

Big Picture Applications of Bioregional Planning in Ontario

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Abstract

The purposes of the “Big Picture” and “The Bigger Picture 2001/2002” projects are to assemble and interpret the best available, digitally mapped data on the biological diversity of southern Ontario, and to generate replicable, rule-based mapping of a landscape-scale natural heritage system for southern Ontario. Multiple spatial data layers are analyzed using ArcInfoGIS software in order to identify a potential natural heritage area network consisting of buffered core protected areas and corridors that would increase landscape functionality, ensure ecological integrity, and help to focus biodiversity conservation activity within the region. Cores and corridors are buffered to capture high quality habitat in adjacent areas and to identify areas with potential restoration value. Key assumptions are: 1) where possible, more than 30% of the non-urban area of each ecological district in the study area be identified as part of the natural heritage system; 2) area selection should prefer intact natural areas with larger interior habitats, natural habitats adjacent to Great Lakes coasts, and regions with high percentages of natural cover; 3) areas should include viable occurrences of globally rare species and vegetation community types, and concentrations of same; 4) minimum core size should exceed 200ha (500ha on Canadian Shield, with smaller high-quality areas in ecoregion 7E); 5) minimum corridor widths should be at least 200m and include any adjacent areas of natural cover. Corridors and other areas with the potential for restoration or rehabilitation are selected by creating a “resistance” layer identifying optimal (i.e. least-resistance) pathways between natural areas. Resistance values are based on combined weightings of compatible and incompatible land uses. As a result, all of the mapped system is currently in natural cover with the exception of some 200m-wide corridors, which represent restoration challenges that could also be met through alternative design. The resulting mapped natural heritage network should increase public awareness and inspire land-use planners to work more cooperatively in developing a regionally integrated natural heritage system.

Background

The need for conservation efforts to expand beyond protecting small, fragmented “islands of green” has been expressed for many years (Ehrlich and Ehrlich, 1981;

Noss, 1993). Habitat fragmentation at a variety of spatial scales has been widely acknowledged as a primary cause of the global decline of biological diversity (Wilson, 1988, 1992). Habitat fragmentation generally leads to smaller and more isolated wildlife populations. Smaller populations are less viable and hence more vulnerable to local extirpation due to stochastic events (Shaffer, 1981; Gilpin and Soule, 1986), and are typically more susceptible to the negative effects of inbreeding depression and poor demographic makeup (Lande, 1988). To reverse the trend toward isolation, conservation biologists (e.g. Noss, 1983, 1987; Noss and Harris 1986) have recommended maintaining or even increasing landscape "connectivity" as a means of preserving habitat for the movement of species between remaining habitat fragments. A system of core natural areas functionally united by a network of habitat corridors would result in a whole that is greater than the sum of its parts (Noss and Cooperrider, 1994). Species unable to maintain viable populations in isolated habitats may be able to do so in a connected landscape.

Parks and protected areas, particularly those that are small and/or isolated, are often not sufficient to protect viable populations of species and biological diversity as a whole (Noss & Harris, 1986; Harris *et al.* 1996a, 1996b). Reserve networks are now considered by many to be an effective means of conserving biological diversity and ensuring ecological integrity in the face of rapid human population growth and habitat fragmentation (Harris, 1984; Noss & Harris, 1986; Noss, 1987; Harris and Gallagher, 1989; Harris and Atkins, 1991). More recent advances in conservation biology and landscape ecology have led to the emergence of reserve design concepts and principles to address both site specific and regional conservation issues (Poiani *et al.* 2000).

Conservation Reserve Networks

When designing reserves, we are trying to conserve as much of the natural landscape connectivity as possible in the face of human population growth and encroachment. The basic network model generally consists of a core area where human activities are limited, and where the maintenance of wildlife habitat and biodiversity are the primary goals. Surrounding the core is a buffer zone where increasing amounts of human impacts are allowed, but can also support many species of wildlife. Outside of the buffer zones, land use is primarily human-oriented and only very human-tolerant wildlife species would be found here. This multiple-use model (Noss and Harris, 1986) is essentially an extension of UNESCO's Biosphere Reserve concept (Batisse, 1986). Whenever possible, core reserves are connected by secure corridors also surrounded by buffer zones.

The need for landscape connectivity (through habitat corridors) is a complex and contentious issue among conservation biologists (e.g. Beier and Noss, 1998; Hobbs, 1992; Noss, 1993; Simberloff *et al.* 1992). What conservation biologists are interested in is not simply some corridor that can be recognized on the landscape or drawn on a map, but rather functional connectivity. Functional connectivity is usually measured in terms of the potential for animal movement and genetic inter-

change among populations of a target species (Noss, 1995) or in terms of the ecological composition, structure, and functions occurring at local to regional scales (Poiani *et al.* 2000). Conceptual and practical models of corridor networks have been proposed by several workers (Hoctor *et al.* 2000; Noss, 1995; Noss and Harris, 1996) as frameworks for long-term, regional scale conservation of wildlife.

Functional conservation reserve networks have several characteristics that are equally important at local and regional scales (Poiani *et al.* 2000). First, the size, configuration, and network design will be determined by focal ecosystems, species, and supporting ecological processes. Second, a network is functional if it maintains the focal abiotic and biotic patterns and processes within their natural ranges of variability over time frames relevant to conservation planning and management (e.g. 100-500 years). Third, functional networks do not necessarily preclude human activities, although their functionality or integrity may be greatly influenced by such activities. Finally, a functional conservation network may require ecological management or restoration (e.g., prescribed burning, invasive species removal, species reintroductions) to maintain essential ecological processes.

In Southern Ontario, particularly within the Carolinian Zone, habitat fragmentation has greatly reduced the habitat connectivity for the majority of wildlife species. Studies in Ontario and elsewhere have shown that species requiring interior habitats or large tracts of intact habitat are unable to maintain viable populations in landscapes greatly fragmented by agriculture, roads, and urbanization (e.g., Burke and Nol, 1998; Spellerberg, 1998). Therefore, a reserve network that increases habitat connectivity (i.e., reduces fragmentation) by functioning as dispersal and/or migration pathways for wildlife and their genes would be a highly valuable conservation tool (Beier and Noss, 1998). One of the benefits of corridors is intra-specific gene flow from one population to another within a single generation, over several generations, and over evolutionary time. A key demographic function of corridors is that they allow dispersing individuals to “rescue” a small or declining population by colonizing habitats. This rescue effect occurs when an influx of animals from outside the population maintains that population, even though its mortality rate may exceed its recruitment rate. Similarly, colonization occurs when enough dispersing individuals find unoccupied habitat and establish a new population. Re-colonization of habitat patches is another potential benefit for a species that has been extirpated locally.

A corridor need not consist of contiguous habitat. For many highly mobile species such as butterflies, passerine birds, waterfowl, or raptors, a corridor may be composed of stepping stones of habitat connecting breeding areas with wintering areas. Migratory waterfowl that breed in the far north require stepping stones of open water habitat in order to migrate to and from their wintering areas in the south. Some stepping stones, such as wetland areas used by staging waterfowl, may be utilized as brief stops to rest, whereas others that contain good foraging

habitat may be used for several days. Point Pelee, Rondeau, and Long Point are exemplary in terms of their importance to migratory song birds, waterfowl, and Monarch butterflies, which use these areas as stepping-stones. Increasing the connectivity of these three areas, for example, would not only enhance their biological significance, but would also help re-establish some of the ecological integrity of the intact Carolinian landscape that was present prior to large-scale conversion to agricultural and urban uses. Moreover, increasing connectivity between the Carolinian Zone and regions to the north of it would also help restore the composition, structure, and function of additional ecosystems that support biodiversity at all levels (genes, species, and communities).

Project Scope

With the significant financial and technical support of the Nature Conservancy of Canada and the Ontario Ministry of Natural Resources (Forest Management Branch and Geomatics Services Centre), and a number of other conservation groups in Ontario, the Ontario Natural Heritage Information Centre (NHIC) has undertaken such natural heritage systems modeling. The first iteration of this process yielded a mapped vision of a functioning landscape within Canada's Carolinian Life Zone (Ecoregion 7E), known as the "Big Picture Project" (Jalava, 2000, Jalava *et al.* 2001). This ecoregion is widely recognized as one of the most biologically diverse in Canada in terms of the number of species and communities it sustains, yet remains one of the most highly fragmented and degraded as a result of extreme human encroachment. This mixed deciduous forest region was historically a vast expanse of old-growth forests and treed swamps. Today, large, intact examples of such matrix communities are rare, as are the significant, characteristic smaller patch communities, such as oak-savannas, tallgrass prairies, and dune-swale complexes. The Big Picture project was later expanded into the "Bigger Picture" project, which considers the two ecologically distinct regions to the north, namely, the Northern Hardwood Forest Zone (ecoregion 6E) and the Georgian Bay Region (ecoregion 5E) (Figure 1). In contrast to the Carolinian Zone, these two ecoregions are minimally to moderately fragmented, and contain such notable landscape features as the Niagara Escarpment, Oak Ridges Moraine, Frontenac Axis, as well as large and relatively intact natural areas on the southeastern portion of the Canadian Shield in Ontario.

Species at Risk

The entire Bigger Picture study area supports at least 37 globally rare and 68 provincially rare vegetation community types, 500 provincially rare plant and animal species, and 50 that are globally rare. Many of the rare species occur peripherally within Ontario and have more widespread ranges in the United States. One hundred and twenty-one plant and animal species found within the study area are now considered "at risk" in Canada, but only 75 of these species have been officially listed by the Ministry of Natural Resources as either Vulnerable, Threatened, or Endangered in Ontario. At least 27 of the province's extirpated taxa (16 animals

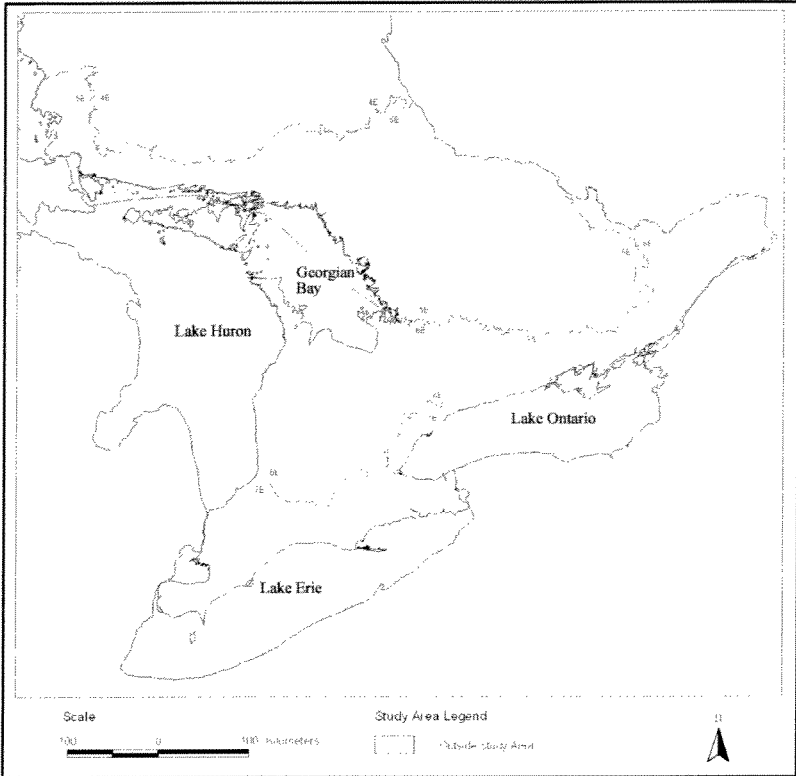


Figure 1. Bigger Picture Study Area

and 11 plants) occurred within the study area, and several additional species that have not been recorded for over 20 years may now be extirpated.

Designing A Natural Heritage Network Vision

The goal of the Bigger Picture project is to develop a long-term vision to assist natural heritage planning within all three ecoregions. The methodology was designed so that it could be applied to a fragmented landscape consisting of remnant natural areas and modified habitat, and uses the best available electronic data from a variety of sources. Several components directed the development of the project:

- 1) Development of a replicable, transparent methodology using GIS,
- 2) Inclusion of existing natural cover in the natural heritage system, existing parks and protected areas, and all recognized areas of ecological importance,
- 3) Favoring of larger intact natural areas, areas with more extensive interior habitat, and regions with high percentage natural cover,
- 4) Increasing connectivity between fragmented patches, (long term goal of at least 30% natural cover per ecodistrict)
- 5) Inclusion of viable occurrences of globally rare elements and concentrations of provincially rare elements,

- 6) Where possible, creation of minimum core sizes (200 ha off the Shield, 500 ha on the Shield) and minimum corridors of at least 200 m width,
- 7) Identification of soil types poorly represented in existing natural areas to prioritize rehabilitation (to approximate historic vegetation patterns),
- 8) Application of an algorithm that incorporates ecological, social and economic considerations; and modification of the methodology through consultation with the technical committee as issues and problems arise, and
- 9) Provision for future updates to data and methods as new information becomes available and knowledge improves.

Methods

1. Select, register and edge match all data sets (Table 1); and convert vector layers to raster (grid) coverages of 25m pixels, for each of which are calculated positive conservation values and negative resistance values.

Table 1. Digital Data Sets and Source

1. LANDSAT image "Ontario Land Cover" (Ontario Ministry of Natural Resources)
2. Ontario Basic Mapping "drainage, street and pitpile" layers (Ontario Ministry of Natural Resources)
3. Natural Resources and Values Information System--Life Science Areas of Natural and Scientific Interest, evaluated and unevaluated wetlands, river corridors, abandoned railways, Agreement Forests (Ontario Ministry of Natural Resources)
4. Provincial Parks (Ontario Parks)
5. Ontario's Living Legacy land use designations (Ontario Parks)
6. Older Growth Woodlands (The Woodland Heritage of Southern Ontario, Larson et al. 1999, Federation of Ontario Naturalists)
7. Forest Interior Outlines and "Internal" Buffers, Utility Corridors (Ontario Hydro / Ontario Power Generation)
8. Element Occurrence Concentrations (species and vegetation communities) (Ontario Natural Heritage Information Centre)

2. Core areas were identified as exceeding specified threshold cumulative values (9 for 7E, 12 for 6E, 15 for 5E and 4E) based on accumulating assigned conservation values: natural cover from LANDSAT image "Ontario Land Cover), from -10 to +5 points; riparian areas and 30m buffers, at +5 points, life science ANSIs, from +5 to +15 based on size and significance; wetlands, from +3 to +15 based on size and significance; coastal natural areas (all ANSIs, provincial wetlands, woodlands >200ha) within 1 km of coast, all +15 points; protected areas (e.g., non-recreational provincial, protection zones in Algonquin Park, Conservation Reserves, National Parks and Wildlife Areas) at +15 points; other Ontario Living Legacy designations +1 to +3 points; "older growth woodlands" in 6E and 7E +15; forest interiors >500ha +3 points; forest interior >100m from edge +2 points; and forest cover concentrations +1 to +4 points (all three final values based on Ontario Hy-

dro forest mapping). To these were added +1 to +10 points on the basis of a generated surface layer of values based on concentrations of rare species and vegetation types. Adjacent areas of natural cover, at values less than the threshold values, were added to build core areas into their larger contiguous “metacore” areas.

3. Other values were added to the core valuations of pixels (above) in order to develop a “cost” or “resistance” surface that would influence the alignment of “least cost” links or corridors between core areas. Least cost alignments follow existing areas of natural cover and riparian areas preferentially because of positive values. Where no such alignments along positive values could occur, the cores were connected along the “highest value per unit length” route (i.e., areas without natural cover), and a minimum width of 200m was assigned to that highest-probability alignment; these areas are the only areas of the natural heritage system not currently in natural cover. The generated “corridor” fabric of pixel values was manipulated to exaggerate resistance costs by raising the cost values by a power of five. The additional “resistance” values were highways at -1 to -5 points based on scale, non-agricultural soils +2, abandoned railways +2, utility corridors +2, agreement forests +10, and conservation areas and recreational provincial parks at +10 points.

4. Review of the developing product visually by project partners and technical committee to adjust methodology, and to assess final alignments of highest-potential corridors.

Preliminary Results of the Bigger Picture Project

In the Carolinian Zone (Ecoregion 7E), cores are generally small (<500 ha) and isolated, have larger perimeter-to-areas ratios, and are separated by large areas of unsuitable habitat. In this ecoregion, physical linkages are needed to increase landscape functionality. The Long Point, Rondeau, and Point Pelee peninsulas situated along the north shore of Lake Erie, and Pinery Provincial Park on Lake Huron were identified as core areas, which were in turn linked to smaller satellite areas. For example, Long Point, Turkey Point, Backus Woods, and the South Walsingham woodlands form an important network of coastal marshes and interior forests, harboring rare species such as King Rail (*Rallus elegans*), Hooded Warbler (*Wilsonia citrina*), Acadian Flycatcher (*Empidonax vireescens*), and Southern Flying Squirrel (*Glaucomys volans*). The Rondeau-Lake St. Clair-Walpole Island network to the southwest provides linkages between a Provincial Park, a National Wildlife Area, and a First Nation, all of which are known to contain habitat suitable for the King Rail and many other imperiled flora and fauna. Point Pelee National Park in extreme southwestern Ontario is one of the most isolated cores in this ecoregion yet contains habitat for a host of rare flora and fauna such as Eastern Prickly Pear Cactus (*Opuntia humifusa*), American Water-willow (*Justicia americana*), Red Mulberry (*Morus rubra*), and Eastern Fox Snake (*Elaphe vulpina gloydi*), to name a few.

The entire length of the Niagara Escarpment, from the Niagara Peninsula to Manitoulin Island, represents a much larger corridor, which was in turn linked to smaller corridor networks consisting of Bruce Peninsula National Park and many other protected areas owned or managed by provincial agencies, conservation authorities, municipalities and non-government organizations. Several existing parks and protected areas, including new provincial parks and conservation reserves identified under Ontario's Living Legacy program, form a vast network of core natural areas stretching from eastern Ontario to the Georgian Bay coast. Within this region, the Frontenac Axis supports one of the largest Black Rat Snake (*Elaphe obsoleta obsoleta*) populations in Ontario, while the rocky shoreline of Georgian Bay provides suitable habitat for one of the last remaining populations of Eastern Masassauga Rattlesnake (*Sistrurus catenatus catenatus*) in Canada.

With the recent expansion of Ontario's protected areas network, large tracts of the Georgian Bay and Northern Hardwood Forest regions on the southern part of the Canadian Shield are either now "protected" or have not yet experienced the same degree of fragmentation as has the Carolinian Zone. These areas are vast in comparison and include almost the entire Georgian Bay Coast north from Honey Harbour to Killarney, the Dalton-Digby Wildlands (30,000 ha), northeast of Orillia, the Kawartha Highlands (35,000 ha) north of Peterborough, Algonquin Park, and many other moderate- to large-sized parks and conservation reserves. A standard ecological gap analysis would consider these as cores at the outset, but would need to incorporate the rest of the land base into a linked system of protected areas, thus increasing ecological representation, ecosystem integrity, landscape functionality, and biodiversity protection. This region is particularly important for large and far ranging mammals such as Eastern Canadian Wolf (*Canis lupus lycaon*) and Canada Lynx (*Lynx canadensis*), whose home ranges do not adhere to protected area boundaries.

Products of the Bigger Picture Project

Products include a coarse scale spatial image that highlights existing habitat cores and wildlife corridors, as well as potential areas for restoration and rehabilitation. Core and corridor boundaries are mapped as soft, fuzzy lines according to criteria agreed upon by the technical committee to communicate the coarse-scale and flexible nature of the mapping, and to minimize private land concerns.

A poster product and compact disc (CD) containing all resulting ArcInfo coverages generated by this project are currently in production. The CD will enable relatively easy transfer of data and images to other GIS applications and publication media such as Acrobat PDF for viewing or printing.

The maps selected to illustrate the project are provided to illustrate some of the real limitations, stresses and conservation achievements on the landscapes of the study area. A "Natural Cover" map illustrates the heavy human footprint that defines southern Ontario south and east of the Canadian Shield. This has been the

fundamental motivation for conservation biologists to assign comparative values to the remaining natural heritage features of the region, and to develop innovative models to portray present and potential, conserved and restored, natural heritage systems. A “Protected Natural Heritage Area” map illustrates the accomplishment to date in formal, regulated conservation areas. Achievement are significant on the Crown lands of the Canadian Shield, while land conservation south and east of the Shield is tied more closely to the stewardship abilities of private landowners and non-government organizations, and the conservation policies of municipal land-use plans. A “Species At Risk” map illustrates the particular jurisdictional and global challenges facing particular parts of southern Ontario with regard to biodiversity conservation. A “Forest Concentrations” map parallels the Natural Cover map, illustrating the convergence of data sets from different sources, and providing a special tool to assess the special conservation needs of forests in the natural heritage system. A “Comparative Conservation Values” map is a summary view of the pixel fabric resulting from the method outlined above, with areas of natural and scientific interest and wetlands highlighted.

The mapped Bigger Picture vision illustrates where restoration and conservation efforts should be focused within 3 distinct ecological regions in southern Ontario. Many of the core natural areas identified in the analysis represent existing national and provincial parks, national wildlife areas, significant First Nations lands, and the original 38 Carolinian Canada Sites, which complement and sometimes overlap with Areas of Natural and Scientific Interest. Also included within this network are sites owned by the Nature Conservancy of Canada, and a number of new provincial parks and conservation reserves identified by Ontario’s Living Legacy program. Over the past century, 6 National Parks, 8 National Wildlife Areas, and 135 Provincial Parks have been established within the study area. These areas have traditionally been set aside to protect representative natural heritage values through legislation, regulation, policies, and management plans. The Bigger Picture vision of the southern Ontario landscape should increase public awareness and inspire biologists, ecologists, municipal planners, resource managers, stewardship councils, conservation organizations and protected areas managers to work more cooperatively in developing a regionally integrated natural heritage system that will preserve biological diversity and ensure ecological integrity over the coming centuries. Please refer to (<http://www.mnr.gov.on.ca/MNR/nhic/bp/biggerpicture.html>) for further project details and updates.

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