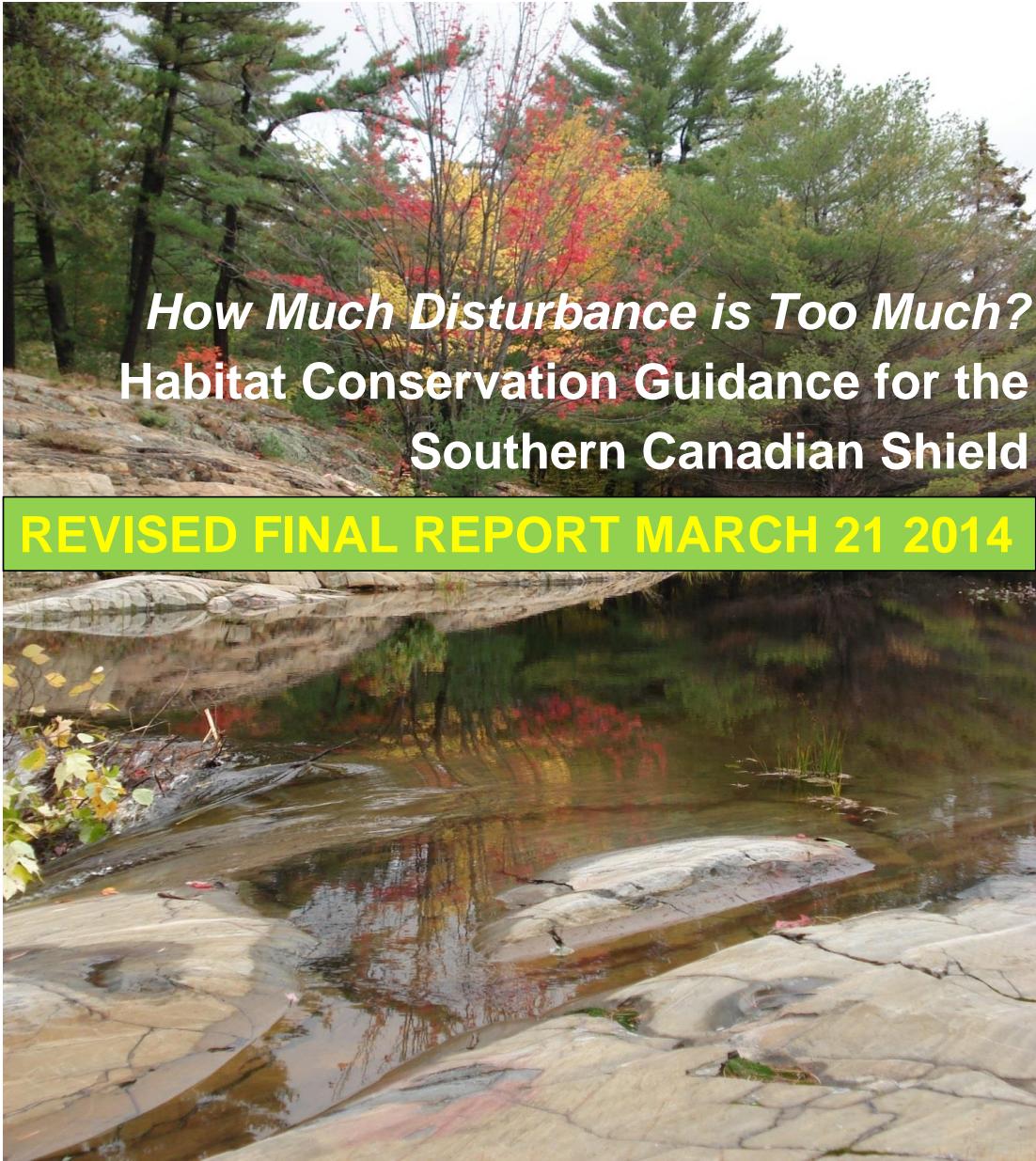




GUIDING SOLUTIONS IN THE
NATURAL ENVIRONMENT



How Much Disturbance is Too Much?
**Habitat Conservation Guidance for the
Southern Canadian Shield**

REVISED FINAL REPORT MARCH 21 2014

DRAFT FOR DISCUSSION ONLY

NOTE:

This unpublished report has been updated by Environment Canada from the final original submitted by Beacon Environmental under contract by Environment Canada in 2012.

This report is intended to initiate discussion as an initial step in providing guidance in regard to the federal biodiversity portfolio in the southern Canadian Shield. **It does not necessarily represent the policy or advice of the federal government** and is no way intended to supplant existing policy, advice or legislation.

It is intended to be in initial release with limited circulation – **if readers wish to circulate further or cite the report they are asked to contact Environment Canada directly.** Likewise, Environment Canada welcomes and encourages comments and review.

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1. Introduction

The Canadian Wildlife Service (CWS) branch of Environment Canada conserves wildlife and habitat under various legislation and agreements such as the *Species at Risk Act* (SARA), *Migratory Birds Convention Act* (MBCA), and *Canada Wildlife Act* (CWA). CWS implements habitat conservation initiatives through regulation, and by facilitating and supporting habitat conservation and stewardship initiatives of partners and other agencies. One effective means of meeting multiple habitat preservation and stewardship mandates is by providing clear guidance, based on the best available science, for the protection, conservation and restoration of wildlife habitat at a landscape scale.

CWS published such a guidance document in 1998 entitled *How Much Habitat is Enough?* The focus of this document was on habitat conservation and restoration in context of the Southern Ontario, and specifically the Great Lakes Restoration Action Plan's Areas of Concern. Since the first publication, these readily understood guidelines have become increasingly cited and used as a basis for target setting and to guide land use planning, habitat restoration, and community action in jurisdictions across Southern Ontario. The popularity of this document, and the importance of keeping the guidelines relevant and reflective of the current best science, resulted in an updates being published in 2004, and 2013. However, no comparable document has ever been developed for the Southern Canadian Shield portion of Ontario, where pressures related primarily to cottage development, have been increasing exponentially over the past decade as the urban areas of Southern Ontario expand and more people turn to nearby Central Ontario as a place to get away for outdoor recreation.

This document is written on the basis of addressing habitat needs for terrestrial species of federal concern. These federal species are embedded within the forests, wetlands and other natural communities that dominate the southern Canadian Shield landscape. Therefore, it is difficult to separate the discussion over the habitat needs of these species from that concerning overall ecosystem integrity and the conservation and planning tools that address that greater ecosystem. In that spirit this report is meant to be a tool to address natural heritage planning and fundamental changes/conversions of land use in terms of urban and peri-urban development. The goal is to foster recognition of the quantity and types of land covers and habitats required for ecological integrity or basic system functions: the subsequent human use of those natural heritage systems/ecosystems, and quality of those systems, through recreation or renewable resource extraction is not the main focus of this report.

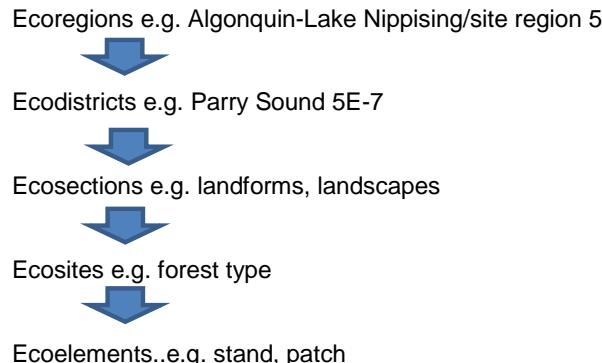
It should be noted that this is report produced under contract to Environment Canada – Canadian Wildlife Service and does not represent policy or advice from Environment Canada but has been produced to foster discussion and represents a first attempt to draw on the current best available science towards developing habitat guidance that is more applicable to Central Ontario.

1.1 Study Scope, Objectives and Limitations

Canada is, for the purposes of ecological land classification, divided into six levels, from the broadest to the most refined:

Ecozones e.g Boreal Shield

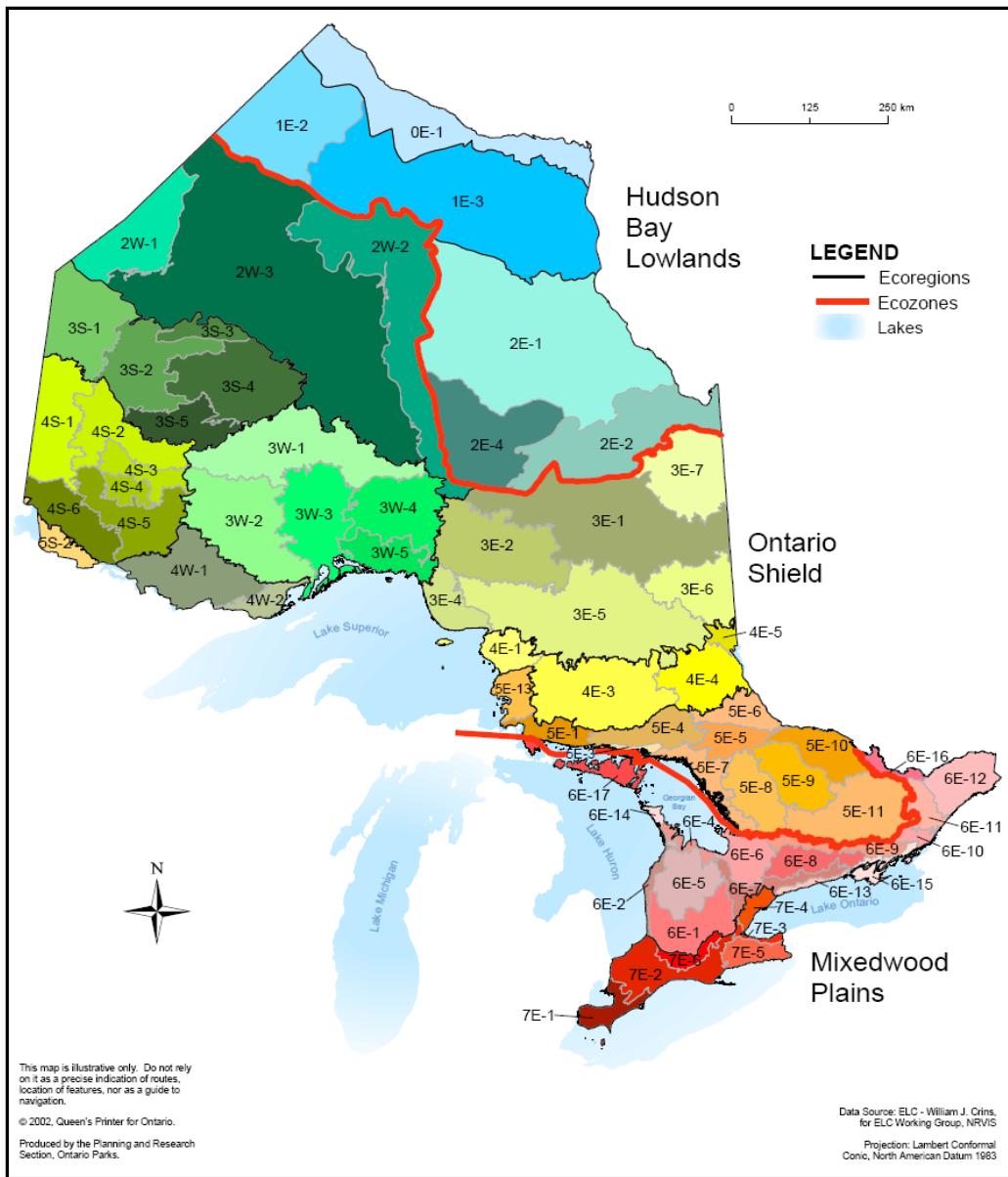




The geographic focus of this report is on the southern portion of the Ontario Shield Ecozone, which is the Georgian Bay Ecoregion (5E) (as described by Crins *et al.* 2009). The Ecodistricts that actually lie along the southern boundary of the Canadian Shield in Ontario are Ecodistricts 5E-7 (Parry Sound), 5E-8 (Huntsville) and 5E-11 (Bancroft) (as described by Henson and Brodribb 2005). These various levels are illustrated in **Figure 1**. This report is intended to inform regional and watershed-scale natural heritage planning. Therefore the emphasis is at the Ecoregion and Ecodistrict level, although some Ecosite types are mentioned in this report to provide local context or illustrate examples of specific habitat types that occur in the area.

This area is also more commonly known as Central Ontario. Its southern boundary follows the Canadian Shield in Ontario from west to east starting north of Port Severn along Georgian Bay, and extending eastwards about as far as the eastern edge of Lake Ontario. While Central Ontario is typically equated with the entire Ecoregion 5E (Chambers *et al.* 1997), the focus of this report is on the following Ecodistricts along the southern boundary of the Canadian Shield (5E-7, 5E-8, 5E-11) where some of the highest levels of extant native wildlife biodiversity, and Species at Risk, occur in the Province (McMurtry *et al.* 2008), and where development pressures related to cottage and recreational development are present. Forestry and its effects were not a focus of this guidance document.

**Figure 1. Map of Federal Ecozones, Ecoregions and Ecodistricts
(from Crins *et al.* 2009)**



The focus of the *How Much Habitat is Enough?* guidelines for southern Ontario has been on how much habitat might be required in order to sustain certain types or levels of biodiversity. However, because the southern Canadian Shield is largely ecologically “intact” (as described in **Sections 1.3 and 1.4** below), the emphasis of this document is on the types of stressors that may threaten the local biodiversity of the area, and at what point impacts to local ecosystems may lead to significant declines of certain species or groups of wildlife.

This report is intended as an initial contribution to discussions concerning wildlife habitat. It can be used as technical guidance related to the following topics:

- Loss of Natural Cover: Riparian Areas and Lakeshores, Forests and Wetlands (**Section 2**)
- Development / Edge Effects into Terrestrial Habitats (**Section 3**)
 - Riparian Areas and Lakeshores
 - Forests
 - Wetlands
- Ecological Effects Associated with Roads (**Section 4**)
- Loss of Habitat Connectivity (**Section 6**)

Each of these topics corresponds to a chapter in this review, and each chapter concludes by providing guidance related to natural heritage planning for each of these topics. The guidance is intended to be as specific and practical as possible, while reflecting the current science.

This review also includes a section (**Section 7**) that discusses a selection of additional current relevant themes in conservation biology in the context of the southern Canadian Shield (i.e., ecological effects associated with recreation, the value of vernal pools and climate change considerations), and a final section that provides an overview of the preliminary guidelines (**Section 8**).

1.2 Literature Search Methodology and Scope

The focus of the literature search was on obtaining relevant peer-reviewed, scientific journal articles. This report has drawn on in-house databases of hundreds of scientific papers, as well as relevant technical reports, selected for recent literature reviews related to forest habitats, wetland habitats, riparian areas, ecological corridors, buffers and edge effects. This literature was supplemented by papers found through additional searches for key words specific to the southern Canadian Shield. Key words used included: habitat, boreal, Canadian shield, central Ontario, riparian, lakeshore, cottages / cottage development, recreation, ecological impacts. In total, several thousand articles were screened, and several hundred were reviewed in detail. In addition, an internet-based search for relevant technical literature involved screening hundreds of links to websites and/or documents made available on-line. A number of these were links to papers already captured through the scientific journal review, but this research did yield a handful of additional papers not captured through the searches on biological science journal databases.

While the papers include some older and more seminal papers, the emphasis of the review is papers published over the last decade or so, and capturing current and emerging trends in landscape ecology and conservation biology.

Start TEXT BOX

Landscape Ecology

The science of studying and understanding the relationships between ecological processes and ecosystems within the environment. Considered at different scales, spatial patterns and organization.

Conservation Biology

The science of studying the nature and status of biodiversity in order to promote the protection of species and their habitats, as well as ecosystems, from extinction and to diminish the rate of attrition of biotic interactions.

END TEXT BOX

The focus of this review is also on broad, landscape scale habitat requirements for species that breed in the southern Canadian Shield, or for species that use habitats in this zone for a critical part of their life cycle. Given the biophysical context of this region (as described in **Section 1.3**), papers favoured for detailed review were generally studies with at least some empirical data collected in eastern temperate North America, as well as studies undertaken in a context where the local matrix is primarily natural as opposed to agricultural or urbanized. However, some additional papers were also included where they provided supporting data on specific topics of interest, or insights considered applicable to the Central Ontario.

Notably, much of the available science on the topics of interest has been conducted in eastern North America south of the Shield where habitats are much more fragmented by urban and agricultural land uses. There are a number of papers that have examined responses of species to certain habitat disturbances on the Canadian Shield. However these studies are largely in the northern and northwestern portions of the Ontario Shield (e.g., Kapuskasing, Thunder Bay), Manitoba or Quebec, which is also not comparable to the southern Canadian Shield from either a biophysical or land use perspective. Therefore, while the overall objective of this review is to discuss specific and practical guidance for natural heritage planning in the southern Canadian Shield at the watershed or regional scale, the guidance must be considered preliminary and subject to refinement as further research and reviews yield more more information and insights specific to the southern portion of the Georgian Bay Ecoregion (5E).

1.3 Biophysical and Land Use Planning Context for the Southern Canadian Shield

Biophysical Context

Ecologically, the southern Canadian Shield is a distinct transition area. From a land use and natural heritage planning perspective it is also a transition area, exhibiting both settlement patterns and municipal planning more associated with the settled landscapes of the Mixedwood Plains and those associated with less fragmented crown land forest to the north. The differences in the types and extent of habitat, and the associated land use pressures and potential impacts, are generally recognized in Ontario planning policy. For example, significant woodlands and valleylands are afforded policy protection under the *Planning Act* only south and east of the Canadian Shield (MMAH 2005).

The geological differences of the landscape from the sedimentary limestone of Southern Ontario to the Precambrian granite of the South Canadian Shield are remarkable and are expressed in the different land uses and extent of natural cover of forest and wetland. The much deeper soils and typically more gentle topography of southern Ontario supports a predominantly agricultural landscape with isolated woodlots and corridors of forest and wetlands. Municipalities that abut the Canadian Shield have a varying extent of forest cover, but it is generally less than 50 percent. In contrast, on the southern Shield very large blocks of continuous natural cover dominate the landscape, with scattered areas of deeper soils that currently or previously supported agriculture. On the whole the southern Shield has a very high percent of natural cover as shown in **Table 1** (98% in 5E-7, 94% in 5E-8, and 93% in 5E-11). The large areas of natural cover provide suitable habitat for large mammals such as wolf (*Canis sp.*) and Moose (*Alces alces*), a high diversity of breeding and migrant birds, and the most abundant and diverse populations of herpetofauna in all of Ontario (McMurtry *et al.* 2008).

**Table 1. Overview of the Ecodistricts of the Southern Canadian Shield
(from Henson and Brodrribb 2005)***

AREA	Ecodistrict 5E-7 (Parry Sound) 625,967 ha	Ecodistrict 5E-8 (Huntsville) 847,130 ha	Ecodistrict 5E-11 (Bancroft) 1,631,205 ha
GENERAL PHYSIOGRAPHY	Predominantly underlain by undifferentiated igneous and metamorphic rock, which is exposed at surface or covered by a discontinuous, thin layer of drift.		
NATURAL COVER	<p>Approximately 98% natural cover, primarily forest.</p> <ul style="list-style-type: none"> ~50% forested areas: upland hardwood and mixed conifer complexes, mixed red and white pine complexes, and tolerant hardwoods ~7% remaining natural cover is wetland, half of which is open muskeg. nearly 80,000 ha of rock outcrops, particularly close to the shores of Georgian Bay (13% cover) 	<p>Approximately 94% natural cover, primarily forest.</p> <ul style="list-style-type: none"> ~ 40% tolerant hardwood forest, majority on bedrock ~15% upland hardwoods and mixed conifer forest ~6% natural cover is wetland ~ 33% of the wetlands are open muskeg ; the remaining are mostly conifer swamps and treed bogs considerable rock outcrops in the southern portion ~ 10% covered by water 	<p>Approximately 93% natural cover, primarily forest.</p> <ul style="list-style-type: none"> ~20% tolerant hardwoods ~22% upland hardwoods and mixed conifers + 9% dominated by oak and oak-pine assemblages ~7% mixed red and white pine ~9% natural cover is wetland, largely deciduous swamps and open muskeg
HUMAN LAND USES	<ul style="list-style-type: none"> +3,000 ha agricultural ~1,000 ha settlement and other developed lands (including Parry Sound) 	<ul style="list-style-type: none"> +21,500 ha agricultural ~6,500 ha settlement and other developed lands (including Gravenhurst and Huntsville) 	<ul style="list-style-type: none"> ~50,000 ha agricultural ~2,000 ha settlement and other developed lands
SPECIES TARGETS	<ul style="list-style-type: none"> Two-thirds of the 47 species of conservation concern in 5E-7 are vascular plants, including many Great Lakes disjuncts. 17 Species at Risk** 	<ul style="list-style-type: none"> Three-quarters of the 28 species of conservation concern are plants, including many Great Lakes disjuncts. Eight Species at Risk** 	<ul style="list-style-type: none"> Nearly two-thirds of the 33 species of conservation concern are plants, including many Great Lakes disjuncts. 19 Species at Risk**

SIGNIFICANT VEGETATION COMMUNITIES	Seventeen of the 47 significant vegetation communities in are globally rare, 26 are provincially rare, and another 17 are considered to be high-quality representative vegetation communities that are important to conservation.	One of the 10 significant vegetation communities identified is globally rare, six are provincially rare, and another four are considered high quality representative communities important to conservation.	Two of the three significant vegetation communities are globally rare, and all three are provincially rare.
EXAMPLES OF UNIQUE SPECIES	Engelmann's Quillwort (<i>Isoetes engelmannii</i>), Massassauga Rattlesnake (<i>Sistrurus catenatus</i>), Five-lined Skink (<i>Eumeces fasciatus</i>)	Butternut (<i>Juglans cinerea</i>), Eastern Hog-nosed Snake (<i>Heterodon platirhinos</i>), Five-lined Skink (<i>Eumeces fasciatus</i>)	American Ginseng (<i>Panax quinquefolius</i>), Five-lined Skink (<i>Eumeces fasciatus</i>)

* These Ecodistrict descriptions are from a document completed by the Nature Conservancy of Canada and the OMNR, and are generally consistent with the Ecodistricts as defined in the most current federal ecological land classification framework for Ontario (Crins *et al.* 2009), but provide more detail than is currently published at the federal level (P. Uhlig, pers. comm., March 2012).

**These numbers are no longer accurate as they are only current to 2005, but provide a general idea of the numbers of Species at Risk in each of these Ecodistricts.

In addition to the high ecological value of large areas of continuous natural cover, one of the particular aspects of the landscape in the southern Canadian Shield is the diversity and interspersion of habitat types. While predominantly forested, much of the southern Canadian Shield supports a habitat mosaic that includes a wide range of open and treed wetlands (open aquatic; shallow aquatic; shallow and meadow marsh; deciduous, mixed, coniferous, and thicket swamp; many fens, and some bogs); with ridges supporting granite rock barrens (open, shrub and treed barrens) and many lakes and rivers (see **Photograph 1 and 2**).

A major factor shaping a dynamic habitat mosaic has been beaver populations. The extent, lifespan and frequency of forest disturbance, wetland and waterbody creation and subsequent open meadow occurrence is greatly influenced by the activities of beavers. Changes that affect beaver food supply – such as the decline in fire and other disturbances that promote the growth of light intolerant plants – can in turn affect the unique and widespread influence beavers have on the landscape.



Photograph 1. Google Earth aerial image of a wetland-rock barren-forest habitat mosaic that is an example of vegetation community diversity in many parts of the southern Canadian Shield.

In areas such as Ecodistrict 5E-7, the southeast-northwest trending rock barren ridges resulting from glaciation, form a dynamic landscape of alternating rock barren ridge habitat, forest in the areas of deeper soils, and various wetlands in the low-lying areas between the ridges. This results in a wide range of vegetation community types, high levels of habitat interspersion and representation of natural edge habitat resulting in high species diversity and many habitat opportunities in a localized and regional context (see **Photograph 3**).



Photograph 2. A wetland-rock barren-forest habitat mosaic that is an example of vegetation community diversity in many parts of the southern Canadian Shield.

As a result of ancient glacial Lake Algonquin, the representation of rock barrens is high in Ecodistrict 5E-7, particularly west of Highway 400 and in municipalities such as Town of Gravenhurst and Township of Muskoka Lakes. Wave action from Lake Algonquin as well as fires that burned through following intensive logging of primary forest have resulted in a high percent of open, shrub, and treed rock barren. This habitat representation along with adjacent organic wetlands and microhabitat features such as rock fissures and cover rocks has resulted in the highest herpetofaunal biodiversity in Canada along the western portion of 5E-7 (Jalava *et al.* 2005). Threatened species such as the Eastern Foxsnake (*Pantherophis gloydi*) and Eastern Massasauga (*Sistrurus catenatus catenatus*) are found specifically in these areas. Similar biodiversity representation including species such as Five-lined Skink (*Eumeces fasciatus*) (Special Concern provincially, Great Lakes/St. Lawrence population found on the Shield is federally listed as Special Concern) is found in other parts of the southern Canadian Shield such as in the Haliburton and the Kawartha regions.



Photograph 3. Example of the complexity of vegetation community habitats along the Georgian Bay coast in Ecodistrict 5E-7.

Land Use Planning Context

Despite the high percentage of natural cover found on the Southern Shield and the many attributes outlined in **Table 1** above, recreational and/or cottage development is resulting in negative impacts across this landscape and better understanding how much disturbance might be too much is very important, although this is a very difficult question to objectively answer..

The landscape character, natural cover and many lakes that represent the southern Canadian Shield area draw for outdoor recreation, as well as second home and shoreline development. In many regions, growth is targeted within designated settlement areas, is relatively dense, and the potential environmental effects are localized to these settlement areas. In contrast, development of seasonal and permanent residences (and supporting infrastructure) along lakes and rivers in the southern Canadian Shield is low density but very widespread across the landscape (typically excluding large Crown Land tracts). Even in the early 1980's Muskoka had substantial variability documented in the extent of habitat disturbance around individual second homes depending on the preferences of the landowner (Racey and Euler 1983); this type of second home development, and associated infrastructure in the form of roads and services has been occurring for almost two centuries in some areas.

However over the past few decades the number and scale of developments has been increasing rapidly, particularly in the western portion of the region (i.e., Muskoka-Parry Sound). In the Muskoka-Parry Sound region nearly all of the larger lakes have significant levels of shoreline development, while many of the medium-sized and smaller lakes have varying levels of shoreline development depending on road access and proportions of Crown Land surrounding the lakes. While Crown Land

may be subject to forestry impacts it is largely free from shoreline development as long as tenure remains in public hands. In many cases, the remaining undeveloped lots have environmental constraints such as fish habitat and/or wetland along the shoreline.

This development has also been accompanied by infrastructure required to support it (e.g., more roads, and widening of existing roads including major highways, clearing for installation of hydro transmission corridors), which has further contributed to the localized and regional (provincial highways) habitat fragmentation and degradation of parts of the southern Canadian Shield. Infrastructure projects such as the ongoing expansion of provincial Highway 400 to Sudbury and Highway 11 to North Bay are examples. And this does not include existing historic and continuing road disturbances associated with logging/forestry.

Traditional recreational activities that have long been popular in these areas (e.g., hiking, nature appreciation, hunting, boating, fishing, cross-country skiing, snowmobiling) persist and expand alongside a range of activities that have gained popularity more recently (e.g., all-terrain vehicles, mountain biking, geocaching). While individually any these activities might not have any measurable ecological effects at the landscape or watershed scale, they are now more widespread and are in association with the expansion of primary and secondary residences in various forms, such as houses and cottages.

With increasing property values, lakefront severances and cottage development pressures have visibly increased further to the east in the Haliburton and Kawartha regions. Because development pressures are increasing in these areas, there are still opportunities to improve the protection and stewardship of sensitive features within the landscape along and adjacent to lakes and rivers that are being developed, and avoid many of the impacts that have resulted from past cottage development (see **Photograph 4**).

Trying to explore and understand the ecological features and functions, sensitivities and potential thresholds of activities that can occur before significant impacts take place at both the local and regional levels can help guide natural heritage and land use planning for this area. Inevitably, given the state of the science today, some of these elements will need to rely on best professional judgements (e.g., recreational carrying capacities)



Photograph 4. Remnant high function shoreline habitat areas in a highly developed shoreline in Muskoka with Northern Map Turtle basking and refuge habitat and Type 1/Type 2 fish habitat.

1.4 Species at Risk and their Habitat on the Southern Canadian Shield

Species at Risk (SAR) have become a priority issue in natural heritage planning over the past decade, primarily because of new legislation both federally (*Species at Risk Act*) and provincially (*Endangered Species Act*) that provides updated mechanisms for listing species and regulates habitat protection for these species.

Depending on the specific region of the southern Canadian Shield, there are approximately 38 species listed as Endangered, Threatened or Special Concern (see **Table 2**). This includes approximately 7 species of plants, 2 insects, 16 birds, 11 reptiles, and 2 mammals. The large number of reptile and birds SAR is noteworthy. In the case of reptiles, the distribution of many of these species, such as the turtles (i.e., Blanding's Turtle, Northern Map Turtle, and Eastern Musk Turtle) is throughout Southern Ontario; however, populations of these species are typically much higher in parts of the South Canadian Shield. The descriptor locally common but provincially rare or at risk is often used to describe the range of these species. For example, in some regions Blanding's Turtles Map Turtles and Musk Turtles are quite common in many sheltered bays along the coast of Georgian Bay or in some of the larger inland lakes such as Lake Muskoka. Eastern Musk turtles can also be very abundant in littoral areas of in many parts of eastern Georgian Bay. In contrast, the highly fragmented landscape in many areas of south of the Canadian Shield simply do not provide the range of habitat requirements needed to support healthy populations of these species.

While the specific causes of decline for bird species found on the southern Canadian Shield that are considered to be Species at Risk varies widely, the large tracts of forest, wetland, and habitat opportunities provides for areas of healthy populations of some at risk species. For example, mixed swamps and riparian zones with a range of vegetation layering and dense understory is are abundant, and provides suitable habitat for Canada Warbler.

For other species such as the Eastern Foxsnake and the Eastern Massasauga, persistence of these species in the southern Canadian Shield is wholly dependent on the unique landscape of the eastern coast of Georgian Bay. Telemetry studies for the foxsnake demonstrate that this snake remains within 1,500 metres of the Georgian Bay shoreline through all stages of its life cycle (MacKinnon 2005). Rock barrens along the coast and immediate inland areas with large flat “table rocks” provide a range of thermal conditions utilized by gestating female Massasaugas and are microhabitats associated with this landscape that are critical to the lifecycle of this species (Rouse 2005). These specialized habitats are not found further south and east of this region.

For many species that are at risk in Ontario, the Southern Canadian Shield is and will continue to be a region critical to the persistence of sustainable populations. The habitat mosaics (forest, wetland, rock barren, and lakes) that are discussed in this report and extent of large areas of connected habitat are the attributes that need to be maintained for such populations to persist.

The federal *Species at Risk Act* came into effect in December 2002. It provides protection to habitat of listed aquatic species and most birds on all lands. However habitat protection for other listed terrestrial species applies primarily to federally owned lands. The practical effects of this Act require the designation of critical habitat.

Ontario's updated *Endangered Species Act, 2007* which came into effect in June 2008, is having a significant influence on natural heritage planning in the southern Canadian Shield jurisdictions. It has broad reaching implications as it applies to all lands (private and public) and general habitat protection is almost immediate for newly listed species and for transitional species specific habitat regulations will be in place by June 2013. In addition so many of the regulated species occur in southern Canadian Shield and their habitats occur almost everywhere. This is partly because this transitional zone between Southern and Central Ontario currently provides habitat for a greater diversity and abundance of some Species at Risk than anywhere else in Ontario (McMurtry *et al.* 2008). This is particularly true for many herpetofauna which are at the northern limit of their range in the southern Canadian Shield but are able to thrive in the complex mixture of wetlands, forests and barrens that dominate this area (see **Photograph 4**).



Photograph 4. Juvenile Northern Map Turtle (Special Concern), Massasauga Provincial Park, May 2006

This review recognizes the importance of protecting habitat for Species at Risk; its focus is on approaches that achieve this in the context of broader watershed or jurisdiction-wide scale planning. This approach may assist land use planners in applying the requirements of the protective legislation in an environment where certain SAR are, in a relative context, locally ubiquitous.

A summary of federally and provincially regulated species that occur in the southern Canadian Shield as of 2010 is provided in **Table 2**, along with their regulated or critical habitats where these have been identified.

Table 2. Species at Risk and Habitat on the South Canadian Shield (Status as of March 2012)

Taxa	Common Name	Scientific Name	COSSARO Rank ¹	COSEWIC Rank ²	Habitat Overview (MNR) ³	Provincial ESA General or Regulated Habitat	Federal Regulated or Critical Habitat
Plants	American Ginseng	<i>Panax quinquefolius</i>	Endangered	Endangered	American Ginseng a long-lived, slow-growing perennial found in rich, moist, mature deciduous forest. In eastern Canada, the range of American Ginseng extends from southwestern Quebec and eastern and central Ontario.	General Habitat protection will apply after June 20, 2013 unless specific Habitat Regulation is released before this date.	Listed on Schedule 1
	Branched Bartonia	<i>Bartonia paniculata</i> ssp. <i>paniculata</i>	Threatened	Threatened	First discovered in Ontario in 1973, this Branched Bartonia is a very small inconspicuous species that grows in peat soils of <i>Sphagnum</i> in fens. It is considered a disjunct Atlantic Coastal Plain plant with nearest populations some 600 km away.	General Habitat protection will apply after June 20, 2013 unless specific Habitat Regulation is released before this date.	Listed on Schedule 1
	Broad Beech Fern	<i>Phegopteris hexagonoptera</i>	Special Concern	-	This is a small fern about 40 cm in length that grows in rich soils in deciduous Maple-Beech forests and other forest associations. Occurrences in southern Muskoka are one of three regions in Ontario where it is found.	Habitat protection under Section 10 does not apply to Special Concern species.	Not protected under SARA
	Butternut	<i>Juglans cinerea</i>	Endangered	Endangered	The Butternut occurs in eastern North America, ranging from Georgia, Alabama, Mississippi and Arkansas west to Iowa and Missouri, north to southern Ontario and Quebec, and east to New England. In Ontario it is found throughout southwestern Ontario to the Bruce Peninsula and the edge of the Precambrian Shield.	General Habitat protection will apply after June 20, 2013 unless specific Habitat Regulation is released before this date.	Listed on Schedule 1
	Forked Three-awned grass	<i>Aristida basiramea</i>	Endangered	Endangered	This grass species is a hardy plant tolerant of dry, sandy soils and is distinctive due to the bristles (awns) on the flowering parts of the grass. It is known from only a few locations in Ontario and is at the northern limit of its range.	General Habitat protection will apply after June 20, 2013 unless specific Habitat Regulation is released before this date.	Listed on Schedule 1
	Engelmann's Quillwort	<i>Isoetes engelmannii</i>	Endangered	Endangered	This aquatic plant grows in shallow waters and lakes and is identified by long, thin, hollow leaves that are up to 20 cm in length. There are only a few known populations including along the Severn River and in the Kawartha region.	Habitat protected under Section 10 through specific Habitat Regulation. The Regulation is for two known areas in Canada on the Severn River along the southern limit of Muskoka and on the Gull River in the Kawarthas. Mapping of the specific limits of regulated habitat are provided by the MNR.	Listed on Schedule 1
	Spotted Wintergreen	<i>Chimaphila maculata</i>	Endangered	Endangered	This is a perennial evergreen plant that grows in dry, mixed coniferous forests with Red Oak and White Pine associations. It is a distinctive plant with whorled arrangement of leaves and a white mid-vein. It is known from the east side of Muskoka and other locations in Southern Ontario.	General Habitat protection will apply after June 20, 2013 unless specific Habitat Regulation is released before this date.	Listed on Schedule 1
Insects	Monarch Butterfly	<i>Danaus plexippus</i>	Special Concern	Special Concern	The Monarch butterfly can be found in Ontario wherever there are milkweed plants for its caterpillars and wildflowers for a nectar source. Monarchs are often found on abandoned farmland and roadsides, but also in city gardens and parks.	Habitat protection under Section 10 does not apply to Special Concern species.	Listed on Schedule 1
	West Virginia White	<i>Pieris virginiensis</i>	Special Concern	-	This moth species is found in deciduous forests typically with Sugar Maple associations where the larvae feeds specifically on the leaves of spring ephemeral plant known as Toothwort (<i>Dentaria</i>).	Habitat protection under Section 10 does not apply to Special Concern species.	Not protected under SARA

Taxa	Common Name	Scientific Name	COSSARO Rank ¹	COSEWIC Rank ²	Habitat Overview (MNR) ³	Provincial ESA General or Regulated Habitat	Federal Regulated or Critical Habitat
Birds	Bald Eagle	<i>Haliaeetus leucocephalus</i>	Endangered	-	Typically found living and hunting near water. Their nests are huge stick platforms, usually placed high in a tree, near water,	General Habitat protection will apply after June 20, 2013 unless specific Habitat Regulation is released before this date.	Not protected under SARA
	Cerulean Warbler	<i>Dendroica cerulea</i>	Threatened	Special Concern	This is a forest interior warbler that utilizes the tree tops of tall canopy mature trees in large forest tracts with limited disturbance. In Ontario this species is found in the Carolinian zone and the southern Great Lakes St. Lawrence zone.	General Habitat protection applies	Listed on Schedule 1
	Golden-winged Warbler	<i>Vermivora chrysoptera</i>	Special Concern	Threatened	Golden-winged Warbler is found in early successional vegetation communities such as field edges, hydro corridors and younger regenerating thickets. One of the threats to this species is hybridization with the more common Blue-winged Warbler.	Habitat protection under Section 10 does not apply to Special Concern species.	Listed on Schedule 1
	Kirtland's Warbler	<i>Dendroica kirtlandii</i>	Endangered	Endangered	This bird is critically endangered, owing in large part to its extremely specific habitat requirements. It nests on the ground, on well drained soil, under the low living branches of 8 to 20 year old jack pines. Older trees that have lost their lower branches provide insufficient cover, and are not used	General Habitat protection will apply after June 20, 2013 unless specific Habitat Regulation is released before this date.	Listed on Schedule 1
	Least Bittern	<i>Ixobrychus exilis</i>	Threatened	Threatened	The main threat to Least Bitterns is draining of wetlands for conversion to farmland and urban development. Bitterns generally require large, quiet marshes and as marshes decrease in size and human recreation increases, the population declines in an area	General Habitat protection will apply after June 20, 2013 unless specific Habitat Regulation is released before this date.	Listed on Schedule 1
	Peregrine Falcon	<i>Falco peregrinus anatum</i>	Threatened	Special Concern	In the wild, Peregrine Falcons usually nest on tall, steep cliff ledges adjacent to large waterbodies, but some birds adapt to urban environments and raise their young on ledges of tall buildings, even in densely populated downtown areas.	Habitat protected under Section 10 through specific Habitat Regulation. The regulation protects natural cliff faces that are at least 15 metres high and that are being used by Peregrine Falcon for nesting within the past 15 years, plus a 1 kilometre area around the cliff face. Protection of artificial sites is also provided.	Listed on Schedule 1 (<i>F. peregrinuspealei</i>)
	Red-headed Woodpecker	<i>Melanerpes erythrocephalus</i>	Special Concern	Threatened	This medium-size bird (20cm) lives in open woodland and woodland edges, especially in oak savannahs and riparian forest, which can often be found in parks, golf courses and cemeteries. These habitats contain a higher density of dead trees, which they commonly use for nesting and perching. It is an omnivorous species, feeding on insects in the summer and nuts in the winter.	Habitat protection under Section 10 does not apply to Special Concern species.	Listed on Schedule 1
	Yellow Rail	<i>Coturnicops noveboracensis</i>	Special Concern	Special Concern	In Ontario, it is mainly found in the Hudson Bay Lowlands region, and is only found in localized marshes in southern Ontario. Yellow Rail populations declined in southern Ontario as wetlands were drained for urban development and agriculture. Expanding Snow Goose populations in the Hudson Bay Lowlands may be destroying habitat. The Yellow Rail has not benefited from the wetlands restoration for waterfowl, as it prefers shallow marshes rather than open waters	Habitat protection under Section 10 does not apply to Special Concern species.	Listed on Schedule 1
	Bobolink	<i>Dolichonyx oryzivorus</i>	Threatened	[—] Assessed as Threatened by COSEWIC in 2010 not SARA-listed.	This medium-sized song-bird breeds in hayfields and grasslands, and is usually easy to spot because of its bubbly song and conspicuous flight display.	General Habitat protection applies	Not protected under SARA
	Eastern Whip-poor-will	<i>Caprimulgus vociferus</i>	Threatened	Threatened	Although there is some uncertainty surrounding the decline of the Whip-poor-will, the main threat to the species is likely habitat loss and	General Habitat protection applies	Listed on Schedule 1

Taxa	Common Name	Scientific Name	COSSARO Rank ¹	COSEWIC Rank ²	Habitat Overview (MNR) ³	Provincial ESA General or Regulated Habitat	Federal Regulated or Critical Habitat
					degradation. The habitat loss is a result of natural changes when open fields and thickets become closed forest in the north, and intensive agriculture in the south.		
	Barn Swallow	<i>Hirundo rustica</i>	Threatened	Threatened	Barn Swallows have only recently been listed as a species at risk due to the steady decline of this species. This bird is found nesting in structures such as barns and other out buildings as well as under bridges. Barn Swallows feed on insects while circling about above a range of habitat types including meadows and marshes.	General Habitat protection applies	Not protected under SARA
	Chimney Swift	<i>Chaetura pelagica</i>	Threatened	Threatened	Before European settlement Chimney Swifts mainly nested on cave walls and in hollow trees or tree cavities in old growth forests. Today, they are more likely to be found in and around urban settlements where they nest and roost (rest or sleep) in chimneys and other manmade structures. They also tend to stay close to water as this is where the flying insects they eat congregate.	General Habitat protection applies	Listed on Schedule 1
	Eastern Meadowlark	<i>Sturnella magna</i>	Threatened	Threatened	The Eastern Meadowlark has only recently been listed as a species at risk due to the steady decline of this species. Similar to Bobolink, this grassland species breeds in hayfields and open meadows.	General Habitat protection applies	Not protected under SARA
	Common Nighthawk	<i>Chordeiles minor</i>	Special Concern	Threatened	Traditional Common Nighthawk habitat consists of open areas with little to no ground vegetation, such as logged or burned-over areas, forest clearings, rock barrens, peat bogs, lakeshores, mine tailings,. Although the species also nests in cultivated fields, orchards, urban parks, mine tailings and along gravel roads and railways, they tend to occupy natural sites.	Habitat protection under Section 10 does not apply to Special Concern species.	Schedule 1
	Canada Warbler	<i>Wilsonia canadensis</i>	Special Concern	Threatened	The Canada Warbler breeds in a range of deciduous and coniferous, usually wet forest types, all with a well-developed, dense shrub layer. Dense shrub and understory vegetation help conceal Canada Warbler nests that are usually located on or near the ground on mossy logs or roots, along stream banks or on hummocks. It winters in South America.	Habitat protection under Section 10 does not apply to Special Concern species.	Listed on Schedule 1
	Olive-sided Flycatcher	<i>Contopus cooperi</i>	Special Concern	Threatened	Olive-sided Flycatchers' breeding habitat usually consists of opening in coniferous or mixed forest adjacent to rivers or wetlands. In Ontario, Olive-sided Flycatchers commonly nest in conifers such as White and Black Spruce, Jack Pine and Balsam Fir.	Habitat protection under Section 10 does not apply to Special Concern species.	Listed on Schedule 1
	Blanding's Turtle	<i>Emydoidea blandingii</i>	Threatened	Threatened	This medium sized turtle inhabits a network of lakes, streams and wetlands, preferring shallow wetland areas with abundant vegetation. It can also spend significant portions of time in upland areas moving between wetlands, In a single season this highly mobile turtle has been known to travel up to seven km in search of food or a mate.	General Habitat protection will apply after June 20, 2013 unless specific Habitat Regulation is released before this date.	Listed on Schedule 1
Reptiles	Northern Map Turtle	<i>Graptemys geographica</i>	Special Concern	Special Concern	Northern Map Turtle is a shy turtle that is often seen basking in sheltered bays on rocks and logs from which they can easily dive into deeper water. This is a gregarious species found in larger rivers and lakes including along the eastern coast of Georgian Bay and larger inland Muskoka Lakes.	Habitat protection under Section 10 does not apply to Special Concern species.	Listed on Schedule 1
	Spotted Turtle	<i>Clemmys guttata</i>	Endangered	Endangered	This is a distinctive turtle species with yellow spots found on the carapace or shell. It is a small turtle found in ponds, marshes, and	General Habitat protection will apply after June 20, 2013 unless specific Habitat	Listed on Schedule 1

Taxa	Common Name	Scientific Name	COSSARO Rank ¹	COSEWIC Rank ²	Habitat Overview (MNR) ³	Provincial ESA General or Regulated Habitat	Federal Regulated or Critical Habitat
	Eastern Musk Turtle	<i>Sternotherus odoratus</i>	Threatened	Threatened	fens as well as areas along the eastern coast of Georgian Bay.	Regulation is released before this date.	
	Common Snapping Turtle	<i>Chelydra serpentina</i>	Special Concern	Special Concern	Snapping Turtles remain almost exclusively in shallow waters of marshes and beaver ponds where they can hide in the soft mud in the bottom. They move from the water to nearby suitable nesting areas of gravel or sand.	Habitat protection under Section 10 does not apply to Special Concern species.	Listed on Schedule 1
	Five-lined Skink	<i>Eumeces fasciatus</i>	Special Concern	Special Concern	The Great Lakes/St. Lawrence populations which are Special Concern Provincially and Nationally, occur on the southern part of the Canadian Shield. Preferred habitat is on rocky outcrops in mixed coniferous and deciduous forests, where they can seek refuge from the elements and predators in rock crevices and fissures	For the Southern Shield population habitat protection under Section 10 does not apply to Special Concern species. A proposed Habitat Regulation for the <u>Carolinian Population</u> was released in December 2011 and is pending finalization after MNR completes a review of public comments.	Listed on Schedule 1
	Eastern Foxsnake (Georgian Bay population)	<i>Elaphe gloydi</i>	Threatened	Endangered	The Georgian Bay population of Eastern Foxsnake are found usually within 150 m of the eastern and southern shoreline of Georgian Bay including the many islands found in this region. They are excellent swimmers and utilize the rocky habitat along the shoreline particularly ecotones of rock barren and coastal marsh areas.	General Habitat protection applies. A proposed Habitat Regulation for the Georgian Bay population (Threatened) and a separate Habitat Regulation for the <u>Carolinian Population</u> (Endangered) was released in December 2011 and is pending finalization after MNR completes a review of public comments.	Listed on Schedule 1
	Eastern Hog-nosed Snake	<i>Heterodon platirhinos</i>	Threatened	Threatened	They prefer sandy well drained habitats such as beaches and dry woods because this is where they lay their eggs in burrows and where they hibernate. But they must have access to wet areas such as swamps to hunt frogs, toads and lizards.	General Habitat protection will apply after June 20, 2013 unless specific Habitat Regulation is released before this date.	Listed on Schedule 1
	Massasauga Rattlesnake	<i>Sistrurus catenatus</i>	Threatened	Threatened	The Massasauga lives in a range of open habitats, where it hunts for small mammals and birds. It shifts its home range seasonally, spending the summer in dry upland sites, and the rest of the year in swamps (forested wetlands). In winter, snakes hibernate underground in damp or even wet sites such as caves, tree root cavities, and animal burrows.	General Habitat protection will apply after June 20, 2013 unless specific Habitat Regulation is released before this date.	Listed on Schedule 1
	Milksnake	<i>Lampropeltis triangulum</i>	Special Concern	Special Concern	It lives in a wide range of habitats, especially old fields and farm buildings where rodents are common. It is more likely to be encountered at night when it is hunting, since during the day it is usually secretive and usually hides under objects.	Habitat protection under Section 10 does not apply to Special Concern species.	Listed on Schedule 1
	Eastern Ribbonsnake	<i>Thamnophis sauritus</i>	Special Concern	Special Concern	The Eastern Ribbonsnake is usually found close to water, especially in marshes where it hunts for frogs and small fish. A good swimmer, it will occasionally dive in shallow water. At the onset of cold weather, individuals congregate in burrows or rock crevices to hibernate together in what is called a hibernaculum.	Habitat protection under Section 10 does not apply to Special Concern species.	Listed on Schedule 1
Mammals	Eastern Cougar	<i>Puma concolor couguar</i>	Endangered	-	Historically, cougars in the east occupied large forested areas that were relatively undisturbed by humans. Cougars in northwestern and northern Ontario are of unknown origin, but may have moved into the province from the west, or may represent remnants of the original	General Habitat protection will apply after June 20, 2013 unless specific Habitat Regulation is released before this date.	Not protected under SARA

Taxa	Common Name	Scientific Name	COSSARO Rank ¹	COSEWIC Rank ²	Habitat Overview (MNR) ³	Provincial ESA General or Regulated Habitat	Federal Regulated or Critical Habitat
					population or be released pets. Cougars in southern Ontario are usually considered to be released pets.		
	Eastern Wolf	<i>Canis lupus lycaon</i>	Special Concern	Special Concern	Eastern wolves live in groups called "packs" which typically number from 3-6 adults and require relatively large areas of unbroken forest. Each pack has a home range that is loosely defended from neighbouring packs and may be as extensive as 500 square km.	Habitat protection under Section 10 does not apply to Special Concern species.	Listed on Schedule 1

Notes:

1. Status as of March 2012, COSSARO = Committee on the Status of Species at Risk in Ontario.
2. Status as of March 2012, COSEWIC = Committee on the Status of Endangered Wildlife in Ontario.
3. Habitat Overview for each species taken from various MNR reference sources including MNR website, links to the Royal Ontario Museum, and MNR species fact sheets.
4. Provincial ESA habitat status based on Species at Risk List in Ontario (SARO List), Ontario Regulation 4/12 as of March 2012.
5. Federal SARA habitat status based on review of Schedule 1 as of March 2012.

2. Loss of Cover: Riparian Areas and Lakeshores, Forests and Wetlands

The conceptual model provided by McIntyre and Hobbs (1999) provides a useful framework for discussing habitat loss in the context of the southern Canadian Shield (see **Figure 2** below). This concept, although necessarily oversimplified, presents four landscape alteration states representing a range from very natural to very unnatural, as follows:

- (1) Intact = at least 90% natural
- (2) Variegated = 60% - 90% natural
- (3) Fragmented = 10% - 60% natural
- (4) Relictual = less than 10% natural

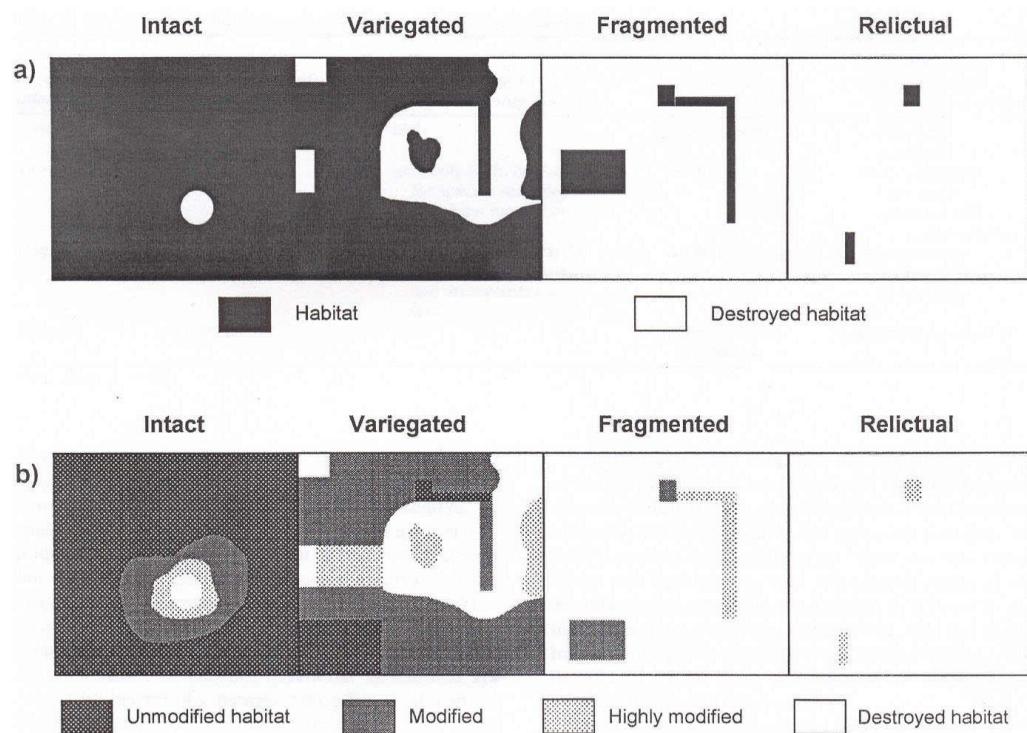


Figure 2. Four conceptual states of habitat alteration (from McIntyre and Hobbs 1999).

In the majority of the southern Canadian Shield, the current natural heritage context can be described as ranging from “intact” to “variegated”. This is in strong contrast to Ontario south of the Canadian Shield where the context ranges from “fragmented” to “relictual”.

Canada is committed to protecting 17% of its land, and protected areas such as National and Provincial parks are the cornerstone of nature conservation in Ontario. And certainly in an ‘intact’ or ‘variegated’ landscape there is much room for other complementary protection efforts. In order to build on protection efforts one approach in an “intact” or “variegated” landscape is not to try and protect, enhance, and connect what else remains, but rather determine how much disturbance can the extant natural areas sustain without unacceptable effects to the ecological functions they provide and / or the species they support. With such an approach the overriding goal is to retain all the ecological functions of a relatively intact ecosystem.

TEXT BOX “Natural”

‘Natural’ is a somewhat subjective term. In terms of pre-European settlement conditions the southern Canadian Shield was a forest biome. A temperate mixed forest (upland and swamp) was the matrix, (or dominant), land cover. Within this matrix were features such as marshes, open water patches and rock barrens. The types and frequency of vegetation patches would change with the effects of fire, wind, insect outbreaks, beaver activity, and other disturbances. These disturbances would create open patches ranging from relatively small meadows, to extensive barrens and scrub following major forest fires. Open areas could be temporary or, in the case of some barrens more or less permanent.

With European settlement and land clearance the types, proportions and temporal aspects of vegetation communities changed, usually to a more open system with anthropogenically created and/or maintained land covers and land uses. These anthropogenic forces subsequently subsided and a secondary forest matrix has re-established itself in many areas. Most of the current forest matrix differs from pre-settlement conditions, including by species composition and abundances. Yet this contemporary ecosystem has many of the same habitat functions, with some species now relying on surrogate habitats such as old fields, hay fields, pastures, conifer plantations and logged areas.

END BOX

In particular, the dominant type of development (second home development) does not always result in the removal of forest cover, but can create stressors on the biodiversity of a given area, especially where terrestrial systems meet open water. Unfortunately, there is no simple or clear answer to the question of “How Much Disturbance is Too Much?”, and professional judgement will likely always be required. However, the scientific and technical literature does provide some guidance, as discussed below.

2.1 Loss of Habitat Cover

Although the discussion below speaks about riparian and lakeshore cover separately from forest and wetland cover, it should be understood that these overlap. For example, forest cover often includes forested wetlands (i.e., swamps), and riparian and lakeshore cover is also often forested, at least in part. Notably, although there are a number of unique terrestrial habitats in the southern Canadian

Shield that are not wetlands or forests (e.g., granitic cliffs or taluses, and rock outcrops) there is very little peer-reviewed science on their ecological value to consider, and they are not discussed here.

Riparian and Lakeshore Cover

The bulk of the literature that has examined the impacts of removal of natural cover along riparian areas¹ and lakeshores did so considering the potential impacts to the adjacent waterbody (e.g., Jones *et al.* 1999, Teels *et al.* 2006), not the loss of the intrinsic habitat provided by the riparian area itself. Furthermore, most of this research has been conducted south of the Canadian Shield where predominant adjacent land uses are agricultural or urban (e.g., Roy *et al.* 2007), although some has been on the Canadian Shield in the context of deforestation (Murphy *et al.* 1986). Nonetheless, there is evidence that not only do riparian and lakeshore areas have intrinsic and unique habitat values (e.g., Croonquist and Brooks 1993, Machtans *et al.* 1986, Crawford and Semlitsch 2007), they can have higher levels of biodiversity than their aquatic or upland counterparts because they are a transition area between the two (e.g., Keeton *et al.* 2007, Miller *et al.* 2003).

Although the proportion of riparian cover required in a given watershed varies depending on the land use and biophysical context, as well as the ecological parameters being assessed, the literature consistently shows links between riparian cover at the watershed scale and both aquatic and terrestrial community species responses.

- Dickson *et al.* (2009) found that the extent of forested riparian cover in the central Great Basin of Nevada was linked to patterns of occupancy, colonization and local extinction for three bird species.
- Stephenson and Morin (2009) looked at the condition of streams in relation to land use context in the Ottawa area and found that catchment forest cover explained more variation in algal, invertebrate and fish biomass than structural metrics of invertebrates and fish. When forest cover was less than 50 percent, algal biomass was relatively high but patterns were variable. Fish biomass began to decline where forest cover was less than 45 percent at the reach scale. The proportion of variability in biomass and structural metrics explained by forest cover generally increased with increasing scale, suggesting that catchment-wide disturbances are the most influential determinants of benthic and fish communities.
- One publication, a Ph.D. thesis from Laurentian University, examined ecological linkages between the condition of streams and their adjacent terrestrial environment on the Shield (Kreutzweiser 2009). Notably, this research, which was conducted in northern Ontario near White River, found that the local effects of removal of riparian forests on stream health were not conclusive, whereas the catchment scale effects were significant and indicated that, on average 10 to 30 percent (but up to 50 percent in some locations) removal of riparian forested buffers did not result in a decline in stream health (i.e., temperature, canopy cover, sediment deposition, leaf litter decomposition).

This limited evidence suggests that, at the watershed scale, forested cover in the riparian zone of between 50 and 90 percent needs to be maintained to support the health of aquatic systems at that

¹ "Riparian areas" are defined in different ways but for the purposes of this report will refer to the terrestrial zone immediately adjacent to a watercourse.

scale. No literature with metrics to inform what is needed to maintain the health of the riparian habitat itself for any biota at the watershed or regional scale, off or on the Canadian Shield, was found.

INSERT TEXT BOX**Leave it to Beaver**

American Beavers have important effect on habitat dynamics. Many wetlands throughout the southern Shield area are created and/or influenced by the activities of beavers.

If beaver influenced wetlands are to be maintained, sufficient food sources (e.g., light intolerant species such as aspen) around the riparian zone of wetlands, creeks and streams need to be present. In order to maintain these preferred tree species on the landscape, ecosystem disturbances need to occur. Historically these would have included disturbance agents such as wildfire, wind throw and insect infestations. Due to fire suppression, current forest management guidelines and economics, disturbance around the riparian areas of lowlands is much lower than historically. A decline in beaver populations could lead to a reduction in wetland habitats.

END TEXT BOX**Forest Cover**

For relatively mobile groups of wildlife, such as birds, the extent of overall forest and/or wetland cover in a given watershed, seems to be just as or more important than the size of the habitat patches in the landscape *per se* in supporting a greater diversity of species (e.g., Villard 1998, Villard *et al.* 1999). Landscape-scale research and multi-species meta-analyses off the Shield has shown that overall levels of forest cover are more important for sustaining higher levels of forest bird diversity than the types of intervening land uses, or the configuration of that habitat. While studies looking at habitat thresholds for individual species have concluded that there is significant intra-species variability in forest cover requirements (e.g., Betts *et al.* 2007, Betts and Villard 2009, Zuckerberg and Porter 2010), on average forest generalist and area-sensitive birds have a high likelihood of occurrence when there is greater than 50 to 60 percent forest cover.

The strongest evidence for this comes from a seminal paper by Zuckerberg and Porter (2010) which examined the habitat thresholds of 25 forest generalist and area-sensitive bird species using data spanning a 25 year period. They found that for these species extinction threshold estimates (i.e., levels below which populations would be expected to drop off dramatically) averaged 58.02 percent while persistence threshold (i.e., levels below which breeding populations would be expected to decline) estimates averaged 60.97 percent forest cover. Notably, species-specific persistence thresholds ranged from 19.11 to 95.83 percent, illustrating the level of variability. Additional support for these metrics come from Donnelly and Marzluff (2004) who found that in a landscape with about 60 percent forest cover, bird species richness increased with reserve size irrespective of the level of urbanization in the surrounding matrix. This suggests that, at least for forest birds, as long as the landscape is at least 50 to 60 percent forested, species diversity levels of forest birds can be maintained irrespective of the configuration of this habitat, or the nature of land uses in the surrounding matrix.

More recently, a number of studies (none from the Shield) have used watershed-scale forest cover mapping in conjunction with site-specific measures of water quality to assess potential links between levels of forest cover and the health of aquatic systems.

- Capiella *et al.* (2005) found healthy aquatic systems in Maryland, U.S. were found in watersheds with at least 45 to 65 percent forest cover (including trees outside natural areas in the urban matrix).
- Goetz *et al.* (2003), also conducting remote sensing analyses in Maryland, linked 29.6 percent forest cover (including trees outside of natural areas) to poor stream health, 37 percent tree cover to fair stream health, 44.6 percent tree cover to good stream health and 50.6 percent tree cover to excellent stream health at the watershed scale.
- Helms *et al.*, 2009 In watershed-scale studies in western Georgia, higher levels of deciduous forest cover (i.e., at least 50 percent) were consistently linked to higher macroinvertebrate species richness, which is generally considered a sign of aquatic ecosystem health.

The importance of landscape scale forest cover has also been illustrated for both birds and herpetofauna, although a significant amount of variability between species has been documented.

- Zuckerberg and Porter (2010) examined habitat thresholds for forest birds in their study of breeding bird data spanning eastern North America over a 20 year period for 25 species of forest generalist and forest obligates. In addition to finding significant variability in intra-species thresholds, they also found that long-term persistence forest cover thresholds for forest breeding birds were, on average, higher than suggested by many other shorter term studies (i.e., close to 61 percent as compared to ranges between 9 and 28 percent reported by Betts and Villard 2009).
- Rioux *et al.*, (2009) found that Wild Turkey male density in southern Quebec peaked in landscapes characterized by 25 to 50 percent forest cover.
- Cottam *et al.*, (2009) found that in areas with forest cover between 29 and 75 percent neither nest predation nor landscape matrix were significant factors in decreasing nesting success of Acadian Flycatcher or Wood Thrush, suggesting that these were adequate forest cover levels to sustain these populations.

For herpetofauna, and specifically amphibians, a number of recent studies have identified and quantified the importance of forest cover within a certain distance from breeding ponds.

- Herrmann *et al.* (2005) found within a 250 to 1,000 metres radius of the breeding pool, less than 40 percent cover supported "depauperate" levels of diversity, while more than 60 percent cover ensured healthy species richness and abundances.
- Eigenbrod *et al.* (2008) found frog species richness was generally positively correlated to areas of high forest cover (i.e., greater than 60 percent) in distances up to 1,500 metres from the breeding ponds.
- Homan *et al.* (2004) examined critical habitat thresholds for two pool-breeding, forest dependent amphibians (i.e., Spotted Salamander and Wood Frog) and found that thresholds varied depending on the spatial scale ranging from 32 to 88 percent, and varied inversely for the salamander versus the frog, possibly reflecting the greater dispersal requirements of the salamander.

- Mazerolle *et al.* (2005) correlated increased Green Frog occurrence with increased with percent forest cover within 1,000 metres of breeding ponds.
- Veysey *et al.* (2009) hypothesize that at the landscape scale at least 30 to 50 percent forest cover would be required to sustain Spotted Salamanders.

In addition to these somewhat local-scale forest cover requirements, there are also regional-scale requirements for many herpetofauna to consider. In a unique landscape scale study, Gibbs *et al.* (2005) examined changes in frog populations over a 30 year period in various locations across New York state near the Great Lakes and found that pond-breeding metapopulation processes occur at much larger scales than expected (i.e., more than 10 kilometres).

While overall forest cover is an important factor for a wide range of fauna, as well as the health of aquatic systems within a given watershed, amphibians require this cover in immediate proximity to their breeding habitats, while for many bird species the specific configuration of the habitat seems to be less of a factor as long as overall cover levels are adequate. The literature suggests this level is, on average, 50 to 60 percent.

It is very important to note that the effect of second home (cottage) development and recreational activities on otherwise intact forest is largely an information gap. This is problematic where most the land use change is of this nature. The existing high forest cover values may be misleading if biodiversity values are substantially altered by, for example, the presence of built structures and recreational activities. Further scientific examination of the relationship of these kinds of disturbances within the forested environment is required. It also speaks to the importance of monitoring development and recreational impacts in the southern Shield in particular.

Wetland Cover

Wetlands have been recognized, since the 1970's, as providing a wide range of ecological and hydrologic functions in the landscape, and have been afforded some protection in Ontario since the 1980's. The current literature on wetland cover focuses more on the conservation of wetland coverage to maintain the various functions that wetlands provide at a watershed scale, and on the importance of historical levels of wetland cover as a reference, than on prescribing generic quantitative percentages or identifying specific proportions of a watershed that should be maintained in wetland cover (e.g., Puric-Mladenovic and Strobl 2006, Austen and Hansen 2008, Cohen and Brown 2007).

The current approaches to wetland cover, both in the scientific and technical literature, are rooted in contexts of extensive wetland loss and degradation, and are almost entirely focused on the southern Ontario context (Snell 2007, Ducks Unlimited 2010). In this context the focus has been on maintenance of current levels and working towards restoration of levels that are closer to pre-settlement values on a watershed level (e.g., Zedler 2003).

In the context of the southern Canadian Shield where wetland cover is between 6 and 10 percent (see **Table 1**), planning generally focuses on protection of those designated as provincially significant (although very few have actually been evaluated) and coastal wetlands. This approach may not protect smaller (i.e., less than 4 hectares) isolated wetlands, or vernal pools, that have been increasingly recognized in the literature over the past decade as fish-free habitats that are important

contributors to herpetofaunal and avian habitat (e.g., Babbitt 2005, Skidds *et al.* 2007, Joyal *et al.* 2001, Werner *et al.* 2007, Pearce *et al.* 2007).

While it is recognized that wetlands are widely distributed across the southern Canadian Shield, it will be important to identify and protect areas that contain both high quality and representative examples of the full range of wetland types across the landscape to continue to support current levels of biodiversity.

Some of the more site-specific information and guidance from the literature related to edge effects is discussed in **Section 3**, and on vernal pools is discussed in **Section 7**.

2.2 Loss of Habitat Quantity, Quality and Structure

While overall natural cover provides a relatively simple and useful metric for guiding landscape planning, this measure provides only a proxy picture of the true condition of a watershed's or region's natural heritage. The importance of the spatial pattern of habitats in the landscape, their different vegetative composition and structure, and the extent to which various areas provide unique or specialized habitats is increasingly recognized just as important in providing for the full range of native biodiversity. These habitat attributes are also discussed below in the context of the current science.

Value in Large Patches

Research continues to show that larger patches of contiguous natural areas, are required for the survival of many area-sensitive birds, and equally important for a number of terrestrial and semi-aquatic amphibians and reptiles in a wide variety of habitat types including forest. However, there continues to be debate about whether large patches are of high ecological value because the unique range of habitats they can provide, or the fact that they tend to provide areas that are subject to less human disturbances. Perhaps it is a combination of both. For forest plants that do not disperse broadly or quickly, preservation of some relatively undisturbed large forest patches is needed to sustain them because of their restricted dispersal abilities and specialized habitat requirements, and to ensure continued seed or propagule sources for restored or regenerating areas nearby (Jacquemyn *et al.*, 2003). However, some of these same forest species have been shown to be sensitive to disturbance as well (e.g., Moffatt and McLachlan 2003).

Older and current research conducted in central and northern Ontario has been able to classify forest breeding birds into three categories: (1) intolerant to cottage development (e.g., Black-throated Blue Warbler), (2) tolerant of some cottage development (e.g., Red-eyed Vireo, Ovenbird) and (3) favour developed patches in otherwise forested (e.g., Yellow-rumped Warbler, Eastern Wood Pewee) (Clark and Armstrong 1984, Ford and Flaspohler 2010). The first "category" of birds require relatively large blocks of habitat that are relatively undisturbed by human activities. Some quantitative guidance is provided from south of the Canadian Shield.

- Keller and Yahner (2007) found that long-distance migrant birds (e.g., Eastern Wood-peewee, Red-eyed Vireo, Wood Thrush, Worm-eating Warbler, and Scarlet Tanager), were more likely to occur in medium-sized (i.e., 40 to 150 hectares) and large (i.e., greater than

1,500 hectares) forest patches than in smaller patches during the breeding and spring-migratory seasons.

- Nol *et al.* (2005) examined occurrence of four forest breeding birds (i.e., Ovenbird, Wood Thrush, Veery and Rose-breasted Grosbeak) in 216 woodlot fragments. Results suggested that maintenance of large forest fragments with at least 90 hectares of "core" area (within 100 metres of the forest edge), and more than 230 hectares of "core" on average is needed to maintain source populations of forest breeding birds in the fragmented landscape of southern Ontario (i.e., patches of at least 127 hectares to about 300 hectares).
- Weber *et al.* (2008) found that the majority of plots with at least five species of forest birds were in forest blocks with at least 120 hectares of interior forest (i.e., at least 162 hectares) in a Maryland conservation network.

Many species of amphibians and reptiles that occur in central Ontario seem to be able to sustain themselves in relatively small areas as long as there are suitable habitat types present, and there is connectivity to other suitable habitat areas (e.g., Semlitsch and Bodie 2003). However, some species appear to require larger areas; the Eastern Massassauga Rattlesnake is thought to require approximately 16 hectares of undisturbed habitat that includes sandy substrates and extensive mixed conifer forests to sustain itself (DeGregorio *et al.* 2011).

One of the primary ecological components that is scarce in southern Ontario but still persists in the southern Canadian Shield is the presence of a healthy diversity of medium and large-sized mammals (with the exception of deer). These species require extensive areas of habitats in part because they have such extensive home ranges (Brodrribb *et al.* 2005; Riverstone 2011). In a species risk assessment of fur-bearers for forest management areas in Alberta (Fiera Biological Consulting 2009) examples of home ranges identified were:

- Pine Marten (200 to 3,000 ha);
- Fisher (2 to 16 km² for females; 5 to 30 km² for males);
- Canada Lynx (8 to 738 km²); and
- Grey Wolf: 300 to 1000 km²

Although these ranges need not necessarily be entirely contiguous or undisturbed, these species do generally require adequate overall levels of habitat as well as the ability to move across the landscape. The effects of barriers such as roads can be significant, as discussed in **Section 4**.

Value in Habitat Diversity and Structural Diversity

Another theme that has emerged in the conservation literature is the need to identify and protect the full range of habitat types in a given landscape if the objective is to sustain existing levels of diversity. Accordingly, to enable this then one approach is to maintain disturbances within a natural range of variation as would be expected with a natural fire, wind, disease, etc. regime. For example, Dettmers (2003) documents how the practice of exclusively conserving what have been considered "high quality" natural upland features (e.g., mature forests) in the northeastern United States has resulted in the loss of younger forests and shrublands to the point that a significant decline in the abundance of bird species requiring these types of successional habitat has occurred. This illustrates how placing anthropogenic values on specific habitat types can be detrimental to biodiversity conservation objectives, and likewise opens the discussion over what baseline is used to measure 'natural' Since

the life-cycle requirements of amphibians are variable (i.e., some spend most of their life cycle in woodlands, others in wet areas, and many require both – [e.g., Richter and Azous 2000a, Guerry and Hunter 2002, Faccio 2003, Regosin *et al.* 2003]), in order to fully protect them requires a combination of high quality forests and wetlands.

Structural diversity in habitats has also been identified as a critical element for many wildlife species.

- Dickson *et al.* (2009) found that the structure of forested riparian cover in the central Great Basin of Nevada – and in particular the presence of understorey shrubs - was linked to greater occupancy and colonization for certain bird species.
- A number of mammals, such as Fisher, are associated with forest stands with a high level of structural complexity such as mature and/or old growth forests (Fiera Biological Consulting 2009).
- Matlack (1997) linked the overall species impoverishment of a relatively large forested area outside a large city to years of management that have resulted in a very young forest that is poorly connected.
- Miller *et al.* (2003) noted that although riparian bird abundance and diversity declined with proximity to urbanization, some local variation was explained by the presence (or absence) or woodland understorey features.

The presence and nature of the forest in riparian and lakeshore areas has also been connected to aquatic health because of the relative contributions of coarse woody debris (also known as CWD).

- Brassard and Chen (2008) found that CWD contributions to aquatic systems increased as stands aged from 25 to 125 years old, and that mixed wood stands contributed more CWD than conifer or deciduous stands.
- Marburg *et al.* (2009) rates of input of CWD to four lakes in Wisconsin varied but argue it is likely an important contributor to aquatic habitat, and particularly micro shoreline habitats.
- Christensen *et al.* (2009) studied 16 north temperate lakes and found a strong negative correlation between the presence and extent of residential lakeshore development, and CWD input to lakes.

These papers all suggest that a certain amount of lakeshore should be kept forested and protected from development in order to ensure continued inputs of CWD into aquatic habitats, and some also suggest encouraging or regulating some tree retention along the shores where development is permitted.

Technical Challenges and Opportunities

Ultimately, even with this guidance, natural heritage planners are left with the daunting task of trying to ensure the habitat requirements of many different species are met. Relatively recent work by Fischer *et al.* (2004) suggests a possible approach that combines evolving Geographic Information System (GIS)-based tools with emerging knowledge about key habitat requirements for some species. Their research puts forward ‘habitat contours’ as a modelling framework with application for regional planning applications. This framework identifies habitat “hot spots” in the landscape by mapping unique layers of habitat suitability contours for different species on top of each other. This model provides a more complex approach able to highlight differing species requirements at different spatial scales, but is limited by (a) the accuracy of the habitat mapping in a given jurisdiction and (b) the

current understanding of a given species' key habitat requirements. It is an approach that is comparable to that undertaken in the Draft Species at Risk Habitat Suitability Modelling that was undertaken for Muskoka District (Glenside Ecological Services 2009) and the Muskoka Official Plan Review Background Study (AECOM and SLR Consulting 2011).

Planning Challenges and Opportunities

Setting conservation targets for different habitat types, particularly in a context that is still largely ecologically intact, can be challenging because such targets could be misunderstood as acceptable levels rather than minimums below which significant species declines may occur. Furthermore, natural habitats are dynamic and always changing (some over periods of years, others over decades, and still others over centuries) and setting targets or guidelines for specific habitat types sometimes overlooks that inherent dynamism of natural systems. However, not setting targets when economic targets are still set for competing resource uses can leave habitat values and functions under-represented in terms of land use policy and planning.

An alternative planning option that has been used in a few jurisdictions is the identification of multi-habitat mosaics that contain a relatively large concentration of natural areas that are relatively undisturbed (as compared to the surrounding landscape). This approach has been taken in the Region of Waterloo through the identification of Environmentally Sensitive Landscapes (ESLs). ESLs are regional scale (e.g., in the order of 2,000 hectares) greenland conservation units containing concentrations of wetlands, woodlands and intervening farmed areas that are not divided by major highways and in which development (apart from existing rural uses) is restricted. This type of planning approach could contribute to effective natural heritage planning in the southern Canadian Shield where the major threats to biodiversity are not overall habitat loss *per se*, but incremental and cumulative fragmentation associated with cottage and other types of lakeshore and riparian development, and associated infrastructure (as described in the following sections).

Currently, the federal *Species at Risk Act* (2002) and the provincial *Endangered Species Act* (2007), may have shifted some of the non-statutory conservation efforts away from landscape-scale habitat considerations to statutory site-specific requirements for particular species in order to ensure conformity with these pieces of legislation. In particular, the provincial Act requires the protection of suitable habitat almost as soon as a species is listed. In many parts of the southern Canadian Shield, especially areas near wetlands and coastlines, the likelihood that habitat exists for one or more of the 37 Endangered or Threatened species (as listed in **Table 2**) is high. Governments must address these requirements while also trying to ensure broader natural heritage system objectives are being met. If habitat mosaics were to be identified on both a regional and a local scale, priority areas could potentially incorporate any known concentrations of habitat for Threatened or Endangered species as well. An approach is to continue to have collections of habitats/ecosystems – including species but not necessarily driven by them –form the cornerstone of natural heritage planning. Niemi *et al.* (1998) strongly supports such an approach:

“Species-centered management ... is doomed to be too complicated and controversial and, therefore, we must focus on ecosystem management and preservation processes that are critical for assemblages of ecologically similar species.”

2.3 Discussion and Preliminary Guidance

Although the southern Canadian Shield, and particularly the western side of it, appears to have been subject to increasing development in the form of lakeshore and riparian residential / cottage developments and associated infrastructure, it remains from a landscape perspective, largely natural in terms of its land cover. In this context, concepts of habitat patch shape generally are seen to have less value, although concepts of overall habitat cover and the maintenance of high quality ecosystem components continue to be of critical importance for the maintenance of current levels of species diversity and abundance. Maintenance of the expected natural full range of habitat diversity (i.e., in terms of habitat types, structural diversity and age class diversity) at the regional and local scales should also be a key conservation principle.

In order to capture these elements through natural heritage planning it is suggested that the identification of “Habitat Mosaics” at the regional and local scales be made, within which most types of new development would be restricted, and changes to existing developments and infrastructure would need to be subject to careful environmental screening. These habitat mosaics would consist of largely forested areas with components of diverse wetlands (e.g. swamps and marshes, as well as fens) interspersed with open, shrub and treed rock barrens. These areas could be identified using a combination of GIS tools, remote sensing and field based data, based on having relatively high levels of the following characteristics:

- **Diversity:** capturing areas that incorporate a range of representative and unique habitat types, including communities considered of conservation concern where possible. The intent is for the protected mosaics to provide, cumulatively, habitat for the full range of species that occur in the area.
- **Naturalness:** Generally, the less disturbed a natural area is, the better its capacity will be for representation and maintenance of biodiversity. Habitat mosaics should be predominantly comprised of natural areas that are subject to low levels of disturbance by human activities (e.g., urban areas, mining, pits and quarries, roads – and particularly major highways).
- **Habitat Area:** All else being equal, large patches of habitat are typically of greater value than small patches from a conservation perspective because they generally have the capacity to sustain a higher level of ecosystem function, and be more resilient to landscape or regional scale stressors or shifts (e.g., shifts in temperature ranges associated with climate change, presence of a pest infestation). Mosaics identified for protection should include relatively large blocks of habitat (e.g., 2,000 to 5,000 hectares), to be determined based on analyses of existing conditions and habitat requirements for the resident wildlife.
- **Proximity:** Closely clustered habitat patches are more likely to provide habitat to a greater range of species than those which are far apart. Habitat mosaics need not be scattered uniformly across a given regional or local jurisdiction. Alternately, they should follow or be clustered along existing natural corridors.

These habitat mosaics should be identified at two levels: (1) Regional Habitat Mosaics and (2) Local Habitat Mosaics. Regional Habitat Mosaics would include blocks of habitat identified as important on a regional scale (and therefore may be across planning jurisdictions) and likely include many of the

Crown Lands in the southern Canadian Shield. Local Habitat Mosaics would include blocks of habitat identified as important on a local scale (e.g., entirely within a County or a Township) but similarly capture concentrations of diverse natural areas that are largely undisturbed and one or more large blocks of habitat. Planning could be coordinated at both regional and local jurisdictional levels to identify opportunities for ensuring Regional and Local Habitat Mosaics are complimentary or in proximity to each other where possible, and where it makes sense within the given biophysical and land use context...

Preliminary Guidance:

Identify and maintain Regional Habitat Mosaics and Local Habitat Mosaics that capture relatively high levels and/or concentrations of habitat diversity and are predominantly natural areas subject to low levels of disturbance by human activities.

Regional Habitat Mosaics and Local Habitat Mosaics should cover at least 50 to 60 percent of their respective jurisdiction. These mosaics should include habitats that are uncommon in the landscape as well as good representations of more common habitat types, a diversity of age classes for forested habitats and promote of landscape connectivity.

3. Ecological Effects Associated with Cottage / Residential Development

Over the past two decades or so there has been a growing body of research examining so called edge effects into terrestrial natural features (e.g., Murcia 1995, Harper *et al.* 2005). Edge effects in this context are the extent to which stressors or disturbances adjacent to natural areas result in effects that extends into the natural feature itself. These include direct and indirect effects, often related to development or changes in adjacent land covers / uses, that are typically measured and assessed at site-specific scales, but can also result in catchment or broader scale effects.

In the context of the southern Canadian Shield, the effects to the extant terrestrial natural heritage are largely coming from various forms of development that encroach into the natural system on the landscape. In the southern Canadian Shield such effects emanate from fragments of development in a landscape which is still predominantly natural. Nonetheless, these effects remain very real, and in the context of Ecoregion 5E may, cumulatively result in important measurable disturbances to some groups of species. In cases where unique and specialized habitats and being disproportionately affected (e.g., lakeshores), species that require such habitats to complete their life cycles may also be disproportionately affected.

In the southern Canadian Shield, as in most landscapes, riparian areas, forests and wetlands are not necessarily discrete and separate features on the landscape, but are typically closely associated with each other and often overlap. For example, lakeshores and riparian areas are often forested, as are wetlands (e.g., swamps). Nonetheless, in the scientific literature and in planning, riparian areas, lakeshores, woodlands / forests and wetlands are typically approached separately. Therefore, in this section we discuss edge effects into these features separately with the understanding that some of the literature can apply to several of them.

As with terrestrial habitat cover research, most of the empirical studies of this nature undertaken to-date have been undertaken in a fragmented or relictual context (as per **Figure 2**), however the types and extent of the documented edge effects can help inform natural heritage planning in landscapes that are intact or variegated (as per **Figure 2**) in terms of the types of impacts that can occur and the extent to which their influence can extend.

Notably, roads are human-related elements that can have significant effects on habitats and species utilization of them, and have also been documented as causing edge effects. These are briefly discussed separately in **Section 4** below. The focus of this section is on the effects of cottage and/or residential development on various groups of wildlife. Studies undertaken in a predominantly natural context have been favoured.

3.1 Development / Edge Effects along Riparian Areas and Lakeshores

There is an abundance of research on the impacts of adjacent human dominated land uses on watercourses, and the potential value in retaining some type of vegetation filter strip or vegetated buffer to protect the watercourse. The majority of these papers are in agricultural contexts south of the Shield, or in the context of silvicultural practices both on and off the Canadian Shield (e.g., Steinblums *et al.* 1984; Welsh 1991; Durst and Ferguson 2000).

It is now well-established in the scientific and technical literature that the maintenance of some natural vegetation along watercourses and wetlands can mitigate against some of the effects related to land use changes on watercourses. The ability of vegetated buffers to protect watercourses against overloads of sediment, nutrients, and toxins as well as increased temperatures, has been studied extensively (e.g., Castelle *et al.* 1992; Wilson and Imhof 1998, Wenger 1999; Blaha *et al.* 2001; Quinn *et al.* 2004; Mayer *et al.* 2006; Zhang *et al.* 2010).

It is also known that riparian and lakeshore areas tend to be used by a wide range of species for a variety of functions because they are the transition zones between terrestrial and open water ecosystems as well as important gradients between wetlands and uplands that provide unique habitats for communities of plants and wildlife adapted to them (e.g., Keddy and Fraser 2000, Keddy 2010, Attum *et al.* 2007, Stevens *et al.* 2002, Meyer *et al.* 2010). They are also well-documented, both on and off the Shield, as being well-utilized corridors for wildlife movement (e.g., Croonquist and Brooks 1993; Spackman and Hughes 1995; Hennings and Edge 2003; Pearson and Manuwal 2001; Perkins and Hunter 2006; Ficetola *et al.* 2008; Wilk *et al.* 2010; Marczak *et al.* 2010) (see more discussion on this topic in **Section 5**).

However, there is limited research on the impacts of development within riparian or lakeshore zones, at the site or watershed scale, when most of the surrounding natural cover is left intact. All the relevant papers found in the literature focused on ecological effects of lakeshore cottage development at the more site-specific scale, and are summarized below:

- Marburg *et al.* (2009) document the ecological importance of coarse woody debris in sustaining aquatic habitats and biota in northern temperate lakes, and emphasize the need for some “no development” zones around lakes to allow for this natural process to continue.
- Research by Stone (2000) that found riparian bird species richness decreased significantly and consistently, with increases in ambient noise (e.g. loud or discordant).
- Cottage development on lakeshores in central and northern Ontario has been shown to be disruptive to some bird species at the local, but not the larger scale.
 - Armstrong and Euler (1983) and Ford and Flaspohler (2010) both categorized birds into three groups – (1) intolerant of cottage development, (2) tolerant of some cottage development, and (3) favouring developed cottage lots.
 - Armstrong and Euler (1983) found Red-shouldered Hawks to be displaced by cottage development, but not Broad-winged Hawks.
 - Newbrey *et al.* (2005) found that most piscivorous waterbirds were not displaced by even high levels of cottage development in northern Wisconsin, with the exception of three species that are seemingly sensitive to human disturbance (i.e., Osprey, Common Merganser, and the Common Loon).
- Cottage development on Lake Muskoka was found to reduce the extent and availability of White-tailed Deer habitat, and particularly wintering habitat, on a local scale (e.g., reduced food supply and thermal cover related to removal of conifers along the shoreline fringe) (Armstrong and Racey 1983, Voigt and Broadfoot 1995).
- Cottage development around 15 lakes in the Dorset village area was found to impact small mammal diversity and abundance, also on a localized level (Racey and Euler 1982). As with birds, some species were found to be intolerant of cottage development (e.g., Masked Shrew, Red-Backed Vole, Woodland Jumping Mouse) while others were found to be tolerant (e.g., Eastern Chipmunk, Short-tailed Shrew, Deer Mouse).

- Green Frog abundance was negatively affected by lakeshore cottage development in northern Wisconsin, presumably because of the removal of suitable habitat in this zone associated with development (Woodford and Meyer 2003).

Research on residential development in riparian areas also has some relevance to the southern Canadian Shield, and some of the particularly relevant research is summarized below.

- Smith and Wachob (2006) studied a gradient of residential development along the Snake River in Wyoming and found that overall bird species richness declined with increasing development, and that neotropical migrants declined while other more generalist species and nest predators increased.
- Moffat and McLachlan (2003) also studied a rural-urban gradient along riparian areas in Manitoba and found that seed banks were increasingly weedy and less diverse as they got closer to the urban matrix.
- Yet another rural-urban gradient study along 16 riparian areas in Colorado by Miller *et al.* (2003) also found that bird use of riparian habitat was negatively correlated with intensity of residential development.

Although cottage and residential development is not the same as silvicultural deforestation, for some species the temporary or permanent loss of canopy as well as understorey could be considered comparable. Some of the available evidence indicates that, at least at the site-specific level, some species may be naturally resilient and adapted to these types of changes in the landscape. For example, Thompson *et al.* (2008) found variable responses among species in response to tree clearing in northern Ontario followed by replanting. American Toads appeared unaffected by the tree clearing in strips and replanting; Wood Frogs suffered a temporary reduction in abundance but “rebounded” in forests after regeneration of about 30 years; and Pine Marten responded positively to clearing and post-harvest planting, possibly due to the increased conifer content. Schmiegelow and Villard (2009), and Kardynal *et al.* (2009) also suggest this kind of resilience is shown for a number of boreal birds, at least in response to short term perturbations.

An additional consideration is migratory bird stopover habitat, particularly along the shorelines of Georgian Bay and Lake Huron. Recent work in Michigan's eastern Upper Peninsula suggests that terrestrial areas bordering northern Lake Huron provide important stopover habitat for spring migrating landbirds, principally because of the presence of emergent aquatic midges (Smith *et al.* 2007). These lakeshore habitats can be seen as a kind of migratory corridor along which thousands of migrants pass every year. The potential for these habitat uses to be disrupted by recreation or road-related fragmentation, and the importance of habitat connectivity for animal movement pathways is further discussed in the following sections.

Removal of riparian and lakeshore vegetation will result in loss of the functions provided by that riparian vegetation, including functions related to water quality as well as local habitat services for a range of species (e.g., Biswas and Malik 2010). Nonetheless, the broader question as to what extent of habitat disturbance or loss will result in measurable effects at the landscape scale or the population level remains. Local displacement of forest birds, mammals and even herpetofauna may not an important concern if there is adequate habitat in the surrounding landscape to accommodate these species. However, it is where the development of multiple lakeshore cottages cumulatively remove large proportions of streamside or lakeshore vegetation (Racey and Euler 1983) that important effects at the broader scale can begin to manifest themselves.

Research on this topic is currently lacking and this is a major gap in our understanding of effects in the southern Canadian Shield. It seems intuitively unlikely that the entire range of species, including Species at Risk, that use these areas are currently unaffected by levels of shoreline development where they exceed 50 to 75 percent of a given lake, and extend across multiple nearby lakes. An approach that assumes that some of these areas should be protected from development, especially where “hot spots” are located, would seem prudent at this time.

Despite this important data gap, there are some tools available to facilitate natural heritage planning. The use of avian functional guilds (as per Bishop and Myers 2005), like those developed by Armstrong and Euler (1983) can help guide conservation planning by ensuring that habitat areas meeting the requirements of each of those guilds are maintained in the landscape. A comparable approach could be adopted for herpetofauna and mammals.

3.1.1 *Riparian and Lakeshore “Buffers”*

There is a tremendous amount of interest among land use and natural heritage planners in what might be appropriate buffers for riparian and lakeshore habitats. Strictly speaking, the primary function of a buffer is to provide a protective function to the associated waterbody, rather than provide habitat in its own right. Areas that provide habitat functions (such as riparian areas for birds) are more properly termed Critical Function Zones. The buffer, or Protection Zone, in turn would be applied to this zone in order to protect it and the ultimate receiving waterbody.

Vegetated protection zones adjacent to lakes and watercourse are well-documented as providing a wide-range of functions including attenuation of sediments and contaminants, localized water temperature moderation, attenuation of storm water flows, screening of human disturbances (e.g., noise, light), barriers to physical disturbances and invasive species, and slope stabilization (Brown *et al.* 1990, Lowrance and Sheridan 2005, Bradley *et al.* 2010, Thompson *et al.* 2004, Leavitt 1998, Forman 2000, DeWalle 2010, Wenger 1999, Nilaweera and Nutalaya 1999, Moore *et al.* 2005, Castelle and Johnson 2000, Gavier-Pizzaro *et al.* 2010).

Surprisingly, little research has been conducted on the effectiveness of different widths and types of lakeshore Protection Zones in terms of providing water quality functions. Conversely, there is a substantial body of literature examining the effectiveness of different widths and types of Protection Zones along watercourses, albeit primarily in rural and urbanizing landscapes south of the Canadian Shield. Protection Zones documented as effectively performing water quality functions range from 1 metre to over 100 metres, and tend to be between 30 and 35 metres (e.g., Wilson and Imhof 1998, Osborne and Kovacic 1993, Castelle *et al.* 1994, Wenger 1999, Environmental Law Institute 2003). The average must, however, be viewed cautiously because of the inherent variability in effective widths for different biophysical and land use contexts. On the Shield it would be expected that wider Protection Zones than the average cited here may be required in many locations to provide water quality functions because of the generally shallow soils underlain with impermeable bedrock.

In addition to their protective functions, vegetated riparian areas almost invariably provide habitat for a range of species as Critical Function Zones (in addition to their protective functions) (e.g., Spackman and Hughes 1995; Pearson and Mauwal 2001; Perkins and Hunter 2006; Wilk *et al.* 2010; Marczak *et al.* 2010). This is no less true on the southern Canadian Shield than south of it. Given the focus of this report is on terrestrial habitat requirements and conservation guidance, these vegetated riparian and lakeshore zones will be primarily considered in light of their Critical Function Zones (i.e., habitat

functions) rather than their protective (buffering) functions. Notably, research set in more natural, as opposed to agricultural or developed settings, was considered more applicable to the southern Canadian Shield, as were papers that address the provision of habitat for terrestrial species.

Relevant examples of research papers that have examined the habitat functions of riparian or lakeshore areas are described below. These papers and others selected examples are summarized in **Table 3** to provide a sense of the range of habitat widths recommended in the literature.

Table 3. Selected papers that recommend Critical Function Zone widths to support wildlife habitat requirements within a riparian area

Focal Species / Guild	Recom-Mendation	Source	Comments
Various	15 to 30 m	Castelle <i>et al.</i> 1994	Note slightly narrower and significantly wider buffers may be required depending on site-specific conditions / circumstances. Mostly protective.
Herpeto-fauna	50 m	Crawford and Semlitsch 2007	Note the buffer may also provide some critical foraging habitat.
Various	100 m	Environmental Law Institute 2003	Meta-analysis of numerous studies recommending buffers ranging from 4 to 1600 m, with 75% extending up to 100 m.
Mosses	+ 30 m	Hylander <i>et al.</i> 2002	In boreal forests in Sweden: 30 m vegetated riparian areas inadequate to maintain moss species; species loss tied to moisture reduction.
Not specified	50 m Range 10 to 200 m	Johnson and Ryba 1992	
Various	+ 50 m	Marczak <i>et al.</i> 2010	Meta-analysis of habitat use of riparian areas by wildlife from 397 studies.
Various	6 to 123 m	Norman 1998	From review of five selected forestry review papers.
Songbirds	45 m	Pearson and Mauwal 2001	
Herpeto-fauna	5 to 23 m	Pollett <i>et al.</i> 2010	Only test limited range of widths and cite other papers recommending 46 m minimum "buffers".
Herpeto-fauna	172 - 349 m	Semlitsch and Bodie 2003	Recommend a 50 m terrestrial width in addition to a 172 - 349 m core habitat protection zone along watercourses.
Songbirds	100 m	Shirley 2005	Set in the coastal montane forests of Vancouver Island.
Various	75 to 175 m	Spackman and Hughes 1995	Width requirements vary with species group – plants, birds, small mammals
Various	10 to 30 m	Wenger 1999	Note this is strictly for protection of the aquatic habitat in the watercourse terrestrial habitat requires min of 100 m.

- Shirley (2005) observed that effects of forest clearing in the coastal montane forest of Vancouver Island on riparian bird communities were greatest where very narrow habitat widths were left adjacent to watercourses. Several forest-interior species were found almost exclusively in wider habitat width (i.e., more than 125 metres) and abundances dropped dramatically between wide (125 metres) and medium (41 metres) widths with replacement by open-edge species. They recommend that in this context Critical Function Zones of at least 100 metres should be retained to provide habitat for such species.

- Bodie (2001) compiled a literature review of habitat needs for freshwater turtles in North America and concluded that there should be at least a 150-metre riparian zone identified to provide critical habitat to freshwater turtles, and then an additional Protection Zone to protect this habitat from adjacent land uses.
- Semlitsch and Bodie (2003) reviewed the habitat requirements for a wide range of herpetofaunal species, including a number that use riparian areas as critical habitat such as freshwater turtles, and based on their meta-analysis recommend a 172- to 349-metre Critical Function Zone along watercourses where such species breed, plus a 50-metre Protection Zone to protect this habitat from adjacent land uses.

Macdonald *et al.* (2006) hypothesized that riparian vegetation would be more structurally diverse and species rich than adjacent uplands. They tested this hypothesis around small lakes in the boreal mixed wood zone of Alberta. Surprisingly, they found that riparian areas were neither more structurally nor biologically diverse than their upland counterparts from a vegetative perspective. However, they did nonetheless support a higher abundance of amphibians (in this case Wood Frog and Boreal Toad), a higher abundance and diversity of songbirds, and a higher abundance of small mammals. This suggests that it is simply the proximity to the lake that makes these habitats more appealing to wildlife, rather than any unique vegetative composition in this zone, even in the absence of an adjacent clearing or disturbance, at least in a boreal mixed woods setting. This could be explained in part by the presence of insects, which tend to be more abundant by lakeshores (Whitaker *et al.* 2000).

Despite the interest in what might be an appropriate Critical Function and Protective Zone width for sustaining habitat values along watercourses and lakeshores, the science speaks to the variability in habitat needs – both between species and species guilds – and indicates that these alone are not enough to sustain most wildlife species in the long term. In their meta-analysis of nearly 400 papers, Marcak *et al.* (2010) found that “buffers” in the 50-metre range did not maintain terrestrial organisms at levels comparable to undisturbed sites. Macdonald *et al.* (2006), based on their studies of dynamics between intact riparian and upland forests around lakes in Alberta’s boreal forest, conclude the following:

“We encourage those responsible for forest management to re-think prescriptive placement of fixed-width forested buffers around all lakes, and instead consider a landscape-scale planning approach that determines the appropriate placement of uncut forest on the landscape to meet broad conservation objectives.”

Although there is some habitat value in maintenance of vegetated buffers adjacent to lakeshores and watercourses, as well as water quality value, the literature suggests that long term maintenance of species diversity requires the identification of areas protected from development at the landscape scale.

3.2 Development / Edge Effects into Forests

The bulk of the scientific research on edge effects around forests and other upland areas has been undertaken in a context where the natural area is a fragment in a largely agricultural or urbanized landscape. On the southern Canadian Shield the more typical context is one where cottage developments around a lake or along a river are encroaching into the edges of the forest with the footprint of the building itself, as well as any associated roads and servicing requirements (e.g.,

transmission line corridors). Nonetheless, the available edge effects research does provide some insight into the types of effects that can be anticipated to forested habitats, as well as the extents these effects can extend from the forest edge. There are also a handful of papers that have specifically examined the effects of lakeshore cottage developments on wildlife, at least on a somewhat local scale, which are discussed in **Section 3.1** above.

Harper *et al.* (2005) compiled a synthesis paper of forest edge effects and concluded that: (1) abiotic and biotic gradients near created forest edges generate a set of primary responses, and that (2) indirect effects from these primary responses and the original edge gradient perpetuate edge influence, leading to secondary responses. Primary responses include reduced moisture – both air and soil – along the edges and increased light. Secondary responses include invasive species establishment and spread, and local declines in or extirpation of songbirds. They also suggest that the magnitude and distance of edge influence are related to the contrast in structure and composition between adjacent communities on either side of the edge, as well as local factors such as climate, edge characteristics, stand attributes, and biotic factors.

An often-used generic distance for the extent to which edge effects extend into a forested area is 100 metres; this distance is used both in some of the scientific research as a reference point (e.g., Driscoll *et al.*, 2005; Dunford and Freemark, 2005; Nol *et al.*, 2005; Weber *et al.*, 2008). However, the scientific literature reports much variability in the distance into forested habitats effects are documented depending on the nature of the forest, the land use context, and the stressor or source of disturbance. There is also evidence of differential responses of species, and species guilds, to such effects with some species avoiding “edge” habitats, others seemingly tolerating them, and others still preferring these newly opened areas (Clark and Armstrong 1984; Ewers and Didham 2006; Ford and Flaspolder 2010). As several authors have pointed out, many species of boreal plants, birds, mammals and insects are well-adapted to sudden and temporary habitat loss because of the significant role that fire has played on the Canadian Shield (e.g., Niemi *et al.* 1998; Biswas and Malik 2010; Kardynal *et al.* 2009; Larivée *et al.* 2008), although it seems unlikely that cottage development mimics this disturbance because it tends to be a permanent rather than a temporary disturbance.

Murcia (1995), in one of the first papers to undertake a systematic review of edge effects, documents edges extending 10 to 600 metres into temperate and tropical forests. Murcia (1995) in her review defines three types of edge effects, as follows:

- (1) abiotic effects (i.e., changes in the environmental conditions as a result of the structurally dissimilar matrix) – ranging from 15 to 50 metres
e.g., changes in light, air temperature and moisture, soil temperature and moisture, penetration of chemical compounds such as herbicides or pesticides.
- (2) direct biological effects (i.e., changes in the abundance and distribution of species caused by changes in physical conditions) – ranging from 15 to 150 metres
e.g., tree density, species composition, species abundance (e.g., Wood *et al.* 2006)
seedling regeneration, plant mortality.
- (3) indirect biological effects (i.e., changes in species interactions related to the difference in physical conditions) – ranging from 10 to 600 metres
e.g., predation, brood parasitism, competition, herbivory, seed dispersal and plant propagation.

Responses of birds and amphibians to local-scale disturbances appear to be negative in fragmented landscapes, but are more variable in landscapes where the predominant land covers are natural. Research conducted in forested habitats adjacent to residential developments in southern Ontario and other fragmented landscapes have documented significant declines in bird density and diversity (particularly neotropical migrants) associated with the establishment and/or increased density of adjacent residential development (Friesen *et al.* 1995; Friesen and Zantinge 2003, Germaine *et al.* 1998; Kluzza *et al.* 2000). However, documented responses of birds to localized disturbances in largely forested settings are variable. For example, Whitaker *et al.* (2008), as cited in Schmiegelow and Villard (2009), in their study of 14 species of boreal songbirds in Newfoundland over a four-year period found that almost all species showed adaptable movement behaviours in response to selective clear cutting in a context where 6 percent of the landscape and less than 15 percent of the productive woodlands were harvested. Responses of amphibians to localized forest clearing in the boreal forest were found to be variable as well. Thompson *et al.* (2008) found that American Toads appeared unaffected by tree clearing in strips followed by replanting in northern Ontario (i.e., Kapuskasing), while Wood Frogs suffered a temporary reduction in abundance but "rebounded" in forests after regeneration of about 30 years.

The use of "buffers" to ensure the protection of a terrestrial wildlife habitat function (e.g, deer yarding, lakeshore animal movement) remains poorly developed. In general, there is a lack of research assessing the effectiveness of buffers to forested areas in fragmented landscapes in mitigating the effects of stressors from development in adjacent lands. In his 1998 publication, Friesen identifies buffers to forests as a fundamental planning approach needed to mitigate impacts in urban contexts, but acknowledged the buffer widths required for this mitigation have yet to be studied. This remains true today. This knowledge gap is partly explained by the challenges in assessing buffer effectiveness in the south because of the confounding of landscape effects (such as habitat loss and fragmentation), which are known with certainty to affect biodiversity, with site-specific effects. However, in the southern Canadian Shield the forest buffer argument is largely irrelevant as the provision of a buffer for a proposed development within a forest unit would be redundant, or could even result in the loss of more forest cover if additional forest were to be removed to accommodate a buffer area.

Recent research on mechanisms to control encroachment into adjacent natural areas is, however, more relevant. Recent research by McWilliam *et al.* (2010, 2011) in natural areas adjacent to hundreds of residential lots across southern Ontario found that some types of encroachments into the adjacent (public) natural areas were evident in almost all cases, but that the most effective tool for reducing the nature and extent of those impacts was the presence of a chain link fence with a mown grassed strip in front of it. This approach would be more difficult to implement in the context of cottage development on the southern Canadian Shield, although it may apply to more urban-type developments...

Overall, what is missing with respect to edge effects to forests in the context of the southern Canadian Shield is research on the cumulative effects of cottage developments, and associated infrastructure, on plant communities and wildlife species on a landscape scale.

3.3 Development / Edge Effects into Wetlands

Development around and adjacent to freshwater wetlands has been linked with a wide range of disturbances. Key documented disturbances (from Sheldon *et al.* 2006) include changes in: water quantity and quality (e.g., levels of nutrients such as fertilizers, grey water and leaky septic beds, chemical contaminants and salt), water regime (i.e., frequency and duration of changes in water levels), acidity levels, sediment levels, vegetation extent and composition, and wildlife abundance and diversity. Empirical studies that have documented such effects are discussed below. Human settlement can also initiate or hasten the spread of invasive alien species as place of release or spread.

The three changes from land use change with the most potential to impact the water balance of wetlands include increased stormwater runoff (due to an increase in impervious surface area, compaction of soils, and the loss of vegetation that once intercepted rainfall), decreased groundwater recharge (and resulting reduction in infiltration due to an increase in impervious surface area and compaction of soils) and flow constrictions (i.e., by the construction of roads, bridges, pipelines or other structures across individual wetlands, or upstream or downstream of them) (Carter 1996).

The water regime, also called the hydroperiod, of wetlands (i.e., the depth, duration, frequency and pattern of flooding) as well as the nature and extent of groundwater contributions are key factors in determining what kind of habitats wetlands provide, as well as how they may be affected by disturbances in adjacent lands (e.g., Azous *et al.* 2000, Acosta and Perry 2001, Schneider 2003, Baldwin *et al.* 2006). Extensive studies conducted by Azous *et al.* (2000) on responses of wetlands to urbanization in the Puget Sound area found that:

“hydrologic changes were having more immediate and measurable effects on the composition of vegetation and amphibian communities than other environmental conditions ... monitored, such as water quality”

and that hydroperiod was a key factor in determining biological responses. It is the relatively small and hydrologically isolated wetlands required by many species of amphibians (and some reptiles) for survival that are most important.

Effects on Vegetation

Freshwater herbaceous plants associated with wetlands have been shown to respond to human disturbances, and specifically increases in nutrient inputs, from adjacent lands with shifts in species composition that favour invasive species and accumulation of dead plant matter faster than it can decompose, resulting in changes to the vegetative and soil structure of the wetland community (Adamus *et al.* 2001). Contamination with pollutants can also have short and long-term impacts for wetland vegetation, and the species that rely on that vegetation for habitat (Chow-Fraser *et al.* 1998).

South of the Canadian Shield, successive years of prolonged flooding or droughts have been shown to result in a reduction in the abundance and richness of native species (Adamus *et al.* 2001; Wright *et al.* 2006), although these impacts to riparian vegetation may not be the same on the Shield. Furthermore, Frieswyk and Zedler (2007) found that once a shift in wetland vegetation communities

occurred in Great Lakes coastal wetlands on Lake Michigan's Green Bay, even reintroduction of more natural water level fluctuations did not seem able to reverse this trend.

Effects on Wildlife

Changes in land use adjacent to forested wetlands have been linked to declines in amphibian and reptile abundance and diversity, as well as some types of birds. For example, research in forested wetlands adjacent to residential developments in eastern North America south of the Shield have documented significant declines in amphibian abundance and diversity (Knutson *et al.* 2000; Richter and Azous 2000). DeLuca *et al.* (2004) found that in an urbanizing context in Massachusetts marsh bird community integrity declined significantly when urban/suburban development within 500 and 1000 metres of the marsh exceeded 14 and 25 percent respectively.

Some changes in amphibian community structure have been linked to a variety of impacts, including nutrient loading (Houlahan and Findlay 2003, Adamus *et al.* 2001), and introduction of toxic chemicals² (e.g., Bishop *et al.* 1999, Laposta and Dunson 2000, Reinelt *et al.* 1998). However, hydroperiod appears to be one of the key drivers for pool breeding amphibians that rely on relatively small (i.e., less than 4 hectares) and seasonally inundated wetlands, to complete their life cycle (e.g., Baldwin *et al.* 2006, Babbitt 2005), even though amphibians, as a group, are adapted to survive temporary droughts and flooding (e.g., Gibbons *et al.* 2006).

Although the technical literature points out the need for simplified, prescriptive Protective Zones to protect wetland habitats from stressors in adjacent land uses (e.g., Wenger 1999), there seems to be broad consensus in the scientific literature that because of the number of site-specific variables that require consideration it is impossible to recommend a single width that will be appropriate for most sites. In addition to site-specific biophysical factors (i.e., soils, slopes, local hydrology), Adamus (2007) asserts that widths must be determined with consideration for:

- Adjacent land use activities;
- The amount and configuration of development in the adjacent lands and landscape;
- The structure and type of vegetation in the buffer; and
- The particular species the buffer is being designed to protect.

In order to address this range of variables but still provide concrete guidance, some review papers identify multiple recommendations for buffers to account for different desired functions and/or existing and anticipated conditions. Many of the studies confound Protective Zones and Critical Function Zones, instead often referring to the generic "buffer":

- In their study of wetlands in East Central Florida, Brown *et al.* (1990) generate the following means and ranges for all wetland types:
 - 24 to 137 metres (range 6 to 168 metres) to minimize groundwater drawdown;
 - 23 to 114 metres (range 23 to 114 metres) to control sedimentation; and
 - 98 to 182 metres (range 98 to 223 metres) to support wetland dependent wildlife habitat needs...

² The science is not equivocal on this point (e.g., Bridges and Semlitsch 2000) and different types of herbicides and pesticides elicit differential responses among species of amphibians and reptiles, and can also affect species differently depending on their life stage, and how they interact with other abiotic factors in the wetland (such as pH).

- Castelle *et al.* (1994) recommended minimums from 15 to 30 metres for both water quality and habitat functions, recognizing slightly narrower or significantly wider buffers may be required depending on site specific conditions.
- The Environmental Law Institute (2003) recommended minimum protection zones of 25 to 50 metres for wetlands for water quality functions.
- Sheldon *et al.* (2005) develop three recommended buffer ranges that require a valuation of wetland functions and proposed adjacent land uses, as follows:\ul
 - buffers between 8 and 23 metres for wetlands with minimal habitat functions and low-intensity adjacent land uses;
 - buffers between 15 and 46 metres for wetlands with moderate habitat functions and moderate or high-intensity adjacent land uses; and
 - buffers between 46 and 92 metres (or more) for wetlands high habitat functions, regardless of the intensity of the adjacent land uses.

Notably, none of these recommendations or papers considers the possibility of reducing vegetative widths if combined with other design elements, such as physical barriers, to support desired functions.

Key considerations such as the size of the core habitat and the overall landscape context, as well as the level of sensitivity of the focal species to disturbance need to be considered. More research is needed in this area, particularly in terms of well-designed long term monitoring to test the effectiveness of different sized buffers in supporting habitat use by wetland-dependent species.

Although edge effects into wetlands are documented at the site scale, they can have broader catchment or watershed-scale impacts. For example, disturbance to wetlands can result in changes to their water and sediment storage capacity, thereby reducing erosion control capabilities which may cause water quality impacts to downstream water bodies (Sheldon *et al.* 2005).

However, as with forested habitats, the available science on the potential cumulative impacts of reduction or loss of function of multiple wetlands in a given catchment or watershed in the context of habitats on the Canadian Shield is largely absent. Although it is recognized in the scientific and technical literature as an important consideration in natural heritage planning, but very little empirical research or even modelling has been conducted to explore such questions. Siegel (1988) identifies the need to consider the interactions between hydrology, water chemistry and biota as part of wetland impact assessment but also acknowledges the difficulty in predicting the cumulative effects of these interactions given our limited understanding of existing or baseline conditions prior to disturbances. More current papers like Crowe and Shikaze (2004) exploring linkages between groundwater and coastal wetlands of the Laurentian Great Lakes also illustrate the complexity and the limitations of our understanding of these hydrologic and hydrogeologic dynamics.

3.4 Discussion and Preliminary Guidance

Currently there is insufficient information related to the extent of edge effects created by cottages and related developments on adjacent riparian or lakeshore, forested or wetland habitats to support the development of quantitative guidelines regarding how much disturbance is too much. In particular, there is information lacking on the cumulative impacts of multiple cottage developments both temporally and spatially. Nonetheless, the available research indicates that there are a number of effects of this type of development on certain guilds or types of wildlife species which suggests that, cumulatively, cottage and residential developments in largely natural landscapes does at the very least displace these species, and in some cases where the cumulative effects are extensive enough may result in local extirpation.

One approach to dealing with this uncertainty is to use functional species guilds based on shared habitat preferences or behavioral characteristics (e.g., Bishop and Myers 2005, Croonquist and Brooks 1991) as a tool to ensure habitat requirements for all species that occur in Ecoregion 5E, and particularly species with greater sensitivities to development, are provided. The first step in this approach is to group species into functional species guilds, particularly recognizing species that are considered more sensitive to disturbance and those that require specialized habitats, such as natural lakeshores, that are under a disproportionate amount of development pressure. The second step is to associate each of these guilds with their habitat requirements in terms of habitat types, levels of cover and levels of disturbance at the landscape scale (e.g., this could be as simple as "high", "medium" and "low"). The third step is to work with existing conditions information to try and define as well as map areas in a given watershed or jurisdiction meeting the requirements for these various species guilds. As stated by Bishop and Myers (2005):

"Spatially clustered blocks of high species richness for a particular guild are more indicative of habitat availability and quality than would be the case for overall species richness. Clusters of blocks having high intra-guild species richness become candidate areas for conservation efforts."

An example of some relatively coarse, preliminary mapping that identifies areas of ecological sensitivity for the Muskoka Watershed in relation to areas of human impact (i.e., associated with road networks) is provided in recent work by Riverstone Environmental Solutions (2011). Combining these types of baseline data (e.g., habitat information, road networks) with species guild information could be used as a GIS-based tool to try and ensure Regional and Local Habitat Mosaics (as described in **Section 2**) include habitat for groups of species considered most at risk from the types of development occurring in the southern Canadian Shield.

A key gap identified in this report is research on the cumulative effects of cottage developments, and associated infrastructure, on plant communities and wildlife species at a landscape-scale. Until some of that information becomes available, planning decisions can only be based on the knowledge that some groups of species have been shown to be disturbed by localized cottage and residential developments, and that presumably, enough of this type of development will result in the local extirpation of those guilds. A further consideration is that while many bird species are predominantly reliant on overall cover levels, as well as the vegetative quality and structure within that cover, herpetofauna seem to be predominantly reliant on the presence of suitable habitat at a much smaller scale, at least for short term sustainability. Therefore, natural heritage planning that accommodates the needs of these different species guilds must be implemented at both local and regional scales.

Outside of these Regional and Local Habitat Mosaics intended to primarily provide habitat for the species most sensitive to disturbances, some more site-specific conservation measures should also be considered to support the habitat requirements of species less sensitive to development, and those that can be conserved on a smaller scale, as well as broader species movement through the landscape.

Preliminary Guidance:

Additional research is required to better inform this guidance.

Identify and make use of species guilds that are functionally related, and their associated habitat requirements, to ensure that both Regional and Local Habitat Mosaics are designed to provide for the full range of riparian / lakeshore, forest and wetland species that occur across the southern Canadian Shield. In particular these Mosaics should provide habitat for those groups of species considered most sensitive to the cumulative effects associated with cottage / residential lakeshore developments.

Outside of the Regional and Local Habitat Mosaics the following habitat-specific guidance should be considered:

- **Riparian / Lakeshore Habitats:** No development zones should be identified around portions of lakes and along rivers to allow for natural functions and dynamics to persist. The extent of these zones will vary depending on the local context, but should include known wildlife movement corridors wherever possible.
- **Wetlands:** Where development is occurring around wetlands, Critical Function Zones and Protection Zones should be determined based on consideration for the site's sensitivities and hydrology, as well as its habitat functions, including habitat requirements for species that extend beyond the wetland boundary.

4. Ecological Effects Associated with Roads

Roads result in a variety of direct, indirect and cumulative impacts to ecosystems, at a variety of scales (see **Figure 3**). Where natural habitat is extensive, the key impacts relate largely to wildlife mortality, potential effects on rare species that have low rates of reproduction, and human safety hazards (typically related to large mammals). Immediate and direct impacts of new roads through natural, and particularly forested, areas include noise, light, poor air and water quality, microclimate moderation, and partial to complete isolation of natural areas for terrestrial species (see **Figure 4**).

Large, busy highways are recognized as creating physical barriers to the movement of amphibians, reptiles, mammals and even some insects, and also contributing directly to their mortality. Busy highways have been shown to be an almost complete barrier for frogs (Eigenbrod *et al.* 2008) and large mammals (Riley *et al.* 2006, Larkin *et al.* 2004). Riley *et al.* (2006) found that even though 5 to

32 percent of the Bobcats and Coyotes sampled over a seven year period crossed the Ventura Freeway near Los Angeles, the populations on either side were genetically differentiated.

Roads not only create barriers for herpetofauna and mammals; in a unique paper by Bhattacharya *et al.* (2003), bumblebees were found to rarely cross roads or railroads in Boston, Massachusetts to move between bushes of the same species, and instead show an innate fidelity to bushes on the same side of the perceived barrier.

No studies were found that directly link the impacts of local road mortalities to the sustainability of the local population. However estimates based on the proportion of fatalities in relation to the numbers of individuals observed suggest that for some species – particularly of reptiles - there could be significant effects. For example, Haxton (2000) found 30.5 percent of the Snapping Turtles observed were killed over a two year period on roads in central Ontario. Furthermore, for frogs, salamanders and turtles peak road mortalities have been linked with periods during the species' life cycles when females are seeking nesting sites (for turtles), moving between breeding and foraging sites, or moving in search of overwintering sites (Ashley and Robinson 1996, Haxton 2000, DeMaynadier and Hunter 2000). Other studies have also documented greater road mortalities among female turtles (e.g., Steen and Gibbs 2004), Steen *et al.* 2006) suggesting that for turtles which have long life spans, and more delayed sexual maturity reproductive cycles, road mortality may have much broader repercussions than the loss of a single individual. Roads are also considered a significant threat for Eastern Massasauga Rattlesnake populations (DeGregorio *et al.* 2011). How road mortalities can result in population effects is illustrated in **Figure 3**.

Figure 3. An illustration of the impacts of a busy road on wildlife at a different scales (from Forman *et al.* 2003)

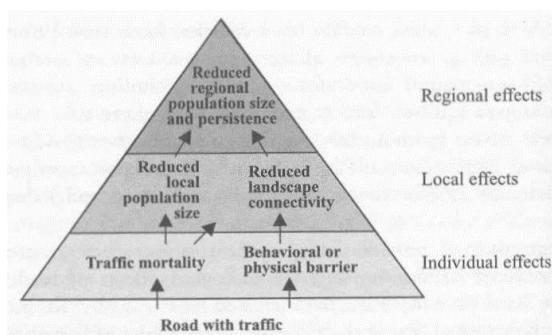


Figure 3 illustrates how the effects of roads on individual species (i.e., direct impacts of road related mortality as well as indirect impacts of the road as a barrier to movement between suitable habitats) can cumulatively result in regional population impacts.

Research on the identification of “hotspots” of road mortality for turtles, and other herpetofauna has found that the location of roads in the landscape in relation to natural habitats can have a significant influence. Studies by Clevenger *et al.* (2003), Mountrakis and Gunson (2009), Gunson *et al.* (2012) and Langen *et al.* (2009) found that road kills are not random occurrences but rather tend to be spatially clustered. For herpetofauna these “hotspots” occur where wetlands occur on both sides of the road (Langen *et al.* 2009, Ashley and Robinson 1996).

For many birds, it is the noise generated by vehicular traffic that poses a significant deterrent to breeding by birds in various types of adjacent habitats.

- In Massachusetts, grassland bird breeding success was unaffected in the vicinity of a road with 3,000 to 8,000 cars per day, but reduced breeding success occurred at 400 metres from the road with 8,000 to 15,000 cars per day; 700 metres from the road with 15,000 to 30,000 cars per day; and 1,200 metres from the road with more than 30,000 cars per day (Forman *et al.* 2002).
- Forman *et al.* (2003) found that the presence of multi-lane (and presumably high traffic volume) highways impacted the presence and breeding activities of birds up to 1,200 metres into the adjacent natural areas from the edge.
- In Holland, densities of breeding birds in woodlands adjacent to a highway were studied. Roads with 10,000 cars / day led to reduced density up to 1.5 kilometres from the road, while roads with up to 60,000 cars / day were linked to reduced breeding bird densities up to 2.9 kilometres from the road (Reijnen *et al.* 1996).
- Houlahan and Findlay (2003) documented significant drops in amphibian species diversity and abundances within 200 metres of busy roads, and recommend that such roads be kept at least this distance from some wetlands and forest in a given planning jurisdiction if amphibian populations are to be maintained. However, as discussed above, edge effect values cannot simply be translated into buffer recommendations.

This evidence, and other related papers (Reijnen *et al.* 1997; Forman 2000), suggests that it is the volume of traffic, rather the size of the road itself, that deters many birds from breeding adjacent to roads. Forman (2000) finds that impacts to forest birds are generally not detected until levels of road traffic reach 10,000 vehicles per day, and that edge effects tend to increase with increasing levels of traffic. However there is some evidence that even unpaved and infrequently used roads in forested habitats can deter some species, like Ovenbirds, from breeding in the immediately adjacent habitat (Ortega and Casper 1999) indicating that, at least for some birds, factors other than noise are at play.

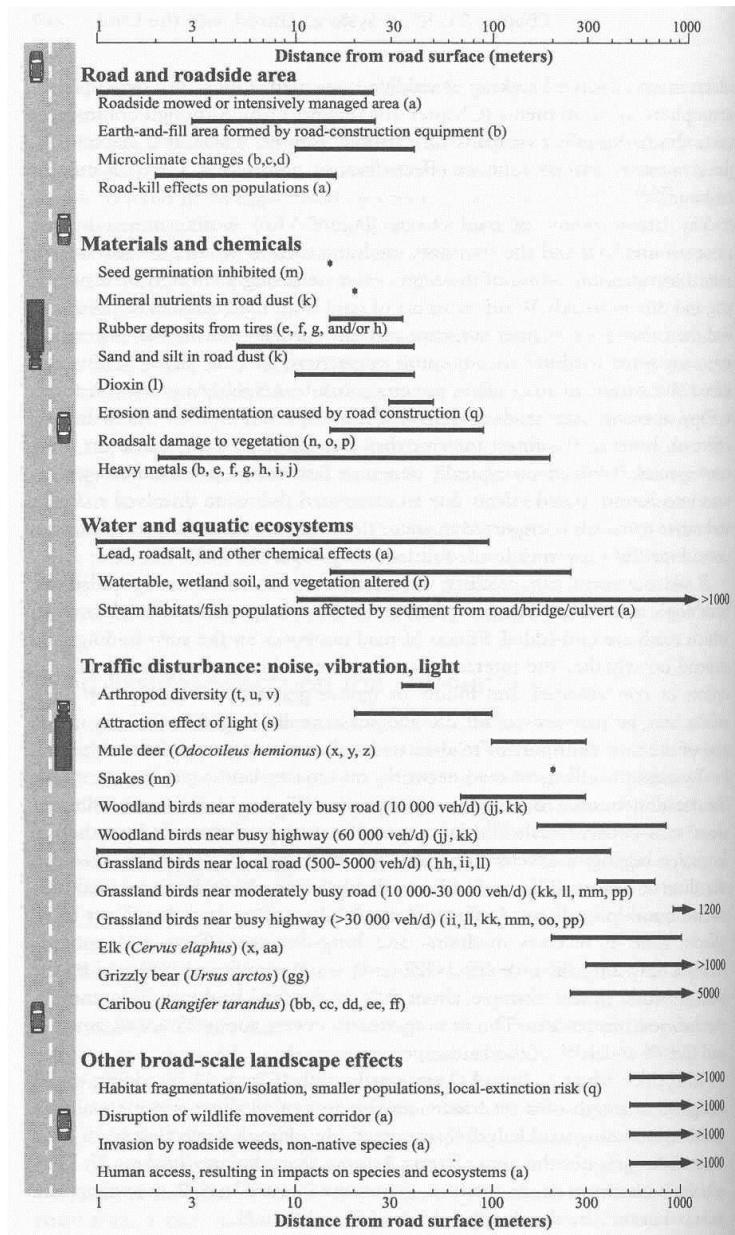
In a synthesis publication by Forman *et al.* (2003) they illustrate the range and types of edge effects associated with roads, as shown in **Figure 4**. These range from immediate and direct impacts (e.g., microclimate changes, road kills) that extend up to about 30 metres from the road edge to impacts to adjacent aquatic and terrestrial habitats related to noise and contaminants that can extend more than 1 kilometre from the road edge.

On a broader landscape level, roads – and particularly busy roads - can contribute to overall habitat fragmentation and disruption of wildlife corridors, as well as introduction of invasive species and facilitation of human access to natural areas that were previously not readily accessible (Meddens *et al.* 2008). These impacts can extend well over one kilometre (as illustrated in **Figure 4**). Some examples from the scientific literature are provided below:

- Houlahan and Findlay (2003) found that the negative impacts associated with road density on amphibian diversity extended from 200 to 3000 metres from the habitat edge.
- Catling and Carbyn (2006) found that invasive European Common Reed was more strongly associated with roads in eastern Ontario, and hypothesized rhizomes extending onto gravel shoulders were broken and transported by construction equipment, graders, ploughs, mowers, and in the treads of many kinds of vehicles.

- DeCatanzaro and Chow-Fraser (2010) examined abundances of freshwater turtles around 77 coastal marshes on the Great Lakes in southern and south central Ontario over a period of six years. They found that Painted Turtles, despite their relative abundance across Southern and Central Ontario, as well as their tolerance for degraded wetland conditions, appear to start to decline in relation to higher road densities in highly developed areas.

Figure 4. Effect distances from roads for diverse ecological factors divided into 5 categories of impacts (from Forman *et al.* 2003).



A study by Jantz and Goetz (2008) in the northeastern United States looked at “exurban” development and found that the proliferation of more scattered residential developments in the rural and natural areas outside cities was beginning to have a significant effect on the deciduous forested habitats because of the fragmentation of previously roadless, predominantly natural areas. This study illustrates how even seemingly benign cottage developments can, over time, have significant impacts on the natural landscape, and the authors conclude that an “*ecologically functional reserve network for the region*” is needed to address this issue.

Notably, although roads are recognized as contributing to habitat fragmentation, other equally influential biophysical and anthropogenic factors also contribute to the patterns of natural area, and in particular forest and wetland cover, on the landscape. Key factors include regional moisture regimes, historic land uses and both historical and current fire dynamics (Meddens *et al.* 2008). In South Central Ontario, the forests are naturally fragmented by extensive networks of lakes and river systems, as well as wetlands that dot the landscape. Presumably, however, the species that occur in these areas are adapted to moving within and across this landscape. The fragmentation created by roads, and particularly large and busy roads, is not something these species are so well adapted to. While for some groups, such as birds, the primary impact of roads appears to be avoidance and displacement, for other groups, such as herpetofauna and some mammals, the effects include direct mortality related to road kills and prevention of migration for breeding which can have short and long term effects for those populations.

Eigenbrod *et al.* (2008) introduce a new approach to landscape scale analyses of road impacts on wildlife, and particularly herpetofauna, with the concept of “accessible habitat” (i.e., amount of forest at least 1,000 metres from the edge of a pond without an intervening busy road). They found that for anurans, total forest cover adjacent to Highway 401 in Ontario was in and of itself not a good predictor of anuran species richness, but that the amount of “accessible habitat” was. This suggests that for pond-breeding amphibians being able to move safely between breeding ponds and upland terrestrial forested habitats on a scale of about 1 km² is more important than overall forest cover levels at the watershed scale, at least for their short term persistence and population viability.

Roads and Species at Risk

Roads are considered a particular hazard for many of the wildlife Species at Risk that occur along the southern Canadian Shield (as listed in **Table 2**), and particularly the herpetofaunal species. In their study of 77 coastal marshes on the Great Lakes in southern and south central Ontario, DeCatanzaro and Chow-Fraser (2010) found that the provincially and federally Threatened Eastern Musk Turtles did not occur in degraded coastal wetlands and areas with high road densities highly urbanized areas or areas with high densities of roads that fall within their historic range. A study of Snapping Turtle, which is now listed as Special Concern, in Central Ontario by Haxton (2000) reported high road mortality during the species’ nesting period and expressed concern about the local sustainability of the population. Recent ecological research on the provincially and federally Threatened Eastern Massasauga Rattlesnake (DeGregorio *et al.* 2011) also recommended minimizing interactions between snakes and roads, particularly in the northern extents of their range where they are typically more active for longer, and thus more mobile. Haxton and Berrill (2001) similarly expressed concern regarding the provincially and federally Endangered Spotted Turtle because of the higher levels of activity demonstrated in the northern extent of its range, which also falls within the southern Canadian Shield in Ontario.

For species that are already at risk due to other factors, additional disturbances that are known to pose a serious threat (e.g., from road development) can cause a disproportionate effect because populations are already under stress." Therefore special care needs to be taken to eliminate, minimize and mitigate such effects (in that order, from most to least preferred).

4.1 Discussion and Preliminary Guidance

Roads, particularly in predominantly natural landscapes like that of the southern Canadian Shield, can be a primary source of significant direct and indirect negative impacts to vegetation communities and various groups of wildlife. Direct impacts include causing road mortality of various wildlife species, contributing to habitat fragmentation (i.e., creation of barriers in the landscape), and interrupting wildlife corridors. Indirect impacts include reduction in species use of habitats adjacent to roads, introduction of pollutants, contaminants and invasive non-native species, and providing access to human intrusion to natural areas that would otherwise be hard to access. Roads are also thought to contribute to the At Risk designation of some herpetofaunal species - turtles and snakes in particular, as well as possibly contribute to the spread of invasive alien species.

An important consideration is that road connectivity at a regional scale is likely less essential for human survival and quality of life at a population level than connectivity of patches for plant and wildlife is for their survival and maintenance of their populations.

Recommended Guidelines:

Avoid the development of permanent roads in Regional Habitat Mosaics and Local Habitat Mosaics and decommission temporary roads promptly.

{A positive guideline that talks about the nature of the habitat mosaic, such as 'over X% of a habitat mosaic should be interior/undisturbed habitat', vs. a guideline that speaks to the amount of disturbance, would be preferred}

Where new roads within Regional Habitat Mosaics and Local Habitat Mosaics are considered essential:

- ***accommodate for substantial buffers between important wetlands and roads wherever possible;***
- ***avoid locating roads where important wetlands occur on both sides; and,***
- ***implement mitigation measures based on the most current tools and data.***

5. Loss of Connectivity Between Habitats

The importance of restoring habitat connectivity is less of an issue on the southern Canadian Shield than in Southern Ontario where the landscape is almost entirely fragmented and relictual, rather than variegated and intact (see **Figure 2** above). Nonetheless, maintaining habitat connectivity remains an important theme as development pressures, and related infrastructure needs increase in this part of Ontario. As Soulé and Terborgh (1999) state:

"The evidence that isolated reserves ... gradually lose native species ... is overwhelming. Such gradual degradation can only accelerate as human activity and development increase on surrounding lands. [However,] the elements of the solution are known: bigness and connectivity".

Although, as described above, the current context in the southern Canadian Shield is generally supportive of habitat connectivity, there are questions around the impacts of breaks such as major highways, as well as the cumulative impacts of smaller roads and localized developments, particularly on the movement of large mammals and reptiles in the landscape.

While many researchers continue to assert that maintaining terrestrial linkages and connectivity in fragmented landscapes is critical for ensuring the movement of flora and fauna between forested patches, particularly for mammals (Angold *et al.*, 2006; Hannah, 2008; Beier and Brost, 2010; Spring *et al.*, 2010), others have questioned the value of wildlife corridors, particularly for certain groups of species and in certain contexts (e.g., Falcy and Estades, 2007; Bailey, 2007; Davies and Pullin, 2007). As with many topics in ecology, there are a variety of factors to consider with respect to corridors. These include: the differing dispersal abilities and mobility among and within different taxonomic groups, the nature of the corridor (e.g., length and width, vegetative structure) and the nature of the matrix surrounding the corridor. There are also negative effects that may result from connectivity, particularly the spread of novel pathogens and invasive non-native species. The negative role of corridors in biological invasions is uncertain, with Beier and Noss (1998) noting a lack of studies on the subject and Damschen *et al.* (2006) finding that corridors do not directly promote invasion by exotic species. Hansen and Clevenger (2005) contend that forest corridor edges and grassland habitats act as microhabitats for non-native species and are more prone to invasion by exotic species than forests, especially if disturbed.

Recent empirical evidence and meta-analyses do, however, support the idea that corridors facilitate movement of a range of both plant and wildlife species (e.g., Damschen *et al.* 2006, Gilbert-Norton *et al.* 2009, Veysey *et al.* 2009), although it has also been shown that not all species require corridors for effective movement, particularly birds (Gilbert-Norton *et al.* 2009, Fraser and Stutchbury 2004).

While these concepts have relevance for the southern Canadian Shield, the extent to which the specific results of the research cited above would apply is questionable. In some areas, the continuity of riparian/lakeshore systems could be described as fragmented by lakeshore development, but this type of fragmentation has not been very well explored in the scientific literature. The existing literature certainly supports the idea that wildlife use riparian areas as corridors, particularly in contexts where some of the adjacent upland forested areas are disturbed or removed. Use of such areas as wildlife corridors has been documented for songbirds (Machtans *et al.* 1996, Pearson and Mauwal 2001, Shirley 2005), flying insects, (Whitaker *et al.* 2000), and various small mammals (Spackman and Hughes 1995). Therefore it is possible that fairly intensively developed lakeshores would disrupt pre-existing wildlife corridors, at least for species more sensitive to human presence and disturbances.

Several general principles with respect to wildlife corridors have been discussed in the scientific literature for well over two decades (adapted from Adams and Dove 1989, and others as cited below):

- Connectivity (also sometimes called ecological linkages) can (and should) function on multiple scales, and typically vary in size (width and length) as well as quality (e.g., plant species composition, diversity and structure).

- Pathways of connectivity used by wildlife often (but not always) follow physiographic features on a regional scale (e.g. stream corridors, lakeshores), but wildlife have also been documented using anthropogenic corridors such as transmission lines and highway rights-of-ways.
- Connectivity should consider the migratory habitat requirements of the species they are intended to support, particularly when they have specialized requirements (e.g., Burbrink *et al.* 1995).
- Pathways of connectivity, when through a hostile matrix, should be wide enough to shelter the animal species from predators, allow for movement, and provide nesting and feeding opportunities for slower moving groups of wildlife groups (Forman 1995, Spackman and Hughes 1995).

The use of so-called ‘umbrella species’, as formerly suggested by Soulé and Terbough (1999) and others, (i.e., species that are high on the food chain that tend to have the largest habitat and connectivity requirements) in identifying regional-scale corridors, have often been used to design corridors. Current thinking is moving away from the anthropocentric view of corridors as there is a realization that most if not all animals do not perceive the ‘best’ pathway the same way as humans do. It is shifting towards concepts like the Circuit Theory Hypothesis (McRae and Beire 2007). This hypothesis recognises that there are a multitude of potential connective pathways, and holds that that it is highly likely that any particular animal using a corridor has no notion of which is the “least cost” pathway when faced with a decision to travel one way or another. The implications of this theory on the southern Canadian Shield may be that wildlife corridors do not need to be specifically identified and confirmed, however multiple opportunities for connectivity should be maintained to accommodate movement. Certainly in the context of the southern Canadian Shield the ranges and sensitivities of large mammals (e.g., Fiera Biological Consulting 2009, Henson and Brodrribb 2005) that occur in the landscape need to be considered.

Roberge and Angelstam (2004) discount the value of the ‘umbrella species’ approach entirely and argue that fulfilling habitat requirements for any one single species cannot ensure conservation of all co-occurring species, and therefore it is best to adopt a multi-species strategy based on systematic selection procedures. This latter approach is more consistent with the framework proposed by Fischer *et al.* (2004), as well as with the identification of species guilds described in **Section 3**, and is something to consider for future directions in natural heritage planning as more local species data is collected and becomes available.

Amphibians tend to have significantly smaller habitat ranges than large mammals, but also require connectivity between their different critical habitats both on a local scale and a regional or watershed scale for long-term survival. Because many amphibians require both upland forests and wetlands to successfully complete their life cycles, to protect them fully requires that these elements do not become separated by barriers such as roads, as well ensuring as larger scale terrestrial habitat connectivity that supports broader population dispersal and movement.

5.1 Discussion and Preliminary Guidance

The long-term viability of many wildlife populations requires the ability of individuals to find adequate resources, and to maintain fitness through genetic exchange. These abilities are both supported by the dispersal capacity (i.e., the capacity of a species to move between suitable habitat areas in the

landscape) of a given species or taxonomic group. For many groups of wildlife species (e.g., amphibians, reptiles, mammals), such dispersal can only effectively occur if there is some degree of connectivity between suitable habitats, or of more relevance on the Canadian Shield, that formidable barriers do not limit movement across the landscape. The level and type of terrestrial connectivity required will vary with the species group in question. In the southern Canadian Shield there is some evidence that riparian areas along lakes and streams provide some major “highways” for wildlife movement. However, for some types of wildlife that are very mobile, such as birds, terrestrial connectivity may not be an important factor as long as there remains sufficient suitable habitat in the landscape.

One of the primary and most obvious barriers to this connectivity in the context of the southern Canadian Shield are roads (as discussed in **Section 4**), however connectivity can also be critically impaired (i.e., for species that use riparian areas as movement corridors) when cottage developments completely surround one or more adjacent lakes.

Therefore important considerations in maintaining connectivity include:

- knowledge of the range, habitat and migration requirements of the various species guilds in a given area; and,
- the current and anticipated barriers in the landscape.

Preliminary Guidance:

Planning should be coordinated at regional and local jurisdictional levels to identify opportunities for ensuring Regional and Local Habitat Mosaics are connected or in proximity to each other where possible.

Lakeshore development plans should include the value of the lakeshore environment for pathways of connectivity for wildlife in Environmental Impact Studies.

Loss of lakeshore connectivity cannot necessarily be compensated by habitat corridors or patches away from the lakeshore.

6. Other Issues for Consideration

Three issues and concepts have emerged from the conservation and applied ecological literature over the past decade and have potential implications for habitat consideration across the southern Canadian Shield. These are the effects of recreational activities, value of vernal pools and climate change considerations. These themes are discussed briefly below in the context of the southern Canadian Shield, and underscore the complexity and challenge of setting simple and scientifically defensible guidelines.

6.1 Ecological Effects Associated with Recreation

Recreational activities have long been popular along the southern Canadian Shield, although with more development pressure and interest from the south, there is potentially more cause for concern around the potential effects of these activities, cumulatively, on the region's native flora and fauna. Recreational activities are not the focus of this report, but are understood to be one of the ecological effects arising from roads and access and cottage/recreational development, and to exacerbate impacts of habitat loss, degradation, and loss of connectivity.

Many recreational activities that take place in these parts are undertaken during the winter (e.g., snowmobiling, ice fishing, cross-country and downhill skiing), but there is hardly any research on the potential ecological effects of such activities in the winter. One paper by Titus and Tsuyuzaki (1998) was found that looked at the impacts of downhill ski slopes on forest vegetation, and found that indeed there were significant impacts on forest vegetation associated with this disturbance. Although it is anticipated that winter activities would have a negligible effect on most wildlife because they are either hibernating or absent at this time of year, the subject warrants further consideration.

Recreational activities that take place during the summer months in and around natural areas include boating (both motorized and non-motorized), cycling, and hiking / nature appreciation. Recently more active "eco-adventures" have increased in scope and extent, introducing for the first time the potential for disturbance in the canopy (from zip-lines). For the purposes of this report we will focus on effects to terrestrial species, and species that use riparian and lakeshore areas.

Some research has been conducted on the distance at which human activities initiate "flight initiation distances (FID)" or "flushing" among birds (e.g., Traut and Hostetler, 2003). These papers study the minimum distances in which wildlife either demonstrate alert signals or behaviours, or are basically scared away by human presence (e.g., walking, cycling). Although these distances cannot be directly translated into appropriate buffer distances, they do provide information on the ranges of sensitivities of different species, and have been used by some authors as the basis for buffer recommendations. Examples of such papers identified through this review are cited below.

- Rodgers and Smith (1997) found waterbirds were flushed by noise within 14 to 24 metres from their nests, with flushing distance being greater from walkers (up to 34 metres) than cars passing by (up to 24 metres).
- Josselyn *et al.* (1989) (as cited in Adamus 2007) found some bird species to be disturbed by humans approaching from as far as 53 metres, although many species of waterbirds appeared to become habituated to human presence over time.
- Sheldon *et al.* (2005) reported studies that found unscreened human activities and noises were disruptive to water birds between 5 and 50 metres, but that nesting herons required at least a 100 metres from human disturbances in order to nest successfully.
- Research by Cooke (1992) found a wide range of flushing distances documented for flocks of waterfowl in natural areas in urban settings, and the paper concludes that buffer widths of 61 to 91 metres beyond wetlands are more likely to support wetland-dependent wildlife, with the large end of the range recommended for higher intensity land uses.

- Rodgers and Schwickert's (2002; 2003) research on flushing distances of waterbird and raptor species in response to personal watercraft and outboard-powered boats on the Florida coast found responses were highly variable and had mean ranges of 20 to 172 metres. Based on their results they recommend buffer zone distances ranging between 100 and 365 metres for different water birds and raptors for this particular recreational activity in that location.

Not surprisingly, these studies include high levels of variability among and even within species responses, and so consideration for species-specific sensitivities as well as the nature of the recreational activity and the local response of wildlife (e.g. varying sensitivities to disturbance due to differing interactions with humans at different locations), should be required on a case by case basis.

Studies documenting responses of plants and wildlife to human recreational activities both within and adjacent to forested areas are scarce, but those that exist report a very wide range of distances at which effects or wildlife responses were detected.

- In a comprehensive review of raptor responses to human disturbances and mitigation approaches, Richardson and Miller (1997) report flushing distances ranging from 17 (e.g., Merlin) to 990 metres (e.g., Bald Eagle), and put forward associated buffer recommendations ranging from 50 (for Merlin) and 1600 metres (for Golden Eagle). However, these buffers are not actually tested for effectiveness in this study or any of those cited.
- Taylor and Knight (2003) document most deer, antelope and bison “flushing” in response to hiking and mountain biking within 100 to 390 metres of park trails in forested areas, although notably these responses were within rather than adjacent to a natural area.
- Hamberg *et al.* (2008) found that the effect of human trampling on vegetation from informal trail formation along the forest edge of boreal forests extended up to 50 metres in from the edge.
- Miller *et al.* (2003) reported that bird species associated with riparian areas in Colorado along a rural-urban gradient that declined with proximity to urbanization were also disturbed by trail development in the landscape.

Evidently, the range in distances illustrates how edge effects can vary depending on the focal species, nature of recreational activity, and nature of the forested habitat itself.

Soil compaction and vegetation disturbances can also occur with the location of recreational trails or heavy equipment from adjacent land use activities. Generally this kind of disturbance can be expected to favour and facilitate the introduction non-native plants in addition to direct effects on vegetation in the affected areas. However the extent to which its influence extends into the affected habitat tends to be relatively limited (e.g., McWilliam *et al.* 2011).

- Based on their synthesis from other studies, Ries *et al.* (2004) recorded average responses to various human disturbances adjacent to forested areas as extending up to 50 metres for plants, up to 100 metres for invertebrates, and between 50 to 200 metres for birds, although examples where responses were recorded deeper into the forest were recorded for all groups.

- In their recent study of over 180 areas adjacent to 40 different publicly owned forests in southern Ontario, McWilliam *et al.* (2010) documented encroachments in 99 percent of areas within 20 metres of the forest edge, with most obvious and severe encroachments recorded within the first 10 metres.
- Odell *et al.* (2003) and Odell and Knight (2001) documented the impacts of residential sprawl in the mountainous shrublands of Pitkin County, Colorado and found that almost all species of shrubland birds sensitive to human activity showed significant declines in abundance 30 metres from the houses, but increased at survey points at 180 and 330 metres from the houses.

Several studies in the boreal forests of Scandinavia have also documented trampling effects associated with trail use extending up to 50 metres beyond the actual trail (Hamberg *et al.* 2008, Malmivaara-Lamsa *et al.* 2008).

Direct encroachments or impacts to vegetation and soils along the edges, or within, forested areas related to recreational activities seem to be restricted to between 10 and 50 metres, while impacts to wildlife can extend much further into natural areas (e.g., upwards of several hundred metres). Such impacts should be considered as part of regional and local scale natural heritage planning.

6.2 Value of Vernal Pools

Currently, because of the abundance of wetlands across the southern Canadian Shield, the emphasis for wetland protection is largely focused on Provincially Significant Wetlands (PSWs) and Coastal Wetlands, although, relatively few wetlands have actually been evaluated in the north. However, over the past decade or so there has been a growing body of scientific and technical evidence that supports the important contribution of relatively small wetlands, at least to amphibian and reptile sustenance (e.g., Semlitsch and Bodie 1998, 2003).

The use of vernal pools (defined as seasonal waterbodies generally less than 0.8 hectares) as essential breeding habitat for many species of salamanders, frogs and freshwater shrimps (Calhoun and Klemens 2002) points to the importance of small, ephemeral wetland habitats. Joyal *et al.* (2001) reported that Spotted Turtles and Blanding's Turtles (both Species at Risk) used multiple small wetlands (i.e., less than 0.4 hectares) throughout the year (including seasonal and permanent ponds, forested swamps and wet meadows), as well as nearby uplands for nesting, dormancy and migration. Semlitsch and Bodie (2003) also that breeding wetlands for forest-breeding amphibians and reptiles were typically small (i.e., as small as 0.2 hectares).

Given that vernal pools and small wetlands are just as important for many of the amphibians and reptiles that occur in the southern Canadian Shield of Ontario, as they are for these species south of the Shield (Seburn 2007), the natural heritage planning in this region should recognize the value of such wetlands and provide mechanisms for addressing their protection. This is not to say that every small pond that occurs on the landscape warrants protection, but that small hydrologically isolated wetlands or vernal pools found within or adjacent to forested habitats that provide documented amphibian or reptile habitat should be considered as potentially important at the local scale. And where applicable, series of vernal pools and small wetlands that exist within a dominant habitat type

(e.g., forest) but act and function as a whole, can be considered as complexes and afforded recognition in natural heritage planning as important habitat for target species.

6.3 Considerations Related to Climate Change

Climate change is, for the most part, widely accepted in the scientific community as a shift that is already occurring and is likely to continue to occur over the next century (Urquiza *et al.* 2000, Johnson 2009). However, many questions remain as to the extent, timing and intensity of this shift, as well as its potentially differential effects on different regions. From an ecological perspective, the potential changes to systems and species may be important, and yet it remains unclear what changes will occur. There is uncertainty regarding the net effect of negative and potential positive changes on the long-term status of natural systems, habitats and species. Uncertainty, risk and change does not foster the long-term stability of natural systems, or at the very least detracts from the ability of humans ability to steward, protect or manage such systems. For example, documented responses of some terrestrial flora and fauna includes range shifts in some species, earlier flowering in some plants, and longer stays by some birds on breeding grounds (Crick 2004, Niven *et al.* 2009). This instability and uncertainty could result in substantive changes to in terms of our assumptions about the system. In the face of this uncertainty maintaining what systems we do have may be the best possible adaptation. In all this uncertainty, one thing is certain: change is coming.

In the southern Canadian Shield in Ontario, and on the shield as a whole, there is concern that some habitats will be vulnerable to the climate shifts and extremes associated with climate change (e.g., Urquiza *et al.* 2000; Niemi *et al.* 1998; Johnston 2009, Muskoka Watershed Council 2011). In their study of Black Spruce, Thompson *et al.* (2009) anticipate this species to be negatively impacted by increases in temperatures in central Ontario because it is already growing in close to its optimum conditions, and the ability of other tree species to keep pace with the anticipated rate of climate change remains a key question (Davis *et al.* 2005, Honnay *et al.* 2002). On a broader level, the Canadian Council of Forest Ministers (Johnston 2009) concludes the following:

“Changes in current climatic niches for tree species across Canada will, in many cases, change at a pace that exceeds the ability of most tree species to adapt or migrate. In most cases, changes will be within physiological tolerance limits of existing trees, at least for perhaps the next few decades. However, given that trees take a long time to mature, future climate change could have important implications for trees that are becoming established today and which will form the next generation of trees; therefore, it is particularly important that climate change considerations be incorporated into current reforestation practices, policies, and approaches.”

However, there is also some current thinking that habitats on the Canadian Shield, and many of the associated species, are already well-adapted to fairly large-scale disturbances (i.e., in the form of wildfires) as well as a fairly wide range of temperatures and weather events, and therefore may be able to demonstrate more ecological resilience in the face of climate change than expected (Schmiegelow and Villard 2009). The shifts associated with climate change may also be less severe for areas near the Great Lakes, as compared to areas further inland.

Further complicating the issue is that any assessment of the potential impacts associated with climate change is limited by the incomplete understanding of existing conditions in ecosystems, and lack of

tools or approaches to fully assess responses in the highly complex paradigms that are ecosystems, as well as the limited understanding of the impacts of other prevalent stressors in the landscape such as habitat fragmentation (e.g., Gardner *et al.* 2007).

Some of the measures being recommended to help improve the resilience of natural heritage systems in the face of climate change include enlarging and enhancing connectivity between existing protected areas, and ensuring representation of a full range of habitat types (e.g., Beir and Brost 2010, Galatowitsch *et al.* 2009, Hannah 2008, Spring *et al.* 2010). These principles, which are in keeping with natural heritage best practices in the context of southern Ontario, do not provide any specific guidance to planners in the context of the southern Canadian Shield where habitats are already relatively large and well-connected, other than to retain natural land-cover and connectivity.

7. Summary of Preliminary Guidelines and Concluding Remarks

Table 4 presents the four preliminary guidelines for the Southern Canadian Sheild. These **preliminary guidelines** above are intended to be applied at the watershed or regional scale, and are **intended only to initiate discussion**.

Table 4. Preliminary Guidelines for the Southern Canadian Shield

Parameter	Preliminary Guidelines
1. Loss of Natural Cover: Riparian and Lakeshore, Forests and Wetlands	<p><i>Regional and local planning authorities should identify, respectively, Regional Habitat Mosaics and Local Habitat Mosaics that capture relatively high levels and/or concentrations of habitat diversity and are predominantly natural areas subject to low levels of disturbance by human activities.</i></p> <p><i>Regional Habitat Mosaics and Local Habitat Mosaics should cover at least 50 to 60 percent of their respective jurisdiction. These mosaics should include habitats that are uncommon in the landscape as well as good representations of more common habitat types, a diversity of age classes for forested habitats and promotion of landscape connectivity..</i></p>
2. Ecological Effects of Cottage / Residential Development (a) Riparian Areas / Lakeshores (b) Forests (c) Wetlands	<p><i>Additional research is required to better inform this guidance.</i></p> <p><i>Identify and make use of species guilds that are functionally related, and their associated habitat requirements, to ensure that both Regional and Local Habitat Mosaics are designed to provide for the full range of riparian / lakeshore, forest and wetland species that occur across the Southern Canadian Shield. In particular these Mosaics should provide habitat for those groups of species considered most sensitive to the cumulative effects associated with cottage / residential lakeshore developments.</i></p> <p><i>Outside of the Regional and Local Habitat Mosaics the following habitat-specific guidance should be considered:</i></p> <ul style="list-style-type: none"> <i>Riparian / Lakeshore Habitats: No development zones should be identified around portions of lakes and along rivers to allow for natural functions and dynamics to persist. The extent of these zones will vary depending on the local context, but should include known wildlife movement corridors wherever possible.</i> <i>Wetlands: Where development is occurring around wetlands, Critical Function Zones and Protection Zones should be determined based on consideration for the site's sensitivities and hydrology, as well as its habitat functions, including habitat requirements for</i>

Parameter	Preliminary Guidelines
	<p><i>species that extend beyond the wetland boundary.</i></p> <ul style="list-style-type: none"> •
3. Ecological Effects Associated with Roads	<p><i>Avoid the development of roads in Regional Habitat Mosaics and Local Habitat Mosaics.</i></p> <p><i>Consider the decommissioning of temporary logging roads.</i></p> <p><i>Where new roads within Regional Habitat Mosaics and Local Habitat Mosaics are considered essential:</i></p> <ul style="list-style-type: none"> • <i>accommodate for substantial buffers between important wetlands and roads wherever possible;</i> • <i>avoid locating roads where important wetlands occur on both sides; and,</i> • <i>implement mitigation measures based on the most current tools and data.</i>
4. Loss of Habitat Connectivity	<p><i>Planning should be coordinated at regional and local jurisdictional levels to identify opportunities for ensuring Regional and Local Habitat Mosaics are connected or in proximity to each other where possible.</i></p> <p><i>Lakeshore development plans should include the value of the lakeshore environment for pathways of connectivity for wildlife in Environmental Impact Studies.</i></p> <p><i>Loss of lakeshore connectivity cannot necessarily be compensated by habitat corridors or patches away from the lakeshore.</i></p>

Where numerical guidance is provided it should be understood that these are neither targets for optimal ecosystem functioning, nor are they thresholds below which ecosystem functions may suddenly drop off, both of which both require much more species and habitat specific data than is currently available. As Price *et al.* (2007) state:

"Threshold identification for ecosystems a priori requires that whole ecosystems are studied for long enough time periods, at appropriate scales, and with sufficient replicates, to allow prediction. These conditions will be met very rarely, likely for a limited suite of ecosystems".

These habitat guidelines nonetheless strive to provide general guidance with respect to specific qualities and parameters needed to ensure a fully functional terrestrial natural heritage system, and suggest where some limits may exist in relation to the tolerance of these habitats, and the species within them, to various types of disturbance.

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