APPENDIX A

A Description of Ramsar Sites, Biosphere Reserves, Carolinian Canada Sites and Western Hemisphere Shorebird Reserve Network and Their Application in Land Use Planning

Appendix A provides a description of natural heritage features and areas that have been recognised as significant at the international or national level. Due to their recognition by the scientific community, planning authorities are also encouraged to recognise these sites.

RAMSAR SITES

A RAMSAR site is a wetland designated under the *Convention on Wetlands* as internationally significant based on a variety of criteria including ecological, biological and hydrological functions and values.

The *Convention on Wetlands of International Importance*, often referred to as the Ramsar Convention from its place of adoption in 1971 in Iran, is an international treaty, which provides the framework for international cooperation for the conservation of wetland habitats.

Canada became a Contracting Party to the Ramsar Convention in 1981. Contracting Parties to the Convention recognise that wetlands are essential not only for their hydrological and ecological processes, but also for the rich fauna and flora they support. The broad objectives of the Convention are to stem the loss of wetlands and to ensure their conservation and sustainable use for future generations. There are presently 114 Contracting Parties to the Convention, with 975 wetland sites, totalling 70.7 million hectares designated for inclusion in the Ramsar list of *Wetlands of International Importance.*

There are three criteria for identifying *Wetlands of International Importance.* They are:

1. Quantitative criteria for identifying wetlands of importance to waterfowl.

   A wetland should be considered internationally important if it:
   a) regularly supports either 10,000 ducks, geese and swans; or 10,000 coots; or 20,000 waders (shorebirds), or
   b) regularly supports one percent of the individuals in a population of one species or subspecies of waterfowl, or
   c) regularly supports one percent of the breeding pairs in a population of one species or subspecies of waterfowl.

2. General criteria for identifying wetlands of importance to plants or animals.

A wetland should be considered internationally important if it:

a) supports an appreciable number of a rare, vulnerable or endangered species or subspecies of plant or animal, or
b) is of special value for maintaining the genetic and ecological diversity of a region because of the quality and peculiarities of its flora and fauna, or
c) is of special value as the habitat of plants or animals at a critical stage of their biological cycles, or
d) is of special value for its endemic plant or animal species or communities.

3. Criteria for assessing the value of representative or unique wetlands.

A wetland should be considered internationally important if it is a particularly good example of a specific type of wetland characteristic of its region.

As of January 1999, Canada has designated 36 wetlands as Ramsar sites. Eight of these sites are in Ontario (Figure A-1). The wetland sites in southern Ontario have also been evaluated using the OMNR's Wetland Evaluation System and are also designated as provincially significant wetlands. All of these wetlands are of global importance and should be recognised by planning authorities.

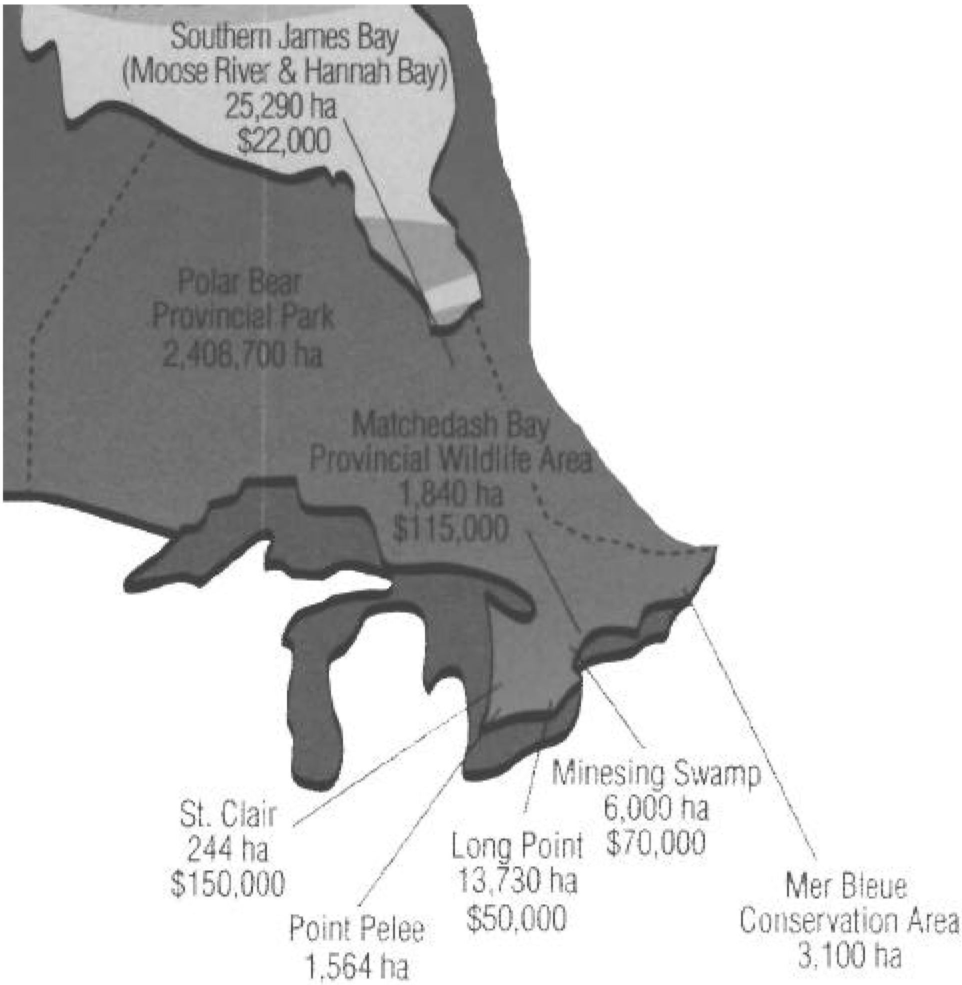


Figure A-1. Location of RAMSAR sites in Ontario.

For additional information please refer to:

Canadian Ramsar Site – http://wetlands.ca/wetcentre/wetcanada/wetcanada.html

Canada and the Ramsar Convention –
http://wetlands.ca/wetcentre/wetcanada/RAMSAR/booklet/booklet.html

The Ramsar List of Wetlands – http://www.ramsar.org/key_sitelist.htm

BIOSPHERE RESERVES

A biosphere reserve is an international designation of recognition from the United Nations Educational, Scientific and Cultural Organisation (UNESCO) under the *Man and the Biosphere Program* (MAB). The designation signifies that the area is a good example of some of the ways in which conservation objectives can be balanced with development.

The term *biosphere* refers to the association of the designated area with the UNESCO/MAB program and the *reserve* means that there are some already protected sites within the biosphere reserve.

The long-range goal of the MAB is to create a worldwide network of biosphere reserves to include examples of all of the globes main ecological systems with their different patterns of human use and adaptations to them. To receive a designation, each biosphere reserve must have a protected *core* of undisturbed landscape, which can provide baseline data for comparison with nearby areas being managed to meet human needs. Fully functional biosphere reserves perform three main roles:

a) conservation of ecosystems and biota of particular interest
b) establishment of demonstration areas for ecologically sustainable land and resource use
c) provision of logistic support for research, monitoring, education and training related to conservation and sustainable issues

Some biosphere reserves provide sites for the monitoring of long-range transport of atmospheric pollutants, or for "integrated environmental monitoring" to correlate ecosystemic changes with pollutant loading.

As of 1999 the province Ontario has two biosphere reserves. One is the Niagara Escarpment (207,240 ha) and the other is Long Point (27,000ha). These are very large sites and are comprised of a mix of publicly and privately owned land. One objective of the biosphere reserve program is to demonstrate through monitoring and scientific studies, a balance between conservation and development. In that regard, it is not the intent of the biosphere reserve program to exclude all development within the total area designated as a biological reserve, but rather to demonstrate how development can occur and still maintain the ecological functions and integrity of the natural landscape. Each biological reserve includes an existing protected core area.

Planning authorities that have a biosphere reserve within their jurisdiction need not be concerned about protecting all lands within the designated area. These sites have been specifically selected because they have existing protected areas that can be compared to areas that are appropriately developed. In some situations protected buffers around a core-protected area may be considered to ensure the ecological functions of the core area are maintained. This may be accomplished by identifying and protecting any one the seven components of the Natural Heritage Areas and Features Policy of the Planning Act.

For additional information, please contact:

1. Long Point Biosphere Reserve –http://www.cciw.ca/cbra/english/biosphere/br_longpoint/
2. Niagara Escarpment Biosphere Reserve – http://www.cciw.ca/cbra/english/biosphere/br_niagara/intro.html
3. World Biosphere Reserve – http://escarpment.org/biosphere/world.html

CAROLINIAN CANADA SITES

Carolinian Canada is a popular name for the extreme southwest region of Ontario where the Eastern Deciduous Forest of North America has its northernmost limits. The Carolinian Life Zone is one of Canada’s most significant landscapes, where a warm climate accounts for the presence of many rare species of plants and animals.

Carolinian Canada is found south of an imaginary line which runs approximately from Grand Bend to Toronto. The climate of this region is the main reason it forms such a unique ecosystem. Often referred to as the ‘banana belt’ of Canada, this zone boasts the warmest annual temperatures, the longest frost-free seasons and the mildest winters in Ontario. For example, Point Pelee near Windsor averages over 170 frost-free days while Guelph, which is just north of the Carolinian Canada boundary averages only 135 frost-free days per year.

Botanists have mapped the distribution of plants in Ontario, and have established the boundary of the Carolinian Life Zone based on the northern limits of the many species, which are found only within this region of Canada. A glance through either the *Atlas of Rare Vascular Plants of Ontario* or the *Atlas of the Breeding Birds of Ontario* will reveal many species whose range corresponds to Carolinian Canada.

Even though Carolinian Canada is small compared with other Canadian vegetation zones, making up only 1% of Canada’s total land area, it boasts a greater number of both flora and fauna species than any other ecosystem in Canada. It is estimated that some 2,200 species of herbaceous plants are found here, including 64 species of ferns, at least 110 species of grasses and over 130 different sedge species. There are 70 species of trees alone. Numerous species of reptiles and amphibians make their home primarily or entirely in this region and close to 400 species of birds have been recorded, representing over half of the species in all of Canada. Several butterflies, such as the Karner Blue and the Frosted Elfin are restricted to this region. Several mammals such as the Badger, the Gray Fox and the Virginia Opossum are primarily restricted to the Carolinian forest. Appendix H provides a list of those animals and plants that are representative of the Carolinian Life Zone of Canada (site regions 6E and 7E).

The most unique feature of the Carolinian Life Zone is the number of rare species found there. The region has one third of the rare, threatened and endangered species found in all of Canada. Sixty five percent of Ontario’s rare plants are found in this region and 40% are restricted to the Carolinian Life Zone. Appendix H provides a list of plant and animal species in Ontario and includes a description of their distribution.

The Carolinian Canada Program was established in 1984 as a partnership between government agencies and non-government conservation groups to address the special needs of the region. This program has protected 38 of the most important sites. These sites have been identified as Carolinian Canada sites and are illustrated in Figure A-2. Each site has been selected as a Carolinian Canada site because it possesses an excellent representation of a unique Carolinian life form. There is no legislation or policies specifically aimed at protecting Carolinian Canada sites. Most of these sites are protected however through the Natural Heritage Features and Areas Policy (provincially significant wetlands [PSW's] and Areas of Natural and Scientific Interest [ANSI's]) and by planning authorities through Endangered Species Act (ESA) designations in official plans. Table A-1 provides a list of all 38 Carolinian Canada sites, the municipal jurisdiction in which they are found, the agencies involved in their protection and the level of protection (i.e. PSW's, ANSI's and ESA's).

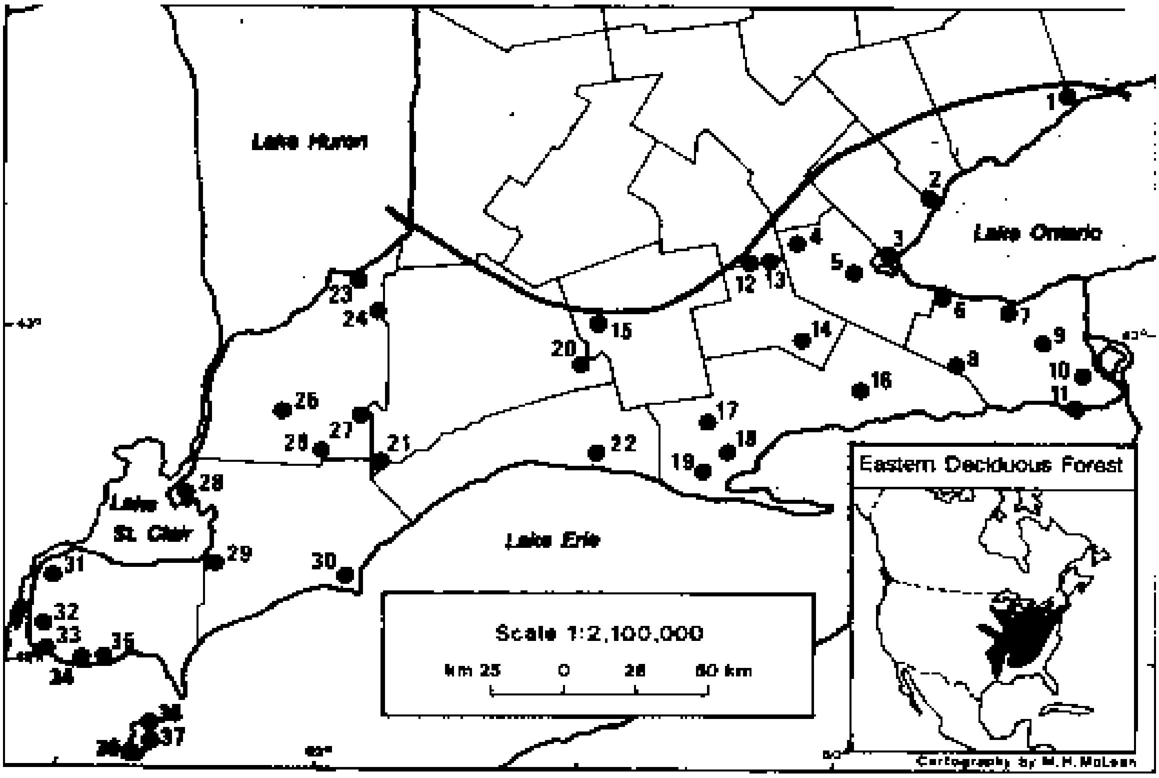


Figure A-2. Carolinian Canada Sites in Ontario.

In addition to the 38 protected Carolinian Canada sites, private landowners have been encouraged as part of the Carolinian Canada program to protect important natural features on their land. Carolinian Canada was the first region in Canada to use a voluntary 'handshake' stewardship agreement as a means of encouraging a commitment to conservation by private landowners. The Natural Heritage Stewardship Award is a plaque given to landowners of Carolinian Canada sites in return for a promise to protect the natural features of their land. As of 1999, 519 landowners that own over 6,000ha in 32 different natural areas have made such agreements.

Planning authorities in the Carolinian Canada Life Zone should be aware the Carolinian Canada sites in their planning area. In most cases the sites already qualify for protection under the Natural Heritage Features and Areas Policy and/or municipal official plan designation. The lands that are under stewardship agreement may or may not be protected. A complete listing of these lands can be found in a report entitled "*Report on Landowner Contact Information for the Carolinian Canada, Niagara Escarpment and Wetland Habitat Agreement Programs*" by van Hemessen, D. et al 1995.

For more information on Carolinian Canada please contact:

1. http://www.carolinian.org

2. Allen, G.M., P.F.J. Eagles, S.D. Price (editors). 1990. Conserving Carolinian Canada. University of Waterloo Press, Ontario.

3. Beechey, T.J. and P.F.J. Eagles. 1985. Critical Unprotected Natural Areas in the Carolinian Life Zone of Canada.

4. Lussier, C. and P. Lawrence. 1999. Natural Heritage Planning in the Carolinian Canada Zone – Final Report. Natural Resources Centre, University of Waterloo. Technical Paper 15.

5. Van Hemessen, D., L. O'Grady and R. Martin. 1995. Report on Landowner Contact Information for the Carolinian Canada, Niagara Escarpment and Wetland Habitat Agreement Programs. Draft. Ontario Ministry of Natural Resources.

<u>Western Hemisphere Shorebird Reserve Network</u>

The Western Hemisphere Shorebird Reserve Network (WHSRN) is an international conservation initiative designed to protect key habitats and resources used by shorebirds throughout their migration ranges. Many species of shorebirds depend on a chain of critically important sites to complete their annual migrations, and for conservation to be successful, all the links in the chain need to be preserved. Fifty-four potential and/or declared WHSRN sites for shorebirds have been identified in Canada (Morrison *et al.* 1985).

Four categories of WHSRN sites are recognised:

> Hemispheric sites: support at least 500,000 shorebirds annually, or 30% of a species' flyway population. Hemispheric Sites are intended to include areas supporting major concentrations of shorebirds, with daily total reaching about 50,000 birds during migration.
>
> International sites: support at least 100,000 shorebirds annually, or 15% of a species' flyway population.
>
> Regional sites: support at least 20,000 shorebirds annually, or 5% of a species' flyway population.
>
> Endangered Species sites: are critical to the survival of endangered species (no minimum number of birds is required).

The most important habitats for shorebirds in Ontario are found along the coasts of James Bay and Hudson Bay (Figure A-3). Habitats in the south of the province are generally smaller in area and are located along the shores of the Great Lakes or of other lakes and rivers. Many of these are affected by fluctuating water levels and thus may vary in importance from year to year, depending on the amount and quality of habitat available. Most are affected by developments, pollution or by increasing recreational use by humans. Few of the numerous lakes in northern and central Ontario are thought to have habitats suitable for shorebirds.

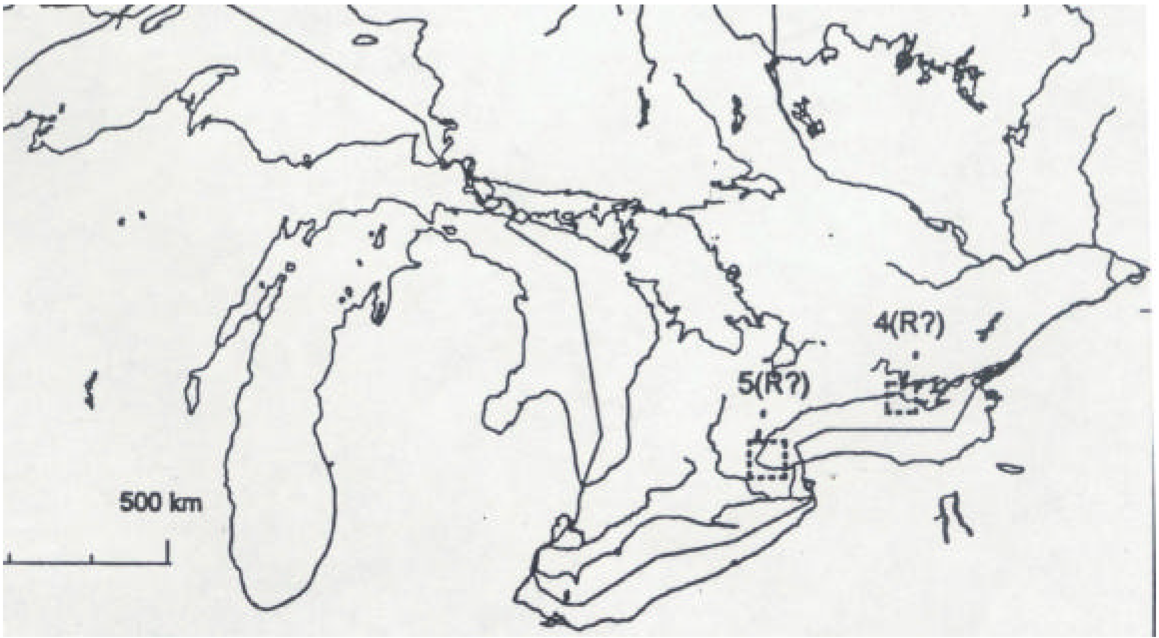


Figure A-3. Potential Western Hemisphere Shorebird Reserves in Southern Ontario.

Presqu'ille Provincial Park (Regional ?)

The long beach and point at this site provide sandy and muddy habitats that can be heavily used by shorebirds, especially when beds of washed up algae accumulate along the lakeshore. Numbers occurring in the park generally range into the hundreds for the more common species (McRae 1982, 1986), although large concentrations can occur when birds are forced down by poor weather. High counts include 5,950 and 7,000 Dunlin in 1983 and 1985, respectively (Morrison *et al.* 1985). McRae (1986) reported that as many as 20,000 shorebirds have been found during northward migration after the birds have been grounded by adverse whether and considers that this many may use the area during the course of a year.

Western End of Lake Ontario (Regional ?)

A complex of sites around Hamilton, including Dundas Marsh, the Windermere Basin, the Smithville Sewage Ponds, and sections of the lakeshore have been estimated to support over 20,000 shorebirds during the course of the year (Clarke 1988, ISS counts), though numbers at the individual sites do not reach levels to satisfy WHSRN criteria. The heavily polluted nature of parts of this area makes its designation as a reserve questionable.

Reference:

Clarke, M.F.G. 1988. A proposal of the Western End of Lake Ontario as a Regional Reserve in the Western Hemisphere Shorebird Reserve Network. Unpubl. Rep. 14 pp.

McRae, R.D. 1982. Birds of Presqu'ile, Ontario. 74 pp. Ontario Ministry of Natural Resources.

McRae, R.D. 1986. Presqu'ile Provincial Park, Ontario, Canada. Site Guide. American Bird 40: 35-36.

Morrison, R.I.G., R.W. Butler, G.W. Beyerbergen, H.L. Dickson, A. Bourget, P.W. Hicklin, J.P. Goossen, R.K. Ross, and C.L. Gratto-Trevor. 1995. Potential Western Hemisphere Shorebird Reserve Network Sites for Shorebirds in Canada: Second Edition 1995. Canadian Wildlife Service Technical Report Series 227, 147 pp. Canadian Wildlife Service, Headquarters, Ottawa.

Table A-1. List of Carolinian Canada Sites in Ontario.

	Site Name	Jurisdiction	Agencies	NGO's	Wetland	ANSI	ESA
1	Rouge River Valley	Toronto	Rouge Park, MNR, MTRCA	Friends of the Rouge	2	*	*
2	Iroquois Shoreline Woods	Oakville/Halton	Town of Oakville, MNR			*	*
3	Sassafras Woods	Halton	Halton RCA, MNR		1	*	*
4	Beverly Swamp	Hamilton-Wentworth	GRCA,HRCA, HamRCA, MNR			*	*
5	Dundas Valley	Hamilton-Wentworth	HamRCA, MNR		5	*	*
6	Grimbsy-Winona Escarpment and Beamer Valley	Niagara	NPCA, HamRCA, MNR, NEC			*	
7	Jordan Escarpment Valley	Niagara	NPCA, MNR, NEC				
8	Caistor-Canborough Slough Forest	Niagara	NPCA, MNR		2	*	
9	Fonthill Sandhill Valley	Niagara	NPCA, MNR, NEC			*	
10	Willoughby Clay Plain	Niagara	NPCA, MNR		1	*	
11	Point Albino Peninsula Sandland Forest	Niagara	NPCA, MNR		2	*	
12	Sudden Bog	Waterloo/Brant	GRCA, MNR		3	*	
13	Grand River Valley Forests and Spottiswood Lakes	Waterloo/Brant	GRCA, MNR		1	*	
14	Six Nations I.R. Forests	I.R.	Six Nations Eco Centre				
15	Embro Upland Forest	Oxford	UTRCA, MNR		7	*	
16	Oriskany Sandstone and Woodlands	Haldimand-Norfolk	LPRCA, MNR		2	*	*
17	Delphi Big Creek Valley	Haldimand-Norfolk	LPRCA, MNR	NFN	1	*	*
18	St. Williams Dwarf Oak Forest	Haldimand-Norfolk	MNR	NFN			*
19	Big Creek Valley - South Walsingham Sand Ridges	Haldimand-Norfolk	LPRCA, MNR	NFN	1&2	*	*
20	Dorchester Swamp	Middlesex	UTRCA, MNR	LAG	2	*	
21	Skunk's Misery	Kent/Middlesex	LTVCA, StCRCA, MNR		2	*	
22	Catfish Creek Slope and Floodplain Forest	Elgin	CCCA, MNR		4		
23	Port Franks Wetlands and Forested Dunes	Lambton	ABCA, MNR	LWI	1	*	*
24	Ausable River Valley	Lambton	ABCA, MNR	LWI		*	*
25	Plum Creek Upland Woodlots	Lambton	StCRCA, MNR	LWI	4	*	*
26	Shetland Kentucky Coffee-tree Woods	Lambton	StCRCA, MNR	LWI			*
27	Sydenham River Corridor	Lambton	StCRCA, MNR	LWI			*
28	Walpole Island I.R.	I.R.			1		*
29	Lake St. Clair Marshes	Kent	LTVCA, StCRCA, MNR		1	*	
30	Sinclair's Marsh	Kent	LTVCA, MNR			*	
31	Ojibway Prairie Remnants	Essex	City of Windsor, MNR	OTPSA		*	*
32	Canard River Kentucky Coffee-tree Woods	Essex	ERCA, MNR				*
33	Big Creek Marsh	Essex	ERCA, MNR		1	*	*
34	Oxley Poison Sumac Swamp	Essex	ERCA, MNR		3	*	*
35	Cedar Creek	Essex	ERCA, MNR		3	*	*
36	Middle Point Woods	Essex	ERCA, MNR			*	*
37	Stone Road Alvar	Essex	ERCA, MNR	FON		*	*
38	Middle Island	Essex	ERCA, MNR			*	*

APPENDIX B

Ecological Considerations Underlying Natural Heritage Planning

Effective implementation of the Natural Heritage Policy requires an understanding of some of the key concepts and ecological factors underlying natural heritage system planning. The text that follows is intended to introduce some of these concepts and factors. This material will help address three fundamental questions in natural heritage system planning:

1. How do surrounding landscapes affect natural heritage protection needs within a planning area?
2. How much natural area should be protected within a planning area?
3. Which are the most important areas to protect within a planning area?

In areas where few natural heritage features and areas remain, or where they are degraded or fragmented, the information provided in this appendix will help determine where improvements (i.e., restoration efforts) would be most effective. This is consistent with Policy 2.3.4 of the Provincial Policy Statement.

Maintaining Natural Heritage Systems

The reasons why natural heritage features and areas need to be protected can be distilled into two key goals:

- to help conserve biodiversity
- to ensure that ecosystems/landscapes are both healthy and functional

Achieving these goals is essential to human survival and to ensure that society can continue to derive benefits from natural heritage systems.

Biodiversity

Biodiversity, or biological diversity, is a concept that expresses the variability of life on earth, and the diversity of ecological processes and dependencies that are characteristic of ecosystems (Riley and Mohr 1994). The United Nations Convention on Biodiversity, which was signed by Canada in 1992, defines biodiversity as follows:

> *Biodiversity is the variability among organisms from all sources including terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems.*

Biodiversity is commonly measured at several levels. Noss and Cooperrider (1994), Decker *et al.* (1991) and Riley and Mohr (1994) describe four-level systems with the following components: genetic; species/population; community/ecosystem; and landscape/region.

- **Genetic variability** refers to the genetic differences that occur within a particular species that can be passed along to offspring. It is the set of traits that allow species to adapt to change over time.

- **Species diversity** refers to the variety of species that occur within a particular area. Collectively, all of the individuals of a particular species in a particular area form a **population**. Management efforts and conservation goals are often directed at populations, or the habitats necessary to sustain them.

- **Community diversity** refers to the associations of species within an area. These associations, also called biological communities, are the living components of **ecosystems**. Ecosystems are composed of two elements: (1) the biological communities within an area, and (2) the physical environment within the area.

In many cases, the most effective way to manage or conserve species or populations is to manage or conserve the communities/ecosystems within which they are found.

- **Landscape/regional diversity** refers to the variety of ecosystems and communities that can be found within the landscape. At this scale, the size, arrangement and degree of interconnection between ecosystems/communities are particularly important.

These four biodiversity levels are interdependent. Conserving the biodiversity within a planning area requires that each of these levels be considered. Management/protection actions are often most appropriately undertaken (effectively) at the community/ecosystem level. Planning for natural heritage values, however, often benefits from considerations at the landscape level.

The conservation of species and ecosystems is fundamental to the protection of the province’s, and the planet’s, biodiversity. The need to protect biodiversity is recognised globally. Canada, with the support of provincial and territorial governments, acknowledged this by signing the United Nations Convention on Biodiversity in 1993. Since that time, the Canadian Biodiversity Strategy has been developed, and all provinces have made a commitment to implement it within their respective jurisdictions.

Healthy/Functional Ecosystems/Landscapes

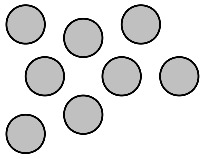
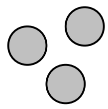
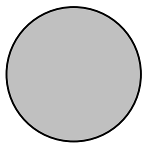
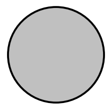
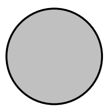
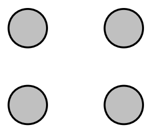
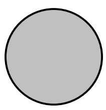
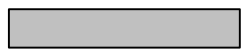
The maintenance of biodiversity, as described above, is of immense importance. However, planning for biodiversity, alone, will not ensure the proper functioning of the underlying ecosystems and landscapes. Additional measures are required in order to ensure the health and proper functioning of the ecosystems in which we live. These measures involve conserving more of the landscape than is required to meet biodiversity objectives alone. Maintaining the health and functionality of ecosystems and landscapes is essential if municipalities are to continue to derive benefits from natural heritage systems.

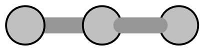
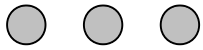
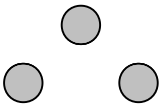
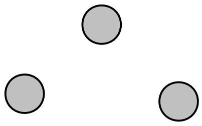
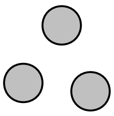
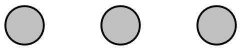
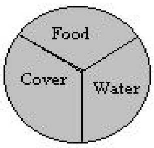
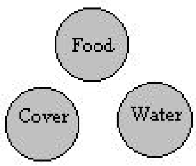
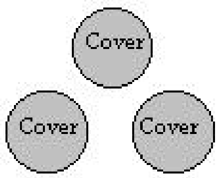
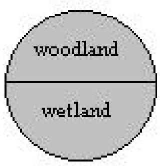
KEY CONCEPTS IN NATURAL HERITAGE SYSTEM PLANNING

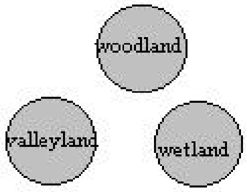
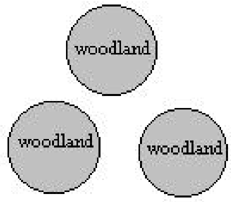
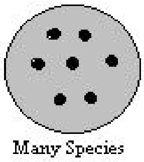
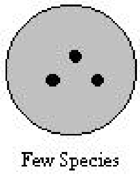
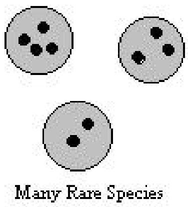
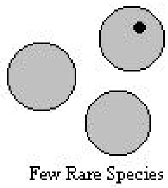
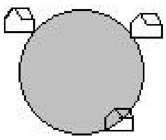
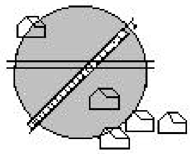
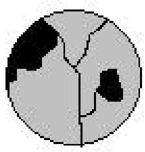
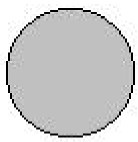
Important steps in natural heritage system planning are to identify the natural areas within the planning area and to assess their ecological importance. Each candidate site can be evaluated using several criteria since natural heritage features and areas provide many values. However, it is often necessary to rely on a limited number of criteria due to constraints such as budget, time or information.

The following is a discussion of some ecological factors that are commonly incorporated into various natural heritage areas, evaluation procedures. These factors are based largely upon Crins (1996), Decker *et al.* (1991), Noss and Cooperrider (1994), Phillips (1996), Primack (1993), Riley and Mohr (1994) and Smith and Theberge (1986). Some are illustrated in Figure 1.

Figure B-1: Relative Habitat Value In Relation to Patch Size, Shape, Arrangement and Function

	Rule	Good	Poor
A	Natural heritage systems that include the full range of habitat-landform types are better than those that contain fewer habitat-landform types.		
B	Large patches are usually better than smaller patches.		
C	Large patches are usually better than clusters of smaller patches with the same total area.		
D	A compact patch with a limited amount of edge is better than a narrow patch with more edge.		

	Rule	**Good**	**Poor**
E	Connected patches are usually better than unconnected patches.		
F	Closely clustered patches are usually better than less closely clustered patches.		
G	Clustered patches are usually better than “in-line” patches of the same total area.		
H	Patches that meet several of the habitat needs of one or more species are more valuable than patches that meet fewer habitat needs.		
I	Clusters of patches that collectively meet several of the habitat needs of one or more species are more valuable than clusters of patches that meet fewer habitat needs.		
J	Natural areas that contain more than one natural heritage feature or area may be more valuable than patches with a single natural heritage feature or area.		

Rule	Good	Poor
K Clusters of patches that contain several types of natural heritage features or areas are more valuable than areas with clusters of patches composed of a single type of natural heritage area.		
L Patches that contain a high diversity of species are usually more valuable than patches that contain fewer species.		
M Patches that contain rare species are generally more valuable than patches without rare species.		
N Patches that are relatively unaffected by human use are more valuable than more disturbed patches.		
O Patches that contain water-bodies are generally more important than those that do not.		

Representation/Distribution

A fundamental step in natural heritage system planning is to ensure that the full range of natural features that occur in an area, including both rare and common features, are protected. The rationale for doing so is to ensure that the full range of species and habitats within those features are protected, thus contributing to the preservation of biodiversity at the species and community levels. Further, species, communities and ecosystems that are well distributed across their native range are less susceptible to decline than species, communities and ecosystems confined to small portions of their historic range (see Figure B -1A).

Representation is normally assessed at the site district level. It forms the cornerstone of the identification and evaluation procedure for the province's ANSI program. Planning authorities can make a significant contribution to the protection of the full range of natural features and species that occur in an area by ensuring the protection of any significant ANSIs that have been identified. Representative areas provide a logical foundation around which a planning area's natural heritage system can be designed.

Rule #1. Ensure that the full range of habitat/landform types that occur in an area are protected.

Size

Large patches of natural areas are generally more valuable than smaller patches (see Figure B - 1B). Similarly, a single large patch is generally better than several smaller patches of the same total area (see Figure B - 1C). There are several reasons.

1. Larger patches tend to contribute more to biodiversity than smaller patches of similar habitat (Phillips 1996). This is because large areas tend to contain a broader diversity of features and habitats than smaller areas. In doing so, larger areas generally

   - contribute more to the diversity of features in an ecoregion/ecodistrict than smaller areas, and

   - meet more of the habitat requirements of a greater number of species than smaller areas. One of the reasons for this is that large areas generally provide more "interior" (i.e., contiguous, relatively undisturbed, unfragmented) habitat than smaller areas. "Interior" habitat is critical to the survival of many species, particularly "forest-interior" birds.

2. Larger natural areas are generally more resilient to the impacts of human disturbance. For example, many of the smaller woodlots in southern Ontario contain a large number of invasive exotic plant species that can or have displaced native species. Larger natural areas are more likely to have internal ecosystem functions like nutrient cycles and food webs intact and to be large enough to permit different successional stages to co-exist on the site.

3. Large areas are capable of supporting larger populations of different species than smaller blocks of similar habitat (Noss and Cooperrider 1994). Large populations tend to be more resilient to human-induced and other disturbances than smaller populations.

4. Cumulatively, small areas can provide significant benefits to the overall landscape by reducing erosion, providing wildlife habitat, etc. These effects, in turn, benefit other critical habitats.

Are small areas worth keeping? Many small natural areas should be protected. There are several reasons why such areas can be important.

1. Small areas, particularly if they provide unique habitat conditions, can support rare plant or animal species found nowhere else in the area. Such small areas are particularly important to species with low mobility (Riley and Mohr 1994).

2. Small areas, particularly if interspersed amongst larger habitat patches, can provide important temporary refuges better enabling more mobile species to move between larger patches.

3. As well, in highly diverse landscapes, the protection of several smaller habitat patches can provide better representation of a wider range of habitats than a single larger habitat patch (Peterson and Peterson 1991; Riley and Mohr 1994).

Rule 2. ***Large patches are generally more valuable than small patches.***
Rule 3. ***A single large patch is generally better than clusters of smaller patches with the same total area.***

Shape

The shape of natural heritage areas affects their value as wildlife habitat and their resilience to disturbance effects. Round or block-shaped patches contain less "edge" per unit of area than long, narrow patches (see Figure 1D). Edge refers to the area where different habitats (or habitat conditions) meet. For examples, edges occur where woodlots meet open fields, where uplands meet lowlands, along shorelines and fencerows, at the interface between deep water and shallow water, etc. Many species of wildlife (e.g., deer, and grouse) need "edge" habitats.

Other species, however, require large contiguous blocks of habitat well away from habitat edges. These areas are often termed interior habitats. Some interior habitat dwelling species will only use an area if it is 100 metres or more away from an edge.

In parts of Ontario, particularly in the south, the fragmentation of natural habitats has created an abundance of edge habitat while, at the same time, reducing the availability of interior habitats. Consequently, in southern Ontario, round or block-shaped areas would normally be higher priority areas for protection than long, narrow habitats of similar composition. In some situations, however, narrow habitat patches may have special value in ensuring the connection of other important patches.

Rule #4. ***Patch shapes that minimise "edge" are generally preferred over patches with more edge.***

Fragmentation/Connectedness

An obvious impact of development on natural areas is fragmentation. Fragmentation refers to the process by which large, interconnected natural areas are converted to a series of smaller, often isolated natural areas. In much of southern Ontario, the landscape has become highly fragmented. In other parts of the province, particularly some northern areas, fragmentation has been less severe.

Rule #5. ***Avoid fragmenting natural areas.***

As indicated above, smaller natural areas generally meet the needs of fewer species of wildlife than larger areas. This results from the fact that the remaining areas may simply be too small to meet the habitat needs of the species that once used the area, and the fact that smaller areas, on average, will contain a lower diversity of habitat conditions than larger areas. Small areas are also more easily damaged by disturbance effects and are less likely to have their functional processes intact.

Another potentially serious consequence of habitat fragmentation is the physical separation, or isolation, of one habitat patch from another. If separation distances are large enough, the movement of plants (i.e., their seeds) and animals from one patch to another can be hindered or prevented. The resultant isolation of one wildlife population from another can:

- lead to inbreeding which, over time, may reduce the ability of the population to survive; and
- prevent the recolonization of an area after local extinction

As a general rule, then, interconnected patches of habitat are better than isolated patches (Figure 1E). However, there are exceptions. Some habitats and species that are found in isolated areas are better protected when they are isolated from other areas. Other habitats (and species) do benefit from connections, but only if the connections between them have the appropriate characteristics. For example, very narrow connections, such as fencerows, which link one woodlot to another, can provide predators with an extremely effective hunting environment, which can put prey species at risk. The key is to plan for connections of larger woodlots or a network of smaller areas. In doing so, the widest possible connections should be protected. Where connections are very narrow, planning authorities should consider improving (i.e., widening) them. This is consistent with Section 2.3.3 of the Natural Heritage Features and Areas Policy.

Rule #6. ***Connected patches are usually better than unconnected patches.***

Arrangement/Proximity

Blocks of habitats that are arranged close together are usually better than blocks of habitat that are located further apart. There are two reasons for this. First, wildlife is able to move more safely between closely spaced habitat patches than between patches located farther apart. Secondly, closely spaced patches are more likely to have important functional (i.e., hydrological or biochemical) linkages than more distant patches (see Figures B - 1F and G).

Rule #7. ***Clustered patches are usually better than "in-line" patches of the same total area.***
Rule #8. ***Closely clustered patches are usually better than more distant patches.***

Habitat Diversity/Complexity

Natural areas (or clusters of areas) that span a range of topographic, soil and moisture conditions, tend to contain a wider variety of plant species and plant communities, and may also support a greater diversity of ecological processes, than similar areas that occupy a narrower range of topographic, soil and moisture conditions. Areas with a high diversity of plant species and plant communities will generally support a correspondingly high diversity of animal species and communities. For example, a natural area that includes both wetland (lowland) and upland components will provide a greater range of habitat conditions for wildlife than either habitat type alone. Similarly, a wetland that contains each of the four wetland types (marsh, swamp, bog and fen) will provide more habitat diversity than a wetland composed entirely of marsh (see Figures B - 1H-K). A variety of techniques are available for assessing habitat and/or vegetation community diversity.

Rule #9. ***Patches, or clusters of patches, that meet several of the habitat needs of one or several species are more valuable than patches that meet fewer habitat needs.***
Rule #10. ***Patches or clusters of patches, that contain more than one natural heritage feature or area may be more valuable than patches with a single natural heritage feature or area.***

Species Diversity

Areas that contain a high diversity of plant and animal species are generally more important than areas that contain a lower diversity of species (Figure B - 1L). In some situations, however, areas that contain a relatively low diversity of plant and/or animal species are important and should be protected, for example, where they provide habitat for an endangered or threatened species, or some other species of particular interest or conservation concern.

Species richness assessments can be undertaken as a means of comparing species diversity between sites. Species lists compiled in OMNR's Site District reports or in individual site inventory reports may be useful in conducting such assessments. It is essential to assess diversity relative to each candidate area's size since the number of species will vary with size.

Rule #11. ***Patches that contain a high diversity of plant and animal species are generally more valuable than patches with a lower diversity of plant and animal species.***

Species Rarity

In general, habitats that contain rare species are more valuable than habitats that do not contain such species (Figure B - 1M). Rarity is a relative term and can be described in 5 different ways:
(1) species that are scarce, but occur over a wide geographical area
(2) species that only inhabit one place
(3) species that are geographically separated from their main range
(4) species that are at the edge of their geographical range
(5) declining species that were once more abundant and/or widespread but are now depleted

Assessments of rarity are often expressed as the number of rare species or features in an area. Lists of species and features considered rare at one or several scales (e.g., local, regional, or national), such as those provided in OMNR's Site District reports or in NHIC's status lists, will be useful in evaluating candidate natural areas for significance. Specifically, the occurrence of rare species may add to the significance of a particular feature or area. However, it is important to realise that rare species are not necessarily endangered or threatened species, as defined in the policy.

Rule #12. ***Patches that contain rare species are generally more valuable than patches that do not contain such species.***

Naturalness/Disturbance

Relatively undisturbed natural areas are generally more desirable than highly altered areas (Figure B - 1N). The manner in which the adjacent lands surrounding a protected natural area are used and/or developed can markedly affect the viability of the natural area or the features within it. The most common rationale for using naturalness as a criterion is that undisturbed, natural areas provide the best source of baseline information to compare with other modified areas. By studying how undisturbed ecosystems function, a better understanding of how human impacts modify ecosystems can be gained. These areas will also provide important clues for restoring ecosystems that have been modified.

Methods used to evaluate naturalness vary depending on the ecosystem, information available and the level of human disturbance. For example, measuring the relative absence of exotic species could assess the naturalness of a valley-land, cattle-grazing or man-made structures such as riprap, dams, roads or buildings.

Rule #13. ***Patches that are relatively unaffected by human disturbance are generally more valuable than patches that are more highly disturbed.***

Hydrologic and Related Values

In many areas, water bodies including wetlands, often represent a relatively small percentage of the total land area, yet they can be disproportionately more valuable than other areas (Figure B - 1O) for several reasons:

- there is a large number of aquatic or riparian (moist-area dependent) plant and animal species that depend upon water bodies or wetlands to fulfil their habitat needs
- there is a large number of other animal species that require access to water bodies for all or part of their life cycle in order to survive
- there is a large number of species that use water bodies, especially streams, as travel or migration corridors
- they are critical to the maintenance of nutrient and other bio-chemical nutrient cycling processes upon which all species depend
- they are integral to the hydrologic functioning of the watershed within which they are located

Water bodies, wetlands, and other areas of significant hydrological importance (i.e., headwaters, recharge areas, discharge areas, etc.) should be protected.

Rule #14. ***Waterbodies, wetlands and other areas (e.g. seeps, recharge/discharge areas) are very important and should be protected wherever possible.***

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APPENDIX C

A List of Area Sensitive Species and Key References

A number of wildlife species require large areas of suitable habitat in order to sustain their population numbers. These species, referred to as *area sensitive species*, are identified in **Appendix G**. Area sensitive species identified in **Appendix G** are listed below. A short list of references to scientific literature that are particular to each species is also provided.

The reference list provided in this section is by no means complete. These references are meant to assist the reader in doing a further search of the scientific literature for information about these particular wildlife species and the habitats in which they live.

There are two parts to this appendix. Table 1 has been arranged by Class. A short list of references associated with each species is provided in this table. These references are listed in the reference section that follows Table 1.

The reference section also is arranged by Family and alphabetically by author. This section includes **additional** references other than those listed in Table 1. The Birds section is subdivided into seven subsections:
1) General
2) Effects of Habitat Fragmentation
3) Waterfowl and Other Marsh Birds
4) Birds Associated with Grasslands and Old Fields
5) Birds Associated with Forests
6) Woodpeckers
7) Raptors

While the majority of bird references listed in Table 1 will be found in subsections 3-7, if an author's name can not be found in these subsections, check the subsection on effects of habitat fragmentation, particularly for grassland or forest species.

Table 1: A list of area sensitive wildlife species and associated references.

SPECIES	REFERENCES
Amphibians Bullfrog *Rana catesbeiana*	Cebek (1986); Coleman (1995); Ontario Ministry of Natural Resources (1994)
Reptiles Spotted Turtle *Clemmys guttata*	Chippindale (1984); Chippindale (1985); Cook *et al.* (1980); Ernst (1967); Ernst (1976); Lovich (1988); Litzgus (1996); Haxton (1997); Haxton and Berrill (1999)
Wood Turtle *Clemmys insculpta*	Obbard (1985); Quinn and Tate (1991); Brooks *et al.* (1992); Foscarini (1994)
Common Map Turtle *Graptemys geographica*	Graham and Graham (1992); Daigle *et al.* (1994)
Eastern Spiny Softshell *Apalone spinifera spinifera*	Campbell and Donaldson (1980)
Black Rat Snake *Elaphe obseleta obseleta*	Fitch (1963); Fitch and Shirer (1971); Parsons (1977); Stickel and Cope (1947)

Eastern Hognose Snake *Heterodon platirhinos*	Platt (1969)

Mammals	
Northern Flying Squirrel *Glaucomys sabrinus*	Cowan (1936)
Southern Flying Squirrel *Glaucomys volans*	Sollberger (1940); Sollberger (1943)
Marten *Martes americana*	Bushkirk and Powell (1994); De Vos (1952); Francis and Stephenson (1972); Koehler *et al*. (1975); Thompson (1991); Watt *et al.* (1996); Wynne and Sherburne (1984)
Fisher *Martes pennanti*	Bushkirk and Powell (1994); De Vos (1952) ; Kilpatrcik and Rego (1994); Garent and Crete (1997)
Lynx *Lynx canadensis*	Quinn (1984)
Moose *Alces alces*	Ontario Ministry of Natural Resources (1984); Ontario Ministry of Natural Resources (1990)
Woodland Caribou *Rangifer tarandus*	Bergerud (1974); Calef (1981); Cringan (1957); Skoog (1968);
Birds	
Red-necked Grebe *Podiceps grisegena*	Cringan (1957); De Smet (1982)
American Bittern *Botaurus lentiginosus*	Gibbs *et al.* (1992)
Least Bittern *Ixobrychus exilis*	Gibbs *et al.* (1992)
Northern Pintail *Anas acuta*	Austin and Miller (1995) Smith (1971)
Canvasback *Aythya valisineria*	Bergman (1973); Dennis and Chandler (1974); Dennis *et al.* (1984); Korschgen *et al.* (1984)
Redhead *Aythya americana*	Dennis and Chandler (1974); Dennis *et al.* (1984)
Common Goldeneye *Bucephala clangula*	Campbell and Milne (1977); Eadie *et al.* (1995); Hume (1976); Mathews (1982); Ross (1984)
Common Merganser *Mergus merganser*	Mathews (1982); Ross (1984)
Red-breasted Merganser *Mergus serrator*	Ross (1984)
Bald Eagle *Haliaeetus leucocephalus*	Broley (1952); McKeating (1985)
Northern Harrier *Circus cyaneus*	Bent (1961)

SPECIES	REFERENCES
Sharp-shinned Hawk *Accipiter striatus*	Bent (1961)
Cooper's Hawk *Accipiter cooperii*	Bent (1961); Penak (1983); Rosenfield and Bielefeldt (1993)
Northern Goshawk *Accipiter gentilis*	Bent (1961); Squire and Reynolds (1997)
Red-shouldered Hawk *Buteo lineatus*	Bent (1961); Bryant (1986); Crocoll (1994); Risley (1982); Sharp *et al.* (1982)
Broad-winged Hawk *Buteo platypterus*	Bent (1961); Goodrich *et al.* (1996)
Sharp-tailed Grouse *Tympanuchus phasianellus*	Connelly *et al.* (1998); Olsen (1959); Snyder (1935)
Yellow Rail *Coturnicops noveboracensis*	Anderson (1977); Bart *et al.* (1984); Brookhout (1995)
King Rail *Rallus elegans*	Meanley (1969); Meanley (1992)
American Coot *Fulica americana*	Friley *et al.* (1938)
Sandhill Crane *Grus canadensis*	Hall-Armstrong and Armstrong (1982); Lumsden (1971); Riley (1982); Tacha *et al.* (1992); Tebbel and Ankney (1982)
Upland Sandpiper *Bartramia longicauda*	Swanson (1996)
Forster's Tern *Sterna forsteri*	Bergman *et al.* (1970)
Black Tern *Chlidonias niger*	Bergman *et al.* (1970); Dunn 1979
Barred Owl *Strix varia*	Bent (1961); Eckert (1974)
Great Gray Owl *Strix nebulosa*	Bent (1961); Eckert (1974); Nero (1979); Nero and Taylor (1980)
Short-eared Owl *Asio flammeus*	Bent (1961); Eckert (1974); Holt and Leasure (1996)
Boreal Owl *Aegolis funereus*	Bent (1961); Bondrup-Nielsen (1978); Eckert (1974)
Whip-poor-will *Caprimulgus vociferus*	Cadman *et al.* (1987)

SPECIES	**REFERENCES**
Hairy Woodpecker *Picoides villosus*	Bent (1939)
Three-toed Woodpecker *Picoides tridactylus*	Bent (1939)
Black-backed Woodpecker *Picoides arcticus*	Bent (1939)
Pileated Woodpecker *Dryocopus pileatus*	Bent (1939); Bull and Holthausen (1993); Bull *et al.* (1992); Freemark and Collins (1992); Kirk and Naylor (1996); Naylor *et al.* (1996)
Acadian Flycatcher *Empidonax virescens*	Christy (1942)
Least Flycatcher *Empidonax minimus*	Breckenridge (1956); Davis (1959)
Tufted Titmouse *Parus bicolor*	Grubb and Pravosudov (1994); Woodford (1962)
Red-breasted Nuthatch *Sitta canadensis*	Bent (1964)
White-breasted Nuthatch *Sitta carolinensis*	Bent (1964); Pravosudov and Grubb (1993)
Brown Creeper *Certhia americana*	Bent (1964)
Winter Wren *Troglodytes troglodytes*	Bent (1964)
Blue-gray Gnatcatcher *Polioptila caerulea*	Ellison (1992)
Veery *Catharus fuscescens*	Bertin (1977); Moskoff (1995)
Hermit Thrush *Catharus guttatus*	Hoover *et al.* (1995); Jones and Donovan (1996)
Loggerhead Shrike *Lanius ludovicianus*	Cadman (1986); Campbell (1975); Yosef (1996)
Blue-headed Vireo *Vireo solitarius*	James (1998)
Yellow-throated Vireo *Vireo flavifrons*	Rodewald and James (1996)
Northern Parula *Parula americana*	Bent (1953); Moldenhauer and Regelski (1996)
Magnolia Warbler *Dendroica magnolia*	Bent (1953); Hall (1994); Sutherland (1986)

SPECIES	**REFERENCES**
Black-throated Blue Warbler *Dendroica caerulescens*	Bent (1953); Holmes (1994)
Black-throated Green Warbler *Dendroica virens*	Bent (1953); Collins (1983); Morse (1993)
Blackburnian Warbler *Dendroica fusca*	Bent (1953); Lawrence (1953); Morse (1994)
Pine Warbler *Dendroica pinus*	Bent (1953)
Cerulean Warbler *Dendroica cerulea*	Bent (1953); Dunn and Garrett (1997); Oliarnyk and Robertson (1996)
Black-and-white Warbler *Mniotilta varia*	Bent (1953); Kricher (1995)
American Redstart *Setophaga ruticilla*	Bent (1953); Sidel and Whitmore (1982)
Prothonotary Warbler *Protonotaria citrea*	Bent (1953); Flaspohler (1996); McCracken (1981)
Ovenbird *Seiurus aurocapillus*	Bent (1953); Burke and Nol (1998); Porneluzi *et al.* (1993); Villard *et al.* (1993)
Canada Warbler *Wilsonia canadensis*	Bent (1953)
Scarlet Tanager *Piranga olivacea*	Bent (1958)
Savannah Sparrow *Passerculus sandwichensis*	Bedard and LaPointe (1984); Dixon (1972); Dixon (1978); Potter (1972); Swanson (1996); Wiens (1973)
Grasshopper Sparrow *Ammodramus savannarum*	Swanson (1996); Whitmore (1981); Wiens (1973)

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APPENDIX D

Guidelines for Conducting Field Investigations

Some seasonal concentration areas, and many rare and specialized habitats and habitats of species of conservation concern in the municipality probably have not been identified or evaluated. Also there may identified habitats currently considered to be “potentially significant wildlife habitat” because the information about them is either insufficient, vague, or outdated. Well-planned field investigations should enable the planning authority to collect sufficient information for the identification, evaluation, and ranking of specific wildlife habitats according to their relative importance.

The following guidelines will help the planning authority to:

- provide comprehensive terms of reference for any field work
- obtain the required information, in a form that is useful to the planning authority
- minimize the cost and time required to conduct field investigations by obtaining sufficient information from a minimum number of site visits
- ensure that proper documentation of important information (e.g., location of rare species and habitats) is obtained by the planning authority
- ensure that field investigations are scheduled to be done at the proper time of year
- ensure that private property rights are respected

Pre-field investigation

- Have clear objectives for any field investigations, preferably in written form (e.g., to determine the significance of a site based on the evaluation criteria provided; to record as thoroughly as possible, all the different habitats on the site; to accurately record observations; to accurately map vegetation communities on the site)
- Determine the detail and intensity of the field investigation. For example, it may only involve a quick reconnaissance to determine whether the site has changed considerably from some earlier description of it, or it may be very detailed (e.g., collecting species information about a rare habitat).
- Collect and review all information pertaining to the identification and evaluation of the site. Such information usually includes OMNR Site District Reports and relevant literature, aerial photographs of the area, topographical maps, Ontario Base Maps, Ontario soils maps, the various atlases, and information from the Natural Heritage Information Centre. Consultation with local naturalists, OMNR staff, scientists, and academics can also help the planning authority obtain relevant information on the area to be investigated.
- Determine specific priorities for site visits (e.g., to assess the nature and level of disturbance on specific portions of the site, to describe the ecological features of the rare habitat, to determine species presence)
- Provide a schedule for the field investigations that ensures that the required information can be obtained at the time(s) of year. For example, to evaluate the significance of a migratory shorebird stopover area, field workers will want to be present at peak periods when the greatest number and diversity of shorebirds will be observed on the site. Most wetland community identification and evaluation is better done in July and August because most wetland plants flower later than most plants of terrestrial/upland communities. Most breeding bird observations should be done between late May and the end of July, but observations of raptors and waterfowl breeding should be done in April and early May. Different seasonal timing is required for amphibian breeding, flowering plants, deer yards, etc.
- Provide operational guidelines for any field investigations on private property

Field Investigations

- Assemble the necessary materials for work in the field. These include topographical maps (1:50,000 scale), Ontario Base Maps (scale 1:10,000, 1:20,000 in the north), aerial photographs (scale 1:10,000, 1:20,000 in the north) of the site; a compass adjusted for declination of the area; information about the site (e.g., existing species checklist, community maps); clipboard with sheets of Mylar; field notebook or small tape recorder; pencils, eraser, sharpener; and miscellaneous equipment such as binoculars and field guides.
- Have a list of basic information to record as field notes or observations. This list usually includes the following information: approximate size of site; level and type(s) of disturbance on the site or within specific communities; diversity of site (vegetation composition and structure, floral and faunal diversity; special or unusual ecological features of the site), and a description of as many site conditions as expertise permits (aspect, slope, soils texture, drainage, moisture regime, microclimates etc.).
- Prior to undertaking fieldwork, take a photocopy of the pertinent aerial photos (use the photo enhancement capability of the photocopier). If the planning authority has the capabilities, it is very useful to scan the aerial photos and print them off to take into the field. Original aerial photos may be used in the field, and erasable grease pencils may be used to write on them. If none of these facilities are available, an overlay of Mylar on the aerial photographs may be useful. Mark on the field map/photos the sites to be visited, your present location, and the location of your parked vehicle. Recording this information before entering the area to be investigated makes it easier to keep track of your location.
- On most aerial photographs, north is found at the top of the photograph, and 1 cm on an aerial photograph is roughly equivalent to 100 metres in the field at a scale of 1:10,000 and 200 m at 1:20,000. Field workers should measure their pace to determine approximately, how many steps are taken to cover a measured distance. This knowledge can provide a reasonable estimate of the distance covered on foot in the field, help field workers know where they are, and even provide rough estimates of the size of areas covered on foot.
- Keep track of your location on the site in order to accurately describe and map it. On sites greater than 100 hectares, pay constant attention to the maps, aerial photographs and compass bearings. Use a compass and prominent landmarks, preferably ones that are visible on both aerial photographs and maps (or at least on aerial photographs) as reference points to travel to desired points of interest. Be sure to record all compass bearings, these reference points, and approximate distances travelled, in a field notebook or on a small tape recorder. For future reference and any mapping, it also helps to sketch simple maps in a field notebook, noting due north and any prominent landscape features.
- Use triangulation to find out where you are in an unfamiliar area. To do this, first locate two recognizable reference points on the distant landscape that are also visible on the aerial photograph (or map). Take bearings from your position to one of these landmarks. Place the compass on the aerial photograph, with the cover opened wide so that the long edge intersects the landmark and the cover is towards the landmark. Rotate the compass edge about the landmark until the parallel meridian lines on the compass are roughly parallel with the vertical edges of the aerial photograph (or meridian lines of the map) and fixed North indicator on the rotating bezel (not the compass needle) is on the North side of the aerial photograph or map. Then starting from the landmark, draw a line on the aerial photograph or map, along the edge of the compass. Repeat this for the second visible landmark. The intersection of the two lines is your position.
- Consider using photography to help further document the overall character, unique features and various communities of the site, for future meetings and discussions.

The above discussion focuses on material and background information to take to the field, and how to determine where one is. It does not provide any information on how to actually collect pertinent data. In many instances, planning authorities may not have in-house expertise for collecting field data and may have to hire consultants or rely on proponents to provide relevant data. There are, however, some planning authorities that have their own environmental staff or that have agreements with conservation authorities or other conservation groups.

Following are some general guidelines for conducting fieldwork for specific natural features:

- A basic requirement is identification of habitat types. The most recent version of the Ecological Land Classification system for southern Ontario should be used (Lee et al., 1998). Similar classification systems are available for the north. Personnel completing this analysis should be capable of identifying tree species, dominant species that occur in the understory, and have an understanding of soil properties.
- A qualified botanist is usually required to identify plant species and also their habitat requirements and the amount of habitat that should be protected to ensure their continued survival in the planning area. It may be necessary to conduct fieldwork during early spring, summer, and early autumn to ensure that most species have been detected (there is no such thing as a “complete inventory”).
- The Canadian Wildlife Service has prepared protocols for monitoring amphibian populations. These are not very useful when working on a site-specific basis. However, they do provide a tape so that one can identify the songs of calling frogs.
- There is no standard protocol for sampling reptiles. For snakes, when a species of conservation concern may occur in the planning area, distributing hiding sites may give an excellent indication of where these species occur. Placing boards and other cover may reveal the location of species and give an indication of their relative abundance.
- For breeding birds, there are several standardized techniques. Fieldworkers should be able to identify birds by song and visually. For most birds, the breeding season extends from very late May until the first week of July. Surveys should be done starting shortly before dawn and ending by 0900 or 1000 at the latest. Calm days with no rain should be selected for surveying. Shorebirds, waterfowl, and raptors nest earlier through April and May. For difficult to detect species (marsh birds, certain hawks, owls) tapes of their calls may be played to elicit a response. There are also special protocols for sampling marsh birds, certain owls, and Red-shouldered Hawks.
- Most mammal observations rely on checking for signs such as tracks, scats, dens, etc. When surveying for a specific species, it is necessary to know its habitat requirements before designing the field methods. Appendix G gives the general habitat requirements of the mammals that occur in Ontario.

APPENDIX E

Natural Heritage Gap Analysis Methodologies Used by the Ontario Ministry of Natural Resources

This appendix was prepared as part of the Living Legacy (Lands for Life) exercise. The methodology was first developed and described as an efficient method for identifying unrepresented or under-represented natural heritage features within an area of interest. However, the principles described for gap analysis can be applied province wide or can be applied to the site district scale as criteria can be added to apply gap analysis to a finer scale.

Natural Heritage Gap Analysis Methodologies Used by the Ontario Ministry of Natural Resources

(DRAFT 25 January 1999)

William J. Crins and Philip S.G. Kor
Open File Natural Heritage Technical Report 9901
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Ontario Ministry of Natural Resources
Lands and Natural Heritage Branch
Natural Heritage Section
Peterborough, Ontario

1.0 INTRODUCTION

The goal of the Natural Heritage Areas Program is "*to establish a system of protected natural heritage areas, representing the full spectrum of the province's natural features and ecosystems*" (OMNR 1997). For life science features, this goal is achieved through an assessment of the landform/ vegetation associations in each Site District, and the selection of a set of natural heritage areas that best meets a set of five selection criteria. For earth science features, the goal is accomplished through the development of environmental themes identified by the record of Earth history in the rocks, landforms and geological processes, both past and present, of Ontario.

The best representatives of the life science and earth science features are denoted as provincially significant. Protective zoning designations in Provincial Parks (Wilderness, Nature Reserve, and Natural Environment zones), Conservation Reserves, and Areas of Natural and Scientific Interest (ANSIs), taken together, provide the mechanisms by which the natural heritage features of each Site District or earth science theme are represented and protected. The focus in site selection is on the best representation of the natural diversity of the Site District or earth science theme. In the case of life science values, both living and non-living components must be assessed; hence, the setting of representation targets is based on combinations of landforms and vegetation.

2.0 LIFE SCIENCE GAP ANALYSIS

Gap analysis, in the conservation biology context, refers to an approach (or a set of methodologies) for setting and filling natural heritage targets. It facilitates the identification of features that are unrepresented or under-represented within a natural heritage areas system. Different approaches have been used in different jurisdictions, but the underlying premise is common to all approaches: natural heritage features are assessed to determine whether or not some of those features require conservation.

The purpose of this chapter of the document is to outline the current life science gap analysis methodology employed in Ontario, and to outline the application of the five site selection criteria. In this province, the primary objectives of life science gap analysis are the assessment of the conservation status of the naturally occurring landform/ vegetation associations of each Site District, and the identification of the best representative areas that together contain the full array of these associations. The selection of the representative areas must be conducted using as rigorous and objective an approach as is possible with qualitative or semi-quantitative site selection criteria.

While being cognizant of the principles of conservation biology, as well as current dialogue regarding the concept of 'biological integrity', the selection of areas must be accomplished within the scope of existing policies and principles. The methodologies described here serve to identify core representative areas only, in as efficient a manner as possible. Resource management activities on the intervening lands must be conducted in a manner that does not compromise the values of these core areas, thereby contributing to the ecological sustainability of these core areas as well as of the landbase as a whole.

The objective of selecting the best representative sites carries with it the need to identify parts of the landscape that have been subject to limited recent human disturbance. The objective of identifying the best remaining examples of each landform/ vegetation association in a Site District means that, on occasion, relatively small remnants will be identified, although in other cases, large aggregations or assemblages of features will occur together. No assumptions about minimum size requirements have been applied *a priori*. Rather, the methodologies focus on the identification of the best examples of what exists. Restoration of areas and their component features, and other conservation biology objectives, potentially can be added to the system in the future, but to avoid arbitrariness in site selection, the search for sites begins with the undisturbed or least disturbed areas.

Most gap analysis projects that have been conducted in various parts of the world have focused on life science features, and in particular, species and habitat representation. Almost all jurisdictions applying gap analysis have used a broad landform template, and some have superimposed habitat or vegetation onto that landform template. Most of the variation in approach occurs in the template on which natural heritage features will be assessed (landforms, soils, vegetation types, species, geographic units, etc.), in the resolution of the targets, and in the determination of adequacy of present conservation of the natural heritage values. The approach used by the OMNR is outlined below.

2.1 General Approach for Life Science Gap Analysis

OMNR's gap analysis method consists of four steps:

- Identifying landform features (coarse filter)
- Identifying vegetation features on each landform unit (fine filter)
- Assessing existing representation
- Identifying the gaps

Step 1: Coarse filter - landform units (enduring features)

For the ecological district being studied (in Ontario, the Site District is the unit of study), available landform maps are examined. Surficial geology, bedrock geology, and combinations of these themes, can be used to delineate the landform patterns of the district. Mapping at a scale of 1:250 000 is suitable for analysis at the Site District scale. Sources such as the biophysiographic mapping produced by Noble (e.g., 1982, 1983) have been used in central Ontario. They were produced through interpretation of surficial geology, the biophysiographic units essentially consisting of aggregations and/or refinements of Ontario Land Inventory (OLI) units, taking account of mode of deposition, major and minor overburden, and ruggedness or irregularity of the terrain. These maps are somewhat similar conceptually to the physiographic mapping produced by Chapman and Putnam for southern Ontario (1984), although produced at a somewhat finer scale.

All landform units within the Site District are tabulated in this first step of the method. The finest level of resolution in Noble's biophysiographic unit classification system is used (i.e., Ia-1 and Ia-4 are considered to be different biophysiographic (landform) units).

OLI units may also be suitable for use at this stage of the analysis, but may require some preliminary aggregation of units, to make them comparable to Noble's units. All landform units recognizable at 1:250 000 scale within the study area are tabulated and mapped in this step. Other alternative landform systems could include Chapman and Putnam's system (1984) or soil surveys for the south, a combination of the bedrock geology and surficial geology coverages produced by the Ontario Geological Survey, or the Northern Ontario Engineering Geology Terrain Study (NOEGTS) coverage in the north. However, some of these coverages are at a coarser scale than OLI or Noble's coverages (with lower resolution), and therefore, are less preferable.

Step 2: Fine filter - vegetation response to landform

Using available databases, reports, and literature, the natural vegetation types known to occur within the Site District are summarized, and are correlated with the landforms examined in Step 1. This may be accomplished by manual overlays of the landform units with vegetation mapping (e.g., Forest Resource Inventory [FRI] maps or classified LANDSAT imagery). However, ideally, gap analysis should be conducted in a Geographic Information System (GIS) environment, where large data sets can be overlaid, analyzed and summarized much more efficiently. In section 2.5 of this document, a step-wise analytical procedure is described for the completion of gap analysis in a GIS environment.

Overlaying the landforms and vegetation types results in tabular and cartographic outputs for each landform/ vegetation unit created within the study area. When FRI is used, the working group (generally, the dominant tree species) serves as a convenient level of classification for forested vegetation types. These are further subdivided by three broad age classes (see Appendix I). Thus, for forest vegetation types, representation targets consist of young, medium-aged, and old forests of each dominant tree species in each Site District. Summary statistics for each vegetation type and age class on each landform unit can be produced.

In all cases involving the use of FRI data as the vegetation coverage, the codes representing rock outcrops and wetland types can serve as a coarse classification system (albeit far from ideal) for non-forest vegetation types.

Step 3: Assessing existing representation

Examination of landform/ vegetation complexes in existing protected areas including protective zones within Provincial Parks (e.g., Wilderness, Nature Reserve, Natural Environment), National Parks, and other land designations (e.g., Conservation Reserves) is undertaken to determine which landform/ vegetation features are currently protected. Only those areas regulated or zoned specifically for natural heritage protection are factored in to the assessment of existing representation.

The landform/ vegetation features occurring within existing protected areas are compared with the landform/ vegetation features found in the Site District as a whole (Step 2, above). The comparison of existing protected landform/ vegetation types with those known to occur in the Site District yields the unfulfilled representation targets, or gaps, that still require inclusion and protection in the natural heritage areas system. In the GIS version of gap analysis, guidelines are applied to ensure that features contained within inappropriate park classes or zones (e.g., Recreation and Historical Parks; Access, Development, Historical, and Recreation/ Utilization Zones) are not considered to be represented. These guidelines do not address the question of adequacy of representation, but simply provide a means of excluding features contained within developed or otherwise disturbed parks and protected areas that might otherwise be factored into the existing representation calculations. In the manual version of the method, these classes of parks and types of zones would be ignored when considering existing protection.

Step 4: Filling the gaps

Landform/ vegetation features that are not yet represented in the natural heritage areas system serve as the focus for the search for new areas to fill those gaps. The focus of the method is to identify suitable sites to fill the representation gaps. Selection criteria for new sites conform to those used in existing OMNR natural heritage programs (Parks systems planning, ANSI program). These include: representation (the basis for gap analysis, including broad age-class representation of forest types), diversity (the number of different landform/ vegetation features within a given area), condition (the degree to which anthropogenic disturbance has occurred), ecological considerations (e.g., local hydrological/ watershed functions), and special features (presence of populations of vulnerable, threatened, and endangered species, localized or unusual features). The application of these five selection criteria allows for the assignment of relative significance levels to each example of the unrepresented features (e.g., provincial, regional, or local significance), taking into account the surrounding landscape (other adjacent unrepresented features, nearby special features, hydrological characteristics, etc.).

FRI or LANDSAT databases and landform maps serve as the background in which the search for unrepresented features occurs. Previous disturbance of the landbase by human influences (logging, mining, road-building, hydro development, agriculture, settlement) reduces the value of certain portions of the landbase for the achievement of natural heritage representation targets. Thus, such disturbances are taken into account in the search for areas to represent required features. OMNR District/ Area Offices are canvassed for cut-over maps and other information relevant to the determination of impacts on the landbase. Other sources of disturbance information may also be sought out and used, including information held by resource-based companies, planning authorities, other agencies, etc.

The entire Site District is scanned for potential representative areas. Each area that is still relatively intact, in the sense that it does not contain extensive cut-overs, road networks, or other developments, is compared with respect to the landform units and forest types (working groups and age classes) that it contains. An assessment of diversity within a block (relatively undisturbed portion of a Site District) is made on the basis of the number of landform units, working groups, and broad age classes, since other site-specific measures of diversity may not be available, especially in the north. Other parameters relevant to the five selection criteria also are assessed, including juxtaposition with existing protected areas, hydrological features, size, and special features. Since very little information is available on special features in many parts of Ontario, this criterion often cannot be applied with any rigor, but when information is available, it can be used to compare otherwise similar areas.

The final result of the gap analysis is a set of provincially significant areas that, taken together, provide the best representation of the array of landform/ vegetation associations known to occur in the Site District. It also results in the identification of additional sites that fulfil all or some of the selection criteria, but that are not deemed to be the best representatives. These sites are assigned lower levels of significance (regionally or locally significant).

2.2 Site Selection Criteria

Five site selection criteria are employed to assist in the determination and delineation of provincially significant sites. These are: 1) representation, 2) condition, 3) diversity, 4) ecological considerations, and 5) special features.

Landscape-scale Criteria

1) Representation

Ontario's approach to life science gap analysis can be considered to be a 'feature-representation' approach. The method attempts to identify the 'best' examples of all landform/ vegetation features (given the set of selection criteria described herein), thereby representing the full array of these features. This approach recognizes the reality that some landscapes are more diverse than others, without assigning a given percentage target, and also acknowledges that the land use history differs among landscapes and/or landform units. As Harris (1984, p. 109) notes "*... the question of how much is enough can only be fairly addressed in the context of surrounding forest conditions.*"

The most important selection criterion is representation, since the entire natural heritage areas system is based on the principle that the areas containing the best representatives of each landform/ vegetation complex are to be conserved, if possible. If an area does not contain a high-quality example of at least one landform/ vegetation feature, then it should not be considered further, in this context. However, determination of the best representative examples may require comparisons among several potential alternatives, and this is where the additional selection criteria become necessary.

2) Condition

In the gap analysis method described above, the landbase under consideration for contribution to representation is screened by considering existing and past land uses (but not proposed future uses), including cut-overs, road networks, mining areas, other unnatural corridors (hydro-lines, railways, etc.), agricultural areas, settlements, and other types of development. In effect, condition, or the degree of anthropogenic disturbance, has already been used as a selection criterion at this point. Potential sites for consideration as natural heritage areas are screened early in the selection process for their relative condition or quality.

Local-scale (Site Comparison) Criteria

Sites that remain under consideration after the Representation and Condition criteria have been applied must be compared using the remaining three criteria. Because there is often a lack of information about special features (populations of rare, threatened, or endangered species, unusual or localized geological features or habitats, etc.), especially on the Precambrian Shield, the special features criterion is best used as a supplementary or supportive one. Thus, all else being equal with regard to representation and condition, the diversity and ecological considerations criteria can be used to determine which of several sites should be regarded as the best site for a given feature or set of features.

3) Diversity

A site is considered to be more diverse than another if it contains more high-quality, representative features. Diversity can be achieved at several scales. However, in the landscape (Site District)-scale gap analysis, assessments of diversity are made at the landform and vegetation community scales, rather than at the species scale. In most cases, species richness is unknown in these sites anyway. Thus, a site that straddles several landform units will be more diverse than a site that is entirely confined to one unit. If the sites being compared are all situated on a single landform unit, then, again all else being equal, the site with the greatest range of vegetation types is preferred. If information sources permit (e.g., FRI data), age-classes within vegetation types also are considered in the assessment of relative diversity. This is done by using broad age classes, defined for each forest vegetation type (see Appendix I). At the present time, there is no method for determining the effects of past logging (particularly when removal of single or a few species was involved) or human-induced fires on age-class structure of the current forests. Thus, the approach taken here is to consider the existing forest, taking account of as much information on forest disturbance as possible.

Unfortunately, most databases available for use in life science gap analysis in Ontario do not do an adequate job of classifying non-forested vegetation types. Nevertheless, an attempt also should be made to consider rock outcrops, shorelines, non-treed wetlands and other non-forested vegetation types in the assessment of diversity, even if only broad categories and presence/absence can be determined.

4) Ecological Considerations

Ecological considerations relate to such attributes as hydrological functions and connectivity (aquatic and terrestrial). An area that provides natural, biologically meaningful connections with other nearby significant areas, or an area that contains headwater lakes, ponds, springs, or streams, will fulfill this criterion. Limiting components of habitat, such as important moose aquatic feeding areas, bat hibernacula, spawning beds, etc., could also fulfill this criterion.
These features are used to refine boundaries where they occur in close proximity to the core representative features. They also may be used to distinguish among areas that otherwise are similar in their representation, condition, and diversity.

5) Special Features

Special features include populations of rare, threatened, or endangered species, and unusual or localized geological features or habitats. Some parts of Ontario are extremely rich in such information (e.g., southwestern Ontario). However, in other areas, there is a lack of information. This lack of information may be due to difficulty of access or limited survey effort, rather than an actual absence of these features. Therefore, this criterion is best used in a supplementary or supportive role. Areas should not necessarily be penalized or downgraded if they lack special features, unless areas against which they are being compared do contain known special features. The Natural Heritage Information Centre is a primary repository for data on special features.

2.3 Step-wise Methodology for Life Science Gap Analysis

This section outlines an algorithm for data analysis which results in the identification of representative core areas that, taken together, will contain the full set of landform/ vegetation features found in a given Site District.

Part 1 - assessment of unrepresented features, and options for filling gaps:

- For each Site District, overlay landform and vegetation layers;
- Summarize proportions and amounts of each landform unit within the Site District (output=table);
- Summarize proportions and amounts of each FRI Working Group by three broad age classes (Appendix I), on each landform unit (output=table); each Working Group age class equals a vegetation type;
- Overlay existing Protected Areas layer;
- Summarize proportions and amounts of landform/ vegetation types for existing protected areas (output=table);
- Subtract landform/ vegetation types found in protected areas from total set of landform/ vegetation types in Site District; produce table of unprotected types.

Rules for determining minimum levels of representation in protected areas:

- At least 50 ha of any landform/ vegetation feature must be contained within a protected area in order to be considered represented, at this stage in the analysis;
- At least 1% of each landform/ vegetation feature must be contained within the suite of protected areas in the Site District in order to be considered represented, at this stage in the analysis.

- Overlay disturbance layers for Site District;
- Remove disturbed areas from Site District land base;
- Identify all areas having unprotected landform/ vegetation types (polygons), subject to the minimum representation rules applied above;
- If there are landform/ vegetation types within the Site District that do not occur in undisturbed areas, re-examine the disturbed landbase for those types; examination of the disturbed areas may occur in a step-wise manner until suitable polygons are found;
- Delineate clusters of contiguous unprotected landform/ vegetation polygons, including single polygons;
- Tabulate and sum the number of polygon types in each cluster; produce a table summarizing the numbers, types and sizes of polygons for each cluster;
- Overlay Special Features data, where available, for the Site District;
- Produce a map of clusters, using the above layers, including labels in hard copy and digital formats, and categorize the clusters on the map according to the number of unrepresented features contained in them - the digital file will be the plot file used to create the hard copy map.

Part 2 - identification of "best" representative areas:

Using an iterative approach, identify those clusters that, together, best represent the features not yet represented in protected areas within the Site District. This will be accomplished by searching for the clusters that contain the most unrepresented landform/ vegetation features, subject to the minimum representation rules noted above.

- Select the cluster identified in Part 1 that contains the most unrepresented landform/ vegetation features, subject to the minimum representation rules used above (50 ha and 1%);
- Subtract the features contained therein from the list of unrepresented features in the Site District;
- Select the next cluster identified in Part 1 that contains the most unrepresented landform/ vegetation features from the revised list, subject to the minimum representation rules used above (50 ha and 1%);
- Subtract the features contained therein from the revised list of unrepresented features in the Site District;

Continue this iterative analysis until all landform/ vegetation features are represented in a set of areas.

Part 3 - option development:

The same approach as outlined in Part 2 can be used to identify optional representative areas, if needed, for planning purposes.

- Re-do the above iterative analysis, using the clusters that contain the second largest set of unrepresented features, assuming that the sites containing the most unrepresented features cannot be protected;
- Re-do the above analysis, using the clusters that contain the third largest set of unrepresented features (development of planning scenarios).

2.4 Assumptions

The life science gap analysis approach described here requires several assumptions. The over-riding assumption implicit in this methodology is that the Site District (ecodistrict) scale is the appropriate scale at which representative features should be selected to build a natural heritage areas system. This assumption also rests on the selection of the Ecological Land Classification (ELC) system originally designed by Hills (1959), and modified by others (e.g., Burger 1993, Jalava *et al.* 1997), as the template within which these gap analyses would be conducted. Arguments for coarser and finer scales of resolution have been made, but the Site District scale has stood the test of time in Ontario (it has been used for over 20 years for the purpose of establishing and meeting natural heritage targets), and it provides a useful scale for the determination of major ecosystem attributes and dynamics. A coarser scale (e.g., Site Region or ecoregion) forces too much generalization. The substantial variation that exists in ecosystem composition, structure, and function across an ecoregion is not well reflected when natural heritage areas are selected at this scale, assuming that the approach described in this paper is used. A finer scale of resolution would be difficult to apply in most parts of Ontario, because of the lack of ecosection definition and mapping (however, this may become available in the near future), and the limited data available on detailed distributions and specific habitat requirements of most species.

In the present approach, it is assumed that landform/ vegetation associations serve as adequate surrogates for ecosystem components, especially relating to habitat. The method attempts to identify potential natural areas on the basis of aggregations of these landform/ vegetation associations, so that at least some of the natural areas will contain diverse assemblages of habitats and associated species.

Another inherent assumption is that undisturbed or least disturbed examples of the landform/ vegetation associations are better, from a conservation point-of-view, than more severely disturbed examples of those same associations. This assumption has as its premise that relatively undisturbed examples of ecosystems are more likely to contain and support the full range of compositional, structural, and functional attributes of those ecosystems. Thus, they provide the best available samples of those ecosystems.

The limitations of the data sets that are used in the life science gap analyses in Ontario (see Sect. 2.5) require that assumptions be made about several types of ecosystems (particularly non-forested, wetland, and aquatic systems). Since the data sets do not contain adequate classifications for these community types, reliance must be placed on very broad categorizations (e.g., 'rock' in the FRI data set would include natural rock barrens, cliffs, alvars, etc.). By including samples of such non-forested categories from each landform type, it is assumed that the range of ecosystems in these categories can be represented in the set of sites selected in the Site District.

The gap analysis method described here uses the concept of efficiency in an attempt to identify a set of areas that represents the landform/ vegetation diversity of a Site District. Thus, areas are selected based on their relative diversity, with the areas containing the most remaining unrepresented landform/ vegetation features selected at each iteration. It is assumed that more diverse areas generally will support more ecological functions, and contain more habitats and species. More diverse sites also tend to be larger, although this is not always the case.
Perhaps the most important assumption, in terms of application of this methodology, is that the remainder (bulk) of the landbase is being managed on an ecologically sustainable basis. This means that, for example, appropriate silvicultural approaches are being used in the forests adjacent to these sites, that guidelines conserving non-timber values are being applied, and that natural patterns are being emulated in resource planning and management activities.

The methodology, as presently designed, focuses on core representative features, with boundaries designed to account for local hydrological, topographic, and special features. There are no provisions for additional 'buffers', because it is assumed that activities on the adjacent lands will not be detrimental to the values of the core areas. This assumption clearly does not hold true in the settled parts of Ontario, but there, natural heritage core area design is constrained largely by adjacent land uses that have removed the natural or near-natural vegetation cover. Other approaches, including restoration activities, would be required to enhance the integrity of the core areas in such landscapes. In the less densely settled or developed parts of the province, forest management can be planned and conducted in an ecologically sustainable manner, through the application of guidelines and silvicultural approaches that maintain forest types that are adapted to the local site conditions. Thus, ecological functions including nutrient and water fluxes, gene flow, and various other components of population genetics and dynamics, can be maintained across the actively managed - protected area boundary interface. The 'edges' in properly managed landscapes containing core protected areas should be soft edges, not sharp discontinuities.

2.5 Limitations

In conducting gap analyses in Ontario, it has been necessary to use data sets that may have been compiled for entirely different purposes. This is because they may be the only data sets available that can provide the necessary thematic information (vegetation, landforms, disturbances, etc.). The various data sets also have been compiled or interpreted at varying scales, so there is the potential for inaccuracies to occur when these data sets are correlated or overlaid. This problem has been addressed, in part, by the exclusion of 'slivers' (landform/ vegetation features less than 1 ha in size) from consideration when assessing the diversity of potential representative areas. Nevertheless, there is still the potential for artifacts when overlaying data sets with different scales of accuracy.

Two existing data sets have potential applicability for the vegetation component of life science gap analysis. These are classified LANDSAT TM imagery, and the Forest Resource Inventory (FRI). Each has advantages and disadvantages. The current classified LANDSAT data set does not provide adequate resolution of many vegetation types. For example, it is not possible to distinguish between spruce species, nor among intolerant hardwood species, nor is it possible to distinguish between ecotypes of a particular species (e.g., upland versus lowland Black Spruce). This is possible to some degree with FRI, by examining the stand composition, and understanding the ecological preferences of the species associated with Black Spruce. Neither LANDSAT nor FRI data sets classify non-forested lands adequately. However, the FRI does contain general categories for rock outcrops and various lake and wetland types. These categories generally are inadequate for natural heritage analysis purposes. Thus, it is necessary to make assumptions about non-forested vegetation communities that may be included within the sites recommended for protection in gap analyses using these data sources. In any event, it would be preferable to have data sets that are more ecologically based. A province-wide classification of ecosections and ecosites would be ideal for gap analysis purposes, and would provide the necessary analogs to the present landform/ vegetation approach.

Another limitation of the vegetation data sets is that they are interpreted, although both data sets have had some degree of ground-truthing. There has been greater emphasis placed on refining the FRI data set on Crown Land, through additional timber cruising, than there has been on private land, although even on Crown Land, the focus always has been on commercial tree species. Also, the age of the actual FRI data varies from area to area. This is also true for disturbance information, such as cut-over information. Up-to-date forest history data (cut-overs, roads, etc.) often exist only in paper (not in digital) form, although some of these data are available in the LANDSAT and FRI data sets. Often, it is necessary to update disturbance coverages by digitizing the newer information, and by vetting the results of gap analyses with knowledgeable staff from the district and area offices. It may be necessary to revise the boundaries of proposed protected areas in the light of these additional disturbance data.

The method focuses on existing diversity. There has been no modeling of previous landscape structure and composition. Therefore, it is possible (likely in some areas) that some landform/ vegetation associations that may have occurred in the past are not included in the sets of sites identified using the current methodology. Future research in natural heritage area systems should include modeling of past ecosystem distribution. Such work could then enable the identification of ecosystems in need of restoration, and suitable locations for such efforts.

Ideally, gap analysis should be conducted with proper spatial analytical tools, such as a Geographic Information System (GIS). Manual analysis of data sets is possible, and has been employed in the absence of the necessary digital data sets, but it is extremely time-consuming and inefficient. However, even with GIS, the size of some of the data sets to be analyzed, especially for the larger Site Districts, can stretch the capabilities of the existing technology.

Several steps in the automated methodology outlined in Section 2.3 have potential limitations that require further consideration and development in the future. The rules with regard to minimum levels of representation in existing protected areas and new candidate sites (50 ha and 1% of the landform/ vegetation feature within the Site District) were designed to ensure that features within inappropriate areas (e.g., Recreation class parks) were not considered to be representative. This does not mean that these minimal levels are adequate for representation. They should be considered for what they were intended to be, minima. Adequacy of representation is an issue that has no resolution at the present time. Adequacy will depend, in part, on the dynamics of the ecosystem being considered, and also on the nature of the land uses adjacent to, but outside of, that ecosystem. Thus, again, with the methodology described here, it is critical that ecologically sustainable resource management occurs outside of the protected core representative areas.

The GIS-based algorithm relies on the contiguity/ adjacency of polygons containing unrepresented landform/ vegetation features when identifying clusters and assessing diversity within those clusters. Thus, breaks in the landscape, whether they are based on features that are already represented, on disturbances, or on other types of polygons that are not classified or not factored in as features for representation, will serve to limit the sizes of the clusters identified as being potential representative core areas. Most of these breaks in the landscape are consistent with the approach of identifying core areas for protection using landform/ vegetation diversity and efficiency assumptions. However, water bodies also cause breaks in the landscape. Ideally, the system of representative areas would include the full array of aquatic ecosystems, as well. The ecological considerations selection criterion assists with this. Nevertheless, water bodies (including lakes, ponds, and large rivers) are not treated as targets for representation up-front in the current methodology, and must be factored in once the clusters have been identified. This also means that water may break clusters that might otherwise have been combined. A method is being developed to minimize this effect, but it is only partially successfully at present, and therefore, it is still necessary to assess this effect manually after clusters have been generated.

Although the present GIS-based algorithm accounts for numerous combinations and permutations in the available data sets, given the current approach to representation, it seems likely that there will always be a need for informed judgment by specialists after the results of any gap analysis have been obtained.

Since gap analysis is extensive, dealing with large land bases, field inventories likely will be limited. However, the results of gap analyses will always benefit from field visits to the sites, even if these occur at some time after the analyses are completed, for the purposes of confirming the results, providing additional details on the vegetation communities of the sites (particularly with regard to understorey species and non-forested communities), and acquiring data on special features. It is possible that boundary revisions may be warranted at such time as site-specific inventories are conducted, or as information becomes available, either from staff or from members of the public who may visit these sites.

Most of the information on populations of rare, threatened, or endangered species is found in OMNR files, and in the north, much of it relates to a few "featured species", such as Bald Eagle. Virtually nothing is known of the botany of large portions of the province. The Natural Heritage Information Centre contains the most comprehensive data sets for rare species, and is constantly updating its data sets, but data for northern areas are still limited.

3.0 EARTH SCIENCE GAP ANALYSIS

3.1 Background

In 1978, a revised Parks Policy established a goal and objectives for Ontario's Provincial Parks. One major objective of the policy is: "*to protect provincially significant elements of the natural and cultural landscape of Ontario"*. This objective was to be satisfied through a system of parks and zoning (now expanded to include Conservation Reserves) founded on the principles of representation, variety and permanence. The policy guideline articulating the Ministry's protection objective as applied to geological component of the natural landscape is: "*to protect a system of earth science features representative of Ontario's earth science history and diversity"*.

Earth science features are defined as the physical elements of the natural landscape, created by the earth's processes and distinguished by their composition, structure, and internal and external form. Earth science conservation is the recognition of the significant elements of the natural landscape and their protection from undue alteration by man's activities. Gap analysis is a term recently coined of a comparative evaluation process which seeks to achieve representation of these elements in a system of protected areas. This section explains the gap analysis process as used for earth science conservation.

The protection of geological and landform elements of the landscape has a long history in Ontario, and was formally recognized in policy as early as 1959. The presented gap analysis process has been in use in Ontario since the early 1970s (Beechey and Davidson 1980; Davidson 1981, 1988), although the term "gap analysis" has only recently been applied to the process. Earth science conservation is becoming increasingly recognized within the context of international environmental circles.

3.2 Earth Science Conservation

To satisfy the Provincial Parks Policy's earth science guideline, a framework, or model, was needed to guide the selection of features. The resulting document, informally called the *Earth Science Framework* (Davidson 1981), essentially a synthesis of the geological history of Ontario, outlines the geologic themes and features which are targeted for representation in a system of protected areas.

Earth science conservation (also known as earth heritage conservation, or geological conservation) concerns the protection of selected, representative features of the province's geological history and its physical expression on the landscape in a system of protected areas, and the monitoring of the remainder of the physical land base to provide alternate sites for scientific and educational opportunities. Earth science gap analysis is a selection process which determines the existing and required levels of representation of the earth sciences in Ontario. Earth science gap analysis identifies the features which are unrepresented or under-represented within a system of protected areas, and identifies sites where features of the geological history, landforms and processes in Ontario will address the completion of that representation.

The objective of the earth science gap analysis process is the identification of the representative features of the province's physical landscape that best define its past and present environments. These environments are interpreted through scientific study of the province's rock record, surface morphology, and geologic processes active in the past and present. In order to determine what features are most important to be set aside, it is necessary to describe the earth science diversity of the land base and to determine the most significant elements essential to the description of that diversity.

The classification of earth science diversity is based on internationally recognized (if not always agreed to) concepts of time, landform evolution (geomorphology) and geologic process. The earth sciences encompass a range of interconnected but quite distinct subdisciplines which together help to explain how Earth formed and changed through time, at depth and at the surface. Earth science representation attempts not only to identify an example of all the known geological features in the province (rock types, fossil assemblages, landforms and geological processes), but also to identify a suite of features which define the significant geological events through time. This time aspect of geological representation is found in the rock record by its lithostratigraphy, in the fossil record by its biostratigraphy, and in the landform record by its morphostratigraphy. Thus earth science representation seeks protection of the elements of the physical makeup of the province, as well as protection of complexes of the physical features of the province that define the passing of geologic time.

In the bedrock record, the protection target is to identify one best representative example of each rock (lithological) type from the full range of identifyable units that we know to occur in the exposed rock record (lithology). In addition, the protection target is to identify examples of each discrete period of time within the sequence of events in the geologic time scale as represented by individual rock units (lithostratigraphy). This inevitably results in the duplication of rock type representation, because of the inherent cyclicity in geologic processes over time .

A similar approach is required for the representation of landforms, which, in Ontario, are predominantly glacial in origin. Representation targets consist of the identification of the best examples of each landform (and its derivatives) that occurs in the province, as individual features (i.e., esker, moraine, drumlin, kame, etc.), and, the identification of landform features which best reflect the major events in the (in this case) glacial history of the province (morphostratigraphy).

The ancient geologic processes which have shaped the province are reflected in the rock record, fossil record and landform record of the current landscape. Representation of these processes is achieved largely through the identification of sites noted for their values in representing chronology and stratigraphy. Representation targets for modern geological processes, such as lakeshore, fluvial and aeolian processes, constitute those sites which best display the current actions of a selected process and its resulting landform(s).

To accommodate the range of geologic time, stratigraphy and landform in the province, the geologic record in Ontario has been classified into 43 **environmental themes** , each of which represents a particular, interpretable environment of formation. Each environmental theme is characterized by a set of features, or elements, of the physical landscape, be it in the rock record, the fossil record, or the landform record, that defines a set of conditions of formation, or environment. In this way, each environmental theme is distinguishable from adjacent themes. The environmental themes are tied closely to the geologic time scale, in that each theme represents a set of conditions known to occur during a particular time period of earth history. Examples of environments that helped shape the landscape and that are accompanied by physical evidence, are periods of mountain building, periods of profound erosion, the incursion of warm tropical seas, the impact of extraterrestrial objects on the earth’s surface, and periods of glacial activity. The elements of each of these themes, that is, the features which serve to characterize the environment which identifies each theme, make up the representational targets of the gap analysis process. The environmental themes used in Ontario are defined and described in the *Earth Science Framework* (Davidson 1981).

The scale of representation of the elements of an environmental theme varies considerably. Individual outcrops of bedrock or unconsolidated sediment are generally small, less than 1 hectare in size . Individual landforms and some process themes may only need a few 10s of hectares to adequately represent enclosed features . Larger landforms, and associations of landforms, may require many 100s of hectares to adequately represent the identified features . The representation of active geological processes often encompasses large areas , sometimes requiring the management of areas beyond the specific identified element(s) in order to assure the continued natural functioning of the identified process(es).

Because of the wide range of scale in the types of earth science features evaluated, no assumptions about minimum size requirements have been applied *a priori.* There are np upper or lower limits set on the amount of land to be protected for earth science features because there is no scientific basis for setting such arbitrary limits. Rather, the methodologies focus on the identification of the best examples of any features appropriate to the scale of that feature. The scale of each feature or combination of features will determine the size and shape of the site boundary required for its adequate protection.

What constitutes "best", as in the "best example" of a geological feature? By virtue of its location, history, etc., each outcrop and landform may be considered unique. Depending on the level of research and study of the geology of a specific region, each unit or feature may have several known exposures or occurrences, recognizing that not all occurrences may be known at the time of study. The best example of a geological element is chosen first from one that is known to occur, and second, one which adequately displays a range of typical characteristics by which the element is recognized. Such a best example is often chosen by the consensus of geoscientists, as reflected by its use in the literature, in field trip guidebooks and by the academic community, to characterize a certain rock type, fossil assemblage, landscape or process. Additional best examples will be determined through literature review, consultation with experts in the various fields of geology, and original field work by OMNR earth science staff or consultants through theme studies or regional inventories. In the identification of elements related to the landform and process themes, an important component of this field work is the review of all available remote sensing information (particularly airphotos and surficial geology mapping).

The selection of the best representative examples of earth science features generally consist of those which have not been altered or impacted by man's activities. It is preferred that the morphological integrity of landform features, and the continuance of active geologic processes, be captured intact. However, for earth science gap analysis, the objective of selecting the best representative sites sometimes requires that parts of the landscape that have been subject to human disturbance be identified. The objective of identifying the best remaining examples of each feature relevant to the geologic history and features of the province means that, where no other examples occur or are available, then sites with acceptable degrees of impact are chosen.

While undisturbed or least disturbed sites are generally preferred in initial evaluations, a significant exception to this rule is in the selection of bedrock sites and sites consisting of unconsolidated sediments. Many of these are significant precisely because they have been artificially exposed through blasting or quarrying to reveal the internal structure of the selected geologic units or features. Road cuts, quarry faces, mine shafts, aggregate pits, etc., have existing or potential significance in defining Ontario's past environments. With every new section that is exposed, there is potential for improvement in our knowledge of an event or aspect of our geological past.

The minimum requirement of a system of protected earth science features is to represent a complete suite of elements that define each of the 43 environmental themes in Ontario. This "one-of-each" approach represents the minimum "line" required to achieve complete representation. This approach is not ideal in that it fails to provide for unforeseen events which may negatively impact this minimum. It also fails to provide the flexibility needed to address changes in ideas and concepts, and associated significant sites, with time and always expanding knowledge. Geology is a fluid science. Theories and hypotheses change as the knowledge base grows, and the list of significant sites which help to identify these new ideas may change or grow as a result.

3.3 The Gap Analysis Process

The methodology for determining the best candidate areas to represent earth science diversity within the context of an environmental theme is a comparative evaluation which has recently come to be known as "gap analysis". Gap analysis involves the description of earth science diversity in a selected theme, the identification of protection targets, the determination of which targets are already represented in a system of protected areas, and, the resultant "gaps" in representation of the diversity that still require protection. This process of comparative analysis as applied to earth science conservation has been followed in Ontario relatively unchanged since the early 1970s (Davidson 1981, Davidson 1988).

The gap analysis process is normally carried out in two phases: a broad analysis of the possible representational targets of a theme (steps 1-4), and a subsequent detailed inventory of specific features and sites required to complete representation (step 5). These steps are summarized below and in the accompanying flow chart , and described in more detail as follows:

Step 1: Identification of significant elements of a theme (representation targets);
Step 2: Distribution mapping of the significant elements;
Step 3: Determination of existing representation within protected areas;
Step 4: Identification of features not in protected areas (the "gaps");
Step 5: Identification and comparison of selected sites capable of filling the gaps.

Step 1: Identification of significant elements of a theme (representation targets)

For the selected environmental theme, this step identifies the significant elements that make up the theme; that is, the features of the theme which characterize it. This step involves the documentation of the complexity of the theme and the variations that exist in individual features of the theme. The suite of elements so identified constitutes the representation targets of the theme.

For themes identified by the bedrock record, the targets will constitute representation of each bedrock unit within the theme and its significant variations, as well as representation of unit contacts and other important associations. A chronostratigraphy, lithostratigraphy and/or biostratigraphy are assembled from this information for each theme. For themes identified in the landscape record, representation targets will consist generally of examples of landforms and landform associations that describe the environmental conditions during the selected theme. A morphostratigraphy will be prepared for each of these themes. Representational targets for landform process themes will constitute a record of the salient elements that characterize the process, be they ancient or modern. A listing of these elements is prepared for each selected theme.

This step is primarily one of information-gathering. All pertinent literature is reviewed, and discussions are sought with experts in the particular discipline or subdisciplines of geology which make up the theme (e.g., Precambrian Grenville Province bedrock; Quaternary glacial themes; Paleozoic fossil assemblages). The expertise and knowledge of the earth science surveyor/ specialist conducting the gap analysis may also contribute to site identification. In this way, features which are important to the recognition of each theme are identified.

Step 2: Distribution mapping of the significant elements

The second step requires the mapping of all significant elements of the selected theme identified in Step 1. Thus, the distribution and/or general location of all features are documented and plotted. Where complete geological mapping is available, the features of a theme may be identified on the maps. The information gathering process in Step 1 will have identified the significant elements of each theme, and will likely have identified several localities for each element. All potential site locations are plotted and mapped so that their values can be evaluated and compared during the field stage of gap analysis.

The scale and complexity of features that make up each theme is dependent on the state of knowledge of its component geology, and the spatial distribution of the theme elements on the landscape. Some environmental themes consist of only a few known occurrences of features, whereas others encompass a large portion of the province and constitute many features. Similarly, some aspects of the province's geology are well documented, whereas others are little known. These discrepancies in scale and knowledge will affect the number and size of representation targets for each theme.

Step 3: Determination of existing representation within protected areas

The next step in the gap analysis method is the identification of the elements of the theme that already occur in protected areas. At the time of writing, protected areas constitute Provincial Parks, Conservation Reserves, and Areas of Natural and Scientific Interest (ANSIs).

For a theme element or feature to be considered represented, it must be provincially significant, and it must be contained by appropriate protected area class or zoning, or have relative protection outside parks through municipal zoning or landowner agreements.

This step is again an information gathering exercise which involves a review of the available literature, notably earth science inventories of individual parks, and earth science theme studies, regional earth science systems plans and earth science checksheets prepared by OMNR since the early 1970s. The Earth Science Data Base housed with Ontario Parks, Peterborough, contains information on all Provincial Parks and earth science ANSIs in an electronic form.

Field work of a reconnaissance nature may also be required at this stage to confirm the quality and condition of identified features, especially in protected areas for which a detailed report has not been prepared.

Step 4: Identification of features not in protected areas (the "gaps")

The previous step serves to identify the elements or features of a selected theme which are formally protected in Ontario's protected areas system. The remaining elements of the selected environmental theme that are not formally protected constitute the "gaps" in representation that require filling. Sites where these elements are found are determined from the lists prepared during Steps 1 and 2. In some cases, specific localities will have been identified. These need to be field checked for quality and condition. In many cases however, specific sites will not have been identified. The geological mapping or literature searches will have identified general localities where certain features may be found. These areas will form the basis for field work to identify more specifically the location of significant features.

Step 5: Identification and comparison of selected sites capable of filling the gaps

As noted in Step 4, some unrepresented features will have been recognized through … Where more than one site is identified as representing a feature, or if a regional or area study is needed to identify new features, a comparison of like elements from the list produced in Step 4 will be required. The comparison of sites and selection of candidate areas for protection is achieved with the application of a set of six primary selection criteria. These criteria are: representation, type sections and related features (including reference sections, type morphologies, type localities), diversity, integrity (condition), life science values and special features. These are described in more detail in the following section of the report.

Step 5 involves original field work by OMNR staff or consultants to locate and evaluate the candidate sites identified in Step 4. Field work is essential in order that the most up-to-date site conditions (quality, integrity, condition), and aspects of the feature(s) not evident in the literature and/or remote sensing reviews, are recorded. A gross filtering occurs at this stage to remove sites that have a history of disturbance, past or present (primarily applied to glacial, landform and process themes). Disturbance consists of any man-made activity which has altered or removed a feature from its natural state. This criterion does not generally apply to bedrock features, which are commonly best displayed in highly altered sites such as road cuts and quarries, or to some exposures of unconsolidated sediment, which may occur in active or abandoned aggregate pits. The resulting list of the best remaining sites constitutes the set of preferred candidate protected areas for the environmental theme under study. Given that they represent the diversity of the theme in question, the sites so identified are ranked as *provincially significant* within the context of the theme.

In a large province like Ontario, there is also a need to provide for the protection of sites of regional and local significance for the benefit of scientific study and educational opportunities. Such sites also serve as back-ups for the provincially significant sites. As such, in addition to the provincially significant sites, a suite of regionally significant sites should be identified and protected. It is not the intent of the gap analysis process to bring forward regionally significant sites for formal protection. Regionally significant sites should be dealt with through other protection mechanisms (such as ANSIs, Areas of Concern, etc.) to ensure their future availability for research, educational and interpretive purposes.

3.4 Selection Criteria

The following site selection criteria are used in the identification and ranking of earth science features. Due to the nature of very different types of earth science features, the application of the criteria vary on a feature, and occasionally per-site, basis. Different approaches are applied to the representation and protection of bedrock sites, landforms, and landform-process themes (where these are modern processes active on the earth's surface today). The differences in approach are discussed in the following section.

1) Representation

The primary criterion for choosing earth science features is representation. A representative feature is one that best displays its components, or make-up, and its environment(s) of formation. A representative feature of the geological record can generally be thought of as one that is typical, or normal, or one that shows "classical" elements of the feature.

In the context of features exposed in bedrock outcrop, representation refers to the best available (or known) examples of each type of lithological unit (rock type) that occurs for a given theme element, as well as examples of each geological time unit as exhibited in the rock record (lithostratigraphy) for that theme element. In order to achieve this chronostratigraphic (time related) representation, the best example of some units may be less-than-ideal because the only known examples may be small, of poor quality, or have been adversely disturbed. In these cases, representation may still be sought in order to satisfy representation of the geologic time unit in the physical record. The best representative examples of the fossil record (in Ontario, Precambrian microfossils and Paleozoic macrofossils) as displayed in the rock record, and the best representative examples of past (ancient) landform-process themes as displayed in the rock record, are also sought for protection. Many of these will overlap with lithological and chronostratigraphic representation at the same site, imparting extra significance to those sites, and reducing the total number of sites identified.

In the landscape perspective, representation is also applied to both the physical form of a selected feature, and the morphostratigraphy (ordering of landform features through time) of a theme. Representation of the physical form of a feature should best display an "ideal" morphology and/or the best example(s) of deviations from the "ideal" form. Morphostratigraphy refers to representation of like features as they relate to events and time through the geologic record (e.g., an ice retreat phase of a glacial theme will produce similar landforms and related features at several stages in its history; elements of all of these may be targets for representation). Representation of the internal components of landforms and landform process themes will be sought in outcrops of unconsolidated sediment. Identification of these will follow the same process as for bedrock outcrops, discussed in the previous paragraph.

Representation also refers to the range of features that identifies a geologic event or process, both active today and in the rock and landform record through time. It seeks to identify the best example of each element of the 8 landform/ process themes that are considered essential to their definition. A combination of all types of geological features, from bedrock outcrops to large-scale landform associations, will be required for complete representation.

2) Type Sections and related features

Type sections provide standard definitions for all representative lithostratigraphic and biostratigraphic rock units. Type sections represent the sites where rock units were first identified, described and formally named. They are the localities against which all other occurrences of the unit are generally compared. Type sections are generally of the highest scientific value, and may also have historical value as locations where the geology of a region was first described and ranked. In Ontario, type sections are generally only applied to stratified rocks. These constitute volcanic and sedimentary rock sequences of Late Precambrian (Keweenawan) age and sedimentary sequences of Paleozoic age (concentrated in southern Ontario and the Hudson Bay/ James Bay Lowland), although some older Precambrian units have also been formalized in this way.

Related features such as reference sections and type localities represent units for which a type section has yet to be defined. This situation is common in central Ontario, where type sections have not been formalized for most of the Paleozoic stratigraphy of Manitoulin Island (most correlative units have type sections described on the Ontario mainland), or for the sedimentary units of the Precambrian Huronian Supergroup. Reference sections may also serve to supplement the type section by representing some variation or additional feature(s) of the original site. Reference sections often represent a regionally accessible site or variation of the original type section, an important factor where the unit has a widespread distribution.

The primary elements of the surficial geology of a region are defined by the distribution and association of related landforms and their stratigraphic makeup (morphostratigraphy), and by the type of individual landforms, the best example of each being referred to as a type morphology (or morphotype). In Ontario, the morphostratigraphy of glacial deposits and landforms, and the type morphologies related to these, have not been used in either a formal or consistent manner. Regional morphostratigraphies have been prepared by OMNR staff since 1972 in order to address this lack of formal structuring of the glacial geology of the province, and have been used to identify protection targets. The assignation of formal type morphologies within this morphostratigraphy has not been attempted to date.

3) Diversity

Diversity addresses the variability of form or features within a candidate site that describes a theme element. A site that incorporates more than one element or feature of the identified geologic unit (i.e., an outcrop of a bedrock formation that exhibits its range of lithologies and its contact relations with adjacent units), or, incorporates an association of features (such as a glacial landscape of drumlins, eskers and meltwater channels), usually occurs in an area more compact than several separate areas. Such associations, offering a diversity of features in a single site, are more efficient, have a higher ecological value, and may generally be ranked more favourably than a collection of individual sites in separated areas.

Very large landform features also require this approach when possible. Their size generally prohibits representation of a complete feature or association of features. This applies to features with extensive linear elements and those with broad areal extent. Examples of linear geological features include bedrock faults and shear zones, glacial features such as meltwater channels, end moraines, eskers and raised shorelines, and geomorphological elements such as bedrock escarpments and riverine environments. Features with a broad areal extent include bedrock domes, glacial features such as ancient lake plains, dune fields, and outwash plains, and topographic forms such as ancient meteorite impact craters.

The approach taken to representation of these large landform features focuses on the identification of the major elements which make up the feature, and seeking representation of the best examples of each of these elements. For example, the Cartier Moraine belt across the north shore of Lake Huron consists of a series of mounds and ridges of ice-contact sediment, anchored to bedrock knolls, which are associated with shoreline elements of glacial Lake Algonquin, such as now-abandoned (raised) beach terraces on perched deltas. Representation of this complex of features focuses on the identification of the best examples of each of these elements: an irregular mound element of ice-contact debris; a ridge element of ice-contact debris, preferably intact (i.e., identified by topography along natural boundaries); the bedrock component integral to the story of formation of the moraine; and, a perched delta with its associated beach elements. Where several elements occur together, and their form adequately display the mode of formation of the features and their link to the ice stand position marked by the moraine, an area boundary encompassing this association of elements is desirable. Such feature associations are preferred particularly because they exhibit the inter-relationships within a diverse morphology, and because they occur together, facilitating protection more easily than would a suite of separate sites.

4) Integrity (Condition)

Integrity refers to the wholeness or completeness, or condition, of a geological feature, and the lack of significant external impacts or alteration by natural or man-induced activities on this wholeness. This applies particularly to landforms, where morphological completeness is a requirement for their adequate definition. Examples of landforms for which complete morphological representation is desirable are usually relatively small and discrete (e.g., drumlins, perched deltas, aeolian dunes, landslides and their ancient scars, etc.). The best examples of these may be considered informal type morphologies.

Site integrity is not as important a factor in the representation of bedrock sites. Adequate representation of a particular lithological (bedrock) unit requires a clear face or surface which exhibits all the elements used to define the unit. These may occur in a natural setting, such as on bare bedrock surfaces (the Georgian Bay Fringe area and north shore of Lake Huron are outstanding examples of this) or in cliff face exposures (the Niagara Escarpment is the best example of this). Here, site integrity may be excellent due to the extent of exposure (horizontally and/or vertically), and constitutes an aesthetic component due to the natural setting.

In most cases, however, the best examples of representative bedrock units occur in man-made exposures such as highway or road cuts, and pits and quarries, where aesthetic qualities may be very low, but representational values are high because of the freshness and quality of exposure. Such man-made exposures are often th eonly available representation of the internal components of the bedrock of a region. They may provide a three-dimensional view not available anywhere else. In such cases, natural site integrity is not a consideration for representational rank. Protection of such sites will focus on ensuring that the selected outcrop is not permanently covered up or removed. Site integrity may, in some cases, be enhanced by one-time or occasional re-exposure, or "freshening", of exposures. This is particularly true of natural riverbank exposures and in man-made aggregate operations and quarries that support outstanding exposures of unconsolidated sediments.

5) Life Science Values

When comparing sites where earth science values are similar, overlapping life science values may be used to choose a site. This approach is generally only relevant to landscape sites (landforms, landform associations and/or process features) which are large enough to support significant vegetation stands or communities. Small sites (outcrop or some landform-scale features) generally do not constitute a large enough area to contribute to protection of most life science values. Smaller geological features can however, form a component of a larger life science site, and would constitute a preferable site choice given equal values elsewhere. The evaluation of overlapping life science values depends on the level of existing life science information or the availability of life science input to site selection.

The life science classification system used in the gap analysis process has a strong landform-based component in its Site District target identification. Protection of the diversity of landform/ vegetation units (LV units) in a Site District ensures that identification of a broad range of landforms is targeted for protection. However, the landforms identified by the life science process may not (and often do not) represent the best examples of those landforms to contribute to representation of earth science targets. Where possible, comparison with selected life science candidate protected areas is always attempted before final determination of candidate earth science areas.

6) Special Features

Where two or more sites have similar earth science values, the presence of special features may determine the selection of a preferred site. Special features may be geological, such as unusual or unique elements of a theme not represented elsewhere, or regionally important sites used for education and/or interpretation. Special features may also constitute less scientific values such as the quality of a feature's setting or the aesthetic values of a site. The geology of an area may contribute significantly to the character of that area’s landscape.

Where known occurrences of a particular unit are already included in the system of protected areas, the selection of discrete bedrock and unconsolidated sediment sites (e.g., road-side outcrops, quarries, aggregate pits, etc.) popular with the geoscience community (i.e., documented in field trip guidebooks), *in addition to the sites identified in protected areas*, may be of importance because they are accessible, known to geologists, and serve to protect significant occurrences for further research and educational values. This duplication has many values, the most notable of which is that units may be observed, studied, and interpreted at some distance from the provincially significant occurrences, thereby allowing interested parties in regional settings access to good sites. Another important value of regional site duplication is in their role as backups or alternatives to the primary sites, should the primary sites be adversely disturbed or lost.

Geology, and particularly geomorphology, often determines the impact of the landscape it creates on the culture that inhabits it. A particular landscape or landform association may be integral to that culture, be it local, regional or national. Any dramatic change in its integrity might have detrimental effects on the overall culture. Where the scientific values are equal, the choice between two or more sites may thus be determined by the cultural or aesthetic values of a particular natural setting. For example, the geology influences the setting and landscape of many areas of Ontario, and influence how these areas are perceived by the population, both residents and non-residents of those areas, beyond the required representation of individual units. Outstanding examples include, but are not restricted to, the low rocklands and lakes of Muskoka, the white quartzite hills and ridges of the LaCloche Range near Killarney, the mesa and cuesta topography of the Nor’Westers around Thunder Bay and Lake Nipigon, the quartzite canyons in the Raven Lake area near Elliott Lake, and the incised valleys of the Pinad Moraine in northeastern Ontario. Representation of such “landscapes” is integral to the earth science protection strategies of many countries world-wide. The maintenance of these landscape values in Ontario may also be considered in earth science gap analysis where appropriate.

3.5 Comparisons with Life Science Representation

There continues to be confusion about the relationship and differentiation between earth science representation targets and life science representation targets. How does earth science representation compare to life science representation?

Earth science classification systems, based on physical features and, importantly, on time, cannot generally be correlated with the life science classification system, which is based on macroclimate, landforms, microclimate, moisture regime, and substrate (Angus Hills' division of the province into Site Regions and Site Districts, with classification of site conditions within each Site District; see Hills 1959, Burger 1993, Jalava *et al.* 1997). Although there may be some correlation between the two disciplines based on landform and substrate, earth science classification is not related at all to present patterns of climate and moisture.

For example, Precambrian Grenville Province rock types and environments occur geologically to a specific area of exposure, in south-central Ontario. The diversity of features which reflect the history of evolution of the Grenville Province can only be found within this specific area of exposure. The geological diversity within the area of exposure of the Grenville Province, and its significance, is not affected by the vegetation patterns which occur on its surface, nor by the classification schemes devised to arrange that vegetation diversity. Therefore, the distribution of significant earth science sites required to represent the Grenville Province geological theme cannot be related to a Site District and is therefore not affected by life science values. However, the type and aspect of the bedrock substrate may have a significant influence on the composition of the vegetation communities and species that grow on that substrate. Obvious examples are the different effects of carbonate versus granitic substrates on the vegetation communities growing on them.

Although earth science and life science classification schemes are not compatible, there is an inter-connectedness between the two disciplines at the landform/substrate level. The diversity of earth science features at the Site District level will determine the diversity of life science representation targets for vegetation communities and species. Earth science diversity in a Site District presents the biological environment with a range of temperature, exposure, aspect, moisture regime, substrate types and habitat on which vegetation types and communities develop and evolve. The land base of an area determines the diversity of the life forms that occupy and characterize that area.

As stated in the previous section, where all other factors are equal, it is a goal of OMNR's gap analysis process, where possible, to combine earth science and life science values into a set of related protected areas. Thus a suite of sites so selected will help to conserve both regional biodiversity and abiotic features.

A comparison of the gap analysis process and the site selection criteria for earth science representation and life science representation shows that these are very similar in approach. The cornerstones of both approaches are the achievement of a suite of sites that are representative, in excellent condition, and reflect the diversity of the features and history identified by the individual disciplines.

3.5 Assumptions

The data sets used in the earth science gap analysis process come in many forms and scales. None exists satisfactorily in any one place or as one unified entity. Primary sources include maps of bedrock and surficial geology, published in a wide variety of scale, detail and coverage, by the Ontario Geological Survey (OGS; Ontario Ministry of Northern Development and Mines) and the Geological Survey of Canada (GSC). Interpretations of the geological history of the province are extracted from a vast base of academic and professional literature sources, as well as discussions with experts in all fields of geology. Interpretations often differ due to the fluid nature of the science, as data becomes available and is disseminated to the field. Given this range of inputs, it is assumed that the present level of knowledge of the geological conditions in the province is the most up-to-date and complete, despite obvious weaknesses in that knowledge. The Geology of Ontario (Ontario Geological Survey 1991, 1992) summarizes the most up-to-date geological picture of the province, and provides the framework on which the interpretations used in gap analysis are based. Detailed information about the geology of much of the province is limited. Because the search for knowledge has been largely driven by past and present interest in the economic potential of an area's mineral or aggregate resources, there remain large areas of the province in which detailed data collection and interpretation has not been attempted or completed.

The geological definition and interpretations of significant sites only reflect the current state of knowledge and/or follow current understanding and theories of concepts in the particular field of geology under consideration. Theories and ideas, and their associated evidence in the field (on the ground) that may be important today, may become less important or redundant in future with the advent of new field work or other studies. Advancement of new theories and concepts will involve new sites of importance in providing proof. Thus where previously important sites become less so, new sites may be introduced to define the new science. What is important in the gap analysis planning process is the opportunity to identify and protect a near-complete system of representative and significant features reflecting the present state of the science, and the flexibility to incorporate changes and advances in the science.

In the case of landforms and landform process themes, an underlying assumption is that the least disturbed a site or feature is, the better its representational value. Where undisturbed features are not available, a site with some disturbance may be preferable to no representation at all. Other jurisdictions world-wide, including ANSIs in Ontario, assume some disturbance is acceptable if that disturbance has not adversely altered the conditions of the feature(s) for which identification was first proposed.

Field investigation of the attributes of the feature(s) of a site is almost always required prior to the determination of significance. For instance, bedrock sites are small enough that no matter how well documented, exact locations and present condition need to be established *in situ* in order to properly verify and protect a site. Although remote sensing techniques can determine the best likely locations for landform and process theme sites, present-day quality and condition of the identified features must be verified and established in the field prior to the determination of representation and/or significance.

3.6 Limitations

As already mentioned, geological mapping coverage and scales vary greatly across the province. Therefore, a lot is known about the geology of selected regions and/or geological environments, and hence selected environmental themes, and less is known about others. The effect this has on representation targets is that the environmental themes with a good base of knowledge may have a great number of representational targets, whereas those environmental themes about which relatively little is known will have fewer representational targets. As the knowledge base in these under-represented themes improves, with new, more detailed mapping of a region, new representational targets will present themselves, and the number of candidate sites may increase.

The data set of information related to the bedrock geology of the province is limited to sites that are known from the published literature, and those known to the geoscience and academic community. The specific attributes and values of bedrock sites are too difficult to identify through remote sensing methods (bedrock sites are generally too discrete), with the result that the geology of an area cannot easily be interpreted and compered with such regional techniques. Landforms and some process themes on the other hand can generally be identified quite easily through remote sensing techniques (through geological and topographical maps, airphotos, etc.). This limits the bedrock site representation to what we know, whereas landform and some process themes can be identified through original field work on a very regional level (i.e., it can therefore be done relatively quickly).

Another limitation of the gap analysis process is that much geological data, especially more detailed information, is not readily available in digital format, although coverage is improving rapidly. This limits the ready comparison of site evaluations on a regional scale through electronic means, and still requires a high degree of manual inputs.

4.0 ACKNOWLEGEMENTS

The life science gap analysis method has evolved from manual approaches used since before 1980, to the electronic iterative process described in this document. Many people have been involved in these processes and its evolution. Specific to the present document, several people have provided comments on earlier drafts of this paper. In particular, Jarmo Jalava, Stewardship Biologist, Natural Heritage Information Centre, Peterborough, provided stimulating discussion and editorial comments at several stages in the writing of this document.

The earth science gap analysis process has been in use, relatively unchanged, since the early 1970s. The concepts and procedures presented in this document reflect the input and refinement of this process by many field staff during that time. Specific to this document, R.J. (Bob) Davidson, Senior Conservation Geologist, and G.S. (George) Cordiner, Conservation Geologist, both of MNR Ontario Parks, Peterborough, provided timely discussion and review.

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Appendix I:

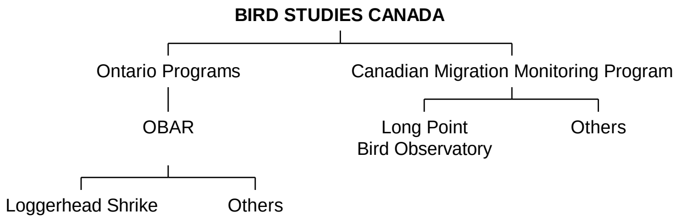
List of broad age classes for working groups likely to be encountered in FRI data.

White Pine	Pw	0-40 (1959-)	41-120 (1879-1958)	121+ (pre-1879)
Red Pine	Pr	as Pw		
Tamarack	L	as Pw		
Black Ash or Ash	Ab or A	as Pw		
Sugar Maple	Mh	as Pw		
Yellow Birch	By	as Pw		
Red Oak	Or	as Pw		
Red/Silver Maple	Ms	as Pw		
Beech	Be	as Pw		
Basswood	Bd	as Pw		
Other hardwoods	OH or H	as Pw		
Jack Pine	Pj	0-30 (1969-)	31-70 (1929-1968)	71+ (pre-1929)
Balsam Fir	B or Bf	as Pj		
Poplar/aspen	Po	as Pj		
White Birch	Bw	as Pj		
Spruces	S, Sb, Sw	0-30 (1969-)	31-100 (1899-1968)	101+ (pre-1899)
Cedar	Ce	0-40 (1959-)	41-110 (1899-1958)	111+ (pre-1889)
Hemlock	He	0-40 (1959-)	41-140 (1859-1958)	141+ (pre-1859)

APPENDIX F

Agencies and Organizations, Their Major Activities and Information Available[1]

This appendix provides a list of key agencies and/or organizations and information that may be useful for the identification of significant wildlife habitat. The websites and phone numbers were current as of October 1999, and however, are subject to change.

AGENCY/ORGANIZATION	ACTIVITY/INFORMATION
Agriculture and Agri-Food Canada http://www.agr.ca/	*Best Management Practices* series of publications : e.g. *Fish and Wildlife Habitat Management, Water Management, A First Look - Practical Solutions for Soil and Water Problems* • also offers a wide range of identification services (e.g. plants, invertebrates) • has a butterfly expert on staff
Bird Studies Canada – Ontario http://www.bsc-eoc.org/ontario.html also see information on **Long Point Bird Observatory**  	Administers a variety of bird monitoring programs. • Ontario Birds at Risk (OBAR) a program started in 1994 to build upon work which began with the *Atlas of the Breeding Birds of Ontario* (1981-1985) and the *Ontario Rare Breeding Bird Program* (1989-1993). The goal of OBAR is to work towards the protection and recovery of vulnerable, threatened and endangered (VTE) and other bird species at risk in Ontario. Target list is derived from COSEWIC, COSSARO lists and recommendations from the OBAR Advisory Committee. • seasonal summaries of bird sightings • Ontario heronry inventory • woodlands fragmentation studies • nocturnal owls survey • survey information about loggerhead shrike, red-shoulder hawks, woodpeckers, barn owls and prothonotary warbler • Great Lakes marsh monitoring program (includes amphibian, marsh bird monitoring)
Canadian Museum of Nature http://www.nature.ca/ P.O. Box 3443, Station D Ottawa, Ontario K1P 6P4	• the library of the Canadian Museum of Nature contains over 42,000 books and 100,000 volumes of periodicals on a wide variety of topics in the fields of biology, biodiversity, botany, ecology, mineral sciences, natural history, paleobiology and wildlife • provides taxonomic identification services • publications (for sale) such as checklists of mosses, vascular plants, lichens of Ontario

[1] The web site addresses in this list were last checked for accuracy on September 21, 2000.

AGENCY/ORGANIZATION	ACTIVITY/INFORMATION
Canadian Wildlife Federation http://www.cwf-fcf.org/ 2740 Queensview Drive Ottawa, Ontario K2B 1A2 Phone: (613) 721-2286 or 1-800-563-WILD	• directory of CWS wildlife surveys • Remedial Action Plans
Canadian Wildlife Service Environment Canada 351 St. Joseph Boulevard Hull, Quebec K1A 0H3 Tel.: (819) 997-1095 Fax: (819) 997-2756 http://www.cws-scf.ec.gc.ca/cwshom_e.html also see **Environment Canada** http://www.ec.gc.ca/ http://www.cws-scf.ec.gc.ca/sara/main.htm Http://www.cws-scf.ec.gc.ca/hww-fap/eng_ind.html	handles wildlife matters that are the responsibility of the federal government • includes protection and management of Migratory Birds (*Migratory Birds Convention Act*), nationally significant habitat and endangered species (Canada *Endangered Species Protection Act*), other wildlife issues of national and international importance; conducts research in many fields of wildlife biology; also conducts research on the socio-economic importance of wildlife • endangered species fact sheets • Wild Animal and Plant Protection and Regulation of International and Inter-provincial Trade Legislation • information on Canada's law to control trade in wild animals and plants • current Migratory Birds Hunting Regulations • environmental assessment guidelines (*Canadian Environmental Assessment Act*) • publications e.g. – Hinterlands Who's Who series; endangered species fact sheets • information on Ramsar Sites and Biosphere Reserves
Conservation Authorities for addresses, phone numbers and web site locations of local offices see: http://www.geocities.com/Yosemite/Trails/1551/conserv.htm or write : Conservation Ontario Box 11, 120 Bayview Parkway Newmarket, ON L3Y 4W3 (905) 895-0716 E-mail - conserve@idirect.com	• watershed plans • floodplain mapping and fill regulations • some inventory or other pertinent information about Conservation Authority-owned lands • natural heritage inventories • information on woodlands, wildlife habitat, wildlife movement corridors, fish habitat, environmentally sensitive areas, wetlands, valleylands, shorelines • GIS formatted natural heritage databases • watershed plans and inventories • floodplain and hazard land mapping

AGENCY/ORGANIZATION	ACTIVITY/INFORMATION
(The) **Conservation Council of Ontario** 43 Sorauren Ave Toronto, Ontario M6R 2C8 phone: (416) 410-6637 http://greenontario.com/cco.htm http://www.greenontario.com/	The Conservation Council of Ontario (CCO) is an association of twenty-five provincial organizations and fifty individual members who work to promote effective action on environmental issues. Our member organizations include environmental, naturalist, and professional associations and our Individual Members reflect a broad range of interests and expertise. • a directory of governments, organizations and major businesses in Ontario
COSEWIC – Committee on the Status of Endangered Wildlife to order copies of status reports write to: Mrs. Sylvia Normand COSEWIC Secretariat c/o Canadian Wildlife Service Environment Canada Ottawa, Ontario K1A 0H3 Tel: (819) 997-4991, (819) 994-2407 Fax: (819) 994-3684 Http://www.cosewic.gc.ca/COSEWIC/Default.cfm http://www.mcgill.ca/Redpath/cosehome.htm http://magi.com/~ehaber/ http://infoweb.magi.com/~ehaber/b_intro.html	COSEWIC determines the national status of wild Canadian species, subspecies and separate populations suspected of being at risk. Decisions are based on the best up-to-date scientific information available. All native mammals, birds, reptiles, amphibians fish, molluscs, butterflies and moths, vascular plants, mosses and lichens are included in its current mandate. • updated lists of extirpated, endangered, threatened and vulnerable species • guidelines for the preparation of status reports • subcommittee for reptiles and amphibians • subcommittee for vascular plants, mosses and lichens • subcommittee for birds
***COSSARO* - Committee on the Status of Species at Risk in Ontario** co-ordinated by Ontario Ministry of Natural Resources	• assigns status and maintains updated lists of extirpated, endangered, threatened and vulnerable species for Ontario • recovery planning and plan implementation
Ducks Unlimited Canada (Ontario) local offices located in Barrie, Timmins, Kingston, Thunder Bay http://vm.ducks.ca/prov/DUCONT.HTM Ducks Unlimited (Canada) The Oak Hammock Marsh Conservation Centre Box 1160 Stonewall, Manitoba R0C 2Z0 Phone (204)467-3000 OR 1-800-665-DUCK.	• advice on wetland management administers *Ontario LandCare* **-** financial incentives and technical assistance help farmers conserve their soil and water resources while improving the environment for wildlife and for people • biological and behavioural information about waterfowl • brood surveys

AGENCY/ORGANIZATION	ACTIVITY/INFORMATION
Eastern Ontario Model Forest http://www.eomf.on.ca/ Postal Bag 2111 Kemptville, Ontario K0G 1J0 Tel: 613.258.8241	• mapping and information services for landowners, governing bodies and organizations • thematic maps, aerial photographs, spatial analysis, topographic maps any size or scale in eastern Ontario • publications
Federation of Ontario Naturalists 355 Lesmill Road http://www.ontarionature.org/ Don Mills,Ontario M3B 2W8 Phone: (416) 444-8419	• a membership-based non-profit, non-government organization dedicated to protecting and conserving Ontario's natural heritage. • conducts scientific research, initiates nature protection programs and contributes to public policy relating to land use issues • information on invasive species, backyard habitats, Great Lakes Wetlands publications • educational resources
Field Botanists of Ontario Bill McIlveen (membership) RR 1, Acton, Ontario N1H 4A6 Ed Morris (newsletter) RR 3, Sudbury, Ontario P3E 4N1	• field trips, workshops intended to provide members and non-members with opportunities to learn Ontario's flora and natural areas • newsletter
Landowner Resource Centre http://www.lrconline.com/ P.O. Box 599 5524 Dickinson Street Manotick, Ontario K4M 1A5 Phone: (613) 692-2390	• information on forestry, agriculture, wildlife, water, soil and any land management issues • environmental facts sheets, publications • workshops
Long Point Bird Observatory http://www.bsc-eoc.org/Lpbo.html	A research and monitoring station operated by Bird Studies Canada • research directed at the conservation of wild birds and their habitats. Programs at Long Point are focused on local breeding and migratory birds. • publishes results of studies of wild birds and their habitats
Natural Heritage Information Centre (NHIC) Ministry of Natural Resources 300 Water Street, 2nd Floor, North Tower Peterborough, Ontario K9J 8M5 Phone: (705) 755-2159 Fax: (705) 755-2168 http://www.mnr.gov.on.ca/MNR/nhic/nhic.html	Compiles, maintains and provides information on rare, threatened and endangered species and spaces in Ontario. This information is stored in a central repository containing a computerized database, map files and an information library, which are accessible for conservation applications, land use planning, park management, etc. • lists of Ontario species • vegetation communities and ecological land classification

AGENCY/ORGANIZATION	ACTIVITY/INFORMATION
Natural Resources Canada **Canadian Centre for Remote Sensing** http://www.ccrs.nrcan.gc.ca **Canada Land Inventory (CLI)** http://geogratis.cgdi.gc.ca/CLI/frames.html	• responsible for the acquisition of earth observation data and for the development of remote sensing applications and related methodologies and systems • CLI is a comprehensive, multi-disciplinary land inventory of rural Canada, covering over 2.5 million square kilometres of land and water. Land capability for agriculture, forestry, recreation and wildlife (ungulates and waterfowl) is mapped. Over 1000 map sheets at the 1:250,000 scale are available on this site for on-line map making and download of desktop publishing, or GIS formats
Ontario Environmental Network http://www.web.net/~oen/ 27 Douglas Street Guelph, Ontario N1H 2S7 (519) 837-2565	• provides a central referral service for anyone seeking environmental information, organizes workshops and conferences, publishes resource materials and facilitates issue specific caucuses. • also maintains a database of Ontario environmental groups and a delegate database for public consultations • web site provides background information about the Environmental Bill of Rights (EBR) and the electronic Environmental Registry
Ontario Federation of Anglers and Hunters http://ofah.org/ P.O. Box 2800 Peterborough, Ontario, K9J 8L5 Phone: (705) 748-6324	• invading species resource library • Invading Species Hotline at 1-800-563-7711 • conservation news updates
Ontario Field Ornithologists http://www.interlog.com/~ofo/ Box 455, Station R Toronto, Ontario M4G 4E1	• an organization dedicated to the study of bird life in Ontario • current field checklist of Ontario birds "Ontario Birds" includes notes and articles concerning the status, distribution, identification and behaviour of Ontario's birds, as well as site guides, book reviews, letters and the Annual Report of the Ontario Bird Records Committee (OBRC)
Ontario Fur Managers Federation 531 Second Line East Sault Ste. Marie, Ontario P6B 4K2 Phone: (705) 254-3338 Fax: (705) 254-3297	• promotes conservation, sustainability of fur bearers and ecosystem • promotes, participates in public education and awareness • fur bearer information

AGENCY/ORGANIZATION	ACTIVITY/INFORMATION
Ontario Ministry of Agriculture and Rural Affairs http://www.gov.on.ca/OMAFRA/english/ http://www.gov.on.ca/OMAFRA/english/products/soils.html	• products and services catalogue • soil survey reports and agricultural capability maps
Ontario Ministry of Natural Resources (also see NHIC) http://www.mnr.gov.on.ca/MNR/index.html Main Office – Peterborough 300 Water Street P.O. Box 7000 Peterborough, Ontario K9J 8M5 Natural Resources Information Centre Toronto: General Inquiry (416) 314-2000 French Inquiry (416) 314-1665 Peterborough: General Inquiry (705) 755-2000	• land use planning and land information • fish and wildlife information • forest information, Forest Resource Inventory (FRI) maps , Forest Management Plans for Crown Lands • maintains provincially and non-provincially significant wetland evaluations • Areas of Natural and Scientific Interest Site District reports • Ontario's parks information • e.g. *Fish and Wildlife Conservation Act* and other related legislation • extinct, extirpated, vulnerable, threatened and endangered species lists for Ontario • regional checklists of Ontario's species at risk • wildlife management guidelines • aerial photographs (1:10,000 and some 1:15,840) • Growth and Yield and Ecological Land Classification information • maintains Natural Values Information System
Ontario Ministry of Northern Development and Mines http://www.gov.on.ca/MNDM/ndmhpge.htm Willet Green Miller Centre 933 Ramsey Lake Road, Level A3 Sudbury, Ontario P3E 6B5 Phone: 1-888-415-9845 (toll-free) Phone: (705) 670-5691 (local calls) Fax: (705) 670-5770	• locations of abandoned mines that might provide potentially significant bat hibernacula • National Topographic System (NTS) of digital base maps, at a 1:250,000 scale • bedrock geology of Ontario data; mining claim maps by township/area • local claim maps are available for viewing at all Mining Lands Consultant's offices as well as at the District Geologist's offices in Kenora and Sioux Lookout • Regional Resident Geologist's and District Geologist's offices provide advice and information on local geology, mineral exploration opportunities and activities, and public access to geological data, including industry assessment files, mineral deposits information and diamond drill core • publication sales, Mines Library, access to assessment files, geoscience information, public education at the Willet Green Miller Centre in Sudbury

AGENCY/ORGANIZATION	ACTIVITY/INFORMATION
Ontario Soil and Crop Improvement Association 1 Stone Road West Guelph, Ontario N1G 4Y2 Phone: 519-826-4214 http://www.ontariosoilcrop.org/	Promotes the responsible economic management of soil, water and crops. • keeps farmers up-to-date on conservation and production issues, including information on government programs and initiatives • develops and delivers educational packages, demonstration projects, environmental improvement programs, and investigative surveys
Parks Canada http://parkscanada.pch.gc.ca/parks/main_e.htm National Office 25 Eddy Street Hull, Quebec K1A 0M5	Offers information pertaining to National Parks • ecological inventories (wildlife and plant species lists), research and studies, information on changes in species occurrence, GIS database
Recovery of Nationally Endangered Wildlife (RENEW) (see COSEWIC)	• co-ordinates preparation, distribution of recovery plans for species designated by COSEWIC as nationally threatened or endangered
Royal Ontario Museum http://www.rom.on.ca 100 Queen's Park Toronto, Ontario M5S 2C6 http://www.rom.on.ca/ontario/index.html http://www.rom.on.ca/ontario/risk.html http://www.rom.on.ca/ontario/fieldguides.html	Canada's largest museum features galleries in Art, Archaeology, Science • index of available information • regional lists and species profiles of the plant and animal species at risk in Ontario (provided by COSSARO) • lists of common mammals, birds, reptiles, amphibians and fish in Ontario by county
Soil and Water Conservation Society http://www.swcs.org/ 7515 NE Ankeny Road Ankeny, Iowa 50021 Phone (515) 289-2331 Fax (515) 289-1227	An international organization comprised of more than 10,000 professionals and students involved in conservation. • publishes *The Journal of Soil and Water Conservation*, a scientific journal; *Conservation Voices: Listening to the Land*, a magazine with articles about relationships between rural and urban dwellers, erosion control, wetlands restoration, and community-supported watershed projects; and *Conservogram*, a newsletter.
Universities	• plant and animal collections (with locations and dates) • plant and animal reports and studies • access to researchers with expertise in a variety of fields

AGENCY/ORGANIZATION	ACTIVITY/INFORMATION
University of Guelph Arboretum http://www.uoguelph.ca/~arboretu/ University of Guelph Arboretum Guelph, Ontario N1G 2W1 Phone: (519) 824 4120 ext 2113 Fax: (519) 763 9598	• coordinator of Ontario Tree Atlas • conducts research • access to researchers
Wildlife Habitat Canada 7 Hinton Avenue N., STE 200, Ottawa, ON K1Y 4P1 Phone: (613) 722-2090 http://www.wetlandfund.com/english.htm	• publications • Wetland Habitat Fund - provides private landowners with financial assistance for projects that improve the ecological integrity of wetland habitats
World Wildlife Fund (Canada) http://www.wwfcanada.org/ 245 Eglinton Avenue East Suite 410 Toronto, Ontario (416) 489-3611 M4P 3J1 Phone: 1-800-26-PANDA (toll free) Phone: (416) 489-8800 (Toronto area) Fax: (416) 489-3611	• maintains lists for Canadian wildlife at risk by province • fact sheets on species and conservation issues • publications