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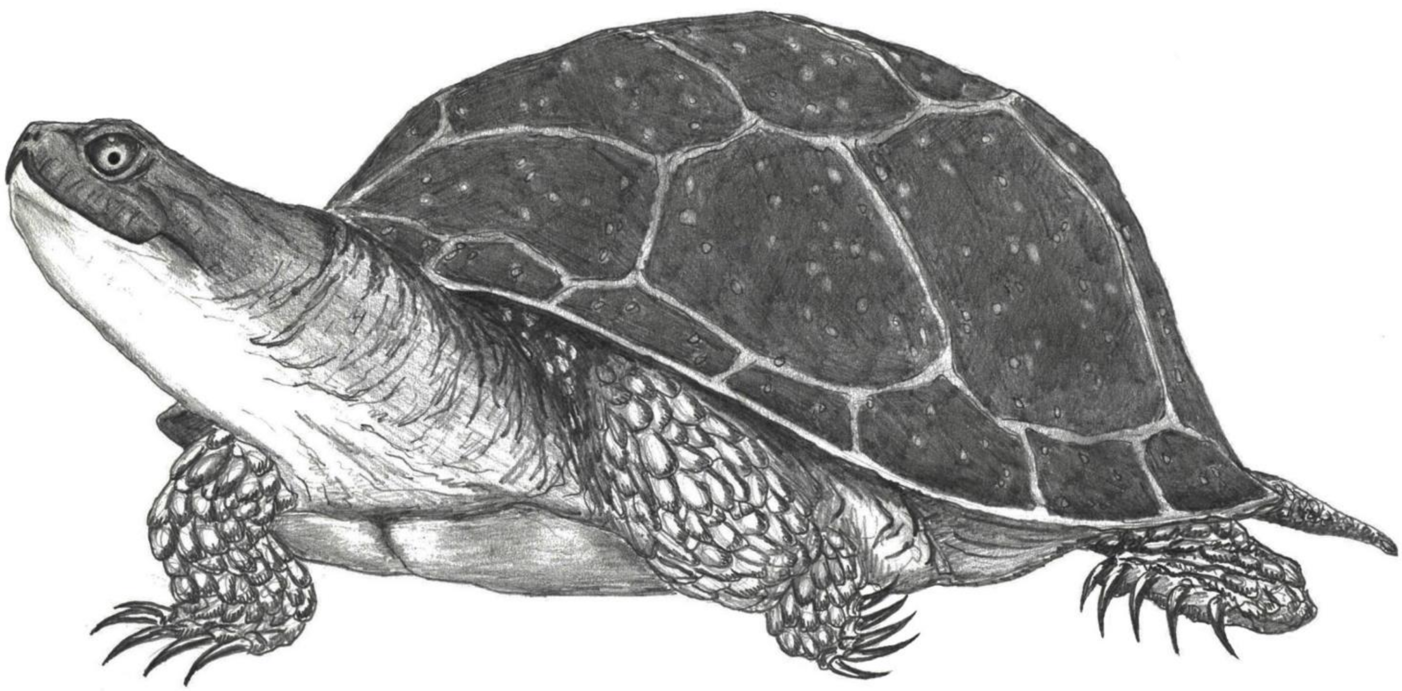
NEW YORK STATE OF OPPORTUNITY. Department of Environmental Conservation

Conservation Plan for populations of the

BLANDING'S TURTLE

(*Emydoidea blandingii*)

January 29, 2018



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Conservation plan for populations of the Blanding's Turtle
(*Emydoidea blandingii*)

January 29, 2018

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MISSION & GOALS

This conservation plan provides basic information about New York State threatened Blanding's turtle's natural history and biology, and identifies conservation goals, objectives, strategies, and actions for approaching a self-sustaining population of the species in New York. Under Environmental Conservation Law (ECL) 11-0535 and New York Codes, Rules, and Regulations (NYCRR) Part 182.6, the New York State Department of Environmental Conservation (DEC) may, at its discretion, prepare and adopt a recovery plan for any listed species. Further, NYCRR states, *"A recovery plan will set forth goals and objectives to foster the continued survival, recovery, and eventual de-listing of the species, and will also include the most current information on the biology, needs, management of and threats to the species. Recovery plans are not required, but may be adopted by the department when sufficient information is available on any particular listed species, especially when such information might be helpful in identifying and recommending conservation measures that will aid in the recovery of the species."* To that end, the actions presented in this conservation plan, if followed, may not explicitly result in self-sustaining populations of the species in New York. However, it represents a culmination of the best science that we have on regarding the species to date. We believe that if these actions are followed, Blanding's turtles will approach a self-sustaining population in New York into the future. To solicit input for the development of this draft, a conservation team of DEC and other interested biologists, non-governmental organizations, landowners, the public, and other stakeholders was formed. The intention of this plan is to guide actions that, if taken, will promote self-sustaining populations of Blanding's turtles in New York.

Suggested citation:

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Last but not least, we thank the Blanding's turtle who, despite all of our poking and prodding, somehow still manages to smile.

EXECUTIVE SUMMARY

Current Status

The Blanding's turtle (*Emydoidea blandingii*) is a threatened species in New York and is considered a candidate (Category 2) for federal listing. In the absence of extensive long term studies, it is difficult to assess the population trends of a long-lived species such as the Blanding's turtle. However, population modeling efforts and information regarding life history characteristics and the degree of threats to the species suggest a population decline in New York. For example, the species is very long-lived, has delayed sexual maturity and very low recruitment into adulthood. In addition, until relatively recently, researchers did not have a comprehensive knowledge of the species' distribution in the state. Researchers have found that the species is distributed in four populations or conservation units: one centered in northern New York in St. Lawrence and Jefferson Counties, one in Saratoga County, one in Dutchess County, and another in Erie County. As of 2017, considerable information regarding the Blanding's turtle's distribution in the Northern New York, Dutchess County, and Saratoga County Conservation Units exists. In addition, while many threats facing the species have been identified, the magnitude of these threats on local populations has not been fully assessed. Modeling of Blanding's turtle population dynamics has shown that the greatest threats to Blanding's turtle populations are likely the loss of individuals to mortality on roads, low survivorship of young turtles (e.g., nestlings), and the loss and fragmentation of habitat due to residential and commercial development. Results of population viability models (PVA) can be found in Appendix 1.

Habitat Requirements and Limiting Factors

In New York, the Blanding's turtle generally occurs in scrub/shrub wetlands dominated by willow (*Salix* spp.) and buttonbush (*Cephalanthus occidentalis*). Across its New York range, the species also regularly uses temporary wetlands such as vernal pools. Such wetlands tend to be distributed in a patchy manner throughout the state. Like most turtle species, female Blanding's turtles travel varying distances, sometimes greater than 1 km, from wetlands to uplands to nest. High quality Blanding's turtle habitat consists of a complex that provides wetland and upland cover types used during foraging, breeding, nesting, summer, and overwintering activities in close proximity to one another. Factors limiting the Blanding's turtle population in New York State include (1) habitat loss and fragmentation, (2) mortality from collisions with vehicles on roads, particularly the loss of older female turtles, and (3) high rates of nest predation.

Conservation Goals[1]

The overall goal of the Blanding's turtle conservation plan is to provide guidance to achieve, protect, and maintain self-sustaining populations of the Blanding's turtle and its essential habitat in New York State. Through a set of conservation actions detailed herein, we propose to ensure a 95 % probability of maintaining extant populations of Blanding's turtles in the four conservation units through the next 300 years (roughly 10 generations).

Conservation Goals are the following:

1. Recruitment into various age classes that is sufficient to prevent population declines in the Northern New York, Dutchess County, Saratoga County, and Western New York Conservation Units.

2. Protection and maintenance of at least 50 % of occupied habitat (wetland and nesting habitat) in each of the conservation units is achieved by direct land acquisition or the establishment of conservation easements.

3. Maintenance of genetic diversity of remaining populations of Blanding's turtles within and across all conservation units is achieved.

Actions Needed[2]

1. Develop more precise estimates of life history parameters such as annual mortality rates, nest success, etc. using data from New York populations and apply this information to refine a population viability analysis.

2. Identify the status and distribution of the Western New York population.

3. Continue periodic monitoring of Blanding's turtle populations consistent with the protocols developed by the Northeast Blanding's Turtle Working Group to identify status and trends of known populations and to identify new populations.

4. Determine which mitigation efforts are effective at reducing road mortality and the impact of ecological traps.

5. Evaluate effectiveness of mitigation efforts employed by developers to provide a net conservation benefit to Blanding's turtles.

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[1] The following actions have been determined with the aid of a population viability analysis (Appendix 1).

[2] All actions identified within this section are determined to be equally important. Some actions can be undertaken simultaneously.

6. Recruit at least one adult female turtle into each of five long-term monitoring sites every 10 years in the Northern New York and Dutchess County Conservation Units to offset the loss due to road mortality.

7. Recruit at least five new females into the breeding population every 10 years in the Saratoga Conservation Unit.

8. Protect at least five nests per year until hatching in both the Northern New York and the Dutchess County Conservation Units, and at least one nest per year in the Saratoga County Conservation Unit.

9. Headstart and release at least 20 individuals (1:1 sex ratio) at age one or older into both the Northern New York and Dutchess County Conservation Units at 10 year intervals. Headstart and release at least 10, 1-year-old females into the Saratoga County Conservation Unit at 10 year intervals.

10. Secure long-term protection of at least 50 % of occupied habitat for Blanding's turtle populations via land acquisition or the establishment of conservation easements. Include all habitats that support essential Blanding's turtle behaviors (e.g., foraging habitat, wintering habitat, nesting habitat, aestivation habitat, and movement corridors).

11. Maintenance of at least 75 % of the initial genetic heterozygosity (i.e., an index of genetic diversity) in the population of Blanding's turtles in the Saratoga County Conservation Unit and 75 % of the initial heterozygosity in at least 5 long term monitoring sites in both the Northern New York and Dutchess County Conservation Units.

12. Continue work with partners in other states and the Seneca and Akwesasne Nations to develop and implement site-specific management plans for the species throughout the northeast.

13. Develop and implement an effective outreach and education program to inform the public about threats to Blanding's turtles and how to mitigate these threats.

14. Protect known extant populations and their habitat using existing regulations and continued administrative support.

Continue to apply those practices which have contributed to Blanding's turtle conservation and monitor results into the future.

Date of Conservation Plan Review

An updated status assessment using state-specific life history information, which will include a refined PVA and a review of conservation efforts completed at that time, shall be developed on or before 2030. The review should identify which conservation actions have taken place and the current population status at that time.

INTRODUCTION

The Blanding's turtle (*Emydoidea blandingii*) is a threatened species in New York and has been considered a candidate (Category 2) for federal listing (US Fish and Wildlife Service). The species also has an unofficial designation as endangered with a declining population trend by the International Union for Conservation of Nature and Natural Resources Red List (van Dijk and Rhodin 2011). In the absence of extensive long term studies, it is difficult to assess the population trend of the species in the state. However, population modeling efforts coupled with information regarding life history characteristics and the degree of threats to the species suggest a population decline in New York. For example, the species is very long-lived, has delayed sexual maturity, and very low recruitment into adulthood (Congdon et al. 2008). In addition, until relatively recently, researchers did not have a comprehensive knowledge of the species' distribution in the state. In 2008, a State Wildlife Grant was funded to draft a Blanding's Turtle Conservation Plan for New York. To write the plan, a meeting was convened with representatives from the New York State Department of Environmental Conservation, universities, non-government organizations, the public and various stakeholders to outline and discuss what management actions should be undertaken to conserve the Blanding's turtle in New York. In short, the conservation plan outlines information regarding the species' natural history and biology, conservation goals, objectives, strategies, and actions that should be explored to meet the overall goal of maintaining a viable population of Blanding's turtles and their associated wetland community in the state.

It is understood that the implementation of this conservation plan will be subject to appropriations and budgetary constraints of participating agencies and organizations. Therefore, some aspects of this plan may not necessarily be implemented immediately or in their entirety. The purpose of this plan is to outline and discuss all possible scientifically tested conservation actions that should be taken to help lead to effective Blanding's turtle conservation.

GEOGRAPHIC SCOPE

This conservation plan focuses on the New York State population of Blanding's turtles, which occur in four disjunct populations: the westernmost in Niagara and Erie Counties, the northernmost spanning from Jefferson County through extreme northern Lewis County through St. Lawrence and into western Franklin County, the east-central in Saratoga County, and the southernmost in Dutchess County (Figure 1). Blanding's turtles have also been reported in Chautauqua and western Cattaraugus Counties in western New York, but these have not yet been verified. In New York, the Blanding's turtle occupies scrub/shrub wetlands with abundant aquatic vegetation dominated by buttonbush (*Cephalanthus occidentalis*) in southern populations, and willow (*Salix* spp.) in northern populations. Other species that may be present are common duckweed (*Lemna minor*), green ash (*Fraxinus pennsylvanica*), red maple (*Acer rubrum*), beggar ticks (*Bidens* spp.), cattails (*Typha* spp.), sedges (*Carex* and *Scirpus* spp.), coontails (*Ceratophyllum echinatum*), aquatic liverworts (*Ricca fluitans* and *R. natans*), foxtail grass (*Alopecurus aequalis*), mannagrass (*Torreyochloa pallida*), and others (see Kiviat 1993 and Hartwig and Kiviat 2007 for full descriptions). New York represents a portion of the easternmost extent of the species' core distribution, which is generally centered on the Great Lakes, but extends eastward to Nova Scotia (Figure 2).

NATURAL HISTORY

Taxonomy

There has recently been much debate on the taxonomy of North American turtles (Bickham et al. 1996, Burke et al. 1996, Feldman and Parham 2002, Spinks and Shaffer 2009). The Blanding's turtle is a member of the order Testudinata and the suborder Cryptodira. Research on Blanding's turtle molecular data has identified four clades: *Terrapene; Clemmys guttata; C. insculpta, and C. muhlenbergii; and Actinemys marmorata, Emys orbicularis, and Emydoidea blandingii* (Feldman and Parham 2002). To date, there are no recognized subspecies of Blanding's turtles. However, Mockford et al. (2006) identified three significant evolutionarily distinct units from genetic analyses of individuals sampled throughout the species' distribution consisting of the following: (1) the main populations west of the Appalachian Mountains, (2) the disjunct populations east of the Appalachians in southern New York and New England, and (3) the highly disjunct eastern population in southern Nova Scotia. Based on recent molecular studies and fossil evidence, it has been argued that Blanding's turtles may be placed in *Emys* with European pond turtles (Congdon et al. 2008). However, *Emydoidea* has been generally accepted by herpetologists to designate the Blanding's turtle (Crother 2008).

Physical Description

The Blanding's turtle is a semi-aquatic species with an average carapace length of 12.5-18cm (Conant and Collins 1998), and a maximum recorded length of 28.4cm (Ernst and Lovich 2009). The species has a hinged plastron that allows for incomplete closure as compared to the box turtle (*Terrapene carolina*), whose shell may close completely. The hinge becomes moveable by ages two to three and the anterior end can close completely by age five and a carapace length of 10.3 cm (Congdon et al. 2008). The carapace is dark and highly domed with light spots that run together forming small bars (Conant and Collins 1998). The plastron is yellow with dark blotches at the outer posterior corner of each scute. A diagnostic feature of the Blanding's turtle is its bright yellow chin and throat in both adults and young. Blanding's turtles weigh between 750-1,400 g and have 24 marginal and 12 plastral scutes and the first of the vertebral scutes touches the four marginals and the nuchal (Congdon et al. 2008).

Males and females are similar in appearance; however, they are sexually dimorphic for size, such that males are larger than females (Ernst and Lovich 2009, Lefebvre et al. 2011). Other differences include the males' darker upper jaw, its cloacal vent extending beyond the posterior end of the carapace, and its slightly concave plastron. Females tend to have a yellowish upper jaw and a flatter plastron. In addition, females tend to have longer plastrons and more highly domed carapaces than males (Rowe 1992).

Geographic Range

The main range of the Blanding's turtle occurs as disjunct subpopulations centered at the southern edge of the Great Lakes from Nebraska through Iowa, extreme northeastern and northwestern Missouri, southern Minnesota and Wisconsin, northern Illinois, Indiana and Ohio, northwestern Pennsylvania and into western New York, and back around through southeastern Ontario and Michigan. Disjunct populations also occur in eastern and southeastern New York, Massachusetts, southeastern New Hampshire, southwestern Maine, and Nova Scotia (Figure 2). With the exception of two western populations (one each in Nebraska and Minnesota), most populations are relatively small and discontinuous (Congdon et al. 2008). In New York, the Blanding's turtle is distributed in four distinct populations, one in Niagara and Erie Counties; one in Jefferson, St. Lawrence, northern Lewis and western Franklin Counties; one in Saratoga County, and another in Dutchess County (Figure 1). The largest population is located in St. Lawrence and Jefferson Counties in northern New York along the St. Lawrence River, with the second largest population located in Dutchess County. Smaller numbers of turtles have been documented in the Saratoga and western New York populations. The northern and western populations may be regarded as relatively contiguous with the Great Lakes population.

BREEDING BIOLOGY AND DEVELOPMENT

Reproduction

Courtship behavior has been summarized by Baker and Gillingham (1983) and Ernst and Lovich (2009) and consists of the following eight behaviors highlighted here: (1) chasing – male pursuit of the female, (2) mounting – male's climbing onto the female's carapace, (3) gulping – taking water in through the mouth and expelling it onto the female's snout, (4) chinning – placing of the male's head onto the females snout and pressing downward and inward, (5) chin rubbing – moving the head by the male from side to side with the chin or gular in contact with the female's snout, (6) swaying – same as (5) but without contact, (7) violent swaying – rapid swaying from side to side of the male's head and neck extending below the female's plastron, sometimes producing an audible sound and (8) snorkeling – the termination of a behavior by remaining motionless and floating toward the surface to breathe. Courtship and mating typically is a spring/early summer event (March to early July), but individuals have been observed conducting mating activities in every month from early March through November (Graham and Doyle 1979, Vogt 1981, Ernst and Lovich 2009).

The Blanding's turtle has delayed sexual maturity and females begin to breed successfully at about 14-20 years old, with a mean of 17.5 years (Congdon and van Loben Sels 1991, 1993).

Little information exists on the age of first reproduction in males. However, authors have inferred this age based on the development of secondary sexual characteristics, such as a concave plastron and a tail having the cloacal opening distal to the margin of the carapace (Graham and Doyle 1977). For example, males of approximately 12 years old appear to be sexually mature in Massachusetts (Graham and Doyle 1977). Despite the Blanding's turtles' long time to reach sexual maturity, the individuals are able to breed throughout their lives, which can be in excess of 83 years (J. Congdon, pers. comm.). Congdon and van Loben Sels (1993) and Congdon et al. (2008) have observed that females reproduce up to 60+ years. Female Blanding's turtles produce no more than one clutch per year, and in some years they may not reproduce (Congdon et al. 2008). Congdon et al. (1993) completed an analysis of Blanding's turtle life tables and determined that the mean time between generations is approximately 37 years. As a long lived species with low productivity and long generation times, it is no surprise that recruitment into adulthood is very low (Congdon et al. 1983, Ross and Anderson 1990, Pappas et al. 2000). However, older female Blanding's turtles (>55 years old) exhibit increased reproductive output as measured in increased clutch size, reproductive frequency, and adult survivorship (Congdon et al. 2001).

The Blanding's turtle has a promiscuous mating system, whereby females and males mate with multiple individuals (Ernst and Lovich 2009, Refsnider 2009). In a Minnesota population, Refsnider (2009) found that 81.2 % of clutches sampled were sired by multiple males and that the frequency of multiple paternity was among the highest recorded in turtles. In addition, Refsnider (2009) found evidence that female Blanding's turtles also store sperm for later use and suggested that there is female mate choice in the population.

Nesting Ecology

Blanding's turtles nest from May through early July, depending on both the geographic region in which they occur and the weather (Ernst and Lovich 2009). Blanding's turtles exhibit considerable nest site fidelity (e.g., over 73 %) (Standing et al. 1999). In a long-term study by Congdon et al. (2000) in Michigan, Blanding's turtles began nesting between 15 May and 9 July. A Nova Scotia study showed that they began nesting from 10 June to 5 July (Standing et al. 1999). Rowe and Moll (1991) observed nesting between 26 May and 22 June in northeastern Illinois. In a population in Nebraska, Rowe (1992) found that females were gravid between 11 June and 10 July. Minnesota turtles begin nesting from 26 May to 12 June (Pappas et al. 2000), whereas Massachusetts Blanding's turtles begin nesting anywhere from 1-24 June (Linck et al. 1989). In New York, female Blanding's turtles have been found to nest between 28 May and 9 July (A. Breisch, pers. comm., Johnson and Crockett 2009). Blanding's turtles tend to nest in the early evening. For example, Congdon et al. (1983) observed female Blanding's nesting from 5:00 pm-12:45 am, spending an average of 2.5 hours to complete the nest. The average time nests were completed was 9:19 pm (n = 45) (Congdon et al. 1983).

Blanding's turtles can make significant overland movements to reach nesting areas. For example, in a Minnesota population, one female was observed to travel >1,900 m to nest

(Piepgras and Lang 2000). In Michigan, females nested anywhere from 2-1,115 m (mean = 135 m, SE = 14.7) from a wetland (Congdon et al. 1983). In northern New York, one of eight radio-tracked females moved as far as 1,343 m in a straight line (Crockett 2008). In addition, New York turtles made round-trip nesting movements averaging approximately 950 m, with some individuals moving as far as 1,365 m. In general, movements made just before the commencement of nesting can take multiple days and may consist of forays to non-nesting habitats such as woodland pools and temporary marshes before an individual heads to the nest site (Ernst and Lovich 2009). However, nesting movements in areas heavily impacted by disturbance tend to be more restricted (Rubin et al. 2001*b*).

Nesting microsites tend to be those with well-drained soils (e.g., sandy or a mix of gravel and sand to gravelly loam, such as the Hoosic gravelly loam in Dutchess County [Hartwig et al. 2009], and good sun exposure, a low percentage of vegetation, and are in close proximity to water (Congdon et al. 1983, Kiviat 1997, Compton 2007). Dowling et al. (2010) observed that nesting females prefer tilled substrates to areas that have been mowed or weeded. Female Blanding's turtles dig a nest approximately 12 cm deep and deposit their eggs within the nest (Standing et al. 1999). After a female has completed laying, she covers her eggs with substrate and then camouflages it by smoothing the surface flat (Standing et al. 1999). Once the nest is constructed, the female leaves the area and the eggs remain unattended to incubate until hatching. Apart for nest site selection, neither the eggs nor the young are afforded parental care at any time during their lives.

Like many turtle species, Blanding's turtles exhibit temperature-dependent sex determination, in which males are produced at lower temperatures (<28.0°C) and females are produced at temperatures above 30°C (Gutzke and Packard 1987). In the laboratory, incubation temperature also affects hatching success where hatching is greatest at 26.5°C and decreases at 30°C (Gutzke and Packard 1987). Blanding's turtle eggs are not tolerant of incubation temperatures as low as 22°C (Gutzke and Packard 1987), but they are relatively tolerant of dry conditions (Packard et al. 1982). Overwintering of hatchlings in the nest does not occur frequently because exposure to ice in the soil at temperatures below -2.5°C causes ice to penetrate the integument and kill the hatchling turtles (Packard et al. 2000).

Blanding's turtle clutch sizes and hatch dates vary depending on geographic location. For example, clutch sizes range from 3-19 (mean = 10.2 ± 2.5 [± SD]) in Michigan (Congdon and van Loben Sels 1991), 4-17 (mean = 11.4 ± 2.9) in Massachusetts (Compton 2007), 5-11 (mean = 8.5 ± 2.1) in Maine (Joyal et al. 2000), 6-11 (mean = 8.0 ± 1.8) in Ontario (MacCulloch and Weller 1988), and 4-15 (mean = 10.6 ± 2.4) in Nova Scotia (Standing et al. 1999). At two sites in New York, mean clutch size was 9.6 and 11 (G. Johnson, unpubl. data). In Michigan, Blanding's turtle eggs hatch from August through October, after being in the nest an average of 84 days (range = 73 – 104, *n* = 16) (Congdon et al. 1983). Standing et al. (1999) found that hatchlings emerged after 80-128 days of incubation in early September through early October in Nova Scotia. Congdon et al. (1983) have observed hatchlings leave the nest from mid-morning through the afternoon (e.g., from 10:00am-3:00pm). In their study, Congdon et al. (1983) observed approximately half (45 %) of the nest occupants to emerge on the same day, and the other half (55 %) over the course of 2-8 days. Standing et al. (1999) found that only 26 % of their nests showed synchronous emergence.

Females show considerable nest site fidelity across years. For example, in Nova Scotia, Standing et al. (1999) found that 73.3 % of females nested on the same beach as they had in previous years. In a Michigan population, 73 % of females showed nest site fidelity to the general area in which they had nested in previous years (Congdon et al. 1983). However, it should be noted that not all of these nesting areas were adjacent to marshes in which the females resided. For example, Congdon et al. (1983) observed that only 20 % of nest sites were adjacent to marshes occupied by the nesting female, whereas the remaining 80 % were located adjacent to other marsh complexes and some were a considerable distance from a female's resident marsh. At Cole's Creek and a site in Lisbon in northern New York and at James Baird State Park in Dutchess County, many females have been using the same cornfield for nesting for several years (Johnson and Crockett 2009; J. Jaycox, pers. comm.; E. Kiviat, pers. comm.).

NON-BREEDING BIOLOGY

Habitat

Primary wetland habitats occupied by the Blanding's turtle usually include productive, eutrophic inland and deep freshwater wetlands (Petokas 1986, Rowe 1987, Ross and Anderson 1990, Bury and Germano 2003, Hamernick 2001, Congdon et al. 2008, Crockett 2008, Innes et al. 2008, Ernst and Lovich 2009, Edge et al. 2010, Millar and Blouin-Demers 2012) especially shrub swamps with alder, willow, cattail, and sedges, as well as emergent wetlands with shallow water composed of reeds, grasses, and cattail (Piepgras and Lang 2000), with a soft but firm organic bottom and abundant aquatic vegetation (Kofron and Schreiber 1985, Ernst and Lovich 2009). Hartwig (2004) reviewed much of the available literature on Blanding's turtle habitat preferences. In New York, Blanding's turtles use wetland areas with the following specific characteristics (Kiviat 1997, Hartwig 2004):

1. Shallow (30 cm) and deep (120 cm) pools connected by channels.
2. Open or absent tree canopy.
3. Tree species often along the wetland perimeter.
4. A dense cover of shrubs, particularly willow (*Salix* spp.) and buttonbush (*Cephalanthus occidentalis*), with components of forbs and graminoids dispersed as hummocks and tussocks throughout the wetland.
5. Coarse and fine organic debris.

In addition, high quality Blanding's turtle habitat consists of a "habitat complex" that provides all wetland and upland habitat types used during springtime, breeding, nesting, summer, and hibernation activities in close proximity to one another (Kiviat 1993). Springtime foraging and basking habitat consisting of deep, fluctuating pools represents important habitat for Blanding's turtles (Kiviat 1993). The use and importance of small isolated wetlands, such as vernal pools and kettle ponds, apart from their larger permanent core wetlands, by Blanding's turtles cannot be overstated. Several studies have shown that these wetlands are important for both juveniles and adults to forage on ephemeral food sources such as tadpoles and aquatic insect nymphs and larva (Pappas et al. 2000, Piepgras and Lang 2000, Ross and Anderson 1990, Butler and Graham 1995, Congdon et al. 2003). Females also visit small wetlands to rehydrate during the nesting period (Kiviat 1997, Congdon et al. 2000, Johnson and Crockett 2009). Blanding's turtles have been documented to make movements greater than 1km from resident wetlands to visit these smaller wetlands (Congdon et al. 2003).

In Wisconsin, Ross and Anderson (1990) observed that Blanding's turtles selected ponds over marshes, but rarely used ponds with sandy substrates devoid of aquatic vegetation. In addition, the species used wetlands which contained cattails with areas of open water created by muskrats (Ross and Anderson 1990). In general, several studies have demonstrated that Blanding's turtles of all age and reproductive classes tend to avoid extensive areas of open water (Hamernick 2000, Millar and Blouin-Demers 2011). In Minnesota, juveniles selected areas with a greater percentage of sedge cover and alder (*Alnus incana* ssp. *rugosa*) hummocks (Pappas and Brecke 1992). Smaller juveniles tended to select small ponds and marshes and avoid open water in Nebraska (Bury and Germano 2003), and both juveniles and subadults selected areas with *Sphagnum* spp. and sweet gale (*Myrica gale*) in Nova Scotia (McMaster and Hermon 2000). In New York, Blanding's turtles have been known to use areas with high concentrations of buttonbush and common duckweed, with lower overall plant species richness in southern populations (Kiviat et al. 2004), and more willow scrub/shrub and associated herbaceous vegetation in northern populations (Johnson and Crockett 2009). A non-native, the floating emergent European frog-bit (*Hydrocharis morsus-ranae*) has recently become pervasive in virtually all wetlands that support Blanding's turtles in northern New York and may serve as an indicator (G. Johnson, pers. obs.).

Blanding's turtles nest in open upland areas and are known to use human-disturbed areas such as plowed fields, roadside berms, active agricultural row crop fields, sand and gravel pits, and compost piles (Linck et al. 1989, Johnson and Crockett 2009, L. Masi, pers. comm.). Natural nesting sites have been observed in grasslands characterized by sandy loam or sandy soils (Ross and Anderson 1990) and areas with sparse herbaceous vegetation interspersed with bare mineral soil (Kiviat et al. 2000). In northern New York, Blanding's turtles are also known to nest in piles of topsoil and along unpaved roads (G. Johnson, unpubl. data).

Johnson and Crockett (2009) observed Blanding's turtles' high use of agricultural fields for nesting. To examine rates of nest predation and temperature regimes in agricultural fields, Johnson and Crockett (2009) placed quail eggs and temperature sensors in "artificial nests" at agricultural fields and at reference nesting habitat (i.e., natural sand deposits where nesting was known to occur). They found that turtle nests closer to edges were more likely to be depredated than nests created at site interiors. In addition, temperatures within artificial nests indicated that agricultural fields may be acting as ecological traps, in which the shade produced by growing vegetation created cooler temperatures and hence led to reduced nest success.

Blanding's turtles may move considerable distances from wetland habitats to upland habitats for nesting. The distance of potential nest sites from water varies from 2.0 m to greater than 1.0 km (Congdon et al. 1983), and nest observations in areas adjacent to wetlands where they are not considered residents have been recorded (Congdon et al. 1983, Ross and Anderson 1990). Although primarily an aquatic species (Graham and Doyle 1977), both sexes of Blanding's turtles occasionally make significant overland movements outside of the nesting season (see Home Range and Movements sections), often staying in retreats in forested uplands or foraging in vernal pools (Joyal et al. 2001, Congdon et al. 2003, Johnson and Crockett 2009). L. Willey and M. Jones (unpubl. data) summarized Blanding's turtle data throughout the northeast (PA, NY, NH, ME, and MA) and found that a distance of 1.3 km represented the 75th percentile of movement length.

Blanding's turtles have been observed overwintering under the ice in a variety of wetland types (ponds and creeks, Ross and Anderson 1990; marshes, Kofron and Schreiber 1985, Newton and Herman 2009; under bog mats, Compton 2007; and in shrub-scrub swamps, Sajwaj and Lang 2000, Compton 2007, Johnson and Crockett 2009) typically where the water depth is less than 1.5-2.0 m (although they have been recorded overwintering in deeper waters) and there are relatively deep organic substrates (Ernst and Lovich 2009). Most turtles overwinter in the same wetlands in which they are summer residents, although some authors have observed individuals moving up to 870 m to different wetlands (Piepgras and Lang 2000). Several authors report considerable activity beneath the ice during winter (Sexton 1995, Kofron and Schreiber 1985, Newton and Herman 2009). While some evidence of winter aggregation and overwintering site fidelity has been observed in more southerly portions of the Blanding's turtle range (Ross and Anderson 1990, Sajwaj et al. 1998), aggregations of up to 7 individuals in Ontario (Edge et al. 2009) and 13 individuals in Nova Scotia (Newton and Herman 2009) with definitive site fidelity have been observed. Overwintering sites of hatchlings are largely unknown. Butler and Graham (1995), Standing et al. (1997) and Refsnider (2005) tracked hatchlings for varying amounts of time, but never through the first winter. Linck and Gillette (2009) followed hatchlings to their presumed overwintering sites and found that most hatchlings selected damp soil on the edge of wetlands and one selected an upland site.

Diet

Blanding's turtles are primarily carnivorous, eating terrestrial invertebrates such as earthworms (*Lumbricus* spp.) and other terrestrial invertebrates such as insect larvae, as well as a whole host of aquatic invertebrates such as leeches (Hirundinea), mayflies (Ephemeroptera), crayfish, and aquatic vertebrates such as minnows (Cyprinidae), central mudminnows (Umbridae), tadpoles (*Lithobates* spp.), frogs (*Lithobates* spp.), and many others (Ernst and Lovich 2009, Flaherty and Johnson 2013). While Ernst and Lovich (2009) suggest they consume plants and algae, Rowe (1992) postulated that since plant material was found in every Blanding's turtle stomach that he sampled, plants were likely ingested incidentally when animal prey was ingested.

Populations

Blanding's turtle population densities have been reported as low as 0.47 to 1.45 turtles/ha in Minnesota (Sajwaj et al. 1998) and 3.9 to 5.9 turtles/ha in Maine (Joyal et al. 2000), to as high as 27.5 turtles/ha in Wisconsin (Ross 1989), and 55 turtles/ha in Missouri (Kofron and Schreiber 1985). In the Northern New York Conservation Unit, turtle densities have been estimated in three wetlands as 0.78, 0.47 and 0.43 turtles/ha (Johnson and Crocket 2009). Chaloux (2011) estimated the minimum density in the Saratoga County population as 0.07 turtles/ha. Both Johnson and Crockett (2006) (NNY) and Chaloux (2011) (Saratoga) estimated densities as the number of turtles present in an area divided by the sum of the areas of estimated 95 % or 100 % minimum convex polygon (MCP) home ranges. There are no other estimates of population density for any other population or conservation unit in New York.

The sex ratio of wild Blanding's turtle populations has been reported as either 1:1 (M:F) or exhibits a weak to strong female bias (up to 1:4) (Congdon and van Loben Sels 1991, Pappas 2000, Lang 2004, Congdon et al. 2008). Temperature-dependent sex determination, differential mortality or gender bias on the rates of immigration have been implicated (Congdon et al. 2008); however, causes are unknown. In addition, there is some evidence that populations near roads may exhibit increased female mortality, potentially leading to a male-biased sex ratio (Steen et al. 2006).

The genetic diversity and structure of Blanding's turtle populations have been examined over portions of the species' range. Disjunct populations in Nova Scotia (Mockford et al. 1999, Osentoski et al. 2002, Mockford et al. 2005) and an isolated urban population in Chicago (Rubin et al. 2001*a*) detected fine scale population structure with loss of genetic variation when compared with other populations. Mockford et al. (2006) examined a larger sample from across the species' range (12 populations, including Dutchess County, New York) and found less fine scale genetic structure than that of populations in Nova Scotia. They suggested three evolutionary significant units: (1) the main range west of the Appalachian Mountains, (2) populations east of the Appalachian Mountains and (3) the disjunct population in Nova Scotia. McClusky et al. (2016) conducted a genetic survey of three of the four conservation units (Northern New York, Dutchess Co., and Saratoga Co.) in New York. Authors found that Northern New York Blanding's turtles exhibited low levels of genetic differentiation and no loss of genetic diversity, whereas Dutchess County turtles were genetically divergent from the Northern New York population, but exhibited no loss in genetic diversity. However, Saratoga County Blanding's turtles showed significant loss of genetic diversity. McClusky et al. (2016) went as far as to suggest that genetic rescue may be necessary to promote long term persistence of Saratoga populations.

Predation and Disease

Adult Blanding's turtles have very few natural predators. However, like other species of turtles, Blanding's turtles experience high rates of nest predation, with some nestlings experiencing mortality from causes not fully recognized. For example, of nine protected nests that were located at a site in northern New York, two did not hatch and six of the seven remaining contained some eggs (53 % or 5.2 per nest) that did not hatch (Johnson and Crocket 2009). At the northeastern edge of the range in Nova Scotia, nest productivity varied by year, presumably due to changes in weather patterns (Standing et al. 1999). For example, Standing et al. (1999) observed that 76 % and 93 % of nests produced at least one young in 1994 and 1995, respectively, yet only 18 % of protected nests were productive in 1996.

Congdon et al. (1983) measured rates of nest predation that ranged from 42-93 % in a Michigan population. In addition, 84 % of nest predation occurred within the first five days after laying, with 42 % occurring during the first 24 hours after laying (Congdon et al. 1983). In Wisconsin, 59 % of nests were depredated within the first two weeks of being laid (Reid et al. 2010). Temple (1987) found that turtle nests that were within 50 m of a habitat edge were significantly more likely to be depredated than interior nests. In addition, Reid et al. (2015) found that nests closer to forested edges were more likely to be depredated. Predators such as raccoons, foxes, skunks, and other mesocarnivores are common nest predators (Ernst and Lovich 2009). Ants (Congdon et al. 1983) and even plant root intrusion (Congdon et al. 2000) may reduce nest and hatching success as well. Once nestlings hatch and emerge from nests, predators such as skunks (*Mephitis mephitis*), raccoons (*Procyon lotor*), coyotes (*Canis latrans*), foxes (*Vulpes* and *Urocyon cinereoargentatus*), and crows (*Corvus brachyrynchos*) prey on hatchlings (Ernst and Lovich 2009). American kestrels (*Falco sparverius*) have also been reported to prey on hatchlings in Massachusetts (Ernst and Lovich 2009).

Leeches (*Placobdella ornata*, *P. parasitica*) parasitize both juveniles and adults (Bolek 2001). In addition, Sarcophagid fly larvae were found in a very high percentage of Blanding's turtle nests in southeastern Ontario, leading to mortality (Gillingwater and Brooks 2002, *cited in* COSEWIC 2005).

Ranavirus was not found in Blanding's turtles in Illinois surveys; however, it has been found in other species of turtles (Allender et al. 2009). The disease was documented to cause mortality in Blanding's turtles in 2012 (J. Holsworth, pers. comm.).

Movements and Home Range

Congdon and Keinath (2006) summarized four major types of Blanding's turtle movements described as follows:

1. **Movements associated with aestivation in summer and overwintering.**

   Blanding's turtles may aestivate for days or even weeks during hot and/or dry periods (Ross and Anderson 1990, Joyal et al. 2001, Crockett 2008, Compton 2007) and they typically use terrestrial situations. Movements associated with brumation (i.e., dormancy without lowered metabolic rates) and overwintering can be affected by the amount of rainfall during the year (Rowe and Moll 1991). For example, Rowe and Moll (1991) observed that Blanding's turtles did not undertake long movements during wet years, and moved more than expected during dry years. Individuals have been reported moving under the ice during winter, but movements are typically around 5 m (Newton and Herman 2009).

2. **Female nesting movements.**

   Nesting in New York has been observed to take place from 28 May - 9 July (A. Briesch, pers. comm., Johnson and Crockett 2009). However, the majority of the nesting activity in northern New York occurs from 1-21 June (G. Johnson, unpubl. data). Slight differences in nesting time frames can be attributed to spring temperatures, with warmer temperatures associated with earlier nesting (Congdon et al. 1983). Crockett (2008) observed females moving up to 1,365 m round-trip from wetlands to nesting sites in northern New York from 2003-2004. In addition, females with radio transmitters traveled up to 1,343 m in a straight-line from resident wetlands to nesting areas (Crockett 2008).

3. **Hatchling dispersal from nests.**

   Blanding's turtles typically emerge from nests in the fall (Congdon et al. 1983, Butler and Graham 1995, Standing et al. 1997). Hatchlings emerge between mid-August and the end of September in Minnesota (Pappas et al. 2000), September to late-October in Nova Scotia (Standing et al. 1997, 1999), late-August to early October in Maine (Joyal et al. 2000), and mid-September to early October in New York (G. Johnson, pers. obs., Johnson and Crockett 2009). Standing et al. (1997) found that hatchling turtles traveled in random directions with respect to water and some actually avoided water. Standing et al. (1997) determined that there was no preference for any habitat type; some hatchlings exhibited fossorial behavior, some remained in the open hiding among cobble, and others spent time in <3 cm-deep water. Overwintering of hatchlings in the nest does not occur frequently because exposure to ice in the soil at temperatures below -2.5^{o}C causes ice to penetrate the integument and kill the hatchling turtles (Packard et al. 2000).

4. **Movements among wetlands during the spring and summer.**

Blanding's turtles can move considerable distances between wetland habitats during the spring and summer. Specifically, movements greater than 1 km have been observed for the species (Sexton 1995). M. Jones and L. Willey (unpubl. data) analyzed movement data from telemetry locations from New York, New Hampshire, Massachusetts, Maine, and Vermont and found that the 75 % percentile of the maximum movement length made by Blanding's turtles was 1.3 km. Movements between wetland complexes can be smaller, depending on the spatial distribution of wetlands. For example, in Wisconsin, Ross (1989) observed that turtle movements were no greater than 652 m, with females moving over greater distances than males. In Central Minnesota, males moved between wetland complexes more frequently, but movements tended to be shorter than those of females (average 491 m for males vs. 543 m for females) (Piepgras and Lang 2000). In New York, Crockett (2008) studied the daily movements of Blanding's turtles and found that on average, males moved greater distances than females per day (46 m vs. 22 m, respectively). Beaudry et al. (2009) found they can utilize as many as 20 unique wetlands and as few as one wetland annually and Congdon et al. (2011) state they can travel extensively across the landscape where they frequently interact with areas of human activity.

Crockett (2008) found average home ranges of females were 12.3 ha, whereas those of males were 7.5 ha in St. Lawrence County, New York. These values are consistent with studies by Ross (1989). Among five occupied sites in Dutchess County, New York, the area of occupied wetland clusters ranged from 9 to 65 ha (average = 34 ha) (Kiviat 1997). Chaloux (2011) found that males occupied home ranges (MCP) averaging 26.8 ha while female ranges averaged 29.8 ha at a site in Saratoga County, New York.

There are numerous published and unpublished accounts of mean home range sizes across the Blanding's turtle's range; however, direct comparisons are difficult due to a variety of home range estimators used. Compton (2007) and Chaloux (2011) reviewed most published accounts of home range size and a sampling is presented in Table 1.

HISTORICAL STATUS ASSESSMENT

Compton (2007) provides a thorough review of historical range and distribution records for Blanding's turtles in the northeastern United States, primarily New England, but including eastern New York. Compton (2007) also reviews fossil and archaeological records from across the species' range. There are no published fossil records and few archaeological records of Blanding's turtles from New York. Preston and McCoy (1971) report on a specimen collected from an archaeological site in western New York near Cuylerville, Livingston County. The earliest published records for Blanding's turtles in New York come from Long Island (Schoonhoven 1911, Murphy 1916); however, later authors largely considered these records as doubtful (Pope 1939, McCoy 1973). Although Ditmars (1907) states Blanding's turtles as occurring in New York, the first record from an extant population was recounted in Hecht (1943), where two specimens were reported from Freedom Plains, Dutchess County in 1941.

CURRENT STATUS ASSESSMENT

The Blanding's turtle is designated as a G4 species or "apparently secure" throughout its range in North America (NatureServe Explorer 2009). However, the International Union for Conservation of Nature and Natural Resources designates the species as endangered and declining (van Dijk and Rhodin 2011). In fact, the Blanding's turtle is of conservation concern in nearly every state and Canadian province in which it occurs; it is listed as either threatened or endangered in most states and all provinces in which it occurs (Table 2).

The Blanding's turtle is considered abundant in only two populations, one in Minnesota and the other in Nebraska. In other areas of its distribution, the species occurs in small insular populations, typically having fewer than 50 adults (Congdon et al. 2008, Compton 2007, McCoy 1973). The Northeast Endangered Species and Wildlife Diversity Technical Committee stated that Blanding's are a high-risk species warranting consideration for federal listing (Therres 1999). Kiviat and Stevens (2003) and Gibbs et al. (2007) cite residential development and the associated loss of vernal pools and existing travel corridors within and among wetlands and nesting habitat as important reasons for the species' decline.

The Blanding's turtle is designated as an S2S3 (imperiled/vulnerable) species in New York (Nature Serve 2009). Due to the species' relative rarity in the state, it had been placed on the New York State Threatened Species List in 1983 and efforts to study the natural history and identify threats have been ongoing. As of 2017, extant Blanding's turtle populations occur in four regions of New York State: (1) in northern New York at multiple sites in the Eastern Ontario Lake Plain, Indian River Lakes, St. Lawrence Plain, and St. Lawrence Transition ecozones (Will et al. 1982) in Jefferson and St. Lawrence Counties, (2) in Dutchess County, (3) in the Towns of Wilton and Northumberland in Saratoga County, and (4) on the Seneca Nation in Erie County (Figure 1).

Beginning in 2012, the Northeast Regional Blanding's Turtle Working Group was begun to develop and initiate a monitoring program for Blanding's turtles in New York, Massachusetts, Pennsylvania, New Hampshire, and Maine. The overall goal of this project has been to develop a robust, flexible, and feasible monitoring framework to quantify the status and trends of Blanding's turtles in the Northeastern U.S. at multiple spatial and temporal scales. This effort was funded by a U.S. Fish and Wildlife Service Competitive State Wildlife Grant awarded to the state of New Hampshire. The five principal objectives of this initiative are the following:

(1) Quantify the abundance of Blanding's turtles at the regional scale;
(2) Identify and quantify long-term trends in the species' abundance at the regional scale;
(3) Estimate Blanding's turtle density at selected key sites;
(4) Quantify long-term trends in the species' density at key sites;
(5) Gather additional information at poorly-characterized Blanding's turtle sites throughout the region.

This work has led to the development of a draft conservation plan for the species that is being finalized (Willey and Jones 2014).

Northern New York

Werner (1959) presented the first published records of Blanding's turtles in northern New York: an individual on Wellesley Island and another on the mainland near Alexandria Bay. However, Werner's (1959) investigations were limited to only 10 islands and the adjacent mainland in the Thousand Islands region of Jefferson County. Prior to 1959, there was a report of a Blanding's on Niagara Island, Ontario (Toner 1936). Petokas and Alexander (1978) reported on additional specimens in northern New York. Petokas (1979) collected five adult Blanding's turtles from Cranberry Creek Marsh in Jefferson County. Petokas and Alexander (1981) reported two additional specimens found in St. Lawrence County: one near Cole's Creek State Park, Waddington, and the other near Hawkins Point, Massena, which represent the first reported records for St. Lawrence County.

The distribution of the Blanding's turtle has been more accurately defined with the development of the Herp Atlas and the subsequent multitude of researchers and volunteers collecting data (New York State Department of Environmental Conservation 2009). From 1990-1999, approximately 55 additional records from 21 USGS quadrangles were added to the species' known distribution (A. Breisch, pers. comm.). Johnson and Wills (1997) reported one turtle at the Fort Drum military installation in Jefferson County, and one near Lake Bonaparte in Lewis County. In addition, there were 42 Blanding's turtle captures as a result of trapping and nest survey efforts in Jefferson County at Wilson Bay Marsh in 1990 (D. Faulknham, unpubl. data). Jensen (2004) reported on Blanding's turtle habitat use in four wetlands along the St. Lawrence River in Jefferson and St. Lawrence counties, where she captured 34 individuals over a two-year sampling period. Additional records have been stored in the New York Natural Heritage Program database and a review (2008) of Element Occurrence records and Herp Atlas records resulted in the map produced for Amphibians and Reptiles of New York State: A Guide to Identification, Natural History, Conservation, Gibbs et al. (2007). Using presence/absence data from 20+ years of surveys, Stryszowska et al. (2016) modeled the distribution of the species across New York and found there to be some additional potential habitat areas that may be occupied that have not been surveyed. More survey work in these areas is necessary to confirm these new potentially occupied locations.

The Blanding's turtle is documented to occur in the vicinity of Cole's Creek State Park, but detailed survey information prior to 2003 and 2004 Blanding's turtle surveys was limited (Johnson and Crockett 2009). Petokas and Alexander (1981) documented an adult female Blanding's turtle (218 mm plastron length) that was dead on the road on New York State Route 37 in June 1979, approximately 0.5 km southeast of the mouth of Cole's Creek and Lake St. Lawrence. In June 1997, a gravid female Blanding's turtle carrying 14 eggs was found dead on New York State Route 37 in the vicinity of Cole's Creek (Jaycox 2003). The New York Natural Heritage Program (NYNHP) conducted surveys for Blanding's turtles at Cole's Creek in 2002. During a two-week period in June, four Blanding's turtles were captured. Additionally, one road-killed and one captured Blanding's turtle were reported in the NYNHP Element Occurrence Record (Jaycox 2003). Blanche Town (DEC, pers. comm.) reported on a single Blanding's turtle observed in Wilson Hill Wildlife Management Area (Louisville) in the 1990s and Hollis White (St. Regis Mohawk Tribe, pers. comm.) found a single adult Blanding's turtle in Brasher State Forest in 1997. On 20 June 2009, an adult female was found on Route 37 on the St. Regis Mohawk Reservation, the first record of a Blanding's turtle from Franklin County (Flaherty et al. 2012).

Blanding's turtles were known as occurring in southern Ontario, but most observations prior to 1983 were limited to the northern shores of Lakes Erie and Ontario (Bleakney 1963). Petokas (1986) reported a substantial population from Grenadier Island in the St. Lawrence River. Since that time, Blanding's turtle records from Ontario have been maintained by the Ontario Herpetofaunal Summary database. There is a Blanding's turtle study being conducted on Grenadier Island (the site of Petokas [1986] study) by researchers from Carlton University (Blouin-Demers, pers. comm.; Millar and G. Blouin-Demers 2011, 2012). Several individual records of Blanding's turtles are also known from southwestern Quebec near the New York border along the St, Lawrence River (NatureServe 2009, Rouleau and Giguere 2012).

Beginning in 1998, Glenn Johnson and students from SUNY Potsdam began a trapping and mark-recapture program for Blanding's turtles at Lisbon Swamp in central St. Lawrence County. These efforts expanded to additional sites in the county, principally in and around Cole's Creek State Park, and to sites in Jefferson County by 2000. One graduate thesis (Crockett 2008) and multiple reports resulted from these ongoing efforts (Johnson and Crockett 2006, Johnson and Crockett 2009, Johnson 2012). Part of these efforts included an evaluation of the effectiveness of a road sign program to reduce turtle mortality in St. Lawrence and Jefferson counties (Johnson 2011). A significant outreach program was implemented in Kejimkujik National Park that implemented road signs and reduced speed limits that was found to be effective (Reed 2008). Results of Reed (2008) suggest that signs will not be very effective at reducing mortality without a significant outreach program.

The New York Power Authority's (NYPA) was issued a new license to operate the St. Lawrence-FDR Power Project in 2003 by the Federal Energy Regulatory Commission. As part of its application for the new license, NYPA signed a Settlement Agreement with state and federal resource agencies, local governments, non-governmental organizations, and other stakeholders to develop several habitat improvement projects (HIPs), including one for the Blanding's turtle. The objective of the Blanding's turtle HIP is to create or restore habitats for Blanding's turtles and increase the breeding population of this species in the vicinity of Cole's Creek. This HIP is ongoing and developments, including the creation of a 2.6 ha potential nesting area, can be found in reports by Northern Ecological Associates (2004*a*, 2004*b,* 2004*c,* 2005*a,* 2005*b,* 2005*c*, 2006*a,* 2006*b*), Johnson and Crockett (2009), Riveredge (2008*a,* 2008*b*) and Riveredge (2010).

Dutchess County

Approximately 12 extant Blanding's turtle populations have been documented in the western section of Dutchess County (Hecht 1942, Hartwig et al. 2009). However, incidental data and Natural Heritage records suggest the presence of additional populations. Most of the documented populations appear to be relatively small, comprising perhaps 5-15 adults (Hartwig et al. 2009).

In 1985, a population of Blanding's turtles was discovered at a Nature Conservancy Preserve in Dutchess County, where females were documented to leave the preserve boundaries to nest. An artificial nesting site was constructed on the property to help encourage the turtles to nest on the property rather than leaving and crossing into a residential subdivision with little success (Emrich 1991). Efforts to increase survival and recruitment at this site included the use of nest predator guards and establishing a headstarting program with Cornell University. Between 1995 and 2000, 59 captive-reared turtles were released into the preserve and by 2004, at least 26 individuals survived at least 2 winters (Breisch and Munger 2005).

In 1996-1997, 1.4 ha of wetland habitat and 3 ha of nesting habitat were designed and constructed by researchers from Hudsonia Ltd. after the loss of Blanding's turtle habitat following a school expansion project (Kiviat 1997). Blanding's turtle responses to these wetlands have been monitored continuously since they were constructed, including studies of movements and habitat selection (Bock 2007, Kiviat et al. 2000, Kiviat et al. 2004, Hartwig and Kiviat 2007, Dowling et al. 2010). These created wetlands and nesting areas have been used by Blanding's turtles extensively. Monitoring at this site consists of a cooperative effort between Hudsonia Ltd. and researchers from Vassar College (M. and M. Pregnall, pers. comm.).

Both intensive and extensive Blanding's turtle population surveys have continued throughout Dutchess County, primarily by researchers at Hudsonia Ltd. and the NYS Office of Parks, Recreation and Historic Preservation (Hartwig 2004). Monitoring of a population at James Baird State Park, began in the late 1980s by Erik Kiviat and researchers from Hudsonia Ltd., continued until 2008 (Pollack et al. 2008). Several sites, including the aforementioned school, preserve and state park, are included in a regional multistate monitoring effort outlined above in the Northern New York section.

Saratoga County

In 2003, a Blanding's turtle was first documented in Saratoga County on the Wilton Wildlife Preserve and Park (WWPP), a park in the Saratoga Sandplains that is composed of a patchwork of parcels, each owned by either New York State Department of Environmental Conservation, Saratoga County, The Nature Conservancy (TNC), or the Town of Wilton. New York State Department of Environmental Conservation biologists documented two additional Blanding's turtles at the same site within one week of the initial sighting. This site is approximately 120 km from the nearest known population. Between 2003 and 2006, New York State Department of Environmental Conservation biologists documented six adults in the population. By radio-tracking five of the turtles, they documented Blanding's turtle occupancy at approximately 26 wetlands and 11 upland areas in and outside the WWPP (Kallaji 2006). Since the area outside the WWPP was experiencing pressure from intense residential development, a conservation-focused trapping effort and radio telemetry project took place during 2007-2008 and 2007-2009, respectively. Project goals were to (1) inform survey protocol recommendations for Blanding's turtles in their Saratoga County habitat, (2) collect basic information on the spatial ecology of the population, and (3) determine the status and distribution of the population and its conservation and management needs. A total of 13 Blanding's Turtles (7 females, 4 males, 2 juveniles) and one dead-on-road juvenile were documented from this effort. Trapping surveys in two previously unsurveyed wetland complexes nearby did not increase the known distribution of the population (Chaloux 2011).

In 2012-2013, additional surveys were conducted using the standardized Blanding's turtle Trapping Rapid Assessment protocol, which brought the total to 14 Blanding's turtles (7 females, 5 males, and 2 juveniles) and one dead-on-road juvenile. In 2014, a trapping effort that consisted of 346 trap nights was conducted, but it did not yield any new individuals (G. Johnson, pers. comm.). In 2017, a similar trapping effort yielded no turtles. While the population occurs in a mostly unfragmented, high-quality habitat complex characterized by many small shallow wetlands in an Appalachian oak-pine forest centered in the WWPP, individuals are nesting and over-wintering on several private parcels outside the preserve. The movements and habitat use of individuals following landscape changes due to residential development (~2000-2002), logging (~2006), and habitat restoration activities (2007-2008) suggest that the turtles are using the landscape opportunistically, responding to activities that open the canopy. Road mortality, loss and degradation of habitat, and extended drought are threats to the species. To date, five conservation or management actions have been implemented: (1) translocation and protection of nests (89 hatchlings were released from 10 protected nests, including 6 translocated nests, from 2004-2009), (2) purchase of land (occupied parcels were purchased by The Nature Conservancy in 2006 and 2007, and a parcel adjacent to occupied habitat was purchased by a local land trust, Saratoga PLAN, in 2010), (3) creation of suitable nesting habitats (in 2008 and 2009, 60 % [3/5] of located nests were in habitat created the year before), (4) installation of turtle crossing road signs seasonally at an identified road crossing hotspot from 2013-2015, and (5) the addition of approximately 113 ha of wetlands to the New York State Department of Environmental Conservation regulated wetland map in 2015, based on documented occupancy by Blanding's turtles. Since the turtles are using critical habitats on private parcels around the preserve, conservation of the population depends on establishing good working relationships with biologists and private landowners around the preserve. Continuing efforts to protect high-priority parcels and install turtle crossing road signs seasonally will likely benefit the population. In addition, the creation and maintenance of suitable nesting areas within the unfragmented habitat of the preserve, and conservation of drought-refuge and overwintering ponds are priorities. Moreover, inventory of suitable habitats capable of supporting viable populations in Saratoga County is also recommended (Chaloux et al. 2016).

Western New York

Blanding's turtles have been reported in four counties in western New York. A *bona fide* population occurs on the Seneca Nation in Erie County. Beginning in 2005, tribal biologists working with Ken Roblee from the New York State Department of Environmental Conservation have conducted a trapping and telemetry study at this site, which consists of 2.4-4.8 ha of scrub/shrub wetland dominated by buttonbush. A total of 11 individual Blanding's turtles were encountered during the trapping efforts.

Two individuals, one in 1990 and a second in 2002, were found in or near Eighteen Mile Creek in Niagara County. However, despite additional trapping efforts, no additional Blanding's turtles have been detected (K. Roblee, pers. comm.). Chautauqua and western Cattaraugus County also have reports of Blanding's turtles that remain to be verified.

THREATS TO SPECIES

Habitat Loss and Fragmentation

Habitat loss and fragmentation is one of the leading causes of population declines in many wildlife species. Loss of terrestrial and aquatic habitat can occur by direct means such as residential and commercial development (e.g., roads and infrastructure) and pollution, and by indirect means such as the introduction of invasive species (Clavero and García-Berthou 2005, Davis 2009). Populations can further be threatened by direct mortality caused by vehicles on new roads or by the human subsidization of predators (e.g., raccoons, etc.) that prey on turtles or their nests (Garber and Burger 1995; Holland 1994, Hayes et al. 1999 *cited in* Spinks et al. 2003). Invasive *Phragmites* spp. and other non-native species have been observed to spread into wetlands and displace native vegetation, which can create a monoculture and potentially interrupt the movement patterns of Blanding's turtles and limit their use of an area (Bolton and Brooks 2010). The loss of habitat in an occupied area can ultimately lead to the loss of the local population and further threaten the overall population.

While direct habitat loss in the Northern New York Conservation Unit is relatively uncommon, it is more pervasive in the Dutchess County and Saratoga County Conservation Units. However, if predicted climate change scenarios leading to greater human population growth in the northeast become a reality, all conservation units would likely experience greater loss and fragmentation of habitat related to development.

Road Effects

The impact of roads on wildlife populations has gained considerable research attention in recent years. To name a few examples, there has been increasing attention on predicting hotspots of road mortality for amphibians and reptiles (Langen et al. 2008) to determining the correlation between the variability in traffic density and amphibian mortality (Mazerolle 2004), determining how roads affect snake densities (Patrick and Gibbs 2009), and how roads have affected the genetic structure of a snake population (Clark et al. 2010). Turtles are particularly vulnerable to road mortality (Gibbs and Shriver 2002, Steen and Gibbs 2004, Gibbs and Steen 2005), and due to overland nesting movements, females perhaps even more so (Steen et al. 2006). Given the high relative importance of older adult female Blanding's turtles to population persistence (Congdon et al. 1993, 2003) and the high traffic density around some populations, road mortality is perhaps the gravest, most immediate threat to Blanding's turtle populations in New York and elsewhere.

Blanding's turtles differ from other species of turtles in the region as spatial clusters of Blanding's mortality on roads are more difficult to predict (T. Langen, pers. comm.). For example, Langen et al. (2008) have indicated that causeways and roads closer to forest patches lead to increased rates of turtle mortality for some species such as painted turtles (*Chrysemys picta*) and snapping turtles (*Chelydra serpentina*); however, Blanding's turtles' patterns were more diffuse. Despite this more diffuse spatial clustering of Blanding's turtle road mortality events, the timing of greatest Blanding's turtle mortality can be very reliably predicted. Beaudry et al. (2010) found that both male and female Blanding's turtles are most susceptible to road mortality in June and early July. This peak in turtle road crossings has also been observed in New York (G. Johnson, unpubl. data). Given that Blanding's turtles are such a long-lived species with low fecundity and low rates of recruitment into adulthood, any additional adult mortality can be detrimental to the population viability of the species.

Not only is direct mortality a threat to Blanding's turtle populations, but the presence of the roads on the landscape may also be detrimental. Proulx (2014) found that Blanding's turtles avoided roads in Québec and cautioned that avoidance of roads could cause greater genetic isolation of populations and ultimately lead to further declines. Holderegger and Di Giulio (2010) found in a review of several studies that many species have suffered loss of genetic diversity and genetic drift as a result of the presence of roads on the landscape.

Collection and Persecution by Humans

Collection of Blanding's turtles from the wild can be considered a permanent removal of the animal from the breeding population. Hence, relative to the population, the collection of an individual is equivalent to a mortality, as the individual will no longer be given the opportunity to breed with wild turtles. Blanding's have been documented to enter the pet trade through both legal and illegal means (Reed and Gibbons 2002), although there is no legal means for collection in New York. In recent years, Blanding's turtles were uncovered in the illegal pet trade during Operation Shellshock, a multi-year undercover operation investigation of the illegal trade in reptiles in New York State. Blanding's were also documented in the illegal pet trade in Ohio and Canada as reported in the proposal submitted for amendment to Appendices I and II to the Convention on International Trade in Endangered Species (http://www.fws.gov/international/cites/cop16/cop16-proposal-appendix-ii-listing-of-blandings-turtle.pdf). Since 1998, there have been two known incidents of Blanding's turtle collections in northern New York that have ended, due to intervention, with the animal being released back into the native population at the point of capture (G. Johnson and A. Ross, unpubl. data). However sparse and isolated these events are, they may be a small sample of the actual number of turtles that experience collections. In addition to collections, some people target individuals to run over on roads with their vehicles. A study in Canada near the Big Creek National Wildlife Area and Long Point Bay found that people intentionally hit reptiles such as turtles and snakes with vehicles (Ashley et al. 2007). In addition, motorists running over turtles in New York have also been observed (A. Ross, unpubl. data).

CLIMATE CHANGE

Predicted climate change scenarios suggest that the future will be warmer and have less precipitation, with more isolated precipitation events (Parry et al. 2007). Changes in climate such as these may lead to decreased wetland area and subsequent lower carrying capacities of Blanding's turtles in the state, which will ultimately lead to range shifts and declines.

In addition, climate change may introduce new emerging diseases. Some examples of recently emerging diseases are a fungal dermatitis that has been observed to negatively affect timber rattlesnakes and other snake species in the northeast, chytridiomycosis (*Batrachochytrium dendrobatidis*) that affects amphibian populations worldwide, and white-nose syndrome that has significantly reduced many cave hibernating bat species in New York and other areas. *Mycoplasma* and *Ranavirus* are also a threat to turtle species. Studies of diseases of bog turtles are being undertaken by researchers at the Wildlife Conservation Society, but little is known about the long term effects this disease will have on the bog turtle population or that of other turtle species. If Blanding's turtles are susceptible to this disease and the disease infects local populations, these populations could decline as a result.

Reptiles such as Blanding's turtles, which have temperature-dependent sex determination during incubation, may exhibit changes in population dynamics such as an altered sex ratio of hatchlings. Janzen (1994) found that sex ratio was correlated with air temperature during a multi-year study of painted turtles. It is conceivable that increasing temperatures could reduce or prevent the production of male Blanding's turtles in some populations and lead to local extinction in small isolated populations. This loss of male young being produced would be ameliorated if the transitional temperature that produces both sexes is relatively wide (Hulin et al. 2009).

An indirect effect of climate change may be an increase in future development in New York. Climate change models predict that with rising temperatures, the northeast will experience increasing development as people move northward in search of cooler temperatures. Such increases in development will likely negatively affect Blanding's turtle populations if wetland and nesting habitat (and travel corridors between such habitats) are not protected. Development (e.g., roads and residential housing) often leads to an increase in subsidized predators like raccoons, whose activities may reduce recruitment to levels below which populations cannot recover. In addition, new road construction is likely to adversely affect the species if road mortality is not mitigated by siting roads properly or by creating safe passage structures such as culverts and fencing that will allow turtles to (1) disperse as hatchlings, (2) move between wetlands (3) move between wetlands and nesting areas during the nesting season, and (4) move between activity centers in the summer and overwintering areas in the fall.

DATA GAPS

As with many long-lived species, very little is known about Blanding's turtle mortality rates before adulthood. Congdon et al. (1993) estimated mortality rates for <1 year old and 1-14 year old age classes by creating a life table. There exists no other published information on mortality rates of subadult Blanding's turtles. Information on mortality rates is integral in determining the viability of a population. A population viability analysis by A. Ross (Appendix 1, unpubl. data), suggested that mortality rates of Blanding's turtles <14 years old significantly contributed to the population's viability. Knowing actual mortality rates by age class will be necessary to update and refine the PVA, so that management actions may be defined and implemented to the degree necessary to promote population persistence. At this time, authors of this plan are confident about which management actions will need to take place to help restore Blanding's turtle populations, but they are less confident about the degree to which such management actions need to be carried out (see Appendix 1 for details of PVA). For example, information on road mortality is a related data gap that contributes significantly to population viability. Road mortality rates will need to be more accurately estimated to adequately assess the species' viability in the state. That said, the management actions identified in the following sections should represent the minimum degree of management intervention necessary that could promote a self-sustaining population of Blanding's turtles in New York into the future.

CONSERVATION STRATEGY

Goals

The ultimate goal of the Blanding's turtle conservation plan is to provide guidance to achieve, protect, and maintain self-sustaining populations of the Blanding's turtle and its essential habitat and wetland communities in New York State.

Through a set of conservation actions detailed herein, we propose to maintain a 95 % probability of having extant populations of Blanding's turtles in the four conservation units (see Conservation Units section below) through the next 300 years (roughly 10 generations). A 300-year period of viability was chosen because of the nature of the turtle; it is a long-lived species and is likely to remain extant in the state for a long period even with a decreasing population growth. Three hundred years represents approximately 10 generations of the species and was hence considered an adequate time period over which to propose to maintain population viability.

Conservation Objectives

The following research and management objectives have been identified by the conservation team with the aid of a population viability analysis (PVA) by A. Ross (unpubl. data) (Appendix 1). These conservation objectives should be used to guide research and management of the species in New York.

All Conservation Units
To promote population persistence of Blanding's turtles in New York, the following research objectives should be pursued: (1) develop more precise estimates of life history parameters using data from New York populations and apply this information to refine a PVA, (2) gain a better understanding of which mortality mitigation efforts are effective at reducing road mortality, (3) determine the efficacy of mitigation efforts employed by developers to provide a net conservation benefit to the species, and (4) continue work with partners in other states to develop a long term monitoring plan. The following management objectives should also be pursued: (1) protect at least 50 % of occupied habitat in the long term, (2) continue collaborations with partners in other states to implement site-specific management plans, (3) raise awareness and appreciation of turtles to reduce human-induced mortality and the permanent removal of individuals from the breeding population, and (4) protect known extant populations and their associated habitat using existing regulations and continued administrative support.

Northern New York and Dutchess County Conservation Units
To promote population persistence of Blanding's turtles in these conservation units, the following management actions will be necessary: (1) recruit at least one adult female into each of five long term monitoring sites every 10 years to offset the impact of road mortality, (2) protect at least five nests per year until hatching in both units, (3) headstart and release at least 20 individuals (1:1 sex ratio) at age one or older at 10 year intervals in each unit, and (4) maintain at least 75 % of the initial genetic heterozygosity in five long term monitoring sites in each unit.

Saratoga County Conservation Unit
To promote population persistence of Blanding's turtles in this conservation unit, the following actions should be taken: (1) recruit at least five new females into the breeding population every 10 years, (2) headstart and release at least 10 females at age one or older at 10-year intervals, and (3) maintain at least 75 % of the initial genetic heterozygosity in the population.

Western New York Conservation Unit
Identify the threats and the status and distribution of the western New York population. Attain an adequate body of information on population status and threats to conduct a population viability analysis.

Conservation Units

Northern New York
The northern New York population is the most extensive and may have the greatest population viability of all populations in the state. The population extends from Jefferson County through the northern tip of Lewis County, through St. Lawrence County and into the northern extreme of Franklin County, generally within the Lake Ontario and St. Lawrence Plains (Figure 1). Occupied Blanding's wetlands (including historical locations) total approximately 2,587 ha, of which 1,331 ha (51 %)[1] are unprotected by state wetland laws or by not being located on either state lands or protected by conservation easements. The US Army Corps of Engineers provides some additional protection of the smaller mapped wetlands.

Dutchess County
The Dutchess County population is the second largest population in New York and may also have significant population viability. The population is distributed in isolated patches throughout Dutchess County (Figure 1). The area occupied by Blanding's turtles is approximately 2,359 ha, of which 1,825 ha (77 %) are unprotected by state wetland laws or by not being located on either state lands or conservation easements. The US Army Corps of Engineers (USACE) provides some additional protection of the smaller mapped wetlands.

[1] These calculations were derived from estimates of area of occupied habitat contained within element occurrence data from the New York Natural Heritage program in ArcGIS.

Saratoga

The Saratoga population is one of the smallest populations in New York and may have limited population viability. The population is located in only one isolated area of Saratoga County (Figure 1). The area occupied by Blanding's turtles is approximately 186 ha, of which 76 ha (41 %) is unprotected by state wetland laws or by not being located on either state lands or conservation easements. The USACE provides some additional protection of the smaller mapped wetlands.

Western New York

The Western New York population is another small and isolated population with presumably low viability (Figure 1). The area in which the species occupies is unknown relative to which parcels are protected.

Additional Information

Mapped wetlands greater than 5 ha (12.4 acres) are protected in New York State under the Freshwater Wetlands Act of 1975 (ECL Article 24 implemented by 6 NYCRR Parts 663 and 664). These wetlands and their 30.5 m (100ft) adjacent areas are also protected. However, wetlands less than 5 ha are not considered protected unless they are mapped as wetlands of Unique Local Importance (ULI) or previous mitigation sites. One category of such ULI wetlands includes known occupied wetland habitat for an endangered or threatened species. In addition, 6 NYCRR Part 182 protects known occupied habitats of State listed Endangered and Threatened species. The USACE regulates the discharge of fill into the Waters of the United States of any size that are connected by surface water to waters of the United States and also navigable waters of the United States (Section 404 and 10, respectively). However, USACE protections do not extend into the adjacent areas or take jurisdiction over isolated wetlands. Additional protection of these smaller wetlands should be explored as not all locations of Blanding's turtle populations are known and these wetlands may provide essential habitat for the species. Protection of other essential habitats such as associated upland nesting habitats is also integral to the species' persistence in New York.

Conservation Plan Time Frame and Follow-up

This conservation plan should be reviewed and evaluated in 2027. At this time, a population viability analysis should be conducted with updated information gathered from monitoring of populations within the conservation units to identify any new research and management needs. Site-specific management plans should be in place to ensure that significant habitats are protected at each of the four populations or conservation units.

Periodic monitoring consistent with the Northeast Blanding's Turtle Working Group protocols should be conducted to ensure that trends are being monitored. Periodic monitoring consists of both long term monitoring and rapid trapping monitoring. Protocols are summarized here:

Coordinated Monitoring Strategy for the Blanding's Turtle in the Northeastern United States[1]

Coordinated Monitoring Strategy Summary

Long Term Monitoring Sites

Every five years, a long term monitoring site should be trapped to assess population trends. Long term monitoring sites have been established in Lisbon, Coles Creek, Wilson Bay, Perch River, and Dutchess County. Efforts to increase sampling at Saratoga and Western New York should also be made. Trapping should take place for a period of 12 nights in each of three seasons: (1) pre-nesting: April 15–May 27, (2) nesting: May 28–July 8, and (3) post-nesting: beginning July 9. An optional fourth trapping event could occur after September 1 in addition to, or as a replacement of a missed season. For each sampling event, 20 hoop traps should be deployed in groups of five within a ≤400 m circular area, with the center of the circles at least 800 m apart from one another. Efforts to set traps at least 20 m from one another should be made. In cases where four circular areas cannot be fit into a wetland, three circular areas can be used. Traps will need to be checked every 24 hours. This effort will allow DEC to evaluate change in site-specific Blanding's turtle density over time, as well as relative age structure and sex ratios at the sites. The trap results will also allow for an assessment of variation in seasonal and annual trap success.

Other Sites

Trapping Rapid Assessments

Trapping should take place across four consecutive nights at each site from April 1–October 1. Twenty traps are also deployed and checked in an identical manner to those outlined in the Strategy. For a five-year assessment, ten sites should be trapped in this manner. An additional five random sites should be trapped using one circular grouping of five traps to look for shifts in site occupancy. The Coordinated Monitoring Strategy should be consulted for guidance on site selection and duration of trapping schedules.

Visual Rapid Assessments

Seven to eight sites should be targeted for visual rapid assessments across a five-year period. Four of these should be new high priority sites with up to two replicates of two sites, and two should be long term monitoring sites. The Coordinated Monitoring Strategy[1] should be consulted for guidance on site selection.

[1] Available at: www.blandingsturtle.org/uploads/3/0/4/3/30433006/appendixb_cms_embl.pdf

CONSERVATION ACTIONS

1. Develop more precise estimates of life history parameters such as annual mortality rates, nest success, etc. using data from New York populations and apply this information to refine a population viability analysis.

2. Identify the status and distribution of the Western New York population.

3. Continue periodic monitoring of Blanding's turtle populations consistent with the protocols developed by the Northeast Blanding's Turtle Working Group to identify status and trends of known populations and to identify new known populations.

4. Determine which mitigation efforts are effective at reducing road mortality and the impact of ecological traps.

5. Evaluate effectiveness of mitigation efforts employed by developers to provide a net conservation benefit to Blanding's turtles.

6. Recruit at least one adult female turtle into each of five long-term monitoring sites every 10 years in the Northern New York and Dutchess County Conservation Units to offset the impact of road mortality.

7. Recruit at least five new females into the breeding population every 10 years in the Saratoga Conservation Unit.

8. Protect at least five nests per year until hatching in both the Northern New York and the Dutchess County Conservation Units, and at least one nest per year in the Saratoga County Conservation Unit.

9. Headstart and release at least 20 individuals (1:1 sex ratio) at age one or older into both the Northern New York and Dutchess County Conservation Units at 10- year intervals. Headstart and release at least 10, 1-year-old females into the Saratoga County Conservation Unit at 10 year intervals.

10. Secure long-term protection of at least 50 % of occupied habitat for Blanding's turtle populations via land acquisition or the establishment of conservation easements. Include all habitats that support essential Blanding's turtle behaviors (e.g., foraging habitat), wintering habitat, nesting habitat, aestivation habitat, and movement corridors).

11. Maintenance of at least 75 % of the initial genetic heterozygosity (i.e., an index of genetic diversity) in the population of Blanding's turtles in the Saratoga County Conservation Unit and 75 % of the initial heterozygosity in at least five long term

monitoring sites in both the Northern New York and Dutchess County Conservation Units.

12. Continue work with partners in other states and the Seneca and Akwesasne Nations to develop and implement site-specific management plans for the species throughout the northeast.

13. Develop and implement an effective outreach and education program to inform the public about threats to Blanding's turtles and how to mitigate these threats.

14. Protect known extant populations and their habitat using existing regulations and continued administrative support.

MANAGEMENT STRATEGY

ACTION 1. Develop more precise estimates of life history parameters such as annual mortality rates, nest success, etc. using data from New York populations and apply this information to refine a population viability analysis.

Initial progress has been made at completing this action by various universities, NGOs, and the DEC. Efforts to acquire new information from other studies should be made to supplement information and if possible, develop age-specific mortality rates.

Rationale: Knowledge of life history parameters (e.g., age-specific mortality rates, nest success, minimum age of reproduction, etc.) of New York Blanding's turtles is important in constructing accurate models to determine the population's viability in the state. To generate models in the PVA in Appendix 1, information was supplemented from Blanding's turtle populations from outside of New York, because it was believed that the information that was available from outside of New York would be similar enough to be relevant to populations within New York. In addition, information from New York was added to estimates to make information more relevant (e.g., minimum values of road mortality rates in observed in New York were added to adult mortality rates measured in a Michigan population without road mortality). However, it must be noted that information such as habitat quality and climate of other geographic locations may be similar to New York populations, but information such as threats affecting populations may be vastly different. One way to increase our confidence about using outside information in the PVA models would be to test the model outcome's sensitivity to variations in the parameter (this was completed for the PVA in Appendix 1). In this way, one can determine that the parameter estimate would either (1) have a small influence on the model outcome, and thus will not likely impact accuracy, or (2) have a large influence on the model outcome and therefore be important to have an accurate estimate of the parameter. In the case of age-specific mortality rates for Blanding's turtle populations in New York, variations in mortality rates greatly influenced model outcomes. Therefore, it is important to ensure that accurate estimates of this parameter are used to assess population viability.

Objectives:

(1) Estimate age-specific mortality rates for all New York Conservation Units.

(2) Improve estimates of nest success at long term monitoring sites.

(3) improve estimates of recruitment into the breeding population at long term monitoring sites.

(4) Refine a PVA using updated New York-specific life history parameters and set priorities for management and research.

Approach:

To estimate age-specific mortality rates for New York Blanding's turtle populations, we will need to organize and examine capture-recapture information that has been collected for all populations within New York. Enough information may exist for accurate estimates in populations in northern New York and Dutchess County, as these populations have been studied continuously for several years. Researchers could then conduct an analysis of capture-recapture data to determine mortality rates by age class using Program MARK. These new age-specific mortality rates can then be used to update and refine a PVA for greater relevancy to New York populations. Program MARK can also be used to estimate recruitment into adulthood. Nest success should also be estimated at long term monitoring sites. Once better estimates of these life history parameters are available, a new PVA could be conducted to determine the magnitude[1] of actions (e.g., improve recruitment rates, nest success, etc.) that need to be conducted that will lead to viable Blanding's turtle populations in New York over the next 300 years.

ACTION 2. Determine the status and distribution of the Western New York population.

Rationale: Little is known about the status of the Western New York Blanding's turtle population (Ken Roblee, pers. comm.). Efforts should be made to identify populations in Chautauqua and western Cattaraugus Counties and to work with First Nation agencies and personnel to determine whether populations of Blanding's turtles exist on those lands. It will also be necessary to determine whether populations found in the above locations are stable, increasing or decreasing. Such information would be useful to determine whether the population in western New York is viable. If the population is found not to be viable over the next 300 years, actions to promote population viability should take place.

Objectives:

(1) Determine the status and distribution of the Western New York Blanding's turtle population.

(2) Conduct a PVA of the Western New York population and set research and management priorities using methods similar to those outlined in Appendix 1.

[1] As stated previously, because PVAs are useful in determining which actions are important to take to maintain population viability via sensitivity testing, it is probable that the actions already determined will not change, but their magnitudes will change with an updated PVA.

Approach:

Work with First Nation agencies to employ methods to assess Blanding's turtle site occupancy such as trapping and visual surveys, on tribal lands. Using a GIS approach, determine if coarse-scale potential habitat exists in and around other historic sites in western NY. Conduct on-site habitat assessments at all identified locations and determine if a trapping survey should be conducted.

Survey methods outlined by Multi-SWG partners can be used to contribute population level information to the ongoing research taking place in the northeastern United States. More intensive trapping may be necessary to estimate numbers of individuals in the population to be used to refine a PVA specific to this population. Once the relevant information has been collected, conduct a PVA for the Western New York population to set research and management objectives. Monitor the population into the future at set intervals according to Multi-SWG protocols.

ACTION 3. Continue periodic monitoring of Blanding's turtle populations consistent with the protocols developed by the Northeast Blanding's Turtle Working Group to identify status and trends of known populations and to identify new populations.

Rationale: Periodic monitoring of rare species is important to identify status and trends to enable researchers to proactively adjust listing protections and conduct habitat management necessary to maintain populations. The Northeast Blanding's Turtle Working Group has developed a protocol for the periodic monitoring of Blanding's turtles at sites identified for long term monitoring and sites identified for rapid assessment. The periodic monitoring protocol should consist of trapping five long term monitoring sites in the Northern New York and Dutchess County Conservation Units (e.g., Lisbon, Coles Creek, Wilson Bay, Upper and Lower Lakes, Arlington) and the Saratoga County Conservation Unit. The Western New York Conservation Unit should also be included once the distribution is identified. Sites should be monitored every five years and can be visited on a rotational basis. Rapid assessments of new sites should also be conducted to monitor shifts in site occupancy across the region. Efforts should be coordinated with the Northeast Blanding's Turtle Working Group for continuity.

Objectives:

(1) Survey long term monitoring sites (five in the Northern New York and Dutchess County, one at the Saratoga, and one in the Western New York Conservation Units) at five-year intervals.

(2) Conduct rapid trapping assessments at 10 sites at five-year intervals.

(3) Conduct visual rapid assessments at eight sites at five-year intervals.

Approach:

For long term monitoring sites, trapping should take place for a period of 12 nights in each of three seasons: (1) pre-nesting: April 15–May 27, (2) nesting: May 28–July 8, and (3) post-nesting: beginning July 9. An optional fourth trapping event could occur after September 1 in addition to, or as a replacement of a missed season. For each sampling event, 20 hoop traps should be deployed in groups of five within a ≤400 m circular area, with the center of the circles at least 800 m apart from one another. Efforts to set traps at least 20 m from one another should be made. In cases where four circular areas cannot be fit into a wetland, three circular areas can be used. Traps will need to be checked every 24 hours. This effort will allow researchers to evaluate change in site-specific Blanding's turtle density over time, as well as relative age structure and sex ratios at the sites. The trap results will also allow for an assessment of variation in seasonal and annual trap success.

Trapping rapid assessments should take place across four consecutive nights at each site from April 1–October 1. Twenty traps are also used and deployed and checked in an identical manner to those in outlined in the long term monitoring strategy. For a five-year assessment, 10 sites should be trapped in this manner. An additional five random sites should be trapped using one circular grouping of five traps to look for shifts in site occupancy. The Coordinated Monitoring Strategy should be consulted for guidance on site selection.

Visual rapid assessments should be conducted at eight sites. Four of these should be new high priority sites with up to two replicates of two sites, and two should be long term monitoring sites to aid in comparison of methodologies. The Coordinated Monitoring Strategy should be consulted for guidance on site selection.

ACTION 4. Determine which mitigation efforts are effective at reducing road mortality and the impact of ecological traps.

Rationale: Mortality from collisions with vehicles on roads may be the most important source of mortality in turtle populations, due in part to the turtle's propensity to make significant overland movements during the nesting season, its long time to reach sexual maturity, and the dependency of population viability on adult mortality (Congdon et al. 1993, Congdon et al. 2003, Compton 2007). Turtles are long-lived species with low recruitment and populations can suffer significant declines by the loss of a few of the reproductive adults (Congdon et al. 2003). Beaudry et al. (2010) suggest that Blanding's turtles are especially vulnerable to road mortality, owing to the species' complex movement patterns and habitat requirements. Compton (2007) suggested that road mortality is likely the single most important threat to Blanding's turtle populations in the northeastern portion of the species' range. Even a very small decrease (e.g., 2-3 %) in annual adult survivorship, which is already high (e.g., 96 %; Congdon et al. 1993), can lead to decreased population viability (Compton 2007).

There is a growing body of knowledge on the effects of roads on wildlife populations. Some researchers have identified areas of high road mortality, called "hotspots", where there is a greater risk of wildlife-vehicle collisions (Langen et al. 2012). Langen et al. (2012) found that roads with wetland on either side (i.e., causeways), roads associated with high vehicular traffic, and roads associated with a high percentage of forest cover were good predictors of hotspots for three turtle species (Blanding's turtle, midland painted turtle [*Chrysemys picta marginata*], and the snapping turtle [*Chelydra serpentina*]). However, patterns of Blanding's turtle mortality hotspots were more difficult to define with respect to landscape features (Langen et al. 2012). In addition, there are patterns of higher rates of movements and consequent road crossing in time as well as space, called "hot moments". For example, Beaudry et al. (2012) found that adult Blanding's turtles of both sexes cross roads more frequently in June and early July in Maine.

A road crossing underpass has been constructed in Algonquin Provincial Park for Blanding's and wood turtles (B. Steinberg, pers. comm.). The structure is accompanied by fencing that directs individuals under the road. Natural substrate (e.g., sand) is lining the bottom of the underpass and the top is constructed of steel decking that allows sunlight to filter through. In addition, lower speed limit signs have been placed along highways and roads that bisect Blanding's turtle habitat in Ontario. G. Johnson (unpubl. data.) found that turtle crossing signs placed along roads during the nesting season were not effective at reducing vehicle speeds. However, driver awareness was not assessed during this study. Hence, more information is necessary to determine if road signs can be an effective alternative to road crossing structures at reducing turtle road mortality. Speed bumps may also be effective at reducing speeds and serve to reduce road mortality. An effective outreach program is paramount to the success of a road mortality mitigation effort (Reed 2008).

Ecological Trap Mitigation

In the absence of quality nesting habitat, Blanding's turtles and other species will nest in recently plowed fields. It has been found that nests in these fields experience greater mortality rates than natural nesting sites from decreased solar exposure and lower temperatures once row crops grow (G. Johnson, unpubl. data). Creating nesting areas near fields used for row crops may result in the spread of nest locations from greater concentrations in poor row crop sites to greater concentrations in the created higher quality sites.

Objectives:

(1) Determine whether road signs or speed bumps are effective at reducing Blanding's turtle mortality.

(2) Assess the feasibility of constructing underpasses, including culverts, on existing roads and planned future roads and test whether different underpasses are being used and whether they are effective at reducing Blanding's turtle road mortality.

(3) Determine whether enhancing nesting sites in proper locations may be an effective alternative for reducing road mortality.

Approach:

Road signs may be an effective road mortality mitigation strategy for freshwater turtles if they serve to make drivers more aware of the potential to hit a turtle. However, a study by Ashley et al. (2007) in Long Point Provincial Park in Ontario found that drivers targeted animals on roads. Therefore, it is possible that making drivers more aware of reptiles on roads may work against conservation goals if drivers begin to target these species while driving on roads. Either way, gaining an understanding of whether road signs are effective at reducing turtle road mortality may be necessary to mitigate the effects of roads on Blanding's turtle populations. Building on G. Johnson's (unpubl. data) study of road signs will be necessary to answer this question. In addition, testing effectiveness of implementing more sign designs like silhouettes of turtles or flashing signs and reducing speed limits in areas of high mortality should also be conducted.

Efforts will need to be made to work with local towns and New York State Department of Transportation staff to design and implement effective road crossing structures on new roads and roads that experience high turtle mortality. New structures and ones that are retrofitted into existing roads will need to be monitored to determine their effectiveness. All management should be conducted in an experimental framework.

Finally, determining whether enhancing or creating nesting habitat between wetlands and roads with high mortality is effective at reducing turtle mortality is also necessary, as it would be a viable and more cost-effective alternative to retrofitting crossing structures to pre-existing roads. A DEC project to enhance a nesting site was completed before the 2015 nesting season. The objective was to determine whether this management method would effectively deter turtles from crossing roads. The hypothesis to be tested was if suitable nesting habitat was available to turtles before reaching the road, would it reduce individuals' propensity to cross the road? In 2015, the DEC did not observe use of the new nesting areas by Blanding's turtles. However, in 2016, plans are to introduce female Blanding's turtles to the nesting areas prior to and during the nesting season as others have found this method to be effective at encouraging use (Grgurovic, pers. comm.).

ACTION 5. Evaluate effectiveness of mitigation efforts employed by developers to provide a net conservation benefit to Blanding's turtles.

Rationale: Development projects are reviewed by DEC every year in areas of potential and known Blanding's turtle habitat, with DEC staff recommending mitigation measures to prevent impacts to this species (CWCS, p. 533). Several projects have implemented these recommendations (e.g., installation of culverts, fencing installation, nesting enhancement and creation, etc.). While surveys and assessments of habitat and Blanding's turtle populations are completed before projects are initiated, investigation of the implementation and effectiveness of these mitigation actions have not been broadly assessed. However, some noteworthy projects have completed follow up monitoring. For example, researchers at James Baird State Park and Arlington High School have conducted follow up monitoring of a habitat improvement project that was completed as mitigation of a school expansion project. Other projects exist that have had no associated follow up monitoring. A review of mitigation measures implemented and assessment of current habitat and populations can help evaluate the effectiveness of these measures at preventing or mitigating impacts and will serve to inform decision makers during future development project review. This information is also valuable to develop Best Management Practices (BMPs) that can be shared with developers (CWCS, p. 376, 379-81, 527, 535; CWCS Appendix A4, p. 62-63). Particular mitigation measures that we would like to test for efficacy are (1) creation or enhancement of nesting habitat for the species, (2) wetland habitat improvement projects, (3) safe passage structures to allow turtles to safely cross roads, (4) fencing to keep turtles off roads.

In addition, an immediate management action is to create or enhance nesting habitat near Blanding's populations to encourage nesting in new areas and discourage gravid female road crossings to existing nesting sites. This can be accompanied by the installation of electric fencing to protect nests from predators in areas where predation is high. Population viability analyses (Appendix 1) have indicated that a reduction in both nestling mortality and adult road mortality can contribute to the maintenance of sustainable populations in New York by improving recruitment into the breeding population. Knowledge of whether these proposed activities increase survivorship of young and adult Blanding's turtle age classes is important to infer project success.

Objectives:

(1) Evaluate the effectiveness of previous Blanding's turtle mitigation measures that have been implemented.

(2) Experimentally create >0.25 acre patches of suitable nesting habitat adjacent to known Blanding's turtle occupied wetlands where road crossings rates are elevated.

(3) Monitor success of created nesting areas and other mitigation measures using trail cameras and surveys.

(4) Determine if created or enhanced nesting areas have led to a reduction in road crossings or road mortality as a proxy for increased recruitment into adulthood.

(5) Develop scientifically-tested BMPs to be used for development projects that will affect Blanding's turtle habitat.

Approach:

A New York State Wildlife Grant project was begun in 2014 to complete some of this work. A review of DEC files for projects and studies that included the development of habitat for Blanding's turtles has been conducted as part of the project. Some examples of mitigation projects include habitat restoration at James Baird and Wellesley Island State Parks; culvert installations for safe passage in Dutchess, St. Lawrence, and Jefferson Counties; and nesting habitat enhancements in St. Lawrence and Jefferson Counties. After locations of target mitigation actions are identified, field investigations of mitigation measures take place to characterize the amount of use by Blanding's turtles. Surveys will use methodology developed by the Multistate Wildlife Grant (Multi-SWG) that was granted to New York, Maine, New Hampshire, Massachusetts, and Pennsylvania. This survey methodology is available at (www.americanturtles.org/uploads/2/6/3/4/26349000/standardizedprotocol_embl.pdf).

Occupancy modeling should be used to estimate detection probabilities of trapping and visual surveys in wetlands. Trail cameras and visual surveys will allow for evaluation of nesting area use and camera traps can be used to characterize effectiveness of electric fencing, drift fencing, and to identify culvert usage. Nesting enhancement areas should be selected based on locations in which road mortality has been documented. A combination of nesting habitat creation and enhancement, drift fencing, and signage should be implemented to reduce road crossings and increase driver awareness of crossing turtles. Sites should be monitored to assess the success of habitat creation (e.g., number or presence of turtle nesting, frequency of road kills). Nest site creation and enhancement will be conducted following guidelines developed by the Massachusetts Natural Heritage and Endangered Species Program[1] and by the Northeast Blanding's Turtle Working Group[2] and summarized below.

Advisory Guidelines for Creating Turtle Nesting Habitat

Potential nesting sites for creation or enhancement will need to have ample sun in a 180-degree arc from east to west throughout most of the day. Total area of each nesting site will be

[1] Available at www.blandingsturtle.org/uploads/3/0/4/3/30433006/nebtwg_nesting_reduced.pdf

[2] Available at: www.mass.gov/eea/docs/dfg/nhesp/species-and-conservation/creating-turtle-nesting-sites.pdf

greater than 6 m in each direction and the site will need to be above the spring/summer flood plain. We recommend a 6 x 15 m berm. The site may need to be larger to get sun exposure throughout the day, depending on the proximity and height of the adjacent trees in forested areas.

If well-drained mineral soil (sand or gravel) is present, removing the vegetation and scarifying the ground to loosen the substrate may be the only necessary step to create or enhance nesting habitat. If good substrate is not present, it will be necessary to bring in clean washed sand from another location. Washing the substrate will be effective in reducing weeds or invasive plant species and can impede rapid growth of new vegetation. If the soil present is not acceptable, substrate can be brought in and should consist of <5 % clay and <25 % gravel. The new substrate can be deposited on top of the existing substrate in a layer 12 in thick. A small clay berm can be added around the perimeter of the new material to keep the newly deposited sand and gravel from eroding. The impermeable clay berm will enhance longevity of the nesting site. Annual maintenance of the site to reduce vegetation growth may be necessary to keep the site open.

ACTION 6. Recruit at least one adult female turtle into each of five long-term monitoring sites every 10 years in the Northern New York and Dutchess County Conservation Units to offset the impact of road mortality.

Rationale: Mortality from collisions with vehicles on roads is likely an important source of declines in Blanding's turtle populations, due in part to the species' propensity to make significant overland movements during the nesting season, its long time to reach sexual maturity, and the dependency of population viability on low adult mortality (Congdon et al. 1993, Congdon et al. 2003, Compton 2007). Blanding's stuck in railroad tracks is also not an insignificant source of mortality. In addition, turtles are long-lived species with low recruitment and populations can suffer significantly by the loss of a few of the reproductive adults (Congdon et al. 2003). Beaudry et al. (2010), suggest that Blanding's turtles are especially vulnerable to road mortality, owing to the species' complex movement patterns and habitat requirements. Compton (2007) suggested that road mortality is likely the single most important threat to Blanding's turtle populations in the northeastern portion of the species' range. Even a very small decrease (e.g., 2-3 %) in adult annual survivorship, which is generally high (e.g., 96 %; Congdon et al. 1993), can lead to decreased population viability (Compton 2007).

Compton (2007) conducted a power analysis and determined that measuring actual rates of road mortality on Blanding's turtles with power to detect a 2 % change at $P \leq 0.05$ using radio telemetry would require 800 animals to be equipped with transmitters each year. Therefore, telemetry would likely not be a feasible option for detecting rates of road mortality. In addition, Compton (2007) pointed out that road surveys would likely need to be too extensive to be cost effective, and would have limited applicability to other populations, as factors such as traffic rates and turtle population parameters (e.g., density, distribution, etc.) vary spatially. An alternative to radio telemetry and extensive surveys would be to generate a GIS model similar to the model developed by Compton (2007), whereby the author applied information on traffic rates, turtle movements, and a road crossing mortality model generated by Gibbs and Shriver (2002) to generate a "footprint" of roads on the Blanding's turtle populations in New York. To get direct information from specific areas, Langen et al. (2007) present a methodology to determine road crossing rates in the field.

We propose to recruit at least one adult female into the breeding population at each of five long term monitoring sites every 10 years in the New York and Dutchess County Conservation Units to offset the effects of road mortality and improve population viability.

Objectives:

(1) Install safe passage structures to roads and train tracks in areas where mortality has been documented to improve Blanding's turtle crossing success and decrease mortality rates.

(2) Undertake surveys near long term monitoring sites and determine new locations of road mortality hotspots and work with local and state departments of transportation to mitigate road mortality.

(3) Protect nests to increase hatchling numbers in the long term monitoring sites to boost opportunities for recruitment into the juvenile and adult populations.

(4) Develop a spatial model that incorporates road traffic volumes, Blanding's turtle movements, and road crossing mortality models for each Blanding's turtle population in New York to better estimate road mortality rates.

(5) Provide and test measures to reduce road mortality.

(6) Monitor recruitment in five long term monitoring sites in Dutchess County and the Northern New York Conservation Units. Update and refine PVA as necessary to update conservation targets.

Approach:

Efforts to collect existing information on turtle movements from researchers in New York (e.g., J. Gibbs, G. Johnson, E. Kiviat, and the DEC) should be undertaken to generate the models to be used in this analysis. If information is incomplete or inaccessible, funding should be provided to improve information on turtle movements in each of the five long term monitoring sites that can be applied to the Gibbs and Shriver (2002) road mortality model. In addition, long term monitoring of populations can provide useful information on recruitment. Once analyses are complete, information should be applied to refine the PVA completed in Appendix 1 to set new appropriate conservation targets.

Road mortality reduction measures can include road crossing barriers (e.g., fencing), and road crossing structures (e.g., culverts). In addition, it has been suggested that road mortality may be reduced by creating or enhancing nesting locations on the side of roads where wetland habitat and turtles occur to discourage turtle crossings to reach areas used traditionally for nesting. Installing fencing and enhancing nesting areas can be an inexpensive alternative to installing culverts to existing roads. Working with local and state departments of transportation is also necessary to opportunistically plan culvert replacements during road resurfacing projects. All management strategies undertaken to mitigate road mortality should be tested in an experimental framework to facilitate quantitative and conclusive results. Periodic monitoring to evaluate rates of recruitment into the breeding population will need to be conducted to determine whether mitigation measures implemented are still working at 10-year intervals.

ACTION 7. Recruit at least five females into the breeding population every 10 years in the Saratoga Conservation Unit.

Rationale: Results of a New York Blanding's turtle PVA completed by A. Ross (unpubl. data) (Appendix 1) have indicated that mortality in the 1–14-year-old age class in the Saratoga population greatly affects population viability. Across the species' range, little information exists on Blanding's turtle mortality rates for the 1–14-year-old age class that has not been estimated indirectly by a life table (Congdon et al. 1993, Pike et al. 2008). Moreover, direct measurements of these rates in New York populations have not been made. The lack of data is attributed to the juvenile age classes' extremely secretive nature and difficulty being captured (Pike et al. 2008). Pike et al. (2008) challenged the generally accepted belief that high mortality rates exist in juvenile turtles by employing computer simulations. Authors argued that if mortality rates of juvenile turtles are as high as generally accepted, populations would not have been viable for as long as they have been. J. Congdon (pers. comm.) confirmed this notion, stating that as the individuals in the juvenile age class reach adulthood, mortality rates must approach that of the adult age class. According to PVA simulations (Appendix 1), a 10 % decrease in mortality of 1–14-year-old individuals will contribute significantly to improving the species' viability in the Saratoga population. However, since we do not accurately know the number of animals in the starting population, recruitment into adulthood will be a better life history measure to monitor and improve. Hence, ensuring recruitment to adulthood from this juvenile age class is essential to ensuring population viability in the Saratoga County Conservation Unit. In addition, other action items highlighted above and detailed below will need to be carried out in conjunction with this action to achieve the goal of maintaining viable populations in Saratoga.

Objectives:

(1) Increase juvenile survivorship into the breeding population.

(2) Develop a New York-specific life table.

(3) Provide and test measures to reduce mortality rates of juveniles.

Approach:

Information on individual captures and recaptures exists for the Saratoga population (A. Chaloux, unpubl. data). However, there have been very few individuals (*n* = 14) observed in this population (A. Chaloux, pers. comm.). If estimates of mortality for this age class cannot be made due to small sample sizes, it will be necessary to supplement information from other New York populations such as that from northern New York and Dutchess County. With sufficient information, a direct estimate of mortality rates can be made, or a life table can be constructed to estimate mortality using methods by Congdon et al. (1993). Once measures to reduce mortality of juveniles and improve recruitment into the breeding population are known, implement these measures to promote the addition of at least five new females into the population every 10 years.

ACTION 8. Protect at least five nests per year until hatching in both the Northern New York and the Dutchess County Conservation Units, and at least one nest per year in the Saratoga County Conservation Unit.

Rationale: Nest mortality is a significant source of mortality for Blanding's and other turtles (Congdon et al. 1987). Placing nest guards on Blanding's turtle nests can be an effective measure of reducing hatchling turtle mortality (Standing et al. 1999, G. Johnson, unpubl. data). In addition, placing temporary electric fencing around nest sites to exclude predators can be effective at reducing turtle mortality (Geller 2012). Other methods such as removal of predators may also be effective, but may be more difficult to implement or study. Christiansen and Gallaway (1984) examined the effects of reducing predators at turtle nesting sites on nest success with positive results. More recently, Urbaniek et al. (2016) detected a marked reduction in nest predation following predator removal but the effect appeared to be short-lived. A Nova Scotia population of Blanding's turtles experienced 76 % and 93 % nest success in 1994 and 1995, respectively, from placing nest guards on nests (Standing et al. 1999). In a population of Blanding's turtles in northern New York, wire nest guards were placed on more than 50 nests from 2003-2012 with only two nests failing due to predation (G. Johnson, unpubl. data). The failed nest guards presumably failed because one was placed on a steep incline and the other was not anchored to an adequate depth (G. Johnson, unpubl. data). In 2016, of eight nest guards placed in northern New York, two failed due to skunks getting into the hatchling egress holes. Egress holes were cut in order to allow hatchlings to escape after they emerged. However, these holes were cut slightly too large, allowing for skunk access. Such methods of erecting nest guards can be effectively employed in other populations to ensure higher nest survivorship. According to a New York Blanding's PVA (Appendix 1), the protection of at least five nests in each of the Northern New York and the Dutchess County Conservation Units, and the protection of at least one nest in the Saratoga County Conservation Unit will contribute to the maintenance of viable Blanding's turtle populations over the next 300 years in each respective population.

It is important to note that in the PVA model by A. Ross (unpubl. data) (Appendix 1), the assumption is that a large portion of the mortality of the 0-1 age class is due to nest depredation. Therefore, the effect of protecting nests with guards on population viability may be overstated. It is possible that hatchling mortality is also extremely high, particularly in areas with inflated populations of subsidized mesocarnivore predators that dig up nests and hatchlings in the nest, as densities of these predators can be very high near human activity. Despite protecting nests to increase nest success, there may still be little to no recruitment into the breeding age classes. However, due to the hatchlings' small size and difficulty in locating them, it is difficult to study survivorship of these individuals.

Objectives:

(1) Locate Blanding's turtle nests and protect at least five nests in both the Northern New York and Dutchess County Conservation Units every year.

(2) Locate and protect at least one nest in the Saratoga County Conservation Unit each year.

(3) Monitor effects of nest protection methods on turtle nest mortality.

Approach:

Evaluate each population for the best methods of nest protection (nest guards, predator removal or predator exclusion) based on staff time and resources available and the amount of area that will need to be protected to achieve target numbers of nests protected.

Electric Fencing
Since temporary electric fencing is effective at reducing nest depredation (from 87 % to 15 % predation in control and fenced areas, respectively [Geller 2012]), it may be a cost-effective strategy at reducing nest mortality in areas where nests are dense. For example, nesting areas in the northern New York population at Cole's Creek and Lisbon Swamp have been carefully identified and would benefit from temporary electric fences. In addition, areas in Saratoga and Dutchess Counties have also been identified and would be appropriate for electric fencing. Methods to construct fencing and monitor effectiveness should follow methods by Geller (2012). In 2015 and 2016, fences that followed Geller (2012) exactly were not effective at

keeping out raccoons and skunks. Ross and Johnson (unpubl. data) split fences into two at four sites and added an additional live fence wire to the outside of one of the fences to determine if raccoons and skunks would be deterred. These modifications need further study.

Nest Guards

If it is determined that electric fencing is not feasible in nesting habitat, nest guards may be the most appropriate method of predator exclusion. However, this method may be more expensive over time as it requires significant staff time to identify nests. Nest sites will need to be visited from 6:00 pm-12:00 am each night from 1-21 June or until the target number of nests have been protected. For a full description of an appropriate nest survey protocol, see Appendix 2. If the target numbers of individuals have not been reached by 21 June, the period can be extended. Once a Blanding's turtle has been found in the nesting area, it should not be touched or approached. The individual should be left to dig and begin laying before being approached, otherwise she will likely abandon efforts. Once staff suspects that the individual has begun to deposit eggs, they may slowly approach to confirm that laying has begun and mark the area, but not before then. Once the female has completed nest burial and moved out of the area, the nest guard can be placed on the nest. To place nest guards on nests, a template (i.e., ring) can be made in the sand with the bottom of the nest guard, with the center of the nest guard directly above the center of the nest. The template will ensure that the nest will not be disturbed when excavation takes place to seat the nest guard. A hole should be carefully dug by with a trowel or by hand (a spade can be used in firmer substrates) by digging out the outside of the ring. It is essential not to disturb the immediate nest area, so the ring should be dug to the outside of the template or nesting microsite. Once the ring is about 30 cm deep, the nest guard can be fitted on top of the nest so that it is at least 30 cm below the surface of the substrate and backfilled from the outside. The outside should then be packed down so that a predator could not easily dig into the substrate and expose the nesting area. Once nest guards are in place, visits should be made to the nests daily from August 15 until hatching to remove the nest guard. If visits cannot be made as frequently, a small hatchling-sized hole can be made in the guard at ground level so that hatchlings may escape on their own. Care should be taken to make this egress hole as small as possible to reduce the chances of skunks entering the nest guard.

Nest guards should be constructed from 1-cm cell (or similar) hardware cloth shaped into an approximately 50-cm diameter cylinder and be approximately 70 cm long. The tops should be constructed of hardware cloth that overlaps the sides and is secured to the sides with heavy gauge cable ties or metal wire ties, although other methods and materials have been used and can be effective.

Predator Control

Predator control should be explored as a measure to reduce predator densities in turtle nesting areas and improve nest survivorship. If the control is effective in reducing predator numbers, there may be a concomitant reduction in hatchling mortality through the first year.

ACTION 9. Headstart and release at least 20 individuals each (1:1 sex ratio) at age one or older into both the Northern New York and Dutchess County Conservation Units at 10-year intervals. Headstart and release at least 10, 1-year-old females into the Saratoga County Conservation Unit at 10-year intervals.

Rationale: Headstarting can be a relatively inexpensive and effective means of bolstering turtle numbers within populations. A PVA (Appendix 1) suggested that headstarting may be an important management action for New York populations of Blanding's turtles to boost numbers and maintain genetic diversity of remaining populations. Headstarting was conducted at the Overlook Preserve in Dutchess County in 1997 and animals were monitored until 2009 (K. Munger, pers. comm.). Breeding was expected to occur in these individuals for the first time around 2016, but more recent monitoring of this population has not taken place. Buhlmann, et al. (2015) have conducted headstarting in the Assabet River National Wildlife Refuge, Massachusetts from 2007-2011. Authors compared turtles that they released directly after hatching to turtles that were headstarted for nine months. Headstarted turtles were approximately double the size of direct release individuals (Buhlmann et al. 2015). Buhlmann et al. (2015) had approximately 10 % mortality of nestlings in captivity, hence collection of target numbers of to-be releases should be buffered at least 11.2 % above targets to account for this mortality. To identify whether headstarting is a viable means of conserving populations, more work should be conducted to evaluate these and additional headstarting efforts.

Objectives:

(1) Collect 10-12 target numbers of individuals from each conservation unit at 10-year intervals thereafter from nest sites.

(2) Raise individuals until they are one-years old or the size of a wild one-year-old turtle (whichever is sooner) and release at point of capture.

Approach:

Nesting site surveys will need to be conducted using methods outlined in Appendix 2. Once nesting females are found, two methods of headstarting could take place: (1) placing nest guards on nests and waiting until the young emerge for collection, or (2) carefully digging up nests by hand and incubating until hatching. If collecting eggs for incubation, eggs will need to remain in the same orientation as they were laid so that turtle embryos will not suffocate. Care should be taken to ensure that temperatures are within the normal range limits of natural nests to ensure a 1:1 sex ratio. With either method of collection for headstarting, young turtles will need to be placed in tanks and provided with natural food and commercially available turtle pellets until they are the size of a one-year-old wild individual[1]. A biosecurity plan will need to be in place, where details of the plan will depend on where headstarted individuals will be housed. Individuals should be brought to the point of collection and released. In addition, turtles should be marked so that success of headstarting can be assessed. At the release period, turtles should be marked with external notches or Passive Integrated Transponder (PIT) tags. If individuals are large enough, PIT tags should be used as they offer a more permanent solution for marking.

Since Blanding's turtles have temperature-dependent sex determination, meaning that a nestling's sex is determined by the outside temperatures, it will be possible to control the number of male and female turtles hatched. Goals will be to headstart and release at least at least 20 individuals each (1:1 sex ratio) at age one into the Northern New York and Dutchess County Conservation units at year 0 and at 10-year intervals thereafter. We recommend headstarting and releasing 10, one-year-old females into the Saratoga population at 10 year intervals (on average) starting immediately. Efforts should be made to release 10 individuals at 10-year intervals, but the frequency of headstarting could increase, provided that there are 10 released every 10 years on average. This frequency should not decrease to more than 10-year intervals as variations in predators or other environmental factors may have unforeseen negative impacts to the newly released individuals. It may be more effective to raise individuals and release them into the populations at a gradient of ages, to ensure that the environment is not saturated with one age class. According to PVA models (Appendix 1), this action should be carried out throughout the duration of the plan period to help ensure viable populations of Blanding's turtles in the state.

ACTION 10. Secure long-term protection of at least 50 % of occupied habitat for Blanding's turtle populations via land acquisition or the establishment of conservation easements. Include all habitats that support essential Blanding's turtle behaviors (e.g., foraging habitat, wintering habitat, nesting habitat, aestivation habitat, and movement corridors).

Rationale: Occupied Blanding's turtle wetlands are typically protected if they are greater than 5 ha. Wetlands greater than 5 ha are protected in New York State under the Freshwater Wetlands Act of 1975 (ECL Article 24 implemented by 6 NYCRR Parts 663 and 664). However, there is no additional protection afforded to wetlands less than 5 ha, unless these wetlands are regulated by the USACE or they are mapped as wetlands of Unique Local Importance (ULI) or previous mitigation sites. In addition, associated upland nesting habitat outside of wetland buffers (30.5 m) are not protected under this legislation. It is important to note that nesting habitat protection is integral to the species' persistence in the state. There are many instances of Blanding's turtles using vernal pools in many parts of the species' range, including New York. In populations of Dutchess County and Saratoga County, vernal pool wetlands are thought to be

[1] Turtles that are reared in captivity can grow at a much faster rate than wild turtles.

essential to the species' persistence. In addition, Blanding's turtles have been observed to use wetlands smaller than 5 ha in northern New York. Protecting habitat is essential to ensuring that the species will have the opportunity to persist in New York into the future.

In the Northern New York Conservation Unit, occupied Blanding's wetlands (including historical locations) total approximately 2,587 ha, of which 1,331 ha (51 %)[1] are unprotected by state wetland laws or by not being located on either state lands or protected by conservation easements. In the Dutchess County Conservation Unit, the area occupied by Blanding's turtles is approximately 2,359 ha, of which 1,825 ha (77 %) are unprotected. In the Saratoga County Conservation Unit, the area occupied by Blanding's turtles is approximately 186 ha, of which 76ha (41 %) is unprotected. In the Western NY Conservation Unit, the area in which the species occupies is unknown relative to which parcels are protected. The USACE provides some additional protection of the smaller mapped wetlands. The area occupied and focus areas for land and conservation easement acquisition should be better identified and delineated so that land acquisitions and easements can be established to protect the species' valuable occupied habitat.

Objectives:

(1) Conduct a more detailed analysis of protected and unprotected lands and map these locations to develop conservation focus areas.

(2) Rank sites to determine priorities for land acquisition or easement establishment.

(3) Protect wetlands less than 5 ha known to be used by Blanding's turtles or are potentially used by Blanding's turtles due to their proximity to occupied wetlands through regulatory and non-regulatory approaches as appropriate.

(4) Protect known upland nesting areas and areas that are not known, but may be potentially used by Blanding's turtles.

Approach:

Examine the most recent location and occupied habitat data for Blanding's turtles in the four conservation units in ArcGIS. Identify areas that are protected by New York State as regulatory freshwater wetlands and overlay these on the occupied habitat data layer. Ensure that nesting habitat is included within the occupied habitat data layer. Determine which parcels remain that have no protection. Prioritize land acquisitions in nesting areas and areas in close proximity to occupied protected wetlands. Long term management sites should be priority for acquisition. Purchases of land in fee-title or purchases of conservation easements should be explored if willing landowners are identified. If landowners with significant populations or with significant

[1] These calculations were derived from estimates of area of occupied habitat contained within element occurrence data from the New York Natural Heritage program in ArcGIS.

nesting habitat are unwilling to set up conservation easements, attempt to foster good working relationships with these landowners to ensure that habitat management can and is conducted to promote population persistence. Help find funding opportunities to maintain nesting habitat on these priority lands. Add land protection priorities into the Open Space Conservation Plan[1].

ACTION 11. Maintenance of at least 75 % of the initial genetic heterozygosity (i.e., an index of genetic diversity) in the population of Blanding's turtles in the Saratoga County Conservation Unit and 75 % of the initial heterozygosity in at least five long term monitoring sites in both the Northern New York and Dutchess County Conservation Units.

Rationale: Species that occur in small, isolated populations are of conservation concern because they can be more vulnerable to extinction due to random environmental and demographic events than larger, more robust populations. Models of population viability can show rates of loss of heterozygosity through time and can be used as a guide to monitor genetic diversity. Genetic monitoring of populations can also be conducted from collecting DNA and evaluating heterozygosity of genetic markers. From 2012-2016, blood samples have been collected from five long term monitoring sites (Lisbon, Coles Creek, Wilson Bay, Dutchess County, and Saratoga County) in New York as part of a Multistate Wildlife Grant (Multi-SWG) project involving Massachusetts, New Hampshire, Maine, Pennsylvania, and New York. Preliminary analyses showed that there was more variation within New York populations than across New York populations. Only one sample was collected from the Saratoga County Conservation Unit. In the future, new samples can be collected and genetic diversity or loss thereof can be re-evaluated. The maintenance of heterozygosity can also be modeled using program PVA software such as Vortex.

Objectives:

(1) Model heterozygosity using PVA and ensure that percent heterozygosity does not fall below 75 % of initial levels after 25 years at the Saratoga County Conservation Unit and in the five long term monitoring sites in both the Northern New York and Dutchess County Conservation Units.

(2) Protect populations by acquiring wetland, lands surrounding wetlands, and upland nesting areas and other occupied habitat or adjacent areas in fee or by establishing conservation easements.

[1] Available at http://www.dec.ny.gov/lands/98720.html

(3) Reduce nest and hatchling mortality rates, reduce road mortality, and improve recruitment in remaining populations.

(4) Update evaluations of genetic diversity of populations beginning in 2032. Improve sampling of individuals within the Saratoga County and Western New York Conservation Units.

Approach:

Population viability analysis software such as Vortex can be used to model heterozygosity across time. Samples for quantification of genetic diversity can be collected from five long term monitoring sites in both the Northern New York and Dutchess County Conservation Units, and at the Western New York and Saratoga County Conservation Units. Microsatellites should be analyzed to determine changes in genetic diversity since the 2016 analysis. Other measures to maintain genetic diversity can be accomplished through implementing conservation actions defined in all other sections outlined in this conservation plan. Improving retention of turtle numbers as much as possible will ensure the greatest maintenance of genetic diversity into the future. If heterozygosity falls below 75 % of 2016 levels by 2032, discussions on management to improve genetic diversity can take place.

ACTION 12. Continue work with partners in other states to develop and implement site-specific management plans for the species throughout the northeast.

Rationale: In 2011, a Multistate Wildlife Grant (Multi-SWG) was awarded to the northeastern states with populations of Blanding's turtles (Maine, Massachusetts, New Hampshire, New York, and Pennsylvania). Objectives of the Multi-SWG included the development of site specific management plans. Plans will need to be finalized for all of the long term monitoring sites that have been identified in New York. Funding will need to be sought for the implementation of these plans.

Objectives:

(1) Complete and implement site specific management plans for Blanding's turtles in the four conservation units in New York and implement these plans.

Approach:

Work with the Northeast Blanding's Turtle Working Group partners to complete and implement site specific management plans at long term monitoring sites. Participate in Multi-SWG projects to further conservation efforts in New York and across the northeast.

ACTION 13. Develop and implement an effective outreach and education program to inform the public about threats to Blanding's turtles and how to mitigate these threats.

Rationale: Effective outreach and education to inform the public about the negative effects of road mortality and collecting turtles can have multiple positive impacts on a successful conservation program. Raising awareness about this species within New York State among various stakeholders, landowners, and members of the public can lead to increased support, including lobbying legislators and providing conservation dollars for research, monitoring, and protection.

Effective outreach and education can have positive effects on both the species and the public. Of notable concern is the occasional take of a Blanding's turtle for a pet by an individual who does not know that the species is rare (G. Johnson, pers. obs.). A take in such a manner is the permanent removal of the individual from the breeding population. Such a take would have effects as serious as road mortality, which could confer dramatic negative effects on the population. Educating the public on Blanding's turtle identification may be the only means of decreasing these incidences. In addition, educating the public about the importance of avoiding running turtles over on roads, and how important the adult individuals are to the population's viability, may be an effective means of reducing road mortality rates. It will also be important to educate the public that they should not move turtles they find, on roads or elsewhere, to a "better" location. Turtles found on roads should be moved to off the road in the direction they were going only as far as is necessary to avoid road mortality.

In addition, various landowners' own properties that harbor Blanding's turtle populations and landowners may want to voluntarily enhance nesting habitat for the species. Providing scientific assistance and advice to landowners is necessary to ensure that the species will be managed for in a scientifically sound manner, and that monitoring before and after management will occur to ensure that effects of management are fully understood. We should explore a mechanism, such as a Landowner Incentive Program and work with the Natural Resources Conservation Service to complete management and protection of this species on private lands.

Objectives:

(1) Inform landowners who own land with or within close proximity of Blanding's turtle populations about the presence of the Blanding's turtle, and the value of having the species on their land.

(2) Increase landowner cooperation with the DEC for managing nesting habitat for Blanding's turtles by meeting with them and discussing management options.

(3) Provide technical assistance to landowners who wish to create or enhance Blanding's turtle nesting habitat. Begin monitoring on these lands before and after experimental management.

(4) Provide technical assistance to developers conducting construction activities in wetlands to communicate proper equipment disinfection protocols that will prevent the spread of diseases such as Ranavirus and chytridiomycosis, and invasive species.

(5) If management for Blanding's turtles is not of interest to the landowner, increase landowners' knowledge about how to work with the DEC to manage their land in a way that benefits the landowner without harming the turtle.

(6) Increase public knowledge of the presence of Blanding's turtle populations in the area and the importance of avoiding running these animals over or moving them to new locations.

Approach:

Design a brochure that discusses the identification of the Blanding's turtle and talks about the species' status and threats in the state and how to get involved in nesting habitat management. Distribute the brochure to landowners near local populations. Write an article to local newspapers just before the turtle nesting season (June 1) to educate the public about the importance of avoiding turtles on roads and how important individual turtles are to population viability. Develop a web page that can be accessed on the DEC website that informs the public about the potential for turtles to be on roads.

Action Steps:

Identify target audiences for expanding education and outreach. Examples include: Land Trusts, Sportsman's shows; New York State Fair; County Fair, Adirondack schools; ORV groups; landowners; sportsman clubs; Visitor's Interpretive Centers, The Wild Center, zoo exhibits, veterinary clinic waiting rooms, and other relevant museums or places designed to deliver outreach.

1. Continue to present information to various segments of the community about the natural history, conservation, and value of Blanding's turtles in the state, using such venues as local nature centers, Adirondack Interpretive Centers, The Wild Center in Tupper Lake, etc. Add venues such as Conservation Field Days, Trapper's Associations and Sportsman's Federation Meetings for such outreach and education.

2. Develop a Blanding's turtle nesting habitat management workshop for DEC biologists and foresters, forest land managers, independent foresters, large landowners and other stakeholders. A habitat management guide should be produced and provided to these stakeholders at or in lieu of these meetings.

ACTION 14. Protect known extant populations and their habitat using existing regulations and continued administrative support.

Rationale: Regulations (6 NYCRR, Part 182) are in place that prohibit the take of endangered and threatened species and their habitat. In addition, New York State laws (Articles 15 and 24 Freshwater Wetlands Act) provide legal protection for many stream and wetland habitats. A considerable amount of Blanding's turtle protection can be achieved by using these existing regulations. However, more information exchange regarding endangered species and their habitat is necessary between stakeholders (i.e., the DEC, municipalities, developers, and private landowners) that will allow existing regulations to be better understood and thus more effective. A public information campaign should be launched by the DEC or other organizations to educate the public to leave turtles in the wild when they are encountered. Avoiding translocations of these animals into areas in which they do not belong, and the possibility of spreading diseases into natural populations from releasing turtles and frogs from the pet trade should also be shared with the public. At the time of delisting of the species, information exchange will also be necessary to ensure that efforts to restore populations of Blanding's turtles will not be undone. Site-specific management plans will need to be in place and implemented even after delisting as these plans are integral to keeping the Blanding's turtle off the list.

Approach:

(1) Protect populations and habitat: Regulations exist that prohibit the take of endangered and threatened species and their habitats. Send informational pamphlets to municipalities, developers, and landowners that inform them about the importance of keeping wild turtles wild and that they may have endangered species present on their land. Include information on actions each partner can take to protect and conserve this species including how to partner with the DEC on any habitat manipulations that may affect Blanding's turtles, such as, but not limited to mowing during the nesting season or mining gravel or sand.

(2) By adopting this conservation plan, New York has identified four conservation units: Northern New York, Dutchess County, Saratoga County, and Western New York that will facilitate and help prioritize conservation efforts. All conservation units identified in New York have similar research and management objectives that should be

implemented and monitored. Information specific to each conservation unit is provided.

(3) Use the newly developed screening tool for development projects and permits that may affect Blanding's turtles and their habitat. Submit species occurrence records to the New York State Natural Heritage Program Database to ensure that the database contains the most current Blanding's turtle locations and that "hits" are adequately screened early in the planning process. Encourage communication between the DEC Wildlife and Permits staff to ensure that projects are adequately screened. Train DEC staff at the state and regional levels in the identification of Blanding's turtle habitat on the ground. Keep regulators informed about threats to the species and its habitat.

(4) Ensure that data is shared with the Northeast Blanding's Turtle Working Group for analysis of trends and maintenance of the regional database.

(5) Maintain a database with updated contact information of the Blanding's Turtle Conservation Team and establish a regular (annual) meeting of this team to discuss the Conservation Plan action status.

(6) Ensure that there is continued support for work on site-specific management plans in the four conservation units.

CONSEQUENCES OF NO ACTION

Population viability analysis (PVA) modeling (A. Ross, unpubl. data) indicated that there is a 95 % probability that a lack of action will lead to the species' extirpation in New York State before the target date of 300 years. Specifically, the PVA indicated that the average probability of viability for each population ranged from 56.2 % to 0.4 % over the next 300 years, which is well below the goals of ≥95 % over the next 300 years. Moreover, sensitive parameters such as estimates of mortality in the models were likely conservative, as no effort was made to extrapolate actual numbers without necessary data; therefore, the actual viability of the populations may be lower than the models indicated. To reach our goals of 95 % probability of population viability over the following 300 years, the "no action alternative" should not be followed. Conducting no conservation or management actions could result in an acceleration of extinction rates, if for example, threats such as road mortality and residential and commercial development increase with projected human population increases in the northeast due to climate change.

Coda

The Blanding's turtle is a peripheral species at the southeastern edge of its range in New York State. It is represented by both a peripheral population (eastern edge of the Great Lakes Range) and disjunct populations (Dutchess and Saratoga County). Allocation of conservation resources toward such peripheral populations may be subject to debate. However, these populations may be important both ecologically and socio-politically within a regional context. For example, they may possess characteristics, at the genetic level, that make them valuable for conservation within the species' broader range (Hunter and Hutchinson 1994, Lesica and Allendorf 1995). Species at the southern periphery of their range may be critically important in understanding adaptation to climate change, and the preservation of genetic diversity found at the periphery may be critical to a species' ability to cope with these changes. Conservation of a peripheral species, such as Blanding's turtle in New York, may provide additional values within the region by focusing conservation efforts and by serving as an umbrella for the protection of, in this case, all scrub/shrub wetland inhabitants. Efforts should be made to better identify the distribution of Blanding's turtles in New York to aid in species conservation.

In these times of increasing need for conservation efforts directed towards a myriad of threatened species and degraded ecosystems all competing for shrinking conservation dollars, it is clear that priorities need to be set to maximize such efforts to meet conservation goals. It is the opinion of the DEC that all of the proposed action steps must be taken to accomplish the goal of stabilizing the population and eventually removing the Blanding's turtle from the New York State Threatened Species List.

IMPLEMENTATION OF CONSERVATION ACTIONS

The purpose of this section is to serve as a guide to the reader for the partners involved with ongoing work as per the date of this plan. In no way are the identified partners meant to be an exhaustive list of potential partners that could be involved in the completion of these actions.

Action 1. Develop more precise estimates of life history parameters such as annual mortality rates, nest success, etc. using data from New York populations and apply this information to refine a population viability analysis.

Researchers from SUNY Potsdam, Hudsonia Ltd., and the New York Natural Heritage Program have extensive capture-recapture data that can be used to estimate mortality rates by age class. Such data can be supplemented with new data collected in the field by the DEC, with the assistance of other partners. In addition, the DEC has already completed a population viability analysis for the species (Appendix 1) that can be refined with updated information as it becomes available.

Action 2. Determine the status and distribution of the Western New York population.

Biologists at the DEC have previously worked with Seneca Nation collaborators to trap Blanding's turtles on the Reservation. Collaboration with Seneca Nation staff will need to continue if we are to determine the status and distribution of this population and include it in conservation efforts. In addition, Chautauqua and western Cattaraugus County records need to be verified to determine if these locations harbor populations and whether these populations are viable.

Action 3. Continue periodic monitoring of Blanding's turtle populations consistent with the protocols developed by the Northeast Blanding's Turtle Working Group to identify status and trends of known populations and to identify new known populations.

Work on this action should occur between the DEC, the Northeast Blanding's Turtle Working Group, the New York Natural Heritage Program, Hudsonia, SUNY ESF, SUNY Potsdam, and other universities.

Action 4. Determine which mitigation efforts are effective at reducing road mortality and the impact of ecological traps.

Work on this action should occur between the DEC and the New York State Department of Transportation and by engaging other partners.

Action 5. Evaluate effectiveness of mitigation efforts employed by developers to provide a net conservation benefit to Blanding's turtles.

Biologists at the DEC have begun work on this in 2014. These projects ranged from creating nesting sites to adding or replacing culverts under new or existing roads. More work may be necessary to identify whether these mitigation measures are effective. Extending this project to include more survey work and to employ the use of trail cameras will be necessary to effectively monitor success of mitigation actions. Additional work at new projects may also be beneficial to identify effective fencing or culvert designs.

Action 6. Recruit at least one adult female turtle into each of five long-term monitoring sites every 10 years in the Northern New York and Dutchess County Conservation Units to offset the impact of road mortality.

Work with Department of Transportation to identify hotspots of road mortality on the ground and to reduce mortality rates of Blanding's turtles on roads to increase recruitment of juveniles into adulthood in these conservation units.

Action 7. Recruit at least five females into the breeding population every 10 years in the Saratoga Conservation Unit.

DEC staff are the most logical to complete this long-term management task. Partners such as SUNY Potsdam, Hudsonia Ltd., and the New York Natural Heritage Program can also be engaged to assist locating nests or nesting areas and monitoring this population.

Action 8. Protect at least five nests per year until hatching in both the Northern New York and the Dutchess County Conservation Units, and at least one nest in the Saratoga County Conservation Unit.

DEC staff are the most logical to complete this long-term management task. Partners such as the New York Natural Heritage Program, SUNY Potsdam, and Hudsonia Ltd. can also be engaged to assist locating nests or nesting areas and monitoring these populations. In addition, local trappers should be engaged to assist with the reduction of skunks and raccoon populations near important nesting areas.

Action 9. Headstart and release at least 20 individuals each (1:1 sex ratio) at age one or older into both the Northern New York and Dutchess County Conservation Units at 10-year intervals. Headstart and release at least 10, 1-year-old females into the Saratoga County Conservation Unit at 10 year intervals.

The DEC may complete this work in partnership with various zoos, universities, and high schools. Bio-safety protocols would have to be strictly followed and young turtles will need to be maintained on a proper diet. These efforts have been undertaken by high schools in other states for various turtle species and have proven to be successful at meeting conservation goals. There is an added benefit of increasing awareness of conservation issues facing these threatened species.

Action 10. Secure long-term protection of at least 50 % of occupied habitat for Blanding's turtle populations via land acquisition or the establishment of conservation easements. Include all habitats that support essential Blanding's turtle behaviors (e.g., wintering habitat, nesting habitat, aestivation habitat, and movement corridors).

The DEC and other partners such as SUNY Potsdam, Hudsonia Ltd., local land trusts, and the New York Natural Heritage Program will need to determine which parcels of land will be the most important to conserve. These areas can then be developed into larger Conservation Focus Areas identified for Blanding's turtles (Figure 3). Once parcels or focus areas have been identified, they should be added to the New York State Open Space Plan so that acquisition of land in fee or the establishment of conservation easements can be possible. The DEC will need to work with private landowners and land trusts to draw up easement language to ensure that activities on new easements would support Blanding's turtle conservation and habitat management. New land purchases and conservation easement establishment should be a priority in areas that are considered quality nesting habitats.

Action 11. Maintenance of at least 75 % of the initial genetic heterozygosity (i.e., an index of genetic diversity) in the population of Blanding's turtles in the Saratoga County Conservation Unit and 75 % of the initial heterozygosity in at least five long term monitoring sites in both the Northern New York and Dutchess County Conservation Units.

The DEC would benefit from partnerships with universities for this analysis. The DEC, universities within and outside of New York and the New York Natural Heritage Program can be partnered with to collect DNA samples. Population viability should be remodeled and assessed by 2027 using Vortex or similar program.

Action 12. Continue work with partners in other states to develop and implement site-specific management plans for the species throughout the northeast.

The DEC, New York Natural Heritage Program, Northeast Blanding's Turtle Working Group, NGOs, and local universities are logical partners to implement this action. Management plans have been drafted for a variety of long term monitoring sites in New York by the Northeast Blanding's Turtle Working Group and will need to be finalized and approved. More sites should be added to this effort to meet the goals of managing five long term monitoring sites.

Action 13. Develop and implement an effective outreach and education program to inform the public about threats to Blanding's turtles and how to mitigate these threats.

Providing technical advice to landowners is primarily the responsibility of the DEC. An effective outreach program can be developed by the DEC and partners such as SUNY Potsdam, Hudsonia Ltd., The New York Natural Heritage Program, Northeast Partners in Amphibian and Reptile Conservation, and local universities. SUNY Potsdam has made some headway by developing and distributing pamphlets educating the public about Blanding's turtles. More materials should be developed and distributed.

Action 14. Protect known extant populations and their habitat using existing regulations and continued administrative support.

The DEC will continue this work by adequately screening development projects for potential impacts to Blanding's turtles or their habitat. To further this activity, the DEC will update regulatory screening tools as new information on Blanding's turtle movements becomes available. The DEC will also continue to provide technical advice to the Natural Resources Conservation Service (Wetlands Reserve Program) and to private landowners who may wish to manage habitat for Blanding's turtles. In addition, the DEC will need to increase public education in order to reduce collections and translocations of Blanding's turtles into other areas. In addition, a campaign to educate the public on the negative effects of releasing pet turtles into the environment should be initiated.

TIMELINE FOR CONSERVATION ACTION IMPLEMENTATION

Develop more precise estimates of life history parameters such as annual mortality rates, nest success, etc. using data from New York populations and apply this information to refine a population viability analysis.
Several years of trapping data have been collected that can be used to determine mortality rates by age class. In addition, there are several years of nest success data that have been collected at some of the more productive sites (long term monitoring sites). The focus of much of the previous work has not been on determining specific rates of road mortality, which is an important component of regular mortality. Implementing this action should begin in 2016.

Identify the status and distribution of the Western New York population.
Begin work by 2018 and complete by 2027.

Continue periodic monitoring of Blanding's turtle populations consistent with the protocols developed by the Northeast Blanding's Turtle Working Group to identify status and trends of known populations and to identify new known populations.
Work on this was begun in 2012. Begin next round of monitoring in 2017 and continue. No deadline. Long term monitoring and management of sites and populations should be conducted in cooperation with other states in the northeast.

Determine which mitigation efforts are effective at reducing road mortality and the impact of ecological traps.
Clarkson University in partnership with the New York State Department of Transportation has constructed fencing along an occupied Blanding's turtle wetland in St. Lawrence County. Work has also been conducted by SUNY Potsdam beginning in 2012 to determine if turtle crossing signs serve to reduce vehicle speeds and can make drivers more aware of turtles on roads. Results are inconclusive as of 2017. More work should be devoted to this question as signs would be an inexpensive way to decrease road mortality. Complete work on these actions by 2027.

Evaluate effectiveness of mitigation efforts employed by developers to provide a net conservation benefit to Blanding's turtles.
Work was begun in 2014 and should be complete by 2027. New York State Department of Environmental Conservation has completed some of this work in Dutchess County, but efforts to increase sampling of these mitigation activities should continue until Best Management Practices have been identified.

Recruit at least one adult female turtle into each of five long-term monitoring sites every 10 years in the Northern New York and Dutchess County Conservation Units to offset the impacts of road mortality.
Begin work in 2017 and continue. No deadline.

Recruit at least five new females into the breeding population every 10 years in the Saratoga Conservation Unit.
Begin work in 2017 and continue. No deadline.

Protect at least five nests per year until hatching in both the Northern New York and the Dutchess County Conservation Units, and at least one nest per year in the Saratoga County Conservation Unit.
Nest guards are placed in several nests in the Northern New York Conservation Unit at the Wilson Hill Wildlife Management Area, Coles Creek Blanding's Turtle Habitat Improvement Project, and the Lisbon area each year. Nest guards have been placed at both the Dutchess County and the Saratoga populations in the past. Begin work in 2017 and continue. No deadline.

Headstart and release at least 20 individuals (1:1 sex ratio) at age one or older into both the Northern New York and Dutchess County Conservation Units at 10-year intervals. Headstart and release at least 10, 1-year-old females into the Saratoga County Conservation Unit at 10 year intervals.
Begin work in 2017 and continue. No deadline.

Secure long-term protection of at least 50 % of occupied habitat for Blanding's turtle populations via land acquisition or the establishment of conservation easements. Include all habitats that support essential Blanding's turtle behaviors (e.g., wintering habitat, nesting habitat, aestivation habitat, and movement corridors).
Begin work in 2017 and continue until targets are reached. Make efforts to complete these acquisitions by 2067.

Maintenance of at least 75 % of the initial genetic heterozygosity (i.e., an index of genetic diversity) in the population of Blanding's turtles in the Saratoga County Conservation Unit and 75 % of the initial heterozygosity in at least five long term monitoring sites in both the Northern New York and Dutchess County Conservation Units.
Begin work on maintaining genetic diversity in 2017 by implementing conservation actions that improve survivorship and continue into the future. Begin re-evaluation of genetic diversity in 2027. No deadline.

Continue work with partners in other states to develop and implement site-specific management plans for the species throughout the northeast.
Begin work in 2017 and continue. No deadline.

Develop and implement an effective outreach and education program to inform the public about threats to Blanding's turtles and how to mitigate these threats.
Begin work in 2017 and continue. No deadline.

Protect known extant populations and their habitat using existing regulations and continued administrative support.
Ongoing. No deadline.

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TABLES

Table 1. Comparison of Blanding's Turtle home range sizes. Methods used were minimum convex polygon (MCP), multinuclear cluster (Cluster), and adaptive kernel density estimator with a 95 % probability (AK), fixed kernel density estimator with a 95 % probability (FKE), bivariate normal density kernel with a 95 % probability (BNK), Poly-Buff (PB), and grid summation (GS).

Investigators	Location	Mean HR Size (ha)	Sample Size (M/F)	Method
Chaloux, 2011	Eastern NY	Male=26.8, Female=29.8	5, 19	MCP
Crockett, 2008	Northern NY	Male=2.5, Female=3.2	5, 15	Cluster
		Male=7.5, Female=12.3		MCP
		Male=14.4, Female=31.4		AK
Innes et al., 2008	NH, Site 1	Male=3.7, Female=1.5*		MCP
	NH, Site 2	Female=6.8*		MCP
	NH, Site 1	Male=8.7, Female=2.7*		AK
	NH, Site 2	Female=12.5*		AK
Beaudry et al., 2007	ME	134.2		FKE
		74.2		MCP
Grgurovic and Sievert, 2005	Eastern MA	Male=27.5, Female=19.9	14,27	FKE
Edge et al. 2010	Ontario	Male=57.1, Female=61.2	5,16	MCP
Millar and Blouin-Demers 2011	Ontario	Male=8.5, Female=7.3	20,5	MCP
		Gravid Female=20.3	12	
Jensen, 2004	Northern NY	25.4 ha		Kernel
Hamernick, 2001	SE MN	Male=94.9, Female=60.8		MCP
		Male=122.9, Female=58.4		BNK
		Male=56.9, Female=18.9		PB
Piepgras and Lang, 2000	Central MN	Male=7.8, Female=7.8	8,16	GS
		Male=38.4, Female=35.4		MCP
		Male=53.4, Female=63.0		AK
Joyal, 1996	Maine	0.91**		MCP
Rowe and Moll, 1991	NE Illinois	Male=1.4, Female=1.2**	4,3	MCP
Ross and Anderson, 1990	Central WI	Male=0.76, Female=0.64**	2,4	MCP
Rowe, 1987	NE Illinois	9.5		MCP

* = median home range size, rather than mean home range size
** = derived from summed centers of activity

Table 2. Blanding's turtle conservation status in North America. S1 = Subnationally critically imperiled, S2 = Subnationally imperiled, S3 = Subnationally vulnerable, S4 = Subnationally apparently secure, S5 = Subnationally demonstrably secure, N3 = Nationally vulnerable, N4 = Nationally secure.

Location	State Listing	NatureServe Status	Source
USA	Endangered*	N4	IUCN Red List
Iowa	Threatened	S3	Iowa Department of Natural Resources
Indiana	Endangered	S2	Indiana Department of Natural Resources
Illinois	Threatened	S3	Illinois Department of Natural Resources
Massachusetts	Threatened	S2	Massachusetts department of fish and game
Maine	Endangered	S2	Maine Department of inland Fisheries and wildlife
Michigan	Special Concern	S3	Michigan Department of Natural Resources
Minnesota	Threatened	S2	Minnesota Department of Natural Resources
Missouri	Endangered	S1	Missouri Department of Conservation
Nebraska	Not listed	S5	Nebraska nongame and endangered species program
New Hampshire	Endangered	S1	New Hampshire Fish and Game Department
New York	Threatened	S2/S3	New York Natural Heritage Program (2014)
Ohio	Special Concern	S2	Ohio division of natural resources
Pennsylvania	Candidate species	S1	Pennsylvania game commission
South Dakota	Endangered	S1	Northern Prairie Wildlife Research Center
Wisconsin	Threatened	S3/S4	Wisconsin Natural Heritage Working List
Canada	-	N3	Committee on the Status of Endangered Wildlife in Canada
Nova Scotia	Endangered	S1	Committee on the Status of Endangered Wildlife in Canada
Ontario	Threatened	S3	Committee on the Status of Endangered Wildlife in Canada
Quebec	Threatened	S1	Committee on the Status of Endangered Wildlife in Canada

*IUCN Red List designates the species as endangered in the USA.

FIGURES

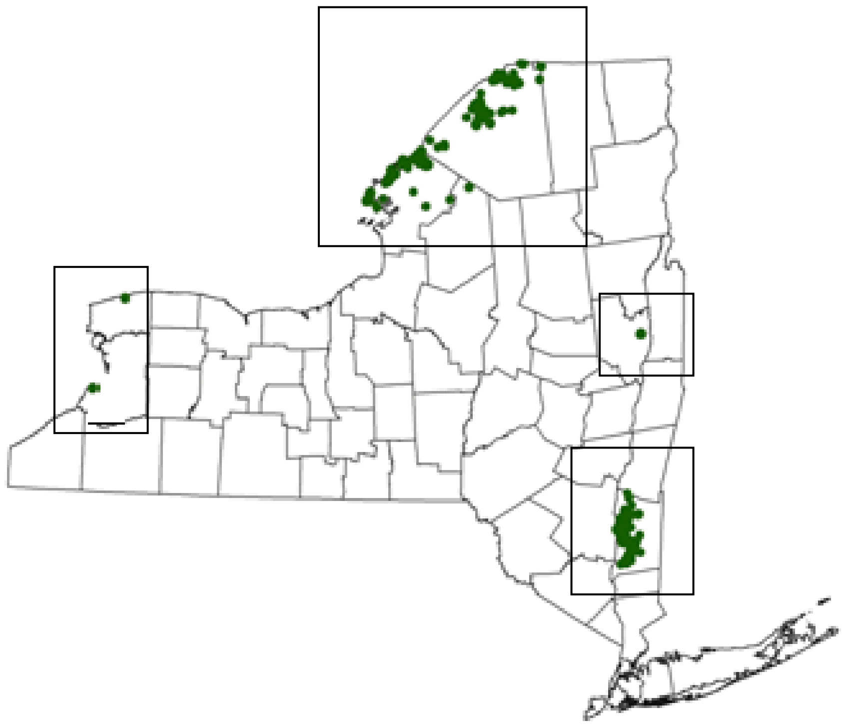

Figure 1. Blanding's turtle distribution in New York State and the four conservation units (clockwise from top: Northern New York, Saratoga County, Dutchess County, and Western New York Conservation Units). Location data from the New York Natural Heritage Program.

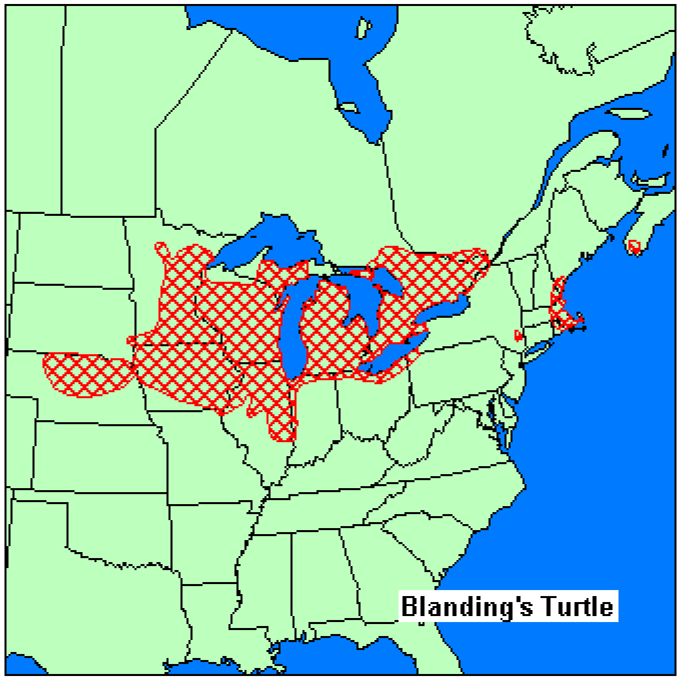

Figure 2. Rangewide distribution of Blanding's turtles. Map from New York State Department of Environmental Conservation.

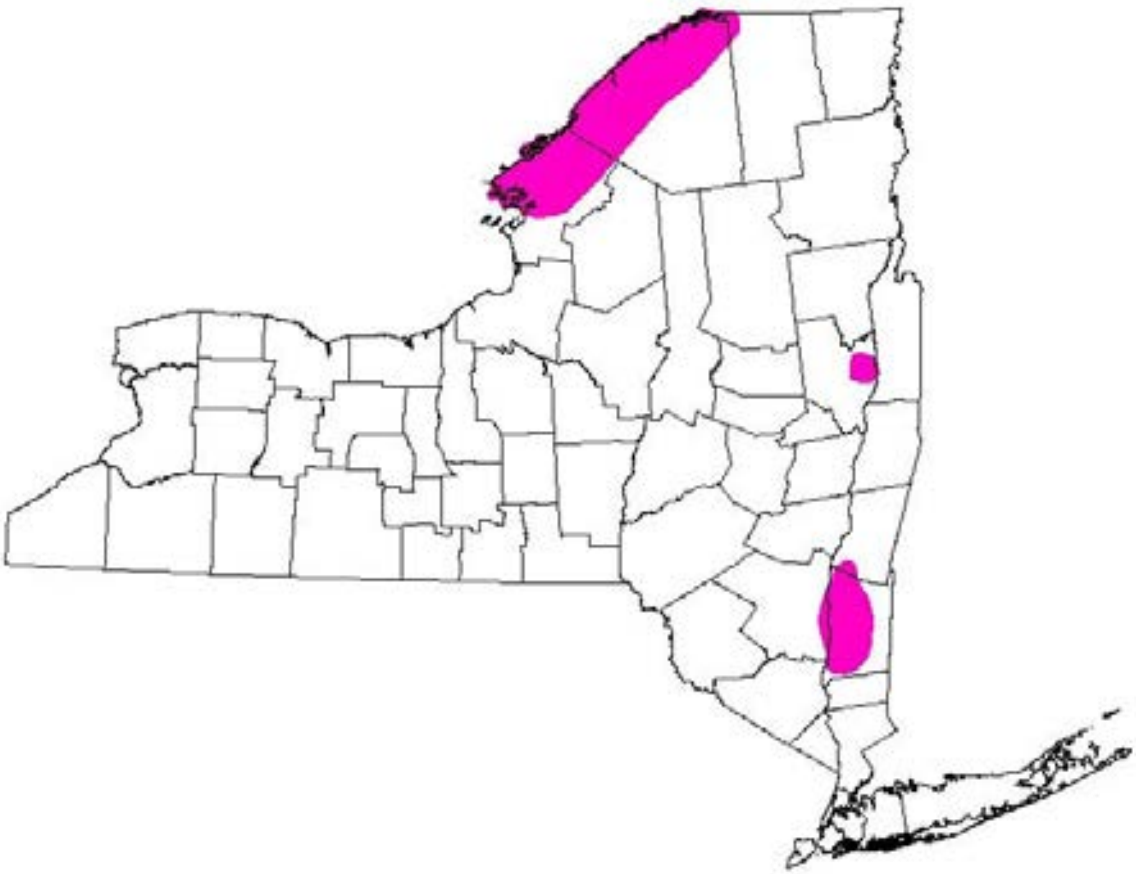

Figure 3. Blanding's turtle Conservation Units that should be targeted for land protection.

APPENDICES

Appendix 1. Blanding's turtle (*Emydoidea blandingii*) population viability analysis for New York populations using Vortex 9.99 (Lacy et al. 2009).

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Introduction

Blanding's turtles are distributed throughout the Great Lakes states region and Canada from southeastern Ontario and some areas of southern Quebec, with a separate population in southern Nova Scotia. In the United States, the population occurs in disjunct segments south into New England, west into Nebraska, Iowa and extreme northeastern Missouri (Congdon et al. 2008). In the northeastern United States, populations are very disjunct. New York represents a portion of the eastern most reaches of the Blanding's turtle's distribution and they are listed as both a threatened species and a species of greatest conservation need in the state. In New York, the Blanding's turtle is distributed in four disjunct populations: (1) Niagara and Erie Counties, (2) Jefferson, St. Lawrence, Lewis, and western Franklin Counties, (3) Saratoga County, and (4) Dutchess County. The largest population is located in upstate New York along the St. Lawrence River, with the second largest population being the Dutchess County population. Smaller numbers of turtles have been documented in the Saratoga and western New York populations. Both the northern and western New York populations may be regarded as relatively contiguous with the Great Lakes population.

To assess the relative health of the Blanding's turtle population in New York and to determine how sensitive the population is to intrinsic and extrinsic factors such as inbreeding depression, habitat loss and fragmentation, catastrophes and other stochastic events, we conducted a population viability analysis (PVA). Conducting a PVA on a species is a good way to determine the likelihood that a population would become extinct in a specified time frame. PVAs can also be used to determine species' population growth trajectories. In addition, PVAs are useful in sensitivity testing, in which one demographic or environmental variable can be altered at a time to determine its magnitude of effect on the model outcome. Model outcomes could be measures of probability of extinction, stochastic population growth rate, genetic diversity, etc. Sensitivity testing is very valuable in determining and prioritizing (1) which research objectives would be most important to study in a population and (2) which management methods would be most effective at achieving self-sustaining populations.

Methods

We conducted a PVA for Blanding's turtles using Vortex 9.99 (Lacy et al. 2009) for the northern New York, Dutchess County, and the Saratoga populations. The western New York population was not analyzed because there is too little information on number of individuals and their distribution in that region. A priority should be to collect information on the Blanding's turtles in that region and apply it to a refined PVA to set management priorities in that region. Both the northern New York and the Dutchess County populations have been well-studied. However, there are different threats facing both populations. For example, residential and commercial development in Dutchess County severely threatens Blanding's turtle populations in that region. The Saratoga population is small and isolated and is also well studied. For all populations, we ran a baseline model (Table 1) of population viability based mostly on demographic information gathered from the New York Blanding's turtles. In instances in which data were lacking, we supplemented information from a long term Blanding's turtle study in Michigan (Congdon et al. 1993). When we were uncertain of specific demographic parameters, including those gathered from populations outside of New York, we conducted sensitivity testing to determine that parameter's influence on the model's outcome. We also used sensitivity testing to determine which parameters in our models have the greatest impact on Blanding's turtle probability of population persistence over 300 years to help identify useful management actions.

Table 1. Demographic input parameters for the baseline Vortex simulation model for Blanding's turtles in New York gathered from New York datasets. When data gaps existed, available literature relevant to northern Blanding's turtle populations was used to estimate parameters.

Parameter	Control
Inbreeding depression	No
Environmental variation correlation among populations	1
Reproduction correlated with survival	No
Age 1st female reproduction	17
Age 1st male reproduction	17
Maximum age of reproduction	100
Sex ratio at birth	1:1
Maximum brood size	19
% Females with litter/year	80
Mortality at age 0-1 (%)	83.080[1]
Mortality ages 1-14 (%)	21.826
Mortality at age >14 (%)	4.55
Number of catastrophes (probability)	1
% Reduction in reproduction (catastrophe)	0
% Reduction in survival (catastrophe)	0.2
% of Adult males breeding	80
Starting population size (NNY, Dutchess, Saratoga)	(3,000, 3,000, 30)
Carrying capacity (SD)	57 / ha
% Change in K per year	0

[1]22% survivorship of age class with an increase of 19.5 % of nests failing, with 45 % of the remaining experiencing a loss in 10 % of eggs (Congdon et al. 2003).

Baseline population model settings and justification

Scenario Settings:
We ran 500 simulations (iterations) for each of our population viability analysis (PVA) model scenarios. Population viability analyses for many species are typically run through 100 years. However, since Blanding's turtles are very long-lived, and therefore likely to have a relict population that is extant but not viable over the long term, we ran our models through 300 years, consistent with a Blanding's turtle PVA in Illinois (Benda 2007). We assumed a population to be extinct when only one sex remained. We ran separate PVAs for three populations (northern New York, Dutchess County, and Saratoga), representing the range of conditions for each of the four populations in New York: northern New York, Dutchess County, Saratoga County, and Western New York. For the baseline model, we did not run simulations that include inbreeding depression because we assumed our population was too large for inbreeding depression to affect viability. However, we did include inbreeding depression in our sensitivity analysis to see what effects, if any, it had on population viability.

Species Description:
We modeled environmental variation concordance of reproduction and survival and we modeled one catastrophe (drought or flood) to occur at 5 % intervals. We assumed that the catastrophe would have no impact on adult survivorship, as adults are fairly vagile and can either move out of suboptimal areas or tolerate wet and dry conditions. We also assumed a 2 % reduction in breeding, as nests cannot be moved once laid.

Reproductive System:
We modeled Blanding's turtles to have a promiscuous breeding system (Refsnider 2009) and females to have one brood per year, with an average clutch size of 10.2, consistent with Congdon et al. (1993), and a maximum clutch size of 19 eggs. We also modeled the sex ratio at birth to be 50:50 (S. Gillingwater, unpubl. data, *cited in* Congdon et al. 2008; T. Herman, unpubl. data, *cited in* Congdon et al. 2008), even though some populations in other areas of the species' range apparently have sex ratios that are slightly female biased (Congdon and van Loben Sels 1991, Pappas et al. 2000). We assumed no density-dependent reproduction.

Age of first reproduction for males and females was set at 17 years (Congdon et al. 2008), as Vortex requires the age at first reproduction to be the average age of first reproduction.

We estimated that 80 % (SD = 10%) of females breed during each year (Congdon et al. 2003), with 100 % of breeding females having one brood and that there was no environmental variation in breeding. With no data to support otherwise, we also assumed that the number of offspring per female per brood conformed to a normal distribution.

Mortality Rates:
Congdon et al. (1993) summarized mortality rates from data collected during Blanding's turtle studies from extensive periods from 1953-1991 at the George Reserve, Michigan. The George Reserve is an approximately 650 ha fenced in area that has been maintained by the Museum of Zoology since 1930. Lands adjacent to the Reserve are also protected from development, as

they are owned by the State of Michigan and are used primarily for recreation purposes (Congdon et al. 2008). Using Blanding's turtle demographic information from locations where there are few threats may provide overestimates of population viability if such information is naïvely applied to areas where threats are present. However, in New York there is a lack of published demographic data; therefore, information from other regions of the species' distribution is necessary to apply to New York.

Johnson (2012) conducted road surveys to estimate Blanding's turtle mortality and to determine whether turtle road crossing signs were effective at reducing drivers' speeds or reducing turtle mortality. From 2008-2009, Johnson (2012) surveyed 10 to 16 1-km routes for Blanding's turtle road kills and live crossings. Routes were selected on roads near wetlands where Blanding's turtles were known to occur. In 2008 and 2009, four Blanding's turtles were found dead on the survey routes in June 1-30, which also happens to coincide with the peak of nesting and movement activity.

Other information on road mortality in New York exists over a broader time period and geographic distribution. For example, G. Johnson (unpubl. data) collected information on 50 incidental road kills from 1999-2012 in areas of Jefferson and St. Lawrence Counties. If we assumed that all animals killed on roads were found and reported, it would represent a 0.55 % annual mortality rate[1] of adult Blanding's turtles (assuming a stable age distribution) over the nine years of study. It is important to note that this rate of road mortality is likely a gross underestimation of the true rates of road mortality occurring as these data do not represent organized searches for road mortality events, just incidental observations of dead turtles as researchers were driving to field sites for other activities such as trapping and radio telemetry.

We assumed regular adult annual mortality rates to be 4 %, consistent with those of Congdon et al. (1993), and we added a road mortality rate of 0.55 % to adults (total = 4.55 %), assuming that adults are the age class most commonly killed by vehicles. We added one fourth of the rate of adult mortality to age class 1-14, since individuals of that age class have also have been found dead on roads, but to a much lesser degree than adults. Age-specific mortality rates in Blanding's turtles in New York were not accessible, so we estimated mortality of juveniles using data from Congdon et al. (1993): 0-1 years = 83.08 %, 1-14 years = 21.8 % (i.e., 21.7 % + 0.1 %, or one quarter the rate of adult road mortality). We assumed that mortality rates of males and females (other than road mortality) were similar across sexes (Congdon et al. 1993).

<u>Catastrophes</u>:
We assumed that there would be one type of catastrophe (e.g., drought or flood) that may affect populations of Blanding's turtles. We assumed that adult survivorship would not be affected by drought or flooding, but that reproduction may be affected as much as -2 %. We

[1] We estimated road mortality of adults by taking the number of turtles found dead on roads from G. Johnson (unpubl. data) = 50 over 13 years, or 3.84 per year and applied it to the number of individuals in the breeding age class (700) = 3.84/700 = 0.55 %.

also assumed that a drought may occur once in 20 years and that the effects would be equivalent throughout the population.

Mate Monopolization:
We assumed that 80 % of males were in the breeding pool and that 80 % of adult females breed each year (Congdon et al. 2003).

Initial Population Size and Carrying Capacity:
Northern New York - A search of the New York Natural Heritage Program database shows that there were approximately 2,500 ha of both known occupied and previously occupied (pre-2000) wetlands in the northern New York population. Post-2007 records indicate that there have been 1,907 ha of wetlands known to be occupied in 14 wetland complexes. We began our baseline survey by assuming that there were approximately 1.5 turtles/ha for 1,907 ha, or approximately 3,000 individuals in the northern New York population. We assumed that carrying capacity (K) could be as high as 57 turtles/ha (Congdon et al. 1993) or approximately 108,000 turtles and we did not assume that there was any environmental variation in K. It is important to note that there may be unknown populations present on the landscape and that each of the known occupied wetlands may not be occupied every year. Without evidence to suggest otherwise, we assumed a stable age distribution.

In the following sensitivity analysis section, we represented changes in the initial population size by calculating the percent of mortality observed from 1999-2007 (*n* = 50) in a population of 1,500, 3,000 and 4,500 turtles, corresponding to changes in adult mortality rates of ±1.1 %, ±0.55 %, and ±0.035 % respectively.

Dutchess County – A search of the New York Natural Heritage Program database shows that there were approximately 2,371 ha of both known occupied and previously occupied (pre-2000) wetlands in the Dutchess County population. Post-2000 records indicate that there have been 741 ha of wetlands known to be occupied. We began our baseline survey by assuming that there were 1.5 turtles/ha for 741 ha or approximately 1,000 turtles. We assumed that K could be as high as 57 turtles/ha (Congdon et al. 1993) or approximately 57,000 turtles and we did not assume that there was any environmental variation in K. It is important to note that there may be unknown populations present among the landscape and that each of the known occupied wetlands may not be occupied every year. We also assumed a stable age distribution for this population (default) as the age distribution is not known.

Saratoga – A total of 14 individuals have been documented at the Saratoga population in an extensive study by Chaloux (2011) and additional surveys in 2012-2013 (G. Johnson, unpubl. data), with an additional individual juvenile found dead on a road (Chaloux 2011). Our best estimate of initial population size for the Saratoga population was 30 individuals (A. Chaloux, pers. comm.). A search of the New York Natural Heritage Program database showed that the Saratoga population occupies approximately 186 ha of land area. Assuming that habitat is of high quality, we estimated the carrying capacity of Blanding's turtles to be 57 turtles/ha or approximately 10,500 turtles. We did not assume that there was any environmental variation in K.

For the baseline models for the northern New York, Dutchess County, and the Saratoga populations, we did not speculate on measures of harvest[1], supplementation, and genetic management. In addition, because parameters within the models will not vary significantly between populations in New York, we conducted a single sensitivity analysis to cover all populations in New York. We assumed that there would be little to no interactions between parameters, and where data were specific to one population (e.g., initial population size, K, etc.), we used data from the northern New York population.

Sensitivity analysis model settings and justification

We conducted a sensitivity analysis to determine which parameters in our models have the greatest impact on Blanding's turtle population growth, to help define management goals and set future research and monitoring objectives. To conduct this analysis, we selected 10 demographic parameters that (1) are possible to influence with management or (2) we believe to have high degree of uncertainty in estimation. Demographic parameters tested were the following: inbreeding depression (% of lethal equivalents), initial population size, % of females breeding, # broods/female, % males breeding, juvenile mortality (0-1 year olds), subadult mortality (>1-14-year olds), adult mortality (>14 years old), road mortality, and supplementation. All parameter estimates (e.g., high and low) included in each simulation were biologically reasonable. Only one variable was varied at a time, i.e. all other parameter estimates were held at baseline values for each simulation (Table 1). We then compared the stochastic population growth rates of sensitivity models to those of baseline models.

<u>Lethal equivalents</u>:
A percentage of lethal equivalents of 6 is generally considered an average value for most populations (K. Shoemaker, pers. comm.). Blanding's turtles in New York State are disjunct and populations are not very dense. Hence, populations in the state may be susceptible to inbreeding depression. We tested the influence of inbreeding depression on the northern New York population at 0, 6, and 10 lethal equivalents, which represent an extremely low, medium and high range of normal values.

<u>Initial population size</u>:
We estimated the initial population size of Blanding's turtles as 3,000 individuals based on 1.5 turtles/ha. There is a great deal of uncertainty in generating an estimate of initial population size, which is why this variable was chosen for a sensitivity analysis. We also tested population viability at an initial population size of 1,500 and 4,500 individuals. Because estimated values of mortality in the literature (e.g., Congdon et al. 1993) did not include estimates of road mortality, we had to alter our annual mortality rates as a percentage of the initial population

[1] In Vortex, removal of animals from a population is regarded as "harvest". To facilitate repeatability of this modeling effort by others, we chose to keep the same terminology as Vortex.

size. For example, for a 1,500 initial population size, we used 50 turtles killed in 13 years (G. Johnson, unpublished data) and extrapolated the percent of annual percent mortality over the 300-year period ([50/13]/342 adults [# adults based on stable age distribution] = 1.1 %). We repeated this calculation for an initial starting population of 4,500 to get an additive mortality rate of 0.35 % (or [50/13]/1,096).

<u>% females breeding</u>:
We assumed that the vast majority of females were breeding annually (80 %, SD = 10%) (Congdon et al. 2003). Because there was a considerable amount of uncertainty in our estimates of the number of females breeding each year, we chose to test the sensitivity of this parameter in the model by running a scenario with 70 % and 90 % of females breeding.

<u># broods per female</u>:
Many turtle researchers suggest that the most important components of turtle populations are the older females as they may produce more than one clutch per year and they do not experience a decrease in reproductive output with age (Congdon et al. 2003). However, Congdon et al. (2003) suggested that the reproductive output of females over 66 years old may increase as much as 10 %. To test whether the models were sensitive to changes in reproductive frequency of females, we simulated populations in which each reproductive female produced one clutch per year (baseline) and we compared it with a simulation in which each reproductive female produced two clutches per year.

<u>% males breeding</u>:
Since there are few data about the percentage of males that may breed in turtle populations at any one time and since we are unsure of the percentage of males breeding in the New York populations, we varied inputs to the percent of males breeding to determine whether this parameter was important. We tested 70, 80, and 90 % of males breeding.

<u>Road mortality and mortality of each age class</u>:
Juveniles (0-1 years), Subadults/Adults (>1-14 years) and Adults (>14 years) - We used mortality information calculated for a population of Blanding's turtles at the George Reserve in Michigan: 83.08 % for 0-1 year old individuals, 21.7 % for >1-14-year olds and 4 % for 14+ year olds and added the calculated minimum road mortality in northern New York to each age class (0.55 % for adults, 0.1 % for ages 1-14, 0 % for 0-1 year olds). It is possible to mitigate the effects of road mortality with crossing structures and it is also possible that road density, and therefore road mortality, could double over the next 300 years. Therefore, we ran one simulation with no road mortality and one with double the estimated rate of road mortality. It should be noted that road mortality is probably not a significant threat to young Blanding's turtles, but we included ages 1+ in the analyses to determine the effects. Most observations of Blanding's turtle road crossings are of adult females during the nesting season, but some younger individuals are also observed (G. Johnson, unpubl. data).

Supplementation:
We added two simulations with varying levels of supplementation to determine whether this management strategy would be effective at maintaining turtle populations over the 300-year period. We simulated two supplementations: release of 50, 1-year old females and release of 100, 1-year old females. Each supplementation was conducted on the first year of the simulation and again at 10-year intervals.

Setting management actions and research priorities

Northern New York

The purpose of this exercise was to determine if it is possible to conduct targeted management to help maintain viable populations of Blanding's turtles in northern New York, and to which degree such management actions would need to be carried out. We modeled three separate conservation scenarios: (1) reducing estimated rates of road mortality by 20 %, (2) placing nest guards on 5 nests per year[1], and (3) headstarting 20 individuals (1:1 sex ratio) every 10 years throughout the 300-year period. We also modeled every combination of each pair of scenarios and all scenarios together to determine the probability of extinction.

Dutchess County

We conducted this analysis to determine whether it is possible to conduct targeted management to maintain viable populations of Blanding's turtles in Dutchess County, and to which degree such management actions would be required. We modeled three separate conservation scenarios: (1) reducing estimated rates of road mortality by 20 %, (2) placing nest guards on 5 nests per year, and (3) headstarting 20 individuals (1:1 sex ratio) every 10 years throughout the 300-year period. We also modeled every combination of each pair of scenarios and all scenarios together to determine the probability of extinction.

Saratoga

Since the Saratoga population is small and the results of baseline simulations have indicated that it is unlikely that the population will continue to persist over the following 300 years, we decided to simulate actions to help further define conservation criteria. Specifically, we wanted to determine (1) whether it is possible to maintain persistent populations of Blanding's turtles in Saratoga, and (2) which actions that, if taken, would result in the maintenance of persistent populations in Saratoga.

For this exercise, we modeled five conservation scenarios: (1) nest guards on 10 % of the nests, (2) reduction in mortality of >1-14-year olds, (3) nest guards on 10 % of the nests and reduction

[1] It is important to note that in the model, the assumption is that most of the mortality of the 0-1 age class is due to nest depredation. Therefore, the effect of protecting nests with guards on population viability may be overstated if this assumption is not true.

in mortality of >1-14-year olds, (4) nest guards on 10 % of the nests, reduction in mortality of >1-14-year olds and supplementation of 10 1-year old females every 10 years, and (5) no action (for comparative purposes). We ran simulations through 400 years at 100-year intervals for each potential management action and determined the mean probability of population persistence for each simulation.

Results and Discussion

Baseline simulations

For the northern New York baseline population model, we found that the probability of extinction over 300 years was 43.8 %, with a stochastic population growth rate of -0.02 %, a final average population size of approximately 15 individuals, and a mean heterozygosity of 74.20 % (SD = 21.36 %). Heterozygosity values range from 0-100 % with 0 % having no one set of alleles remaining and 100 % having the same number of alleles as the starting population.

For the Dutchess County baseline population model, the probability of extinction over 300 years was 80.8 % with a stochastic population growth rate of -0.02 %, a final average population size of approximately 4 individuals, and a mean heterozygosity of 68.37 % (SD = 13.21 %).

For the Saratoga baseline population model, we found that the probability of extinction over 300 years was 99.6 %, with a stochastic growth rate of -0.025 %, and a mean heterozygosity of 34.86 % (SD = 7.55 %).

It should be cautioned that relying on absolute values for estimates such as probability of extinction, time to extinction, stochastic population growth rate, etc. estimated from model simulations may be misleading. The real strengths of a PVA are to determine which parameters have the greatest influence on model outcomes (e.g., sensitivity analysis), so that the information can be applied to conducting effective management for a species.

Sensitivity analysis

Results indicate that mortality of 0-1-year old turtles, followed by mortality of >1-14-year olds, and finally the mortality of >14-year olds, had the greatest influence on stochastic population growth rate (Figure 1). Parameters such as the effects of road mortality, the number of females breeding, and the effects of inbreeding had lesser, but noteworthy effects on the model outcomes. Whether an individual had one or two broods per season and whether the population had a variable percentage of males breeding had little influence on model outcomes. It should be noted that very conservative rates of road mortality from northern New York were used in this analysis and that all age classes were allowed to be affected. A more realistic scenario would be to determine actual rates of road mortality for each New York population and include information relevant to each age class to refine the present population viability analysis. In addition, methods to increase survivorship of 0-1-year old and >1-14-year old age classes should be developed and implemented.

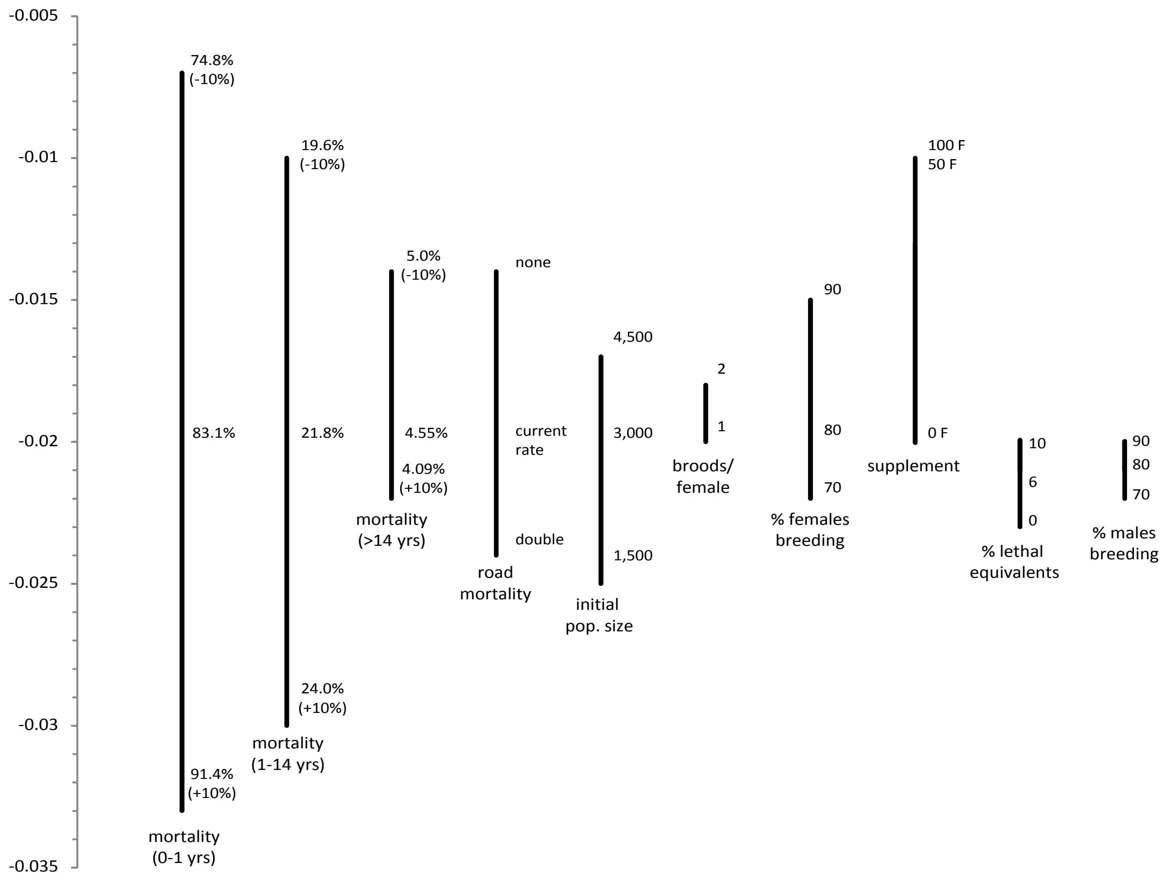

Figure 1. Ranges of stochastic population growth produced by varying parameters in the baseline population model within biologically reasonable limits.

Management actions – Northern New York

We are 95 % confident that there will not be a population of Blanding's turtles in New York at the specified time frame of 2313 (300 years) if no management actions are taken (Figure 2, Table 2). However, there may be a population of Blanding's turtles in northern New York until the year 2213 (200 years) with 95 % confidence (Figure 2). While this may be probable, the model indicates that there will be less than 94 individuals present in the population 200 years from now. As noted previously, measures of road mortality were likely underestimated and estimates of mortality for each age class were applied from a population on a conservation reserve outside of New York. Both are scenarios which would lead to elevated population viability estimates.

Results showed that to maintain a viable population of Blanding's turtles in northern New York, it is necessary to conduct all three management actions: reduce the estimated rates of road mortality by 20 %, place nest guards on 5 nests per year, and headstart 20 individuals every 10 years into the northern New York population (Figure 2, Table 2). Headstarted individuals should be released at one year of age or when their body size is at least the size of a one-year-old individual in nature (whichever is sooner). Individuals should be released only during the active period so they may find habitat for overwintering.

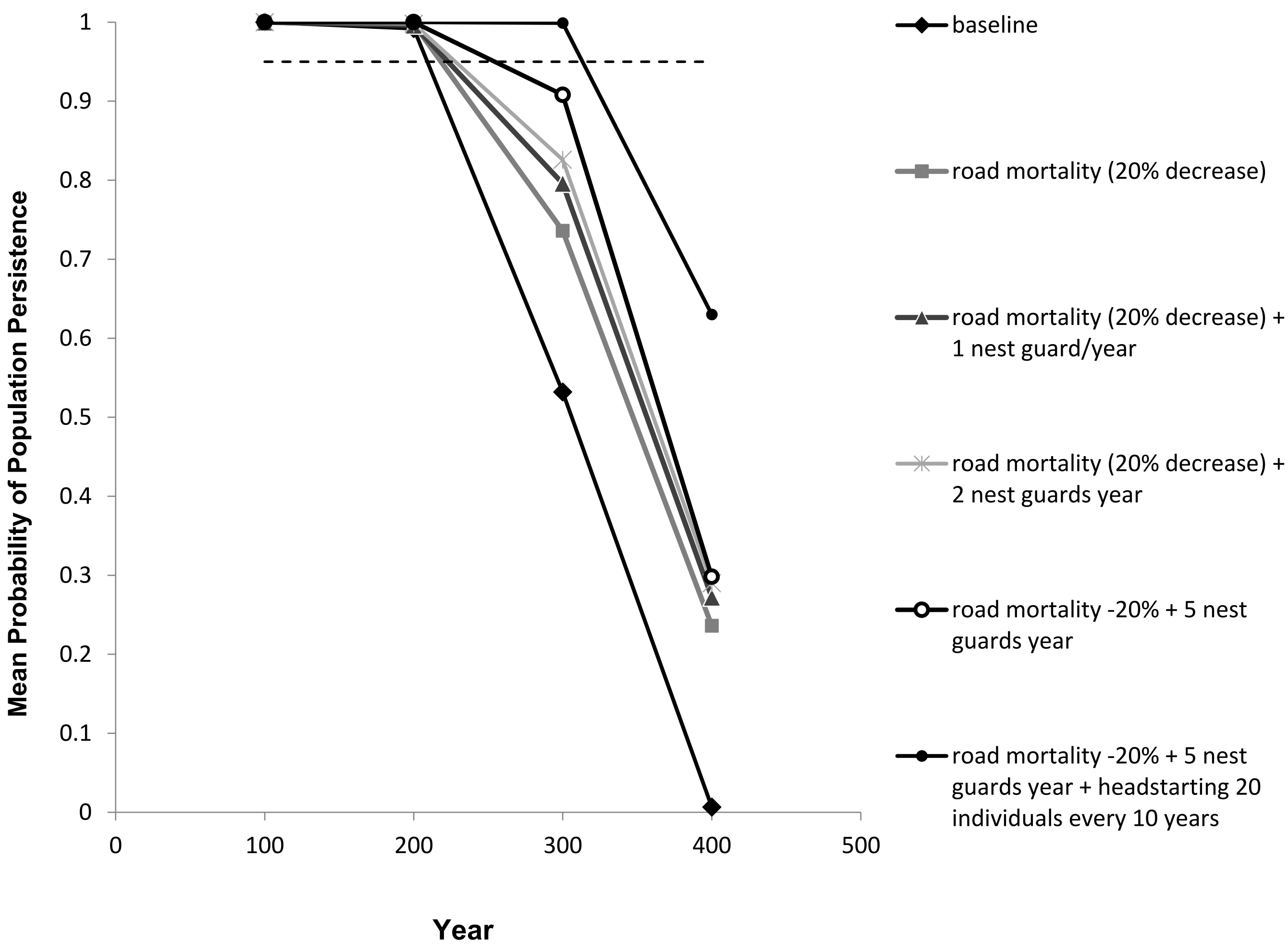

Figure 2. Management scenarios and mean probabilities of population persistence by 100-year intervals for the northern New York Blanding's turtle population. Dotted line represents a 95 % probability of population persistence. Note that population viability drops off sharply after 200 years and that only one management scenario will achieve our goal of maintaining viable populations for 300 years.

Table 2. Population viability analysis framework for the northern New York Blanding's turtle population over 300 years. Input parameters specified for each conservation scenario: control, 20 % reduction in mortality, nest guard placement, and both reductions in mortality and nest guard placement. Input data from Congdon et al. (1993) and G. Johnson (unpubl. data).

Parameter	Control	20 % reduction in mortality	5 nest guards per year	Supplement	All
Inbreeding depression	No	No	No	No	No
Reproduction correlated with survival	No	No	No	No	No
Age 1st female reproduction	17	17	17	17	17
Age 1st male reproduction	17	17	17	17	17
Maximum age of reproduction	100	100	100	100	100
Sex ratio at birth	1:1	1:1	1:1	1:1	1:1
Maximum brood size	10.2	10.2	10.2	10.2	10.2
% Females with litter/year (SD)	80 (10)	80 (10)	80 (10)	80 (10)	80 (10)
% Female/male mortality (age 0-1)	83.08	83.08	83.08	83.08	83.08
% Female/male mortality (age 1-14)	21.83	21.83	21.83	21.83	21.83
% Female/male mortality (age >14)	4.55	4.44	4.55	4.55	4.44
Nest guards (% added to mortality for age class 0-1)	0	0	-1.79	-1.79	-1.79
Number of catastrophes (probability)	1 (5)	1 (5)	1 (5)	1 (5)	1 (5)
% Reduction in reproduction (catastrophe)	0	0	0	0	0
% Reduction in survival (catastrophe)	2	2	2	2	2
% of Adult males breeding	80	80	80	80	80
Starting population size	3,000	3,000	3,000	3,000	3,000
Carrying capacity (SD)	57/ha	57/ha	57/ha	57/ha	57/ha
Headstarting 20 individuals every 10 years for 300 years.	No	No	No	Yes	Yes
Probability of Extinction	**25.2**	**12.0**	**14.8**	**7.4**	**<0.1[1]**

[1] This scenario is the only acceptable scenario consistent with our management goals of 95 % probability of maintaining an extant Blanding's turtle population in Northern New York throughout the next 300 years. It should be noted that current rates of road mortality are not known and may have been grossly underestimated. For every scenario pair combination, PE >5.0 (not shown).

Management actions – Dutchess County

Similar to the northern New York population, results showed that to maintain a viable population of Blanding's turtles in Dutchess County, it is necessary to conduct all three management actions: (1) reduce the estimated rates of road mortality by 20 %, (2) place nest guards on 5 nests per year, and (3) headstart 20 individuals every 10 years into the Dutchess County population (Table 3). Headstarted individuals should be released at one year of age or when their body size is at least the size of a one-year-old individual in nature (whichever is sooner). Individuals should be released during the active period so they may find habitat for overwintering.

Table 3. Population viability analysis framework for the Dutchess County Blanding's turtle population over 300 years. Input parameters specified for each conservation scenario: control, 20 % reduction in mortality, nest guard placement, and both reductions in mortality and nest guard placement. Input data from Congdon et al. (1993).

Parameter	Control	20 % reduction in mortality	5 nest guards per year	Supplement	All
Inbreeding depression	No	No	No	No	No
Reproduction correlated with survival	No	No	No	No	No
Age 1st female reproduction	17	17	17	17	17
Age 1st male reproduction	17	17	17	17	17
Maximum age of reproduction	100	100	100	100	100
Sex ratio at birth	1:1	1:1	1:1	1:1	1:1
Maximum brood size	10.2	10.2	10.2	10.2	10.2
% Females with litter/year (SD)	80 (10)	80 (10)	80 (10)	80 (10)	80 (10)
% Female/male mortality (age 0-1)	83.08	83.08	83.08	83.08	83.08
% Female/male mortality (age 1-14)	21.83	21.83	21.83	21.83	21.83
% Female/male mortality (age >14)	4.55	4.44	4.55	4.55	4.44
Nest guards (% added to mortality for age class 0-1)	0	0	-1.79	-1.79	-1.79
Number of catastrophes (probability)	1 (5)	1 (5)	1 (5)	1 (5)	1 (5)
% Reduction in reproduction (catastrophe)	0	0	0	0	0
% Reduction in survival (catastrophe)	2	2	2	2	2
% of Adult males breeding	80	80	80	80	80
Starting population size	1,000	1,000	1,000	1,000	1,000
Carrying capacity (SD)	57/ha	57/ha	57/ha	57/ha	57/ha
Headstarting 20 individuals every 10 years for 300 years.	No	No	No	Yes	Yes
Probability of Extinction	**80.8**	**63.6**	**53.6**	**10.4**	**2.6**[1]

[1] This scenario is the only acceptable scenario consistent with our management goals of 95 % probability of maintaining an extant Blanding's turtle population in northern New York throughout the next 300 years. It should be noted that current rates of road mortality are not known and may have been grossly underestimated. For every scenario pair combination, PE >5.0 (not shown).

Management actions – Saratoga

From the model scenarios tested, to maintain a population of Blanding's turtles in Saratoga over the next 300 years with 95 % certainty, biologists will need to place nest guards on at least 10 % of the nests, provide for measures to increase survivorship of >1-14-year olds, and release 10, 1-year old females at 10 year intervals (Figure 3).

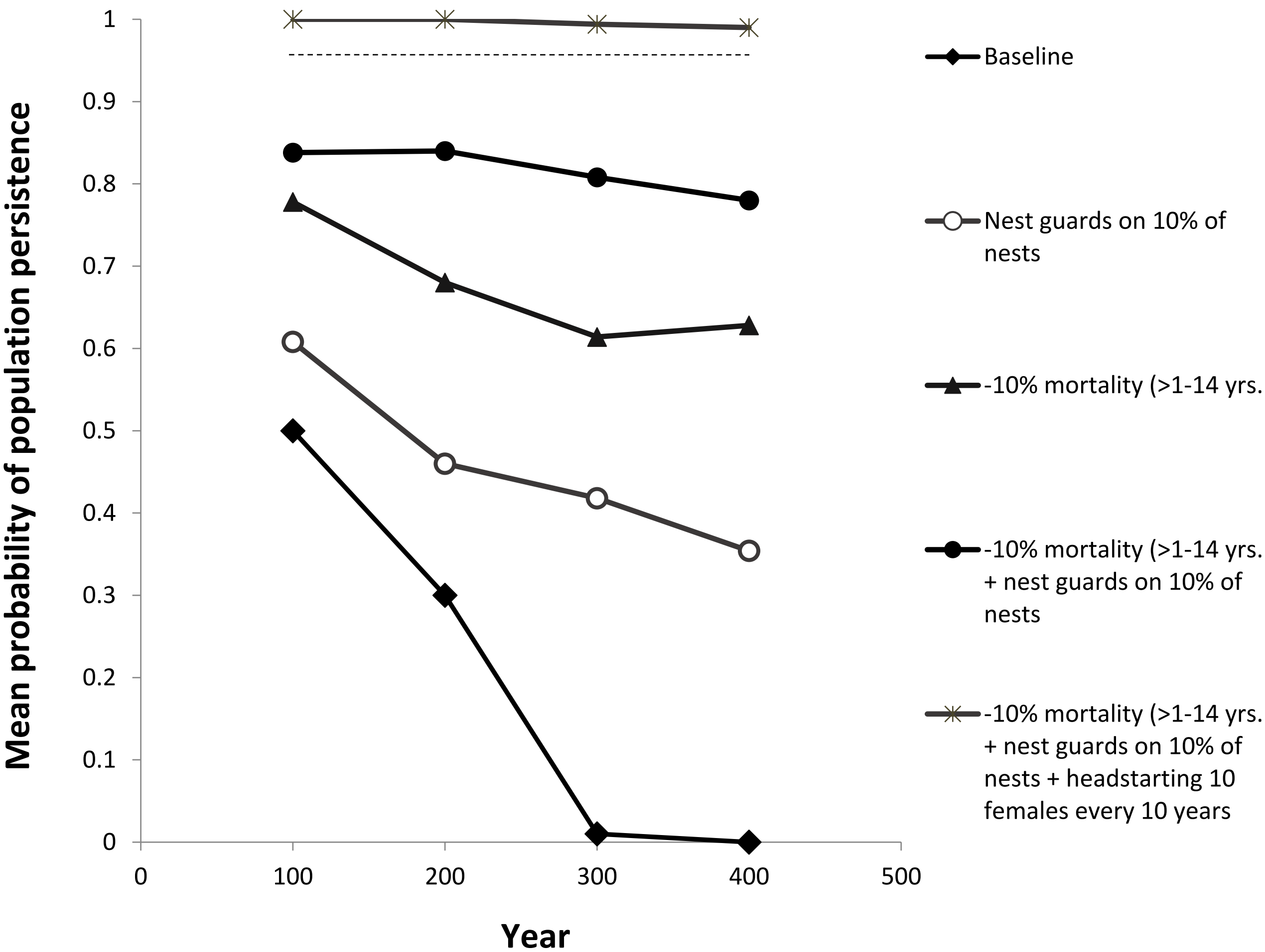

Figure 3. Model results of five conservation scenarios: (1) nest guards on 10 % of the nests, (2) reduction in mortality of >1-14-year olds, (3) nest guards on 10 % of the nests and reduction in mortality of >1-14-year olds, (4) nest guards on 10 % of the nests, reduction in mortality of >1-14-year olds and supplementation of 10 1-year old females every 10 years, and (5) no action or baseline (for comparative purposes). Dotted line represents a 95 % probability of population persistence.

It is important to point out that little is known about the habits of the Blanding's turtle from ages 1-14. Moreover, the mortality rate of that age class has not been directly estimated for any population across the species' range. Therefore, it may not be feasible to decrease mortality rates of individuals in the 1-14-year-old age class and hence it may not be a reasonable management scenario. However, one can presume that if habitat is of high enough quality (i.e., has good structural diversity, good foraging opportunities, etc.), young individuals will have places to hide from predators and will be able to fulfill their necessary life requisites, which may lead to decreased mortality. It is our hope that these management recommendations can be implemented and will be effective at maintaining viable populations of the Blanding's turtle in New York.

Future Directions for a New York Blanding's Turtle PVA

It is important to note that the results of the present PVA are subject to change as more accurate and updated information becomes available. In addition, data relevant to New York populations may be necessary to increase our confidence in model outcomes and hence management priority setting. As stated previously, we are confident that the results of the sensitivity analysis presented herein are accurate. However, we would like to emphasize that we are less confident about the exact magnitude of management necessary to help maintain viable populations of the Blanding's turtle in New York State. What appears to be true is that our estimates of management efforts would be conservative and therefore would represent the minimum work necessary to achieve conservation targets. Efforts to refine the present PVA with data collected from New York populations should be undertaken to improve the accuracy of these models. We also would like to state that we are confident that the management strategies identified within the present PVA will further the conservation of the Blanding's turtle in New York.

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Appendix 2. Nesting activity protocol for Blanding's turtles (*Emydoidea blandingii*) in New York State.

Nesting Activity Survey Protocol for Blanding's Turtles (*Emydoidea blandingii*)
Drafted by Angelena M. Ross, Region 6 Wildlife Biologist
Version 1: May 6, 2009

Purpose
The purpose of this document is to provide guidance on how to identify and characterize Blanding's turtle nest sites. These guidelines are designed specifically for landowners or potential developers so that Blanding's turtle nesting areas may be documented and plans to avoid or mitigate impacts to these sensitive areas may be developed and followed.

Please note: an Endangered/Threatened Species Permit must be obtained before conducting nest searches or handling Blanding's turtles.

Methods
Nesting Activity Surveys for Blanding's turtles should be conducted in suitable areas such as grasslands characterized by sandy loam or sandy soils, areas with sparse herbaceous vegetation interspersed with bare mineral soil and human-disturbed areas such as plowed fields, cornfields, road side berms, active agricultural lands and gravel pits. Blanding's turtle nests have been observed from two to over 1,000 m from an occupied wetland. The nesting period is approximately between 28 May and 8 July in northern New York, with early and mid-June coinciding with the peak of nesting activity. At a minimum, surveys should focus on the peak of the nesting activity (1-21 June).

Blanding's turtle Nesting Activity Surveys should focus on locating (1) nesting female turtles, (2) evidence of digging, (3) turtle tracks and (4) nests destroyed by predators. Because nests destroyed by predators may be more readily identified than non-depredated nests, searches should include habitat edges, as these areas are where predators tend to be more successful at locating nests. Turtle tracks and depredated eggs should be identified to species level if possible. Locations of Blanding's turtle nests should be recorded using a global positioning system (GPS).

Surveys should be conducted on foot with binoculars and/or with night vision goggles. To minimize disturbance to females found during the process of nest excavation, observations should be made using binoculars at a minimum distance of 20 m. During very low ambient light conditions, spotlights fitted with red filters may be used to observe turtles, taking care to cause no disturbance.

Surveys should be conducted by direct observations from 1800-0400 hours daily for at least six consecutive hours each day from 1-21 June and when air temperatures are $\geq 50^{o}$F. Observers should walk potential nesting areas within 1,000 m of all wetlands that contain suitable habitat (see above for description of nesting habitat). General weather conditions (%

cloud cover, temperature, relative humidity, wind speed, etc.) and precipitation should be recorded at the beginning of each survey and after any significant change in weather conditions occurs. Thermometers should be used to determine air temperatures in the field. If air temperature falls below 50°F or no Blanding's turtles are observed on land by 12:00 am, surveys may be concluded for that night. Observers should record the date, time, turtle species encountered, GPS coordinates of each individual (include all species) and nest (intact or depredated), turtle behavior, sex and whether or not a female Blanding's turtle is gravid under the following conditions: no Blanding's turtle shall be handled for any reason until after it moves out of a potential nesting area.

Any potential nesting area that is visited by a female Blanding's turtle should be considered occupied. Once a potential nesting area is considered occupied, that area no longer needs to be surveyed.

Use of Radio Telemetry

Gravid female Blanding's turtles leaving the nesting area may be fitted with radio transmitters to aid in the detection of new nest sites. In addition, if members of a population have been trapped and contain radio-tagged females, turtle locations should be checked each night during the nesting period. If no radio-tagged females have left the water by 12:00 am, surveys may be concluded for that night. Radio tags may be affixed by observers if a female is found within 2 m of the water's edge. Radio tags should be attached with a bead of plumber's epoxy without picking up the turtle.