impractical at multiple sites. The effort required to gain a reliable estimate of population size should be considered an intensive study, and the ability to make inferences to other sites is low. Surveys should usually focus on presence/absence or coarse estimates of relative abundance.

Modeling studies

Because Blanding's turtles are relatively difficult to detect, expensive to track, and have long generation times, extensive field research on population status and trends has not been conducted in the past, and will likely be conducted only in limited fashion in the future. Modeling studies

offer a relatively low-cost way of partially meeting these needs. Applied conservation modeling is currently being carried out at both the University of Maine (F. Beaudry, pers. comm.) and the University of Massachusetts (B. Compton, unpublished data). Because the results of modeling often present new insights, pose new questions, and suggest further refinements, it is likely that continued research into modeling of population viability, habitat selection, and movements on the landscape will be appropriate. Initial rounds of modeling may help identify further empirical data to be collected. Field-based validation of models (e.g., surveys at predicted sites) can help inform future rounds of modeling. Current modeling needs (which are being addressed by both current efforts) are a better understanding of potential population viability at individual sites. It is important to note that with a species as long-lived as Blanding's turtles, absolute measures of viability can only be modeled, never tested in the field. Models of population viability are typically fraught with error, such that results are more usefully viewed as relative rather than absolute measures of viability (Beissinger and Westphal 1998, pp. 833-834). As such, results from such spatially-explicit population viability models can be used to help identify populations that have the highest chance of persisting over time, thus helping to focus conservation efforts.

Other regional assessments

A conservation assessment of Blanding's turtles in Nebraska and South Dakota has been prepared for the USDA Forest Service, Rocky Mountain Region (Congdon and Keinath 2006). Although focused on populations at the western edge of the range, where some extremely large populations occur, much of the discussion is pertinent to Blanding's turtles in the Northeast. This assessment covers life history, ecology, and conservation issues of Blanding's turtles. It includes a detailed life history model as an appendix (discussed on page 39, above). The following recommendations are summarized from the section on "conservation elements, tools, and practices."

Habitat and population management

- Populations are best maintained in areas with uncontaminated wetlands, relatively large areas of associated nesting habitat, and minimal road mortality. To this end, buffer zones should be maintained around wetlands, including small and temporary wetlands.
- Water control structures should be screened to prevent trapping turtles.
- Water drawdowns can be detrimental if conducted during the winter; drawdowns during the active season can lead to high road mortality. If drawdowns are necessary, they should be conducted during the active season, or turtles can be moved to temporary wetlands, holding ponds, or cattle tanks during the drawdown.
- Heavy usage of power boats in large turtle wetlands risk injury and death of turtles, pollute water, damage aquatic vegetation, and damage shoreline habitat used by hatchlings and juveniles.
- Terrestrial corridors should be maintained for movements among wetlands and to nesting sites.
- Controlled burns should be scheduled just after early spring migration from overwintering sites, and in late fall after hatchlings have left nests. Mowing should be avoided during

nesting season, when nesting females would be most at risk.

- Grazing and vegetation control at nesting sites may improve habitat. Overgrazing may increase erosion, and grazing in riparian areas should be discouraged. Forestry should be limited to outside of the nesting season.
- Off-road vehicles should be discouraged, or at least restricted to seasons when turtles are less terrestrial.
- Populations can be extirpated by chronic road mortality. If possible, new roads should not be built in movement corridors; if roads are built, designs should include barriers and culverts or preferably underpasses.
- Surveys of road mortality during periods of high movement (spring, nesting season, and fall) can identify areas with high mortality. Turtle crossing signs should be placed in these areas; if mortality continues, culverts and fencing should be installed. Road mitigation projects should be monitored to assess their effectiveness.
- Collection for the pet trade may be a threat but the extent of collection is unknown; collection has devastated populations of wood turtles.
- Mortality prevention techniques, such as screening nests to prevent predation should be considered for small threatened populations. Consider burying edges 10-15 cm to prevent predation by burrowing mammals. Ensure screening does not excessively shade nests, which can result in male-biased sex ratios and developmental problems.

Inventory and monitoring

- Aquatic trapping and searches of nest sites are effective ways to capture animals. Counts of predated nests can help estimate numbers of females. Censuses of nesting females may be able to take advantage of road crossings; strategically-placed drift fences can help capture nesting females.
- Visual surveys with binoculars or spotting scopes can give reliable presence/absence indications. Dip netting and muddling can be used to capture previously-sighted animals.
- Abundance estimation techniques such as mark-recapture can be effective for small-scale or detailed studies, but are too expensive for large-scale, long-term monitoring. Broader studies may better rely on detection/non-detection surveys.

Captive propagation and reintroduction

- Root causes of extirpated populations must be addressed before captive propagation and reintroduction can succeed. Headstarting programs require intensive effort, and are only likely to be effective where predation rates of hatchlings and juveniles are high. Headstarting hatchlings is less effective than protecting adults, because population stability depends most on survival of reproductive females.

Recovery plans

To date, recovery plans for Blanding's turtles have been completed in Nova Scotia (The Blanding's Turtle Recovery Team 2003) and Québec (Équipe de rétablissement des tortues du Québec 2005).

Nova Scotia

Nova Scotia's Natural Recovery Plan for the Blanding's Turtle Nova Scotia Population lists four strategic objectives: (1) maintain and restore Blanding's turtle population sizes, (2) maintain and restore Blanding's turtle habitat, (3) maintain metapopulation structure, and (4) remove or reduce threats to Blanding's turtles and their habitats. The plan includes a detailed list of actions to address each of these objectives. These actions are presented in condensed form below:

Objective 1: Maintain and restore Blanding's turtle population sizes

- Continue to systematically capture, mark and measure adults and juveniles in each population; develop and evaluate monitoring protocols and capture protocols; standardize data collection, and conduct regular population sampling to monitor demographic structure.
- Continue and expand volunteer nest monitoring program.
- Maintain, validate and update the unified Blanding's turtle database.
- Conduct analysis of long term data sets: estimate population sizes, analyze age structures, calculate survivorship, estimate growth rates, assess reproductive status, and conduct a PVA for each population.
- Continue and evaluate management actions that increase population size, including volunteer nest monitoring, nest protection, and headstarting; promote stewardship and education.

Objective 2. Maintain and restore Blanding's turtle habitat[

- Identify and characterize habitat for Blanding's turtle in each population; develop and refine habitat sampling protocols; monitor change in habitats and habitat use.
- Assess Blanding's turtle movements at multiple spatial and temporal scales; incorporate habitat and movement components into the database; assess the influence of habitat on movements and distribution.
- Develop and implement a habitat protection plan.

Objective 3: Maintain metapopulation structure

- Conduct research and monitoring necessary to better understand metapopulation structure in Nova Scotia Blanding's turtles; systematically survey sites with credible reports and confirm anecdotal sightings.
- Assess the genetic relationship between existing populations and new populations as they are found; periodically assess known populations for change in genetic heterogeneity; adapt and

apply analytical tools to assess the influence of landscape on metapopulation structure; and assess the instability in demographic structure of each population in Nova Scotia.

- Develop an overall strategy for the conservation of the Nova Scotia metapopulation that incorporates the ecological scales of Blanding's turtles; maintain processes that contribute to the current genetic sub-structuring.

Objective 4: Reduce or remove threats to Blanding's turtles and their habitat

- Conduct research and monitoring to assess threats, including threats to nest success; monitor threats to habitat including agriculture, forestry, and development; develop tools to model threats; and develop strategies to address threats.
- Continue to increase habitat protection; deal with specific threats as they arise; continue to promote stewardship; and develop and implement a communications plan for the recovery and conservation of Blanding's turtle.

Québec

In Québec's Plan de Rétablissement de Cinq Espèces de Tortues au Québec pour les Années 2005 à 2010, several actions are proposed to meet the objectives of (1) maintaining stable or growing populations of Blanding's turtles at known sites, and (2) securing habitat for known populations. The actions summarized below are highest priority ("essential actions"):

- Adopt a protocol to estimate population size; design and implement standard surveys and resurvey every five years.
- Evaluate the importance of the road mortality threat, based both on existing data and new monitoring.
- Evaluate the importance of illegal collection and commerce by surveying pet stores, herpetological societies, veterinary clinics, etc.
- Define and characterize used habitats where information is lacking (e.g., neonates and juveniles).
- Gain better information on species range via herp atlas, validation of historic records, and new surveys.
- Identify and inventory essential sites such as mating and nesting areas to help determine the status of each regional population.
- Reduce excessive predation on adults and eggs at vital sites preferably via indirect measures such as fencing, but possibly including predator control (after thorough review and approval from regional director).
- Reduce road mortality where it is an important threat and in protected areas via fencing, underpasses, artificial nesting sites, and motorist education.
- Reduce illegal collection via tougher enforcement if it is determined to be an important threat.
- Designate essential habitat.
- Protect essential habitat by administrative and legal means.

- Protect habitats on private property by encouraging voluntary conservation efforts.
- Seek financial partners.
- Continue efforts to list Blanding's turtle as Threatened or Endangered at both the provincial and federal levels.
- Monitor and evaluate proposed actions.
- Establish a code of ethics to guide collaborators in turtle handling, population and habitat management, data management and release, etc.

Several "important" actions were considered of secondary priority:

- Characterize population genetics and connectivity among populations.
- Determine individual health by evaluating the presence of infectious disease, malformations, and injuries.
- Survey to better determine the extent of known populations.
- Control feral exotic turtle species.
- Manage essential habitats.
- General public education on conservation of turtles and their habitat.
- Educate the population on the effects of pet collection.

Finally, these actions were a third priority, to completely meet objectives:

- Determine the parameters of a viable population via PVA.
- Determine the effects of pollutants.

Support populations where necessary via head-starting, captive breeding, introducing individuals to increase genetic diversity; only after careful evaluation.

Northeast partnership in Blanding's turtle research and monitoring

This project (the Northeast Blanding's turtle assessment and associated regional conservation plan) represents one of the first multi-state cooperative projects conducted in the region for a threatened herptile. It is the result of cooperation among federal and state agencies and university researchers, an approach recommended by the federal State Wildlife Grants program. This collaboration among four states, two USFWS offices, a USGS Cooperative Fisheries and Wildlife Research Unit, as well as academic researchers and ecological consultants has resulted in the sharing of available data, information, and informed opinion. This cooperative multi-partner approach is expected to result in a coherent conservation strategy across state lines, and to strengthen future cooperation among researchers and management agencies.

Listing Priority

THREAT			
Magnitude	Immediacy	Taxonomy	Priority
High	Imminent	Monotypic genus	1
		Species	2
		Subspecies/population	3*
	Non-imminent	Monotypic genus	4
		Species	5
		Subspecies/population	6
Moderate to Low	Imminent	Monotypic genus	7
		Species	8
		Subspecies/population	9
	Non-imminent	Monotypic genus	10
		Species	11
		Subspecies/population	12

Rationale for listing priority number:

Magnitude: Threats to Blanding's turtles occur throughout their northeastern range, affecting every population to some extent. Analyses included in this status assessment suggest that road mortality rates are so high that the great majority of Blanding's turtle populations (which are already small and isolated from one another) are severely declining (e.g., 55-71% of land area in the four counties with the majority of Blanding's turtle records in Massachusetts and Maine have road densities and traffic rates high enough to lead to 90% population declines in less than two generations; page 61). These threats are based on current traffic rates, but road mortality has been ongoing at lesser rates for several decades, and is expected to increase in the future. Other effects of development are also ongoing, including habitat loss, population fragmentation, and increases in populations of subsidized predators. The effects of habitat loss and increased traffic are expected to be relatively permanent, absent a radical change in transportation patterns. Based on this assessment, we conclude that the magnitude of threats to the eastern DPS of the Blanding's turtle is high.

Imminence: The major threats to Blanding's turtles (road mortality, habitat loss, population fragmentation, and reduced recruitment due to subsidized predators) are imminent, ongoing, and, in many cases, expected to increase in the future. In particular, road mortality rates have continued to increase with road extent and traffic rates, and will continue to do so in the future. Populations are already severely fragmented, and the great majority of populations are believed to consist of very few animals (less than 50 adults).

Rationale for Change in Listing Priority Number (insert if appropriate)

X Have you promptly reviewed all of the information received regarding the species for the purpose of determining whether emergency listing is needed?

Is Emergency Listing Warranted? After reviewing the current status, distribution and threats associated with the eastern DPS of the Blanding's turtle we have determined that an emergency listing is not warranted at this time. Although the threats to Blanding's turtles in the Northeast are of high magnitude and ongoing, their effects are chronic and incremental. Immediate action is warranted, but the time required by a routine listing process will not add significantly to risks of extinction.

Description of Monitoring

The states within the eastern DPS of the Blanding's turtle plan to continue surveys and monitoring. States will use results of the NEEMBL model of potential habitat (Compton et al. 2007a) to help direct surveys. Coordination among states will continue through the Northeast Blanding's Turtle Working Group.

Coordination with States

Indicate which State(s) (within the range of the species) provided information or comments on the species or latest species assessment: New York, Massachusetts, New Hampshire, Maine

Indicate which State(s) did not provide any information or comments: None.

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Appendix A. Summary of Responses to Blanding's Turtle Status Questionnaire

A questionnaire was sent to members of the Blanding's Turtle Working Group in August 2004. Two additional responses were obtained in July 2006. The thirteen respondents included:

Mark McCollough, USFWS Maine Field Office, Maine
 Stephanie Koch, USFWS Eastern Massachusetts NWR Complex, Massachusetts
 Alvin R. Breisch, Department of Environmental Conservation, New York
 Jesse W. Jaycox, New York Natural Heritage Program, New York
 Michael Marchand, NH Fish & Game Nongame & Endangered Wildlife Program, New Hampshire
 Lori Erb, Natural Heritage and Endangered Species Program, Massachusetts
 Phillip deMaynadier, Department of Inland Fisheries and Wildlife, Maine
 Bradley W. Compton, University of Massachusetts, Amherst
 Frederic Beaudry, University of Maine, Orono
 Brian Windmiller, Hyla Ecological Services, Inc., Massachusetts
 Brian Butler, Oxbow Associates, Inc., Massachusetts
 Tanessa Hartwig, Hudsonia Ltd., New York
 David M. Carroll, artist and naturalist, New Hampshire

Summaries of responses (mean, range, and number of respondents) are sorted by mean priority within each group.

1. What do you see as the major threats to Blanding's turtle populations in your state?

(1 = high, 2 = medium, 3 = low, 4 = not a threat).

a. General categories

1.2 (1-2, n=13)	Direct adult mortality
1.3 (1-3, n=13)	Habitat loss and modification
1.7 (1-3, n=11)	Reproduction and recruitment failure
2.0 (n=1)	Other: Genetic isolation/fragmentation/drift

b. Specific categories

Direct adult mortality

1.1 (1-2, n=13)	Road traffic mortality
2.5 (1-4, n=12)	Increased predation of adults by human-subsidized predators (e.g., raccoons)
2.7 (2-3, n=13)	Agricultural and forestry activities (e.g., mowers or skidders)
2.7 (2-3, n=13)	Casual collection/moving of adults

3.2 (3-4, n=11)	Collection for the pet trade
3.5 (3-4, n=10)	Introduced diseases

Habitat loss and modification

1.2 (1-2, n=13)	Loss of connections among wetlands and nesting habitat due to development
1.9 (1-3, n=13)	Changes in habitat quality due to wetland and upland habitat modification
2.0 (1-3, n=13)	Loss of vernal pools to development and associated hydrological changes
2.7 (1.5-3, n=13)	Changes in habitat quality due to introduction of invasive species
3.5 (3-4, n=11)	Conversion of seasonal to permanent wetlands by increased beaver activity
1.0 (n=1)	Other: urban sprawl

Reproduction and recruitment failure

1.6 (1-3, n=12)	Nest predation by human-subsidized predators
2.0 (1-3, n=13)	Road mortality of hatchlings and juveniles
2.1 (1-3, n=12)	Predation of hatchlings and juveniles
2.3 (1-4, n=13)	Loss of nest sites to habitat modification and succession
1.0 (n=1)	Other: Loss of extensive, interspersed, interconnected habitat mosaics that provide “nursery” habitat
2.0 (n=1)	Other: Destruction of nests in agricultural fields and gravel pits by human activities
3.0 (n=1)	Other: Cool summers at northern edge of range

2. How would you prioritize Blanding’s turtle conservation/recovery needs in your state?

(1 = high priority, 2 = medium priority, 3 = low priority, X = useless or detrimental).

a. General categories

1.0 (1-1, n=13)	Site protection
1.5 (1-2, n=12)	Research
1.6 (1-3, n=13)	Education, outreach, and law enforcement
2.2 (1-3, n=12)	Habitat/population management

b. Specific categories

Site protection

1.0 (1-1, n=13)	Protect known sites through land acquisition and conservation restrictions
1.4 (1-2, n=13)	Protect sites from development through environmental review
1.4 (1-2, n=13)	Identify, protect, and/or establish habitat corridors
2.2 (1-3, n=12)	Protect connectivity between wetlands with passage structures (e.g.

	tunnels)
1.0 (n=1)	Other: Establish conservation planning data and tools for municipalities (e.g. Maine's "Beginning With Habitat" program)

Research needs

1.1 (1-2, n=13)	Research focused on identifying viable populations and strategic conservation
1.4 (1-2, n=13)	Surveys to determine population size/structure/density at known sites
1.4 (1-3, n=12)	Survey potential habitat to identify new populations
1.4 (1-3, n=12)	Survey/assess threats to extant sites
1.9 (1-2.5, n=13)	Basic research into life history, habitat use, and movement patterns
2.1 (1-3, n=12)	Survey/assess historic sites
1.0 (n=1)	Other: Research to assess population response to habitat protection or population augmentation

Education, outreach, and law enforcement

1.0 (1-1, n=13)	Education regarding land protection needs for Blanding's turtles/how to get a CR on your land
1.3 (1-2, n=13)	Education regarding turtles crossing roads
1.6 (1-2, n=13)	Education regarding turtles as pets/casual collection
1.6 (1-3, n=13)	Education regarding turtle life history strategy
1.7 (1-3, n=13)	Education regarding nest sites/what to do when turtles nest on your property
2.3 (1-3, n=12)	Law enforcement targeting commercial collection & trade
2.4 (1-3, n=11)	Prevent poaching or casual collection through law enforcement
2.5 (1-4, n=12)	Law enforcement targeting casual collection

Habitat/population management

1.8 (1-3, n=12)	Nest site management/creation of artificial nest sites
2.1 (1-3, n=11)	Protect Blanding's turtle nests from predators
2.3 (1-3, n=10)	Predator control
2.4 (1-4, n=12)	Restore or modify the hydrology of known sites
2.6 (1-4, n=12)	Vegetation management
2.9 (2-4, n=12)	Conduct head-starting to supplement existing populations
3.0 (2-4, n=11)	Reintroduction of populations
3.3 (2-4, n=11)	Captive breeding of Blanding's turtles for release into the wild
1.0 (n=1)	Other: Use of state and fed funds to protect Blanding's habitat
1.0 (n=1)	Other: Ensure Blanding's have a high priority in SWG plans
1.0 (n=1)	Other: Allow for beaver-dam succession – here are the best "managers"

3. Do you know of any instances of illegal commercial collection in your state? What do you believe is the extent of casual/non-commercial collection?

Commercial:

- **No known commercial collection (n=8)**
- Not popular pets
- Such information would be very difficult to attain
- We suspected collection but never confirmed it was commercial
- In the past 22 years, no Blanding's turtles are known to have been offered for sale through a pet store or other outlet in Massachusetts.

Casual:

- **Thought to exist at a low level (n=12)**
- I know of one or two instances of casual collection.
- I'm sure casual collection occurs (I've seen it in at least one instance), but this is probably infrequent.
- Approximately 15 known cases of opportunistic collection over the past 22 years in Massachusetts.
- We see casual and non-commercial at a rate of 1-2 nests annually.
- Eggs poached from study site. Extent is probably low, but potentially very significant with regard to particular loci/populations.
- Individuals thinking they are doing good by moving turtles when habitat doesn't 'appear' suitable (e.g., road crossings).
- Blanding's turtles are a bit large for the average aquarium, but I think people probably pick them up to show their friends or family and keep for a while, then let them go in the nearest pond or wetland.
- I would estimate that the extent of casual collection is low based on my interactions with the public.
- ...more significantly, re-location (well-intended but ill-advised)

4. Please briefly describe your state's environmental review process. How far from known Blanding's wetlands do you protect? How do you decide how much to modify a project? How could environmental review in your state be improved?

a. For an isolated record from the EO database

- If the record is not in a regulated wetland we don't protect it at all. We would notify an developer that a Blanding's turtle might occur on their property.
- Unfortunately, we have very few data on Blanding's turtles in NH. We have identified a few 'good' sites but most sites in the state are incidental encounters of 1-2 individuals. Even at our 'good' sites, we don't have population estimates. Blanding's turtles have been reported in most towns in southeastern NH. Therefore, element occurrence 'hits' come up frequently during environmental reviews. Blanding's turtles are species of Special Concern in NH. Although technically not afforded the same protection as a T&E species, rare species are

included in wetland permit reviews. There is no standard mandatory minimum distance that development must be from wetlands, whether there is a Blanding's turtle or not. Some towns have special buffer protections, few of which include vernal pools. Environmental Review could be greatly improved by increasing our knowledge of Blanding's turtle populations in NH. Without knowing where the populations are or the status of those populations, it is difficult to prioritize protection.

Depending on the distance from the EO to the proposed development and the habitat in the area, a Blanding's turtle habitat suitability assessment may be requested. Usually, this does not involve trapping.

- This is a complex question, historically sites have not been heavily ranked based on population status, more so now. Extent of at least partial protection may extend overland hundreds of meters pursuant to MESA.
- Generally I require a 250-300 ft setback from an isolated turtle wetland for single house lot developments.
- We map regulated "priority habitat" to incorporate suitable wetland and nesting habitat within +/-1300 m of the record
- For larger subdivision projects I require the 250ft setback and also get into the issue of rearranging house lots to cluster them away from occupied pools and/or compensating for impacts by having the subdivision designate a large block of open space (~ 1/3 of total project acreage) around the wetlands in question. Other issues that I have regulated in larger developments include road access width (narrow), type (unpaved), and wildlife underpass standards. Also, in larger subdivisions I require that each individual house/lot footprint size not exceed 4,300 sq ft for house, septic, yard, garage, etc.
- My personal experience leads me to state that environmental review (i.e. environmental consultant's to developers' assessments, recommendations, and designs, et al.) utterly fail to truly protect habitat, and therefore the species.
- Currently, NY Natural Heritage Blanding's turtle occurrences are mapped as a) occupied wetlands, b) occupied wetlands and associated uplands known to be used by the Blanding's turtle population, and c) road-crossing records (including turtles found DOR).

NY Heritage has been reporting Blanding's turtles as "on-site" hits within 200 meters of a project site. This means we report detailed location information and show the location on a map. If a Blanding's turtle location is beyond 200 meters but within 1 kilometer of a project site, we consider it an "off-site" hit. We report that there is a record in the vicinity of the project site but we do not give any detailed location information.

The NYSDEC Endangered Species Unit and appropriate NYSDEC Regional office are cc'd on NY Heritage Program information requests and it is up to the DEC to decide if a project needs modification.

b. For a site with several known individuals and some information about particular wetlands used.

- Same general standards as isolated EOs but the buffers and corridors start to overlap and the development opportunities become more and more restricted.
- NYS law only allows us to protect 100 ft from a regulated wetland. We notify developers if

they are within 1000 ft of the wetland.

- Currently, NY Natural Heritage Blanding’s turtle occurrences are mapped as a) occupied wetlands, b) occupied wetlands and associated uplands known to be used by the Blanding’s turtle population, and c) road-crossing records (including turtles found DOR)

NY Heritage has been reporting Blanding's turtles as “on-site” hits within 200 meters of a project site. This means we report detailed location information and show the location on a map. If a Blanding's turtle location is beyond 200 meters but within 1 kilometer of a project site, we consider it an “off-site” hit. We report that there is a record in the vicinity of the project site but we do not give any detailed location information.

The NYSDEC Endangered Species Unit and appropriate NYSDEC Regional office are cc'd on NY Heritage Program information requests and it is up to the DEC to decide if a project needs modification.

- Attempt to limit development and protect best areas with conservation easements/restrictions. Limiting development in a meaningful way isn’t easy!!
- If there are multiple records on the landscape, we map regulated “priority habitat” to incorporate suitable wetland and nesting habitat within up to 2250 m of the record. Projects resulting in a “take” of the state-listed Blanding’s Turtle must meet the standards for issuance a Conservation & Management Permit, pursuant to the MA Endangered Species Act Regulations (321 CMR 10.23). The extent of impact that our review will have on a development depends on a number of factors including, known turtle population size and movement patterns and juxtaposition of proposed development relative to key habitat features and likely movement corridors. Increased site, specific data on population size, physical extent of population, and movement patterns would (and has) significantly improved our ability to conduct reviews.

5. What should be the fate of marginal Blanding’s turtle habitat (e.g., occupied habitat that may not be capable of supporting a viable population due to its small site, poor habitat quality, high road density, or other threats)? Check all that apply.

(n=13)

10	Protect it if it is connected or proximate to another occupied Blanding’s site
8	Instead of protecting it, require mitigation (at another site) if someone proposes to degrade or destroy it
3	Protect it, regardless of size, habitat quality, or threats
0	Do not attempt to save it
0	Supplement the population via head-starting
1	Other: We don’t have a policy. This should be a major discussion point

Comments:

- Be careful about writing off “marginal” populations!!!
- Headstarting is a terrifically bad idea in my estimation
- In applying our Endangered Species Act I am forced to be consistent across all locales in terms of enforcement. I also question whether we know enough about what landscape metrics/thresholds constitute a viable population so would be inclined to be conservative and

apply equal protection to all occurrences. If, however, by “protection” you mean the full tool chest of nonregulatory options (landtrust activity, state acquisition, landowner outreach, etc.) then I agree that a triage approach should be implemented with attempts made to prioritize among populations.

6. What would be the most useful products of a regional conservation plan to your state?

(1 = high priority, 2 = medium priority, 3 = low priority, X = useless or detrimental).

1.0 (1-1, n=11)	Discussion of a conservation strategy (to help define priorities)
1.1 (1-2, n=11)	Discussion of conservation tactics (e.g., land protection, headstarting, etc.)
1.5 (1-3, n=11)	Maps/GIS layers based on modeling of potentially viable populations at a broad scale (regionally or statewide)
1.5 (1-3, n=11)	Maps/GIS layers based on modeling of viability at a finer (e.g., town) scale
1.6 (1-2, n=11)	Basic Blanding’s ecology: discussion of habitat use, movement patterns, and life history strategy
1.6 (1-3, n=11)	Summary listing population sizes, etc. at known sites (from EO databases)
1.9 (1-3, n=10)	Maps/GIS layers based on modeling of probability of occurrence at a very fine scale (e.g., probability of crossing at a specific road segment)
2.1 (1-3, n=10)	Additional information for known sites from GIS and modeling
1.0 (n=1)	Other: Assess population viability rangewide/population modeling
2.0 (n=1)	Other: Assess state/NatureServe status

7. Who is the target audience of a regional conservation plan? (check all that apply) (n=11)

11	State Fish & Wildlife staff
11	Nongovernmental conservation organizations (e.g., TNC)
8	Consultants for development projects
7	Town or county-level governments
6	Large landowners (e.g., agricultural or timber interests)
1	Other: U. S. Fish and Wildlife Service for listing purposes
1	Other: Landowners in known Blanding's habitat

Appendix B. Summary of Blanding's turtles research in the Northeast

This appendix summarizes significant studies of Blanding's turtles in the northeastern United States (New England and eastern New York). Some minor studies (e.g. small telemetry studies as part of a development project) have been omitted. Each project lists investigators (in alphabetical order; emails are listed for primary contacts), the years and location of the study, a brief summary of the scope and techniques, and references to unpublished reports and published literature.

Maine

Study: Joyal study

Researchers: Malcolm L. Hunter, Jr., Lisa Joyal, Mark McCollough
(mark_mccollough@fws.gov)

Years: 1992-1993

Location: York County

Summary: 9 Blanding's turtles were tracked with radiotelemetry. Focus on habitat selection, seasonal movement patterns, population structure, and nesting.

Unpublished reports: (Joyal 1996), (Hayes 2000)

Publications: (Joyal et al. 2000, 2001)

Study: Beaudry study

Researchers: Frederic Beaudry (frederic_beaudry@umit.maine.edu), Phillip deMaynadier
(phillip.demaynadier@maine.gov), Malcolm L. Hunter, Jr.

Years: 2004-2006

Location: York County

Summary: Ongoing study has captured 135 Blanding's turtles (54 recaptures and 81 new animals); tracked 50 with radiotelemetry over the course of three years. Average tracking period for individual turtles was 162 days. Focus on movements, habitat selection, and road crossing behavior, with goal of modeling road mortality hot spots and building spatially-explicit population viability model.

Unpublished reports: (Beaudry et al. 2005; Haskins et al. 2005)

Publications:

Study: MDIFW surveys

Researchers: Phillip deMaynadier (phillip.demaynadier@maine.gov), Jaime Haskins, Mark McCollough

Years: 1990-2003

Location: York County

Summary: Ongoing field surveys since 1990 with nearly 3,000 wetlands surveyed by binocular, wading, trapping, and/or telemetry; in 2002-2003, 75 wetlands with previous (>10 yrs) Blanding's turtle records were resurveyed. Blanding's turtles were found in only 20% of wetlands surveyed; likely because insufficient survey effort was expended. Preliminary analysis shows that turtles were significantly less likely to be detected in wetlands close to

major roads than those far from major roads, suggesting ongoing reduction or extirpation of populations due to road mortality (P. deMaynadier, Maine Division of Inland Fisheries and Wildlife, pers. comm.).

Unpublished reports: (Haskins and deMaynadier 2001, 2003)

Publications:

New Hampshire

Study: UNH telemetry study

Researchers: Kim Babbitt (kbabbitt@hypatia.unh.edu), Robin Jenkins, John Kanter (jkanter@wildlife.state.nh.us)

Years: 2000-2002

Location: southeastern New Hampshire (two sites: Great Bay and Concord)

Summary: 18 Blanding's turtles tracked for three years. Home range, habitat, movements, nesting, etc.

Unpublished reports: (Babbitt and Jenkins 2003)

Publications:

Study: New Boston Air Force Station

Researchers: Stephen Najjar (stephen.najjar@newboston.af.mil)

Years: 2004-present

Location: Amherst, Mont Vernon and New Boston, New Hampshire

Summary: Currently have 6 Blanding's from New Boston AFS with transmitters and one Blanding's with transmitter that NH Fish and Game released there.

Unpublished reports: (Najjar and Drake 2004; Kostrzewski et al. 2005)

Publications:

Massachusetts

Study: UMass Blanding's turtle project

Researchers: Brad Compton (bcompton@nrc.umass.edu), Mark Grgurovic (markg@swampwalkers.com), Dave Hastings, Paul Sievert (psievert@nrc.umass.edu)

Years: 2001-2003 (telemetry), 2001-2004 (field component), 2001-present (modeling)

Location: >10 sites in northeastern Massachusetts, centered on Groton and on Groveland

Summary: Telemetry study at multiple sites. 4500 telemetry locations of 69 animals, 50 nests found, hatchlings tracked, surveys, habitat analysis, viability modeling.

Unpublished reports: (Grgurovic 2002; Jones 2002; Compton and Sievert 2004; Grgurovic 2007)

Publications: (Grgurovic and Sievert 2005)

Study: Fowle surveys

Researchers: Suzanne Fowle, Scott Melvin (scott.melvin@state.ma.us)

Years: 1998-2000

Location: Various sites in eastern Massachusetts

Summary: Surveys of promising sites for several rare herptiles, including Blanding's turtles, and design of proposed reserves. Blanding's turtles were found at six sites.

Unpublished reports: (Fowle 2001)

Publications:

Study: Hyla Great Meadows study

Researchers: Ian Ives and Bryan Windmiller (bwindmiller@hyla-ecological.com)

Years: 2003-present

Location: Great Meadows NWR

Summary: Captured 38 adults and juveniles; radiotelemetry of 38 adults. Small-scale headstarting and tracking of headstarted juveniles.

Unpublished reports: (Hyla Ecological Services 2003; Windmiller 2004; Windmiller and Ives 2005)

Publications:

Study: Oxbow nest tracking, etc.

Researchers: Brian Butler (butler@oxbowassociates.com), Christine Kavalasuskas, Scott Smyers, et al. at Oxbow Associates

Years: ca. 1984-present

Location: eastern Massachusetts

Summary: Annual monitoring of nesting females, nest protection, hatchling release, and headstarting. Sixty-three hatchlings followed with fluorescent dye in 1990.

Unpublished reports: (Butler 1986, 1992; Oxbow Associates 2003, 2004, 2005)

Publications: (Butler and Graham 1993; Butler and Graham 1995; Butler 1997)

Study: Terry Graham's Great Meadows work

Researchers: Terry Graham, et al.

Years:

Location: Great Meadows NWR

Summary: Trapping, mark-recapture, nesting ecology, and physiology.

Unpublished reports:

Publications: (Graham and Doyle 1977; Graham 1979; Graham and Doyle 1979; DePari et al. 1987; Linck et al. 1989; Graham and Butler 1993)

Study: Towermarc

Researchers: Brian Butler, Scott Smyers (smyers@oxbowassociates.com), et al.

Years: 1996-2000

Location: Boxborough

Summary: Several turtles tracked at site where office park was to be built; site later taken on by UMass Blanding's project

Unpublished reports: (Smyers and Egan 1997; Oxbow Associates 2000)

Publications:

Study: NHESP surveys, 2004-2006

Researchers: Mark Grgurovic (markg@swampwalkers.com)

Years: 2004-2006

Location: various sites in eastern Massachusetts

Summary: Visual and trapping surveys, radio-telemetry, nest site surveys, mapping potential habitats. Initiated a citizen science approach to turtle conservation; public outreach, nest protection and monitoring, surveys, and land acquisition.

Unpublished reports: (Grgurovic 2004, 2005, 2006)

Publications:

New York (eastern population)

Study: Hudsonia study

Researchers: Tanessa Hartwig (hartwig@bard.edu), Erik Kiviat (kiviat@bard.edu), et al.

Years: 1996-present

Location: Dutchess County

Summary: Ongoing studies of movements and habitat selection. Monitoring turtle responses to constructed wetlands as part of a school expansion project.

Unpublished reports: (Kiviat 1993)

Publications: (Kiviat 1997; Kiviat et al. 2000; Kiviat et al. 2004)

Study: Breisch/TNC headstarting

Researchers: Al Breisch (arbreisc@gw.dec.state.ny.us)

Years: 1994-present

Location: Dutchess County

Summary: Habitat and population management study: nest site creation; females tracked; 59 headstarted hatchlings released between 1995 and 2000; ongoing monitoring of survival of headstarted and wild-hatched juveniles.

Unpublished reports:

Publications:

Study: Disjunct population in Saratoga County

Researchers: Al Breisch (arbreisc@gw.dec.state.ny.us)

Years: 2003

Location: Saratoga County

Summary: Four gravid females have been found at this disjunct site. Two female turtles were radio-tracked in 2003 and five turtles (four female and one male) were radio-tracked in 2005 (Michael Kallaji, pers. comm.).

Unpublished reports: NYS DEC (Michael Kallaji) has unpublished report.

Publications:

Study: State Wildlife Grants High Priority Reptile and Amphibian Survey

Researchers: Jesse Jaycox (jwjaycox@gw.dec.state.ny.us); Dutchess County Blanding's turtle study contracted to Hudsonia, Ltd. (Erik Kiviat (kiviat@bard.edu), Tanessa Hartwig (hartwig@bard.edu))

Years: 2006

Location: Dutchess County

Summary: Standardized trapping protocol was tested at three wetlands (two wetlands known to be occupied by Blanding's turtles, and one potential wetland). Trapping took place at two week intervals at each wetland from May to September in an effort to define the most effective trapping periods for Blanding's turtles in southern NY.

Unpublished reports: A report outlining the survey efforts and results, including suggested standardized survey protocol, is expected in January 2007.

Publications:

Appendix C. Summary of Heritage Element Occurrences in the Northeast

Element occurrences by county

Table 13. Element occurrences (EOs) in the Northeast summarized by county. EOs are the number of processed element occurrences (page 30). First-obs and last-obs are first and last observation dates within each EO. Min-turtles is the sum of the minimum number of observed turtles in each EO; N-roadkills is the sum of roadkills.

County	EOs	First-obs	Last-obs	Min-turtles	N-roadkills
Maine					
Androscoggin	1	2000	2000	1	0
Cumberland	7	1975	2002	7	0
Oxford	3	2001	2004	3	0
York	34	1963	2006	88	0
Massachusetts					
Bristol	4	1974	2002	3	0
Essex	15	1975	2005	68	4
Middlesex	22	1949	2005	243	9
Norfolk	5	1972	2004	10	0
Plymouth	4	1992	2004	4	0
Worcester	9	1868	2004	291	18
New Hampshire					
Belknap	1	2002	2002	1	0
Carroll	1	2004	2004	1	0
Cheshire	1	2003	2003	1	0
Grafton	1	2003	2003	1	0
Hillsborough	14	1900	2004	27	0
Merrimack	13	1939	2004	13	1
Rockingham	19	1900	2004	53	5
Strafford	12	1966	2004	27	0
New York					
Dutchess	13	1937	2006	51	1
Saratoga	1	2003	2006	6	0

Element Occurrence Mapping Criteria

The following is reproduced from NatureServe Explorer's description of Blanding's turtle (NatureServe 2006, pp. 17-18)

Minimum Criteria for an Occurrence: Occurrences are based on evidence of historical presence, or current and likely recurring presence, at a given location. Such evidence minimally includes collection or reliable observation and documentation of one or more individuals (including eggs) in or near appropriate habitat where the species is presumed to be established and breeding.

Mapping Guidance: Occurrences should include nesting areas, travel corridors between the wetlands and nest sites, and other upland use areas, if known, but occurrences based on captures/observations of individuals in wetlands should include only the known distribution of the population and not include large areas of upland habitat (not known to be occupied) that may extend between occupied wetlands within the appropriate separation distances.

Separation Barriers: Busy highway or highway with obstructions such that turtles rarely if ever cross successfully; untraversable topography (e.g., cliff); densely urbanized area lacking aquatic or wetland habitat.

Alternate Separation Procedure: Separation distances are as follows: continuous riverine-riparian corridors, 10 km; mosaics of aquatic-wetland and undeveloped upland habitat, 10 km; continuous, undeveloped upland habitat lacking aquatic or wetland habitat, 5 km; upland habitat with significant but not intense development (e.g., scattered buildings in otherwise "natural" habitat), 2 km. Other separation distances may be used when adequate site-specific data indicate that these separation distances are inappropriate for a particular population. Any such deviations should be explained in the element occurrence record.

Inferred Minimum Extent of Habitat Use (when actual extent is unknown): 1 km

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Appendix D. Historical Records of Blanding's Turtles in the Northeast

This appendix summarizes pre-1960 historical records of Blanding's turtles in the Northeast from the historical literature. With the exception of Holbrook's description, records from the main range (which includes central and western New York and Pennsylvania) are excluded.

Holbrook (1838, pp. 39-42): Species description of *Cistuda Blandingii* Holbrook (= *Emydoidea blandingii* Holbrook, 1838). "This animal was first observed by Dr. William Blanding, of Philadelphia, an accurate Naturalist, whose name I have given to the species." "The sole locality that can at this moment be assigned to the *Cistuda Blandingii*, is the prairies in the state of Illinois and territory of Wisconsin, where they are said to be abundant. The only specimen I have seen came from Fox river, a tributary of the Illinois."

Storer (1839, pp. 215-216): "By the kindness of Mr. Edward Appleton I have received from Haverhill [Massachusetts] a fine living specimen of this rare species." [= **first Massachusetts record**]

De Kay (1842, p. 26): Not yet found in New York, but probably there. Found by Storer in Haverhill, New Hampshire. [This is in error: Storer is almost certainly referring to Haverhill, Massachusetts].

Linsey (1844, pp. 40-41): "In August 9, 1843, I saw mounted on a stick projecting from a small pond in Darien in this state [Connecticut], a tortoise I took to be this [*Cistuda Blandingii*]; I came so near as to be on the point of laying my hand on him, when he slid off and escaped to my great regret. I believed it certainly this, or the preceding species [*Cistuda clausa* = *Terrapene carolina*], to which it is nearly allied; and as I have never seen the latter in water, it was probably the true Blanding's Tortoise."

Bumpus (1884-1886, p. 5): "Vary rarely found in New England, though abundant in its regular habitat, the prairies of Illinois and Wisconsin." "A specimen [was] captured in Seekonk, Massachusetts (but a short distance from Rhode Island)..."

Abbott (1884, p. 253): According to Schoonhoven (1911, p. 917), Abbot mentions finding a "fierce and snappish" Blanding's turtle in central New Jersey. Discounted by McCoy (1973, p. 1). A review of Abbot's book by James. A. Allen in *The Auk* (1885, p. 88), provides this lovely quote: "Throughout the work the author betrays a penchant for gratuitous and not particularly sagacious speculation..."

Huse (1901, pp. 50-51): A specimen found in Manchester in 1900; another found in Manchester and one in Auburn. [= **1st New Hampshire record**]

Henshaw (1904, p. 3): Present in New Hampshire; Lancaster, Concord, North Reading, Haverhill, and Tyngsborough, Massachusetts, and in Rhode Island. No details given.

Drowne (1905, pp. 5-6) “Recorded in R.I.,” but gives no details. Notes that a specimen in the Roger Williams Park collection is from New York.

Ditmars (1907, pp. 56-57): “Eastward of the Central States it is a comparatively rare species, though the range extends into the Alleghanean region and northeastward through Pennsylvania and New York, into Massachusetts, Rhode Island, and New Hampshire. The species does not occur near the coast regions of New York, Connecticut, or New Jersey.”

Howe (1911, p. 272): Second record from Concord, Massachusetts. Blanding’s turtle captured on July 19, 1911, in the Concord River. The only other Concord record is a specimen taken by Thoreau in the same river.

Schoonhoven (1911, p. 917) “I beg leave to report finding this turtle at Queens, L.I., in June, 1909. It has been placed on the records of the Natural History Survey of Long Island now being made by the Brooklyn Institute of Arts and Sciences. This is the first report, so far as we know, of Blanding’s turtle having been found on Long Island, but Abbott in ‘A Naturalist’s Rambles about Home’ mentions finding it in central New Jersey.” [Both of these records were discounted by McCoy (1973, p. 1)].

Murphy (1916, pp. 59-60): Blanding’s turtle from Long Island. [“Old records from Long Island (Schoonhoven 1911; Murphy 1916) and central New Jersey (Abbott 1884) are unsupported by recent collections, and perhaps should be ignored” (McCoy 1973, p. 1).]

Babcock (1919, pp. 82-83): “While this turtle is nowhere common in New England, it is recorded from Manchester, Milford, and Auburn, New Hampshire; from Haverhill, Lancaster, Concord, North Reading, Tyngsborough, and Billerica, Massachusetts. Drowne states that it is ‘recorded in Rhode Island’ but does not give any definite records. Linsley says there is no absolute Connecticut record, but he thinks he saw one. There is a single record from Long Island, at Queens (Schoonhoven 1911). In a collection of the Boston Society of Natural History are specimens from Billerica, Mass.; Tyngsborough, Mass.; and Concord, Mass. This last specimen (a shell only) is of special interest, as it was collected and presented to the Society by Henry David Thoreau.” “Blanding’s turtle is rare in New England, although reported as abundant in Indiana and other Central States.”

Stewart (1928, p. 24): Reports two specimens from the Lewisburg area, along the Susquehanna River in central Pennsylvania, one taken in 1905, and the other in 1927.

Babbitt (1932, p. 26): “One specimen was taken by me at Canton [Connecticut] in May, 1925.”

Netting (1932, pp. 173-174): Discusses Pennsylvania records: two specimens from Crawford County (in the main range), and two specimens from Union County in central Pennsylvania (Stewart 1928). Netting presents several hypotheses for their presence, and includes this interesting statement: “In a letter to me Dr. Stewart writes, ‘It is possible that in some years past teachers of zoology here may have liberated some imported material.’ ... The fact that Blanding’s turtle was used widely in the past in comparative anatomy classes lends credence to this view.” **Lamson (1935, p. 32):** “This is a western species, which sparingly occurs

in the eastern states. It does not, however, occur near the coastal areas of Connecticut, New York, or New Jersey. Connecticut records appear to be confined to westerly portions of the state, and are not common.”

Netting (1939, p. 124): “Records from Union and Northumberland County [Pennsylvania] probably represent escaped specimens.”

Pawling (1939, p. 168): “Several specimens have been picked up in the county [Union County, Pennsylvania]. There is the possibility that these are releases.” **Pope (1939, p. 110):** “East of the territory already outlined, Blanding’s Turtle has two small areas of distribution: one (in which the species is not rare) in eastern Ontario along the lower St. Lawrence and the country bordering the eastern end of Lake Ontario; the other (in which it is rare) in eastern Massachusetts and the southeastern corner of New Hampshire. Bordering on the latter area one finds a recent reliable record for central Connecticut [presumably Babbitt (1932)], a sight identification for the southwestern part of the same state [(Linsley 1844)]; a reliable record for the Lewisburg region, eastern Pennsylvania [(Stewart 1928)]; a highly questionable one for central New Jersey [(Abbott 1884)], and one for Long Island that is little better [Schoonhoven (1911)]. There is in addition an old indefinite record for Rhode Island. It is possible that some of these peripheral records are based on escaped specimens; on the other hand the fact that this turtle has a habit of turning up rare in widely separated places argues against such an explanation. Netting [(1932)] offers five possible explanations of the spotty Pennsylvania distribution, which, though interesting, are too detailed to be taken up here.”

Hecht (1943, pp. 196-197): Two specimens collected in August 1941 near Freedom Plains, Dutchess County, New York. Both deposited in AMNH. “These records shorten the distance between the isolated records of New England and other colonies to the west. The only other record for eastern New York is a doubtful one for Long Island (Pope 1939).”
[= **1st eastern New York record**]

Finneran (1948, p. 126): “*Emys blandingii* (Holbrook). A male of this species was taken [in Branford, Connecticut] during the summer of 1940. This appears to be the first recent record for the Connecticut coast.”

Schmidt (1953, p. 93): In the east, Blanding’s turtle is found in “New York, Massachusetts, and New Jersey. Occurrence in the east in isolated colonies.”

Barden (1952, pp. 279-280): A Maine record for Blanding’s turtle. [“This report is based on a misidentification (*vide* R. Conant)” (McCoy 1973, p. 1)].

Packard (1960, p. 86): A road-killed Blanding’s turtle found in Waterboro, Maine. [= **1st Maine record**]

Bleakney (1958; as cited in Bleakney 1963, pp. 67-69) Three nesting females observed (one captured) in 1953 on the shore of Lake Kejimikujik, Nova Scotia. [= **1st Nova Scotia record**]

McCoy (1973, pp. 1-2): Reviews some distributional records.

Klemens (1993, p. 151): Lists Blanding's turtle as an extralimital species in Connecticut:

“Blanding's turtle, *Emydoidea blandingii*, has been reported from widely separated sections of Connecticut by Linsley (1844), Babbitt (1932), and Finneran (1948). I have been unable to locate any populations of Blanding's turtles within Connecticut. Although secretive, this large species is readily trapped and basks conspicuously, therefore a population could not easily escape detection. The range of Blanding's turtle is characterized by disjunct populations, therefore it is conceivable that some Connecticut records represent extirpated populations. If these literature reports were from the same section of the state, a stronger argument could be made for this species' historical occurrence within Connecticut.”

APPROVAL/CONCURRENCE: Lead Regions must obtain written concurrence from all other Regions within the range of the species before recommending changes, including elevations or removals from candidate status and listing priority changes; the Regional Director must approve all such recommendations. The Director must concur on all resubmitted 12-month petition findings, additions or removal of species from candidate status, and listing priority changes.

Approve: _____
Regional Director, Fish and Wildlife Service Date

Concur: _____
Director, Fish and Wildlife Service Date

Do not concur: _____
Director, Fish and Wildlife Service Date

Director's Remarks:

Date of annual review:

Conducted by: