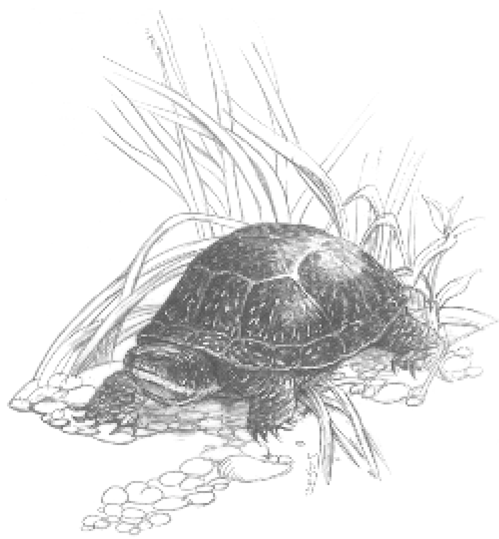
National Recovery Plan for the

BLANDING'S TURTLE

(*Emydoidea blandingii*)

Nova Scotia Population

January 2003



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Disclaimer

This Recovery Plan has been prepared by the Blanding's Turtle Recovery Team to define recovery goals, objectives, strategies, and actions that are deemed necessary to protect, conserve, and recover the Nova Scotia population of Blanding's turtle. The Plan does not necessarily represent the views of all of the individuals involved in its formulation or the official positions of the organizations with which the individual team members are associated. The goals, objectives, strategies, and actions are based on the best existing knowledge and are subject to modification resulting from changed objectives and new findings. The implementation of the recovery plan will be subject to appropriations, priorities, and budgetary constraints of the participating jurisdictions and organizations. Therefore, some aspects of this Recovery Plan may not necessarily be implemented immediately, concurrently, or in their entirety.

Acknowledgements

The Blanding's Turtle Recovery Team has produced this plan with input from additional individuals. We would like to thank the following for their contribution to the project: Nova Scotia Department of Natural Resources (NSDNR), Wildlife Division; Kejimkujik National Park and National Historic Site (KNP); Acadia University Biology Department; Dalhousie University Biology Department; Nova Scotia Museum of Natural History; Bowater Mersey Paper Company Limited; Nova Scotia Community College, Centre of Geographic Science; Parks Canada National Office and Atlantic Service Centre; Southwest Nova Biosphere Reserve Association; DesBrisay and MacDonald Museums; Nova Scotia Power Incorporated. We also thank the many members of the public who have helped and continue to help in the recovery of this species.

Jurisdictions

Legal responsibility for Blanding's turtle in Nova Scotia is shared between the Government of Nova Scotia (Department of Natural Resources), as detailed in the Endangered Species Act (1998) and the Government of Canada (Parks Canada Agency and Environment Canada) through the Species at Risk Act (SARA).

Recommended Citation

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Executive Summary

Blanding's turtle (*Emydoidea blandingii*) is a North American freshwater turtle with a main range centered on the Great Lakes. Populations are distributed patchily throughout this range (McCoy 1973). The Nova Scotia population, which occurs at the northeastern periphery of the range, is the most isolated single disjunct in the entire range and is considered a relict from a warmer climatic period (Herman *et al.* 1995). Here, Blanding's turtles are restricted to the warmest region of the province, the southwestern interior.

The Nova Scotia population is an important evolutionary unit of the species; it has significantly diverged genetically from populations in the main range and contains a high degree of genetic variation (Mockford *et al.* 1999; Ruben *et al*. 2001). As well, recognizable genetic spatial structure also exists within Nova Scotia, suggesting a metapopulation (population of populations) structure in the province; this further enhances its importance as an evolutionary unit within the species (Ruben *et al*. 2001).

Currently, three relatively discrete populations have been documented on two watersheds in Nova Scotia; additional, anecdotal sightings have been reported on two adjacent watersheds. The Kejimkujik National Park and National Historic Site (KNP) population occurs on the Mersey River watershed primarily within the boundaries of KNP and has been studied since 1969 with intensive work occurring since 1987. Two populations have been identified on the Medway River watershed; these occur in working landscapes owned by a variety of private individuals, resource-based industry, and provincial government agencies. The McGowan Lake population has been studied intensively since its discovery in 1996. Intensive work at the Pleasant River population began in 2002.

The Nova Scotia population was designated as "Threatened" by COSEWIC (Committee on the Status of Endangered Wildlife in Canada) in 1993 as a result of a 1993 status report (Herman *et al.* 1995), based on the small, isolated range, the population's uneven age structure and apparent low recruitment of juveniles or young adults. In response to the COSEWIC designation, the Blanding's Turtle Recovery Team was formed and a Recovery Action Plan was written (Herman *et al.* 1998). The Recovery Strategy outlined in this Plan builds on the actions identified in the 1998 Plan, incorporating new knowledge of the turtle's distribution, spatial structure, habitat requirements, behavior, genetic structure, and threats.

The goal of this recovery plan is to maintain and, where appropriate, restore population size and structure of Blanding's turtle within Nova Scotia through the maintenance and restoration of habitats and ecological processes. Our understanding of and actions to conserve Blanding's turtles in Nova Scotia are confounded by the extreme longevity (70+ years) and late maturation (20-25 years) of the species. As a result, conservation actions or acute environmental changes are followed by significant time lags; in many cases their impacts may not be measurable for decades. Although this Recovery Plan will be evaluated after 5 years, many of the objectives outlined here will require long-term commitments.

The strategic recovery objectives in this Plan are as follows:

I. Maintain and restore Blanding's turtle *population sizes*,

II. Maintain and restore Blanding's turtle *habitat*,

III. Maintain *metapopulation structure*,

IV. Remove or reduce *threats* to Blanding's turtles and their habitats.

I. Maintain and restore Blanding's turtle *population sizes:* Maintaining and/or restoring population size requires detailed information on demographic structure, spatial structure and the threats facing each population. Little is known about historical population sizes although an apparent decline in population size has been noted at KNP, particularly at Grafton Lake; this has been attributed to habitat alteration by dam construction (1937), collection for museum specimens (1950's-1960's) prior to park establishment, and road construction and human activity subsequent to park establishment (1968).

Collection of detailed demographic data in each population requires regular systematic sampling of all age classes, following standardized capture and data collection protocols that are presently being refined. All data will be stored in a single integrated database that will be regularly maintained and updated; this will facilitate analysis and dissemination of data. Analysis of both historical and recent data from the database will allow us to determine trends in population estimates, growth rates, fecundity and survivorship. Ultimately, combining analysis of demographic data with genetic and habitat parameters will allow development of spatially explicit Population Viability Analysis (PVA) models, sufficiently realistic to assist in designing management strategies.

Current management actions aimed at increasing recruitment include protecting nests and nesting habitats, and head-starting (captive rearing and release) of wild-born hatchlings. Intensive annual monitoring of nesting sites began in 1993 in KNP; a volunteer-based nest-monitoring program was formalized in 1999. This program, which protects nests from predation, provides valuable data on reproductive success and promotes local stewardship; it will be continued and expanded to all populations. Building on a pilot study showing that head-started hatchlings survive and behave like wild hatchlings (Morrison 1996), we have initiated an attempt to restore a historically reduced population of turtles at Grafton Lake (in conjunction with restoration efforts by Parks Canada) by captive rearing of wild-born hatchlings for release in Spring 2003.

II. Maintain and restore Blanding's turtle *habitat:* Habitat is key to the recovery of Blanding's turtles in Nova Scotia. We must determine how habitat and its spatial distribution affect turtle distribution, abundance, behavior and productivity and we need to incorporate both habitat variation and variable response (at both individual and population levels) to habitat in management plans. Identifying the appropriate scale for managing habitat (*i.e.*, one that recognizes the ecological scales important to the turtles) is a major challenge.

A habitat protection plan will be developed for each population that will incorporate requirements of both federal (Species at Risk Act (SARA)) and provincial legislation (NS Endangered Species Act), as well as education and stewardship initiatives. The plan will be regularly evaluated, and must evolve to incorporate both new information on turtle-habitat dynamics and changes in habitat threats.

An effective habitat protection plan that includes site-specific stewardship depends on reliable data on location and habitat use. All seasonal and age-specific habitats, including those used for overwintering, nesting, basking, mating and feeding must be identified. Movement patterns through and between these habitats will be tracked at multiple spatial and temporal scales. Assessing habitat characteristics including hydrology, geology, vegetation and temperature at each site will help us understand the habitat requirements of Blanding's turtles. As well, it will provide us with detailed baseline data to monitor habitat change. Long-term surveys will be established to monitor and assess changes in the quality and availability of habitat for supporting Blanding's turtles in Nova Scotia. Both habitat components (including field collected data and spatial imagery) and precise movement data must be incorporated into the database. GIS analysis of the data will be instrumental in describing and interpreting large scale patterns essential for the development of an effective habitat protection plan.

III. Maintain *metapopulation structure:* Blanding's turtles in Nova Scotia occur in a metapopulation structure (a population of populations interconnected by infrequent movements). Genetic analysis has revealed that movements between the KNP and McGowan Lake populations are rare, sufficiently infrequent to make the two populations genetically distinguishable but sufficiently frequent to maintain genetic variation within each population. We do not adequately understand the historical connections within the metapopulation and how human activity has recently modified those connections. Although we can readily identify several spatial scales in distribution of Blanding's turtles in Nova Scotia (concentration, population, watershed) and in the distribution of their genetic diversity, the influence of habitat heterogeneity on movements and distribution adds additional complexity to the system. Again, identifying the appropriate management scales in such a system is key but perplexing.

Understanding the extent of the metapopulation (and the factors that limit it) is necessary to understand the overall structure and to initiate effective management of that structure. We will attempt to determine the range of Blanding's turtles in Nova Scotia by continuing a public poster and survey campaign that solicits the aid of local residents by asking them to report sightings of Blanding's turtles. This method has proved successful in past, and led to the discovery of both the McGowan Lake and Pleasant River populations. Areas identified through the campaign will be systematically searched in order to substantiate sightings.

It is important to maintain processes that contribute to current genetic sub-structuring within the metapopulation. Samples from newly identified populations will be compared to currently known populations, in order to assess the extent and degree of genetic structuring in the Nova Scotia metapopulation. Each population will be periodically re-sampled, genotyped and assessed for the loss of genetic diversity. This is a long-term objective, as the generation time of this long-lived species probably approaches 40 years.

Recent developments in quantitative ecological modeling allow a more sophisticated analysis of spatial behaviour and the influence of landscape on population structure. These models will help provide more accurate parameter values to enable more realistic Population Viability Analysis for the metapopulation.

IV. Remove or reduce *threats* to Blanding's turtles and their habitats: Blanding's turtles in Nova Scotia are inherently constrained by geography (isolation, small population size, northern limit of range), demography (longevity, late maturation) and behaviour (strong site-affinity, seasonal aggregations) that make them particularly vulnerable to disturbances. Human activities exacerbate the inherent threats in a variety of ways. Immediate threats induced by humans include: water level manipulation, habitat fragmentation, and direct vehicular mortality. Climate change and increased pressures from invasive species are expected to impact turtles in future.

Threats will be monitored adaptively and specific threats will be dealt with as they arise. Currently recognized threats to adult survivorship, nest success, and habitat will be monitored and strategies will be developed to address these threats. Modeling tools may help us to predict the future impact and extent of these threats as well assess ramifications of potential management techniques. Continued public education and the promotion of landowner stewardship will inform stakeholders of methods to reduce threats to turtles and their habitats.

Five interrelated, broad strategic approaches have been defined in order to provide an organizational framework upon which to develop and implement the Recovery Action Plan.

The strategic recovery approaches are to:

A. Improve the *information* upon which conservation and recovery initiatives are based,

B. *Manage* effectively and efficiently to further protection, conservation and recovery;

C. Encourage and implement *stewardship*, enhanced by communication and education,

D. *Evaluate* regularly the Recovery Plan, including all objectives, approaches, and actions,

E. Connect the *recovery process* to broader biodiversity and ecosystem conservation.

The recovery process for Blanding's turtle to date has been strongly science-based. It has also allowed us to challenge the conventional wisdom about the structure and importance of small peripheral, disjunct populations and about the behaviour of aquatic turtles. Strong underlying science on which to base management actions is particularly important in a long-lived species, where the ramifications of such actions may not be apparent for many years. Regular evaluation and refinement of the Plan will allow it to evolve to incorporate both new information on turtle-habitat dynamics and changes in habitat threats.

Local stewardship is essential to the long-term success of Blanding's turtle conservation. Contacting and collaborating with stakeholders in each population, combined with ongoing public education and conservation activities, will foster an ethic of local stewardship and help ensure long-term habitat protection.

Blanding's turtle is a model umbrella species for conserving wetland ecosystems. Although a single-species approach has been adopted in this Recovery Plan, the protection of the turtle and its habitat will ultimately conserve a suite of species and ecological processes.

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Section I: Introduction
A brief introduction to the Blanding's turtle in Nova Scotia, why the species is at risk, the history of Blanding's turtle recovery work, including a brief overview of actions already underway, the formation of a recovery team, and initial action plan. It also includes an overview of the recovery process in Canada and Nova Scotia.

Section II: Background Information
An overview of the information necessary for the development of the recovery strategy and action plan. This includes species information, distribution, national significance of the Nova Scotia population, population structure, population size and trends, reproduction, limiting factors, threats, protection, habitat requirements, ecological role, socio-economic considerations, recovery rationale and potential, recommended approach and scale for recovery, and knowledge gaps.

Section III: Recovery Strategy
The Recovery Strategy includes goals, objectives, and approaches and how they interact in the process to recover Blanding's turtle in Nova Scotia. These are strategic in nature and are used to guide the development of recovery actions outlined in Section IV. This section also includes a brief assessment of potential management impacts on other species and ecological processes, and a description of the process for overall evaluation. Finally, there is a summary table of the status of actions recommended in the 1998 Blanding's Turtle Recovery Plan, with cross-references to recommended actions in the current Plan.

Section IV: Recovery Action Plan
The Recovery Action Plan includes a detailed step-down outline of specific actions, presented and organized according to the four strategic objectives of Section III. The narrative of the step-down outline provides the rationale for each action, with a summary of progress and related successes to date. This section ends with a discussion of implementation, including the challenges of integrating recovery in both working and protected landscapes.

Section I: Introduction

Species Introduction and a Brief History of the Recovery

Blanding’s turtle (*Emydoidea blandingii*) (for review of nomenclature see McCoy 1973) is a North American freshwater turtle with a main range centered on the Great Lakes. Populations occur in southern Ontario, southwestern Quebec, Wisconsin, Illinois, Michigan, Ohio, Minnesota, Iowa, Indiana, Nebraska, South Dakota and Pennsylvania (Ernst and Barbour 1972; Ernst 1973; McCoy 1973; Conant 1938; Cochran and Lyons 1986; Olson 1987; Oldfield and Moriarty 1994). Isolated populations of Blanding's turtle occur outside the main range in Massachusetts (Ernst and Barbour 1972), Maine (Graham *et al.* 1987), New York (Petokas and Alexander 1981), New Hampshire (Ernst and Barbour 1972), and Nova Scotia (Bleakney 1958a, 1963; Dobson 1971). Of these disjunct populations the Nova Scotia population is the most spatially isolated (Herman *et al.* 1995). Efforts by the Ontario Herpetofaunal Survey and others have produced additional records but have not significantly extended the known range of the species (Petokas and Alexander 1980; Weller and Oldham 1988). Blanding's turtle is distributed patchily throughout its range (McCoy 1973). In the United States the species is listed as State Endangered or State Threatened through most of its range (Appendix II). In Canada, the Nova Scotia population was listed as Threatened by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) in 1993 and as Endangered by the province of Nova Scotia in 2000.

The species was not described in Nova Scotia until 1953 (Bleakney 1958a). The first Blanding’s turtle found by Bleakney was at the mouth of Grafton Brook in Kejimkujik Lake; this site would become part of Kejimkujik National Park and National Historic Site (KNP) at its founding in 1968. At that time, it was believed the only concentration of turtles occurred in KNP, although there had been anecdotal sightings from several areas outside of the park. Since 1969 the staff at KNP has tracked incidental sightings and individual turtles have been marked opportunistically. Several studies were conducted by KNP in the 1970’s (Thexton and Mallet 1977-1979; Weller 1971-1972) and a management plan for the species in the park was prepared (Drysdale 1983).

More intensive research on Blanding’s turtle ecology began in the mid 1980’s (Power 1989; Eaton 1989; Herman *et al.* 1989) as a result of concern about the population’s status. This work led to the development of a 1993 status report (Herman *et al*. 1995) that was the basis of the COSEWIC designation as Threatened in 1993. The status report offered two principal reasons that the species was threatened: 1) the range is restricted and well isolated from other populations, and 2) the age distribution appeared to be unstable, with a bias towards older adults and with little apparent recruitment of juveniles or young adults. Also in 1993, a meeting was organized by Nova Scotia Department of Natural Resources (NSDNR) to consider the need for a recovery team and recovery plan. A recovery team was formed, with Dr. Tom Herman of Acadia University as Chair. Over the next two years the team developed a recovery plan that formed the basis for conservation and recovery action. The plan was approved by Recovery of Nationally Endangered Wildlife (RENEW) in 1998 and since then new information has become available and research has raised new issues that require incorporation into a recovery plan. This updated Recovery Plan will cover the five-year period from 2003 to 2008. The current version of the plan was initiated in 2002. The status of Blanding’s turtle is due for review by COSEWIC in 2003.

Since the COSEWIC listing, concerted research has been carried out in a number of areas. Attempts to describe age structure and its determinants have included studies of nesting ecology (Standing 1997, Standing *et al.* 1999), hatchling and juvenile ecology and movement (McMaster 1996; McNeil 1996; Standing *et al*. 1997) and predator interaction (Oickle 1997; Shallow 1998). Attempts to determine the extent of the species range in Nova Scotia have been made by trapping areas identified from anecdotal reports (McNeil and Herman 1996; McNeil unpublished data) and by radio-tracking individuals. In addition, initial attempts at genetic assessment by Eaton (1989) have been followed by more comprehensive analyses (Mockford 1996; Mockford *et al.* 1999) which are continuing. This work has focused on determining the genetic relationship between the Nova Scotia population of Blanding's turtle, other disjunct populations on the eastern seaboard and those populations in the main range, as well as looking for evidence of genetic structuring within the Nova Scotia population.

Several other conservation actions have taken place including the closing of a hiking trail within KNP which lead to nesting sites (Drysdale 1983) and the removal of Grafton Lake dam which restricted Blanding's turtle movement (Drysdale 1992). Blanding's turtle nesting has been systematically monitored since 1987. Nesting beaches are monitored throughout the nesting season, during which the identity of nesting females along with a variety of parameters including the number of eggs per nest, location, time, and weather, are recorded. On completion of nesting each nest is covered with a protective enclosure to exclude predators. In the fall during hatchling emergence the nests are monitored daily and hatchlings are released after being measured, weighed and given a nest-specific identifying notch (Standing *et al.* 2000a).

Other direct conservation actions include an ongoing program of public education within and outside of KNP. Since 1996 information posters have been used to solicit reports of Blanding's turtle sightings, particularly outside KNP. In addition to posters, a variety of researchers and interpreters have given public presentations at schools and community halls in southwest Nova Scotia. A Blanding's turtle website and telephone hotline was developed, and the Blanding's turtle has been featured in traveling and permanent exhibits throughout western Nova Scotia. This program has revealed that in Nova Scotia significant numbers of Blanding's turtle occur in both protected and working landscapes and led to the identification of at least two significant populations outside KNP. To better facilitate research and recovery actions in working landscapes we have been consulting directly with landowners.

The recovery process for Blanding's turtle to date has been strongly science-based. Research has increased our understanding of the ecology of the species and has helped to identify the threats that this population faces. It has also allowed us to challenge the conventional wisdom about the structure and importance of small peripheral, disjunct populations and about the behaviour of aquatic turtles. When the species status was first reviewed it appeared that the majority of the population existed in a protected landscape (KNP); we now know that a large part of the population actually occurs in working landscapes, where agriculture, forestry, water level manipulation and cottage development may pose substantial risks.

Our understanding of and actions to conserve Blanding's turtles in Nova Scotia are additionally confounded by the extreme longevity (70+ years) and late maturation (20-25 years) of the species. As a result, conservation actions or acute environmental changes are followed by significant time lags; in many cases their impacts may not be measurable for decades. This poses one of the greatest challenges to recovery since it taxes the administrative memory and conventional structures.

Recovery Process

Recovery at the National and Provincial Level

This Recovery Plan document will serve as a strategic instrument for guiding the recovery of Blanding's turtle in Nova Scotia. This document meets the requirements for recovery plans under the National Accord for the Protection of Species at Risk, the Nova Scotia Endangered Species Act, and the federal Species at Risk Act (SARA).

Recovery Plans under the National Recovery Working Group's (NRWG) Recovery of Nationally Endangered Wildlife (RENEW) framework consist of two parts: a Recovery Strategy and a Recovery Action Plan. The recovery strategy identifies and provides the rationale for the goals and objectives for recovery and identifies key strategic approaches required to meet these goals and objectives. The recovery action plan identifies actions required for recovery that correspond to goals, objectives, and strategic approaches identified in the strategy. This is a five-year recovery plan (2003-2007) and an adaptive management approach has been adopted; changes will be made as new information warrants.

Participation in the Recovery of Blanding's Turtle in Nova Scotia

There are multiple avenues through which people can get involved in the recovery process for Blanding's turtle in Nova Scotia. Individuals and groups should use this recovery plan to guide their involvement, but any actions should be reviewed and coordinated through the Blanding's Turtle Recovery Team (Appendix 1).

Section II: Background Information

Species Information

Scientific Name: *Emydoidea blandingii*

Common Name: Blanding's turtle

Occurrence: Southwestern Nova Scotia and southern Ontario, Great Lakes region

Reason for COSEWIC Designation: Limited distribution within the province, the population's uneven age structure, and the low rate of recruitment into the breeding population.

Table 1. A summary of status information for the Nova Scotia population of Blanding's turtle.

Ranking	Status	Year of Designation	History of Status Review
COSEWIC[1]	Threatened	1993	-
Provincial Status[1] **(*NS Endangered Species Act*)**	Endangered	June 2000	Status has not been reviewed since 2000
Provincial General Status[1]	Red (*At risk, or maybe at risk*)	1995	Status reviewed every 5 years
National General Status	Red (*At risk*)	2000	Status reviewed every 5 years
CITES	Not Listed	-	-
Sub-National[1]	S1 (*Extremely rare throughout its range in the province, may be especially vulnerable to extirpation*)		
Global	G4 (*Apparently secure globally, may be rare in parts of its range*)		

[1] Nova Scotia population

Distribution

Global Range

The Blanding's turtle has a northern distribution, centered in the Great Lakes region (Herman *et al.* 1995). The current range of the species extends from extreme southern Quebec and Ontario, south and west to central Nebraska, including parts of Ohio, Michigan, Indiana, Illinois, Wisconsin (Cochran and Lyons 1986), Minnesota (Ernst 1973; Olson 1987), Iowa, Missouri, and South Dakota (Figure 1).

Isolated local populations occur at the eastern periphery in New York (Petokas and Alexander 1981), Maine (Graham and Doyle 1973; Graham *et al.* 1987), Massachusetts (Graham 1986), New Hampshire, and Nova Scotia (Herman *et al.* 1995). Throughout its range Blanding's turtle is patchily distributed, especially in peripheral regions (McCoy 1973).

Canadian Range

In Canada, populations are restricted to southern Ontario, the southwestern corner of Quebec, and the interior of southwestern Nova Scotia. Efforts by the Ontario Herpetofaunal Survey and others have produced additional records but have not significantly extended the known range of the species (Petokas and Alexander 1980; Weller and Oldham 1988).

Nova Scotia Range

The Nova Scotia population is the most isolated single disjunct in the entire range of the species, and is considered a relict from a warmer climatic period (Bleakney 1958a). The late discovery of this population (1953) was largely due to the secretive habits and low local density of the species. Despite recent searches in adjacent areas, the known range of the Nova Scotia population remains restricted to the southwestern interior of the province, although its overall detailed distribution is poorly understood (Figure 2).

Confirmed sightings in Nova Scotia are within federal park land as well as private and provincial Crown lands, but are limited to the Mersey and Medway watersheds (Powell 1965; Dobson 1971; Bleakney 1976; Drysdale 1983; Herman *et al.* 1989; Hope, unpublished). Additional yet unconfirmed sightings have been reported from the LaHave and Roseway watersheds (McNeil and Herman 1996) (Figure 2). Three relatively discrete populations are presently recognized: Kejimkujik National Park and National Historic Site (Mersey), McGowan Lake (Medway) and Pleasant River (Medway) (Figure 2).

Within these populations there appear to be local concentrations. The KNP population appears to concentrate in three areas, one on the Mersey River and two on inflow streams and adjacent lakeshore coves on Kejimkujik Lake. The McGowan Lake population concentrates in at least two sites, both associated with beaver-maintained lakeshore wetlands. The Pleasant River population is more widely dispersed across small forested and open feeder brooks and adjacent beaver-modulated wetlands, although recent evidence identifies at least three areas of concentration

Historical Range

A comparison of past and present distributions over the entire range shows that the species' distribution has changed considerably (Figure 1). Fossil evidence, which occurs to the south and west of the centre of the present distribution, suggests that the species' range has shifted eastwards since the last glaciation. This shift may have resulted from habitat disappearance (Jackson and Kaye 1974) and changing climatic conditions (Preston 1971).

Although nothing is known of the history of Blanding’s turtle in Nova Scotia, it is likely (based on estimates of genetic diversity) that populations were once larger and more widespread than at present.

Percentage of Global Distribution in Canada

Approximately 20 percent of the global distribution exists in Canada and less then five percent of this exists within Nova Scotia.

Distribution of Blanding's Turtles *(Emydoidea blandingii)* in North America

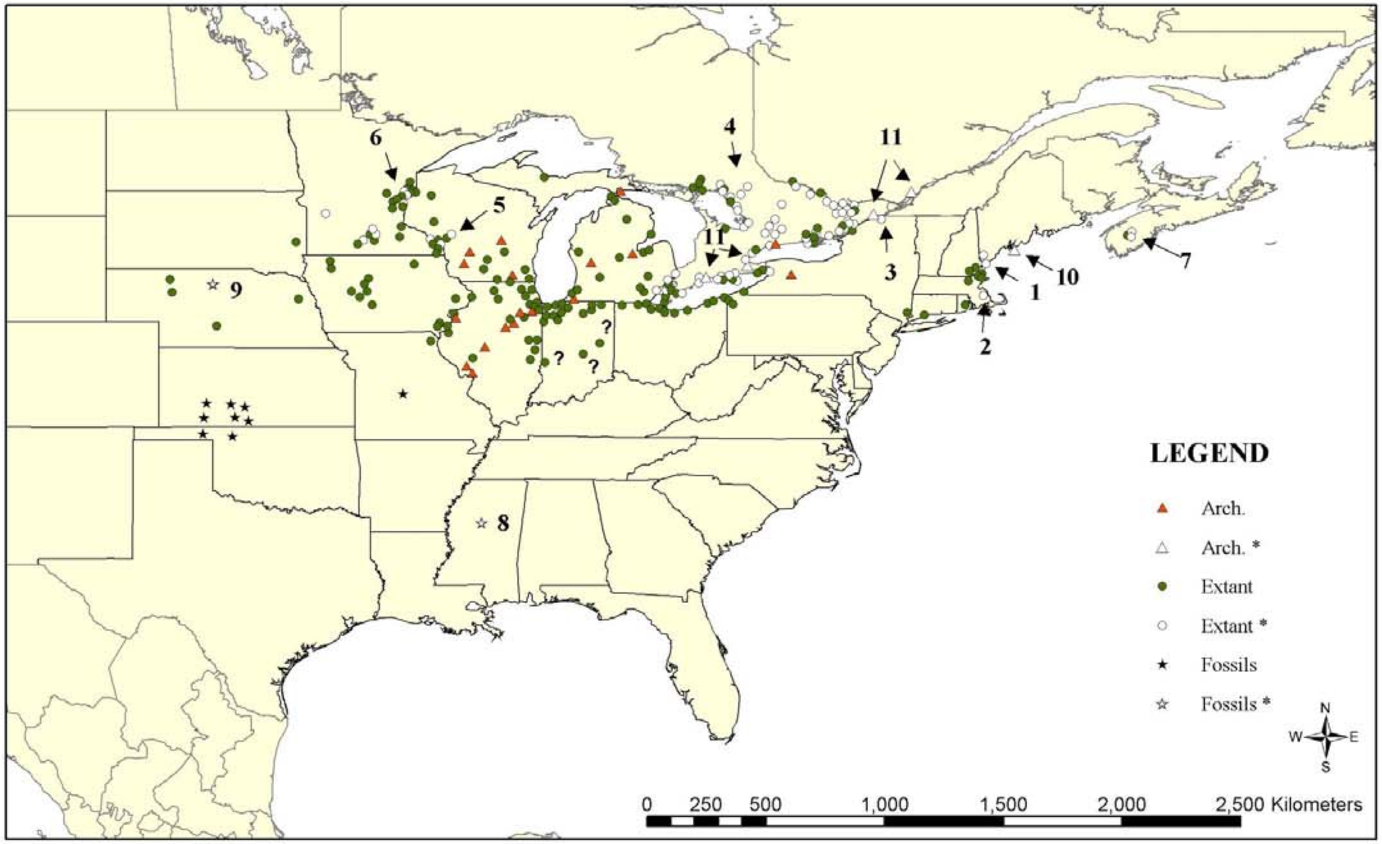


Figure 1. Past and present distribution of Blanding's turtles *(Emydoidea blandingii)* in North America (O'Grady 2002a). Circles represent extant populations, stars represent fossil finds, triangles represent archeological finds.

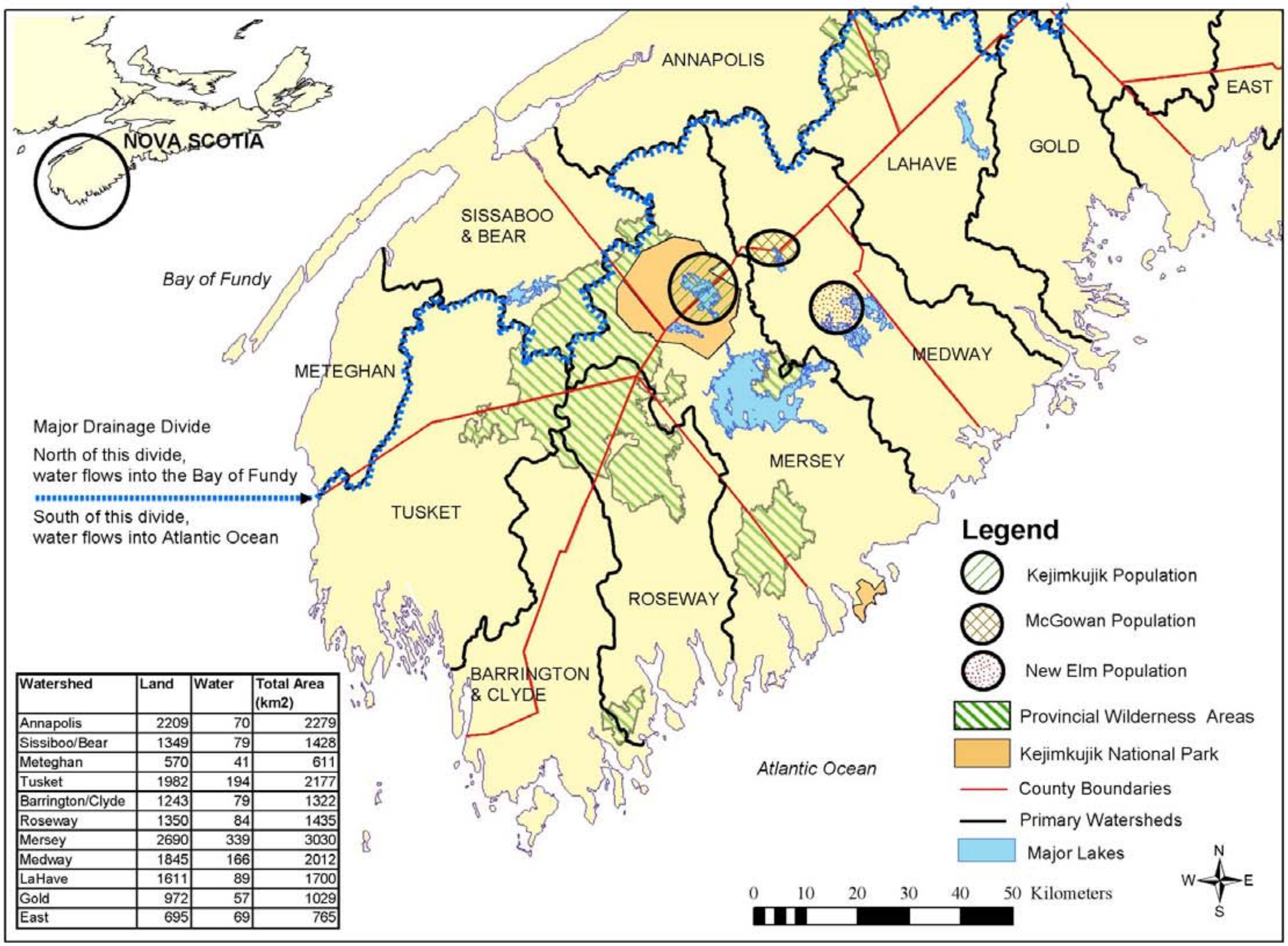
Sources:
Closed symbols are after McCoy (1973)
Open symbols with the * denote other authors
Numbers refer to references for updated information

Extant populations:
1- Maine (Graham and Doyle 1973; Graham and et al. 1987)
2- Massachussets (Graham 1986)
3- New York (Petokas & Alexander 1978, 1981)
4 - Ontario (Petokas & Alexander 1980, Weller & Oldman 1988)
5 - Wisconsin (Cochran & Lyon 1986)
6 - Minnesota (Ernst 1973; Olson 1987)
7 - Nova Scotia (NS Blanding's Turtle Recovery Plan - 2002)

Fossil records:
8 - Mississippi (Jackson & Kaye 1974)
9 - Nebraska (Hutchison 1981)

Archeological finds:
10 - Maine (French 1986)
11 - Quebec and Ontario (Bleakney 1958b; Bider & Matte 1991)

Distribution of Blanding's Turtles(*Emydoidea blandingii*) in Nova Scotia



Watershed	Land	Water	Total Area (km2)
Annapolis	2209	70	2279
Sissiboo/Bear	1349	79	1428
Meteghan	570	41	611
Tusket	1982	194	2177
Barrington/Clyde	1243	79	1322
Roseway	1350	84	1435
Mersey	2690	339	3030
Medway	1845	166	2012
LaHave	1611	89	1700
Gold	972	57	1029
East	695	69	765

Figure 2. Distribution of Blanding's turtles (*Emydoidea blandingii*) in Southwestern Nova Scotia (O'Grady 2002b).

Nationally Significant Populations

Although several disjunct populations of Blanding's turtle occur on the eastern seaboard of North America, the Nova Scotia population is the most spatially isolated, and presumably the most temporally isolated. Theory suggests that a small isolated population should lose genetic variation due to the effects of inbreeding and genetic drift. To the contrary, studies have shown that the degree of genetic variation in the Nova Scotia population is similar to that of populations in the species' main range (Mockford *et al.* 1999; Ruben *et al*. 2001). In fact, the Nova Scotia population had higher variation than some populations from within the species' main range (tested samples include: Massachusetts, Wisconsin, Minnesota, Illinois, Michigan and Ontario). The process of maintaining genetic variation in this small population is not yet clear but may be related to metapopulation dynamics. The Nova Scotia population has significantly diverged genetically from populations in the main range (Mockford *et al.* 1999; Ruben *et al*. 2001; Mockford unpublished data) and is therefore likely an important evolutionary unit of the species. Work is underway examining mitochondrial sequence variation; this work will be combined with work already completed using Random Amplified Polymorphic DNA (RAPD) (Mockford *et al.* 1999; Ruben *et al*. 2001) and microsatellite markers (Mockford unpublished data) to assess the significance of this population as an evolutionary unit.

Population Structure

Population structure is dynamic, with both spatial and demographic components. Both components have a temporal element. For instance, while current spatial structure can be measured directly by accumulating geo-referenced records on individuals, the temporal components (in the absence of historical data) of that structure can only be inferred from the genetic composition of existing populations. Demographic structure can be measured at a point in time (static approach) or by tracking known-age individuals over time and recording their fate (cohort approach); both approaches produce age-specific estimates of mortality and survivorship. Recognizing and understanding both spatial and demographic population structure is essential in the development and implementation of a Blanding's Turtle Recovery Plan.

Spatial Structure

Our original perception of the Nova Scotia population was as a single panmictic (interbreeding) unit lacking spatial structure. Knowledge gained from telemetry and capture-mark-recapture assessments of movements and distribution (Power 1989; McMaster and Herman 2000; McNeil 2002), and from assessments of the historical database by the Recovery Team (unpublished), in concert with genetic assessment in Nova Scotia and across the species range (Mockford *et al*. 1999; Ruben *et al*. 2001), has challenged this view and fundamentally altered our understanding. We now see this as a metapopulation (a population of populations) rather than as a single panmictic unit, with at least three distinct populations.

Not only is the Nova Scotia metapopulation significantly genetically distinct from populations in the species' main range (see Nationally Significant Populations above); recognizable genetic spatial structure also exists within the Nova Scotia population. This further enhances its importance as an evolutionary unit within the species (Ruben *et al*. 2001).

Radio telemetry and capture-mark-recapture studies carried out since the discovery of the McGowan Lake population in 1996 show there to be little, if any, current movement between these populations (McNeil and Herman, unpublished data). Recent genetic work using microsatellites shows that there is substructuring within the Nova Scotia metapopulation between these two populations (Fst = 0.0416 p = 0.00190 +/- 0.0004; Mockford unpublished data). The cause of the restriction of gene flow between these groups is not known, but watersheds are believed to play a role in determining population structure. While this genetic structure is significant, it reflects sufficient gene flow to indicate metapopulation structure.

Recently, a third population of Blanding's turtles was identified near Pleasant River, also within the Medway River watershed. Through radio telemetry and capture-mark-recapture studies are underway at this site, data at present are insufficient to estimate the size of this population. Analysis is currently underway to determine the genetic relationship between this and the two previously known populations.

Populations at McGowan Lake and KNP are genetically distinguishable. These populations also exhibit significant biological differences in behaviour and fecundity. In particular, we have noted distinct differences in nesting patterns between these two populations, which probably reflect local adaptation to differences in substrate and lake level regime (McNeil and Herman in progress).

The degree of genetic heterogeneity within the Nova Scotia metapopulation remains uncertain. In fact, there may be structure among concentrations within populations as well as between populations. Identification of the critical landscape elements that influence population structure is a key research priority in the recovery effort.

Demographic Structure

Analysis of the Nova Scotia population's age structure suggests that, as in other populations, these turtles exhibit delayed sexual maturation and are long-lived. Sexual maturation occurs later in Nova Scotia than in other regions, with individuals maturing in their late teens or early 20's. Regional environmental constraints (*e.g.*, cooler incubation season, nest flooding) and high rates of nest and juvenile predation appear to be hindering clutch success and recruitment into the breeding population in Nova Scotia.

Age structure in Nova Scotia appears to vary among populations. Table 2 provides definitions of terminology used to describe age structure in Nova Scotia Blanding's turtles. In KNP the apparent age structure is biased towards older individuals: 31 of 48 individuals examined in 1989 were greater than 30 years old (Herman *et al*. 1995). Recent work in KNP suggests that juveniles were underrepresented in earlier samples (McMaster 1996; Morrison in progress). A total of 65 juveniles have been encountered in KNP since 1994. Many of these are young juveniles (33 of 46 encountered in 2001 were under 10 years old). Some of the additional juveniles recently encountered may represent enhanced recruitment resulting from the nest protection program in the Park. Fifteen young juveniles encountered in 2001 had notches that indicated that they were from protected nests. Four juveniles that were headstarted in the early 1990's (Morrison 1996) were also encountered in 2001.

Although the number of known juveniles in KNP has greatly increased, age structure still remains a concern. There are still relatively few older juveniles (13 encountered in 2001 all of which had been previously marked) and young adults (under age 30). Only three young female recruits were identified during intensive nesting surveys between 1994 and 2002 (Standing 1997; KNP Database 2002). At least 10 of the 34 current known nesting females (encountered since 1999) were adults by 1972 and are a minimum of 50 years old.

At McGowan Lake, 21% of the marked turtles (13 of 60) are juveniles. Of these, only three are young juveniles (under 10); ongoing work is attempting to locate additional young juveniles. Four young adult males and one young adult female have been identified. The annuli on the remaining adults have worn smooth, indicating that most are likely over 30 years old.

Intensive work at Pleasant River began in 2002; based on early evidence, there appears to be an usually high proportion of young turtles in this population (Caverhill in progress). Of the 29 turtles marked, ten were juveniles and seven were young adults. Again, there is a lack of young juveniles in the sample; none of the turtles encountered in 2002 were under 10 years old.

Although our understanding of age structure in Nova Scotia has increased in recent years, ongoing monitoring is necessary to determine recruitment rates, age at maturity, reproductive lifespan and the effect of conservation practices. Understanding demographic processes in this species is hampered by its extreme longevity and long generation time. Significant lags in response time to environmental change could result in unstable age distributions, which at times may even appear chaotic.

Increasing rates of environmental change as well as variations in the scale of disturbance on the landscape may profoundly influence both spatial and demographic structure. Tracking the influence of these elements is essential.

Table 2. Age categories for Nova Scotia Blanding's turtles: working definitions

Age Category	Definition
Hatchling	A young turtle from the time it hatches from the egg (prior to emergence from the nest) until the onset of overwintering the following year (approx 0 to 14 months of age)
Headstarted Hatchling	A hatchling that was collected prior to or following emergence from the nest and kept in captivity during its first winter. Most headstarted hatchlings are fed during the winter and released in the following spring/summer when they are considerably larger than their wild counterparts.
Juvenile ***- young*** ***- old***	A sexually immature turtle. Turtles are considered to be juveniles if they are still growing (indicated by a white midline on plastron), are not known to have reproduced (no nesting/gravid data) and show no external sexual characteristics (penis, concave plastron, etc...). Juveniles are subdivided into two categories: *young* juveniles (under age 10) and *old* juveniles (age 10 to sexual maturity) due to apparent behavioural differences. Young juveniles are more easily sighted visually and old juveniles are more easily trapped (McMaster and Herman 2000). Ongoing work is attempting to further resolve the differences in behaviour, movement patterns and habitat use throughout the juvenile life stage.
Adult	A sexually mature turtle. Turtles are considered to be adults if a) there is evidence of reproduction or external sexual characteristics (gravid, penis) and/or b) there is no evidence of new growth (no white midline, growth annuli worn, typical adult size). It is believed that sexual maturity occurs between 17 and 24 in most Nova Scotia Blanding's turtles.
Young Adult	A sexually mature turtle under age 30 is considered to be a young adult.

Population Sizes and Trends

Population estimates exist for two of the three recognized populations within the Nova Scotia metapopulation. Based on a comparison of census data from three discrete marking intervals between 1969 and 1988, the estimated adult population within KNP is 132 (95% CI 99.4 - 178.9; Herman *et al.*, 1995). An apparent decline in population size in the known population has been attributed to habitat alteration by dam construction (1937), collection for museum specimens (1950's-1960's) prior to park establishment, and road construction and human activity subsequent to park establishment (1968) (KNP, unpublished records). Since 1969 there have been 125 adult turtles marked at KNP (Table 3); while it is not known how many of these turtles have died since being marked, 33 of the 58 females marked over that 33 year period have been encountered at least once since 1999. Despite intensive nesting surveys between 1994 and 2002, only four previously unidentified adult females were observed nesting in KNP, three of which were likely young recruits. While we feel that there are few unmarked adult females in the KNP population (due to intensive nest monitoring over the past 15 years), data on males are less complete. The population estimate for KNP is outdated, and due for re-estimation in 2003 (following a thorough review and error-check of the historical database, in progress).

Based on capture-mark-recapture data from 1996 to 2001 the population at McGowan Lake is estimated to be 79 adults (95% CI: 59.9-116.5; McNeil 2002). During the period 1996 - 2002 61 individuals have been marked at McGowan Lake (Table 3). There are insufficient data at this time to estimate the population size at Pleasant River but 29 individuals were marked between 1997 and 2002; 19 of these were newly marked during intensive efforts in 2002 (Caverhill in progress).

Table 3. The number of Blanding's turtles marked in each area as of October 31, 2002.

	Marking Interval	Male	Female	Juvenile	Sex Unknown	Total
Kejimkujik National Park (KNP)	1969-2002	67	58	72	2	199
McGowan Lake	1996-2002	23	25	13	-	61
Pleasant River	1997-2002	8	11	10	-	29

Reproduction

In Nova Scotia, Blanding's turtles mate in early spring and from July to November (Power 1989, McNeil 2002). Mating activity appears to peak in fall when turtles are aggregated in overwintering areas (McNeil 2002 and Power 1989).

Nesting normally occurs from mid-June to early July, slightly later than in other populations of Blanding's turtles. Onset varies annually, and appears to depend on cumulative heat in May and early June. As in other populations, only one clutch is produced per year. Turtles nest in a variety of substrates with open southern exposure. In KNP most nesting occurs on lakeshore cobble beaches; in contrast, at McGowan most nesting occurs on slate outcrops, many of which are located well inland. In both populations, some turtles nest on anthropogenic sites including roadsides, gravel roads and gravel quarries. Females show high fidelity to nest sites (Standing *et al.*, 2000a; McNeil, 2002).

Clutch size varies among individuals and populations. Mean clutch size in the KNP population (1987-1997) was 10.6 eggs (range 4-16 eggs) (Standing *et al.* 2000a). In contrast, mean clutch size at McGowan Lake (2000-2002) was smaller (7.8 eggs, range 5-10). In KNP, nesting frequency appears to be low, with only 26-33% of females nesting in a given year (Standing *et al.* 2000a). Initial results from the three years of nest monitoring at McGowan suggest that nesting frequency may be higher than reported by Standing *et al.* (1997). In 2001, 81% of the marked females in the main bog were captured and confirmed to be gravid. Of the 9 females observed in all three years, all nested each year except one; this turtle nested in two out of three years.

Hatchlings generally emerge from the nest in early fall. Over 11 seasons (1987-1997), incubation time (number of days from nest laying until emergence of first hatchling) in individual nests in KNP ranged from 80 to 128 days. Emergence in single nests can be highly asynchronous, often lasting more than a week.

Both egg failure within successful nests and total nest failure can be high. Overall egg failure from observed nests within KNP from 1987 to 1997 was 58% (Standing *et al.* 2000a). Failures were attributed to predation, flooding, low incubation temperatures and unknown factors (Standing *et al.* 2000a).

Although hatching success from protected nests is known, the subsequent overwinter survival of these hatchlings is not, and limited data on early post emergence suggest that predation can be high in the first few days (Smith in progress, Standing 1997). All hatchlings from protected nests are given a notch on their marginal scutes that identifies them to nest and year of emergence, enabling us to monitor their survival.

Limiting Factors

Energy

Restricted heat units at the northern limit of the species range conspire with oligotrophic (low productivity) conditions in the region to significantly constrain energy availability in this metapopulation. Sufficient heat units are required for completion of embryonic development, hatching and emergence before onset of winter. Poor hatchling success, high rates of developmental abnormalities and lethargy in hatchlings are apparent in some years (Standing *et al.* 2000 a,c). If hatchlings survive over winter, they begin to feed the following spring; but oligotrophic conditions may limit population density and, in conjunction with low temperatures, inhibit individual growth rates. As a result, maturation is substantially delayed; in fact, this metapopulation has the highest age of maturity ever recorded in the species. Individual longevity is also extended in this species.

Predation

Predation risks are greatest in early life, a pattern typical of most turtles (see Section II: Threats). Once turtles in this metapopulation grow beyond the approximate gape size of raccoons, their risk of mortality probably declines substantially. However slow individual growth delays the age at which this size is attained.

Life History

Long lived species with substantially delayed maturation are especially vulnerable to increases in adult mortality. Even slight increases in adult mortality, by reducing lifetime reproductive output, can drive populations to local extinction (Compton 1999, Congdon *et al.* 1993, Heppel 1998). In the Nova Scotia metapopulation, collection for museum specimens (in past) and from public curiosity (present and past) and vehicular related mortality have likely contributed to mortality.

Threats

Inherent Threats

Blanding's turtles in Nova Scotia are inherently constrained by geography, demography and behaviour. Geographically, as a small, isolated peripheral population complex, these turtles are vulnerable to stochastic (chance) processes. Local disturbances such as unusually high predation, extreme weather and disease, which would have little or no effect on a large population, can be devastating. This complex is also theoretically vulnerable to genetic drift and bottlenecks, which reduce genetic variability. Since Nova Scotia is near the northern limit of the species range, these turtles are probably constrained physiologically. Potential nest sites, with sufficient thermal gain to incubate nests, may be limiting. Cold temperatures during nest incubation can reduce hatching success and hatchling vigour, and extend incubation time. This in turn increases vulnerability of lakeshore nests to flooding during fall. Demographically, longevity and late age at maturity in this species make populations vulnerable to even small increases in adult mortality (Congdon *et al.* 1983; Congdon *et al.* 1993). Behaviourally, strong site affinities and the tendency for adults to aggregate throughout much of the year place them potentially at risk from stochastic mortality forces. Aggregated nesting behaviour exposes eggs and hatchlings to increased risk from opportunistic predators, particularly raccoons. These constraints often interact; for instance, physiological constraints reducing juvenile growth rate can increase age at maturity, which in turn exacerbates the vulnerability of this metapopulation to increases in adult mortality.

Human Activities

Human activities compound the inherent threats in a variety of ways. Direct threats to the immediate survival of individuals include vehicles, collection, disturbance and increased predation.

Vehicles, both on road and off road, pose a threat as human activities increase and habitats become increasingly fragmented. Females are particularly vulnerable to road mortality during nesting movements; some even nest directly on road sides or in gravel road beds. Hatchlings emerging from roadside nests are also at risk. Disturbance of nests by off road vehicles throughout the incubation season is a particular threat in working landscapes, such as McGowan Lake and Pleasant River, where both inland nesting and off-roading are common.

Blanding's turtle are occasionally collected as curiosities, particularly by well meaning but misinformed children. This can lead to inadvertent transplanting of turtles between populations or effective elimination of an individual from the gene pool through isolation. Presently, professional collectors are not considered to be a threat in southwestern Nova Scotia, but indiscriminate distribution of site maps could encourage poaching. Disturbances of hatchlings and nesting adults by humans or dogs, trampling of nest sites or disturbing turtles and their habitat can also have a negative impact.

Invasive species such as smallmouth bass, which have recently established in the Mersey River, may prey on hatchling turtles. Elevated raccoon populations can substantially increase predation on eggs and hatchlings. However, these predator populations occasionally experience disease-driven declines, which might lessen the long-term impact on turtle populations.

Fragmentation from forestry, agriculture and cottage development disrupts metapopulation structure by reducing the amount of habitat and impeding movements within and between populations. Development of commercial cranberry bogs or harvesting of peat can directly eliminate or degrade critical aquatic habitats for juveniles and adults. The long-term impacts of agricultural pesticides on this long-lived species are unknown.

Alteration of hydrology by human activity may pose the greatest threat. Blanding's turtles require seasonally predictable water levels at nesting, over-wintering and drought refuge sites. Hydropower generation in this region tends to accentuate variability and unpredictability in water level. Lake draw-downs in mid and late summer reduce or eliminate drought refuges and create large uninhabitable expanses. Lake draw-downs in winter can increase mortality by exposing wintering turtles. Retention of water during wet summers can flood shoreline nests. In contrast, impoundments controlled by beavers reduce variability and increase predictability in water level. Removal or control of beaver activity by cottage owners, farmers, foresters and highway maintenance crews potentially threatens all life history stages of the turtle. Human activities that deliberately or inadvertently increase run-off or reduce retention of water (*e.g.,* forestry, agriculture, highway maintenance) also degrade habitat for turtles.

In the longer term, Blanding's turtles in Nova Scotia face an uncertain climatic future. One would expect a species at the northern limit of its range to benefit from a warming event but present models for this region suggest that warming is not inevitable. Even under a general warming scenario, an overall temperature increase does not necessarily translate to an increase in nest temperature. Seasonal shifts in weather patterns could actually result in cooler, cloudier summers which could retard development and hatchling emergence and increase risk of nest flooding. Additionally, warmer winter temperature reduces ice scour that normally removes vegetation from nesting beaches. In the absence of scour this vegetation quickly overgrows beaches, possibly interfering with nest digging and reducing nest temperature by shading. Although the predictions of climate models (particularly for local seasonal conditions) vary tremendously, nearly all predict increasing frequency of extreme events. These two factors, extremes and uncertainty, pose the greatest risk.

Landownership and Threat

Landownership influence both the nature of the threats and the degree of control over human activity. The greatest challenge arises from addressing the diverse array of threats on small private landholdings, including alteration of hydrology, and disturbance and alteration of nesting habitat. Although control in protected areas (KNP) is more easily achieved, threats are still apparent. In protected areas, turtles are at risk of disturbance, trampling, mortality by vehicle and boat, particularly in areas of high visitor use. Habitat modification for visitor use (campground, beaches) and simple proximity of Blanding's turtle habitat to visitor areas has historically degraded or eliminated some Blanding's turtle habitat as well as influence predator dynamics.

Protection

In the United States, Blanding's turtle is listed as State Endangered in Maine, Indiana, Missouri, and South Dakota. It is listed as State Threatened in Massachusetts, New York, Wisconsin, Illinois, and Iowa. Blanding's turtle is a Species of Special Concern in Michigan and a Candidate Species in Pennsylvania. The species has no official conservation status in Ohio or New Hampshire.

In Canada, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) listed the Nova Scotia population of Blanding's turtle as Threatened in 1993. In 2000, Blanding's turtle in Nova Scotia was listed as Endangered under the Nova Scotia Endangered Species Act. Blanding's turtle is protected in all national parks where it occurs. The species has no official conservation status in either Ontario or Quebec. See Appendix 2 for summary of protection and status across North America.

Habitat Requirements

Habitat is key to the recovery of Blanding's turtles in Nova Scotia, and understanding the relationship between turtles and their habitat is one primary objective of this plan. We must determine how habitat and its spatial distribution affect turtle distribution, abundance, behavior and productivity. We need to incorporate both habitat variation and variable response to habitat when constructing legal definitions of habitat under the federal Species at Risk Act (SARA) (critical habitat) and the provincial Nova Scotia Endangered Species Act (core habitat). Identifying the appropriate scale for managing habitat (*i.e.*, one that recognizes the ecological scales important to the turtles) is a major challenge.

The array of seasonal and age-related components of habitat use is displayed in Table 4. This is intended to serve as a template for defining those habitats that fall under federal and provincial jurisdiction.

Blanding's Turtle Habitat Use

Although the ancestral habitat of Blanding's turtle likely was prairie marsh, today populations occur both in prairie and forested regions. Macro-habitats include lakes, ponds, marshes, low fields, ditches, creeks, river sloughs, and bogs (Conant 1938; Langler 1943; Breckenridge 1944; Pope 1949; Carr 1952; Adams and Clark 1958; Preston and McCoy 1971; Ernst and Barbour 1972; Ernst 1973; Graham and Doyle 1979; Gilhen 1984; Kofron and Schreiber 1985; Power 1989; Ross 1989; Ross and Anderson 1990; Power *et al.* 1994). Within these macro-habitats, Blanding's turtles tend to frequent shallow water containing submergent or emergent vegetation (Conant 1938; Pope 1949; Carr 1952; Adams and Clark 1958; Ernst and Barbour 1972; Gilhen 1984; Kofron and Schreiber 1985; McMaster and Herman 2000), often with deep, organic sediments (Ernst and Barbour 1972; Graham and Doyle 1979; Ross 1989; Ross and Anderson 1990).

In Nova Scotia, the distribution of Blanding's turtle closely parallels that of highly coloured acid waters and peaty soils (Power *et al.* 1994) and living sphagnum mats (McMaster and Herman 2000). Extensive beaver activity is also apparent at most known Blanding's turtle sites in Nova Scotia.

Habitat use varies throughout the year (Table 4). Turtles tend to show high fidelity to specific areas, particularly nesting and overwintering sites. Concentrations of activity have been noted in all populations. In KNP, three concentrations are apparent, each associated with darkly coloured brooks (Power *et al.* 1994). This pattern presumably reflects increased secondary productivity, and therefore food availability for turtles, in these waters. To date, two concentrations have been identified at McGowan Lake; the greater occurs in a beaver-maintained wetland complex and the lesser on a small inflow stream. Three concentrations have been identified to date near Pleasant River, each in small forested and open streams and adjacent beaver-maintained wetlands. In all three populations, movements between these concentrations appear to be infrequent.

Habitat attributes associated with individuals' behaviors vary among the three populations (Table 4). This may reflect differences in local adaptation or differences in local habitat availability. For instance, turtles at McGowan Lake appear to be more densely concentrated and to move less during the summer than those at KNP (McNeil 2002). Understanding how habitat heterogeneity ultimately affects distribution, abundance and behavior is key in the Nova Scotia metapopulation**.**

Habitat Trends

Since European colonization, the two principal changes in habitat have been increased fragmentation of forests and alteration of water flow regimes. Both, particularly the latter, have probably had profound effects on turtles, although these effects were undocumented. Water flow regimes were first altered by intensive trapping of beavers for the fur trade and later by construction of impoundments and diversions of waterways, for power generation or for fish, waterfowl, or recreational habitat management. Changes in water flow may impede seasonal movements and affect the turtles' ability to nest, feed, and access overwintering sites. In 1996 the Grafton Lake dam in KNP was removed, in part to restore Blanding's turtle habitat and traditional movement corridors (Drysdale 1992). The expanded inflow streams and lake shallows resulting from the dam removal are already showing encouraging signs of habitat recovery.

Road and trail construction, beach modification and associated human activity have altered turtle behaviour and habitat availability. One known nesting beach (Merrymakedge) within KNP was eliminated by reducing substrate size for recreation. Road construction in both protected and working landscapes has created new nesting habitat (shoulders and borrow pits) and travel corridors, while at the same time increasing mortality risks to all age classes.

Habitat Protection

Landownership in this metapopulation is diverse and includes private individuals, resource-based industry and provincial and federal government agencies. While most of the KNP population is located within the boundaries of a National Park, the McGowan Lake population occurs on lands owned by Nova Scotia Power, Bowater Mersey Paper Company Limited, a variety of individual private landowners, and the provincial Crown. The Pleasant River population occurs primarily on an array of privately owned lands. Ongoing public education and communication with landowners is essential to develop a strong ethic of local stewardship and ensure long-term habitat protection.

Blanding's Turtle Critical Habitat

SARA will require that the critical habitat of endangered, threatened, and extirpated species be identified in recovery strategies and action plans, and will include provisions to protect such habitat. Critical habitat is defined as habitat necessary for the survival or recovery of a species.

This Recovery Plan does not explicitly define critical habitat for Blanding's turtle in Nova Scotia, as the definition and criteria for defining critical habitat are still in development, and since research on Blanding's turtle habitat is still in progress.

Table 4. Seasonal and age-related habitat use by the Nova Scotia population of Blanding's turtles.

Seasonal Activity	Site Description	Seasonal Timing	Primary Activities	Known Habitats		
				KNP	McGowan	Pleasant River
OVERWINTERING						
Adults and Juveniles	Includes the specific sites where turtles spend the winter as well as surrounding areas frequented immediately prior to and after wintering. Sites may be lotic or lentic, and turtles may remain on the bottom, in bank undercuts, or suspended in the water column. Turtles often densely aggregate at these sites and individuals typically, return to the same sites each year. Some limited movement occurs throughout the winter.	Mid fall to early spring	- mating - winter dormancy	- lake inflow streams - seasonal floodplain ponds	- permanent bog basins - seasonal floodplain ponds	- streams - permanent bog basins
Hatchlings	Overwinting sites for hatchlings (first winter) are not known; limited evidence suggests some may overwinter on land.			- unknown	- unknown	- unknown
NESTING						
Nesting areas	Areas where females excavate their nests. Includes both specific nesting sites and surrounding areas that are used as refuges by females and hatchlings (*e.g.,* rehydration ponds). Females may nest densely in one area; individuals show high fidelity to specific nesting areas.	June	- nesting - emergence	<u>Lakeshore</u> (most) - cobble beaches <u>Inland</u> - roadsides - borrow pits	<u>Lakeshore</u> slate outcrops <u>Inland</u> (most) - slate outcrops - borrow pits - gravel roads	- still largely unknown <u>Inland</u> (likely) - railbeds - gravel roads - slate outcrops
Pre-nesting centers	Areas adjacent to nesting sites where gravid females aggregate prior to nesting. These sites are particularly evident in KNP and are associated with basking.	May-June	- basking - feeding	- shallow, vegetated lakeshore coves - roadside bog	- shallow, vegetated lakeshore coves - beaver maintained bog	- unknown
BASKING						
	Specific sites (occurring within other habitats) that turtles consistently use for basking. Sites can be located near overwintering areas, in pre-	Primarily spring (also seen	- basking	<u>Terrestrial</u> - logs, rocks, banks	<u>Terrestrial</u> - logs, banks - vegetation	<u>Terrestrial</u> - vegetation clumps

Seasonal Activity	Site Description	Seasonal Timing	Primary Activities	Known Habitats		
				KNP	McGowan	Pleasant River
	nesting areas and in summer habitat. These sites are important for accumulation of heat, particularly for gravid females.	in summer at Pleasant River)		- vegetation clumps Aquatic - sphagnum mats	clumps Aquatic - shallow vegetated pools	- banks, logs Aquatic - shallow pools - sphagnum mats
SUMMERING						
	Areas used by adults and juveniles during summer. Although adult and juvenile habitats overlap, microhabitats and seasonal use patterns sometimes differ. Juveniles in KNP are highly associated with sphagnum mats and overhanging shrubs. For all populations, beaver activity is present at most summer habitats and may provide important drought refuges.	May-Aug	- feeding - mating - basking	- shallow vegetated lakeshore coves - vegetated streams and rivers	- beaver maintained bog - lakeshore coves and streams (when seasonally available)	- streams and associated wet meadows - bogs
TRAVEL ROUTES						
Overwintering	Turtles may move extensively between summer and winter areas, or between winter sites. Most travel is aquatic but some is terrestrial. Aquatic travel can often be gradual, lasting more than a month.	Early fall, early –mid Spring	- travel - basking - mating	- streams - rivers	- streams - seasonal floodplains	- streams - seasonal floodplains
Nesting	Females often travel extensively, by either aquatic or terrestrial routes, to nesting sites.	June	- travel	- downstream, along lakeshores - woodland, roadsides	- woodland - gravel roads - across lakes and along lakeshores	- unknown
Mating	Males may move considerable distances, both overland and in water to find females.	July-Nov, early Spring	- travel - mating	- streams, lakeshore and woodland	- within bog	- unknown

Seasonal Activity	**Site Description**	**Seasonal Timing**	**Primary Activities**	**Known Habitats**		
				KNP	**McGowan**	**Pleasant River**
Hatchling	Beyond the first few days post-emergence, routes of hatchlings are not well known although radio tracking of headstarted hatchlings in KNP identified extensive overland travel in some individuals. Routes for hatchlings from nests distant from summer habitat could be particularly important.		- travel	- unknown	- unknown	- unknown
Juvenile	Although juveniles and adult travel routes may overlap, juvenile-specific also occurs. Juveniles occasionally shift activity centers within summering areas. Terrestrial travel has been documented (particularly along roadsides) but its extent is unknown.		- travel	- streams - roadside	- within bogs - seasonal floodplains	- streams
Between concentration/ populations	Movement between activity centers has been documented within KNP. This activity, though infrequent, is important to maintain genetic and metapopulation structure.		- travel			

Ecological Role

The ecological role of the species in Nova Scotia has probably changed since European settlement, due to land use changes, particularly those influencing surficial hydrology. The low density of Blanding's turtles in Nova Scotia probably reflects the nutrient-poor conditions of their habitat. Fresh waters throughout interior southwest Nova Scotia are generally unproductive; Blanding's turtles are tightly linked with highly coloured waters (Power *et al.* 1994), which tend to be the most productive in this region. The contribution of the species to the total energy flux in the Mersey River and Medway River systems is unknown. Blanding's turtle is primarily an aquatic predator that feeds at several levels of the food chain. Food items include insect larvae and nymphs, especially Odonata, freshwater snails, leeches (*Hirudinea*), and small fish (*e.g.*, threespine stickleback (*Gasterosteus aculeatus*); ninespine stickleback *(Pungitius pungitius)*; white perch (*Morone Americana)*; and yellow perch (*Perca flavescens*) and tadpoles (*Rana* spp.). They also consume fresh seed heads of cow lily (*Nuphar variegatum).*

Crayfish, an important food item through most of the species' range, do not occur in Nova Scotia. Although small fish make up less than 25% of the food intake of Blanding's turtle elsewhere (Ernst and Barbour 1972), anadromous fish (particularly eggs, larvae and juvenile stages) in Nova Scotia may have originally served as an important food source. Unfortunately, these fish, including gaspereau (*Alosa pseudoharengus*), rainbow smelt (*Osmerus mordax*), Atlantic salmon (*Salmo salar*), and sea run brook char (*Salvelinus fontinalis*), have been unable to migrate through the upper Mersey and Medway rivers for more than 70 years due to the construction of hydroelectric dams; as a result, system productivity may have been reduced dramatically.

A variety of generalist predators including raccoon (*Procyon lotor)*, skunk (*Mephitis mephitis),* (Petokas 1986), raven (*Corvus corax)*, short-tailed shrew (*Blarina brevicauda)*, (Standing *et al.* 2000b), and ants (Weller 1971-1972) prey on the eggs and hatchlings. Although predation has been identified as a probable limiting factor for the Nova Scotia population of Blanding's turtle (Herman *et al.* 1995), it is unlikely that any predator species in turn depend heavily on Blanding's turtles.

Socio-economic Considerations

In many cultures, the turtle is a symbol of longevity and wisdom; turtles fascinate people throughout the world. In the Mi'kmaq culture the turtle was considered to be spiritually and physically important. The Mi'kmaqs shared the belief with other aboriginal peoples that the continent of North America represented a giant "Turtle Island". Turtle shell rattles were used in songs that related to mother earth.

However, most people are unaware that turtle populations may be experiencing a global decline of similar proportion to that of amphibians. This concern arose repeatedly at the Second International Conference on the Conservation of Turtles and Tortoises (New York, 1993). This global decline can be attributed to a number of causes including habitat degradation and loss, climate change, environmental pollution, disease, introduced invasive species and unsustainable use (Gibbons *et al.* 2000). Ironically, the last two causes grow directly out of our close relationship and fascination with turtles.

For the public of Nova Scotia, Blanding's turtles are synonymous with Kejimkujik National Park and National Historic Site. They are a symbol of species at risk programs in the province and serve as a flagship species for conservation of the province's southwestern relict, or disjunct fauna and flora.

Recovery Potential and Rationale

Ecological and Technical Feasibility of Species Recovery

Among North American freshwater turtles, Blanding's turtle has one of the most latitudinally compressed ranges. The species is intolerant of high temperatures, having one of the lowest critical thermal maxima of any semi-aquatic turtle (Hutchinson et al. 1966); this could explain why the species distribution does not extend very far south. Also, Blanding's turtle eggs incubated at temperatures below 22°C fail to hatch (Gutzke and Packard 1987). Such a high critical thermal minimum for incubation may limit the northern distribution of the species. In Nova Scotia, the population is restricted to an inland plateau characterised by higher summer temperatures than elsewhere in the province (Gates 1973). This population is thought to be a relict of a warmer climatic period (Bleakney 1958a).

The compressed species' range, in addition to the fragmented distribution of existing populations, suggests that the adaptability of the species is limited. Because of its limited physiological tolerance and long generation time (greater than 35 years), Blanding's turtle is limited in its ability to respond genetically to climatic change. Substantial changes in climate may occur within the lifetime of an individual turtle; adaptive responses to such changes would have to be behavioural rather than genetic (Herman and Scott 1992). Regional impacts of global warming are uncertain. Recent models suggest that although average global temperatures will likely increase, coastal temperatures in Atlantic Canada may actually decrease. If that occurs, particularly in summers, it could profoundly restrict the amount of available suitable nesting habitats and reduce nest survivorship even further.

Although turtles are not noted for their behavioural plasticity, Blanding's turtles may adapt to changes in the availability of nesting habitat. This includes the use of artificial nesting sites both in Nova Scotia (Bleakney 1963; Weller 1971-1972; Thexton and Mallet 1977-1979; Drysdale 1983; Power 1989; MacCormack and KNP, unpublished records) and elsewhere (Graham and Doyle 1979; Petokas 1986; Briesch and Eckler 1988; MacCulloch and Weller 1988; R. J. Brooks, pers. comm.). However, the use of such sites may expose adult female turtles to increased mortality (Ashley and Robinson 1996) and their nests to increased predation (Temple 1987). Within KNP, predation on nests, especially by raccoons may be elevated, particularly near the main campground (Morrison in progress).

There is limited evidence that the viability of nests constructed along road shoulders or other human-made habitats, is lower than in those in natural beach habitat (unpublished records, KNP). These nests may experience lethal thermal extremes, and higher rates of desiccation than beach nests (Standing 1997). These factors could reduce hatching success. Further, hatchlings may have difficulty emerging from roadside nest cavities because of the compact soil (Morrison and Standing, pers. obsv.). Having successfully emerged from roadside nests, hatchlings seeking overwintering sites may be exposed to elevated rates of predation (Temple 1987) and road mortality (Ashley and Robinson 1996). Orientation to hibernacula may be impaired (Standing *et al.* 1997) and suitable overwintering sites may not be available (Butler and Graham 1995; Standing *et al.* 1997; Standing 1997).

Anticipated Conflicts or Challenges

Conflicts and challenges exist in the development of any recovery plan for species at risk. Multi-stake holder processes, such as the development and implementation of a recovery plan, involve a range of potentially divergent views. Thus in the conservation and recovery of Blanding's turtle there exists the potential for conflicts. There are several concentrations of Blanding's turtle found on working landscapes outside the boundaries of Kejimkujik National Park and National Historic Site. As a result, public and industrial landowners must be engaged in the recovery process. Desired land uses that may negatively impact this nationally Threatened and provincially Endangered species may have to be evaluated and modified. Because the recovery planning and implementation process must involve the community, industry, and landowners to ensure its success; effective communication and collaboration is essential.

Recommended Approach / Scale for Recovery

Following the RENEW guidelines, a single species approach has been adopted for the recovery of the Nova Scotia population of Blanding's turtle, due to its distinct habitat requirements, life history, distribution, and threats. Although actions will be directed specifically towards the Blanding's turtle a broader ecosystem context underlies this plan.

Knowledge Gaps

Conservation and recovery actions have been underway for over twenty years, and a formal recovery programme has been in place since 1994. As a result, the information base for recovery actions has steadily grown to the point that it is adequate to accurately define recovery objectives, approaches, and actions. However, gaps in our knowledge still exist; further research and monitoring of the spatial and temporal dynamics of the turtle and its habitats, and the threats facing the species, are required to close these gaps. Detailed descriptions and an outline of the necessary actions are provided in Section IV, the Recovery Action Plan.

Section III: Recovery Strategy

In 1998, a Recovery Action Plan was written for the Nova Scotia population of Blanding's turtle; many of the actions recommended therein are already completed or underway (Table 5). The following Recovery Strategy builds on this original Recovery Action Plan and is intended to provide the Recovery Team with a strategic framework upon which to base specific actions. The strategy is broad in scope, providing a science-based overview of the goal, objectives, and approaches necessary for the recovery of Blanding's turtle in Nova Scotia. This Recovery Strategy is guided by, and continues to build on, the initiatives outlined in the 1998 Blanding's Turtle Recovery Action Plan. As with the actions, these strategic objectives and approach must be dynamic and adaptive in order to integrate new information and accommodate change.

Recovery Strategy Goal

The goal of this recovery plan is to maintain and, where appropriate, restore population size and structure of Blanding's turtle within Nova Scotia through the maintenance and restoration of habitats and ecological processes. Due to the extreme longevity (more than 70 years) and late maturation (20-25 years) of this species, both the process of recovery and its evaluation present major challenges.

Recovery Strategy Objectives

In order to achieve the strategic recovery goal we will strive to meet the following recovery objectives:

I. Maintain and restore Blanding's turtle *population sizes*,

II. Maintain and restore Blanding's turtle *habitat*,

III. Maintain *metapopulation structure*,

IV. Remove or reduce *threats* to Blanding's turtles and their habitats.

Strategic Recovery Approaches

Five interrelated, broad strategic approaches have been defined in order to provide an organizational framework (Figure 3) on which to develop and implement the Recovery Action Plan (Section IV). Each strategic recovery objective can be met using one or more of these approaches. The approaches should also help guide participants in the recovery process to determine their specific role in effecting recovery actions. All approaches are interrelated, integral and essential to the recovery process. A description of each approach, with a discussion of its relevance to the recovery of the Blanding's turtle, is provided below.

The strategic recovery approaches are to:

A. Improve the *information* upon which conservation and recovery initiatives are based,

B. *Manage* effectively and efficiently to further protection, conservation, and recovery,

C. Encourage and implement *stewardship*, enhanced by communication and education,

D. *Evaluate* regularly the Recovery Plan, and

E. Connect the *recovery process* to broader biodiversity and ecosystem conservation.

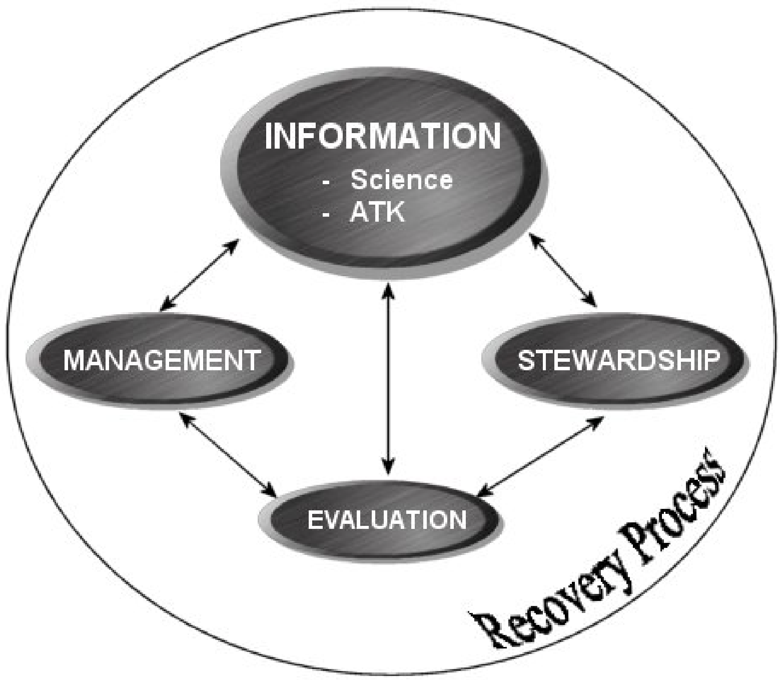


Figure 3. Model showing nesting of strategic recovery approaches within the recovery process.

A. Improve the *information* upon which conservation and recovery initiatives are based
All recovery actions must be based on sound information; within this plan *information* includes science-based knowledge as well as Aboriginal Traditional Knowledge (ATK), or Traditional Ecological Knowledge (TEK). Scientific information includes data gathered from research, including experiments, monitoring, surveys, and inventories. ATK incorporates cultural, spiritual and historical information that can contribute to conservation and recovery initiatives.

Information drives other strategic recovery approaches (including management and stewardship), forms the basis for conservation and recovery initiatives, and is therefore integral to any recovery strategy (Figure 3).

B. *Manage* effectively and efficiently in order to further protection, conservation, and recovery
As a strategic approach, *management* offers several tools to effect recovery. These include: planning, policies, programs, legislation, and protected areas. Management can occur at various spatial and organizational levels, *e.g.*, populations, specific sites, crown lands, public lands, and different levels of

government (municipal, provincial, and federal). It is key that species at risk and their habitats receive early attention and high priority during planning and decision-making.

It is important that managers act in a timely fashion, but it is essential that they base their actions on sound science and other information. Effective management should be adaptive; it therefore requires frequent evaluation. Without evaluation, actions may waste resources or actually result in negative impacts**.** Management must also be sensitive to the ecological scale of the organism(s) being managed, and adjust the management scale accordingly. Under circumstances where populations are discrete and fragmented between protected and working landscapes (as in the case of Blanding's turtle in Nova Scotia), the development of individual site-specific management plans might be most appropriate.

C. Encourage and implement *stewardship*, enhanced by communication and education

Stewardship is an important strategic approach that complements management in the recovery process by building local capacity for conservation. *Stewardship* encompasses an assortment of "less formal", often voluntary actions associated with the care and responsibility for species, habitat, landscapes, soil, water and air. It can include monitoring as well as active conservation of species and their habitats. Effective communication and education promote and sustain stewardship initiatives, helping to insure that species and their habitats are looked after in the long term.

Stewardship can be initiated by the public, non-government organizations, industry or governments. Effective stewardship, like management, requires good information; without it, valuable resources, time, and effort can be wasted.

D. *Evaluate* regularly the Recovery Plan

Evaluation of the recovery of the Blanding's turtle is challenging due to its longevity; as a result the impacts of some recovery actions will not be measurable for many years. None the less, evaluation and re-assessment of objectives, strategies, and actions (including knowledge acquisition, management and stewardship) are always necessary and useful. The effectiveness of recovery strategies will be evaluated by assessing measurable targets for recovery action items.

E. Develop the *recovery process* in order to contribute more broadly to biodiversity and ecosystem conservation

This plan strives to conserve and recover a single species located within a specific geographic location. However, the development and implementation of this plan is set within a broader ecosystem context, for example, recognizing that Blanding's turtle is one of a suite of species with disjunct ranges, which are at risk in this unique southern region of Canada.

Including this concept as a strategic approach demonstrates the commitment of the Recovery Plan to develop innovative, effective recovery actions that extend beyond this species and this specific area. Ultimately this plan will contribute more broadly to biodiversity and ecosystem conservation and ideally can serve as a model for the recovery process. Recovery of species at risk is continually evolving; it is important that this broader context be recognized, highlighted and incorporated into the recovery process.

Potential Management Impacts for Other Species/ Ecological Processes

Blanding's turtle serves as a model *umbrella species* for conserving wetland biodiversity and ecosystem processes. Its diverse seasonal and age-dependent movement patterns and habitat requirements, along with its extreme longevity and late maturation, require that large areas of wetland and adjacent upland habitats be protected for the long term. Conservation and recovery actions aimed at Blanding's turtle will yield positive impacts for other wetland species and ecological processes in this region. Further afield, lessons learned and approaches taken with this species recovery should ideally contribute to the recovery and well-being of other long-lived, late-maturing species. Finally, our own health and welfare, which are integrally connected to the sustainable use and protection of landscapes and associated biodiversity, stand to benefit.

Evaluation

Evaluation of the Recovery Plan and process is essential, and thus is included as one of the five approaches in the Recovery Strategy (Figure 3). The Blanding's Turtle Recovery Team meets at least twice a year, and will be responsible for evaluation of the Recovery Plan, including both the Strategy and the Action Plan. The Team is proactive, with most members intensely engaged in some capacity in the actual activities of recovery. A partial record of these is evident in the "Progress to Date" narratives of the step-down outline of actions in Section IV.

The Team's Project Planning Subcommittee meets frequently to assess science, stewardship and management needs, and to identify approaches for meeting those needs. It then brings a set of recommended priorities and approaches to the full Team for approval. The Team's Data Management Subcommittee insures that the information base, upon which recovery ultimately depends, is current, correct and accessible. Because of its structure and membership, the Team is well positioned to define measurable targets for recovery actions before they are implemented. This will provide a means for routine evaluation and assessment of recovery, on appropriate time scales. Adaptive management is part of this recovery strategy, and has been since the Team's inception a decade ago; new information guides our actions on a regular basis. By legislation, the Recovery Plan will be reassessed in its entirety after five years (2008).

However, the extremely long generation time, late maturation and ecological complexity of Blanding's turtle conspire to limit the utility of such short-term evaluation. In this case, political time and ecological time are highly mismatched. The requisite five-year interval barely represents a tenth of a single Blanding's turtle generation. Herein lies the challenge; effective recovery of the species requires both short and long term commitment (in "turtle time") to research, management, and monitoring activities, and ongoing evaluation with appropriate refinements to the Recovery Plan.

Actions Completed or Underway

Recovery and conservation of Blanding's turtle have been underway for many years; a number of actions outlined in the 1998 Recovery Plan are already completed or underway. The status of actions from the 1998 Plan, with cross reference to relevant actions in the current Plan is provided below (Table 5). These are further elaborated under the "Progress to Date" narratives of the step-down outline of actions in Section IV.

Table 5. The status of 1998 Recovery Plan Actions with a cross-reference to actions in the current plan. Actions listed as "completed/ongoing" include elements that have been completed and related elements for which work is still underway.

1998 Recovery Action Plan Nos.	Recovery Actions	Status of Action	Current Recovery Action Plan Nos.
1	**Determine habitat requirements and availability**		3
1.1	***Locate and describe***	Completed/ongoing	3.1.1, 3.2.2
1.1.1	Feeding and basking	Completed/ongoing	3.1.1 & 3.2.2
1.1.2	Courtship and Breeding	Completed/ongoing	3.1.1 & 3.2.2
1.1.3	Nesting centres	Completed/ongoing	3.1.1 & 3.2.2
1.1.4	Travel routes	Completed/ongoing	3.1.1 & 1.1.4
1.1.5	Hibernation	Completed/ongoing	3.1.1 & 3.2.2
1.2	***Describe age related movement and distribution***	Completed/ongoing	3.2.2
1.2.1	Immature turtles	Completed/ongoing	3.2.2
1.2.2	Neonates	Completed	3.2.2
1.2.3	Hibernation sites of juvenile and hatchlings	Ongoing	3.1.1 & 3.2.2
1.3	***Estimate range of population***	Underway	5.1
1.3.1	Predictive model	Not yet done	-
1.3.2	Public surveys and poster campaign	Completed/ongoing	5.1.1
1.3.3	Survey potential sites, confirm anecdotal sightings	Completed/ongoing	5.1.2
1.3.4	Prepare map of all captures to date	Underway	-
1.3.5	Describe habitat use in new areas	Underway	3.1.1
1.3.6	Habitat/turtle relationship	Underway	3.4
1.4	***Environmental parameters of nests***	Completed	3.1.2
1.4.1	Consult historical records	Completed/ongoing	-
1.4.2	Monitor nesting sites	Ongoing	3.1.3
1.4.3	Determine critical features of nesting centres	Completed/ongoing	3.1.2 & 3.4
1.4.4	Identify and monitor potential nesting sites	Underway	3.1.1 & 3.1.3
1.5	***Monitor habitat change***	Underway	3.1.3
2	**Implement habitat protection**		4
2.1	***Protect and manage nesting centres***	Underway	4

1998 Recovery Action Plan Nos.	Recovery Actions	Status of Action	Current Recovery Action Plan Nos.
2.1.1 2.1.2	Natural beaches Other nesting sites	Completed/ongoing Underway	4 4
2.2	***Establish artificial nesting habitat***	Not yet done	4.1.3
2.3	***Reduce nest predation***	Completed/ongoing	2.1.1
2.3.1 2.3.2	Protect nests with screens Manage predator population	Ongoing Ongoing	2.1.1 8.2
2.4	***Protect and manage feeding and basking areas***	Underway	4
2.4.1 2.4.2	Is basking habitat limiting? Limit development in critical habitat	Not yet done	- 4.1
2.5	***Protect and manage migration routes***	Underway	4
2.5.1 2.5.2	Terrestrial routes Aquatic routes		4 4
2.6	***Protect and manage habitat of immature turtles***	Underway	4
2.7	***Protect and manage breeding and overwintering habitat***	Underway	4
3	**Clarify understanding of life history**		1
3.1	***Determine age structure of population***	Completed/ongoing	1.4.2
3.1.1 3.1.2 3.1.3 3.1.4	Age determination Trapping for age cross-section of population Re-examine existing age impressions Monitor age structure	Completed Underway Not yet done Ongoing	1.1.1 & 1.4.2 1.1 - 1.1.2
3.2	***Determine adult and juvenile survivorship***	Ongoing	1.4.3
3.2.1 3.2.2 3.2.3	Calculate abundance in park Monitor adult turtles in park Determine effects of predation and other mortality	Not yet done Ongoing Ongoing	1.4.1 1.1.2 1 1.4.3.1 & 7.1
3.3	***Assess reproductive potential***	Completed/ongoing	1.4.5
3.3.1 3.3.2 3.3.3 3.3.4	Female fecundity, nest beach fidelity, and survival rates Clutch size, egg and hatchling survivorship Determine factors limiting turtle productivity Describe early life history	Completed/ongoing Completed/ongoing Underway Ongoing	1.4.5.1 1.4.5.2 3.4.1 1.4.3, 3.1.1, 3.2.2
4	**Stabilize population age structure**		2
4.1	***Protect nests against predation***	Ongoing	2.1.1
4.2	***"Headstart" turtles through captive breeding***	Completed/ongoing	2.1.2
5	**Population genetics**		5.2, 5.3
5.1	***Develop genetic markers***	Completed/ongoing	-

1998 Recovery Action Plan Nos.	Recovery Actions	Status of Action	Current Recovery Action Plan Nos.
6	**Data storage and access**		1.3 & 3.3
6.1	***Unified database***	Completed/ongoing	1.3.1
6.2	***Facilitate data access***	Completed/ongoing	1.3.2
6.3	***Provide Information and promote public relations***	Completed/ongoing	8.4

Section IV: Recovery Action Plan

The Recovery Action Plan coupled with the Recovery Strategy (Section III) form the new Blanding's Turtle Recovery Plan. These actions build on the 1998 recovery action plan and are developed to meeting the strategic recovery goal and objectives (Section III). Many of the actions outlined in the 1998 Blanding's Turtle Recovery Plan were completed. Actions from the 1998 plan that were not completed, are underway, or are ongoing (Table 5) are included in the step-down outline within this plan. Recovery actions are organized according to the current strategic recovery objectives (Section III).

Step-down Outline of Recovery Actions

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

1. **Conduct research and monitoring necessary for conservation and recovery**
    - ***1.1. Continue to systematically capture, mark and measure adults and juveniles in each population***
        - *1.1.1. Develop and evaluate monitoring protocols for Blanding's turtle*
            - 1.1.1.1. Implement and refine juvenile capture protocol *(1998 Action 3.1.2)*
            - 1.1.1.2. Refine adult capture protocol
            - 1.1.1.3. Standardize data collection, refine marking techniques and turtle handling procedures
        - *1.1.2. Conduct regular sampling of each population to monitor demographic structure (1998 Action 3.1.4 and 3.2.2)*
    - ***1.2. Continue and expand volunteer nest monitoring program*** *(1998 Action 1.4.2)*
    - ***1.3. Maintain, validate and keep current the Blanding's turtle database*** *(1998 Action 6)*
        - *1.3.1. Continue developing a secure, unified database for the Nova Scotia population (1998 Action 6.1)*
        - *1.3.2. Facilitate data access and use (1998 Action 6.2)*
    - ***1.4. Conduct analysis of long term data sets***
        - *1.4.1. Determine population estimates (1998 Action 3.2.1)*
            - 1.4.1.1. Develop estimation models that incorporate sampling biases and differences in turtle detectability
        - *1.4.2. Determine and analyze age structure of the populations (1998 Action 3.1 and 1998 Action 3.1.3)*
        - *1.4.3. Calculate adult and juvenile survivorship (1998 Action 3.2 and 3.3.4)*
            - 1.4.3.1. Determine the effects of threats on survivorship *(1998 Action 3.2.3)*
        - *1.4.4. Determine and compare juvenile growth rate and size at maturation among populations*
            - 1.4.4.1. Compare growth rates among all populations
            - 1.4.4.2. Determine the cause of differences in growth rates between population
            - 1.4.4.3. Examine the effects of slow growth rates on age at maturity, clutch size and generation time
            - 1.4.4.4. Examine the influence of environmental variability on annual growth
        - *1.4.5. Assess reproductive success (1998 Action 3.3)*
            - 1.4.5.1. Analyze and define female fecundity including clutch size, nesting frequency and nest site fidelity *(1998 Action 3.3.1.1)*
            - 1.4.5.2. Determine egg and hatchling survivorship *(1998 Action 3.3.2)*
            - 1.4.5.3. Analyze and define recruitment into adult breeding populations *(1998 Action 3.3.1.2)*

1.4.5.4. Measure relative reproductive success among individuals and sites
1.4.5.5. Assess the extent of multiple paternity

1.4.6. Conduct Population Viability Analysis(PVA) for each population
1.4.6.1. Perform comprehensive analysis of all existing demographic data (including estimation of detection probabilities for all age classes) to determine or confirm demographic parameters for use in PVA
1.4.6.2. Continue the ongoing assessment of population genetic structure
1.4.6.3. Determine extent of multiple paternity in clutches
1.4.6.4. Calculate effective population size (N_e) for each population
1.4.6.5. Continue fine scale habitat characterization for all age classes, in order to incorporate habitat parameters into PVA
1.4.6.6. Undertake comprehensive review of existing PVA models for relevant approaches to develop a spatially explicit PVA model for Blanding's turtle in Nova Scotia that incorporates genetics, habitat and demography

2. Implement management, stewardship, and education initiatives for maintaining and restoring population size

2.1. Continue and evaluate management actions that increase population size *(1998 Action 4)*
2.1.1. Continue and expand nest protection element of the volunteer nest monitoring program (1998 Action 4.1)
2.1.2. Headstart turtles by captive rearing of newly emerged hatchlings over their first winter (1998 Action 4.2)
2.1.2.1. Headstart hatchlings for Grafton Lake
2.1.2.2. Conduct a risk assessment of headstarted hatchlings

2.2. Continue to promote stewardship and implement education initiatives as a means to improve conservation and recovery of population size

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

3. Conduct research and monitoring necessary for conservation and recovery

3.1. Identify and characterize habitat for Blanding's turtle in each population *(1998 Action 1)*
3.1.1. Locate and describe seasonal habitats and use (1998 Action 1.1 and 3.3.4)
3.1.2. Physically characterize key habitats used in each population (1998 Action 1.4.3)
3.1.2.1. Develop and refine habitat sampling protocols
3.1.2.2. Develop methods to analyze aerial imagery
3.1.3. Monitor change in habitats and habitat use (1998 Action 1.5 and 1.4.2)

3.2. Assess Blanding's turtle movements at multiple spatial and temporal scales
3.2.1. Track both long-term and seasonal movement patterns of individuals
3.2.2. Describe age-related movements and distribution (1998 Action 1.2 and 3.3.4)
3.2.3. Track movements along travel routes (1998 Action 1.1.4)

3.3. Incorporate habitat and movement components into the database *(1998 Action 6)*

3.4. Assess the influence of habitat on movements and distribution
3.4.1. Determine the relationship between habitat and turtle productivity (1998 Action 3.3.2.1.1)
3.4.2. Determine how habitat heterogeneity influences movements and distribution

4. **Implement management, stewardship and education initiatives for protecting habitat** *(1998 Action 2)*
    4.1. ***Develop and implement a habitat protection plan*** *(1998 Action 2.4.2)*
        4.1.1. *Define and map critical and residence habitat, including areas not presently occupied*
        4.1.2. *Define and map core habitat and dwelling places*
        4.1.3. *Implement habitat restoration and enhancement where needed (1998 Action 2.2)*

    4.2. ***Evaluate the effectiveness of the habitat protection plan and address any gaps***

    4.3. ***Continue to promote stewardship and implement education initiatives as a means to improve conservation and recovery of habitat***

Objective 3: Maintain *metapopulation structure*

5. **Conduct research and monitoring necessary to further the understanding of metapopulation structure in Nova Scotia Blanding's turtles**
    5.1. ***Determine the range of the metapopulation*** *(1998 Action 1.3)*
        5.1.1. *Continue the use of public presentations and posters to identify potential sites*
        5.1.2. *Systematically survey sites with credible reports and confirm anecdotal sightings (1998 Action 1.3.3)*

    5.2. ***Assess the genetic relationship between new populations, as they are found, and populations at KNP, McGowan Lake and Pleasant River*** *(1998 Action 5)*

    5.3. ***Periodically assess known populations for change in genetic heterogeneity*** *(1998 Action 5)*

    5.4. ***Adapt and apply analytical tools to assess the influence of landscape on metapopulation structure***

    5.5. ***Assess the instability in demographic structure of each population in Nova Scotia***

6. **Implement management initiatives that maintain metapopulation structure**

    6.1. ***Develop an overall strategy for the conservation of the Nova Scotia metapopulation that incorporates the ecological scales of Blanding's turtles***

    6.2. ***Maintain processes that contribute to the current genetic sub-structuring***

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

7. **Conduct research and monitoring necessary to assess threats**
    7.1. ***Continue to identify and assess the relative importance of existing and anticipated threats*** *(1998 Action 3.2.3)*

    7.2. ***Monitor threats***
        7.2.1. *Monitor threats to nest success*
            7.2.1.1. Monitor nesting substrate condition on known nesting beaches, including influence of ice scour

7.2.1.2. Monitor fluctuations in lake levels and the flooding of nests

7.2.1.3. Monitor predator abundance and movements

7.2.1.4. Monitor the effects of seasonal temperature on nest timing and success

7.2.2. Monitor threats to adult and juvenile survivorship

7.2.2.1. Monitor and manage traffic activity during nesting and nest emergence where feasible

7.2.2.2. Monitor water level manipulations by remote sensing

7.2.2.3. Access existing databases on beaver control

7.2.3. Monitor threats to habitat

7.2.3.1. Monitor agricultural, forestry, and residential development disturbance trends

7.3. Analyze threats and develop contingency plans

7.3.1. Develop analytical tools for modeling threats and their impact

7.3.2. Continue to scrutinize the management actions in aid of Blanding's turtle recovery and the science underlying them

7.3.3. Develop strategies to address threats

8. Implement management, stewardship and education initiatives that remove or reduce threats

8.1. Continue to increase habitat protection

8.2. Implement threat management to deal with specific threats as they arise *(1998 Action 2.3.2)*

8.3. Continue to promote and develop stewardship

8.3.1. Enhance landowner contact

8.3.2. Continue collaboration with private and corporate landowners

8.3.2.1. Continue cooperation with Bowater Mersey Paper Company Limited

8.3.3. Formalize conservation agreements

8.3.4. Approach the aboriginal community to determine interest and role in Blanding's turtle conservation

8.4. Develop and implement a communications plan for the recovery and conservation of Blanding's turtle *(1998 Action 6.3)*

Narrative of Step-down Outline of Recovery Actions

This section contains a narrative for each of the actions included in the step-down outline above, again organized according to strategic recovery objectives. For each action the rationale is provided and the progress to date is summarized.

Objective 1. Maintain and restore Blanding's turtle *population sizes*

1. Conduct research and monitoring necessary for conservation and recovery

1.1 Continue to systematically capture, mark and measure adults and juveniles in each population

Rationale: Regular sampling of each population is essential to monitor the long-term demographic trends of Blanding's turtles in Nova Scotia.

Progress to Date: Turtles in KNP have been opportunistically marked since 1969. The first, and most intensive, systematic capture program was undertaken throughout the Park in 1987 and 1988 resulting in the capture of 60 turtles (Power 1989). Prior to 1994, only seven juvenile turtles had been located at KNP (McMaster and Herman 2000). Initial trapping efforts in 1994 yielded 5 juveniles (Morrison unpublished data). The first systematic survey focusing on juvenile turtles was carried out in 1995, resulting in the marking of 17 additional juveniles (McMaster 1996). In 2001 and 2002 systematic surveys of juveniles were carried out at the two largest known concentrations in the Park, to determine the best methods for capturing juveniles (Morrison and McNeil in progress). In 2002, the search for turtles in KNP was extended outside the areas of known concentrations, especially on Grafton Lake, where turtles were known to occur historically. Despite recent efforts, adults at known hotspots have not been systematically sampled for capture-mark-recapture analysis since 1988. Data on adult males are particularly lacking. Although many adult females are encountered nesting each year, additional adult females may be missed during nesting surveys.

Outside the Park, the McGowan Lake population has been intensively sampled each year since its discovery in 1996 (McNeil 2002). In 2002 an intensive study began at Pleasant River to capture and mark individuals in that area, resulting in the capture of 26 individuals (Caverhill in progress).

1.1.1 Develop and evaluate monitoring protocols for Blanding's turtle

1.1.1.1. Implement and refine juvenile capture protocol *(1998 Action 3.1.2)*
1.1.1.2. Refine adult capture protocol
1.1.1.3. Standardize data collection, refine marking techniques and turtle handling procedures

Rationale: Standardized protocols must be developed to effectively monitor demographic trends over the long term. Protocols should include capture method, data collection and turtle handling procedures. Understanding the efficiency of capture methodologies is important in both accurate interpretation of data and determining the most effective and cost-efficient long term monitoring strategy. Once the protocols are developed they should be reviewed and updated periodically as new data become available.

Progress to Date: Data cards (for field use) were developed in 2002 to standardize data collection, and lists of all known turtles, including any individual-specific characteristics (*e.g.*, developmental deformities, mutilations, scarring, etc.) were distributed to researchers to minimize identification errors; these will be refined for upcoming research. Standard capture procedures now include recording the ID, annually measuring all juveniles, photographing and scanning the plastrons of all turtles (once for adults, annually for juveniles) as well as recording data on turtle behavior, capture method, habitat parameters and precise location.

In 2001 and 2002 a study was undertaken to determine the most efficient sampling method for monitoring juveniles. Juveniles were captured at the known "hot-spots" at KNP and McGowan. Initial results suggest that younger juveniles are more easily detected visually and older juveniles are more easily trapped. Habitat may influence capture methodology; a higher percentage of juveniles were captured visually in KNP than at McGowan (Morrison and McNeil in progress). Data from this study are presently being analyzed and a capture protocol is under development for implementation in 2003. It is recommended that this protocol be implemented yearly for the first 5 years to allow refinement and be expanded in 2003 to include adults. Subsequently, data will be analyzed to determine the appropriate frequency of long-term monitoring.

1.1.2. Conduct regular sampling of each population to monitor demographic structure (1998 Action 3.1.4 and 3.2.2)

Rationale: Using the capture protocols that have been developed, regular sampling will be undertaken at each population. This sampling will provide long term, standardized data that are required for analysis of the population's structure, including population size, age structure, survivorship and growth. As well, initial effects of conservation actions can be monitored (*e.g.*, the fate of hatchlings that were head-started or released from protected nests).

1.2. Continue and expand volunteer nest monitoring program *(1998 Action 1.4.2)*

Rationale: The volunteer nest-monitoring program not only protects nests from predation (see Action 2.1.1) but also provides valuable data on nest success and hatchling emergence, clutch size, hatchling size and condition, female fecundity and nest site fidelity (Action 1.4.5). Efforts have been made to identify additional nest sites in 2002 on Grafton Lake, Little River, Frozen Ocean Lake, Mt. Tom Brook, Still Brook, Cannon Brook, Innis Brook, and West River as well as in areas adjacent to KNP.

Progress to Date: In KNP, scattered nesting observations dating back to 1969 occur in the Park's database (Drysdale 1983); however little was known about nesting until 1987 and 1988 when Power (1989) identified the major nesting centres in the Park. Intensive annual monitoring at these sites began in 1993. Each year since 1999, a volunteer-based nest monitoring program has effectively searched all known nest sites within the Park.

Nest sites at McGowan Lake were first located in 2000 and monitoring of these sites and the location of additional sites continued in 2001 and 2002. At Pleasant River, the nesting areas for two females were identified in 2002 and all other females encountered throughout the summer were outfitted with radio transmitters to allow them to be tracked in 2003. Once major nesting areas are identified outside the Park, monitoring of these sites will be done on a regular basis.

1.3. Maintain, validate, and keep current the Blanding's turtle database *(1998 Action 6)*

1.3.1. Continue developing a secure, unified database for the Nova Scotia population (1998 Action 6.1)

Rationale: It is essential to develop a single integrated database for this metapopulation that is housed in a long-lived institutional environment, with an off-site back-up system. With generation times approaching 40 years, these turtles outlive the professional lives of the humans monitoring them.

Progress to Date: Data in the Park have been collected since 1969 and include general observations, trapping data, radio tracking locations, imagery, nesting monitoring data, hatchling statistics, morphological measurements, predation studies and more. Detailed data have been collected outside the Park since 1996. Data arise from Park staff (Dobson 1970; Drysdale 1983; Morrison 1992; Morrison 1993; Morrison 1996; Thexton and Mallet 1977-79, Weller 1971-72), volunteer programs, reported sightings from the public, NS Museum, and university-based research, including B.Sc. Honours projects (Eaton 1989; McMaster 1996; McNeil 1996; Mockford 1996; Oickle 1997; Shallow 1998), M.Sc. projects (McNeil 2002; Power 1989; Smith in progress; Standing 1997;) and PhD projects (Mockford in progress).

In 2002, we began a major review of the general database, which contains capture information on all marked turtles. Missing data have been retrieved from archived field books and reports. Assessment of this database revealed several problems with misidentification of marked turtles, caused by natural nicks in marginal scutes, abraded radio holes from past studies and counting errors. The Recovery Team's Database Subcommittee met and discussed each identified discrepancy, resulting in over 50 changes to the database (primarily ID, sex or age-class changes). These changes affected the known sex ratio, number of nesting females and nesting frequency of individual females. Any changes made to the general database have repercussions in all related databases (*e.g.*, nesting and hatchling databases). Trial data cards have been created for the 2002 season and a list of all known ID's and their deformities has been made to minimize these problems in future.

1.3.2. Facilitate data access and use (1998 Action 6.2)
Rationale: The need for access to information by a diverse set of land users and jurisdictions continues to grow as our knowledge of this metapopulation and the threats that it faces increase.

Progress to Date: At present, access to the database is available through formal requests made to designated authorities at KNP. Once the database upgrades are completed, consolidating data from multiple studies will be much easier. Although the park responds to data requests, authority for this response ultimately resides with the Recovery Team, which must assess the sensitivity of data and determine appropriate restrictions on dissemination.

1.4. Conduct analysis of long term data sets

1.4.1. Determine population estimates (1998 Action 3.2.1)

1.4.1.1 Develop estimation models that incorporate sampling biases and differences in turtle detectability

Rationale: Population estimates should be routinely updated as new sampling data are collected.

Progress to Date: Initial population size estimates were calculated for turtles in KNP using data from 1969 to 1988; these resulted in an estimate of 132 adults (Herman *et al.* 1995). These estimates should be re-calculated with inclusion of recent data, as well as corrected archival data, to obtain accurate population estimates.

Based on capture-mark-recapture data from 1996 to 2001 the population at McGowan Lake is estimated to be 79 adults (95% CI: 59.9-116.5; McNeil 2002). There are insufficient data at this time to estimate the population size at Pleasant River but 29 individuals were marked between 1997 and 2002; 19 of these were newly marked during intensive efforts in 2002 (Caverhill in progress). Applying estimation techniques that incorporate sampling biases and differences in turtle detectability will provide more accurate estimates in all three populations.

1.4.2. Determine and analyze age structure of the populations (1998 Action 3.1 and 1998 Action 3.1.3)

Rationale: Understanding age structure is critical to predicting future population behaviour and determining appropriate management measures to counter de-stabilizing influences.

Progress to Date: Our current knowledge of age structure has increased recently, with age structure appearing to vary among the three known populations (see Section II Demographic Structure). Refining adult and juvenile monitoring protocols, along with adopting standardized approaches for counting growth annuli should more accurately portray age structure in the future. Repeated sampling of known age individuals has shown that counts of annuli accurately reflect age up to maturity. However, age of adults can only be inferred from long-term capture histories of those individuals, because most growth ceases at maturation, and older annuli become abraded

1.4.3. Calculate adult and juvenile survivorship (1998 Action 3.2 and 3.3.4)

1.4.3.1. Determine the effects of threats on survivorship *(1998 Action 3.2.3)*

Rationale: Understanding long term trends in survivorship is key in assessing a population's stability. Because Blanding's turtles are long-lived, with delayed maturation, they are especially vulnerable to increases in adult mortality (Congdon *et al.* 1993, Heppel 1998).

Progress to Date: Calculating survivorship ideally requires long-term capture data on individuals (cohort life tables). Static life tables can be constructed to predict survivorship in juveniles but beyond the age at maturation age estimates become unreliable. Turtles in KNP have been opportunistically marked since 1969 and many of the females that were marked in the early years are still encountered during nesting season each year. This suggests that adult survivorship may be extrodinarily high. The intensive surveys that were conducted in 1988 and 1989 will provide good baseline data for comparison with new surveys scheduled to start in 2003. Most marking outside the Park has occurred since 1996; therefore accurate assessment of long term survivorship in these populations is a long way off.

1.4.4. Determine and compare juvenile growth rate and size at maturation among populations

1.4.4.1. Compare growth rates between all populations

1.4.4.2. Determine the cause of differences in growth rate between populations

1.4.4.3. Examine the effect of slower growth rates on age at maturity, clutch size, and generation time

1.4.4.4. Examine the influence of environmental variability on annual growth

Rationale: Blanding's turtles appear to cease or greatly reduce growth shortly after sexual maturity. Measurements of individual adults in KNP do not appear to have increased appreciably in the last 30 years. Attainment of sexual maturity may be size related rather than age related (Congdon and van Loben Sels 1991). If so, environmental influences that reduce growth could retard maturation to the point where population structure becomes unstable (Congdon *et al.* 1993).

Progress to Date: Juveniles at McGowan grow more slowly (based on a static approach) and mature at a smaller body size than those at KNP (McNeil, 2002). These analyses need to be refined and expanded to include the Pleasant River population. Analyzing plastral scans and measurement of individuals over time will help to clarify trends in growth rate. Analysis of habitat characteristics (see Action 3.4.1) may resolve differences in productivity that influence growth rates. McMaster (1996) noted evidence of synchronous variations in annual growth rates across individuals, which she attributed to variation in annual temperatures.

1.4.5. Assess reproductive success (1998 Action 3.3)

1.4.5.1. Analyze and define female fecundity including clutch size, nesting frequency and nest site fidelity *(1998 Action 3.3.1.1)*
1.4.5.2. Determine egg and hatchling survivorship *(1998 Action 3.3.2)*
1.4.5.3. Analyze and define recruitment into adult breeding populations *(1998 Action 3.3.1.2)*
1.4.5.4. Measure relative reproductive success among individuals and sites
1.4.5.5. Assess extent of multiple paternity

Rationale: Understanding varibility in reproductive success (both within and among individuals) is critical in small populations living near the limits of their physiological tolerance.

Progress to Date: We have detailed data on fecundity, egg survival and hatchling emergence from known females in KNP since 1993, and from known females at McGowan since 2000 (see Section II. Background Information: Reproduction). Current estimates of nesting frequency for known individuals are probably conservative, since not all gravid females are encountered during nesting surveys. Implementation of regular demographic sampling of adults prior to nesting (see Action 1.1.2) should reduce this error.

Multiple paternity within single clutches has been reported elsewhere in Blanding's turtles, and is suspected but not yet confirmed in Nova Scotia. If widespread in this metapopulation, it could significantly increase estimates of N_e (effective population size, *i.e.*, the average number of individuals in a population that contribute genes to succeeding generations (King and Stansfield 1996)). We routinely collect and bank blood or tissue samples from all captured individuals, including hatchlings; these are available for subsequent analyses.

Relatively little is known about recruitment into the breeding population. In KNP, only three young female recruits have been observed nesting since 1987 (Standing 1997; Parks database). Outside the Park, particularly at Pleasant River, a higher proportion of young adults has been encountered. Reproductive success, nest site selection and age at maturity in these young recruits still remain largely unknown.

Survival of hatchlings once they leave the nest is not known. We have intensively tracked hatchlings immediately following emergence (Standing *et al.* 1997, McNeil *et al.* 2000, Smith in progress). Predation can be high in the first few days (Smith in progress, Standing 1997), but the fate of hatchlings over the first winter is largely unknown. All hatchlings from protected nests receive a nest-specific mark. We have begun to recapture some of these individuals, and may ultimately be able to detect differences in success among nesting females.

1.4.6. Conduct Population Viability Analyses (PVA) for each population

1.4.6.1. Perform comprehensive analysis of all existing demographic data (including estimation of detection probabilities for all age classes) to determine or confirm demographic parameters for use in PVA
1.4.6.2. Continue the ongoing assessment of population genetic structure
1.4.6.3. Determine extent of multiple paternity in clutches
1.4.6.4. Calculate effective population size (N_e) for each population
1.4.6.5. Continue fine scale habitat characterization for all age classes, in order to incorporate habitat parameters into PVA
1.4.6.6. Undertake comprehensive review of existing PVA models for relevant approaches to develop a spatially explicit PVA model for Blanding's turtle in Nova Scotia that incorporates genetics, habitat and demography

Rationale: Population viability analysis has become an important tool in conservation biology, and has undergone substantial evolution since its inception in the late 1970's (Beissinger and McCullough 2002). Although the utility of PVA in estimating absolute extinction risk or establishing realistic minimum numbers for survival is controversial, PVA is a useful tool to assess how changes in model parameters affect the relative risk of extinction, and as such should help to define ground rules for conservation strategies.

Existing PVA models, although numerous, may not be appropriate for Blanding's turtle in Nova Scotia. The extremely long generation time (greater than 35 years) constrains measurement of demographic parameters and their variance. Variances could require hundreds of years to measure adequately, and would be swamped by shorter-term environmental variance. In metapopulations of long lived species, genetics and habitat appear to be more important in modelling outcomes than demography alone. Development of habitat theory and incorporation of habitat parameters into PVA models is underway, and is crucial in populations where loss or alteration of habitat is a problem (Boyce 2002). Consequently any model developed must include genetics and habitat parameters as well as, to the extent possible, demography. Since there are apparently only few nodes in this metapopulation, with very slow turnover, we should also explore independent models for each population.

Progress to Date:
There is well developed theory showing the genetic consequences of small and fluctuating population size; these include an increased occurrence of inbreeding and an overall loss of genetic heterozygosity. Although genetic structure in most species is poorly understood, we have a growing understanding of the structure of Blanding's turtle in Nova Scotia which should allow us to incorporate genetics in the development of a PVA model.

The calculation of effective population size (N_e) is critical to the inclusion of genetics in PVA. Multiple paternity, known to occur in the species elsewhere (Osentoski 2002), will affect this parameter. However, the rate of multiple paternity in Nova Scotia is unknown. We have the majority of nesting females at KNP genotyped already; we should be able to analyse sufficient clutches of hatchlings to confirm the existence and determine the rate of multiple paternity in this population.

Although some parameters required for traditional demographic PVA's (*e.g.*, immigration, emigration, density dependent dispersal and variance in survival) are unlikely to be measured from field studies of this population, we do have substantial long term data (particularly in the KNP population). General observations recorded since 1968 and specific data (distribution, seasonal movement and nesting, including fecundity) collected since 1987, have allowed us to construct encounter histories of known, marked individuals over time; these in turn allow us to estimate fundamental population parameters and their temporal, spatial and individual variation. However, to assess the accuracy of these parameters requires estimation of the probability of detection for marked individuals and rigorous statistical analysis (available in recently developed software *e.g.*, MARK). Analysis of data on age-related variation in detectability is presently underway.

Understanding the spatial and temporal dynamics of critical habitat is key to developing a realistic PVA that links extinction risk to habitat and bridges the gap between theory and practice. Characterization of critical habitat, including response of turtles to habitat heterogeneity at multiple spatial scales, is underway in all three known populations (see 3.1.2).

2. Implement management, stewardship, and education initiatives for maintaining and restoring population sizes

2.1. Continue and evaluate management actions that increase population size *(1998 Action 4)*

Rationale: Current management actions that increase population size include protecting nests, nesting habitats, and headstarting hatchlings. It is essential to evalute the impact of these actions over time. Regular sampling of juveniles (Action 1.1) will help to determine survivorship, but recruitment (to the breeding population) of individuals from these actions will not be apparent for at least 20 years after release.

2.1.1. Continue and expand nest protection element of the volunteer nest monitoring program (1998 Action 4.1)

Rationale: Predation on unprotected nests can be high, in some years approaching one hundred percent. Limited recruitment and the apparent top-heavy age structure in KNP prompted establishment of the nest protection program. Increasing the number of hatchlings produced each year is presumed to bolster recruitment, although this is controversial within the turtle conservation community.

Progress to Date: Nests have been systematically protected in KNP since 1988 as part of the volunteer nest monitoring program (Action 1.2). Volunteers cover all nests that they locate with wire mesh enclosures to protect the nests from predators and allow monitoring of emergence. Recent monitoring in KNP suggests that these efforts may be working; several juveniles have been encountered with hatchling notches indicating that they are from protected nests. These notches, which are given upon emergence from the nest, can last at least six years. Turtles that are recaptured are then given unique notches so that their eventual recruitment into the adult population can be monitored.

2.1.2. Headstart turtles by captive rearing of newly emerged hatchlings over their first winter (1998 Action 4.2)

2.1.2.1. Headstart hatchlings for Grafton Lake

2.1.2.2. Assess need and feasibility for headstarting across the range in Nova Scotia

Rationale: Head started hatchlings are reared in captivity and fed over their first winter in order to increase their chances of survival by maximizing their size on release. We have evidence that headstarted turtles do survive (Morrison 1996) and it is felt that head starting could be used to restore population size where it has been historically reduced.

Progress to Date: In 1994 and 1995 15 headstarted hatchlings were successfully reared and released (Morrison 1996) in a pilot study to test the viability of headstarted hatchlings in the wild, and the feasibility of using them to locate wild juveniles. Newly emerged hatchlings were collected after natural incubation in the nest and reared over their first winter. Released hatchlings were radio-tagged to track initial survival and movements. Survival was high and headstarted hatchlings behaved like wild hatchlings. At least four of these headstarted hatchlings have survived and were recaptured in 2001-2002.

An evaluation of Grafton Lake was conducted in 2002 to assess the suitability of that site for releasing additional headstarted hatchlings. This site historically supported an adult breeding population, but intensive trapping through 2002 suggests that few turtles currently remain (Newbold in progress). Collection for museum specimens, construction of the fish hatchery dam and road mortality have probably all contributed to the current state of the population. The dam was recently removed from the site, in part to restore turtle habitat, both on the lake and in outflow and inflow streams. Because we know that the Grafton Lake population was historically higher and that habitat restoration has occurred here, we feel that it is appropriate to headstart hatchlings in an attempt to restore the population in this system. To this end, 24 emergent hatchlings from three nests (two of which were laid by females with Grafton origin) were brought into captivity for headstarting, immediately following emergence in Fall 2002.

A strategy for assessing need and feasibility for future headstarting efforts across the metapopulation is required.

2.2. Continue to promote stewardship and implement education initiatives as a means to improve conservation and recovery of population size

Rationale: Public involvement in the nest protection program increases local stewardship. Education aimed at decreasing mortality and disturbance of turtles caused by collection, vehicles, and trampling of nests will help ensure the objective of maintaining population size (see Objective 4 Actions).

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

3. Conduct research and monitoring necessary for conservation and recovery

3.1. Identify and characterize habitat for Blanding's turtle in each population *(1998 Action 1)*

3.1.1. Locate and describe seasonal habitats and use (1998 Action 1.1 and 3.3.4)

Rationale: It is important to locate specific sites that turtles use in each population for all stages of their life history. Site-specific stewardship and habitat protection measures depend on reliable location and habitat use data. All seasonal and age-specific habitats, including those used for overwintering, nesting, basking, mating, and feeding, must be identified (Table 4).

Progress to Date: Many of the nesting, overwintering, spring basking and summering sites have been identified for the known concentrations at KNP and at McGowan (Table 4). Work at Pleasant River began in 2002, during which summer and winter sites were identified. Many sites, particularly overwintering locations in KNP, have not been searched since Power's work in 1987-1988; revisiting these sites would help determine long-term use patterns. We are continuing to identify new sites at all three locations by radio tracking individuals and surveying potential sites.

Knowledge of habitats used by hatchlings is limited. It is not known where hatchlings spend their first winter since the small size of the newly emerged hatchlings prevents the use of conventional radio transmitters. Evidence from early post emergent behaviour indicates that hatchlings do not seek water, suggesting that hatchlings may possibly overwinter on land (Standing *et al.* 1997). Freeze tolerance in hatchlings has been identified elsewhere within the species range (S. Dinkelacker, pers. comm.).

Knowledge of travel routes between sites is also limited (see Action 3.2.3). Locating specific routes used and important microhabitats within these routes (*e.g.*, hydration pools near nesting sites) is an important component of habitat identification.

3.1.2. Physically characterize key habitats in each population (1998 Action 1.4.3)

3.1.2.1. Develop and refine habitat sampling protocols

3.1.2.2. Develop methods to analyze aerial imagery

Rationale: Assessing habitat characteristics including hydrology, geology, vegetation and temperature at each site will help us understand the habitat requirements of Blanding's turtles. As well, it will provide us with detailed baseline data to monitor habitat change (see action 3.1.3). Habitat analysis will be conducted on several scales using a combination of field-collected data and aerial image analysis.

Progress to Date: The substrate and temperature profiles of the nesting beaches in KNP were examined by Standing (1997), who found that nests are laid on southeast to southwest-facing slopes. Nest sites were significantly warmer than randomly chosen sites on the nesting beach (Standing 1997). Nest substrates consisted of a variety of size classes with no evidence of substrate selection for the nest sites. No comparable analysis has been done for sites outside the Park, most of which differ considerably from those within the Park.

Detailed habitat analysis is lacking from most seasonal sites. Habitat analysis began in 2002 to investigate the effect of vegetation, cover, bank structure, depth and other habitat characteristics at trapping sites. These methods will be refined and incorporated into the normal sampling protocols.

On a larger scale, low level high resolution (0.25m) digital aerial photographs were taken at sites at KNP (including Heber Meadow and Mersey River sites), McGowan and Pleasant River in 2002 (on file with Paul Illsley, COGS). The Recovery Team is collaborating with the Nova Scotia Community College Centre of Geographic Sciences to analyze these images.

3.1.3. Monitor change in habitats and habitat use (1998 Action 1.5 and 1.4.2)

Rationale: Long-term surveys (using habitat sampling protocols) will be established to monitor and assess changes in the quality and availability of habitat for supporting Blanding's turtles in Nova Scotia. Regular sampling of individuals at all seasonal habitats (see Action 1.1 and 1.2) will not only give us data on demography but also trends in long-term habitat use and individual site affinities.

3.2. Assess movements at multiple spatial and temporal scales

Rationale: Understanding movement patterns at multiple scales is key to understanding the relationship between turtles and their habitat. For instance tracking precise movements of hatchlings on their first day upon emergence from the nest will yield important information on cover-seeking behaviour. Tracking lifetime shifts in home ranges is equally important for determining connectivity between concentrations and populations.

3.2.1. Track both long-term and seasonal movement patterns of individuals

Rationale: Understanding both seasonal and long-term movements of individuals will help clarify the influence of habitat on behaviour. Home ranges can be calculated through multiple recaptures of individuals (see Action 1.1) over time as well as through detailed radio-tracking of movements.

Progress to Date: Power (1989) collected detailed movement data on individuals in KNP and documented home ranges, seasonal movement patterns and travel routes for these individuals. Although most turtles remained within specific areas, at least three males shifted their home ranges during Power's study. Movements of individuals at McGowan have been tracked since 1996. Turtles at McGowan appear to have smaller home ranges than those at KNP (McNeil 2002). Movements of individuals at Pleasant River were tracked in 2002; data are presently being analyzed (Caverhill in progress).

3.2.2. Describe age-related movements and distribution (1998 Action 1.2 and 3.3.4)

Rationale: Juvenile turtles may have different habitat requirements than adults. Unfortunately juveniles of nearly all turtle species are notoriously cryptic.

Progress to Date: In KNP, juveniles are highly associated with aquatic sphagnum and shrub cover (McMaster 1996). Young juveniles tend to remain in brooks (Atkins) and coves (Heber) during summer, while the adults disperse more widely along lakeshore coves (McMaster 1996). At McGowan, where less sphagnum is present than at KNP, juveniles occupy areas used by adults; however, juveniles are concentrated in two distinct areas of the main bog, with occasional movements between the two during summer, while adults are found throughout the bog (McNeil 2002).

Early post emergent behaviour of hatchlings has been studied by tracking turtles that were dusted with fluorescent powder (Standing *et al.* 1997; McNeil *et al.* 2000; Smith in progress). Experimentation with the use of transponders (diodes) has had limited success in extending the tracking period (Smith, in progress). Through these techniques, hatchlings were tracked up to 24 days after emergence from the nest. The majority of hatchlings do not go to water immediately upon emergence from the nest (Standing *et al.* 1997; McNeil *et al.* 2000). Little is known about the movements of hatchlings into their first winter and summer habitats.

3.2.3. Track movements along travel routes (1998 Action 1.1.4)

Rationale: It is important to understand not only seasonal locations of the turtles but also the travel routes within and between these sites. Most travel is associated with aquatic routes but turtles occasionally move considerable distances overland. Overland movements have been associated with nesting, overwintering, mating and range shifts between habitats (Power 1989, McNeil 2002).

Progress to Date: Data on travel routes between nesting, summering and overwintering sites have been reported at the main concentrations in KNP (McMaster 1996, Power 1989; Standing 1997) and at McGowan (McNeil 2002). In KNP, turtles move down stream from their overwintering sites in early spring (Power 1989). Females may travel considerable distances to their nesting areas and tend to aggregate in warm shallow coves near the nesting beaches prior to nesting (Standing, 1997). During the summer, many adults disperse to coves along the lakeshore. Turtles begin to move toward their overwintering areas from late August to early September (Power 1989). Turtles at McGowan, most of which remain within the main bog and surrounding wooded swamp, except during nesting, appear to travel less than those at KNP (McNeil 2002).

Although general travel routes have been identified in some areas, detailed movements along these routes have yet to be determined; such detail could provide valuable information on habitat characteristics and protection needs.

3.3. Incorporate habitat and movement components in the database *(1998 Action 6)*
Rationale: Both habitat components (including field collected data and spatial imagery) and precise movement data must be incorporated into the database. GIS analysis of the data will be instrumental in describing and interpreting large scale patterns.

Progress to Date: The data proofing and updating process will continue into the spring of 2003 at which time the correction of any erroneous spatial data will be undertaken. Though in the recent past there has been concerted effort to collect accurate locational data (GPS, 1:10000 maps, radio telemetry, even traditional survey techniques) over the past 40 years there have been different (and at times coarser) methods of collecting spatial data, resulting in varying degrees of accuracy. Much of the historical spatial information was recorded from 1:50000 topographic maps, using generalized UTM coordinates (to the nearest 100m or even at times 1000m grid). Better spatial accuracy will be gained by reviewing each individual record's descriptive locational information against the 1:10000 base maps and georeferenced 2001 air photos and updating the Blanding's turtle databases accordingly. GIS analysis and integration (in the form of point on polygon analysis, habitat fragmentation analysis, and temporal changes analysis) will summarize trends and build relational functions among databases but the level of confidence in any spatial analysis is dependent upon the degree of spatial accuracy.

3.4. Assess the influence of habitat on movements and distribution

3.4.1. Determine the relationship between turtle productivity and habitat (1998 Action 3.3.2.1.1)

Rationale: Turtle productivity (growth and reproduction) may be limited by habitat productivity and other characteristics (*e.g*., thermal regime, hydrology, geology, vegetation structure). Understanding how habitat affects distribution, growth and fecundity is important in identifying management actions to protect habitat.

Progress to Date: Power *et al.* (1994) noted that turtles occur in areas of relatively high secondary productivity in KNP. However, little is known about the ultimate impact of habitat on turtle productivity. Turtles at McGowan grow more slowly, mature at a smaller body size but later age, and lay smaller clutches than those at KNP, suggesting that habitat differences between the two areas may affect turtle productivity (McNeil 2002) (see Action 1.4.4). Differences in nesting substrate and nest site locations (inland vs. lakeshore) may ultimately affect survival and recruitment rates.

3.4.2. Determine how habitat heterogeneity influences movements and distribution
Rationale: Understanding the influence of habitat heterogeneity on turtle movements and distribution is critical in the development of an effective habitat protection plan. For Blanding's turtles, configuration of habitat likely exerts a greater influence than does amount of habitat.

4. Implement management, stewardship, and education initiatives for protecting habitat *(1998 Action 2)*

4.1. Develop and implement a habitat protection plan *(1998 Action 2.4.2)*
Rationale: The habitat protection plan will incorporate requirements of both federal (SARA), and provincial legislation (NS Endangered Species Act) as well as education and stewardship initiatives for private landholders to protect Blanding's turtle habitat. An effective management plan must occur at a scale that is appropriate to the turtle's ecological needs and incorporate protection of all seasonally important habitats.

Progress to Date: Although a formal habitat protection plan has not yet been developed, we have begun to initiate habitat protection at important sites for Blanding's turtles. In KNP, the major nesting beaches as well as several of the summer habitats, (particularly at Heber Meadow, Atkins Brook, Grafton Lake, and along the Mersey River) have been designated as Special Preservation Areas (Zone 1), the highest level of protection in the Park's Management Plan (1995). At Heber Meadow, which is located near the public campground, a trail to the nesting beach was closed in 1983 to minimize disturbance to the area. At McGowan Lake, dialogue is ongoing with landowners (Bowater Mersey Paper Company Limited, NSDNR, and a private landowner) to protect Blanding's turtle habitat on the west side of the lake (see Objective 4 Action)

4.1.1. Define and map critical and residence habitat, including areas not presently occupied
Rationale: Under the Species at Risk Act (SARA) critical habitat and means for its protection must be identified in recovery strategies and action plans for species at risk on federal lands. A critical habitat protection plan will be developed for Blanding's turtle existing within KNP (Drysdale KNP).

Progress to Date: This Recovery Plan does not explicitly define critical habitat for Blanding's turtle in Nova Scotia, as the necessary research is still in progress. However, information exists on "residence" and other habitat particularly in KNP and secondarily at McGowan Lake. Work in 2002 will expand this information base to include the Pleasant River population. Low altitude, high resolution imagery is being used in conjunction with field data on turtles and biophysical parameters to define and map critical habitat and to identify potentially destructive or adverse activities. This approach will contribute to development of a critical habitat protection plan in KNP.

4.1.2. Define and map core habitat and dwelling places
Rationale: Under the Nova Scotia Endangered Species Act, core habitat and dwelling place must be identified and means for its protection identified for all species on provincial land, listed under the act.

Progress to Date: This Recovery Plan does not explicitly define core habitat for Blanding's turtle in Nova Scotia, as the necessary research is still in progress. However, as outlined above (Action 4.1.1), remote imagery combined with intensive field data will be used to identify and map core habitat.

4.1.3. Implement habitat restoration and enhancement where needed (1998 Action 2.2)
Rationale: Active management of specific sites might be beneficial, particularly if that habitat is limiting. For example, maintaining existing nesting sites at McGowan by removing seedlings that are starting to overgrow the area may prevent turtles from nesting in more unsuitable habitats (such as mid-road). Habitats that are already degraded (*e.g.,* through dam construction, beaver removal) could potentially be restored.

Progress to Date: The most extensive habitat restoration effort at present involves the removal of a dam and re-establishment of historical water regimes at Grafton Lake within KNP (See II. Habitat).

4.2. Evaluate the effectiveness of the habitat protection plan and address any gaps
Rationale: The habitat protection plan will be developed based on current knowledge. However, the plan must evolve to incorporate both new information on turtle-habitat dynamics and changes in habitat threats.

4.3. Continue to promote stewardship and implement education initiatives as a means to improve conservation and recovery of habitat
Rationale: Landowner involvement in habitat conservation increases local stewardship. Education aimed at decreasing disruptive habitat uses (*e.g.*, All-terrain Vehicle (ATV) use in nesting areas, timber harvesting near critical summer or winter refuges, water level manipulation in concentration areas) will help ensure the objective of conserving habitat (see Objective 4 Actions).

Objective 3. Maintain *metapopulation structure*

5. Conduct research and monitoring necessary to further the understanding of metapopulation structure in Nova Scotia Blanding's turtles

5.1. Determine the range of the metapopulation *(1998 Action 1.3)*
Rationale: Understanding the extent of the metapopulation (and the factors that limit it) is necessary to understand the metapopulation structure and to initiate effective management of that structure.

Progress to Date: Knowledge of the range of the metapopulation has increased in recent years. Historically, it was thought that the majority of Blanding's turtles in Nova Scotia resided within KNP; however, a search to locate additional turtles was initiated in 1996 (see 5.1.1) resulting in the discovery of at least two previously unknown populations outside the Park, both on the Medway watershed. Confirmed sightings remain limited to the Mersey and Medway watersheds (Powell 1965; Dobson 1971; Bleakney 1976; Drysdale 1983; Herman *et al.* 1989; Hope unpublished). Credible reports of additional yet unconfirmed sightings from the LaHave and Roseway watersheds also exist (McNeil and Herman 1996, McNeil 2002); these areas have not yet been systematically searched for turtles.

5.1.1. Continue the use of public presentations and posters to identify potential sites
Rationale: The abundance of water bodies in southwest Nova Scotia presents a challenge in locating additional populations of turtles. A public poster and survey campaign that solicits the aid of local residents by asking them to report sightings of Blanding's turtles

increases the chances of successfully locating additional turtles. This method, which has proved successful in past, also increases public education.

Progress to Date: A public survey and poster campaign was initiated in 1996 to locate turtles outside of KNP. Posters contained a picture and a brief description of the Blanding's turtle and its life history, and identified contacts for people to report possible sightings. Surveys were distributed to naturalist, sportsman and outdoor recreation groups, community events, sports stores and schools. The campaign (intensive in 1996 and posters 1997, 1998) yielded 73 responses, 30 of which were deemed credible Blanding's sightings. The majority of the sightings occurred on the Mersey and Medway watershed, with additional credible reports from two adjacent watersheds, the Roseway and the Lahave (McNeil 2002). With an updated poster, designed in 2001, we are continuing to seek the public's assistance in locating more turtles outside the Park (Appendix III).

5.1.2. Systematically survey sites with credible reports and confirm anecdotal sightings (1998 Action 1.3.3)

Rationale: In order to substantiate sightings reported by the public (5.1.1), identified areas must be systematically searched. If Blanding's turtles are captured during initial searches, additional efforts will attempt to confirm the existence of a population.

Progress to Date: Nineteen water bodies on the Mersey and Medway watersheds were trapped in 1996 and 1997, resulting in the discovery of the two known populations outside the Park: McGowan Lake and Pleasant River. Additional water bodies on the Mersey and Medway watersheds, have been opportunistically sampled since 1997. However, many of the areas identified by the public campaign have not yet been sampled, especially those on other watersheds.

5.2. Assess the genetic relationship between new populations, as they are found, and populations at KNP, McGowan Lake and Pleasant River *(1998 Action 5)*

Rationale: Samples from newly identified populations should be genotyped using microsatellite markers and compared to currently known populations, in order to assess the extent and degree of genetic structuring in the Nova Scotia metapopulation.

Progress to Date: A recent study using microsatellites confirmed genetic substructuring between the populations at KNP and McGowan Lake (see Section II: Spatial Stucture) (Mockford in progress). An assessment of the degree of genetic substructuring between the Pleasant River population and those at KNP and McGowan is currently underway (McEachern in progress). We are continuing to collect and archive blood samples from all individual turtles encountered for future genetic work.

5.3. Periodically assess known populations for change in genetic heterogeneity *(1998 Action 5)*

Rationale: Small populations and subpopulations risk the loss of genetic diversity through the processes of inbreeding and genetic drift. Although such loss has not been detected to date in Nova Scotia, these populations should be periodically re-sampled, genotyped and assessed for the loss of genetic diversity. This is a long-term objective, as the generation time of this long-lived species probably approaches 40 years.

Progress to Date: Current genetic assessments (Action 5.2) and the on-going collection of blood samples from all individuals encountered will provide good baseline data for future comparisons.

5.4. Adapt and apply analytical tools to assess the influence of landscape on metapopulation structure

Rationale: Recent developments in quantitative ecological modeling allow a more sophisticated analysis of spatial behaviour and the influence of landscape on population structure. These models will help provide more accurate parameter values to enable more realistic Population Viability Analysis (see Action 1.4.6).

5.5. Assess the instability in demographic structure of each population in Nova Scotia

Rationale: Uneven age structure is commonly observed in Blanding's turtle populations. In some cases this may be apparent rather than real due to age-related differences in trappability or visibility. In Nova Scotia, age structure appears to differ among the three populations (see Section II. Demographic Structure); the significance of this is unclear. It is conceivable that stable age distributions are rarely, if ever, achieved within this metapopulation.

6. Implement management initiatives that maintain metapopulation structure

6.1. Develop an overall strategy for the conservation of the Nova Scotia metapopulation that incorporates the ecological scales of Blanding's turtles

Rationale: Although we can readily identify several spatial scales in distribution of Blanding's turtles in Nova Scotia (concentration, population, watershed) and in the distribution of their genetic diversity, we do not adequately understand the historical connections within the metapopulation and how human activity has recently modified those connections. The influence of habitat heterogeneity on movements and distribution further complicates the system. Identifying the appropriate management scales in such a system is key but perplexing.

6.2. Maintain processes that contribute to the current genetic sub-structuring

Rationale: This metapopulation appears to support a disproportionate amount of genetic diversity for its size. This may in part reflect historically larger populations but it may also reflect restricted gene flow among populations.

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

7. Conduct research and monitoring necessary to assess threats

7.1 Continue to identify and assess the relative importance of existing and anticipated threats *(1998 Action 3.2.3)*

Rationale: Most of the inherent threats that this small isolated metapopulation faces are exacerbated by human activity. These include stochastic risks (genetic, demographic, and environmental) associated with small populations, physiological constraints of life at the northern limit of the species range and delayed maturation (resulting in increased susceptibility to adult mortality) (see Section II. Background Information: Threats). Immediate threats induced by humans include: water level manipulation, habitat fragmentation, and direct vehicular mortality. Climate change and increased pressures from invasive species are expected to impact turtles in future.

7.2 Monitor threats

Rationale: Threats will be monitored adaptively. Those currently recognized or anticipated as being important are described in the following actions.

7.2.1. Monitor threats to nest success

7.2.1.1. Monitor nesting substrate condition on known nesting beaches, including influence of ice scour

7.2.1.2. Monitor fluctuations in lake levels and the flooding of nests
7.2.1.3. Monitor predator abundance and movements
7.2.1.4. Monitor the effects of seasonal temperature on nest timing and success

Rationale: Current threats to nest success include predation, low incubation temperatures and nest flooding; all could increase under a regime of climate change. Reduced winter severity, as predicted from most climate change scenarios, may reduce the extent of ice scour on nesting beaches and lead to overgrowth of nesting substrate by vegetation. As well, milder winters may reduce winter mortality of warm-adapted predators like raccoons. Altered water levels, which may also accompany global warming, could change lakeshore nesting patterns and increase nest flooding.

Progress to Date: Anecdotal evidence suggests that severity of ice scour on Kejimkujik Lake has been reduced in recent years, resulting in some overgrowth of nesting substrate.

In some years, flooding of lakeshore nests can result in high nest failures. In 1996, 10 of 22 protected nests failed due to flooding (Standing *et al.* 2000a). Low incubation temperatures are also thought to cause nest failure as well as excessive numbers of hatchling deformities (Standing *et al*. 2000 a,c).

In KNP predation by and movements of raccoons were studied in 1996 and 1997. Despite exceptionally low raccoon population levels in 1997, 5 of 13 unprotected nests were predated (Shallow 1998*)*. Lake shore nests appear to be particularly susceptible to predation, although susceptibility varies with nest density (Shallow 1998).

7.2.2. Monitor threats to adult and juvenile survivorship
7.2.2.1. Monitor and manage traffic activity during nesting and nest emergence where feasible
7.2.2.2. Monitor water level manipulations by remote sensing
7.2.2.3. Access existing databases on beaver control

Rationale: Any increase in adult mortality could severely threaten populations due to excessively late maturation in these populations. McGowan Lake boasts the latest age at maturation (24 years) ever recorded in a Blanding's turtle; this population may be particularly susceptible as a result. Some of the threats to adult and juvenile survivorship can only be practically monitored indirectly. Vehicular mortality or other forms of predation are easily missed (although vehicular mortality of all age groups has unfortunately been reported in this metapopulation), and must be inferred indirectly from disappearance of marked individuals from intensively monitored populations.

Human manipulations of water level by impoundments or removal of beavers can directly increase mortality. Disruption of natural transit routes can also induce movement to areas with vehicle traffic.

7.2.3. Monitor threats to habitat
7.2.3.1. Monitor agricultural, forestry and residential development disturbance trends

Rationale: As human development increases, threats to habitat availability and quality will continue to increase. Agricultural, forestry and residential development can fragment and degrade important habitat. Water level changes caused by modified watercourses, shoreline development, highway maintenance and altered run-off patterns are of particular concern.

7.3. Analyze threats and develop contingency plans

7.3.1. Develop analytical tools for modeling threats and their impacts.

Rationale: Modeling tools may help us to predict the future impact and extent of threats as well assess ramifications of potential management techniques.

7.3.2. Continue to scrutinize the management actions in aid of Blanding's turtle recovery and the science underlying them

Rationale: Strong underlying science on which to base management actions is particularly important in a long-lived species, where the ramifications of such actions may not be apparent for many years. Incomplete knowledge could result in actions that are inadvertently detrimental. For instance, at one time, hatchlings were routinely taken to the water's edge after emergence from protected nests until it was later discovered that most hatchlings do not go to water (Standing *et al.* 1997). In fact, many tend to move away from water when placed by the water's edge (McNeil *et al.* 2000) so these actions may have actually placed them at greater risk of predation. Continuing to scrutinize and test the science is an important component of Blanding's turtle recovery.

7.3.3 Develop strategies to address threats

Rationale: Strategies to deal with both current and anticipated threats will be developed based on the analysis described above. For instance, a predator contingency plan can be developed to control predation pressure on nests and hatchlings.

8. Implement management, stewardship, and education initiatives that remove or reduce threats

8.1. Continue to increase habitat protection

Rationale: Longterm protection of key habitat is essential to reduce threats. The development and implementation of a habitat protection plan for each population (see Action 4.1) will reduce risks from local activities.

A new management plan is currently being developed for the Park and land-use zoning of Blanding's turtle habitats are under review for this plan. Important areas identified from recent research will be considered for re-zoning.

8.2. Implement threat management to deal with specific threats as they arise *(1998 Action 2.3.2)*

Rationale: Specific threats will be dealt with as they arise based on the analysis described in Action 7.3.

8.3. Continue to promote and develop stewardship

Rationale: Local stewardship is essential to the success of Blanding's turtle conservation. Contacting and collaborating with stakeholders in each population, combined with ongoing conservation activities such as the volunteer nest-monitoring program, will foster an ethic of local stewardship.

8.3.1. Enhance landowner contact

Rationale: Most landowners are unaware that Blanding's turtles exist on their lands. A program to systematically identify and contact landowners for each population will increase awareness of the turtles and encourage local stewardship.

Progress to Date: No formal landowner contact program has been developed. However, several of the landowners at McGowan Lake have been contacted and we are presently working with them to protect habitat on the west side of the lake. Local citizens in the Pleasant River area were opportunistically contacted in 2002.

8.3.2. Continue collaboration with private and corporate landowners

8.3.2.1. Continue cooperation with Bowater Mersey Paper Company Limited

Rationale: Collaboration with local landowners will encourage habitat protection and reduce threats from disruptive activities.

Progress to Date: The majority of Blanding's turtle habitat on the west side of McGowan Lake is owned by three landowners: Bowater Mersey Paper Company Limited, NS DNR, and a private landowner. We are currently collaborating with them to protect important turtle habitat.

Bowater Mersey Paper Company Limited managers have agreed to develop a management plan for the area to accommodate the needs (both aquatic and overland) of the turtles, based on the information that we have gathered to date. The Recovery Team and Bowater Mersey Paper Company Limited are both committed to working together and cooperating to the fullest extent possible to aid in the delivery of the actions proposed within the Recovery Plan that are relevant to this area. Full membership of Bowater Mersey Paper Company Limited on the Recovery Team will help to insure open communication and integration of activities.

8.3.3. Formalize conservation agreements

Rationale: Conservation agreements should be formalized to ensure that they are implemented and widely publicized.

8.3.4. Approach the Aboriginal community to determine interest and role in Blanding's turtle conservation

Rationale: The Aboriginal community may have an interest in Blanding' turtle conservation, as turtles are considered to be spiritually and physically important in the Mi'kmaq culture.

8.4. Develop and implement a communications plan for the conservation and recovery of Blanding's turtles *(1998 Action 6.3)*

Rationale: Recent discoveries of Blanding's turtle habitat on private lands and working landscapes, in addition to public lands, introduced new challenges for communication and stewardship. A communications plan will facilitate species recovery by ensuring that critical information is disseminated in a coordinated fashion appropriate for various turtle protection needs within the national park, on private and provincial crown lands. Media approaches can be linked with Recovery Plan objectives, and targeted to specific audiences to facilitate desired knowledge levels and/or behavioral changes to reduce threats. The communications plan should be developed by a multi-disciplinary team including representatives from KNP, NSDNR, Municipalities, NS Museum, DesBrisay Museum, NS Nature Trust, Southwest Nova Biosphere Reserve, and interested businesses, in collaboration with the Blanding's Turtle Recovery Team.

Progress to Date: The KNP Interpretive program has effectively presented the Blanding's turtle story since the 1970's using a variety of media including evening presentations, guided walks, school programs and brochures. The Blanding's Turtle Recovery Team has facilitated the development of an excellent web page. A poster campaign and telephone hotline have resulted in many sighting reports, and have established contacts with interested members of the public. The Nova Scotia Museum continues to present the unique story of Nova Scotia's rare species. The Southwest Nova Biosphere Reserve Association used Habitat Stewardship funds to develop high quality exhibits with a species at risk theme that continues to circulate to schools in the region. Similarly volunteer organizations such as the Nova Scotia Nature Trust have helped educate the public through workshops and other programs. National and regional television coverage has enhanced awareness of Blanding's turtles and the recovery program among a wider audience.

Recovery Actions by Landscape Type (National Park versus Working Landscape)

Blanding's turtles do not recognize political boundaries. They occur in landscapes experiencing a wide range of human activities and threats. In Nova Scotia, they exist as several apparently independent, spatially segregated evolutionary units (populations), with recognizable differences in morphology and behaviour. One of these is largely contained within a National Park; the other two occupy working landscapes. Herman *et al.* (1998) argued strongly for the importance of linking conservation efforts for this species in protected and working landscapes. However, identifying the appropriate management scale in this ecological and political matrix is challenging.

Many of the proposed Recovery Actions apply universally to all populations; others are specific to one population or one landscape type. Information gaps differ substantially among populations, as does the range of potential management options, particularly those involving habitat. Stewardship is universally important, but especially so in working landscapes. The biological and political realities necessitate that we recognize this heterogeneity and incorporate it in species recovery.

Implementation Schedule

The implementation schedule is not yet complete, but will include an outline of the recovery actions and their priorities over the duration of the Recovery Action Plan period (2003-2007). This implementation schedule will provide guidance to the Team over the course of the five-year plan and will be important in the evaluation of progress.

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APPENDIX 2: Summary of Protection and Status Across North America

State/ Province	Status	Source of Info	Web Source
Nova Scotia	Endangered (NS Endangered Species Act) Threatened (COSEWIC)	Nova Scotia DNR	http://www.gov.ns.ca/natr/wildlife/endngrd/specieslist.htm http://www.cosewic.gc.ca/eng/sct0/index_e.cfm
Ontario	Not listed	Ontario MNR	http://www.mnr.gov.on.ca/
Quebec	Not Listed		
Maine	State Endangered	ME Dept of Inland Fish and Wildlife	http://www.state.me.us/ifw/wildlife/endangered /index.htm
New Hampshire	Not listed	New Hampshire Fish and Game Dept	http://www.wildlife.state.nh.us
Massachusetts	State Threatened	Mass Wildlife	http://www.state.ma.us/dfwele/dfw/dfwamph.htm
New York	State Threatened	NYS Dept. of environmental conservation	http://www.dec.state.ny.us/website/dfwmr/wildlife/endspec/bltufs.html
Michigan	Special Concern	Michigan DNR	http://www.michigan.gov/dnr/
Wisconsin	State Threatened	Wisconsin DNR	http://www.dnr.state.il.us/
Indiana	State Endangered	Indiana DNR	http://www.in.gov/dnr/
Illinois	State Threatened	Illinois DNR	http://dnr.state.il.us/
Missouri	State Endangered	Missouri Dept. of Conservation	http://www.conservation.state.mo.us
Iowa	State Threatened	Iowa DNR	http://www.state.ia.us/dnr/
South Dakota	State Endangered	USGS Northern Prairie Wildlife Research Center	http://www.npwrc.usgs.gov
Nebraska	UnKnown		
Ohio	Not listed	Ohio DNR	http://www.dnr.state.oh.us
Pennsylvania	Candidate Species	Pennsylvania Fish and Boat Commission	http://sites.state.pa.us/PA_Exec/Fish_Boat/ja2001/raspeciespos.pdf

APPENDIX 3: Blanding's Turtle Information Poster