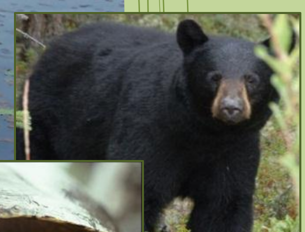

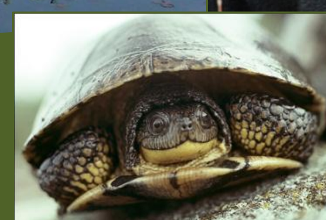

April 2012

A SPECIES-BASED APPROACH TO DETERMINE STANDARDS FOR LARGE NATURAL AREAS IN MUSKOKA

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A SPECIES-BASED APPROACH TO DETERMINE STANDARDS FOR LARGE NATURAL AREAS IN MUSKOKA

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Muskoka Watershed Council
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Dear Ms. Brouse:

We are pleased to submit one hard copy of the Final Report of A Species Based-Approach to Determine Standards for the Large Natural Areas in Muskoka. This project has been carried out in affiliation with the ENVS*4011/4012 Project in Environmental Sciences course in partial fulfilment of the Bachelor of Science in Environmental Sciences degree at the University of Guelph.

The report examines one species relationship and four indicator species to determine the habitat types and appropriate sizes of habitat types for large naturals areas within Muskoka for conservation purposes. Recommendations have been provided based on conclusions from the peer-reviewed literature, with a comparison to the existing habitat standards.

Sincerely,

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TABLE OF CONTENTS

LIST OF FIGURES

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EXECUTIVE SUMMARY

Introduction

Muskoka is a forested environment located at the northernmost edge of southern Ontario that supports extensive cottage, recreational and tourism activities. Currently, there are no standards for large natural areas available for Muskoka that are based on sound population dynamics or landscape ecology. "How Much Habitat is Enough?" (Bryan 2004), developed in support of habitat restoration in the Great Lakes Areas of Concern, is currently the sole guideline for habitat protection in Ontario. There is concern regarding whether these guidelines would be adequate to develop a starting point for the creation of standards in Muskoka.

The objective of this literature review was to provide scientific evidence for the optimum amount of area of different habitat types required to maintain wildlife values, ecological integrity, and ecosystem goods and services in Muskoka. The deer-wolf relationship and four species: the American Black Bear (*Ursus americanus*), the Blanding's Turtle (*Emydoidea blandiggi*), the Eastern Massasagua Rattlesnake (*Sistrurus catenatus*) and the Eastern Hognose Snake (*Heterodon platirhinos*) were investigated. Values of the home range for the chosen representative species of a given habitat type were compared to current habitat protection guidelines for Ontario.

Review

Examination of the deer-wolf relationship revealed a species preference for dense mixed forest and successional forest, with a home range size that differs with season and density of each interacting species. The American Black Bear uses habitats of either dense mixed and deciduous forests or wetlands, with a home range of approximately 19,400 ha. The Blanding's Turtle predominantly resides in wetlands, with a home range size of approximately 3.6 ha. The Eastern Massasauga Rattlesnake is best described as a generalist species making use of open, forested and wetland habitats, with a home range of 25.0 - 200 ha. The Eastern

Hognose Snake prefers open habitats characterized by sandy soils, with a home range of approximately 91.6 ha.

Recommendations

The following species were determined to be best representatives for habitat type as follows: the American Black Bear for forested habitats; the Blanding's Turtle for wetland habitat; and the Eastern Hognose Snake for open areas. The needs of the Eastern Massasauga Rattlesnake as a generalist should be fulfilled by the requirements of the other species. Size of habitat patches should be maintained to reflect the maximum average male home range where possible. This equates to 19,400 ha for forested habitats, 3.6 ha for wetland habitats and 91.6 ha for open areas. However, species may be dependent on more than one habitat type and this should be considered. The deer-wolf relationship could not be considered as no value was provided for the approximate area required for the relationship in the literature. In all cases the existing guideline written by Bryan (2004) would provide an adequate starting point for Muskoka standards, with the exception of open areas which were not previously considered under the guideline.

Conclusion

Caution should be exercised when interpreting the results as: (1) limited southern Ontario studies have been conducted for the reviewed species; (2) controversies exist in Conservation Biology over whether a home range or viable population approach should be taken when determining appropriate habitat size required; and (3) the relationship between species and habitat type is not always well-defined, i.e. species may use multiple habitat types over the course of their life. Future studies should directly examine species in Muskoka.

1.0 INTRODUCTION

Forests as a habitat and resource for humans and other fauna have always been of great importance to biodiversity throughout Canada. Since the first European settlers arrived forestry has been a large part of Canada's economy (Government of Ontario 2012a). As human populations began to grow, the removal of forests, especially in the southern part of what is now Ontario, increased in order to create a more inhabitable land. More recently Ontario, being one of the largest provinces, has been looked to as a leader for the country in a multi-million dollar forestry industry. Governments are becoming more aware of the consequences of unsustainable development of land, whether it is for logging or urbanization. A fine line is walked by the Canadian and Ontario Governments to grow the economy while maintaining adequate forest sizes for our magnificent biodiversity.

With increasing populations comes an increase in development of land and urbanization. Southern Ontario was once a dense forested area with minimal inhabitation (Government of Ontario 2012a). Now, however, it is a well-established, heavily populated area where 85% of Ontario's population resides (Government of Ontario 2012b). With over 12 million people occupying an area of 127,000 km^2 in the south and only 805,000 people occupying 803,000 km^2 in Northern Ontario, the distribution of population densities (86.4 people km^{-2} in the south, 0.9 people km^{-2} in the north) is extremely unbalanced (Government of Ontario 2012b). The high population densities observed in southern Ontario inevitably leads to an expansion of urbanized areas and lower green space.

Muskoka is located at the northernmost edge of southern Ontario (see Figure 1) and, as a result, has not yet experienced the same level of development that has occurred in the Greater Toronto Area (GTA) and beyond. Muskoka is prime 'cottage country' for more than 20,000 people in southern Ontario but is home to only 58,000 year-round residents (Government of Ontario 2012b). The increase in populations of southern Ontario cities has forced movement of urbanization north and is now pushing the boundaries of Muskoka. Decreasing land fragmentation is an important factor in maintaining species biodiversity for the

Figure 1. Map of Muskoka (North Simcoe Muskoka, unreferenced, see “Notes”).

Muskoka area. As a result, fragmentation of forested land is becoming a more prevalent issue in this area, especially wetlands, for the species at risk that exist here.

Canada's Species at Risk Act (SARA) and Ontario’s Endangered Species Act (ESA 2007) are used to determine species which are especially at risk of becoming endangered and why. This act states that it is then responsible for forming a plan for how to preserve the species. The key to doing this correctly is understanding why the species is at risk and identifying the underlying reasons. The species covered by SARA are based on recommendations from the Committee on the Status of Endangered Wildlife in Canada (COSEWIC); provincially the species protected by the Ontario ESA are based on recommendations from the Committee on the Status of Species at Risk in Ontario (COSSARO). These organizations use scientific research from experts on particular species who present status reports based on the most up to date research and have similar mandates. The criteria used by COSEWIC for designating species as one status or another is based on several factors, many of which have some overlap and all of which are useful when determining how best to help a species at risk. The main criteria used by the Committee are:

A) The decline in number of mature individuals of a species, the decline in the index of area of occupancy of the species, and the size and quality of the species habitat. Whether these factors are affected by the potential levels of exploitation, the effects of introduced species, hybridization, introduction of pathogens, pollutants, competitors or parasites.

B) The species has a small distribution range and the range is very fragmented.

C) The species has a small or declining number of mature individuals.

D) The species has a very small or restricted total population.

E) The area occupied is very small or there are very few total areas of occupancy of the species. The 'Threatened' species may have area of occupancy < $20km^2$ or < 5 locations which is prone to the effects of activities in an uncertain future and thus capable of becoming endangered in a short period.

F) Through quantitative analysis, population projections show the probability of extinction of the species is at least 20% within 20 years or 5 generations for endangered status or 10% within 100 years for 'Threatened' status.

Studies show that landscape variables at multiple spatial scales will have a significant influence on the health of wetland animal populations. This is especially true for the loss of preferred habitats and/or the increased fragmentation of these habitats. When wetlands are isolated and/or road density is high nearby, species richness and diversity is negatively affected. Urban land use also negatively affects species richness in wild habitats; these geographic relationships are consistent throughout published studies. There is a clear relationship between reversing these landscape changes and increasing the health and numbers of animal populations (Lehtinen et al*.* 1999).

A cause for concern occurs when habitat restoration efforts are done improperly: species may not have a better chance of thriving compared to pre-restoration. Amphibians in restored wetlands and artificial breeding habitats often have no connectivity and are vulnerable to site-wide extinctions. A 13-year study by Petranka and colleagues (2007) in a North Carolina watershed examined the persistence of amphibian populations in an isolated area where a complex of breeding sites were built to buffer populations from external environmental stressors. They created 10 constructed wetland sites, with 10 existing reference ponds in the boundary as well. Over the course of the study the numbers of species were estimated based on larvae found in the ponds, as well as documented changes in adult populations. Most ponds did not produce juveniles after several years due to droughts, pathogen outbreaks and occupancy of ponds by fish. However, some ponds were not affected and produced juveniles at rates where populations could persist at high levels. The results showed that it is possible for complex wetland designs to improve persistence of populations that have little connectivity to other populations. As wetlands make up much of Muskoka, this research is important as it provides evidence that thorough knowledge and careful planning are required when restoring wetland habitat to ensure the maximum chance of survival for species that live there.

Very little work has been completed in the area of standards used to maintain intact tracts of land. The aforementioned report by Bryan (2004) of Environment Canada for southern Ontario is often used as the standard in this area for land protection. Unfortunately Muskoka is considerably different from the GTA in geology and landscape; therefore there are concerns that these standards are not the most appropriate for Muskoka. The previously mentioned six criteria used by COSEWIC show that fragmentation and degradation of habitat and its effects on species are a clear priority. Thus restoration of fragmented and debilitated habitat is an important step towards restoring species populations which are threatened with extinction. This idea forms the basis of our approach to restoring the Muskoka Watershed; by monitoring populations of various local species listed under SARA we can determine the health of the restored habitat.

The goal of this report was to determine the habitat types and intact sizes that are required to maintain current levels of biodiversity in the Muskoka region and to compare these values to previous literature. To accomplish this, the following objectives have been satisfied: a thorough literature review of the habitat types and size required by four indicator species and one inter-species relationship as chosen by the client and a summary of findings; the selection of the best indicators for forested, wetland and open land-types and the creation of guidelines regarding the amount each land-type that should be protected based on the needs of the chosen indicator species. For this report the habitat needs of the deer-wolf relationship, the American Black Bear (*Ursus americanus*), the Blanding's Turtle Blanding's Turtle (*Emydoidea blandiggi*), the Eastern Massasauga Rattlesnake (*Sistrurus catenatus*) and the Eastern Hognose Snake (*Heterodon platirhinos*), all found in Muskoka, have each been reviewed. These values have been compared to current habitat protection guidelines for Ontario and a conservative estimate of required habitat size has been determined. The health of these species populations will be directly related to the quality of habitat restoration (GOC 2010).

2.0 REVIEW

2.1 Deer-Wolf Relationship

The relationship between White-tailed Deer (*Odocoileus virginianus*) and Grey Wolves (*Canis lupus*) in Ontario is tightly linked and habitats and ranges for each species are similar as a result (Taylor and Pekins 1991).

Deer inhabit areas of forest where shelter and food sources are available. In the winter access to dense coniferous canopy cover at night and open field areas during the day increase chances of survival during this time of year (Armstrong et al. 1983). This is likely the result of the need to insulate and block cold winds at night and access direct sunlight throughout the day to increase body temperature. The presence of deciduous trees such as Oak (*Quercus*) and Birch (*Betula*) in close proximity to the coniferous breeding area is essential for the foraging of acorns and pine cones throughout the winter (Armstrong et al. 1983). Herds of deer congregate together in deer yards before reproduction and stay together all winter to strengthen the safety around pregnant does (Broadfoot et al. 1996). The density of the deer population in the nine deer yards throughout Ontario is 10 times higher than those seen during the summer when populations disperse (Broadfoot et al. 1996) because wintering ranges are 10-15% the size of the summering area (Viogt et al. 1997).

Throughout the summer months, deer work to maintain the energy lost from the growth of antlers and energy expended on lactation raising fawns (Viogt et al. 1997). Therefore, the ideal habitat is early successional forests where forbs and young trees are plentiful and full of high energy nutrients or in forested areas close to small open fields for easy access to crops. Deer tend to feed on species that are flowering or leafing out as these are high energy foods (Viogt et al. 1997). The focus of management practices for White-tailed Deer populations should be on this summering habitat as it will likely incorporate the wintering grounds (Viogt et al. 1997).

Wolves are migratory predators and will follow their prey across large areas of land (Quinby et al. 1999). However, dens in Algonquin Provincial Park are selected based on the surrounding habitat over the availability of food (Norris et al. 2002). Wolves den in pine forests which extend out as much as 1000 m, potentially overlapping with deer wintering grounds (Norris et al. 2002). An increase in fragmentation south of Algonquin Park by roads and human inhabitation has minimized the amount of continuous forest area needed for the hunting and denning patterns of wolves. As a result, Quinby et al. (1999) proposed the conservation of an intact corridor from Algonquin Park to Adirondack Park in New York; Muskoka would very likely be incorporated into this tract.

Taylor and Pekins (1991) found using mathematical modelling that wolves are scarce in areas between two packs and as a result a higher density of deer may be found in these buffer regions. With increasing fragmentation, these buffer zones decrease and both deer and wolf populations are forced into closer proximity to one another. This would result in more predation of deer by an increased number of wolves as multiple packs may be located in the area where only one previously hunted. This increase in wolf abundance may also lead to the decline of wolves as they hunt a denser but constant deer population. As fragmentation is a significant factor in the mitigation of biodiversity in Muskoka, it is suggested that the heavy cutting of smaller areas of land is preferred over sparse cutting of larger pieces (Viogt et al. 1997). This will help preserve the White-tail Deer populations which will in turn benefit the

Grey Wolf and the complete clearing of smaller areas will allow for a few cottages to be built in the openings. As long as the number of clearings is minimized, this should maintain a favourable balance between increased human populations to the region while protecting the deer-wolf relationship.

2.2 American Black Bear

2.2.1 Significance and Location

American Black Bears can be considered as a different type of indicator species. In a comprehensive paper, Beazley and Cardinall (2004) concluded that although the American Black Bear is not suitable as an umbrella or indicator of habitat health, they can be used as a flagship species. Due to their charisma and recognisability, the American Black Bear could be used as the focal point of a conservation campaign. Therefore, it should be noted by the reader that although the American Black Bear should not be used as an indicator it was deemed suitable for enticing the general public to learn about and participate in a conservation strategy.

In North America, American Black Bears can be found in all Canadian provinces and territories with the exception of Prince Edward Island, which they were extirpated from in 1937 (Vaughan and Pelton 1995).

2.2.2 Habitat Requirements

Like many other large mammalian carnivores, the American Black Bear has a specific set of needs that require a large, diverse habitat (Lowman 1975). In a study conducted by Rudis and Tansey (1995), there were five important factors that needed to be considered when attempted to model habitat selection by American Black Bears: foraging and denning, dispersal movements, behaviour, home range and density and finally minimum area requirements.

2.2.3 Habitat Type

This section will be divided into two discussions. First, the necessary “natural” habitats that are used American Black Bears will be evaluated, followed by a smaller examination of “altered” habitats that have been selected by American Black Bears. There is also a distinct difference between the habitats used by bears in the spring to early summer season and those used in the late summer to fall season; this will be discussed as well.

In a study by Obbard et al. (2010) conducted on a relatively small, isolated population of American Black Bears in the Bruce Peninsula, it was found that bears of all ages predominantly chose dense mixed-forests over other habitat types in the spring to early summer season. There are many characteristics of dense mixed forests that are likely appealing to bears due to a higher selection of nutrition sources. First, the complexity of debris on the forest floor would provide a multitude of different insect habitats, leading to a higher insect abundance (Mattson 2002; Beeman and Pelton 1980). On top of this, there is a documented relationship between canopy density and the types of fruiting plants that are able to survive (Noyce and Coy 1990; Chambers et al. 1996) that could play a role in habitat selection by bears. In forests that have 70-100% canopy cover, there are many fruiting plants that thrive including (but not limited to): dogwood (*Cornus alternifolia* L.f.), common red raspberry (*Rubus idaeus*), American fly honeysuckle (*Lonicera canadensis*) and thick-leaved wild strawberry (*Fragaria virginiana* Duchesne) (Coady 2005). Beyond the drive to find calorie-rich foods, dense forests provide many places for a cubs to rest and remain protected while accompanying their mother; female bears with cubs tend to prefer dense forests over sparse stands for this read (Rogers 1993).

In contrast to the aforementioned paper, in a study conducted in northeastern Minnesota it was concluded that American Black Bear activities in the spring to early summer relied more heavily on wetlands and marshes (Rogers 1987). There are many benefits within marshes and wetlands accessible to a bear. Like a dense forest, it is possible that the sources of food available within a marsh or wetland are the primary reason for a black bear using it. For example, plants that grow around the perimeter of a wetland or marsh early in the spring have a higher protein content and low cellulose content (Rogers 1987; Romain 1996) which would be useful to a bear due to their inability to digest cellulose (Kolenosky and Strathearn 1987). Beyond plants that are early in their growth stage, marshes and wetlands are rich with invertebrate organisms which could act as a further source of protein for bears (Newmaster et al. 1997). Although not studied, it is possible that this stark difference in spring to early summer habitat selection is dependent on what habitat is available to the bear.

In the late summer to fall season, there is a difference in food sources available to a bear; the habitat selection by bears follows accordingly. As stated by Obbard et al. (2010), the studied specimens chose dense deciduous forests rather than mixed forests. Within a dense deciduous stand there is a higher occurrence of many of the important foods that bears rely on to store fat before the winter season including: acorns, beechnuts, feral apples and many more (Obbard et al. 2010). Dense deciduous forests also have many of the hardwood tree species that female black bears seek out in order to provide enough energy for herself as well as the production of milk for her cub(s) (Jonkel and Cowan 1971; Rogers 1987). Beyond the need to find high-calorie foods, bears that endure severe winter weather conditions prefer to den in large, hollow trees that can be found within dense deciduous forests (Johnson and Pelton 1981; Pelton 1986; Weaver et al. 1990).

Obbard et al. (2010) also recognized that there is an important role for areas that have been disturbed within the range of an American Black Bear. Although it was concluded that the bears did not choose a home-range to include a disturbed area, if they happened to exist within their established range then they made use of them. Generally, bears avoided roads during the spring to summer seasons when traffic was heavier due to tourists and cottage vacationers. However, there are many foods that are eaten by bears that grow along road margins (Beringer et al. 1990; Hellgren et al. 1991; Romain 1996) and when traffic becomes lighter in the summer to fall months it is possible that bears will travel along roads and forage for these foods (Chambers et al. 1996). Pastures and croplands provide a source for nutrition including corn, wheat and soybeans (Maddrey 1995) and although not commonly used young bears will forage within them, particularly in the late summer to fall season (Obbard et al. 2010).

2.2.4 Home Range Size and Minimum Area Needs

There are many factors that influence the home range size of an American Black Bear. Male bears have larger ranges than females (Pelton 1982; Powell et al. 1997). Powell et al. (1997) hypothesized that differences in male home ranges could be the result of the higher or lower female population density. On the other hand, female bear home range size could be easily related to habitat productivity and quality (Koehler and Pierce 2003). After tracking the home ranges of bears in three different locations, Koehler and Pierce (2003) found that ranges varied extensively depending on habitat location. They found that male bears had an average home range of 8,080 ± 6,920 ha, whereas the female bears' home range was found to be an average of 2,140 ± 1,550 ha.

In another study (Hellgren and Vaughan 1990) it was estimated that female American Black Bears require a home range of between 550 and 10,540 ha, while male bears require a home range of between 1,680 and 42,760 ha They concluded that the main factor influencing American Black Bear home ranges was the availability of food sources. However, in another study it was concluded that habitat fragmentation can also lead to large differences in home ranges. Mollohan and LeCount (1989) determined that while the average home ranges for female and male bears were 4000 and 19,400 ha respectively, in fragmented areas the average home ranges for male and female bears increased to 10,400 ha and 60,900 ha respectively. Although not extensively studied, it is possible that the habitat fragmentation led to a diminished amount of nutrition for bears and that this is the cause of larger home ranges in fragmented areas.

In terms of supporting an American Black Bear population, it is important to note that rather than considering home range size, we may instead consider a minimum area need. A viable population (as defined by Shaffer 1981) is the smallest isolated population that has a higher than 95% chance of persisting for over 100 years; in a broad-reaching study it was concluded by Thomas (1990) that at least 1000 animals are necessary to maintain a genetically diverse population. For the purposes of this paper, two different outlooks on measuring minimum area needs will be observed. In a study examining already studied areas that contained viable American Black Bear populations (Pelton 1991), it was concluded that a 32,000 ha area of forested wetland or 80,000 ha of forested uplands is required to sustain a population. Hellgren and Vaughan (1990) studied the amount of area required for 50, 200 and 1000 bears and determined that for these different population sizes, 75,800 - 83,300 ha, 30,300 - 33,300 ha and 152,000 - 1,670,000 ha of habitat are required respectively.

2.3 Blanding's Turtle

2.3.1 Significance and Location

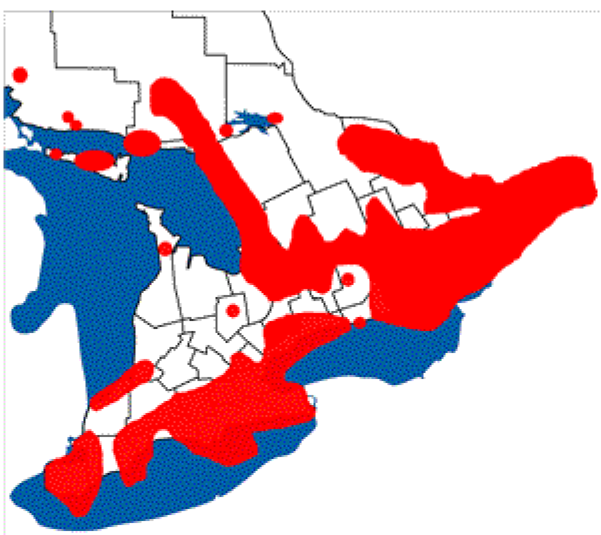

Figure 2. Distribution of Blanding's Turtle (*Emydoidea blandiggi*) in Ontario (ROM, unreferenced, see "Notes").

Blanding's Turtle is a suitable indicator species for determining the health and viability of wetland habitats in Ontario. It is a small turtle species which has high sensitivity to habitat changes and requires very specific environmental characteristics in its preferred habitat (Hartwig et al. 2007). They inhabit temperate wetlands of North America from the Midwestern United States to Nova Scotia (Innes et al. 2008, see Figure 2 for distribution in Ontario). This species does not usually overwinter in the same habitat for two consecutive winters; overwintering happens roughly 38% of the time (Innes et al. 2008). An average clutch of turtles contains 10.6 eggs; after an incubation time of 80 - 128 days the eggs will hatch, usually in the early fall (Standing et al. 1999). However, in northern populations roughly 50 - 75% of clutches contain unhatched eggs; after correcting for predation it appears cool temperatures and nest flooding are the major causes (Standing et al. 1999). Female nesting patterns near roads can lead to increased mortality with an average annual survivorship of 59% for females and 90% for males (Ruane et al. 2008). Due to these and other factors affecting the integrity of local wetlands, the Great Lakes and St. Lawrence region populations of the Blanding's Turtle are currently listed as 'Threatened' under Schedule 1 of SARA in Canada (GOC 2011). The Ontario population of the Blanding's Turtle have been classified as 'Threatened' by COSEWIC since its last assessment in May 2005 (GOC 2011). Therefore, if a wetland in the Muskoka watershed can support a threatened species such as the Blanding's Turtle, it is reasonable to believe that it is a healthy, productive wildlife habitat for additional species.

2.3.2 Habitat Type

Blanding's Turtles have been found to have a strong preference for specific conditions in their environment; it is important that these are not overlooked in conservation efforts. The wetlands that would best sustain this species contain muck substrates and abundant vegetation of many types covering over 80% of the area (Hartwig et al. 2007). Buttonbush (*Cephalanthus occidentalis*) was the most common vegetation in areas where Blanding's Turtles are found at a 29% mean cover (Hartwig et al. 2007). Blanding's Turtles also need plentiful basking areas where they can maintain their body temperature, floating vegetation in the ponds and wet areas with shallow water of 30 cm depth (Hartwig et al. 2007). They are most active in water above 10°C upon coming out of dormancy, but in the heat of summer sightings decrease when water is warmer than 30°C (Rowe et al. 1991). Usage patterns in studied wetlands indicate that turtles require complex, interconnected habitats (Hartwig et al. 2007). In short, a constructed wetland made as a habitat for Blanding's Turtles will require careful planning to meet their environmental needs. Due to the extensive wetland coverage in the region this species makes an excellent indicator for the health of wetland environments such as those found in the Muskoka watershed.

2.3.3 Home Range

The Blanding's Turtle has core home ranges measured from 1.6 - 3.6 ha and although they may travel from 3.7 - 12.5 ha to reach overwintering sites, typical activity rarely exceeds 2 ha. These ranges were found from a study conducted by Innes et al. (2008) of an intermediate range population of Blanding's Turtle in the eastern United States. As far as the turtle's annual activity, they are typically most active between March and November (Rowe et al. 1991), coinciding with winter dormancy which ends as the temperatures rise in spring and begins in the late fall. Daily aquatic movement ranges from 1 - 230 m per day with males typically moving significantly more than females (Rowe et al. 1991). These turtles are primarily aquatic and most terrestrial activity occurs in the spring and consists typically of short journeys between ponds or when a female leaves for a nesting place (Rowe et al. 1991). They usually prefer to use cobblestone beaches for nesting as it provides the best conditions (Standing et al. 1999). The peak movement time of female turtles is around June which coincides with the mating season, while for males it is later in the summer (Innes et al. 2008). Breeding and nesting season typically occurs from mid-June to early July however about 80% of nesting occurs in just 10 days in late June (Standing et al. 1999). It has been found that about 73% of turtles will use the same nest area in subsequent years but that 67.9% females do not nest annually, and when they do, they will never produce more than one clutch in a season (Standing et al. 1999). As nesting habits and activity information are important factors in the survivability of any species, this information should prove useful in the conservation of the Blanding's Turtle.

2.4 Eastern Massasauga Rattlesnake

2.4.1 Significance and Location

The Eastern Massasauga Rattlesnake was classified as ‘Threatened’ as of its last COSEWIC assessment in November 2002 and is currently listed as ‘Threatened’ under Schedule 1 of SARA (GOC 2011). Additionally, the Eastern Massasauga Rattlesnake is listed as a ‘Specially Protected Reptile’ under the Ontario Fish and Wildlife Conservation Act. Threats to the Eastern Massasauga Rattlesnake include a decline in quantity and quality of habitat, increasing fragmentation of habitat, increasing high mortality on roads, small numbers and isolated populations, slow rate of reproduction and delayed maturity and persecution by people (Rouse and Willson 2002). The Canada National Parks Act offers protection to the populations found within the Georgian Bay Islands and Bruce Peninsula National Parks (GOC 2011).

The Eastern Massasauga Rattlesnake occurs in the states of Illinois, Indiana, Iowa, Michigan, Minnesota, Missouri, New York, Ohio, Pennsylvania and Wisconsin, as well as in the province of Ontario (Johnson et al. 2000). Within Ontario, populations are located in central and south-western areas at: (1) the eastern shores of Georgian Bay; (2) the Bruce Peninsula; (3) an area near Windsor and (4) the Wainfleet Bog on the northeast shore of Lake Erie (GOC 2011, see Figure 3). These populations are disjunct and are of unequal size and extent (Prior et al. 2000). The Georgian Bay population ranges from near Port Severn ON north to Killarney ON and is approximately 5,484 km^2 (Rouse and Willson 2002). The relative size of the four Eastern Massasauga Rattlesnake populations in Ontario can be approximated from the quantity of habitat at each site. The Georgian Bay population is most likely to contain the greatest number of snakes, followed by the Bruce Peninsula population. The sizes of the southern Ontario populations are much smaller than the above populations (Rouse and Willson 2002).

2.4.2 Habitat Type

The Eastern Massasauga Rattlesnake inhabits many different habitats across their range. According to Harvey and Weatherhead (2006a), Eastern Massasauga Rattlesnakes on the Upper Bruce Peninsula are best described as habitat generalists that use open, wetland, sparse forest, dense coniferous forest, and dense deciduous forest habitats. Likewise Weatherhead and Prior (1992) found that Eastern Massasauga Rattlesnakes exhibited nonrandom use of habitat and strongly associated with wetlands and coniferous forests and avoided open areas, such as roads and trails, open water, and mixed forests. Therefore, in order to minimize human interaction with Eastern Massasauga Rattlesnakes, individuals should stay in open areas. They also found

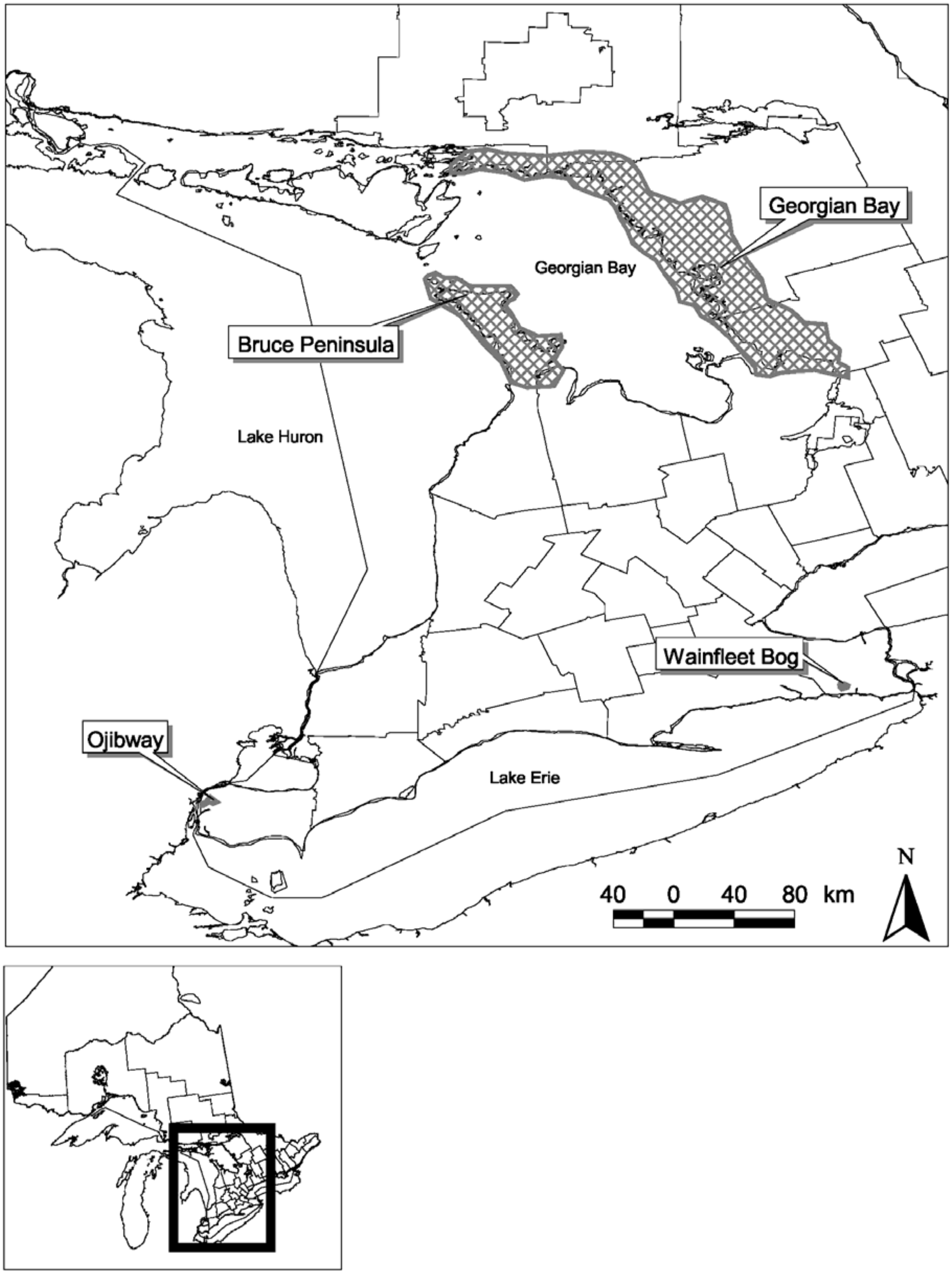

Figure 3. Distribution of the Eastern Massasauga Rattlesnake (*Sistrurus catenatus*) in Ontario based on records from the Natural Heritage Information Centre (Rouse and Willson 2002).

that hibernation sites occurred in wetland and coniferous forest habitat. Further reviews of many published habitat descriptions for the Eastern Massasauga Rattlesnake have shown that they prefer open, low-lying habitats and habitats in the vicinity of wetlands (Wright AH and Wright AA 1957; Klauber 1972).

All of these habitats possess distinct microhabitats exhibiting physical similarities. For example, granite table rocks situated in rock barrens in Georgian Bay offer similar daily temperatures to gestating females as mounds of rotting vegetation or brush piles found in old fields or prairies (Rouse and Willson 2002). Harvey and Weatherhead (2006a) looked at four years of telemetry data from 34 Eastern Massasauga Rattlesnake individuals and determined that, at the microhabitat scale, snakes prefer using locations with close retreat sites and shrub. They found that gravid females used sites with more rock cover and less canopy closure than sites used by males and nongravid females and that individuals preferred forested habitats for hibernation and steadily increased their use of open and wetland habitats to a peak in mid-summer. Conversely, Johnson et al. (2000) found that populations of Eastern Massasauga Rattlesnakes used wetland habitats to hibernate. Therefore, in order to minimize human interaction with Eastern Massasauga Rattlesnakes, areas located near wetland habitats, particularly those surrounded by coniferous forest, should be protected (Weatherhead and Prior 1992).

2.4.3 Habitat Characteristics

The Eastern Massasauga Rattlesnake prefers an environment with an open vegetative structure (Johnson et al. 2000). This is because snakes are dependent on patches of open-canopy habitat for thermoregulation. The Eastern Massasauga Rattlesnake requires semi-open habitat that provides cover from biotic and abiotic threats while also providing thermoregulatory opportunities necessary for critical activities, such as digestion and gestation (Rouse and Willson 2002). A study conducted by Moore and Gillingham (2006) used radio telemetry and geographic information systems (GIS) to investigate the habitat selection by Eastern Massasauga Rattlesnakes from 2003 to 2004 at an 815 ha fen preserve located in southeastern Michigan, USA. The populations exhibited complex microhabitat selection based on multiple climatic and structural variables such as soil temperatures, relative humidity, canopy cover, and litter depth. They found that during the summer months Eastern Massasauga Rattlesnakes are found in open-canopied microhabitats with a high percentage of surface vegetation, a deep litter layer, and sufficient ground cover. This is because warmth and camouflage potential are key determinants of basking-site quality (Shoemaker and Gibbs 2010). The basking sites are used to increase body temperature and once the snakes have achieved their optimum core temperature they retreat into more camouflaging microhabitats (Shoemaker and Gibbs 2010). It was also found that Eastern Massasauga Rattlesnakes actively established home ranges in areas with disproportionate quantities of wetland and all human-altered landscapes were rarely used, even though they were available.

Eastern Massasauga Rattlesnakes overwinter in damp or water-saturated sites (Rouse and Willson 2002). They look for areas with a close proximity to water and with saturated soil (Johnson et al. 2000). A study conducted by Harvey and Weatherhead (2006b) used three years of radio telemetry to locate 46 hibernation sites of 32 individual Eastern Massasauga Rattlesnakes in the Upper Bruce Peninsula ON. They found that the snakes hibernated individually in old root systems, rodent burrows, and rock crevices in forested areas. It was also found that almost all of the hibernation sites found on the Bruce Peninsula occurred in forests. In contrast, Eastern Massasauga Rattlesnakes in more southern latitudes hibernate in open-canopy wetlands. Studies conducted on the Georgian Bay population of Eastern Massasauga Rattlesnakes could not be found and, therefore, information from the Bruce Peninsula population should be used.

2.4.4 Home Range Size

Studies conducted by Weatherhead and Prior (1992) and Johnson and colleagues (2000) on the Bruce Peninsula population of Eastern Massasauga Rattlesnakes found that the average habitat range size is approximately 25.0 ha. The Weatherhead and Prior (1992) study used radiotelemetry to monitor 12 Eastern Massasauga Rattlesnakes within Bruce Peninsula National

Park (Ontario) for 419 days. Likewise, Durbian et al. (2008) studied the spatial ecology of 87 Eastern Massasauga Rattlesnakes at two sites in Wisconsin and three sites in Missouri over an 11 year period using radiotelemetry. It was determined that a minimum home range size of 100 ha is required for these populations. Studies conducted in a peninsular population of Eastern Massasauga Rattlesnakes in Killbear Provincial Park, Ontario, show that males and nongravid females can move within an area of up to 500 m by 1000 m in any one active season. Males and non-gravid females within a study population further inland from Georgian Bay have shown activity ranges up to 1000 m by 2000 m (Rouse and Willson 2002).

It is suggested that the average male activity range of the nearest known population should be used to estimate the home range size of the Eastern Massasauga Rattlesnake as studies suggest that male snakes use the largest ranges and show the greatest range lengths (Johnson et al. 2000; Weatherhead and Prior 1992). Therefore, home ranges between 25.0 ha and 200 ha should be considered for Muskoka.

2.5 Eastern Hognose Snake

2.5.1 Significance and Location

The Eastern Hognose Snake is classified as 'Threatened' by COSEWIC as of the last assessment in November 2007 and is listed as 'Threatened' under Schedule 1 of SARA (GOC 2011). A classification of 'Threatened' has also been assigned by COSSARO (MNR 2012). The Eastern Hognose Snake is primarily threatened due to severe habitat fragmentation caused by an expanding road network and increased traffic as well as habitat loss from agricultural and beachfront development (COSEWIC 2007).

The Eastern Hognose Snake is additionally offered protection under the Ontario Fish and Wildlife Conservation Act, 1997 and under the Ontario ESA, 1997 (which also includes the protection of its habitat, GOC 2011). Although it has been difficult to estimate the abundance of the Eastern Hognose Snake due to limited Canadian studies on the species, the total number of

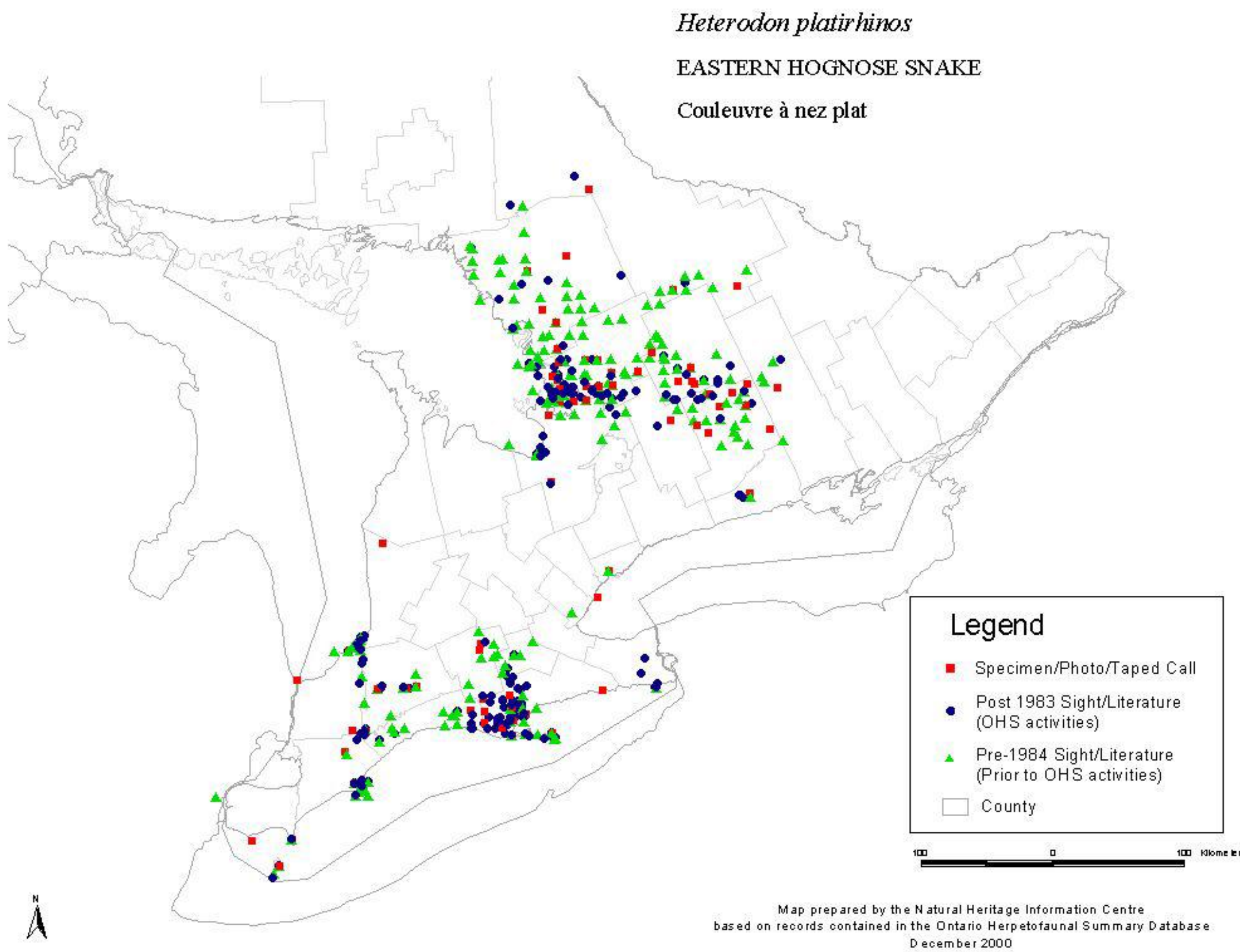

Figure 4. Canadian range map for the Eastern Hognose Snake *(Heterodon platirhinos)*. Red squares: specimen/photo/taped call; blue circles: post-1983 sight/literature; green triangles: pre-1984 sight/literature (COSEWIC 2007).

adult snakes in Canada has been estimated at under 7,500 (GOC 2011).

In the United States the Eastern Hognose Snake can be found from southern New England, western Minnesota, and South Dakota south to Texas and east to Florida; while in Canada it is restricted to Ontario (GOC 2011). Within Ontario, the Eastern Hognose Snake can be found in two main geographic areas: (1) the Carolinian region of southwestern Ontario and (2) the Great-Lakes St. Lawrence region of central Ontario south of the French River and Lake Nipissing and east of Georgian Bay (GOC 2011, see Figure 4). The Eastern Hognose Snake can be found in two National Heritage Protected areas, Georgian Bay Islands and Trent-Severn

Waterway, managed by Parks Canada (COSEWIC 2007). Pinery, Komoka, Rondeau, and Wasaga Beach Provincial Parks are some of the protected areas within Ontario that provide refuge for known populations of the Eastern Hognose Snake (GOC 2011), although these locations may have inadequacies (Cunnington and Cebek 2005; COSEWIC 2007). This is largely due to the protected areas' small size, intensive use by people and vehicle traffic (Kerr and Cihlar 2004; Crowley 2006, cited in COSEWIC 2007).

2.5.2 Habitat Type

According to Platt (1969), there are five key physical features of an optimum habitat for the Eastern Hognose Snake: (1) well-drained soil; (2) loose or sandy surface soil; (3) open vegetative cover such as open woods, brushland, forest edge, or disturbed sites; (4) proximity to water; and (5) climatic conditions typical of the eastern deciduous forest biome. This has been reflected widely in the literature as the ideal habitat for both nesting and survival (Michener and Lazell 1989; Burger and Zappalorti 1986 in Cunnington and Cebek 2005; Cunnington and Cebek 2005; Plummer and Mills 2000; Lagory et al. 2009).

In a recent study Lagory and colleagues (2009) examined the scale-dependent resource use of Eastern Hognose Snakes at the New Boston Air Force Station (NBAFS) in southern New Hampshire, as habitats can be heterogeneous across multiple scales. Three primary hierarchical orders of resource selection exist as follows: (1) selection of a physical or geographical range (first order); (2) selection of a home range within a landscape (second order) and (3) selection of specific locations within the home range (third order) (Johnson 1980). It was found Eastern Hognose snakes overused old field and forest edge habitats at the landscape scale, while forested habitats and wetlands were underused compared to their availability (Lagory et al. 2009). Developed areas were used as expected; greater than forest habitats, significantly greater than wetland habitat but less than forest-edge habitats and significantly less than old-field habitats.

Confirmation can be provided for this preference for Eastern Hognose Snakes south of Parry Sound with a telemetry study by Rouse (2006) finding that grass (meadows), sand, forest habitats and human impacted areas (e.g. private dwellings, trailer parks, and sand/gravel pits) were preferred over rock and wetlands at the landscape scale. However, this should be interpreted with caution as although no statistical difference was found between the first four categories, rank ordering showed preference from greatest to least to be grass, sand, forest, human impacted areas, wetlands and rock. Likewise, Plummer and Mills (2000) found resident snakes at their study area in the easternmost part of the Arkansas River Valley of the Ouachita Mountain region of Arkansas to be associated with macrohabitats of grass growth for 91% of locations, including open forest, field, oldfield, clearing, road or trail. The grassy areas accounted for 68.3% of the microhabitats and contained various amounts of leaf litter, herbs, and shrubs.

Platt's (1969) study sites at Harvey County Park and Graber Pasture in Kansas where populations of Eastern Hognose snakes were found were associated with grassland communities. The Harvey County Park location was at the edge of a mixed grass prairie and consisted of a dense cover of moderately tall upland, climax grasslands, weedy grasslands, and weedy communities. In contrast, Gaber Pasture was heavily grazed with a low and sparse vegetative cover of a Weedy Upland Grass community. This agrees with Lagory et al. (2009) findings that the snakes chose habitats with a greater percentage of graminoids in the herbaceous layer. Inactive Eastern Hognose Snakes and those released have been documented to be hidden under or coiled at the base of a clump of grass or shrub (Platt 1969; Plummer and Mills 2000). For active Eastern Hognose Snakes the most characteristic microhabitat is to be crawling through the grass (Plummer and Mills 2000).

The type of plant climax community can be an important direct and indirect factor affecting the distribution of Hognose (Platt 1969). Open habitats, such as that of old-field and forest edge likely provide the optimal thermal conditions for nesting and survival as it allows for high levels of sunlight penetration (Platt 1969; Burger and Zappalorti 1986 cited in Cunnington and Cebek 2005; Seigel and Collins 1993, cited in Lagory et al. 2009; Rouse 2006; Lagory et al. 2009). This supports the theory that thermoregulation is the primary driver for snake habitat selection (Seigel and Collins 1993, cited in Lagory et al. 2009) and is especially important to consider at the northern limit of the species range, in order to provide good hatching success (Cunnington and Cebek 2005). Cunnington and Cebek (2005) measured mean nest temperatures to be 23.4 to 26.1°C at their Blueberry Plains study site of Wasaga Beach Provincial Park.

Despite having a preference for open areas, some exceptions have been found. Plummer and Mills (2000) found one snake in their study to spend time in a closed forest. Platt (1969) also state that the Eastern Hognose Snake is most abundant and widespread in deciduous forest communities of eastern North America including: Southern Mixed Forest, Oak-Hickory Pine Forest, Oak-Hickory Forest, Mixed Mesophytic Forest and in parts of the Appalachian Oak Forest. However, it is likely this is in reference to the climatic conditions and that snakes are found on the edge or in open areas of these locations. Lagory et al. (2009) described their NBAFS site to be mostly forested (86%), dominated by conifers such as white pine and eastern hemlock, however snakes were predominantly found to occupy the old field and forest edge habitats at this site. Similarly, Michener and Lazell (1989) noted New Hampshire populations of the Eastern Hognose Snake occupied habitats dominated by white pine; although these were typically sandy sites. Eastern Hognose Snakes have also been found in abundance in sandy regions of Coastal Plain, such as the New Jersey Pine Barrens (Platt 1969; Michener and Lazell 1989). On the peninsula of southern Ontario Eastern Hognose Snakes have also been present in Oak Savanna and Beach-Maple Forest, extending northward into the Northern Hardwoods Forest and Great Lakes Pine Forest (Platt 1969; Cunnington and Cebek 2005).

At both the home range and landscape scale, sites with sandy loam were overused by the Eastern Hognose Snake, with exposed rock, hydric soil, and gravelly loam sites being underused at the NBAFS (Lagory et al. 2009). Observations based on study site locations would also indicate a preference to sandy soils. Platt's (1969) study sites at Harvey County Park and Graber Pasture in Kansas were located on a strip of sand dunes consisting of medium-fine sand many feet deep, with little organic matter or soil development. Similarly, Cunnington and Cebek's (2005) Blueberry Plains study site was located on network of parabolic sand dunes. The soil at the study site of Plummer and Mills (2000) site was described as loose, sandy, thin, and often rocky.

Sandy soils are of great importance to fossorial species, such as the Eastern Hognose Snake (Burger and Zappalorti 1991; Lagory et al. 2009). Burrows may be used for many purposes including to escape pursuit in field, to capture prey, and for nesting (Evermann and Clark 1915; Platt 1969; Cunnington and Cebek 2005), although egg-laying may also occur within small depressions in the soil, under rocks, in mammal burrows, or in sawdust piles (Ernst CH and Ernst EV 2003, cited in Cunnington and Cebek 2005). Nests at Wasaga Beach Provincial Park were found to be between 10 - 14 cm below the surface (Cunnington and Cebek 2005), with some indication that burrows may be as deep as 20 cm (Platt 1969). Burrows may also be used for hibernation from October to April, depending on the availability of an acceptable pre-existing burrow (Plummer 2002, cited in COSEWIC 2007).

The availability of sandy soil can act as a strong limiting factor on the distribution of the Eastern Hognose Snake (Platt 1969; Cunnington and Cebek 2005; Lagory et al. 2009). Lagory et al. (2009) noted this problem at the NBAFS which had an abundance of rocky areas and gravelly soils. Cunnington and Cebek (2005) found that sandy sites with adequate sunlight required for oviposition of the Eastern Hognose Snake only accounted for 1.3% of their 1320 ha study site at Wasaga Beach Provincial Park. The soil preference for the Eastern Hognose Snake adds additional pressure as it is ideal for agricultural practices and beach/water related recreation (COSEWIC 2007). Although sandy soils are the dominate type, Eastern Hognose snakes have also been reported on clay, loam, and rocky soils (Platt 1969). In regions where soils are less suitable for burrowing, the snakes may use burrows of other animals (Platt 1969).

Eastern Hognose snakes are unlikely to be found within swamps or poorly drained areas, but are often found in close proximity to water bodies including lakes, rivers, wetlands and floodplains (Platt 1969; Plummer and Mills 2000). This is likely due to the abundance of amphibians at these locations, which are an important part of the Eastern Hognose Snake diet (Platt 1969). Eastern Hognose Snakes are prey specialist on toads (*Bufo spp.*) (COSEWIC 2007), and as noted by Lazell and Michener (1976, cited in Michener and Lazell 1989) the abundance of toads may influence the distribution of these snakes. In regions with an abundance of wetlands, the proximity to water may not have an impact on the distribution of Eastern Hognose Snakes (Lagory et al. 2009).

2.5.3 Habitat Characteristics

Unlike most snakes, it is found that the Eastern Hognose Snake will only seek shelter under logs, boards, rocks, and debris on occasion (Platt 1969; Plummer and Mills 2000). Plummer and Mills (2000) found that taking refuge under surface objects only accounted for 0.17% of locations in their study, despite an abundance of microhabitats formed by logs, rocks and human related litter (including cardboard, plywood, etc.) within the study area. In shoreline areas of beach and beach dune habitats it has been noted Eastern Hognose Snakes will make use of ground cover such as driftwood to hide from their prey (Seburn 2005, cited in COSEWIC 2007).

Lower slopes have been found to be preferred by the Eastern Hognose Snake at the landscape scale, which may be due to the lower energy expenditure required (Lagory et al. 2009). Nesting sites have generally been found on small rises with a south-east aspect (Cunnington and Cebek 2005). Southern facing aspects would provide a thermal advantage in the northern hemisphere and if such sites with sandy soils are available, the Eastern Hognose Snake may be able to extend its range into areas further north (Brooks et al. 2003) than its typical 120-day-frost-free-period (Schueler 1997, cited in COSEWIC 2007) or 2100 Annual Crop Heat Units (OMAFRA, cited in COSWEIC 2007, unreferenced, see “Notes”) cut-off.

2.5.4 Home Range Size

The Eastern Hognose snake is considered to be highly mobile for a snake (COSEWIC 2007), with its greatest activity observed in spring and fall, coinciding with the mating seasons (Platt 1969; Gibbons and Semlitsch 1987, cited in Plummer and Mills 2000; Plummer and Mills 1996). Mean movement of the Eastern Hognose Snake has even been found to be more than twice that of the Western Hognose Snake (*Heterodon nasicus*, Platt 1969). Movements in a single day can reach 100 m or greater (Plummer and Mills 2000; Cunnington 2004a, cited in COSEWIC 2007)

A home range size that varies from 21.4 – 72.8 ha was found by Plummer and Mills (2000) for the Eastern Hognose Snake. Although, a reported home range size for a male Eastern Hognose Snake of 91.6 ha demonstrates larger home range sizes may occur (Lagory et al. 2009), with Cunnington (2004b, cited in COSEWIC 2007) suggesting adult snakes can reach home ranges of over 100 ha. Typically, males have been reported to have a larger home range size than female snakes (Brito 2003; Marshall et al. 2006; Richardson et al. 2006) as movement of female snakes may be restricted to areas of optimal thermal quality for egg development (Marshall et al. 2006; Row and Blouin-Demers 2006, cited in Lagory et al. 2009). This can be observed from the smaller mean home range size found for 7 females, of 46.0 ± 15.6 ha (Lagory et al. 2009). Although sex-based differences have been documented, it should be noted Lagory et al. (2009) found no relationship between snake mass and home range size.

Mean home range size of both sexes has been calculated using minimum convex polygons to be 51.7 ± 14.7 ha by Lagory et al. (2009) and 50.2 ± 6.4 ha by Plummer and Mills (2000). These mean values are larger than any of the home range sizes determined in a review of 45 studies spanning 33 snake species by MacCartney et al. (1988) with the exception of the Timber Rattlesnake (*Crotalus horridus,* 56.9-207.4 ha). The Diamond Python (*Morelia spilota*, males 52 ha; Slip and Shine 1988, cited in Plummer and Mills 2000) and the Whip Snake (*Mastiphocis flagellum*, 53 ha; Secor 1992, cited in Plummer and Mills 2000) have been found to have roughly the same mean home range size as the Eastern Hognose Snake.

Plummer and Mills' (2000) time series analysis supports the notion of a single, well-defined area for the home ranges of Eastern Hognose Snakes. Plummer and Mills (2000) also noted home range size, location, and use were often similar for resident snakes in successive years.

Extensive overlap has been observed with the home ranges of the Eastern Hognose Snake and taking this into account Plummer and Mills (2000) found the "combined" home range, calculated as the sum of non-overlapping portions, averaged 41.9 ± 7.1 ha, 89.1% of the mean estimate for home range size in their study.

Mean core area size, which examines concentrated activity and therefore has limited influence from extreme or irregular movements unlike the minimum convex polygons, was calculated using 50% fixed kernels as 6.5 ± 1.4 ha by Lagory et al. (2009). Other studies have observed similar patterns in core habitat use among snakes (Richardson et al. 2006).

3.0 RECOMMENDATIONS

3.1 Discussion of Results

Based on the above findings from the literature, three clear habitat types of forests, wetlands and open areas can be represented by the selected species. Ideal representation is as follows: the American Black Bear for forested habitats, the Blanding's Turtle for wetland habitats, and the Eastern Hognose Snake for open areas (discussed in detail below). The Eastern Massasauga Rattlesnake is a generalist species, with connections to forested sites, wetlands, and open areas (Harvey and Weatherhead 2006a), and therefore habitat preserved for the selected species should enable protection of the Eastern Massasauga Rattlesnake. The deer-wolf relationship is dependent on dense mixed and successional forests, but the area required varies with the season and density of each interacting species, so it is unclear whether the needs of the American Black Bear will encompass that of the deer-wolf relationship.

Home ranges of the species associated with the given habitat can be used as an indication of the appropriate size for the large natural areas of that habitat type to be maintained in order to support a functioning ecosystem. Where possible, the maximum average value of the male home range size as found in the literature was used to provide a conservative estimate of habitat size needed (personal contact, unreferenced, see “Notes”). This was chosen as: (1) average values act to limit the effect of large outliers that may be observed with use of a maximum value; and (2) generally males have larger home ranges than females of a species; this was documented for the America Black Bear, the Eastern Massasauga Rattlesnake and the Eastern Hognose Snake. Home ranges for the females, or average home ranges including the females, would not account for the larger spatial needs of the males.

In the subsequent sections, no comments can be made in relation to the deer-wolf relationship as no numerical representations of the required area needed to maintain the relationship were found.

3.1.1 Forest Habitat

The American Black Bear can act as a surrogate for the standard size of a large natural area of forest that should remain intact. From the literature the maximum average value for a home range size for male American Black Bears was found to be 19,400 ha (Mollohan and Lecount 1989). Values for home ranges based on fragmentation were excluded from this estimation, as ideally we are examining how large a single patch should be.

The goal of the size of large natural areas for intact forest should reflect the size of 19,400 ha. It should be noted that it has been found that up to 80,000 ha (Pelton 1991) may be required to support a sustainable population of American Black Bears in upland forests, although this number is dependent on the number of bears present (Hellgren and Vaughn 1990). With a smaller home range from 25.0 - 200 ha (Weatherhead and Prior 1992; Johnson et al. 2000), protection of forest habitats to meet standards for American Black Bears would ensure protection of forests for use by the Eastern Massasauga Rattlesnake.

3.1.2 Wetland Habitat

The Blanding's Turtle has proven to be a suitable indicator species and may act as a surrogate for how much wetland cover should remain intact. To err on the side of caution since no average home range value was provided for the Blanding's Turtle, the upper limit for the range of core home ranges of the Blanding's Turtle was selected to estimate the size needed for wetland habitats. Based on this value, large areas of intact wetland should aim to cover 3.6 ha (Innes et al. 2008). It is important to note that both the American Black Bear and Eastern Massasauga Rattlesnake make use of wetlands, primarily for food in spring to early summer (Rogers 1987) and hibernation (Johnson et al. 2000), respectively, and therefore should be taken into consideration when examining sizes of wetlands. A sustainable population of American Black Bears can require 32,000 ha (Pelton 1991) of forested wetlands, although as mentioned above, this may depend on the size of the bear population (Hellgren and Vaughan 1990). The Eastern Hognose Snake also relies on wetlands for its food source (Platt 1969), although with greater wetland cover the importance of proximity to water is lowered (Lagory et al. 2009).

3.1.3 Open Area

The Eastern Hognose Snake can act as a representative of open area habitats, as it is largely dependent on these habitats. Based on a male home range of 91.6 ha (Lagory et al. 2009) for the Eastern Hognose snake, large natural open areas should aim to reach this goal. However, it should be noted that adult Eastern Hognose Snakes can reach home ranges over 100 ha (Cunnington 2004b, cited in COSEWIC 2007) while the Eastern Massasauga Rattlesnake, a generalist which will use open areas, may have a home range up to 200 ha (Johnson et al. 2000; Weatherhead and Prior 1992).

3.2 Comparison to Existing Guidelines

Currently, the only guideline for habitat protection in Ontario is "How Much Habitat is Enough" (Bryan 2004), herein referred to as the guideline, prepared by the Canadian Wildlife Service of Environment Canada. The guideline dictates recommendations as a starting point for the minimum habitat required to support wildlife populations based on the needs of migratory birds. The framework was developed in support of habitat restoration in the Great Lakes Areas of Concern. The guideline states it has been applicable in jurisdictions across Ontario; however there was concern over whether these guidelines would prove to be adequate to develop a starting point for Muskoka standards. When possible, it is always preferred to develop a strategy to cater to local needs.

3.2.1 Forest Habitat

It is recommended under the guideline that 30% forest cover be achieved. As a rough estimate using the size of Muskoka, 476,100 ha (4,761 km^2, unreferenced, see "Notes"), 30% cover would equate to approximately 142,830 ha. As indicated by Pelton (1991), 80,000 ha may be required to support a sustainable population of American Black Bears. The guideline could be considered a reasonable starting point for Muskoka based on the use of American Black Bears as an indicator species. However, the guideline additionally indicates the largest forest patch should be at least 200 ha (minimum 500 m in width) but as indicated by the maximum average value for the home range of the American Black Bear of 19,400 ha, a larger patch size is required. Other local values that have not been considered in this limited review may indicate even larger patch sizes are beneficial.

Additional factors discussed in the guideline outside the scope of this report include: the percent of watershed to be forest covered away from the forest edge; forest shape, proximity to other patches, roles of corridors, and forest cover. As recommended, forest cover should be greater than 10% 100 m away from the forest edge and greater than 5% 200 m away; forest patches should be round or circular to minimize edge habitat; forest patches should be within 2 km of each other; corridors designed for species movement should be 50 m to 100 m in width; and species should reflect the full diversity of forests associated with the given latitude.

3.2.2 Wetland Habitat

It is recommended under the guideline that greater than 10% of each major watershed should be covered in wetland habitat. As a rough estimate using the size of Muskoka, 476,100 ha (4,761km^2, unreferenced, see "Notes"), this would equate to approximately 47,610 ha of wetland cover. Our results concluded that a patch of intact wetland habitat should cover 3.6 ha, while larger animals which make use of wetland habitats, such as American Black Bears, may require 32,000 ha of forested wetland. This would suggest the guideline provides an adequate starting point.

Additionally, the guideline includes further parameters that should be taken into consideration, including amount of vegetation adjacent to the wetland, wetland type, wetland location, wetland size, and wetland shape, which fall outside the scope of this report. To best support wildlife, swamps should be regular shaped to minimize edge and maximize interior habitat; with natural vegetation covering 100 m adjacent to the wetlands for marshes, fens and swamps, and the total catchment area for bogs. Marshes and swamps are the only wetland types suited to widespread rehabilitation, and maximum function will be achieved if they are located at headwater areas or flood plains. It is recommended that a variety of sizes and shapes should be located across a landscape, but based on our findings the minimize size should incorporate the 3.6 ha home range of the Blanding's turtle.

3.2.3 Open Area

Currently, no recommendations are found in the guideline for the minimum viable size of open areas to support wildlife. This enforces the importance of generating one's own guidelines based on local wildlife needs. From the literature value of a home range size for a male Eastern Hognose Snake, a minimum intact area for open habitat of 91.6 ha should be used as a starting point; however based on the literature review it cannot be determined the number of these patches that should be included on the landscape.

3.2.4 Considerations

When following the above suggestions for developing a reference point for the size of large natural areas, two key points should be considered:

- Historical land cover of Muskoka should always take precedent to determine appropriate habitat and ecosystems needs, unless current information suggests these are inadequate (i.e. too low)
- Primary objective should be to maintain existing natural areas that meet minimum habitat requirements; restoration should be second priority

The standards developed above based on the selected species will benefit species designated federally under SARA, a desirable attribute (Bryan 2004).

4.0 CONCLUSION

4.1 Summary

The goal of this paper was to determine the minimum area of forests, wetlands and open fields required to maintain biodiversity in the Muskoka region and to compare these values to previous literature. These goals were accomplished by reviewing peer-reviewed and organizational literature; based on this review an outline of the habitat type and size needs of the deer-wolf relationship as well as the American Black Bear, the Blanding's Turtle, the Eastern Massasauga Rattlesnake and the Eastern Hognose Snake was derived.

It was found that forests require the most amount of area in order to fulfill their role in the livelihood of indicator species and although the literature indicated that wetland and open areas may not need to be as large relative to forested areas, they nevertheless are crucial to the reviewed species and relationship and require conservation. The guidelines prepared by Bryan (2004) provide an adequate starting point for forest and wetland habitat protection in Muskoka however there were no suggestions for open areas in the publication. As is the case with all planning, it is important to consider local wildlife population needs while developing a habitat-protection plan.

4.2 Considerations

Several unforeseen problems were encountered in the preparation of this report.

(1) Difficulties were encountered locating literature pertaining to the southern Ontario populations for some of the reviewed species that discussed their habitat needs. This was rarely the case, however it led to some set-backs and called for a greater time allotment for the literature review than previously scheduled. There was also a gap in the literature as no explicit area requirements for the deer-wolf relationship were found in previous research.

(2) As evident from the literature, controversies exist in Conversation Biology as to what is an appropriate measure of area required for a species. In most studies an average home-range was determined for the species; however in some cases the amount of area needed for a “viable population” as defined by Thomas (1990) and Shaffer (1981) was the final result of the research. This led to difficulties in determining the appropriate size of habitat types to be protected. To remain consistent, the maximum average male home range of a species as found in the literature was used for our recommendations; however this is not a comment on the futility of numbers derived from a study of a viable population.

(3) Relationships between species and habitat type were not clear cut as initially expected, making it arduous to definitively conclude how much area of each land type should be protected. Often, one species was not solely dependent on and representative of one habitat type, but dependant on a mosaic of different habitat types throughout their lives. For example, the American Black Bear, although predominantly associated with forest habitats, also

had connections to wetlands in the spring to early summer (Rogers 1987), while the Massasauga Rattlesnake was defined as a generalist (Harvey and Weatherhead 2006a). This led to difficulties in determining what species was best suited to represent each habitat type, and by extension, the amount of forested, wetland and open area necessary to sustain the indicator species and theoretically, a substantial amount of biodiversity.

4.3 Future Research

There are many possibilities for further research in this area of study. It would be beneficial to conservation authorities and other interested parties to compile literature on any specialist species in the Muskoka region. It may also be useful to research community-based marketing in regards to involving cottage patrons in the protection of important habitats in order to make the recommendations of this report more applicable in a real world setting. It would also be useful to study the amount of each land type used by organisms that are not confined to one land-type. This would enable conservation authorities and other interested parties to make decisions based on more precise information about the different land-types used by the indicator species. Finally, much more research on the deer-wolf dynamic is needed; current research focuses on two separate species and not the relationship. More research of these species in the Muskoka area as it is a unique habitat, joining urban southern Ontario to rural northern Ontario and is quickly changing in population size causing fragmentation.

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An approximate geographic size for Muskoka was provided by Judi Brouse of the Muskoka Watershed Council.

An attempt was made to contact the researchers that had previously conducted work at Wasaga Beach Provincial Park via the park; however no current research is being conducted at the park and the park is no longer in contact with any present day researchers. For information on the Eastern Hognose Snake we were referred to the COSEWIC (2007) document.

Andrew Promaine, Manager of Resource Conservation at Georgian Bay Islands National Park, was consulted in limited e-mail communication for recommendations on the appropriate use of home range. His suggestions were taken into consideration in combination with our professional judgement based on the values available.

Maps of Muskoka and the distribution of Blanding's Turtle in Ontario were obtained from the webpage entitled "Information Resources North Simcoe Muskoka" and the Royal Ontario Museum website, respectively. The latter map was modified from the COSEWIC 2005 report "COSEWIC assessment and update status report on the Blanding's Turtle *Emydoidea blandingii* in Canada".

Information on the Annual Crop Heat Units at the northern portion of the Eastern Hognose Snake range in Ontario was reported by COSEWIC (2007) from www.OMAFRA.on. Not enough information was provided in the secondary source to locate the primary source in its full context.

APPENDIX A: Summary of Results

Table 1. Summary of results of the habitat type, habitat characteristics and approximate home range size of the one species' relationship and four species as found in the literature. Sources: (1) Armstrong et al. 1983 (2) Vigot et al. 1997 (3) Norris et al. 2002 (4) Obbard et al. 2010 (5) Rogers 1993 (6) Rogers 1987 (7) Mollohan and LeCount (1989) (8) Hartwig et al. 2007 (9) Innes et al. 2008 (10) Harvey and Weatherhead 2006 (11) Shoemaker and Gibbs 2010 (12) Weatherhead and Prior 1992 (13) Platt 1969 (14) Lagory et al. 2009.

Species	Habitat Type	Habitat Characteristics	Approximate Home Range Size
Deer-Wolf Relationship	○ Dense mixed forest[1]	○ Foraging for deer[1] ○ Denning for wolves[3]	○ Differs with season and density of each interacting species
	○ Successional forest[2]	○ Large selection of nutrition sources for deer[3]	
American Black Bear (*Ursus americanus*)	○ Dense mixed and deciduous forest[4]	○ Large selection of nutrition sources[4] ○ Protection for cubs[5] ○ Denning[5]	○ 19,400 ha[7]
	○ Wetland[6]	○ Large selection of nutrition sources[6]	
Blanding's Turtle (*Emydoidea blandiggi*)	○ Wetland[8]	○ 80% vegetation cover[8] ○ Basking sites[8] ○ Shallow water[8]	○ 3.6 ha[9]
Eastern Massasauga Rattlesnake (*Sistrurus catenatus*)	○ Open[10]	○ Basking sites[11]	○ 25.0-200 ha[12]
	○ Wetland[10]	○ Camouflage[11] ○ Hibernation[11]	
	○ Coniferous forest[10]	○ Camouflage[11] ○ Hibernation[11]	
Eastern Hognose Snake (*Heterodon platirhinos*)	○ Open (open forest, field, old field, clearing road, trail)[13]	○ Basking sites[13] ○ Dry, sandy soil for burrows[13] ○ Close proximity to water and prey (toads)[13]	○ 91.6 ha[14]