

Natural Heritage Systems in Urbanizing Settings: Sustainable Practices for the Oak Ridges Moraine



Prepared on behalf of
**Save the Rouge
Valley System Inc.**
and the
City of Toronto

By

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1. Introduction

1.1 Genesis of This Report

This report draws from the experience of a team of experts (biologists, toxicologists and environmental planners) in considering the implications of “Smart Growth”, as they are being applied to development and protection of natural heritage on the Oak Ridges Moraine.

The Oak Ridges Moraine is a significant landform in southern Ontario, comprising an irregular ridge that extends some 140 kilometres, between the Niagara Escarpment to the west and the County of Northumberland to the east. It was left behind by receding ice sheets following the most recent glaciation, and has a complex geology comprising mainly porous materials which collect, store and release water. It forms the headwaters for numerous streams that flow to the north, and to the south into Lake Ontario. The Moraine comprises an important regional scale corridor for the movement of wildlife and plant materials. It contains a high concentration of important natural heritage features including hydrologic and hydrogeologic features. The Moraine has become subject to increasing development pressure in recent years, particularly in the area north of Toronto. The natural features of the Moraine and its hydrologic functions, which include supply of drinking water and flood control, are vulnerable to the effects of development.

The authors of this report were originally brought together to review specific development proposals in the Town of Richmond Hill, known as “Yonge East” and “Yonge West”, which would have been located in the Moraine north of Toronto. The proposals would have interrupted the connectivity of the Moraine at a “pinch point” where areas of development extending from the north and south near Yonge Street have already displaced significant areas. The team was initially retained by the City of Toronto to provide expert witness evidence for an Ontario Municipal Board hearing that would consider the proposals. The team ultimately provided consulting services to Save the Rouge Valley Systems Inc. (SRVS), which had Party status at the hearing, when the City’s request for standing was denied.

In May 2001, public reaction generated by the Richmond Hill proposals and other concerns for the Moraine prompted the Ontario government to suspend the hearing, to declare a moratorium on new development proposals on the Oak Ridges Moraine, and to begin consulting stakeholders and preparing a plan for the Moraine as a whole. The experience gained by the expert team in considering the Richmond Hill proposals contributed to comments that were provided on the Government’s “Share Your Vision” document (August 2001) and a draft Oak Ridges Moraine Conservation Plan (ORMCP) (November 2001). In December 2001, the government passed the Oak Ridges Moraine Conservation Act and in April 2002 it released a final ORMCP. This will be followed by the release of a number of technical and guidance documents, and the expert team also hopes to provide input to these. Government material relating to the ORMCP may be found at www.mah.gov.ca.

The new Plan applies to the entire Moraine, except for the area of Richmond Hill that was disputed at the Ontario Municipal Board hearing. Part of this area has been designated as a public park. In June 2002, the Minister of Municipal Affairs and Housing released a Ministerial Order under the Oak Ridges Moraine Conservation Act 2002, establishing Official Plan designations and zoning to permit residential development on the remaining developable lands in Yonge East and Yonge West. The SRVS expert team provided input to participants in the negotiations that preceded this Order, but was not included in the actual negotiations.

1.2 “Smart Growth” and the Precautionary Principle

1.2.1 Smart Growth in Ontario

Southern Ontario’s population has been growing rapidly since the 1950s, and this growth has been accompanied by increasing development in the residential, industrial, and commercial sectors. This growth has caused existing communities to expand and coalesce, displacing agricultural and other rural land, and this growth is often termed ‘sprawl’

Historically, the design of towns, villages, and cities was predominantly based on a grid pattern of roads that supported public transit (in larger communities) and pedestrian movement, and often encouraged higher density development. On the other hand, ‘sprawl’ is often dominated by lower density development in automobile-oriented communities that are less supportive of transit or pedestrians.

Older communities tended to displace natural heritage features, opting to protect lands as parks, sometimes left in a natural state (e.g. High Park in Toronto). While modern urban planning usually attempts to protect priority natural features, little regard is typically given to how these areas will function when they are surrounded by urban development and isolated from other natural areas.

Various levels of government throughout North America, including the Province of Ontario, have recognized the environmental costs of previous forms of development, and have also initiated new forms of infrastructure financing. These approaches have been given the umbrella term “Smart Growth”. According to the provincial government, Smart Growth is a means of fostering and managing growth that is based on the principles of “strong communities, a strong economy, and a clean, healthy environment”. The ORMCP is one of the Ontario Government’s “Smart Growth” initiatives. The meaning and implications of “Smart Growth” in the context of built development in sensitive natural and hydrological areas have been explored and clarified through the process described in this report.

The U.S. Environmental Protection Agency, which provided the model for Ontario’s Smart Growth program, has developed this idea to include principles such as preserving open space, farmland, natural beauty, and critical environmental areas, strengthening and directing development towards existing communities, taking advantage of compact building design, and encouraging community and stakeholder collaboration in development decisions (http://www.epa.gov/smartgrowth/about_sg.htm).

Addressing growth in this way means reconsidering the existing approach to planning. “Smart Growth” requires planners and decision-makers to turn the process upside-down and to protect natural features and farmland as a first priority. In addition to protecting the most sensitive natural features, surrounding buffers and connecting corridors must also be designated as off-limits to development to ensure that quality habitat and hydrological functions are maintained.

Once the natural heritage system and required buffers and corridors have been identified, the remaining areas can be designated for varying types and densities of development, with additional protections incorporated as required. This, essentially, is the approach that has been taken in developing the ORMCP. The “Smart Growth” concept encourages high-density development within existing urban areas so that infrastructure, including public transit, can be provided in a cost-effective manner.

A key concept for urban growth (smart or dumb) is the recognition that biological features and functions seldom, if ever, respect the boundaries of municipalities and other jurisdictions involved in planning. We also now recognise that impacts from urban development do not respect development boundaries. The ORMCP encompasses the entire natural feature of the Moraine,

and this approach is a positive step, but the Plan is still to be implemented and monitored by individual municipalities, with little or no coordination across the Moraine as a whole. The Plan's provisions also do not address buffering of sensitive features on the edge of the Moraine against off-Moraine development, or protection of valleylands that extend off the Moraine.

The term "Smart growth" implies that there is sufficient information to make intelligent decisions. Therefore, natural heritage study and plan monitoring requirements must be sufficiently comprehensive to provide reliable data so that the effects of different forms of development can be assessed with a reasonable degree of certainty. "Smart growth" can only be distinguished from "dumb growth" by the reliability of the information used to make a decision on the location, the form of growth which gets approved, and ultimately, the extent to which natural heritage is protected or enhanced while other societal needs are met.

1.2.2 The Precautionary Principle

The Precautionary Principle is a concept that is emerging as a guiding principle when examining the potential effects of undertakings. It was defined at the 1992 World Conference on Environment and Development (known as the Rio Conference), as follows:

"Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation."

In this report, the Precautionary Principle forms the basis for advocating a more cautious and reasoned approach in the planning and design for natural heritage protection in the vicinity of future urban areas.

1.3 The Purpose and Contents of This Report

1.3.1 Purpose

The ORMCP imposes new responsibilities on numerous municipalities across the Moraine, and it forms part of a broader thrust towards greater protection of water and natural heritage resources in Ontario. The Plan is a considerable advance over the previous planning framework. Municipalities, proponents, community groups and individuals will learn a good deal about the way it applies to individual proposals as its implementation unfolds, through reviewing the required studies and the way development is modified to fit the natural characteristics of a site, where it is permitted. At the same time, there is a lack of readily available and accessible information that provides some of the context in which the Plan's policies were developed—the nature and connectedness of the natural heritage resources of the Moraine, and the effects that can occur when development occurs in such a sensitive area. Also, there is a need for general information on best practices when planning for development that may affect sensitive natural heritage resources. The authors of this report feel that the knowledge gained and the implementation tools that were considered in generating evidence for the Ontario Municipal Board hearing, and in reviewing Plan documents, will have more general application. We hope it will provide useful background information to those who are involved in development decisions that may affect natural heritage resources on the Moraine, in other parts of Ontario, and beyond.

1.3.2 Contents

Section 2 of this report briefly describes an instance in which “environment first” planning on the Moraine was undertaken with assurances that the environment would be protected and that environmental effects would be monitored, but which did not achieve the desired outcome. The section provides background to our current understanding of natural heritage systems, and describes the landscape, wildlife and plant communities of the Moraine that were considered in developing evidence for the Ontario Municipal Board hearing, and the measures that can be taken to protect these resources. While this research was undertaken in response to specific development proposals and did not cover the entire Moraine, most of the information and many of the recommendations have more general application.

Section 3 of the report deals with both the water quantity and quality aspects of stormwater management on the Moraine. While stormwater management and natural heritage are interrelated, this section identifies a number of specific concerns and best practices.

Section 4 describes the planning framework in Ontario, and the way this can affect decision making. It summarizes some of the legislation and policies other than the ORMCP that can apply to development and site alteration, and discusses cumulative effects and the importance of an effective monitoring framework. The Section identifies a number of ways in which the planning framework can be used to protect natural heritage.

Section 5 concludes with a summary of the lessons learned in attaining the achievements accomplished to date, and the issues still to be addressed.

2. Interface of Natural Heritage and Urban Development

2.1 The Town of Richmond Hill's "Environment First" Approach – A Cautionary Tale

In 1995, the Ontario Municipal Board approved Amendment 129 to the Richmond Hill Official Plan (OPA 129), which permitted primarily residential development in an area of the Oak Ridges Moraine, immediately to the north of the Yonge East and West lands that were the subject of the OMB hearing in 2001. OPA 129 was approved as an "Environment First" plan, and the Board's Decision required that the implementation of the Amendment be monitored. Some of the residential areas approved by OPA 129 have now been developed and occupied. On behalf of the City of Toronto and later SRVS, Dougan and Associates (James Dougan is one of the authors of this report) conducted a performance evaluation of the implementation of OPA 129. The findings are reported in Natural Heritage Protection Under OPA 129: Performance Evaluation (June 2001)

The evaluation examined the history of "Environment First" commitments including Town policies and OPA 129 OMB Conditions of Approval, documents prepared in support of development applications, and Conditions of Draft Plan Approval for plans of subdivision. Field assessments were undertaken between March and October 2000 to photo-document conditions on OPA 129 lands under active and completed development.

The author concluded that despite the "Environment First" principle, natural heritage protection in OPA 129 resembles the results of more conventional planning policies designed to meet the Provincial Policy Statement (discussed in Section 2.2.1), as found in most municipalities in Ontario. Key natural heritage features are protected in principle by OPA 129, but their quality, functions and ecological integrity can be expected to 'wind down' (i.e. degrade) over time due to:

- a) the change in landscape matrix from low to high landscape resistance,
- b) inadequate corridors to compensate for increased landscape resistance,
- c) inadequate buffers to address encroachment from adjacent residential uses, let alone support natural functions, and
- d) large scale urban 'footprint' effects relative to the limited area of natural cover.

These issues are further discussed later in this report. The author concludes that the buffers provided for in OPA 129 are not sufficient to provide flexibility in adaptive management, and that this will make management more expensive (if it is undertaken at all) in the future. Limitations of human and financial resources to monitor and maintain resources, and political constraints on pro-active management are predicted, assuming the municipality and agencies accept the responsibilities implicit in OPA 129 policies and objectives.

The performance review found a cumbersome load of information requirements to support development applications, reflecting a micro-management process focused on minimizing loss of development yield. There was unevenness in objectivity in Environmental Impact Studies provided by some consultants, and these documents were not visionary in terms of future ecosystem quality and functions.

In the implementation of OPA 129, weaknesses were apparent in implementing, monitoring, maintenance and enforcing standard protective practices. For example, the performance evaluation found that wetlands had been inundated by silt from adjacent construction activities, and that natural features had been damaged by grading and filling and used to dump construction waste. Where buffer areas had been provided between the rear property lines of residences and

adjacent natural features, they had often been cleared and maintained as if they were part of the adjacent property. These incursions sometimes extended into the area designated for protection. The failure to follow through (to date) with required monitoring indicates that there is no adaptive process in place to increase compliance with OPA 129 objectives and OMB Conditions over time.

Stormwater management facilities completed in OPA 129 have integrated existing wetlands into the extended water quantity detention areas. The evaluation identified problems caused by the installation and operation of these facilities including inadequate buffering (including physical encroachment), sediment loading and urban pulse (abnormal cycles of flooding and drying) effects. Given current science on urbanization effects, permanent changes to these natural wetlands will occur over a period of years, affecting their ability to sustain the natural plant communities and wildlife that rely on them.

Although natural heritage features and functions could be partially sustained with intensive intervention using community-based stewardship, the evaluation concludes that it is unreasonable to expect new residential communities to have the skills, common landscape values, and consensus necessary to carry out such a project. The future urban natural heritage system will only be operational after OPA 129 lands are completely built out, and therefore ecological integrity will have declined irreversibly.

The OPA 129 evaluation recommends a review of natural heritage objectives to reduce the future risk and liability exposures of municipalities and agencies with respect to natural heritage management. Adaptive management at meta-scales, and updating of urban design standards based on available science, are tools to improve natural heritage protection. The study recommends a comprehensive review of longer term public and private development costs and timeframes to identify areas where burgeoning 'micro-management' needs can be curtailed.

The evaluation provides a clear illustration of the difficulties to be overcome and the commitment required to maintain robust natural heritage systems near urban development. Municipalities and agencies may well be liable in the future for downloaded responsibilities for natural heritage protection and incursions onto public land. Protective policies such as those found in the ORMCP are only worthwhile to the extent that they result in real, long term protection on the ground. This requires that features and functions are given sufficient room to operate so that they will not require detailed and expensive ongoing management, and that policies and management techniques are monitored for their effectiveness. It also requires appropriate construction practices to be applied more rigorously, and significant shifts in thinking so that the respective roles of developers, contractors, municipalities and occupants of development are clearly defined and consistently applied. Similar issues will need to be addressed in the monitoring and implementation of the new ORMCP.

2.2 Natural Heritage Systems: Core Habitats, Corridors and the Matrix

2.2.1 History and Planning Context

Planning for the remaining natural landscapes in southern Ontario has evolved significantly over the past 50 years. Devastation caused by Hurricane Hazel in 1954 caused land managers to pause and review the impacts of deforestation on watershed hydrology, and led to the establishment of floodplain regulations administered by Conservation Authorities. Until the late 1960's, new urban developments rarely incorporated habitat remnants, except for major valleylands that became servicing corridors for conveyance of sanitary sewage, and for the discharge of urban storm runoff resulting from the great increase in runoff that accompanies urbanization. By the 1970's, the fruits of these practices had reached a crisis level of non-sustainability as public authorities were faced with cleaning up the cumulative effects of compounded urbanization in watersheds, which had created serious erosion, loss of public open space amenity, and threats to property, basic infrastructure and public safety.

Renewed interest in the conservation of remaining natural landscapes, coupled with initiatives in Ecological Land Use Planning (as advanced by Angus Hill in Ontario and Ian McHarg in the U.S.) led to attempts to evaluate and protect 'islands of green', that is, the biggest and best remaining examples of natural habitat in regions and in expanding cities. In southern Ontario, these took the form of Environmentally Sensitive Areas (ESAs), Nature Reserves, and Areas of Natural and Scientific Interest (ANSIs). In 1967, the Theory of Island Biogeography had been advanced by MacArthur and Wilson, based on population studies of the effects of oceanic island size and isolation on their relative ability to retain species over time. It was soon apparent to other scientists that 'islands' could also include natural habitat fragments set in a 'sea' of agricultural or urban land. Researchers came to the conclusion that without regular immigration, progressive extinction of species on isolated habitat 'islands' was inevitable.

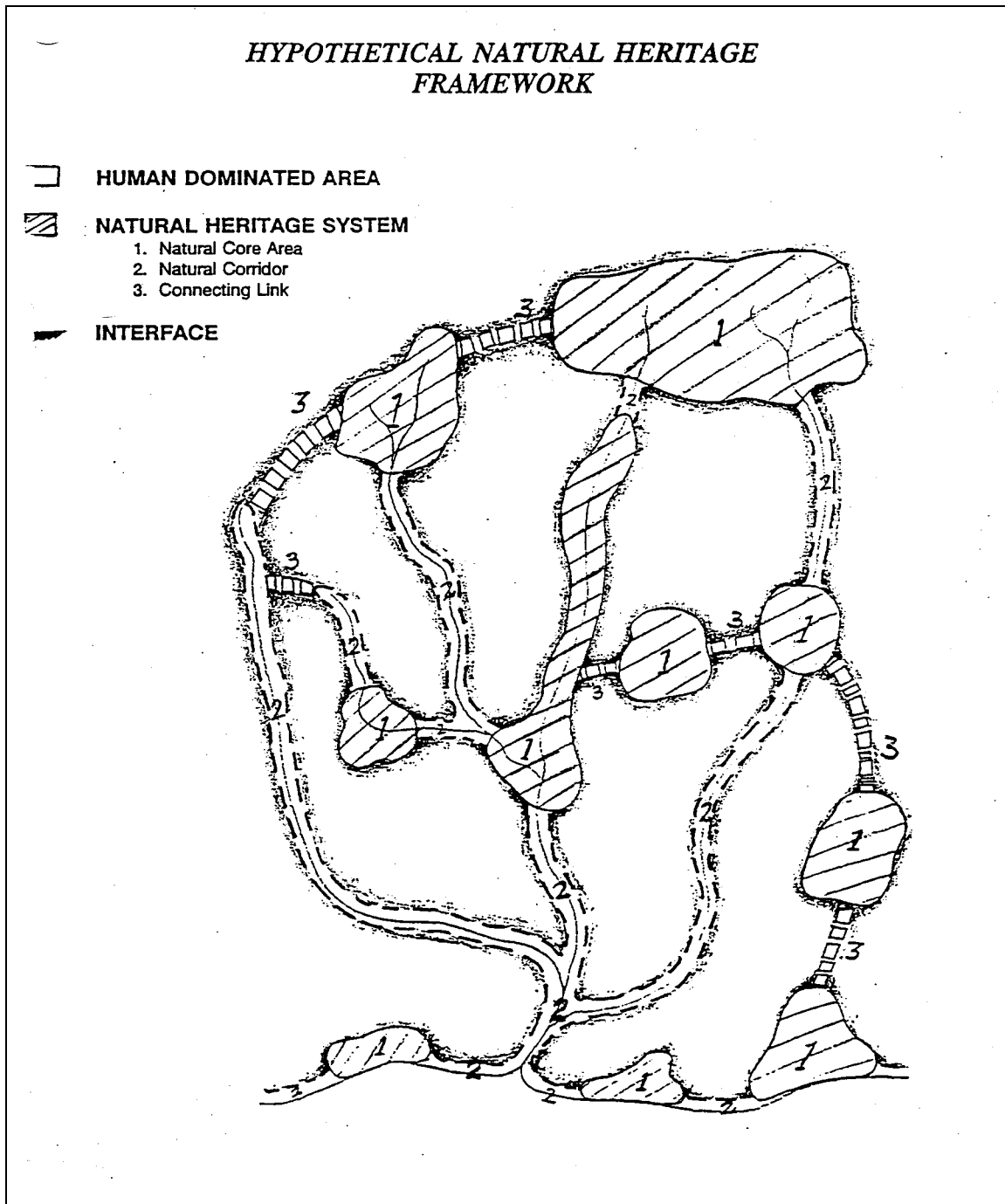
By the mid-1980's it was clear that 'islands of green' alone were inadequate to protect and manage the remaining biodiversity in southern Ontario. In 1984, a paper published by one of the authors of this report (Dougan), entitled The Fate of ESA's in Urban Environments: Two Case Histories in Peel and Halton, examined two natural areas which had been designated for protection in the late 1970's. The article recounted a litany of planning conflicts, unrealistic expectations, inadequate municipal resources, and urban encroachment, ultimately leading to the downgrading of these significant natural areas as urbanization proceeded.

In Canada and elsewhere, land managers have grappled with the concept of 'sustainable development' since the late 1980's, and as the new sciences of landscape ecology and conservation biology gained momentum over the same period. In 1991 the Greater Toronto Area (GTA) Branch of the Ministry of Natural Resources (MNR) released a discussion paper entitled A Natural Heritage Framework: A Strategy for the Protection and Management of Natural Heritage in the Greater Toronto Area. Based on the emerging literature in landscape ecology, the document laid out a conceptual approach for a Natural Heritage Framework based on natural core areas, natural corridors, and connecting links (see **Figure 1**).

Natural core habitats are the most extensive and significant natural features in the landscape, and typically include significant wetlands and woodlands, ANSIs, ESAs, major valleylands and water bodies, and conservation lands such as major reforested areas and flood hazard lands. Natural corridors are typically existing significant valleylands, but also include shorelines, and streamcourses that provide substantial connective benefits between core areas for diverse species. Connecting links are smaller features that connect natural core areas, either existing or to be established.

Although useful for explaining the Natural Heritage Framework (NHF) concept, the model depicted in **Figure 1** has a significant weakness, namely the lack of consideration of the functions that the "human dominated area" will play in the system. A rural landscape could well support NHF objectives, allowing the NHF to maintain the dominant role in landscape dynamics, and retaining that dominance despite rural impacts. However, in a suburban or urban core context, the "human dominated area" includes functional dominance due to urban hydrology, infrastructure, and human activities.

Figure 1 - Hypothetical Natural Heritage Framework



Source for Figure 1: MNR 1991

In their seminal textbook, *Landscape Ecology* (1986), Richard Forman and Michel Godron laid out fundamental principles for the science of landscape ecology, which deals with the distribution of landscape elements/ecosystems, flows of biota, matter, energy and water, and changes in the landscape mosaic over time. A central concept is that of the *landscape matrix*, defined as: “the most extensive and most connected landscape element type present, which plays the dominant role in landscape functioning”.

Under urban and suburban conditions, the “human dominated area” is the matrix, and its functions largely overwhelm those of remnant natural environments in the urban setting, when one considers a) the great increase in runoff that results from urbanization, b) the host of contaminants and nutrients from urban areas and c) the effects of pets, increases in urban-adapted predators (loss of top predators), introduced exotic plants, pedestrian impacts, noise, garbage and yard waste. Valley corridors, upland woodlots and wetlands that were adapted to pristine pre-settlement conditions, become the downstream receptors of key impacts as urbanization is initiated and becomes entrenched as the matrix. It is clear that this Natural Heritage System, rather than retaining natural integrity, is being transformed through catastrophic and chaotic events (including global warming), into a largely undefined and uncharted urban ecosystem.

In 1994, MNR published The Natural Heritage of Southern Ontario's Settled Landscapes: A Review of Conservation and Restoration Ecology for Land Use and Landscape Planning by John Riley and Pat Mohr. This was a comprehensive review of the state of southern Ontario's natural landscapes, current scientific literature in the fields of *landscape ecology*, *conservation biology*, and *restoration ecology*, and a proactive framework for improvements to natural heritage protection and management in southern Ontario, based on habitat *retention*, *restoration* and *replacement*.

Ecology has until very recently been a descriptive, reductionist field of science. *Restoration ecology* represents a *synthetic* or ‘building’ approach to ecology that originated with the American ecologist, Aldo Leopold's prairie ecosystem reconstruction work during the Great Depression (Jordan et. al., 1987). Notably, reforestation efforts on the Moraine were undertaken in the same period, and for similar reasons: stabilization of agriculturally damaged soils, and re-investment in future productive uses. Leopold held a vision of a ‘*land ethic*’, a positive, healthy relationship between humans and the land. Restoration ecology was only formally recognized as a science in the 1980's. Notably, to date the ecosystems we have attempted to ‘restore’ from the 1930's onward still have not achieved the levels of biodiversity and integrity found in natural ecosystems.

The Provincial Policy Statement (PPS) is a government document, released in 1997, which is intended to guide the application of the Planning Act. While this document has now been largely displaced by the ORMCP within the Plan area, it remains the effective statement of provincial policy for the remainder of Ontario (except for the Parkway Belt and the Niagara Escarpment) and was in effect on the Moraine during the Richmond Hill Ontario Municipal Board hearing. The PPS is currently undergoing a five-year review. Its Natural Heritage policies clearly evolved from the 1991 and 1994 MNR background documents, as did the implementation guidelines contained in the Natural Heritage Reference Manual, (OMNR, 1999). The wording of the PPS is reflective of and adaptive to ongoing scientific advances in *landscape ecology*, *conservation biology* and *restoration ecology*.

The Sections of the PPS that are of particular relevance to the desirable ultimate condition of ecosystems such as the Oak Ridges Moraine, include Sections 1.1.1 (e) and (f), 2.3.1 (a), (b), 2.3.2 (a) and (b), 2.3.3, and 2.4.1. Key concepts under the Policy Statement include *ecosystems and watersheds*, *ecological functions*, *no negative impacts*, *maintain and improve*, *diversity of natural features*, and *natural connections*. The PPS clearly supports the *holistic treatment* of the resources on the Moraine under Policy 1.1.1 sections (e) and (f). The PPS also clearly supports the *protection of and precautionary treatment* of natural heritage features and ecological functions under Policies 2.3.1 and 2.3.2.” The PPS defines ‘*Negative impacts*’ as “*the loss of the natural features or functions for which an area is identified*”

Official plans and other municipal planning documents incorporate the philosophy and wording of the Provincial Policy Statements. The Natural Heritage component of the PPS is intended to be balanced against other policy considerations, particularly economics, and other land uses such as agriculture and aggregate production. Apart for the constant struggle to achieve a ‘balance’ (which is altogether undefined in either time or scale) between competing policies, the Natural

Heritage policies of the PPS have not been implemented to the greatest benefit since 1997 due to:

- a) Lack of a credible economic formula with which to compare natural ecosystems 'services' to those offered by urban development;
- b) inexperience of planners and scientists in regard to the interpretation of the PPS policies;
- c) inadequate field study of resources at various stages of planning;
- d) inadequate consideration of scales of resources and impacts (particularly urban matrix impacts) based on available scientific information; and
- e) adoption of unrealistic protective standards that fail upon application, but are not consistently monitored and adapted to improve their effectiveness over time.

Despite this, at the OMB Hearing into the Richmond Hill applications the province's natural heritage system approach provided the only scenario where:

- a) the "maintain and improve" tenet of the PPS is respected, ensuring "net gain" in habitats and functions over time;
- b) the local, meta- and inter-regional/continental scale systems are clearly addressed;
- c) resources receive protection on a functional basis rather than on an ad-hoc site-specific basis; and
- d) this functional approach leaves adequate room for adaptive management subject to further knowledge.

This system aggressively reflects known science and international approaches. It ensures that features and functions can be optimized, and avoids unworkable *micro-management* issues.

The Implementation Guidelines: Provincial Interest on the Oak Ridges Moraine of the Greater Toronto Area (IG) (OMNR / MMA / MOEE 1991) presented principles and evaluation criteria to guide the consideration of land uses on the Moraine, that are largely reflective of the principles set out in the PPS although they predate the PPS by several years. The Sections of the Guidelines that are of particular relevance to the desirable ultimate condition of the Moraine ecosystem include Sections 4.2 (Ecological Integrity), 4.4 (Significant Natural Areas), 4.5 (Woodlands), and 4.6 (Watercourses and Lakes). These Sections clearly address key matters and relevant concepts including: *natural systems and processes, maintain or enhance, biodiversity of flora and fauna, health and functionality of natural corridors, boundaries between development and natural areas, incompatible land uses, indigenous species, and buffers.*

The IG clearly advocated the need to adequately assess, protect and enhance *natural systems and processes* on the Moraine, under Principle 4.2.1. As in the PPS, the IG identify *the status quo of natural diversity as a baseline condition* that should be maintained *in an area*, obviously implying that the natural resources must be understood adequately so that 'maintenance' can be demonstrated. Again, *loss of natural diversity is not an option* to be qualified on the basis of compensatory actions. Thirdly, *the desirability of 'enhancement' of natural systems* is identified (i.e. restoration). The IG provided more detailed guidance relating to Moraine-specific habitats, corridors and anticipated rural/urban conflicts. For example there is explicit reference to buffers in a variety of settings, and to the importance of the use of indigenous tree species.

For the purpose of rating future land use options, there are three possible cumulative outcomes from an ecosystem perspective, which are an effective test under the provisions of the PPS and the IG:

- Net loss of natural heritage features and functions
- Maintenance of existing natural heritage features and functions
- Net gain (or optimization) of natural features and functions

In 1994 a draft "Oak Ridges Moraine Area Strategy for the Greater Toronto Area" was produced

with supporting documentation, but this was never finalized.

The Oak Ridges Moraine Conservation Plan (ORMCP) supersedes the Implementation Guidelines, and applies to the entire Moraine, rather than being limited to the GTA. The main body of the Plan is a regulation provided for by the Oak Ridges Moraine Conservation Act, 2001 - this is preceded by an Introduction, and followed by an Implementation section. The ORMCP requires municipalities in the Plan Area to amend their official plans and zoning by-laws to be consistent with the Plan. It places greater priority on the protection of natural heritage and water resources than the PPS. While decision makers must “have regard” for the PPS, which, historically, has allowed for a degree of flexibility, they “must comply” with the ORMCP. While this helps to resolve the issue of balancing natural ecosystems services with economic development, some uses are permitted in sensitive areas. For example, infrastructure is permitted in key natural heritage features under certain circumstances.

The stated purpose of the ORMCP is “to provide land use and resource management direction to provincial ministers, ministries, and agencies, municipalities, municipal planning authorities, landowners and other stakeholders on how to protect the Moraine’s ecological and hydrological features and functions”. The objectives that relate directly to natural heritage protection are:

- Protecting the ecological and hydrological integrity of the Oak Ridges Moraine Area;
- Ensuring that only land and resource uses that maintain, improve or restore the ecological and hydrological functions of the Oak Ridges Moraine Area are permitted;
- Maintaining, improving or restoring all of the elements that contribute to the ecological and hydrological functions of the Oak Ridges Moraine Area, including the quality and quantity of its water and other resources, and
- Ensuring that the Oak Ridges Moraine Area is maintained as a continuous natural landform and environment for the benefit of present and future generations.

Other objectives relate to providing for land and resource uses compatible with the other objectives of the Plan, continued development in urban and rural settlement areas, and a recreational trail and other recreational access.

The Plan divides the Moraine into four land use designations. *Natural Core Areas* protect the areas with the greatest concentrations of “key natural heritage features”. *Natural Linkage Areas* protect natural and open space linkages between the Natural Core Areas, and along valleys and streams. *Countryside Areas* provide agricultural and rural transition areas, and also include Rural Settlement Areas. *Settlement Areas* are existing communities, with development as permitted by municipal official plans.

Section 20 of the Plan requires that all development applications identify planning, design and construction practices that protect the movement of plants and animals among key natural heritage features, hydrologically sensitive features and adjacent land within Natural Core Areas and Natural Linkage Areas. The government is currently preparing a technical paper to assist in interpreting this Section.

Section 22 of the Plan defines “key natural heritage features”. The range of uses permitted within these features is restricted, and they are to be protected by “minimum vegetation protection zones” which are to be defined when development or site alteration is proposed within “minimum areas of influence”. Section 23 sets out requirements for “natural heritage evaluations”. These would be required to demonstrate that development or site alteration will have no adverse effects on the key natural heritage feature or on related ecological functions, to identify measures to maintain or, where possible, improve the feature, to demonstrate how connectivity would be maintained or improved, and to evaluate whether minimum vegetation protection zones should be created or extended.

The Implementation section contains provisions for performance indicators and monitoring. The provincial government would take the lead in developing performance indicators, but no timelines are provided for this. Monitoring would be a municipal responsibility and may not be adequately resourced or coordinated across the Moraine.

There are many other sections of the Plan that have a bearing on natural heritage protection. For example, Section 35 includes provisions for maintaining connectivity in Natural Linkage Areas when aggregate extraction takes place. The Plan includes transitional provisions that restrict the requirements that apply when land was previously zoned to permit a use, or where an application for development or site alteration was submitted but not decided upon before the Plan came into effect. The Plan's provisions relating to hydrology and hydrogeology will be discussed in Section 3 of this Report.

2.2.2 Scales, Functions and Matrix

2.2.2.1 Landscape Scale and Sensitivity on the Moraine

The Oak Ridges Moraine is an inter-regional landform with highly significant physical, biotic and cultural complexity, with its limits defined not simply on the basis of soils, topography and distinctive landforms (such as kame moraine and kettles), but also in consideration of the extensive functions and their planning protection (surface drainage, groundwater, landform identity, and terrestrial and aquatic ecology). Maintenance of a substantive non-urban natural heritage system is the most viable strategy to achieve inter-regional natural heritage objectives, and the local and meta-scale requirements of sensitive species on these lands. For example, the particular value of the lands of Yonge East and West for these uses includes:

Inter-Regional/Continental

- Direct linkage to other major natural heritage systems: Niagara Escarpment, Trent-Severn, Frontenac Axis (Algonquin Park to Adirondacks)
- Location in the headwaters of the Humber, Don, Holland and Rouge Rivers;
- Linkage to the areas covered in the Rouge Park North Management Plan (2000)
- Linkages to the Maple Uplands, Happy Valley and York Region forest tracts
- Close proximity to the northern limit of the Carolinian Zone

Meta-scale

- Proximity to the Jefferson Forest, Don headwater forests, York Region Forests
- Internally-drained catchments and associated kettle wetlands which sustain breeding of migratory forest amphibians
- Concentrations of highly diverse wetlands and upland habitats.

Local

- Presence of larger kettle lakes (Bond Lake/Bond lake Bog and Phillips Lake) with established ecological and cultural significance
- Presence of Jefferson Forest

In terms of scale and natural diversity, the Moraine is comparable to the Niagara Escarpment, a geologic feature that has been protected under the Niagara Escarpment Plan, and recognized as a Biosphere Reserve by UNESCO. The Moraine contains extensive remnants of forest cover, and unusual wetlands associated with headwater discharge zones, kettle lakes and kettle bogs. Key recharge zones in the Moraine are associated with some of the largest remaining natural forest and wetland areas in Ontario south of the Precambrian shield. These habitats support plants and

animals, many of which require large undisturbed natural areas (OMNR 2000a).

An extensive and complex hydro-geologic system of provincial significance has been identified, associated with the Moraine, which yields baseflow in streams, sustains high quality natural habitats and wildlife populations within and beyond the area of proposed development, and provides potable water resources for at least 250,000 residents and thousands of livestock. The Oak Ridges Moraine contains the headwaters of the Rouge, Credit, Don, Humber, Duffins, Oshawa, Lynde, Bowmanville, and Ganaraska Rivers that form a regional network of ravines and associated stream courses across the Greater Toronto Area. The only coldwater fisheries in the GTA are associated with the upper reaches of streams fed by the Moraine. Streams flowing north from the Moraine sustain coldwater fisheries and the Lake Simcoe fishery.

Despite its large scale, the glacially and fluvially deposited materials that form the physical substrate of the Moraine make it more vulnerable to degradation than the Escarpment, which is formed from bedrock. The prevalence of shallow bedrock on the Escarpment has constrained agricultural and urban development activities, with the result that natural ecosystems including forests, wetlands and other communities have persisted extensively along the Escarpment. The Moraine, on the other hand, has been subjected to high levels of disturbance from agriculture, aggregate extraction, and encroachment by urban development.

Many jurisdictions in Canada and elsewhere are grappling with landscape management at a series of scales. In southern Ontario, the Niagara Escarpment and Great Lakes Basin have been the subject of research, policy development, and legislation to protect their values and functions as large-scale units or provincial, national and international significance. However to date there has not been an integrated approach to planning simultaneously for the series of scales (i.e. local, meta-scale, inter-regional or continental) of natural heritage systems in Ontario. Planning at these scales is being advocated by conservation biologists, and is already underway in some other jurisdictions, including Florida, Appalachia, Colorado, Central America and the European Community.

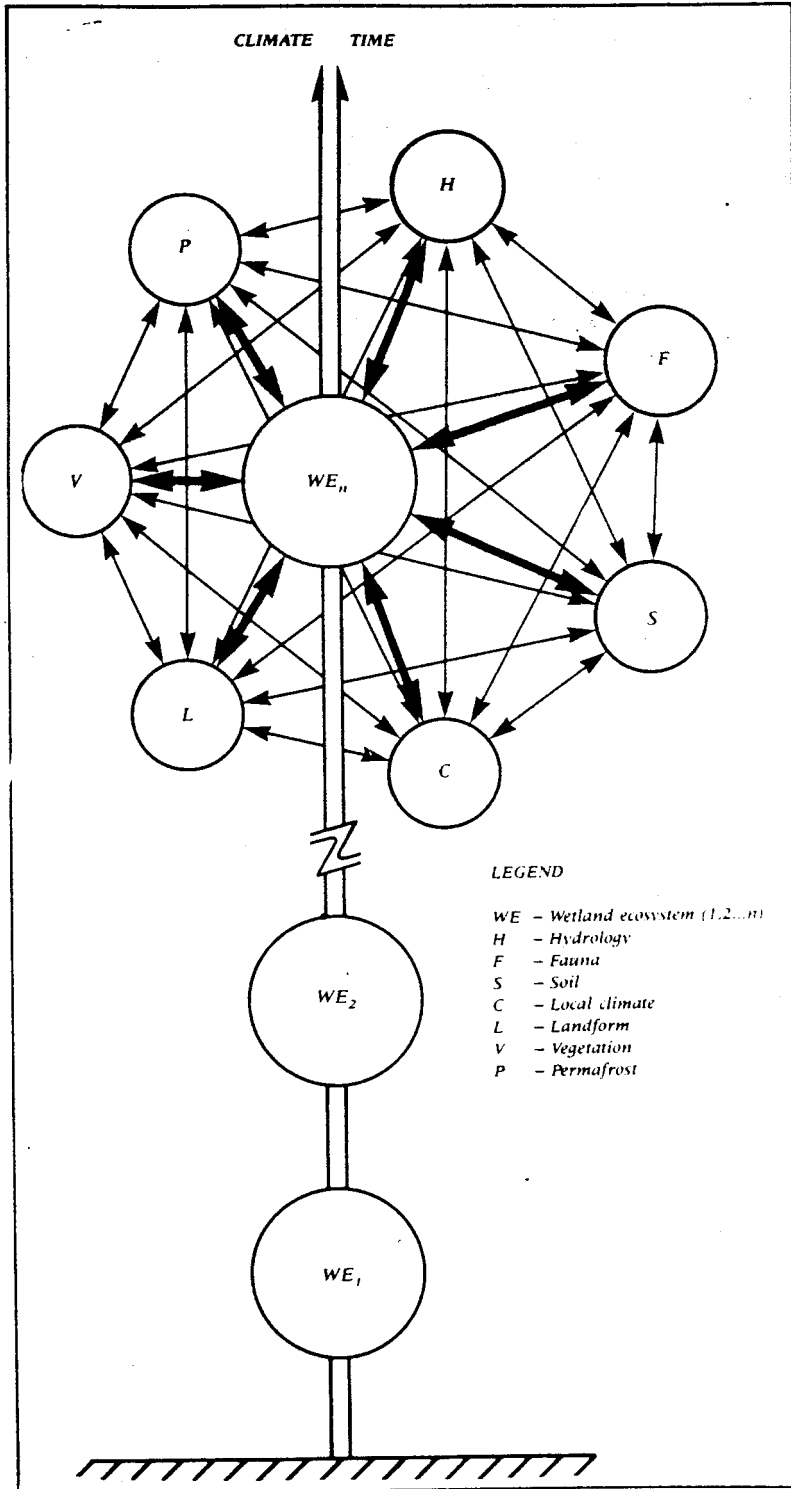
The Moraine is part of a major landscape corridor, which has been identified connecting the Niagara Escarpment to Algonquin Park and the Adirondack Mountains in New York State. The NOAH System (Niagara Escarpment--Oak Ridges Moraine--Algonquin to Adirondack Heritage System) is proposed as a restored system of continental significance, facilitating the protection, restoration and movement of flora and fauna to maintain functional continental and evolutionary scale movement across southern Ontario and eastern North America. The NOAH System thus acts as an 'Ark' to protect and enhance source areas of biodiversity and water from these landforms and feeding downstream via watersheds to the Great Lakes. The NOAH System can extend to connect across to other areas now being protected in Ontario such as Carolinian Canada and the Canadian Shield protected through the Ontario Living Legacy program (NOAH-CC-OLL "Noah sees all") to form a holistic vision for landscape scale natural heritage system planning, protection and stewardship integrated as 'Smart Conservation' as part of the 'Smart Growth' concept.

2.2.2.2 Landscape Functions and the Moraine

Ecological functions are simple to highly complex interrelationships between physical and biological systems in a landscape. They operate across vastly different scales, from minute to global in extent. **Figure 2** is a diagram that summarizes the inter-related functional factors influencing a wetland ecosystem (from Zoltai and Tarnocai, 1976, in Environment Canada, 1988). Hydrology, soils, landform, vegetation, fauna, climate and people all contribute to the manifestation of a wetland ecosystem in the landscape. The diagram also emphasizes the fact that ecosystems are not static in space and time, but are continually evolving in response to time and fluctuations in climate. Restoration ecologists define that pathway as the *trajectory* of the

ecosystem.

Figure 2 - Diagram of Interactions between Environmental Parameters and Wetland Ecosystems through Time and Changing Climate



The Provincial Policy Statement (1997) defines *Ecological functions* as:

“the natural processes, products or services that living and non-living environments perform within or between species, ecosystems or landscapes. These may include biological, physical and socio-economic interactions.”

The ORMCP expands this definition to include hydrological and chemical interactions.

The *products* referred to include not only those derived from soil fertility or mineral resources that directly benefit our economy, but include energy and material exchanges between species and communities in the ecosystem. The *services* include not only actions that benefit humans, (e.g. wetlands filtering runoff prior to infiltration) but also the provision of habitat structure, food and other resources shared by plants, wildlife and microbial communities. There are many services that we as humans regularly take for granted, or that we do not fully comprehend.

Source for Figure 2: Environment Canada, 1988

Figure 3 graphically summarizes many of the known services of plant materials. When quantified, these services are valued at millions of dollars per year in a typical jurisdiction. For example, in 1995 a non-profit group in Fairfax County, Virginia used software developed by the Davey Tree Expert Company with support from the U.S. Forest Service and the International Society of Arboriculture, to calculate that the estimated 57 million trees located in their 9.7 square kilometer County delivered \$398 US million annually in environmental benefits. The benefits considered included air pollution mitigation, carbon storage, stormwater runoff reduction, and energy conservation. (Knapp, M.P. and A. Jordan, 1996).

On a *functional* level, the Oak Ridges Moraine is of greater significance than the Niagara Escarpment, given that:

- a) It sustains the baseflow of all streams traversing the Lake Ontario and Lake Simcoe basins over an extensive area of southern Ontario.
- b) It is a strategically located, topographically rich primary natural heritage corridor connected to:
 - The Niagara Escarpment on the west (forming a continuous corridor between Tobermory and Niagara Falls);
 - Numerous ravines and floodplains of major rivers extending to the shorelines and marshes on Lake Ontario and Lake Simcoe;
 - Major concentrations of regionally and provincially significant habitats on the Lake Iroquois shoreline and the extensive Black Creek wetland system south of Lake Simcoe, and
 - Lakes Scugog and Rice Lake on the east, and to the Bay of Quinte and eastern Lake Ontario via the Trent River system, and into the Frontenac Axis.
- c) It is situated in direct proximity to the most heavily populated area in Canada, providing a range of natural and rural landscapes that are readily accessible to urban residents.

It is clear that the Moraine provided functional services to the natural ecosystem prior to settlement, and has contributed heavily to sustaining Ontario's economy since settlement, providing forest and agricultural products, recreation, safe and dependable water supplies, stream baseflow services (power, irrigation water, and fisheries), climatic moderation, and air quality enhancement. These benefits have accrued to the Moraine proper and to the downstream habitats such as the Rouge River system that are sustained by the functions of the Moraine. These services have a substantial economic value on a regional basis, yet this value has not been quantified and taken into account as part of achieving the 'balance' between economic growth and natural heritage protection that the PPS seeks to ensure.

Considering these services and their beneficiaries, the relationship of ecological functions with landscape scale obviously has important implications for the Moraine. At the OMB hearing on the future of the Yonge East and West lands, there was an attempt to apply a strictly physical interpretation of the Moraine, depicting it as a "smaller and discontinuous feature". Defining it strictly on the basis of the area of well-drained sands and gravels (Pontypool Sandy Loam) is a denial of the true extent of the Moraine, the forces that formed it, and the extent and range of the functional services to its beneficiaries. Indeed, the provincial geomorphologists, Chapman and Putnam, took a much broader view of the extent of the Moraine in The Physiography of Southern Ontario, 3rd Ed. (1984). The official boundary of the Oak Ridges Moraine Planning Area encompasses many expressions of the functions of the Moraine, most particularly related to irregular topography, groundwater recharge / discharge zones, and associated natural habitat features such as kettles, dry forests and headwater valleys.

Figure 3 - Summary of Known Services of Plant Materials

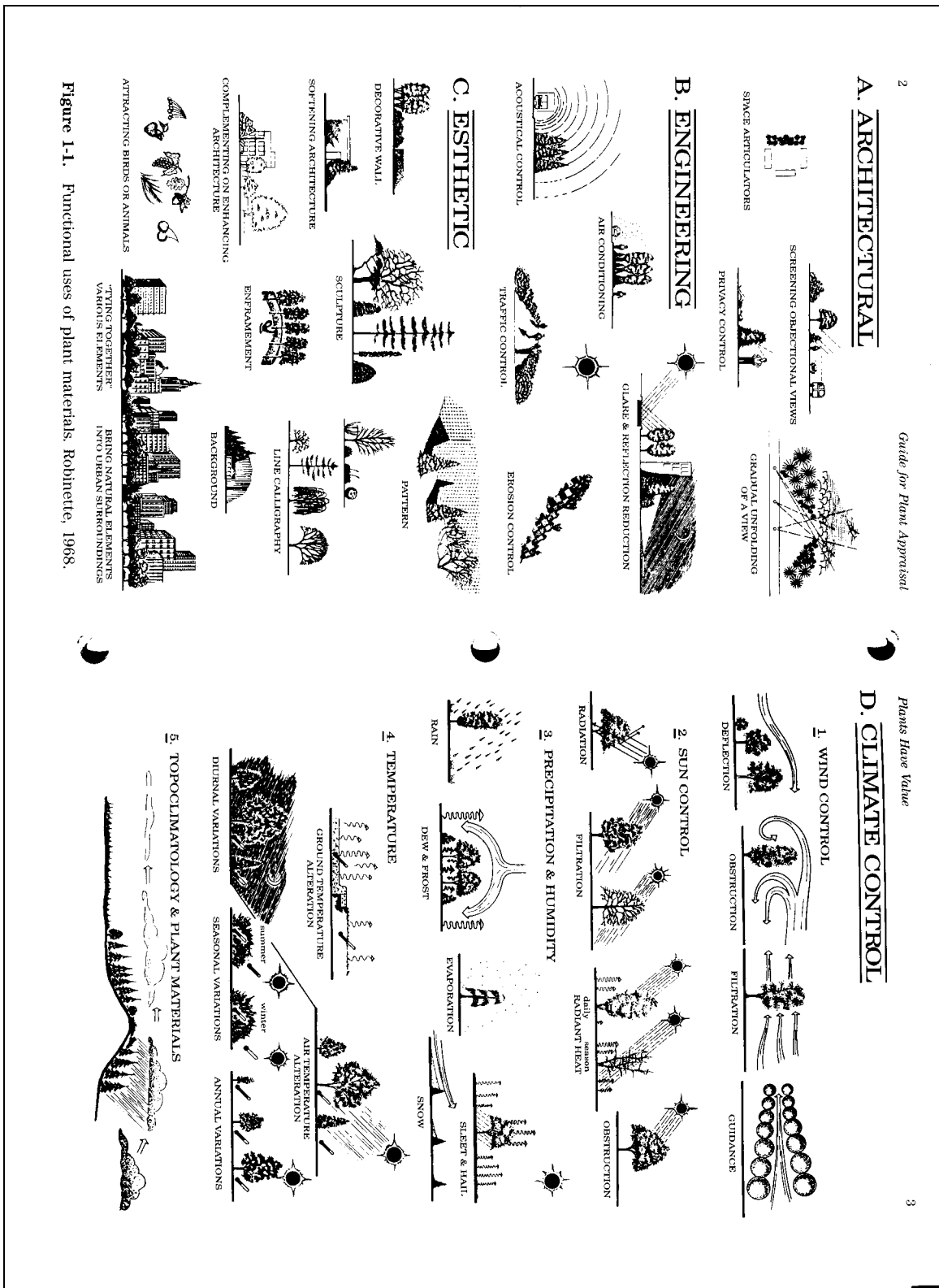


Figure 1-1. Functional uses of plant materials. Robinette, 1968.

Source for Figure 3: Robinette 1968 as cited in Council of Landscape and Tree Appraisers, 1992

What constitutes *loss of ecological function*? Obviously any action which permanently removes or diminishes the ability of attributes to provide “*the natural processes, products or services that living and non-living environments perform within or between species, ecosystems or landscape*”. The PPS defines *negative impacts* as “*the loss of the natural features or functions for which an area is identified*” (the term is not defined in the ORMCP, which uses the term “adverse effect”, meaning “*any impairment, disruption, destruction or harmful alteration*”).

The PPS definition includes a broad range of factors, such as quality and quantity of adapted species and habitats, ground and surface water, soil stability, nutrient management, climate moderation, carbon storage, productive capacity for forestry and agriculture, etc.

Diverse natural ecosystems, as part of the global ecosystem, have a direct role in the maintenance of these functions, and the removal or diminishing of natural features and biodiversity is a critical measure of loss of ecological function. The importance of protecting biodiversity is recognized in the Preamble to the Convention on Biological Diversity (1992) (see **Appendix A**), to which Canada is a signatory. The PPS clearly supports the protection and precautionary treatment of biodiversity and connectivity of habitats on the Moraine under Policy 2.3.3., which advises:

“The diversity of natural features in an area, and the natural connections between them should be maintained, and improved where possible.”

This clause of the PPS is extremely important from several standpoints. Firstly, it identifies *the status quo of natural diversity as a baseline condition* that should be maintained *in an area*, recognizing that the natural resources must be understood adequately so that ‘*maintenance*’ can be demonstrated. Secondly, *loss of natural diversity is not an option*, qualified on the basis of compensatory actions. Thirdly, it *introduces the desirability of ‘improvement’ of natural diversity*. Although “*area*” is not exclusively defined under PPS Section 2.3.3, the wording of Sections 2.3.1 and 2.3.2 suggest the broadest interpretation: reference to *natural features* and *areas* (i.e. collectively), and *ecological functions for which the area is identified* (i.e. including those extending beyond a “feature”). The PPS clearly supports the *holistic treatment* of the resources on the Moraine under Policy 1.1.1 sections (e) and (f). The PPS also clearly supports the *protection of and precautionary treatment* of natural heritage features and ecological functions found on the Moraine under Policies 2.3.1 and 2.3.2.

2.2.2.3 Landscape Matrix and Corridors on the Moraine

Landscape Matrix

A comparison of 1954 and 2000 aerial photographs reveals that there have been some changes in the extent and character of natural cover in the Yonge East and West lands over a period of 46 years. However, as a general observation, the natural features on these lands have proven themselves to be resilient in an agricultural matrix. Varied changes in the type and extent of wetland habitat cover reflect the unique hydrological characteristics and sensitivities of each kettle catchment. The effects of human intervention are quite obvious in some particular cases, such as the conversion of several of the wetlands from woody cover to open water.

A historical account of natural heritage resources in the vicinity of the site was provided by Mayall in The Natural Resources of King Township, Ontario, 1938. This study, which included field plots examining forest cover and wildlife species density, was commissioned to provide a demonstration plan for restoration of soils and natural resources generally. It documented the decline in wetlands and stream fisheries in King Township between 1840 and 1890, related to clearing and grazing of woodlands. It is notable that some sensitive species reported by Mayall in 1938 have persisted in an agricultural matrix on the subject lands despite intensified agricultural

practices.

It is clear that in a highly fragmented agricultural landscape that the matrix is comprised of the cultivated lands which predominate; these dominate key processes such as runoff, infiltration and nutrients in the system. The concept of *landscape resistance* (Forman 1995) is described as “*the effect of structural characteristics of a landscape impeding the rate of flow of objects (species, energy, and material)*”. The agricultural matrix and blend of habitats existing on the Yonge East and West lands is largely favourable to the functions and needs of remnant natural heritage present on the lands and in their immediate proximity, as evidenced by the persistence of species with complex habitat requirements such as forest interior and area sensitive birds, and woodland amphibians. These species are in general decline in the GTA and their persistence here reflects the low resistance offered by this landscape to their seasonal movements and the ability of habitat elements available in this landscape to meet their basic needs.

This matrix is also conducive to the movement and habitat needs of generalist species such as deer, coyotes, raccoons, skunks, toads, mice, chipmunks, and voles. Although these species are less sensitive than those described above (several could even benefit from urbanization), species such as toads, chipmunks and voles would be negatively affected. Agricultural fields provide cover, habitat structure and food which has enabled these species to be sustained at higher levels than in urban settings.

Plant species and habitats in the vicinity of Bond Lake and Jefferson Forest on the Moraine contain evidence of native plant guilds including Trillium, diverse fern species and numerous wildflower species (a “guild” is a suite of species with similar life history traits). The associated tree and shrub cover is of good native quality and condition, which is fortunate given the presence of steep slopes and highly erodible soils. The condition of these habitats indicates that despite the extent of the agricultural matrix, longstanding agricultural uses have not greatly impaired the quality of these habitats in terms of their ability to retain native plant species guilds.

Corridors

There has been considerable debate over what constitutes a corridor, and the minimum requirements to ensure the effectiveness of corridors. In terms of the lands on the Moraine, we know for certain that the present land use matrix and practices have enabled a number of sensitive as well as common species to be sustained on these lands over many decades. These species are being sustained by a mosaic of forest and wetland habitats set in an agricultural matrix which offers low resistance to species movements. The key debate is over the ability of artificial corridors set within a new urban environment to sustain the plant and animal species present in the area in the long term. In terms of Provincial Policy, this is about ecosystem connectivity, and maintaining and improving features and functions.

Mosaics of habitat (i.e. a blend of forest, wetland and successional habitats) are known to be of greater value to organisms than consistent blocks of uniform habitat. Riley & Mohr (OMNR 1994) placed emphasis on “countryside” as complementary to and equivalent to corridors, with the implication that we should be considering rural landscapes as part of an overall natural heritage approach.

A broader range of connectivity approaches need to be considered than the rather simplistic forested strips being typically considered. It is noteworthy that new communities are planned with a hierarchy of roads, ranging from narrow residential streets to controlled access inter-regional roads. We likewise need to adopt standards for landscape connectivity that also operate at local, municipal, inter-regional and continental scales. Artificial strip corridors are only part of the toolkit. The Natural Environmental Planning and Development Guidelines for the North Urban Area (Gore & Storrie, 1993) provided an alternative to planted corridors to provide a broader matrix of habitat patches: “by conserving a variety of smaller natural features such as hedgerows, small groves of trees, ponds, and grassy areas between major habitat patches.”

Virtually all scientific study of corridors has been conducted in rural or natural settings, not in urban settings. A review of more than 80 scientific papers published between 1974 and 2000 found that only two contained information on natural wildlife use of corridors in urban areas (see Appendix B). Because we obviously lack a detailed understanding of how species movements operate in urban settings, a precautionary approach must be adopted when preparing standards for habitat size or buffers or size of connecting links to maintain function.

On the other side of the equation, we have more knowledge about the extent of urban impacts when urban development occurs next to a natural feature such as a woodlot or wetland.

Appendix C summarizes, from the literature, some key dimensions of known urban impact factors, such as the scale of domestic cat and urban wildlife movements, effects of road noise, effects of residential proximity on forest and wetland functions, and direct impacts of various types associated with residential uses. These numbers suggest that impacts of residential and urban uses generally extend well beyond the protective setbacks and buffer limits that are routinely prescribed in southern Ontario. Indeed, development setbacks of at least several hundred metres are required before urban impacts dissipate, and natural systems can continue to operate with the same stability and resilience that they have maintained over many decades. Buffers and setbacks as part of artificial corridors in urban areas rarely allow for the complexities of species movements over time, cannot replace the supporting role of farmland, and are therefore incapable of replacing the connectivity of countryside corridors.

When artificial corridors are to be constructed in an urbanizing setting, the existing landscape functions have to be maintained throughout a protracted period of development, typically extending over a period of 2-5 years in good economic times. Federal fisheries policies require that construction in stream channels occur outside fish spawning and migration periods. In the case of sensitive terrestrial species such as migratory frogs or salamanders, how can habitat connection functions be maintained over several years of continuous disturbance? Current development practices (such as on the OPA 129 lands in Richmond Hill) leave large areas without vegetative cover for one or more years, and there are no regulatory restrictions on timing of grading or servicing. A single episode of poor timing could eliminate a local population of amphibians. Whereas a developer could be charged under the Federal Fisheries Act for working in a restricted period, no comparable regulations protect terrestrial organisms. Legal penalties will not, however, re-establish a damaged system.

2.3 Target Wildlife Species and Key Conservation Issues

2.3.1 Top Predators

Rural land uses on the Moraine have enabled a number of sensitive as well as common species to be sustained in the mosaic of forest and wetland habitats which are set in an agricultural matrix, and which offer low resistance to species movements. If a “maintain and improve” approach is to be adopted which would have regard for the PPS (and, in the Moraine, comply with the ORMCP), the natural heritage connection should accommodate all key species of concern that are currently associated with the local and meta-scales, as well as facilitating inter-regional and continental movements of other area-sensitive species. By focusing on predatory mammals (such as lynx and fisher) as target species, the greatest accommodation can be assured for all species.

The trophic web or food chain is the most fundamental concept in ecology. Loss of forest cover, habitat fragmentation, and extermination of predators based on agricultural concerns have rendered most predator-prey relationships dysfunctional in southern Ontario. At the present time populations of species such as black squirrels, raccoons, red fox, white-tailed deer and skunk are

wildly out of control in urban and urban fringe areas, and are in turn having severe impacts on other species such as forest interior birds (nest predation by raccoon and skunk and squirrels), and native plants (foraging by deer). These urban-adapted species can carry serious diseases (rabies and lyme disease) which are a significant risk to humans. The coyote, an immigrant predator from the western provinces which is adapted to fragmented forests and farmland, has moved into our region over the past 100 years, and is now regularly observed in urban areas. The fisher is a sophisticated, forest-based predator that feeds on small mammals and birds up to and including porcupine. Lynx and bobcat are also highly secretive species that primarily target small mammals and are occasionally spotted in agricultural areas of southern Ontario. Timber wolves are occasionally seen along the Oak Ridges Moraine as single males or in small packs of 2 to 3 individuals. Concern has been expressed regarding the 'acceptability' of mammalian predators such as wolf, coyote, cougar, lynx, bobcat, fisher and black bear as potential inhabitants of natural habitats near urban areas; meanwhile prey species are out of control in these environments and are becoming a nuisance.

Safety concerns about predators are largely folklore, compared to real threats from common urban hazards such as traffic accidents and contaminated air. There have been only 40 fatalities attributed to black bears in North America over the past century, six of them in Ontario (OMNR, 2000b). By comparison, in 1994 the Centre for Disease Control and Prevention in Atlanta estimated that 4.7 million Americans were bitten by domestic dogs annually. Many more people are killed by lightning, bee stings, and domestic dog attacks in a single year than by black bear attacks in the past century. An American bear expert has calculated that humans are 160,000 times more likely to be killed in a car accident than by a black bear. Wolves, lynx, cougar, coyote, and fisher, as well as raptors such as hawks and owls, undoubtedly pose a threat to free-roaming domestic dogs and cats. However, the services provided by natural predators in maintaining balance in natural ecosystems far outweigh the potential inconvenience of occasional human encounters with wildlife, or of keeping pets on a leash. Humans living in more remote and northern areas that do live with these large predators around have learned to adapt their patterns of behaviour to avoid interaction with these species. Most large predator species are afraid of humans and avoid interaction with us as well.

Landscape measures that restore trophic integrity (i.e. provide for the full range of species, including predators) are generally desirable. Higher order predators, and large omnivorous species (i.e. black bears) would benefit from a rural connection across the Moraine. These species are capable of long treks, which apparently they are already making; there have been new records of wolf, black bear, lynx and bobcat within the GTA and its periphery over the past decade. This does not imply that these species will become sufficiently numerous to become a problem to humans; large blocks of forested habitat are required to sustain significant populations, and are simply not present in the GTA and most of southern Ontario. Other key predators such as hawks and owls will directly benefit from sustainable natural linkages in the landscape. These species also provide direct services to humans in terms of controlling rodents skunks and raccoons.

The provision of relatively broad (i.e. 0.5 km or wider) corridors through settled areas in southern Ontario is key to "maintaining and improving" a healthy natural heritage system. Where the corridor passes through urban areas, additional corridor width is required to buffer the intense impacts of urban proximity (see Section 2.2.2.3). An inter-regional corridor system should address the buffer needs by placing the corridor in countryside, containing agricultural lands and well linked core blocks of upland forest and wetland habitats, capable of sustaining typical predatory species such as red fox and coyote. In the case of the Moraine, this system would inevitably encourage movement of predators such as black bear and lynx between major regional habitat features (e.g. Bruce Peninsula on the Niagara Escarpment, Algonquin Park, Adirondack Mountains), maintaining gene flow which is essential to sustaining healthy populations in the long term.

Core areas needed to sustain predator territories range in the order of 100 square kilometres for

male cougars (5 times smaller for females) up to 275 square kilometres for wolf packs (range 110 to 275 km²). Coyotes, on the other hand, require a much smaller range of 30-60 square kilometres (1/6th that of wolves) with correspondingly smaller pack sizes. Red-shouldered hawk, once the most common forest raptor, and now the least common hawk in southern Ontario, requires about 2 square kilometres of foraging and nesting habitat near wetlands.

Key Points on Top Predators

- Top predators should be target species for ecosystem management on the Moraine and other landscapes
- Landscape corridors of different scales are critical to sustaining top predators at local, meta and inter-regional or continental scales

2.3.2 Birds

Since the early 1960's, many songbird species associated with 'forest interior' areas (i.e. forested blocks with at least 100 m from any edge) have undergone serious declines in population. These migratory species (known as 'neotropical' species) have suffered from loss of forest cover both in North America and in the tropical countries where they overwinter. International efforts have been underway for more than a decade, to identify and protect remaining large blocks of forested habitat at both ends of their range, to rebuild blocks of forested habitat, and to better understand the factors that reduce the value of habitat for interior species.

Research by Friesen (1995,1998) and others has shown that forest bird species are not uniformly affected by forest fragmentation, and that proximity to residential development reduces the ability of individual woodlots to sustain quality interior species. A key concern is whether smaller habitat areas contribute positively to populations at the regional level (i.e. operate as *source* habitats), or simply draw birds away from larger productive habitats into forest fragments which, because of nest predation and parasitism, are non-productive in terms of the regional population (i.e. operate as *sink* habitats). Friesen (1999) found that Wood Thrushes were productive in small rural woodlots, whereas Rose-breasted Grosbeaks were not. In a study on the nesting success of five forest-nesting bird species in southern Ontario, Burke and Nol (2000) observed that only 1% of available forest fragments serve as sources for these species, and 82% of fragments lack any interior core. Obviously, the restoration of blocks of forest with interior core components will be critical to sustaining populations of these migratory species. Environment Canada (1998) developed guidelines for habitat rehabilitation in Great Lakes Areas of Concern, which concluded that 30% of watersheds should be in forest cover, including at least one 200 ha forest patch which is at least 500 metres wide.

Corridor creation concepts in Richmond Hill focused on the creation of forest interior conditions between core areas, a perspective that may be invalid in the long term as other species and habitats become threatened, or as factors such as climate change come into play. Tradeoffs should be avoided which sacrifice known habitat of open meadow species (such as the Vesper Sparrow and Bobolink - currently considered "species of concern" by TRCA, and species of "conservation priority" by Bird Studies Canada) to create reforestation. Open meadow species may have their status upgraded to "vulnerable and threatened" well before the forest interior species can successfully utilize the reforested open habitats. Based on the precautionary principle, the protection of countryside corridors containing large, diverse mosaics of habitat (open to forested; upland to wetland) is more prudent than creating small, uniform blocks of forest surrounded by intensive urban or agricultural land uses. Such mosaics are most consistently sustained through succession in a 'countryside' context; reforestation within urban boundaries is structurally uniform, and vulnerable to simplification to fit shifting human priorities.

Key Points on Birds:

- Restoration and enhancement of forest interior habitat should be a priority, but an overall mosaic of habitats is also highly desirable
- The goal of maintaining and enhancing habitat to sustain forest interior as well as open meadow and wetland species requires corridors at different scales; 'countryside' is critical to sustaining many species.

2.3.3 Amphibians

Given their limited range and ability to move quickly, amphibians, which are terrestrial species that need to move overland between upland and wetland habitats, are ideal to use as indicators of the maintenance of both terrestrial and aquatic ecosystems and overland connectivity between these habitats. They are also good indicators of the health of both terrestrial and aquatic environments themselves owing to their need to live in both habitat types. They are sensitive to drought, flooding, water fluctuations, chemical perturbation, forest desiccation, as well as habitat degradation and loss. They respond to negative impacts quickly, often immediately with acute impacts, to a few years with chronic impacts, with different species varying in their response to negative impacts. Loss of particular species or guilds can point to specific negative impacts. For example, as herbivorous tadpole larvae, they contribute enormously to the cleansing of water through removal of excess nutrient loading in wetlands via consumption of vast quantities of algae. Loss of amphibian reproduction can show up as eutrophication and degraded water quality, which itself is often the cause of the amphibian decline. Their place in the food chain as mid-level predators and prey makes it important to maintain their numbers and diversity due to their high reproductive rate, as they often contribute to more biomass than all other species combined in both wetland and forest ecosystems. They are also easily identified by sight and calls and are abundant and often ubiquitous, so are a good monitoring indicator to use to track changes in the environment.

Recommendations can be derived for guilds of amphibians that mainly reside either in woodlands or wetlands throughout most of the year. These allow for connectivity to be achieved between various habitats that otherwise may be isolated if only birds or mammal species were used as 'indicators' of connectivity. Woodland amphibians need to migrate in spring from wooded habitat where they overwinter to nearby wetlands to breed and then back to woodland habitat soon after breeding. Aquatic amphibians migrate in spring or summer from deep or moving waterbodies where they overwinter to shallow breeding waterbodies nearby. These latter species will often reside all summer along the edge or within the waterbody, sometimes moving to forage in more upland habitat, often meadows, during rain events. In late summer and fall, they will migrate back to overwintering areas.

Using the habitat requirements and responses of amphibians to their habitat and surrounding land use we can see that amphibians are the most sensitive of the terrestrial taxa since they require both upland and wetland habitats within 1 km of each other. This is the typical distance that can be covered by an individual amphibian during migration, although migration from 1.6 km has been recorded. Dispersal distances of juveniles moving out from their natal wetlands to find their own territories to occupy is often much greater than 1 km (6 km + in green frogs and leopard frogs) and need to be accounted for in any system design in order to retain functional connectivity across the landscape.

The 'core' habitat for amphibians needs to be identified as both the breeding and overwintering habitat and adult migration pathways in between these habitats. Woodland amphibians will often seek out shelter under tree canopy and emerge only into open field habitat as a last resort, as close to their breeding wetland as possible in order to minimize exposure to predators and desiccation. This migration to breeding wetlands can often be from many directions in a woodland

area or from many surrounding woodlands, depending on where adults have chosen to set up their summer and wintering territories. The best migration route is not necessarily the shortest distance between the two closest woodland and wetland habitats.

Migration direction from woodlands will depend on the size and number of woodlands, with larger woodlands being chosen and successfully occupied by more amphibians, and the number and location of suitable breeding wetlands. Migration drift fence studies often need to be done to determine these routes if development is to be allowed near migration routes in order to still provide for functional amphibian habitat as long-term amphibian success in urban areas is very low (see Helferty 2002 for further detailed analysis on amphibian requirements).

The most sensitive amphibian species are those that are woodland residents, like the nationally threatened Jefferson salamander. These species require good quality woodlands (moist, shaded mature hardwood or mixed forest with ground cover) within 1 km of good quality wetlands (clear water, natural water fluctuation, some egg laying substrates and cover) with defined migration routes in between that are not blocked by obstructions. Migration occurs over one to a few nights and so sheltered areas during the day need to be provided along those defined routes in order for the amphibians to avoid desiccation and predators. Urban habitat does not provide enough of these suitable conditions as obstructions, predators and desiccation risk all increase in urban areas. Thus, urban environments often result in the extirpation of most or all woodland species. The more terrestrial aquatic species, like leopard frog and green frog, as well as the drought-tolerant American toad, can often survive in greenbelts within urban settings, but not within a wholly developed area devoid of wetland and meadow habitats.

Therefore, it is essential that core areas used as source habitat for biodiversity and high population abundance are identified properly and protected. The best quality, largest and most abundant forest and wetland habitats where reproduction takes place successfully year after year need to be set aside as core areas with little to no human interference. These areas will be the source habitat for amphibians to disperse via linkages into other nearby more human-dominated urban areas that will be influenced by negative impacts.

Dispersal routes for juveniles occur radially outward from the natal wetland in no particular direction, so numerous riparian and woodland 'linkage' routes to adjacent woodland and wetland 'cores' need to be provided as well. The more 'linkage' provided, the better the chance that more juveniles will successfully disperse to occupy adjacent 'core' areas, thus providing gene flow over the long term.

Maintaining an overland 'linkage' of suitable habitat is required to ensure that sensitive species can successfully colonize nearby sink habitats. This linkage habitat needs to be comprised of non-breeding habitat that is used for foraging, shelter and potential over-wintering habitat in order for the dispersing individual to survive over a number of years as it emigrates from the source habitat and establishes its own territory as it matures. Juvenile amphibians that disperse out from breeding wetlands to new habitats in summer and early fall require either 'core' or 'linkage' habitat to ensure a successful journey to an overwintering site for that winter and then to a new breeding habitat in subsequent years once they reach maturity.

Linkage habitat can consist of lower quality habitat that is not adequate for reproduction or over-wintering, but is adequate for dispersal and foraging. Riparian areas, fields, small woodlots, hedgerows, ditches etc. can all be considered 'linkage' habitat. Wetlands and ponds can also act as 'stepping stones' for juvenile dispersal until they reach maturity and decide to breed in a particular wetland. Like 'core' habitat, linkage habitat needs to be of adequate quality to allow for long-term survival of the species as a whole within a particular geographic area.

Often a wide and radial dispersal pattern occurs as young amphibians emerge from wetlands. Some amphibian species do not disperse far and some disperse long distances immediately. As the edge of 'core' areas are reached after a number of days, months or even years go by, the

habitat that is of lower quality (often through open agricultural or urban areas) needs to be of sufficient size and width to: 1) allow a high proportion of juveniles to find the linkage and 2) attract the juveniles through the area.

Attraction of amphibians to habitat is usually 3-fold. The area has to be 1) shaded enough to avoid predation, but well-lit enough so they can see it is a passageway, i.e. not a dead-end, 2) moist enough to avoid desiccation, and 3) provide foraging opportunities (plenty of invertebrates). The third criterion will only be required if the length of the 'linkage' is required over a number of days. A wildlife underpass under a 4-lane road, for example, which is relatively short, can meet the first two criteria to be a suitable linkage for most amphibians. A fourth (often ignored) criterion is width to length ratio. The longer the 'linkage' area is, the wider it should be. If an amphibian has to travel over many weeks or years to reach an adjacent 'core' area, then sufficient habitat for prey production needs to be considered. A 20 km strip of habitat 1 m wide, such as a drainage ditch, will usually not provide sufficient habitat for invertebrate reproduction (or shelter) given the enormous length that is needed for an individual amphibian to travel.

Also, the type of habitat within that 'linkage' must be taken into consideration. In the above example, a number of 'stepping-stone' habitat areas would be required along that 20 km stretch to provide for suitable overwintering and foraging conditions, even if breeding could not occur there. The 'linkage' habitat used for dispersing juveniles can consist of small woodlands, streams, ditches and adjacent riparian zones, and meadows. Agricultural lands, to some extent, as well as associated hedgerows, can also be considered 'linkage' habitat, provided the open active agricultural land is not too wide to traverse and/or some vegetated cover is available for foraging and movement along a hedgerow. If the first two criteria are violated, i.e. no cover and no moisture, then the 'linkage' habitat will not be useful for amphibians even if invertebrates are available. Most amphibians can move up to 100 m in one evening, with ranids (i.e. "true" frogs) moving further than treefrogs and salamanders can. Daytime movement is kept to a minimum in most species, unless it is raining and moisture conditions thus permit it. Therefore, stepping stones should be a maximum of 100 m apart to allow for easy access between suitable habitat and a minimum of exposure to open conditions.

Depending on the species, more aquatic amphibians prefer linear stream corridors and adjacent meadows to disperse along. More upland species prefer wooded habitats or meadows to disperse through. Leopard frogs may also be found in wooded habitats on occasion if stream corridors are not available to retain moisture. American toads, being the most drought tolerant, can often live and overwinter successfully in mature urban areas that have sufficient vegetation and insect production within yards and parks.

From the review of the information provided on negative impacts, maintaining 'core' areas as sources of reproduction for a variety of species is essential. The lands on the Oak Ridges Moraine, particularly in Richmond Hill where many breeding wetlands are in close proximity to a large forest block (Jefferson Forest) and old fields near headwater streams, should be considered a 'core area' in its entirety. The 'linkage' habitat should be provided along wooded riparian stream corridors to downstream wetland locations and across farm fields of the Oak Ridges Moraine to other 'core' woodland and wetland areas.

Key Points on Amphibians:

- Overland connectivity between wetlands and woodlands is essential. Wide corridors between these habitats are needed. Widths of corridors need to be as wide as the breeding wetland and woodland block.
- Radial dispersal patterns from wetlands to adjoining habitats (i.e. other wetlands, ponds, lakes, woodlands, rivers) should be recognized in designing proper connectivity patterns. Multiple corridors or whole wetland/forest/river complexes need to be protected.

- Countryside and rural land uses are more compatible with wetland/forest/river protection for amphibians than are urban uses. Wider buffers and corridors are required to protect wetland/forest/river habitats within an urban matrix than are required in a rural matrix.

2.3.4 Fish and Invertebrates

Benthic invertebrates and fish are of conservation concern mainly due to their role as indicators of the health of an ecosystem. Streams and lakes devoid of fish are generally considered of degraded quality when compared to those with a diverse fish fauna. Similarly streams supporting dragonflies, stoneflies and mayflies are generally considered of higher quality than those supporting only sludge worms or air breathing mites.

2.3.4.1 Benthic Macroinvertebrates

Benthic macroinvertebrates or 'benthos' are terms used to describe the animals that live in water for part or all of their life and are generally associated with the bottom substrata. In fresh water, the organisms prevalent in this group include worms, clams, crayfish and a wide variety of insect species. Benthos have been recognized for well over 100 years as an indicator of the health of both marine and freshwater environments and are used in quality surveillance monitoring. Books have been written describing the use of benthos as indicators of water quality (e.g. Rosenberg and Resh, 1993). Recently in Ontario the Ministry of the Environment has developed a system for assessing Southern Ontario streams using a technique known as BioMAP (Griffiths, 1999). These references should be consulted by those interested in the science of biomonitoring freshwater systems using invertebrates.

Generally the public is unaware and unconcerned with the health of the benthic community in urban streams. These organisms are, however, important as a food source for fish and act as sentinels of environmental quality. These organisms live in water for most, if not all, of their lives and, therefore, are exposed to episodic changes in water quality, which could be easily missed in a chemical quality sampling program. Benthos are also sensitive to physical changes in aquatic systems such as inputs of sediments that are associated with the construction phase of urban development.

2.3.4.2 Fish

Unlike invertebrates the fish fauna are more obvious to the general public. They are also protected by federal legislation, the Federal Fisheries Act (FFA). This is the most significant environmental legislation in Canada to provide protection to indigenous fauna. Harmful alteration, disruption or destruction of fish habitat can result in charges and fines under this Act, and orders to rehabilitate the damage caused.

In the case of development proposals on a feature such as the Moraine, fish can be particularly susceptible to changes in both water quality and water quantity. Moraines collect water and discharge this cool water months or years later. Fish such as brook trout (*Salvelinus fontinalis*) have stringent environmental requirements for spawning. They are dependent on groundwater discharge zones in headwater streams. Disruption to groundwater recharge areas, which can be remote from the spawning stream, can result in extirpation of local fish populations. Concentrating recharge in a few rapid infiltration basins may result in increased discharge to one headwater tributary and a decrease to another. Such injection sites for groundwater were proposed for the Young East and West developments (although they are now prohibited by the

ORMCP) and no analysis of potential changes to the amount or quality of either ground or surface water at identified trout spawning site was completed.

Other species of fish are also afforded protection under the Federal Fisheries Act. Indeed the Act does not differentiate between fish species. In addition to sensitive cold or cool water sport species, species such as the redbreasted dace (*Clinostomus elongatus*) are listed by COSEWIC (2002) as a “species of special concern”. Species in this category are listed by COSEWIC because they are particularly sensitive to human activities. This species prefers clear, cool flowing water with a gravel or stony bottom and is quite sensitive to increased turbidity (Scott and Crossman, 1998). Developments, even with stormwater management ponds, can change the hydrology and water quality beyond the tolerance range for this species. Overflow facilities that were proposed for the stormwater management ponds of the Young East development would have resulted in periodic discharges to the headwaters of tributaries of the Rouge River system. The impacts of such discharges on the geomorphology of these headwater tributaries and associated erosion and sedimentation in off site areas remain unknown.

This is a general problem of site specific impact assessments which fails to address off-site and downstream impacts. By the time changes in the downstream area are evident, it is generally too late to implement effective remedial measures to avoid or mitigate adverse effects on the biota of the streams

Key points on fish:

- Changes in groundwater quality and quantity on a development site can adversely affect fish habitat at sites remote from the development
- Need to assess sensitive species habitat requirements, even if the habitat is adjacent to the development site, and not on-site.
- Water quality models must be calibrated when used on lakes that are significantly different than the lakes for which they were developed
- Models are not a substitute for collection of site specific data. Even the best of models require calibration

2.3.5 Roads and Wildlife

Existing and future roads represent a constraint to the functioning of natural heritage systems. Each year, countless millions of birds, small to large mammals, amphibians, reptiles and invertebrates are killed when they collide with moving vehicles; the overall impacts of these losses on species population viability are generally poorly understood with, for example, amphibian studies showing reduced calling, and thus population size, over time in wetlands adjacent to major roads. However, the matter of wildlife conflicts with the existing road grid should not discourage the consideration of a more viable natural heritage system. Despite the presence of major multi-lane roads, there is evidence of significant wildlife movement through agricultural landscapes, including the Moraine. Indeed, encounters between vehicles and more secretive wildlife (such as lynx) provide clear evidence that these landscapes are part of vital wildlife corridors.

There are existing and future opportunities to enhance wildlife movements across local and regional roads including 400-series Highways. All roads are subject to regular rebuilding and improvement to meet new standards; the provision of safer roads should encompass the reduction of conflicts between the natural movements of wildlife, and vehicular traffic. Technologies (a.k.a. “ecological engineering”) are now available and being actively pursued in the design and reconstruction of major and local roads to enhance the movement of wildlife.

Roads of different scales have different impacts on wildlife. Major multi-lane expressways with high traffic volumes and speeds (eg. 400-series Highways) create major barriers to most terrestrial species; New Jersey barrier medians and tall chain link property fences increase the effects of fragmentation. However, these roads often include major overpasses, bridges and large culverts that could permit focused wildlife movement. All classes of wildlife can typically cross major urban arterial roads that have a rural cross section (i.e. no curbs and gutters); on busy roads, wildlife are typically exposed to high levels of mortality except for late at night when traffic levels are diminished. Roads with an urban cross section (local residential streets, and arterials with curb and gutter configuration) also contribute to high wildlife mortality, and pose additional problems for animals such as salamanders, which cannot mount the steep curbs.

Road and wildlife conflicts are a regular issue in the design of new or upgraded roads. Projects to promote the safe movement of wildlife under or over roads are being designed in Canada, the US, and in Europe. In general these projects have been initiated based on concerns from citizens and wildlife managers over wildlife and human safety. Approaches to increase compatibility between roads and wildlife movements include:

- Reflectors, mirrors, repellents, bait, one-way gates and fencing to discourage or physically prevent wildlife access to roads (especially for large mammals such as deer, elk, and moose);
- Wildlife crossing warning signs;
- Overpasses, culverts, tunnels or land bridges specifically designed to permit safe wildlife movement;
- Fences, walls, berms or plantings to channel wildlife movements to safer crossing points.

These measures have been implemented successfully for a full range of terrestrial species. Prefabricated culverts designed for amphibian movement are commercially available. However, the successful application of these approaches requires careful design and monitoring with an understanding of the behavioural requirements of target species.

Sections 41 (2) and (3) of the ORMCP require that where transportation, infrastructure and utilities are proposed in Natural Core and Natural Linkage Areas, the project must “allow for wildlife movement”, *“to the extent that it is possible while also meeting all applicable safety standards”*.

Appendix D contains a profile of approaches from Forman (1995).

Key points on road and wildlife conflicts:

- Wildlife conflicts with the existing road grid should not discourage the consideration of a more viable natural heritage system
- The provision of safer roads should encompass the reduction of conflicts between the natural movements of wildlife, and vehicular traffic
- ‘Ecological engineering’ approaches to improve wildlife and human safety should be considered whenever new roads are designed or existing roads are upgraded

2.3.6 Domestic Pets and Urban Affiliated Wildlife

Domestic cats were referred to by one OMB hearing witness as “subsidized predators” that alter natural wildlife populations in urban settings. They are known to move up to 190 m from home under urban conditions (Haspel & Calhoun, 1991) and have a home range of 30-40 ha under rural conditions (Ogan & Jurak, 1997). Dogs, even when they are on leashes or penned in

backyards, disrupt wildlife utilization of adjoining habitats.

Wildlife populations are significantly altered by human proximity, due to factors as varied as provision of bird feeders, access to garbage, lack of top predators, high numbers of road killed animals and general tolerance of these species to humans. Urban affiliated wildlife include raccoons, opossums, skunks, blue jays, grackles, and grey squirrels and all are implicated in the decline of forest birds in woodlots near urban areas. Large populations of some of these urban-affiliated wildlife also alter the composition of forest cover allowing exotic species to replace more conservative native plant species. Increasing forest cover (reduced forest fragmentation) and maintaining adequate open space will allow for maintenance of top predators such as foxes, coyotes and great-horned owls to keep the numbers of these nest predators in check.

Key points on domestic pets and wildlife:

- The predatory and disruptive aspects of pets need to be recognized and addressed in the planning and design of urban natural heritage systems
- Managing the landscape to minimize the impacts of human affiliated wildlife requires corridors at different scales; 'countryside' is critical to sustaining stable populations of wildlife species.

2.4 Plant Communities and Related Conservation Issues

The preceding sections have discussed target wildlife species and key conservation issues that affect them. This has encompassed matters such as the need for mosaics of habitat, minimum size of habitat blocks to sustain key wildlife species, provision of corridors to sustain seasonal and sporadic migration of wildlife, and approaches to reduce the impacts of roads on these movements.

Plant communities are also strongly affected by the nature and extent of human activities on adjacent lands. In the following discussion, key impact issues are identified, and measures to avoid or reduce impacts are outlined.

2.4.1 Wetlands

There are six key sources of impacts that typically threaten quality and sustainability of natural wetlands:

- 1) *modification of catchment boundaries (affects runoff quantity and hydroperiods)*
- 2) *increased imperviousness of catchments (affects runoff quality, quantity and hydroperiods);*
- 3) *change from relatively diffuse to point source discharges of runoff into wetlands (affects quantity attenuation, hydroperiods, and runoff quality);*
- 4) *conversion of wetlands from closed to open systems (affects hydroperiods and quality);*
- 5) *the change in surrounding landscape/habitat matrix from rural to urban; and*
- 6) *the introduction of intensive human activities into the immediate vicinity of the wetlands.*

Urbanization typically results in changes to known wetland functions including:

Impacts attributable to changes to water quantity and quality

- *simplification of habitat structure and loss of species diversity*
- *local extirpation of plant and animal species, with negative implications on populations elsewhere on the Moraine*

Other impacts attributable to urbanization

- *transformation of matrix*
- *removal of some existing wetlands and adjoining upland habitat*
- *fragmentation by urban uses*
- *intrusion of human proximity effects*

The assessment of the acceptability of the predicted impacts of development must ultimately be made based on their effects on *ecosystem functions*. A similar term, “ecological functions”, is defined in the PPS (1997) as: “*the natural processes, products or services that living and non-living environments provide and perform services within or between species, ecosystems and landscapes. These may include biological, physical and socio-economic interactions.*” The ORMCP expands this definition to include hydrological and chemical interactions.

The Region of York Official Plan (1999) defines *Functions* as: “The physical processes or actions in the landscape related to the movement and interaction of ground and surface water. The provision of vegetated terrestrial habitat and aquatic habitat as support for fauna.”

The Region’s OP does not permit the following within 120 metres of an identified wetland:

- i. loss of wetland functions;
- ii. creation of subsequent demand for future development that will negatively affect existing wetland functions;
- iii. conflict with existing site-specific wetland management practices; or
- iv. loss of contiguous wetland area.

As discussed in the Manual of Implementation Guidelines for the Wetlands Policy Statement (OMNR & MMAH, 1992), modern wetland science includes ecological functions and wetland benefits under the umbrella of “wetland functions”. The Ontario Wetland Evaluation System (May 1994) recognized ecosystem values as well as human utility values of natural wetlands, scoring wetland values in each of four separate functional components: *biological, hydrological, social, and special features*. This yields component scores as well as an overall score. However, only the biological and special features scores trigger ‘provincially significant’ status in their own right; utilitarian benefits related to hydrologic functions and social values (e.g. recreation, forestry use) are deemed to be secondary to the intrinsic biological and special features of wetlands in southern Ontario. Therefore if existing wetland functions such as presence of rare species and interspersions are disrupted by urbanization, wetland significance will be reduced in the critical biological and special features.

Specific impacts to wetlands of changes to water quantity and quality characteristics are discussed in Section 3. Other changes to wetlands are discussed below.

Key points regarding wetlands (see also Water Quantity and Quality)

- Wetland protection must consider the surrounding landscape matrix; the sustainability of wetland functions (i.e. biological, hydrological, social and special features) is reliant on maintaining a rural and natural matrix

2.4.2 Upland Habitats

In most of southern Ontario, there has been ongoing loss of woodland cover under agricultural and urban tenure. The Federation of Ontario Naturalists (1999) provided a comprehensive accounting of the status of upland and wetland cover in southern Ontario since settlement. Before settlement, approximately 64% of the land base was upland (dry-mesic) forest. Between 1850 and 1920, 93.7% of this original forest was converted to non-forest uses, and further loss of the remaining original forest has occurred since 1920. As of 1978, 17.4% of southern Ontario consists of upland forest or scrub succession. Only 0.07% of the original forest remains. These values represent overall averages; the most heavily agricultural and urban areas contain less than 10% forest cover, whereas portions of eastern Ontario and northern counties south of the Precambrian Shield contain greater than 25% forest cover. There has been some recovery of forest cover in some areas of southern Ontario due to abandonment of marginal agricultural lands. However, forest cover has continued to decline in most areas where urban sprawl has progressed.

Upland habitats that become surrounded by urbanization are prone to a range of impacts that are somewhat different in scope than those affecting wetlands. Uplands typically receive less policy protection than wetlands, and physical intrusion of development into wooded areas is still quite common in the GTA. Urbanization has had profound regional effects on air quality, which stresses forest vegetation with air-borne pollutants and excessive nutrients, altering soil chemistry and basic forest functions such as litter decomposition and nutrient cycling. Those upland natural areas that are ostensibly protected in new urban areas are subjected to runoff from nearby construction sites, alterations of local hydrology, intensive recreational use, microclimate change, encroachment by adjacent uses, and invasion by non-native flora and urban – adapted fauna. The following sections discuss some of the local scale impacts.

2.4.3 Impacts of Urban Proximity on Terrestrial Communities

2.4.3.1 Microclimate Alteration

Urbanization produces changes to fundamental physical attributes of landscapes, including hydrology and local climate. Oke (1987) summarized the changes to surface and atmospheric properties of a region associated with urbanization; typically they encompass the transformation of radiative, thermal, moisture and aerodynamic characteristics, and dislocate the natural solar and hydrologic balances. In essence these systems become greater heat sinks and lower moisture sinks than the undeveloped landscape. Built form provides a hardness to the landscape that contributes to an 'urban boundary layer' and 'urban plume' which extends downwind of the urban area. Within the urban area, a 'heat island effect' causes conditions at the ground level to be warmer than the surrounding countryside. In addition, urban areas experience more extreme microclimates with greater winds and temperature extremes. The associated effects of urban climate on remnant natural systems are not well understood, but represent environmental stressors that will likely have profound impacts in the long term.

The intrusion of urban thermal effects into adjoining natural habitats can be expected to be pervasive given the complex of hard surfaces (roads, driveways, masonry) in the built urban environment. For example, in the low density urban developments such as was proposed for the Yonge East and West lands on the Moraine, approximately 25% of the future land area would be dedicated to roads, approximately the same combined area as that of existing habitats plus proposed corridors and stormwater management areas. Urban heat island effects resulting from the hard surfaces cause more extreme summer and winter temperatures. Snow cover is retained for shorter periods in forests and wetlands, thereby reducing infiltration and affecting habitat composition, structure and resilience. Given the overall mass of urban cover, these effects

encroach several kilometres beyond the limits of urban areas; no remnant natural features within the GTA are large enough to escape these effects.

Key points regarding microclimate and terrestrial features:

- Managing the landscape to minimize the impacts of urban microclimate requires corridors at different scales; 'countryside' may be the only option for sustaining the quality of some sensitive plant communities
- Urban microclimate effects should be considered as part of natural heritage system planning processes

2.4.3.2 Urban Encroachment

Encroachment by residential uses is a key matter that has profoundly affected remnant habitats in southern Ontario. It is an issue at various scales, whether in the context of farmland, estate development, low density residential, or higher density residential. Matlack (1993) summarized human impacts into suburban forest fragments in northern Delaware, which included dumping of all types of compost, rubble and debris, pruning and vandalism of trees, extension of lawns, construction of huts and treehouses, campsites, and firewood gathering. In his study these impacts extended up to 70 m into forest fragments. Such impacts are a persistent problem in southern Ontario municipalities, and will require costly interventions to manage due to the intensity of urban development in typical subdivisions.

An encroachment study in Kitchener in 1996 examined residential encroachments into regionally-designated Environmentally Sensitive Policy Areas (ESPA's). Of 444 lots studied, encroachments were observed on 88% of lots. Types of encroachments included:

- Extension of mowed, planted or cleared property
- Private laneways constructed
- Construction of fences
- Pool construction
- Construction of sheds, swing sets, composters
- Woodpiles and abandoned vehicles
- Construction of permanent buildings
- Dumping of yard debris and garbage, building materials
- Spread of exotic plant species

Since 1999 the City of Mississauga has dedicated four staff to document encroachments by residents onto City owned open space. They have documented more than 5,000 individual encroachments; by-law enforcement notices were issued to residents. Subsequently there was only 50% compliance with the notices. The City has increased its liability coverage to protect itself from the risks associated with encroachment. In June 1999 the City adopted a tougher policy on Open Space fencing that includes provisions for publicly owned fences as private ownership often encourages encroachment.

Urban encroachment was also identified as a serious concern in the performance review of Richmond Hill Official Plan Amendment 129, as discussed in Section 2.1.

Residential encroachment into natural areas is a fact of life in urbanized municipalities. Residential encroachments cause negative changes to natural habitat quality, structure and functions including:

- Structural changes – loss of native species, damage to physical structure, soil compaction and erosion;

- Functional changes – changes in nutrient cycling, microclimate, decomposition;
- Uncertain long term implications.

Key points regarding urban encroachment

- Encroachment by residential uses into natural open space is a widespread problem that is progressively degrading urban natural areas
- Planning processes need to recognize the cumulative impacts of inadequate buffering from residential uses; these place the municipality at higher liability.

2.4.3.3 Invasion of Exotic (Non-Native) Plant Species

Exotic or introduced plant species have emerged as a significant issue in natural area management in North America and globally. In general, species have spread from introductions, either through direct planting, or dissemination by wind, water or wildlife. They can affect forest, wetland or meadow communities. Urban Forest Associates and the Federation of Ontario Naturalists (undated) produced a list of species considered to be problematic in Ontario. Havinga et. al. (2000) have produced a strategic plan to manage invasive plants in southern Ontario in order to restore and sustain native plant communities.

The reasons that these species have become problematic are varied and in many cases not fully understood. Plants such as Periwinkle (*Vinca minor*) are intentional introductions that take over shaded forest and gradually eliminate diverse wildflower species. Species such as Garlic Mustard (*Alliaria petiolata*) and Dog Strangling Vine (*Cynanchum spp.*) are less well understood, and represent a significant threat to valued native species such as the Trillium and other shade-adapted wildflowers. Common Buckthorn (*Rhamnus cathartica*) is a shrub species that is upsetting normal forest succession processes, and a recent study (Schmidt & Whelan, 1999) indicates that its presence is affecting nesting success of songbirds. Norway Maple (*Acer platanoides*) is an introduced shade tree species that is invading natural forests and contributing to erosion and habitat degradation on slopes and in ravines, as well as shading out spring ephemeral wildflowers.

The spread of non-native species into natural ecosystems is in part a response to environmental stress. Our understanding of how stressors affect plant communities is limited. There is now evidence (van der Heijden et. al., 1998; Read, 1998) that fungal microbes associated with the root tips of plants are closely tied to succession and the expression of plant community diversity. Disruption of such close relationships by urban-related stressors such as soil disturbance, drought, heat and excessive nutrient deposition may undermine the sustainability of native plant communities, allowing monocultures of non-native species to invade.

Management of invasive plants is already proving a daunting task to municipalities in the GTA. The City of Toronto has conducted pilot studies on the control of a number of species including Garlic Mustard, Norway Maple, and Dog Strangling Vine in ravines and parks. On the Crossmar Property in the OPA 138 lands in Richmond Hill, Gartner Lee Limited has identified a significant problem with Common Buckthorn, and has recommended an eradication program. Norway Maple is also spreading aggressively from past plantings on that site, into areas with forested slopes. The current literature on these species suggests that intensive control efforts, involving manual labour and herbicide treatment for five years or longer, are required to achieve control. Some municipalities are beginning to take steps to eliminate problematic species. For example, the City of Cambridge has mounted a public education program entitled "Say No to Norway Maples".

Obviously, the placement of residential uses close to remnant natural habitats is bound to result in the movement of plant species. Typically there is a rapid turnover of plant materials on

residential lots; a typical homeowner may introduce dozens of new species to their lot in a given season, discarding undesired plant materials into compost heaps at the rear of their yard. An increase in human use of an adjoining woodlot will also increase the risk of seed dispersal of invasive species into that habitat. Problems with exotic species constrain the resources of municipalities in areas where intensive residential development interfaces with an extensive network of natural habitats. Cost-effective management using tools such as prescribed burns and herbicides is possible, but intensive development and inadequate buffers generally limit the use of more cost-effective and less labour-intensive methods.

In existing agricultural matrix areas, crops which are produced are relatively inert from an ecological point of view i.e. the corn and soybean crops are subtropical annuals that will not persist in the landscape if their culture is abandoned. However, their cultivation, or past agricultural uses (e.g. livestock grazing) lead to the presence of 'common travellers' or weedy species which can affect natural habitats, such as Reed Canary Grass. Many of these plant species persist in meadows where they may overtake more diverse native species. This is certainly the case on areas of the subject lands where active cultivation has been abandoned. Most of these associated plant species are limited by light requirements, and cannot successfully invade woodland habitats where they would compete with native plants.

Key points regarding exotic plant species:

- The spread of exotic plant species into urban natural areas is widespread and pervasive
- Management of exotics will require increased expertise and resources on the part of municipalities in the future
- Management of species quality through the use of native species in public plantings, and restrictions on the planting of problematic species, represent positive steps that municipalities can take to change the tide of exotic invasions.

2.4.3.4 Buffers and Monitoring

Obviously any discussion of encroachments and related impacts leads to consideration of buffers and development setbacks. On July 13, 2000, natural heritage experts for the Oak Ridges Moraine hearing came to the following agreement regarding the functions of a buffer, which consisted of the following:

- protection of natural heritage features from development & vice versa
- vegetation management
- trails
- control of invasive plants and animals
- providing habitat
- erosion control
- slope stability
- noise attenuation
- light attenuation
- chemical attenuation
- mitigation of encroachment
- temperature attenuation
- wind attenuation

Buffers from new development must operate at two stages:

Stage 1: Prevent or minimize severe impacts to biological and ecological systems due to relatively sudden change in land uses i.e. the physical change in landform and hydrology.

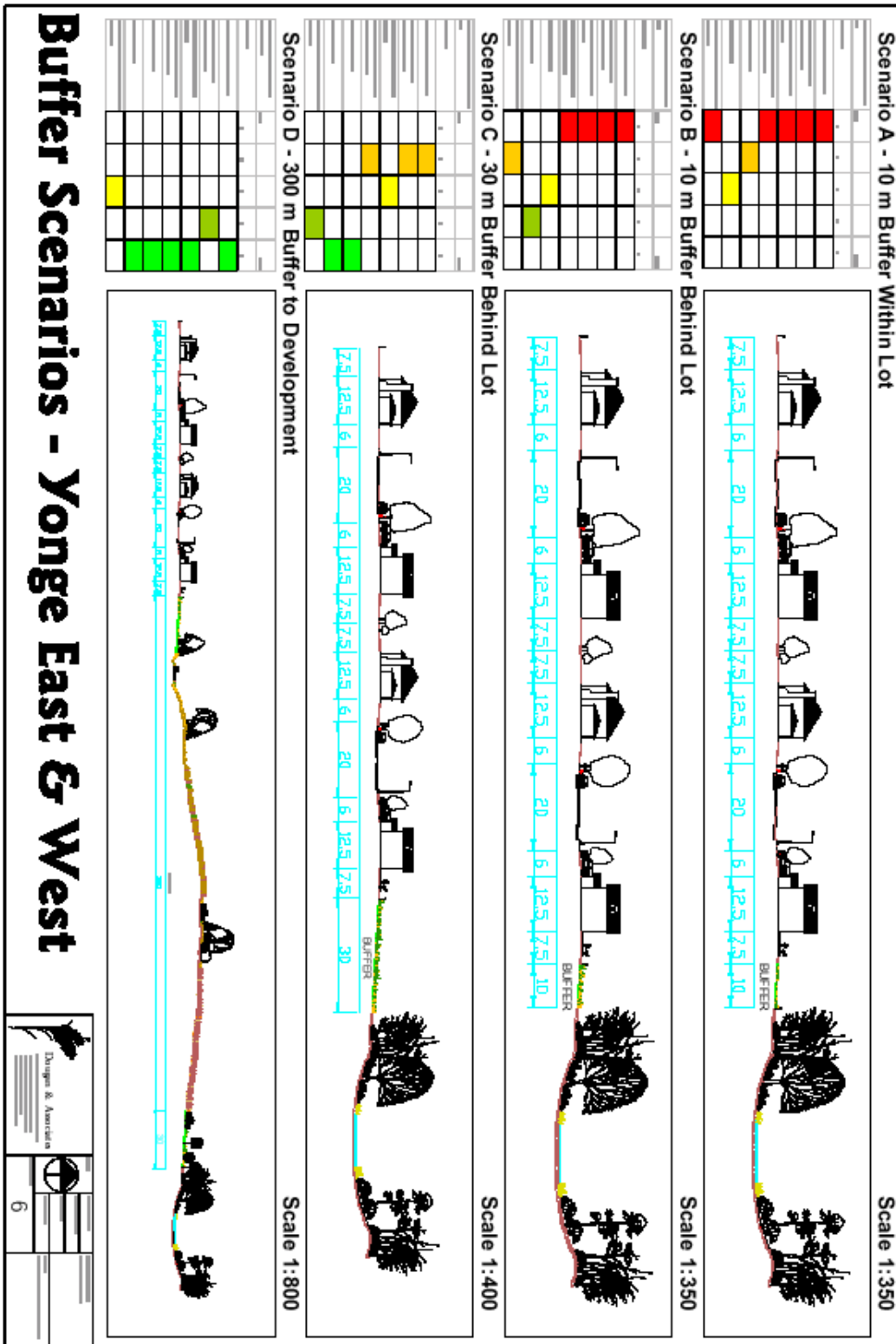
Stage 2: Ensure the ongoing health and ecological integrity of biological and ecological systems in the context of ongoing human activities.

The ability of buffers to facilitate “adaptive management” is a factor that is now being recognized as important in natural area management. Adaptive management was defined by Dunster and Dunster (1996) as “A dynamic planning or modelling process that recognizes the future cannot be predicted perfectly. In response to these imperfect predictions, planning and management strategies are modified frequently as better information becomes available.” Peck (1998) discussed the value of adaptive management for the management of natural areas and implementation of conservation plans, and highlighted the need for a long term view and institutional commitment. Buffer planning should reflect an adaptive management approach which acknowledges uncertainties, evaluates alternative approaches according to objectives, subjects the chosen alternative to long term monitoring, and is capable of adaptation to ensure that objectives are achieved.

Figure 4 summarizes an assessment of four approaches to buffers, ranging from 10 metres to 300 metres. This generally conforms to the range of buffers summarized by Norman (2000) at a conference on buffers sponsored by Carolinian Canada in May 2000. Buffer scenarios are summarized under the following objectives:

- 1) **Minimize Ecotonal Conflicts:** A buffer is a transitional or ecotonal area between a natural ecosystem and an urban/residential ecosystem. Potential conflicts include the effects of pets on native fauna, effects of human presence on secretive wildlife, and the likelihood that planted species will invade and affect native ecosystems.
- 2) **Self-sustaining:** Desirably, a buffer should minimize the need for active intervention to protect human or natural features. If routine intervention by municipal staff is required to maintain habitat quality and functions, then the buffer is clearly inadequate.
- 3) **Opportunity to Enhance Ecofunctions:** Planting or natural succession will usually increase the functional value and habitat diversity of a protected natural feature. Buffers may be critical to maintaining adequate space for the seasonal migration of amphibians between uplands and wetlands. Obviously the size of the buffer affects these opportunities.
- 4) **Opportunity for Cost-effective Adaptive Management:** Increasingly, management in urban settings includes addressing problematic forest diseases, or exotic plant species that reduce biodiversity in natural habitats. The ability to periodically use broad-spectrum treatments such as forest canopy management, herbicide application or use of fire as an agent is desirable. Smaller buffers constrain the ability for adaptive management of future situations.
- 5) **Erosion Protection:** Erosion protection includes the ability of the buffer to prevent erosion during lot construction, and the protection from erosion due to pedestrian impacts after development.
- 6) **Tree Protection:** Protection of trees at the edge of a natural feature is the most basic level of buffer function. Root zones typically extend a distance equivalent to the height of trees where active agricultural cultivation has not been practised. Potential sources of impacts to trees include grading, alteration of drainage, competition from managed turf, pruning of edge branches by homeowners, and outright tree removal by homeowners. Sufficient buffer depth to sustain vigorous edge development facilitates protection of other functions.
- 7) **Recreation Opportunities;** often there is a desire to incorporate trails into buffers. This may create ecotonal conflicts, and therefore buffer size is a critical consideration if this type of use is anticipated.

Figure 4 – Buffer Scenarios, Yonge East & West



(For a large-scale version of this figure, download the document at www.hardystevenson.com).

In general, buffers in the 10 m to 30 m range will not be effective at achieving most of the objectives, particularly those related to protecting and sustaining significant functions. The 10 m buffers are really 'arboricultural' buffers that protect the roots and branches of edge trees, assuming the buffer is outside the lot. Although a 10 m buffer may be theoretically adequate to provide filtration of nutrients and sediments contained in post-development runoff from backyards, it is often inadequate to achieve necessary grading and interim management of hydrology associated with the residential development process. This is related to a complex array of factors including inaccuracies in topographic mapping, scale of equipment used to prepare the residential site, and difficulty of achieving municipal requirements for lot grading and active use areas. Often encroachment into the natural area (which was intended to be protected) is undertaken because municipal standards for lot grading and drainage are inflexible.

Kettle wetlands and bogs cannot be adequately protected using buffers of minimal dimensions. Rather, it is necessary to protect the entire catchment in order to maintain function. It is noteworthy that recent scientific research on amphibians and turtles has identified species habitat needs that extend more than 120 m beyond the limits of wetlands. Dodd and Cade (1998) and Semlitsch (1998) cite species moving 700-900 m from breeding ponds, yet recommended buffers extending between 163 to more than 200 m on average from a wetland to ensure the viability of populations. These observations emphasize the inadequacy of the 120 m 'adjacent lands' provision of the OMNR Natural Heritage Reference Manual (1999) and the 120m "minimum area of influence" in the ORMCP, or of simplistic buffer approaches to deal with the actual dynamics of species movements. (See Helferty 2002 for further details.)

As discussed in Section 2.2.2.3, there is minimal empirical knowledge as to how natural corridors operate under urban circumstances, but substantial evidence as to their value under rural conditions. There is ample empirical evidence (see preceding section) that habitats located in close proximity to residential areas are subjected to high levels of encroachment and degradation, which most municipalities cannot address as they lack resources and qualified personnel. This leads to the conclusion that unless very substantial buffers are provided, in conjunction with ongoing monitoring and adaptive management, there is no reason to expect that existing natural habitats will maintain their ecological integrity when integrated into urban settings. The best that can be expected under current approaches, is that remnant natural features will become 'green amenity areas' totally dominated by urban matrix functions. In an urbanizing situation, quality natural heritage features can be expected to 'wind down' ecologically, i.e. to lose species and functions over time.

Key points regarding providing adequate buffers:

- Buffers should be applied to help create landscape corridors of different scales in order to sustain valued habitats and functioning ecosystems
- Urban encroachment effects should be adequately considered when buffers are determined
- Inadequate buffers eventually lead to increased liability of municipalities

2.5 Best Practices for Natural Heritage Protection

The Province's natural heritage system approach provides a scenario where a) the "maintain and improve" tenet of the Provincial Policy Statement is respected, ensuring "*net gain*" in habitats and functions over time; b) the *local, meta- and inter-regional/continental scale* systems are clearly addressed; c) resources receive protection on a *functional basis* rather than on an ad-hoc site-specific basis; and d) this functional approach leaves *adequate room for adjustments* subject to further knowledge.

The following were developed as key criteria to defining a workable land use framework for the natural heritage system for the Yonge East and West lands, however they are relevant in a generic sense to the rest of the Moraine, and indeed to other development situations in Ontario. They are intended to result in an optimized functional landscape dominated by natural processes. This implies that the natural heritage potential of the lands is maximized, and that off-site benefits (such as baseflow of rivers) are maximized.

- **Address the protection and enhancement of natural features and biodiversity at the local scale, meta-scale and inter-regional/continental scales.** This should include adoption of landscape measures that ensure trophic integrity i.e. the ability of top predators to be sustained in the landscape.
- **Ensure that resources receive protection on a functional basis rather than on an ad-hoc site-specific basis.** Consideration of features in the context of the overall physical and biological ecosystem is critical to maintaining and enhancing functions.
- **Employ effective buffer zones, designed to prevent immediate and longer term impacts to biological and ecological systems.** Natural areas in the vicinity of new development will undergo initial impacts due to relatively sudden alterations in their vicinity, and longer term impacts due to the change in the overall landscape matrix.
- **Adopt an adaptive management approach.** This assumes that where future outcomes are uncertain, decisions will be followed up by rigorous monitoring, and appropriate actions where improvements can be made. This also implies that the determination of buffers and contingencies takes into account the possible extent of future adaptive management activities.
- **Maintain a natural heritage system that minimizes landscape resistance, and maximizes mosaic redundancy:** A rural matrix provides a low resistance landscape that obviously benefits many wildlife species adapted to forest and agricultural fields. Multiple forested linkages (300 m minimum width) should be provided to key off-site core natural areas to maximize forest interior movement opportunities and to minimize predator effects.
- **Minimize the need for local roads:** The Yonge East and West proposals would have contributed approximately the same area of road surface as the area of the natural habitats and corridors combined. Local roads should be limited by choosing appropriate land uses. Local roads should be built to a rural cross-section standard (i.e. no curbs) to minimize resistance to amphibian movements, and without encroachment into the protected catchment areas.
- **Employ “Ecological Engineering” for collector and arterial roads:** Culvert clusters, underpasses and directional fencing should be provided as roads are built or reconstructed, to allow safe wildlife passage in identified crossing areas. A hierarchy of crossings should be provided to meet the regular and seasonal movements of amphibians and reptiles, and small to large mammals.

Strong and effective natural heritage protection requires an adequate level of information on which to base decisions regarding appropriate locations and types of development, and selection and implementation of conservation measures. Factors to include in the formulating of guidelines for natural heritage studies (based on Armour (1981)) should include:

Completeness

- identification of key ecosystem components
- identification of legal requirements
- documentation of all data sources used in the impact assessment
- documentation of a methods used in the impact assessment
- documentation of analytical methods used

Accuracy

- factual accuracy
- accurate representation of the facts
- appropriate boundary delineations
- time frame for studies appropriate to ecosystem components present
- validity of sampling procedures
- data accurate and current
- predictions accurate and reproducible
- limitations of study clearly stated

Comprehensibility

- issues clearly stated
- conclusions clearly stated
- underlying assumptions clearly stated
- synthesis clearly explained

Reliability

- biases acknowledged and controlled
- weight of evidence clearly leads to selection of preferred alternative
- assumptions clearly stated

3. Stormwater Management and the Moraine

The Provincial Policy Statement clearly supports the protection, precautionary treatment and enhancement of water quality and quantity under Policy 2.4.1, which advises: *“The quality and quantity of ground water and surface water and the function of sensitive ground water recharge/discharge areas, aquifers and headwaters will be protected or enhanced.”*

The objectives and policies of the ORMCP discussed in Section 2.2.1 address the integrity and function of both the hydrological and the natural heritage aspects of the Moraine.

3.1 Water Quantity Impacts of Urban Development

Management of runoff quantity is a key consideration under existing stormwater management policies, guidelines and practices in southern Ontario, as summarized in the Ministry of Environment and Energy’s “Stormwater Management Practices Planning and Design Manual” (MOEE, 1994).

It is accepted that urban development substantially alters the runoff characteristics of a landscape by increasing the relative imperviousness of surfaces as compared to agricultural or natural (e.g. forest, meadow or wetland) landscapes. This change to imperviousness affects not only the volume of runoff, but also the rate at which runoff accumulates in downstream receiving bodies following precipitation events. This is directly related to:

- a. the loss of attenuative capacity of a watershed due to the increase in impermeable surface area,
- b. loss of surface roughness which would otherwise impede surface flows and thereby encourage infiltration, and
- c. concentration of runoff in piped systems which causes a ‘flashy’ response to storm events.

The detrimental effects of urban hydroperiods (i.e. the frequency of inundation by water) being imposed onto natural wetlands are well documented. Schueler (1992) characterized urban wetland regimes in the mid-Atlantic region as “semi-tidal” i.e. subject to repeated inundation and rapid drawdown, typically 10 to 30 times per year, as opposed to the gradual seasonal cycle in a natural freshwater wetland hydroperiod. Stormwater-influenced wetland communities are overtaken by exotic or invasive species such as cattail (*Typha* spp.) and tall reed grass (*Phragmites australis*), aggressive species that form monocultures. Ehrenfeld and Schneider (1990) observed that stormwater influenced wetlands contained over 65% invasive or exotic species, compared to less than 1% occurrence of these species in natural reference wetlands. Based on a study of urban runoff effects on natural wetlands in Waterloo Region, McBean et. al. (1996) determined that there were on average 7.7 times as many days with non-zero surface runoff to wetlands in post-urban settings than under predevelopment conditions.

Key texts on stormwater design and wetlands have taken a clear position on the role of natural wetlands in stormwater runoff systems since the mid-1980’s: natural wetlands should not be used deliberately in wastewater treatment systems (Livingston, 1989 (in Hammer 1980); Schueler, 1992; Brix, 1993 (in Moshiri, 1993); Olson, 1993; Hammer 1997). In Ontario the use of natural wetlands for stormwater quality enhancement is not allowed (MOEE, 1994).

Reinelt and Taylor (2001) identified *water level fluctuation* as “perhaps the best single indicator of wetland hydrology”. Based on a detailed comparison of urban and non-urban wetlands in Puget Sound, they concluded that in an urbanized watershed, a greater proportion of precipitation was

realized as surface inflow to wetlands. Storm runoff was delivered more quickly and in greater short-term volumes to urban wetlands in comparison to natural wetlands. The result was greater and more rapid water fluctuations in urban wetlands.

In a comprehensive assessment of freshwater wetlands in Puget Sound, Azous and Cooke (2001) concluded that urbanization of watersheds leads to decreased plant diversity along hydrologic gradients, increases in the coverage of common and introduced species, and the loss of uncommon native species. Large storm events can disturb wetland soils through erosion and sedimentation, uproot existing vegetation, adversely alter soil chemistry, and hinder seed germination. Horner (1989) found that greater diversity (particularly of *Carex* spp. sedges) typified the emergent zones of non-urban wetlands in Puget Sound, whereas an opportunist species, reed canary grass (*Phalaris arundinacea*) dominated most urbanized wetland sites.

Ewing (1996) determined that sediment deposits negatively affected sedges and sapling trees by reducing biomass and decreasing photosynthesis. Bedinger (1978) postulated that reduced growth at periodically inundated sites may result from frequent restructuring of root systems in response to alternately flooded and drained conditions. Other effects of higher water tables include shallower and less extensive rooting of herbaceous species, rendering them more vulnerable when the water recedes. The net effects of increased mean water level fluctuation is lower species richness, particularly of herbaceous species.

There is an extensive body of research on the effects of flooding on woody species. In general, woody species associated with wetlands and floodplain environments are considered “tolerant” of periodic flooding, sometimes for extended periods. However, water level fluctuations in natural wooded wetlands normally occur within a discrete range, and within a well-defined seasonal window. Periodic peak water levels related to unusual precipitation may not eliminate woody plant cover, but can nevertheless have detrimental effects on canopy health. In natural wetlands, periodic flooding events often provide essential and positive benefits, by creating canopy gaps that promote understory development.

Alteration of the hydrologic regime from its seasonal norms, routinely results in the catastrophic loss of the tree canopy in forested wetlands. Such alteration may be by natural agents such as beaver, or through development-related changes (road construction, infilling, alteration of catchment areas, increased catchment impermeability, confinement of flows). Chronic inundation in inappropriate seasons results in the conversion of natural ephemeral wetlands to emergent marsh cover (cattail etc.), when oxygen is no longer available to the root systems of woody species during critical seasonal periods.

The nature of tree responses to flooding have been summarized by Kozlowski (1984) and include: reduced seed viability, reduced growth in height, reduced leaf area, early leaf drop, irregularities in the growth of cambium, decreased root to shoot ratio, death of mycorrhizal associates, reduced biomass production, and abnormal root development. Repeated exposure of trees to flooding events during the growing season is inevitably fatal for even the most ‘flood-tolerant’ species.

3.1.1 Stormwater Quantity Models

The use of mathematical models that simulate natural phenomena has become a necessary part of any stormwater impact assessment. Due to the complexity of these phenomena, models are necessarily constrained in scope. However, the separate consideration of complex, interwoven phenomena can lead to over-simplified interpretations of reality. For example, separating water quantity from water quality is an artificial distinction that does not provide a valuable approach for assessing impacts. Water quantity and water quality are intrinsically linked.

The use of a quantity model is justified based upon some identified objective. For example in the case of the Yonge East and West proposals on the Moraine there is a clearly identified sensitive habitat downstream of a proposed subdivision, namely coldwater brook trout habitat. Spawning habitat for this species is sensitive to both the quantity and quality of groundwater. Decreasing the amount or quality of groundwater or increasing the quantity and decreasing the quality of surface water can have a significant impact on the ability of this species to persist in downgradient streams.

These downgradient sensitive habitats were not identified in the development applications for the Moraine. Brook trout lay their eggs in areas of upwelling during the late fall. Cues for the selection of specific sites are not well understood, however, both water quantity and quality are determining factors in site selection and hatching success. Models used in predicting impacts on downgradient areas must, therefore, evaluate the potential changes to the quality and quantity of groundwater on a seasonal basis.

Models are also constrained in their complexity and their ability to simulate site-specific details with fine spatial and temporal resolution. Rather, models simulate “average” conditions. For example, the GAWSER model was used to simulate pre and post development runoff responses in kettle subcatchments based on existing meteorological data (1960’s and 1990-1995) from Pearson Airport and the Richmond Hill WPCP. The GAWSER does not incorporate any site-specific precipitation or water level data for individual kettles. Therefore the model may not reflect the unique physical conditions in particular features.

This shortcoming in models must be considered when evaluating effects on highly variable systems such as seasonal wetlands and dry kettles, and must also be remembered when models are used to predict the results of future conditions such as urban development. The models are useful guides, but their limitations must be clearly noted. As well, the model results must be carefully interpreted in light of experience and qualitative knowledge. An example of the need to carefully interpret results from water-quantity models is illustrated below.

Segments of the GAWSER-generated dataset were used to create graphs of simulated existing and proposed water levels in a kettle wetland (**Figures 5 and 6**). These figures summarize hourly model data for existing and post-development conditions in a kettle over the critical mid-summer period in a ‘dry’ year (1961) and a ‘wet’ year (1986). This is the period of peak wetland productivity, and particularly critical to plant systems.

As indicated in **Figure 5**, under existing conditions there is virtually no response of the pond level to precipitation events in a dry year; the pond was predicted to be dry at these periods, with the simulated events producing less than 0.5 cm of inundation in the pond. Under post-development conditions, repeated inundation events resulting in water level fluctuations of between 1 to 6 cm were forecast for the same events. Although these predicted fluctuations may seem small in magnitude, they are significant in that saturated soil conditions, which deprive tree and plant roots of essential oxygen, will occur and persist through a critical productive period in the growing season even in dry years. The imposition of shallow inundation events in the critical mid-summer period, even in ‘dry’ years, will result in the death of trees and shrubs, due to a reduction in available soil oxygen.

In **Figure 6**, the existing and post-development conditions for the same kettle in a wet year are shown. These indicate that following development, water levels would fluctuate above their existing ‘flat’ condition, causing saturated soils throughout the growing season.

These results clearly demonstrate the need to bring a multi-disciplinary interpretation to a disciplinary analysis. In this case, post-development changes in kettle hydrology may be seen to be minor in terms of the water budget, but these “minor” changes could have profound effects on kettle ecology and function.

Figure 5 – Comparison of Existing and Post-Development Water Levels for Kettle 7, July-August 1986 (Wet Year)

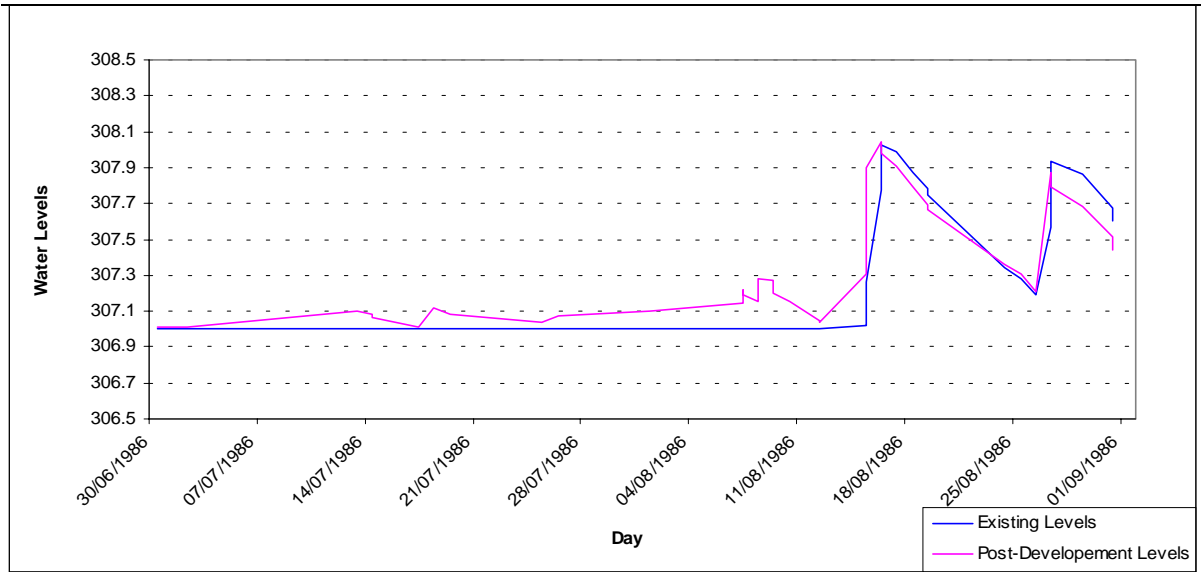
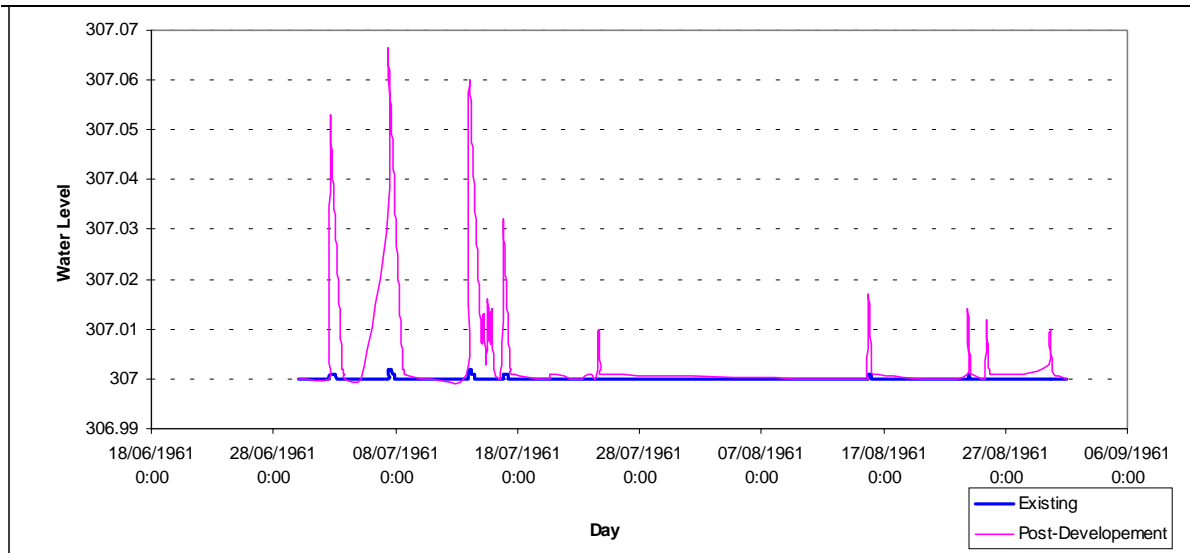


Figure 6 - Comparison of Existing and Post-Development Water Levels for Kettle 7, July-August 1961 (Dry Year)



Original data for Figures 5 & 6 obtained from Exhibit 232, provided by Cosburn Paterson Mather on November 13, 2000. Graphs generated by Mojgan Sharifi, Research Assistant of Dr. M. Diamond, Department of Geography, University of Toronto, February 2001.

3.1.2 Internally Drained Catchments and Biota

Unlike most stormwater planning situations in southern Ontario, the Yonge East and West applications had proposed to release stormwater and the overflow from stormwater management ponds into provincially significant natural kettle wetlands which are predominantly confined and do not normally overflow into other receiving waterbodies. Under pre-development conditions these wetlands are sustained by a combination of surface runoff and shallow interflows. Each kettle is unique in the relative balance between inflows, infiltration, and local discharge which creates a hydroperiod regime with standing water conditions in the spring of most years, gradually drawing down over the summer due to reduced precipitation and shallow groundwater inputs, with peak evapotranspiration levels, followed by replenishment over the late autumn and winter through rain and snowmelt to re-establish high water levels in spring. The simulated datasets for the Yonge East and Yonge West kettles support this hydroperiod pattern.

The physical character of each kettle catchment is unique, and the delineated boundary of a wetland does not capture the full extent of the wetland's ecological and hydrologic functions. The hydrologic response of the contained wetland feature is a manifestation of the unique biophysical catchment characteristics that currently exist over much of the Moraine. The catchments are set within an agricultural regime at present. The catchments could be restored to forest cover, which would moderate inflows, produce a more conservative hydrologic response to precipitation events with greater infiltration, and result in greatly enhanced biological functions over the medium to long term.

Under post-development conditions the inflows would be modified to become less conservative, with a high proportion of inflow arriving from an adjoining storm water management (SWM) pond and via impervious overland runoff, producing a hydroperiod which is much more responsive to individual storm events than currently exists. Even in predicted dry years, events causing shallow inundation would occur with much higher frequency and intensity than under existing conditions according to the hourly Yonge East simulations. These events would extend the period of soil saturation present in the portions of the wetlands which would otherwise dry out and become oxygenated in most years, permitting increased productivity of most tree, shrub and herbaceous species.

Some instructive situations include:

- Kettle wetlands with deciduous swamp cover and regionally-rare shade-adapted plant species. Under urbanization the hydroperiod would become 'semi-tidal', leading to loss of tree cover. The GAWSER data indicated the imposition of shallow inundation events in the critical mid-summer period, even in 'dry' years. This would result in the death of trees and shrubs, due to a reduction in available soil oxygen. The woody cover and rare species would likely be lost under post-development runoff conditions.
- Kettle wetlands with bog elements. Bogs are the most sensitive of wetland types based on their isolated catchments and low nutrient, low pH status. Numerous regionally-significant bog-affiliated tree, shrub and groundcover species indicate that these kettles retain a regular hydroperiod and adequate water quality to sustain this sensitive cover. The persistence of the woody species indicative of bog conditions indicates that the systems have retained sufficient resilience to sustain bog characteristics. Loss of woody cover, rare species, and conversion to a nutrient-enriched system would occur if such kettles were integrated into urban stormwater management.
- Kettle wetlands with highly interspersed communities. Interspersion refers to the complex edges or ecotones that form in quality wetland habitats. The presence of a highly-interspersed wetland is rewarded with enhanced scoring (up to 30 points for open water

interspersed) under the Ontario Wetland Evaluation System because interspersed is typically associated with higher biodiversity. High interspersed reflects consistent seasonal water cycles and stable summer water levels that are themselves reliant on specific physical catchment characteristics. Even relatively minor catchment changes will trigger water level changes that can upset this balance and result in loss of interspersed qualities. Typically urban runoff will generate a deficit under springtime conditions, and higher than average runoff during the growing season.

The landscape configuration of kettle wetlands renders it impossible to incorporate urban stormwater uses while maintaining existing wetland quality and functions. The only reasonable means to protect existing wetland communities, biodiversity and functions is to protect their entire catchment.

The ORMCP, which was developed and finalized after the suspension of the OMB hearing that considered the Yonge East and West proposals, now prohibits disposal of stormwater into kettle lakes. Protection of kettle wetlands from stormwater disposal is not as specific in the Plan, but where kettle wetlands are provincially significant the Plan's provisions intended to protect these wetlands would apply.

3.1.3 Downstream Effects

Certain species of fish in riverine systems are sensitive to ambient conditions, due mainly to seasonal changes in temperature. While most fisheries biologist are quite familiar with the upper lethal temperature thresholds of brook trout in summer conditions, few appreciate the dependence of this species on groundwater during the cold winter season. Freezing in winter, due to the formation of frazil ice, can be as disadvantageous for species that incubate their eggs over the winter months, as can high summer extreme temperatures.

In addition to the potential changes to the amount and quality of groundwater, is the potential change to surface waters associated with land development. Changes in flood frequency, duration or magnitude can affect stream morphology, including erosion and sedimentation processes. Increased runoff during warm summer months will result in greater quantities of warm surface water entering a stream. Even if ground water discharge rates providing cool water to the stream are maintained, greater quantities of warm surface water can result in thermal thresholds for sensitive species being exceeded. This will result in the extirpation of cold and cool water species.

3.2 Water Quality Issues

Chemical emissions to air, water, soil, vegetation, and other surfaces are an inevitable feature of urban development. Currently, technologies to either contain these emissions or remediate their effects are inadequate and existing research on the effectiveness of control technologies is seminal and incomplete. Thus, emissions and potential adverse impacts from these emissions are unavoidable, which has implications for siting decisions regarding new urban residential development on previously non-urbanised land. Because of the overall inadequacy of measures to reduce the impacts on surrounding biota, water and other natural resources, urban development should not be sited on or adjacent to sensitive lands such as internally draining catchments or areas with significant natural features, such as groundwater or rain-fed kettle lakes. Rather, new urban development should be preferentially located on externally draining lands and lands without significant natural features. The following discussion, similar to other sections of this document, supports this argument using scientific evidence compiled during hearings which occurred during the 2001 at the OMB hearings on proposed residential

development in Richmond Hill. The discussion will examine contradictions inherent in current development proposals with the explicit goal of environmental protection. The main focus of the discussion is stormwater, which acts as an integrator of the chemical emissions typical of urban areas, and the special sensitivity of internally draining lands to such chemical emissions.

3.2.1 Chemical Impacts of Urban Development – Stormwater

When an area is urbanized, the proportion of surfaces that are impervious increases. Impervious surfaces greatly reduce water infiltration and accumulate chemicals deposited directly or indirectly from air. Sources of chemicals are diverse and include: abrasion of tires and vehicle brakes, leakage from the crank cases of vehicles, corrosion of metal pipes on roofs, application of road de-icers, the use of solvents and paints, and myriad other human activities. Examples of chemical sources and typical chemicals emitted include:

- Vehicles emit a wide range of organic and inorganic constituents from fuel combustion, uncombusted fuels, crank case leakage, and the operation of catalytic converters. A small subset of the emitted compounds are alkanes, PAH, oil and grease, gasoline additives such as MTBE in the United States and MMT in Canada (or the combustion product manganese dioxide), trace metals from fossil fuel combustion such as mercury, vanadium, and arsenic, and trace elements such as platinum and rhodium from catalyst use (Zereini et al. 2001, Rogge et al. 1997).
- Also emitted from vehicles due to the abrasion of tires and brake linings are elements such as barium and zinc, *n*-alkanes, alkanolic acids and PAH (Rogge et al. 1993).
- Some compounds are intentionally applied to roadways such as road de-icers, notably road salt (sodium chloride), in temperate cities. Application rates range from 29 to 74 kg/m of highway per year and are known to cause elevated salt concentrations in surface soils and waters, and ground water (Buttle and Labadia 1999, Labadia and Buttle 1996, Howard 1986). Because rates of application of road salt can be very high, stormwater runoff contains salt year-round as precipitation removes the salt stored in soils, with the highest pulses occurring in spring (Vickers 1999).
- Products from fossil fuel combustion are emitted from residential heating systems, e.g., PAH, oxides of sulphur and nitrogen.
- Roofing materials release metallic corrosion products and biocides used to reduce decomposition, e.g., Copper, Zinc, Lead (Zobrist et al. 2000, Bucheli et al. 1998, Wallinder et al. 1998).
- Trace emissions occur from external and internal building materials, personal products, etc., e.g., phthalates degas from polyvinyl chloride plastics, chlorinated benzenes (predominantly 1,2-dichlorobenze) from deodorants, chlorinated solvents from paint strippers, degreasers, aerosols and adhesives (e.g., Rudel et al. 2001, Jackson and Dwarkanath 1999)
- Releases of chloroform and trihalomethanes are associated with swimming pools, leakage from aging water distribution systems, and the use of drinking water for lawn watering.
- Highly persistent compounds, such as DDT, DDE, DDD, chlordanes, and hexachlorocyclohexane, do not necessarily originate from within the urban area, but are deposited following regional and long-range transport from other areas . It is difficult to distinguish between the proportion of these chemicals that originate from current use and are transported atmospherically, versus the proportion which originate from past applications (Falconer et al. 1999). In the past, DDT was commonly used as a general pesticide and chlordanes were used extensively in urban areas for termite control.

Some chemical emissions occur directly to impervious surfaces whereas others are emitted to air followed by deposition of a portion thereof. Other emissions or discharges will find their way to soils that have a high capacity for accumulation. With rain or snow melt, the accumulated chemicals are washed from impervious surfaces in the form of stormwater. Stormwater from urban areas, including residential areas, contains a mixture of numerous contaminants (Makepeace et al. 1995), many of which are toxic and known to cause adverse effects on exposed biota (Skinner et al., 2000; Bay et al. 1996). **Table 1** below is a list of some of these contaminants, their sources and toxic effects.

Table 1: Impacts of Some of the Chemicals found in Residential Urban Stormwater on Human Health and Indicator Species

Chemical	Health Impact
phosphorus, nitrate,	Nutrient enrichment, depletion of dissolved oxygen resulting in asphyxiation
ammonia	Highly toxic to fish w/ a lowest concentration of 1.7 µg/L (i.e., will adversely affect fish at concentrations above this value).
sodium	Hypertension in humans
lead	Neurotoxin, behavioural problems and lower IQ in children. Adversely affects health of the waterflea (Daphnids) at concentrations above 12 µg/L. Causes death in 50% of frog eggs at 40 µg/L after 96 hours
copper	Potently affects aquatic organisms at concentrations above 0.23 to 4 µg/L for Daphnids and fish, respectively; death of frog eggs at 40 µg/L
polyaromatic hydrocarbons (PAH)	Mutagenic, carcinogenic; also implicated in reproductive dysfunction of the reproductive and immune systems at low concentrations. All PAH act in the same way, however, some are more potent than others, e.g. benzo[a]pyrene is the most potent. Causes adverse effects in waterflea at concentrations above 0.3 µg/L.
chlorinated solvents, phthalates	Endocrine disruption with effects on reproduction, immune system function, some phthalates suspected to mimic estrogen
chlordanes, diazinon, lindane	Potential carcinogens; adverse effects on reproduction, liver and immune systems at low levels; organochlorines accumulate in fatty tissue of frogs (tail) and kill young frogs when they resorb tail during metamorphosis
atrazine	Chromosomal damage
Shigella	Bacillary dysentery can result from even low doses
Pseudomonas aeruginosa	Swimmer's ear and other contact infections, resistant to antibiotics.

Stormwater must be disposed of somehow. Under natural conditions this water would undergo surface run-off and infiltrate groundwater. These pathways form the hydrologic budget of an area. However, with urban development the water is no longer "clean." Allowing stormwater to follow the hydrologic regime now altered by urban development would result in introducing the chemicals in urban run-off to surface waters (e.g. headwater streams) and groundwater. Since this practice has led to widespread degradation of, at least, surface waters, regulations, policies and practices have been developed to mitigate these adverse effects.

The Ontario Ministry of the Environment recommends that new residential developments treat stormwater by means of stormwater management (SWM) ponds prior to discharge into the environment. SWM ponds are designed to mitigate the harmful effects of stormwater on downstream wildlife habitat by reducing the amount of total suspended solids (TSS) entering surface water via run-off following precipitation. They are a system of control by retention, not

remediation. The highest level of treatment is defined as Level 1 protection, which requires 80% removal of total suspended solids. The intention of Level 1 protection is to protect downstream Type 1 habitats, which are highly productive feeding areas (wetlands), habitats supporting endangered, threatened or vulnerable species, and groundwater recharge areas in coldwater streams. Unfortunately, it is questionable whether a Level 1 protection pond will adequately protect Type 1 habitats.

SWM ponds are only a partial measure to prevent the negative effects of urban stormwater on surface and groundwater quality. The removal of suspended solids, while undoubtedly important, is preferential for larger size particles and is incomplete. Unfortunately, smaller size particles, of the size less effectively retained by SWM ponds, tend to carry adsorbed chemicals which are generally more toxic than those adsorbed to larger size particles. Chemicals that settle with TSS in the pond can return to the water column in the dissolved phase and then leave the SWM pond via outflow. In this way, the SWM pond simply delays the entry of some chemicals into downstream waters. Suspended solids, of course, are not the only toxic feature of stormwater run-off. Many toxic compounds are dissolved in stormwater and as such, are not captured by the ponds. Sparingly few studies have examined the fate of dissolved or adsorbed chemicals and pathogens that enter the ponds.

Furthermore, there are very few studies that have examined SWM pond efficiency over the long-term nor the effects of climate and other local conditions on the efficacy of SWM ponds in different areas. The few studies that have been done suggest that SWM pond efficiency decreases with the age of the facility. For example, Tanner et al. (1998) found a 50% reduction in the ability of a constructed wetland to retain phosphorus over a 5 year period.

Since wildlife habitat is in increasingly short supply, SWM ponds are inevitably used as habitat. This is of concern because biota using SWM ponds will inevitably be exposed to the compounds intended for containment. As SWM ponds function to contain compounds, it is not surprising that concentrations of metals and polycyclic aromatic hydrocarbons in sediments of SWM ponds in Ontario will rapidly exceed MOE guidelines for the protection of aquatic biota (Bishop et al., 2000, Licsko and Struger 1995). Concentrations of salt in SWM pond water can be very high and increase with the age of the pond. Over the course of a year, salt concentrations peak upon snow melt and the peak in SWM pond concentrations can coincide with the sensitive life stages of many amphibians. Again, few studies have examined the fitness of biota using SWM ponds. Bishop et al. (2000) found lower reproductive success of frogs using Greater Toronto Area (GTA) SWM ponds as habitat. Based on this direct evidence and evidence from a risk assessment, we conclude that SWM ponds should not be sited in ecological corridors or to compensate for lost habitat; they are not good habitat for wildlife (Bishop et al. 2000).

Several of the chemicals typically found in SWM ponds can adversely affect biota using the ponds as habitat. **Table 2** below summarises the results of a screening level risk assessment of concentrations of various chemicals in GTA SWM ponds and the associated potential for adverse effects on biota. A similar assessment of salt concentrations in SWM ponds found that all of the species examined, including minnows, sunfish, toads and waterfleas, were at high toxicological risk due to salt. This assessment assumes exposure to a single compound and contains considerable uncertainty.

Table 2: Toxicological Risks posed to Biota using SWM Ponds in the Greater Toronto Area (GTA) as Habitat

Chemical	Species	Life stage	End point	Degree of potential risk
copper as copper oxichloride	clawed toad	stage 37/38	48 hr LD ₅₀	high
copper as copper sulphate	clawed toad	3 – 4 weeks	48 hr LC ₅₀	high
mercury	gray tree frog	Embryo	96 hr LC ₅₀ posthatching	moderate
zinc	spotted frog	Tadpole	48 – 96 hr LC ₅₀	high
zinc as zinc sulphate	clawed toad	Embryo	96 hr LC ₅₀	high
chromium VI	Rana tigrina	Tadpole	3 d 100% mortality	moderate

In reality, biota are exposed simultaneously to many stresses, such as toxic chemicals, microbes, fine particles, temperature stress and variable food supplies. In terms of the toxic chemicals, the combined effect of exposure to the numerous different contaminants present in the pond water are unknown. It is possible that numerous exposures to even low levels of a variety of contaminants can impair the general fitness of an organism, increasing the risk of later infection or of a catastrophic toxic effect following a seemingly benign future exposure (Yang, 1994). Standard methods of aquatic toxicity testing are based on chronic exposures to single compounds rather than pulsed exposures which are typically created in SWM ponds following storm events when injections of fresh chemicals occur (Burton et al., 2000). In some circumstances, pulsed exposures to contaminants pose a greater health risk to biota than a consistent exposure. Standard toxicity testing, upon which much environmental protection regulation is based, does not account for compounded stress factors, such as those listed above

3.2.2 Internally Draining Catchments and Kettle Lakes as Sinks

The Oak Ridges Moraine has a complex water budget. The porous moraine supports a high quality aquifer that in turn feeds the head waters of numerous streams that flow into Lake Ontario. The aquifer is recharged by precipitation infiltrating porous soils and through features such as “dry kettles” that act as natural soakaway pits. Similar to many moraines, the area has several kettle lakes that do not have river/stream inflows and outflows. In addition, the area contains ephemeral wetlands called kettle wetlands. These are ephemeral wetlands that are dry for large periods of the year, fill with water following periods of precipitation and then slowly drain into groundwater.

Water bodies vary widely in their ability to dilute inputs of different chemicals. A fast-flowing stream or a lake drained by streams “clears” inputs of chemicals at rates orders-of-magnitude greater than the kettle lakes on the Oak Ridges Moraine or an aquifer. Consequently, the kettle wetlands, kettle lakes and aquifers of the Oak Ridges Moraine are all uniquely sensitive to inputs of nutrients and toxic contaminants. The risks posed by urbanization to the internally draining system of Oak Ridges Moraine are addressed below.

Kettle wetlands serve as sinks in the landscape, that tend to accumulate materials and chemicals due to their closed system hydrology. As such they have only a limited carrying capacity to process and manage sediments, nutrients and chemicals contained in runoff. Employing these features in stormwater management uses will accelerate the accumulation of materials and substances that are deleterious to the natural wetland habitats and their functions.

Proximity to developed areas itself will also compromise the quality of the systems. Developed

areas generate significant emissions of a wide range of compounds to the air and these will deposit throughout the landscape. As mentioned above, kettle lakes and wetlands have limited ability to assimilate these inputs and thus will accumulate atmospherically deposited contaminants over time.

Ewing (1996) determined that sediment deposits negatively affected sedges and sapling trees by reducing biomass and decreasing photosynthesis. It would be impossible to avoid sedimentation of the kettle systems from development if they receive urban runoff. A Level 1 treatment for water quality was proposed in Yonge East and West; this design standard would treat only 80% of the runoff, allowing 20% to be released into the downstream kettle wetland systems under routine events. This would convert the wetlands to monocultural systems that are tolerant of sedimentation. Typically this will eliminate species such as the sedges and regionally rare species noted in several wetlands.

Horner et. al. (2001) found a strong correlation between forest cover and high water quality. They noted that extremes in water quality often have greater impacts on biological resources than average conditions. In terms of water quality, considerable variability between stormwater pond systems can be expected; on this basis Environment Canada (1999a) released a fact sheet warning of the potential exposure of wildlife to contaminants in these systems. Due to the 'sink' characteristics of the kettle wetlands, and the fact that 20% of runoff will be untreated under routine events, dredging of natural kettle wetlands (i.e. periodic destruction of wetland plant communities) could be required every five years should monitoring indicate that toxic compounds are accumulating.

The accumulation of nutrients from urban sources (turf and garden fertilizers, pet faeces) in the kettle wetlands is a concern, given that they will concentrate these over time. Bogs in particular are very susceptible to nitrification. The combination of changes to wetland hydroperiod, the 'sink' role of the kettle wetlands in this landscape, and increased nutrient levels, will lead to loss of quality plant species and habitat structure in the wetlands.

Catling and McKay (1980) reported on the shifts in distribution of salt-tolerant plants caused by the use of road de-icing salt in southern Ontario. Isabelle et. al.(1986) determined that exposure of wetland plant seeds to increased concentrations of roadside snow melt caused significant declines in growth, community biomass, species diversity, evenness, and richness. Only the invasive common cattail (*Typha latifolia*) and non – native purple loosestrife (*Lythrum salicaria*) were able to germinate when watered with full strength roadside snow melt. Panno et. al. (1999) studied the impacts of sodium chloride from a private septic system and road source on a fen wetland, and determined a strong correlation between invasion of the fen by Cattail (*Typha angustifolia*) and the sodium chloride plume from the septic and road sources. Detectable community change was noted where chloride was present at levels well under 100 mg/l. In light of the findings for the Pinhook Bog study (Wilcox 1986), this suggests that chronic exposure to salt affects the wetland community composition, even though quality species may be able to tolerate higher levels.

In conclusion, the landscape configuration of kettle wetlands will concentrate water quality effects. The only reasonable means to protect existing wetland communities, biodiversity and functions is to protect internally-draining catchments in their entirety.

3.2.3 Groundwater Quality

One of the main conundrums with urban development is simultaneously maintaining water quantity and water quality. Urban development necessarily entails increasing impervious surface coverage, which leads to increased surface run-off and decreased groundwater infiltration. At the same time, urban development inevitably reduces water quality. While reducing water quality on

externally draining lands can be addressed by centralized treatment systems, followed by discharge to a receiving water body, the same can not be done to ensure replenishment of groundwater. First, groundwater infiltration naturally occurs over the landscape. Second, there are far-reaching effects of replenishing groundwater with contaminated surface water. Unlike surface waters, contaminants are highly persistent in groundwater and treatment after release is extremely difficult, expensive and difficult to monitor.

Organic chemicals, such as BTEX, persist longer in aquifers than in surface waters. Dilution by advection is much slower in aquifers than in surface water bodies such as streams and drainage lakes. Once introduced into groundwater, chemicals cannot be geographically contained, in contrast to surface waters. Options for remediation that are available in the case of contaminated surface waters, such as riffles for aeration or settling ponds, are not available in the case of groundwater. In consideration of the sensitivity of aquifers to chemical inputs, the ORMCP does not allow the use of artificial recharge of stormwater into aquifers by use of, for example, rapid infiltration basins (RIBs).

However, is preventing the use of RIBs sufficient to protect groundwater? Evidence is now emerging from large-scale studies by the United States Geological Survey of elevated concentrations of a range of chemicals associated with urban development where overburdens are porous and infiltration is rapid. Among the chemicals found are pesticides, and those associated with vehicles (e.g. BTEX). This contamination is an inevitable outcome of long-term emissions from human activities to areas with large groundwater infiltration capacity. This is the situation on the Oak Ridges Moraine – the moraine has porous soils and high groundwater infiltration capacity, the attributes required for an excellent aquifer recharge area. Those attributes leave it vulnerable to contamination that would be extremely difficult to undo.

Recognizing the vulnerability of aquifers to contamination, many jurisdictions have or are adopting groundwater protection schemes. In the case of Oak Ridges Moraine, the ORMCP prohibits several uses and industries, such as automobile service stations, commercial or industrial dry cleaning, and a wide variety of manufacturing, from occurring in wellhead protection areas. While these provisions require municipalities to restrict these uses, they do not restrict other uses, such as residential, that could also adversely affect the quality of groundwater reaching the well. Residential uses are not benign, as is demonstrated by findings of widespread low-level contamination of groundwater underlying residential areas in the United States. Pesticide use in households has been measured at application rates in excess of those in agricultural settings and numerous other types of contaminants are released in residential areas, including contaminants associated with vehicles, the use of paints, and roofing materials (see Section 3.2.1 above for a more complete list).

It is worth noting that RIBs are not prohibited in other parts of Ontario. One of the major assumptions attached to the use of artificial groundwater recharge technologies is that stormwater, including roof run-off, is sufficiently “clean” to be directed safely into underlying groundwater. The numerous contaminants routinely found in stormwater, urban rainwater and roof run-off, as well as the recent findings of widespread low-level surface groundwater contamination underlying urban residential development, suggest this assumption is flawed. As noted above, sand filters attached to RIBs are not effective at retaining soluble chemicals, such as sodium chloride, atrazine and BTEX. Indeed, the contaminants identified in widespread groundwater contamination associated with residential development are predominantly water soluble ones such as trichloroethylene and atrazine. In addition, infiltration into the aquifer may occur outside of the controlled regimen of re-directed stormwater.

3.2.4 Cumulative Effects of Stormwater

An important, and frequently neglected, consideration when understanding the impact of new urban development is taking accurate measure of current and future inputs of contaminants due to sources other than those immediately attributable to the development at hand. Often, prior to a residential urban development being proposed, other types of infrastructure have already been constructed nearby, e.g. highways. There are frequently relatively new residential areas contiguous with or near to the proposed development. Since these developments precede the proposal under consideration and any effects are already occurring, they are usually considered irrelevant to consideration of a new development proposal. These precursor developments contribute to the “chemical halo” and landscape changes brought on by urbanization. Part of this halo includes atmospheric deposition of a wide range of contaminants. This atmospheric load will negatively impact sensitive systems located in ecological corridors and “protected” areas. Atmospheric deposition prevents us from truly protecting areas nearby developments. We have learnt this lesson with the acidification of remote lakes, the blanketing of southern Ontario with airborne smog, half of which comes from the U.S., and most dramatically, through the accumulation of “southern” PCBs and DDT in Arctic polar bears.

Closer to home, concentrations of chemicals such as sodium chloride (road salt) in an aquifer are influenced by nearby and future urban development. By extension, the extra input of salt due to a proposed development will have an effect on salt concentrations in areas downgradient from the new development. Even if inputs of road salt are fairly low following the construction of a proposed development, the amount of salt in the aquifer will increase as yearly inputs exceed “outputs” from the aquifer via groundwater flow and recharge.

Cumulative effects on water quality are difficult to assess. They depend on the quality and quantity of runoff from developed sites as well as the degree of mitigation afforded by best management practices (BMPs). For this reason it is more effective to assess cumulative effects on a watershed or subwatershed basis. Individual developments cannot be effectively assessed on their individual contribution to water quality impacts.

In the case of 2001 hearing on the Richmond Hill lands, watershed level effects were not assessed. This oversight was surprising since much of the land proposed for development was at the headwaters of several streams. If a watershed approach was not used in the headwater area, then its use in downstream areas would be less effective. In the present study the boundaries of the property formed the basis of the boundaries of the impact assessment. This is not appropriate for biological studies, and does not meet the intent of the Province to evaluate large development applications on a watershed or subwatershed basis.

Moreover, we should remember that our ability to assess long-term cumulative effects is limited. Few long-term studies are available to guide our decisions and our time horizon for projecting impacts often extends only to 20 years.

3.2.5 Use of Models of Contaminant Fate

In the absence of comprehensive or complete monitoring data, models often provide the only means of predicting complex environmental events (Cohen 1986) and are integral to the assessment of risk and the design of remedial measures. Mass-balance models of contaminant fate define a natural system as a set of processes such as the transformation and transportation of a contaminant, where inputs are mathematically reconciled with outputs from the system. Mass-balance models can elucidate, for example, the relative contributions of various contaminant sources to concentrations in ecosystem components, the time required for a system to adjust to loading reductions, and the benefits possible following various abatement strategies. Parameters typically considered in a model include hydrodynamics, movement and abundance of particles, system morphology and trophic status.

Some of the parameter values and process descriptions used in model equations are poorly known and are estimated on the basis of empirical relationships found in other, hopefully similar, natural systems. Mass-balance models are parameterized iteratively, i.e., unknown parameters are adjusted over numerous model “runs” until they fit some measured data, a process known as calibration. If model results based on the set of estimated and measured parameters agree satisfactorily with measured data, the model is applied further. Determining what is reasonable, is a delicate process, and models can be manipulated by applying data and empirical relationships out of context. Inappropriately applied empirical relationships can be obscured by adjusting parameters so that results fit data measured during calibration.

Those working with models do not always express the uncertainty associated with their models’ results. The approaches used to propagate the uncertainty of input data and to estimate the uncertainty of the output are not widely applied in the area of modelling fate of nutrients and toxic contaminants in the environment.

Because of these intricacies, models are only as good as the explanations accompanying them. The context of a model – its assumptions, the range of its past applications and its applicability to the current situation given available alternative models – comprises these explanations. Any model used in a process of democratic decision-making should be considered incomplete unless accompanied by some explanation of how different parameters were estimated and a sensitivity analysis to provide some indication of the response of output data to variations in parameter estimates and/or input data. Sensitivity analyses can suggest which parameters in the model most urgently require further experimental investigation.

The use of models in predicting water quality changes associated with development is a well-established practice in Ontario and many other jurisdictions worldwide. None of these models have, however, been tested on or applied to kettle lakes. Kettle lakes differ from most other lakes in that they have no outlet, and generally no permanently flowing inlet. The model used in the review of the kettle lakes near Richmond Hill, the Dillon-Rigler model, suffered from a number of deficiencies including:

- The model was developed “on the basis of data collected for a series of small, oligotrophic and mesotrophic lakes. Extrapolation of this model to lakes that are very different (e.g. extremely large, or eutrophic) is not warranted without further research.” (MMA, 1986). Kettle Lakes have different hydrological processes than the lakes for which this model was developed. Adaptation of this model for use on such lakes must be completed and justified.
- One central concept of the model used in the case of the Richmond Hill ORM developments is that of flushing rates. This concept is based on the assumption that there is a surface water outlet in which some chemical constituents of the loadings to the lake are lost through outflow. In kettle lakes where there is no surface water outflow loss, the use of the same loss equations as for surface discharge lakes must be verified or the equations modified to reflect the unique situation of kettle lakes.
- The quantity of measured data against which the modelled results are compared must meet the normally accepted standards for the use of the model. Too little data introduces greater uncertainty which makes prediction of future impacts imprecise. Basing long term decision on inadequate data will more often lead to projects being approved with inadequate water quality and quantity controls.
- The methods of collecting and analyzing lake water quality data have been standardized. Any deviation from such accepted practices must be justified and the accuracy of alternative approaches verified.
- Runoff coefficients for pollutant exports for various pollutants from different land uses areas are variable. To accurately model potential consequences of development a range of export values should be used which represent the range of literature values.

Such a sensitivity analysis is important in understanding the consequences of the initial assumptions being in error.

The impact of these deficiencies in the Dillon-Rigler model on results are described below. The chosen study site to predict the effects of urban residential development on phosphorus levels was the representative kettle lake, Bond Lake. The proponents of the development used the Dillon-Rigler model with adaptations by Nurnberg, a statistically-derived model which was derived using data from drainage lakes of the Canadian Shield which, as described above, has not been tested on seepage lakes as applies in the case of Bond Lake. The Dillon-Rigler model is inherently less flexible than other models of nutrient and contaminant fate because it does not integrate a wide variety of processes of transport and transformation. Seepage lakes have such low levels of advective outflow via groundwater loss that sediment burial is the main mechanism of loss of phosphorus once it has entered Bond Lake. Sediment burial is tremendously slower than advective outflow, so much so that half-lives of phosphorus in Bond Lake estimated using a more comprehensive, current model (the Diamond-Mackay model) were between 280 and 2600 years, versus five to ten years in a drainage lake. The results of the Dillon-Rigler model were given without a complete explanation of how loadings were estimated. This was a critical failing because the estimates used by the proponents were not consistent with current science regarding eutrophication of lakes following urbanization. Results obtained using the Diamond-Mackay model, which included a sensitivity analysis, referenced and measured data, and a range of scenarios, indicated that, unlike the results of the Dillon-Rigler model, concentrations of total phosphorus in the lake were likely to exceed provincial water quality objectives and, perhaps more importantly, that the actual current trophic status of the lake is unclear.

In summary, models may be, as in the case study above, applied inappropriately in the context of different development proposals. Important questions to consider when evaluating claims derived from models include:

- What is the inherent flexibility of the model?
- How well has the model been evaluated, especially for the conditions being considered?
- Is it statistically-derived, i.e, based on data accumulated in studies of similar natural systems? Or is it based on more general expressions of a variety of environmental processes?
- Is it accompanied by a thorough explanation of the sources of input data?
- Does it include a sensitivity analysis to demonstrate the impact of variations in input data?
- Does it include expressions of uncertainty in the output?
- Are its predictions consistent with what has been previously observed to occur in the system studied or other similar systems?
- Are its predictions based on solid knowledge of current conditions in the system, e.g. ambient concentrations of various compounds?

3.3 Conclusions and Best Practices for Stormwater

In any urban development, residential or otherwise, chemical emissions are inevitable. Stormwater integrates many of these emissions and has been the focus of most efforts to develop treatment facilities. However emissions to air derived from urban areas, and their

subsequent deposition, also impact nearby areas. Thus, even “protected” or “natural” areas nearby developments will be adversely affected to some extent.

The management of stormwater continues to pose the conundrum of aiming to maintain the hydrologic budget (i.e., water quantity) while ensuring protection of water quality. As we work to solve the conundrum, we must recall that treatment systems operate by transferring wastes and contaminants from one medium to another, but do not eliminate nutrients and most chemical contaminants, e.g. a best management practice (BMP) for stormwater transfers the compounds from liquid stormwater to soils in a swale or sediments in a stormwater detention pond. Current practice in high density developments can include collecting stormwater and treating it in a controlled sewage treatment facility prior to discharge to the receiving environment. The advantage of this system is a high level of treatment and hence less impact on the water quality of the receiving environment. The disadvantage is the cost of such a centralized facility and starving the groundwater by eliminating infiltration over a large area.

In contrast, current practice in other new developments is to encourage stormwater infiltration wherever possible and to collect and treat road run-off in decentralized facilities such as wet and dry stormwater detention ponds and other BMPs. These best management practices are low cost and more closely mimic the natural hydrologic regime than the centralized system. The downside is that these BMPs have a lower treatment efficiency and hence will compromise the quality of the receiving environment. The other downside is that wildlife inevitably use these facilities as habitat, which poses to them a health risk..

Since existing measures to contain emissions from urban areas are imperfect, it is unrealistic to claim that urban development can occur without causing harm to natural heritage, especially on sensitive lands. Given that impacts on natural heritage from urbanization are inevitable, the best approach is to preferentially locate new urban development on less sensitive lands, i.e., externally draining lands without internally draining lakes, ephemeral wetlands and aquifers that are the headwaters for high-quality streams. Exercising this principle would, of course, require highly coordinated regional planning because the natural boundaries of aquifers, moraines, and other natural features are generally not congruent with jurisdictional boundaries.

In less sensitive areas designated for development, we seek the use of BMPs to mitigate the negative effects on the surrounding environment. The particular BMP should be selected while understanding its level of performance and particularly its performance over the long-term and the consequences to the receiving environment. BMPs, such as stormwater detention ponds, should not be considered to be green space or included in a wildlife corridor or buffer – they must be regarded as treatment facilities. These facilities require on-going maintenance and monitoring, costs that must be included in any development scheme. Finally, we must encourage long term assessment of these facilities and promote the development of innovative treatment systems based on sound engineering and environmental knowledge.

3.3.1 Stormwater and Natural Heritage

The following are considered key criteria to defining a workable land use framework for natural heritage, with reference to sensitive lands like Yonge East and Yonge West. They are intended to result in an optimized functional landscape dominated by natural processes. This implies that the natural heritage potential of the lands is maximized, and that off-site benefits (such as baseflow of rivers) are maximized.

- ***Protect internally drained catchments in their entirety:*** These catchments should eventually become forested again; a 50% forest cover target will ensure that a mosaic of habitats exist on these catchment areas that is supportive of wetland functions (Azous and Horner, 2000). This will optimize groundwater infiltration quality and quantity, and increased

wetland cover will likely evolve. The principle of protecting internally-drained catchments around individual wetlands has been established as a means of protecting wetlands elsewhere in southern Ontario, such as in the Creditview Swamp in Mississauga, and vernal pools in wet forest habitats in Niagara Region. The ORMCP requires minimum vegetation protection zones for all land within the surface catchment area or within 30 metres of a kettle lake, whichever is greater, where there is an application for development or site alteration within 120 metres of a kettle lake.

- **Minimize impervious surfaces:** Natural infiltration of runoff should be maximized by retaining an agricultural matrix, limiting density of development, maintaining natural topography, and restricting the extent of manicured landscape. In addition to the kettle lake requirements referred to above, the ORMCP contains a number of requirements and targets for limiting impermeability in subwatersheds and landform conservation areas.
- **Protect wetland features from stormwater runoff:** : Some valuable kettle features in Richmond Hill such as the Radio Tower Wetland, and Bond Lake Bog are receiving highway runoff at present. Such situations should be remedied based on detailed site study and adjustment with 'clean' runoff

4. Land Use Planning Framework and Policy Considerations for Natural Heritage Protection

4.1 Recent Changes to the Land use Planning System in Ontario, and Effects on the Consideration of Natural Heritage Values

Previous sections in this report discussed the ways in which our understanding of the significance of the ecological effects of urban expansion is improving, and the practices that can be applied to reduce these impacts. The effective translation of this knowledge into appropriate relationships between development and natural systems in individual cases depends not only on the policy framework, but on the planning system within which that policy framework is applied. This section discusses changes to the planning system in Ontario that have occurred over the last several years, and the way these changes can affect the extent to which the natural environment is protected when development proposals are considered.

Prior to the enactment of extensive revisions to the Planning Act in 1996, proposed official plans, official plan amendments and some other planning proposals were required to be circulated to government Ministries and agencies with a potential interest. The Ministry of Municipal Affairs was, in most instances, the approval authority. Natural heritage protection was the mandate of the Ministry of Natural Resources (MNR), and Conservation Authorities. Individual Ministries and agencies, including MNR and Conservation Authorities, could appeal proposals to the Ontario Municipal Board if their requirements were not met. While proponents were required to undertake studies and to demonstrate how natural heritage features would be protected, there were instances of development approvals in the Oak Ridges Moraine where areas of natural heritage importance such as wetlands were displaced, and development was permitted, for example, in the internally draining areas of kettle lakes.

The 1996 changes to the Planning Act brought about a number of significant changes to this regime, including the introduction “one window” planning service, and Municipal Plan Review.

4.1.1 “One Window” Planning Service

Under the “one window” approach, planning decisions under provincial jurisdiction flow through the Ministry of Municipal Affairs and Housing (MMAH). Although this Ministry consults with other ministries and agencies in making decisions, it has the sole mandate among government ministries to appeal applications to the Ontario Municipal Board based on the provincial interest.

4.1.2 Municipal Plan Review

Municipal Plan Review involves delegation of the review of official plans, zoning bylaws and planning applications from the provincial government to municipalities. Although MMAH still has approval powers for upper tier and single tier municipal official plans, where powers have been delegated the review and approval of official plans for area municipalities within a region, for example, becomes the region’s responsibility. Official plan amendments may be exempt from approval, i.e. the amendment comes into effect automatically if there is no appeal. Other review and decision making powers have also been delegated to regional and area municipalities. Delegation has occurred in a number of regions including those in the Greater Toronto Area, and in a number of counties. In the Oak Ridges Moraine, municipalities must now amend their official plans and zoning bylaws to conform with the ORMCP, but they will still be responsible for planning decisions where these powers have been delegated.

Because municipalities now have responsibility for the technical review of planning applications, relevant data previously held by ministries and agencies has been transferred to the new approval authorities. Although approval authorities may refer back to relevant Ministries for advice in specific instances, the service is not as comprehensive as before. Most municipalities do not have the expertise “in house” that was previously available to them from provincial ministries when the province reviewed these proposals. Also, municipalities have many competing demands on their resources. They may not give priority to natural environment protection, or they may lack the resources to retain consultants or to undertake detailed peer review of the technical aspects of development proposals. Municipal resource concerns are greater in the Oak Ridges Moraine, where, under the ORMCP, municipalities would be responsible for developing and reviewing a range of technical material that would not be required in other areas of the province.

Although these changes were intended to introduce efficiencies to the planning system, they can affect decision making on Planning Act proposals in the following ways:

- Planning decisions that do not comply with provincial policy may be made by municipalities, and the provincial government may not find out about them unless they are appealed. It is more difficult for the ministries to uphold their mandate in this situation.
- Decisions by the provincial government to appeal applications to the Ontario Municipal Board are not made by the Ministry that has the mandate to protect the natural environment.
- Delegation of review functions to municipalities may mean that decisions are made without the appropriate level of expertise.
- The use by municipalities of consultants rather than public servants to peer review the technical aspects of applications can introduce a perception of bias, since consultants may depend on the development community for much of their work, and they may review the work of firms that compete with them in this and other areas of business (this is not to question the professional integrity of the consulting community in general).
- Municipalities may be reluctant to hire expert staff or retain consultants, given increased pressure on resources and other financial priorities. Where a proponent is required to pay for peer review consultants, this may be seen as a disincentive to development.
- Where the public feels that natural environment considerations have not been given sufficient attention or weight, they may be discouraged from appealing a decision by the cost of mounting a credible case at the OMB, and by the prospect of costs being awarded against them.

In the Oak Ridges Moraine, the Conservation Plan is more specific in its requirements for studies and evaluations in support of proposals than many official plans in other parts of the province. Also, compliance with the ORMCP is a legal requirement.

4.2 Ontario’s Legislative and Policy Framework for Land Use Planning and Environmental Protection

4.2.1 The Policy Framework-Planning Act

The Planning Act provides a hierarchy of policy and regulation instruments that set requirements at increasing levels of detail, from the strategic level to requirements for individual proposals. The following is an outline of the mechanisms available under the Planning Act within the Oak Ridges Moraine and elsewhere in Ontario, with discussion of how each may be used for natural heritage protection.

4.2.1.1 The Provincial Policy Statement (PPS) and Other Provincial Guidance

The PPS, approved by the Province under Section 3 of the Planning Act in February 1997, consolidated and expanded Provincial policies relating to land use. Decision makers must “have regard” to the PPS, which includes policies on natural heritage, in making land use planning decisions. The Ministry of Natural Resources has produced a “Natural Heritage Reference Manual” in support of the natural heritage policies in the PPS. A number of municipalities have produced their own guidelines for compliance with the natural heritage policies in the PPS, including guidelines for the preparation of environmental impact studies.

Until the provincial government’s 2001 freeze on development, proposals in the Oak Ridges Moraine within the Greater Toronto area were also subject to the June 1991 “Implementation Guidelines: Provincial Interest on the Oak Ridges Moraine Area of the Greater Toronto Area” This was intended to be an interim document, however a 1994 draft “Oak Ridges Moraine Area Strategy for the Greater Toronto Area” was never finalized.

Both these documents are discussed in more detail in Section 2.2.1.

The ORMCP now takes precedence over the PPS within the Moraine.

4.2.1.2 Regional, Municipal and Secondary Plans (Official Plans)

Official plans are prepared under Part III of the Planning Act. No public work can be undertaken and no by-law can be passed that does not conform with an official plan, where one is in effect. Official plans must have regard to the PPS.

The ORMCP will operate through the existing planning system. The Oak Ridges Moraine Conservation Act (Section 9) requires municipalities to amend their official plans as they apply to land within the Moraine to comply with the ORMCP, within specified timeframes. Planning decisions on development proposals would then be made by municipalities through official plan and zoning amendments, and other mechanisms including those described below. The difference would be that whereas planning decisions must “have regard” to the PPS, in the Oak Ridges Moraine they “must comply” with the Conservation Plan.

Section 16.(1) of the Planning Act requires that an official plan:

- (a) shall contain goals, objectives and policies established primarily to manage and direct physical change and the effects on the social, economic and natural environment of the municipality or part of it, or an area that is without municipal organization; and,
- (b) may contain a description of the measures and procedures proposed to attain the objectives of the plan and a description of the measures and procedures for informing and obtaining the views of the public in respect of a proposed amendment to the official plan or proposed revision of the plan or in respect of a proposed zoning by-law.

An official plan normally includes maps that allocate or designate land for different ranges of uses or types of protection. It may also include proposals for infrastructure. Although a secondary plan would be more detailed than a regional plan, for example, official plans address “what” can be developed rather than “how”.

An official plan can designate ecologically and hydrologically sensitive areas for protection, and can specify required studies and conditions to be met where a development proposal may affect natural heritage features. Although an official plan can require that certain lands such as hazard land be dedicated for public ownership as part of a planning approval, it does not require

landowners to actively conserve lands within their ownership. At the same time, an official plan may express a policy to enact a tree preservation or site alteration by-law.

A municipality also has the ability to acquire and hold land for the purpose of developing any feature of its official plan, provided this is supported by official plan policies (Section 25).

4.2.1.3 Zoning By-laws

Zoning by-laws regulate the use of land. They are more specific than official plans in terms of permitted uses, location, building density, setbacks, building height, parking requirements and other matters. Section 34.(1) 3.2 allows a zoning by-law to prohibit any use of land or development in a range of situations, including land with steep slopes or that is subject to erosion, sensitive groundwater recharge areas or headwater areas or land containing a sensitive aquifer, and in significant wildlife habitat, wetlands, ANSIS, and natural corridors.

As with other approvals under the Planning Act, a zoning by-law can set land aside for protection, but it cannot require active conservation on the part of the landowner. Amendments to by-laws are considered on an individual basis. Even if further development is anticipated in the same area, the cumulative effects of development are difficult to address-although a zoning amendment could be considered in the context of broader official plan policies that take these effects into consideration.

There are a number of other mechanisms that municipalities can use in relation to zoning, and that could be applied to protect natural heritage or hydrological features. These include the ability to authorize increases in the height and density of development in exchange for “facilities, services and other matters” (or “bonusing”-Section 37.(1)) that could include dedication of sensitive lands, if this is provided for in the Official Plan. Interim control by-laws (Section 38(1)) can be used to delay consideration of an application until studies have been completed-for example, where a watershed study or a broader scale natural heritage study is required. Use of these mechanisms is, of course subject to the discretion of the municipality.

4.2.1.4 Site Plan Control and Development Agreements

A municipality can specify an area or areas in its official plan where development is subject to site plan control (Section 41). In these areas a proponent must provide plans showing the location of all buildings and structures, as well as plans, elevations and cross sections of buildings. Residential buildings with less than 25 units are normally exempt from these requirements. A proponent may have to provide features including landscaping and protection of adjoining lands, easements for the construction, maintenance or improvement of watercourses, grading of the land, and stormwater facilities. These provisions are established through a development agreement.

4.2.1.5 Plans of Subdivision

The subdivision of land is subject to Section 50 of the Planning Act, which prohibits the conveyance of land, in most circumstances, without a registered plan of subdivision. The information required to be shown on a draft plan of subdivision includes “natural and artificial features such as.....watercourses, drainage ditches, wetlands and wooded areas within or adjacent to the land proposed to be subdivided”, the availability and nature of domestic water supplies, and any other information required by the approval authority. The required considerations for a draft plan include the provincial interest (as set out in the PPS), conservation

of natural resources and flood control, and areas to be conveyed for public purposes. Required provisions may be set out in conditions of approval, and/or a subdivision agreement.

4.2.1.6 Development Permits

Section 70.2 (1) of the Planning Act and Regulation 246/01 provide for specified municipalities to pass by-laws for development permit systems that may override Part V of the Act (land use controls including zoning). A development permit system may delegate many planning decisions to staff and streamline consultation, within the specified area. Although no municipalities in the Oak Ridges Moraine are authorized to pass development permit by-laws, pilot projects are under way to test the concept in relation to lake capacity in the Township of Lake of Bays, and groundwater protection in the Region of Waterloo. Development permit systems and lessons learned from the pilot studies could be applied in the Oak Ridges Moraine and elsewhere in the future.

4.2.2 Requirements under Other Legislation

Space does not permit a comprehensive review of all legislative requirements that may apply to the natural heritage aspects of proposals within or outside the Moraine. The following is intended to provide an indication of the statutes that may apply. There are also numerous regulations and guidelines related to this legislation that relate to natural heritage protection.

4.2.2.1 Federal Legislation

Canadian Environmental Assessment Act.

Authorizations under the following and other federal legislation, and some other projects including those funded with federal money or on federal land, may be subject to the *Canadian Environmental Assessment Act*.

Fisheries Act

This legislation provides protection for fish and fish habitat, as described in Section 2.3.5.2 of this Report.

Navigable Waters Protection Act

This legislation controls works such as bridges and dams in navigable waters.

4.2.2.2 Provincial Legislation

Aggregate Resources Act

This legislation, administered by MNR, provides for the management of aggregate resources and controls or regulates aggregate operations on crown or private lands.

Endangered Species Act

This legislation provides for the conservation, protection, restoration or propagation of species of fauna and flora that are threatened with extinction in Ontario.

Environmental Assessment Act

Public sector projects are required to comply with the *Environmental Assessment Act*. Regulation 334 provides for exemptions for some projects, and others are subject to Declaration Orders (previously known as exemptions), but may still require an environmental planning and/or consultation process. Private sector projects are only subject to the Act if they are specifically designated.

Some specific types of project, or projects proposed by a particular proponent, may be covered by Class Environmental Assessments which require a prescribed process for those projects. For example, there are Class EAs for municipal road and water projects, provincial highways, flood control structures proposed by conservation authorities, MNR projects on Crown Land, and for provincial parks and conservation reserves (approval pending), and Ontario Realty Corporation projects.

Both public and private sector electricity generation and transmission projects are subject to regulation 16/01 and the MOE “Guide to Environmental Assessment requirements for Electricity Projects”.

Environmental Bill of Rights

The EBR provides a mechanism for the people of Ontario to comment on environmentally significant proposals posted on the Environmental Registry, to request review of a law or policy, to ask a ministry to investigate alleged harm to the environment, to appeal certain ministry decisions, and to take court action to prevent environmental harm. It requires ministries to develop “Statements of Environmental Values”, and provides for an Environmental Commissioner who reports annually to the Ontario Legislature.

Environmental Protection Act

The EPA prohibits the discharge of contaminants that will or are likely to have an adverse effect, without a Certificate of Approval. It is administered by the Ministry of the Environment.

Lakes and Rivers Improvement Act

The *Lakes and Rivers Improvement Act* regulates structures in and alterations to lakes, rivers and streams. It is administered by the MNR.

Ontario Water Resources Act

The OWRA regulates the taking of water from wells or surface water and the treatment and disposal of sewage. It is administered by the Ministry of the Environment. Approval may consist of a permit to take water or a certificate of approval, depending on the proposed undertaking.

Municipal Act

This legislation allows municipalities to enact by-laws to control site alteration (Section 223.1) and to protect trees (Section 223.2). Not all municipalities have enacted these bylaws, and where they have been passed their scope is often limited. Section 23.(1) (f) of the Oak Ridges Moraine Conservation Act empowers the Minister of Municipal Affairs and Housing to require municipalities on the Moraine to enact site alteration and tree by-laws.

Oak Ridges Moraine

The *Oak Ridges Moraine Protection Act* established a six month moratorium on development in the Moraine in May 2001, and in December 2001 the *Oak Ridges Moraine Conservation Act 2001*, which provides for the ORMCP, received Royal Assent.

4.3 Effective Policies for Natural Heritage Protection

4.3.1 General Principles

In proposing and reviewing proposed policies for the Moraine, the study team took a number of general principles into account. Policies should be:

- *Based on clear objectives for protecting natural heritage*

The initial step in developing effective policies is to determine what the policies are intended to achieve. Policy objectives should provide an overall direction for the policies by describing their purpose in a precise manner. For example, the SRVS team proposed the objective of “protecting the entire Oak Ridges Moraine, including buffer areas and significant headwater areas of connecting watersheds, as a continuous rural and natural environment where future urban expansion is prohibited” Similarly, SRVS’ proposed vision for the “Share Your Vision” document was “To protect the character and the ecological and hydrogeological functions of the Oak Ridges Moraine and to ensure that it is maintained in perpetuity as a continuous natural, agricultural and rural working landscape within the fabric of southern Ontario.”

Supplementary objectives can outline how protection will occur, for example they can refer to land uses that are permitted within the natural heritage system, such as recreational uses, and outline how existing developments, including rural settlements, will be addressed.

- *Directed towards the regional level, and then focused on the details*

Effective policies for natural heritage protection must consider the “big picture” in terms of their scope. Policies that protect natural heritage may simply redirect development to other areas worthy of protection, such as prime agricultural land, or they may fall within a broader context that requires higher densities and urban intensification.

Although they are constrained and impacted by decisions made at the municipal and regional levels natural systems do not follow municipal boundaries. For example, the effects of poor planning in the headwaters of river systems are felt downstream. Thus, natural heritage policies need to look at how natural features relate spatially and functionally to one another at the regional level, and identify where connections between different features can be maintained, enhanced, or created.

The SRVS identified the “big picture” by identifying the larger scale potential effects of the types and locations of development and infrastructure that might be permitted in the Moraine, and by examining the way in which they were addressed in the planning documents that came forward for review. This work was assisted by maps of the area prepared by the Ministry of Natural Resources, which allowed the team to identify natural heritage corridors by examining the spatial relationships between significant natural features at the regional level.

Once the larger pattern for protection had been established, it was necessary to address natural heritage protection at the site level. When working at this level, the policies are

considerably more detailed. For example, proposed policies that the SRVS team prepared for specific properties on the Moraine referred to conditions for permitting roads in certain natural features, such as provisions for addressing wildlife movement.

- *Defensible scientifically*

Policies for natural heritage protection must be based on up-to-date scientific information, in part because competing interests may challenge the rationale for protection. Should a formal challenge against policies be launched, the Ontario Municipal Board, and adjudicative tribunals in other jurisdictions, are more likely to accept policies based on sound scientific principles than those with no clear rationale.

The principles of island biogeography and conservation biology, including concepts described earlier in this report, such as habitat fragmentation, edge effects, and fragment connectivity, have been established as cornerstones of effective natural heritage planning. The SRVS team also provided documented findings on the impacts of development on water quality and quantity. When combined with a natural heritage inventory, these and other principles provide a defensible rationale for why certain areas need protecting, and what standards of protection are required.

The ORMCP includes requirements for natural heritage evaluations, hydrological evaluations, watershed plans and water budget and conservation plans. These requirements are to be supplemented with guidelines and further technical advice. In the past, a missing ingredient in the development application process has been the lack of firm guidelines or requirements for completing Impact Assessment (IA) and other studies. Without these guidelines individual Natural Heritage reports vary widely depending on the individual contracted to complete the Natural Heritage studies and the allocated budget. This invariably leads to a difference of opinion on the level of effort necessary to obtain development approvals. The proponent wishes to minimize “up front” costs and thus is inclined to do a little baseline research as possible. When opposition forms and the matter is sent for adjudication, the developer ends up spending a great deal more to collect the basic information that should have been collected to design the development in the first place. In addition, more money is spent on presenting a case at a hearing.

The presence of comprehensive guidelines which identify the Planning Authority requirements for environmental impact assessment would avoid many of these problems and the associated frustration with the process. It would also lead to a higher probability of the goal of “smart growth” being achieved.

- *Acceptable to the public*

Recent events in Southern Ontario have demonstrated that the public and public interest groups can significantly influence policies. Effective policies need to account for the views of the public, and there are numerous means of incorporating those views. During and after the Oak Ridges Moraine OMB hearing, SRVS was successful in mobilizing the public to write letters and attend public open houses where they could provide comments on the proposed plan.

In general, public meetings, open houses, and web sites, are efficient means of disseminating and receiving information from the public at large, whereas working groups and advisory committees can provide detailed and thoughtful analysis from knowledgeable stakeholders.

To ensure that the public is “on side”, it is equally important to document how and why their input was or was not incorporated. This is standard practice in a number of areas of environmental planning in Ontario, but direct responses were not provided to public

submissions in the Oak Ridges Moraine process. A supplementary or background report should have been prepared.

- *Able to be implemented*

The extent to which natural heritage protection policies should be easily implemented—thus providing for “predictability” in terms of the timeframe and complexity of the evaluation and the ability to secure approvals—is an area of much debate. For example, the ORMCP policies propose fixed “areas of influence” for different types of feature within which evaluation should take place, which introduce a degree of predictability in the required evaluation. On the other hand, it can be argued that study areas should respond more closely to the circumstances of each case, even if this requires more expert effort and less certainty.

Strong policies protecting natural heritage are a benefit to municipalities only if resources, expertise, and the political will exists to monitor natural heritage resources. Municipalities that are unable to meet their basic commitments to monitoring are highly unlikely to be equipped to proactively manage natural areas in a way that maintains biodiversity.

Provincial financial support for monitoring is also required if it is to be effective.

4.3.2 Policy Objectives

Effective policies for the protection of natural heritage must be based on clear objectives. Two implicit objectives guided the development of the policies we reviewed or prepared in support of the Oak Ridges Moraine, which were:

1. The maintenance and enhancement of the diversity of plant and animal species within the Moraine, and
2. The maintenance and enhancement of the hydrological functioning of the Moraine.

Regarding the former, the diversity of plant and animal species can be maintained primarily by protecting their habitat, especially of those whose populations are threatened or endangered. The policies developed for the Oak Ridges Moraine case attempt to protect those habitats by conserving areas with the greatest concentrations of significant natural features, such as wetlands, Areas of Natural and Scientific Interest (ANSI), Environmentally Sensitive Areas (ESA), woodlands, waterbodies, watercourses and valleylands, critical fish and wildlife habitat, etc.

The policies also encourage enhancing connectivity throughout the Moraine by maintaining and creating natural linkages between significant natural features. These natural linkages help address fragmentation issues by ensuring that local populations of species are able to migrate between habitats with minimal exposure to human activity.

For both core natural areas and linkage areas, the team encouraged a number of policies that would support these objectives, including:

- Limiting permitted uses within those features to those that will have little or no impact, such as recreation and conservation activities
- Creating buffer areas to provide a transition or a required undisturbed area between natural features and development and thus minimizing the effects of adjacent human activity. The width of an effective buffer depends on the adjacent feature, and may range from 30 metres to 400 metres. The team supported calculation of buffers based on individual circumstances rather than pre-determined areas of influence—the latter approach was the one adopted in the Plan.

While the protection of core natural areas and linkage areas helps to protect the hydrological functioning of natural systems, additional policies are required to maintain the functioning in its current state. The team supported:

- Requiring watershed plans to be prepared and a framework for implementing the plan established
- Limiting impervious surfaces to a certain percentage of the area of a subwatershed (typically 10% or less)
- Prohibiting stormwater management ponds, rapid infiltration basins, rapid infiltration columns, road salt loadings and storm water loading into dry valleys, intermittent streams, internally draining areas, sensitive headwater stream areas, and other sensitive natural features
- Identifying wellhead protection areas and establishing buffers around these areas

Most of these objectives found expression in the Plan.

Other policy objectives that are important, but are lesser priorities for conserving natural heritage, include protecting the visual amenity, character and quality of the area, and providing low-impact recreational opportunities within the natural heritage system.

4.3.3 Land Use Mechanisms for Natural Heritage Protection

The following are examples of specific ways in which the policy framework can be used to enhance natural heritage protection:

- Municipalities off the Moraine can develop guidelines to assist in implementation of the PPS as it relates to natural heritage. For example, a number of municipalities now have guidelines for preparing environmental impact statements. If development applications do not meet these requirements, then the planning authority has the option of returning a development application as “incomplete”.
- The Municipal Class Environmental Assessment- a process that enables municipal infrastructure projects to meet the requirements of the Environmental Assessment Act- contains provisions for its process to be integrated with the land use planning process. The traditional approach is to use the Class EA to examine alternative configurations for infrastructure and their environmental effects, and to prepare land use plans and process development proposals separately under the Planning Act. The new provision makes it easier for both land use and infrastructure to be planned under a common process that could include consideration and comparison of alternative development and infrastructure scenarios, based on a wide definition of the environment that would include cumulative effects.
- Proponents could be required to identify the development carrying capacity of a feature such as a watercourse, aquifer or wetland that might be affected by a proposal, and to justify the proposal in terms of this larger consideration (not dissimilar from the use of retail market studies to justify shopping centres). Later proponents could be required to review and assess the validity of earlier work as a basis for their applications.
- Official plans could assign thresholds of values such as aquifer water levels and contamination in watercourses that would place a hold on further development until concerns have been addressed.
- A municipality could develop standardized approaches to mechanisms such as agreements and tax incentives that could be publicized and used across the municipality to protect sensitive areas without incurring high administrative and legal costs.

- A municipality could initiate a by-law to prevent pesticide use for cosmetic purposes in areas such as wellhead protection areas and hydrologically sensitive areas, or across a municipality as a whole.
- A municipality could initiate informal measures for environmental protection such as providing for appropriate engine oil disposal and disposal of agricultural chemicals, and making aerial photography available to members of the public to compare changes in natural features and development patterns from year to year.
- The Planning Act provisions for development permit systems will likely become more widely used during the life of the Plan. It is possible that development permit agreements could be used in the future to require monitoring and other commitments that support the reduction of cumulative environmental effects.

Land use policies are frequently seen only as a minimum requirement that can be eroded when individual applications are considered. But the policy framework is something that can be utilized and extended to provide protection-particularly in the Moraine, where this is encouraged by the Plan.

4.3.4 Supplementary Mechanisms for Land Conservation

Agencies and non profit organizations are increasingly turning to innovative approaches to natural heritage protection that involve acquisition of sensitive land, or protection through agreements or contractual arrangements with landowners. Some of these mechanisms are supported by tax incentives. While they do not fall within the traditional range of tools used under the Planning Act and other legislation, these mechanisms can be effective as a means of implementing planning policy, or of acting independently to protect natural heritage resources. The following are examples of these supplementary land conservation mechanisms.

Stewardship Agreements are voluntary verbal or written agreements between landowners and conservation organizations. While they are inexpensive, they are not legally enforceable.

Conservation Easements are similar to stewardship agreements but are registered on the title of the property. They provide access to the property for the conservation organization, and set out restrictions on the use of the land, and are binding on current and future landowners.

Tax Incentive Programs: Both the federal and provincial governments provide tax credits to landowners who donate their natural heritage lands to municipalities, conservation authorities and charitable organizations, or who commit to protecting them. For example, the Conservation Land Tax Incentive Program is administered by the Ontario Ministry of Natural Resources. Tax rebates are available to landowners who protect provincially significant natural features, but they must be re-applied for each year. Environment Canada has an Ecological Gifts program which provides significant tax incentives known as “ecogifts” to landowners who donate ecologically sensitive land, or interests in such land.

Land Acquisition Tools: There are a variety of land acquisition options that can be used in response to different circumstances. Property may be donated outright, or there may be a partial transfer whereby the owner and heirs retain certain rights such as access to the property or extraction of firewood. In other situations the former owner may lease back land, for example where an owner wishes to continue farming the land.

These mechanisms may be pursued by a land trust, which is a non-governmental organization that strives to obtain public benefits, including natural heritage protection, on private land. They typically employ a variety of mechanisms to protect valuable land, including easements, acquisition, and private land stewardship programs.

In the Greater Toronto Area, the Oak Ridges Moraine Land Trust has been successful in obtaining several conservation easements since incorporating in 1999. In 2002, a landowner signed an easement for over 700 acres at the headwaters of the Duffins Creek watershed, east of the hamlet of Claremont. The property is located between two provincially significant wetlands: Claremont and Glen Major. Another 18 acre property in King Township was bequeathed to the Trust, and their Land Committee is working on a further 20 properties in communities across the Moraine.

4.4 Cumulative Environmental Effects and the Oak Ridges Moraine

4.4.1 Understanding Cumulative Effects

“Cumulative” environmental effects are effects resulting from individual projects that accumulate or interact with other effects to cause significant impacts on features and processes in the environment. These effects can result from projects that are subject to a legislative and policy framework, or from individual actions that are not closely controlled, such as clearing land or applying pesticides. Cumulative effects can occur in the social and economic environments, but this discussion will focus on the natural environment.

In the case of land development, when only one project or area of development is evaluated at a time, cumulative effects may be neglected and important features and functions that the policy framework is intended to protect may be compromised or lost over the longer term. Also, the presence of development results in unregulated actions that can accumulate to affect the environment, and that would not otherwise have occurred in that location.

Examination of development from the standpoint of cumulative effects is particularly relevant to conditions on the Oak Ridges Moraine, where features and processes have been affected by the steady progression of numerous actions and developments that, individually, are small in relation to the scale of the Moraine and its natural systems.

The following are examples of types of cumulative effects identified by Sonntag et al (1987), and the ways that they have occurred-or may have occurred-on the Moraine.

- Time crowding, which relates to effects that accumulate due to their frequency. For example, as described in Section 2.5.1, natural systems in a wetland may be able to withstand infrequent or gradual changes in water levels, but when stormwater from urban development drains into a wetland the frequency and magnitude of changes increases and this can result in reduced plant and animal diversity.
- Space crowding, which results from a high density of effects on a medium within a limited area-for example, when road salt drains into a nearby wetland (this could also be considered a time crowding effect).
- Compounding, which results from synergistic interaction of different effects. This can result from complex reactions between actions or contaminants or, for example, from the combined effect of water level changes and increased contamination in a wetland.
- Triggers and thresholds, which relate to effects that occur when a critical concentration of a contaminant or level of impact is reached. Evaluation and prediction of these effects requires detailed knowledge of the sensitivity of natural systems, and the stresses placed on them.
- Patchiness and (added by others) nibbling effects, which can fragment ecosystems due to degradation of, for example, woodland areas, resulting in reductions in interior habitat, or by narrowing and eventually interrupting a critical corridor.

4.4.2 Previous Consideration of Cumulative Effects on the Moraine

The importance of cumulative effects has been recognized in a number of the policy documents produced in relation to the Moraine. In 1991, the “Implementation Guidelines: Provincial Interest on the Oak Ridges Moraine of the Greater Toronto Area” stated that:

“Development outside of settlement areas will only be permitted where a municipality has undertaken a comprehensive municipal analysis of the need for this form of development and assesses long term cumulative impacts on municipal servicing costs and the natural environment, including the protection of the integrity of groundwater quality and quantity”.

The 1994 draft “Oak Ridges Moraine Area Strategy for the Greater Toronto Area” sets out proposed policies to prevent and monitor cumulative effects, and was supported by a background report: “A Cumulative Environmental Assessment and Monitoring Framework for the Oak Ridges Moraine Area”. The report reviews a number of approaches to the identification and monitoring of cumulative effects.

4.4.3 The Oak Ridges Moraine Conservation Plan

As noted elsewhere in this report, under the ORMCP the Planning Act will continue to be the primary vehicle for development approvals on the Moraine. Planning approvals have traditionally been considered on an individual basis, with limited regard for other development applications that may affect the same natural systems. At the same time, the ORMCP proposes a number of measures that may assist in reducing cumulative effects, such as the buffering of natural heritage features, the protection of corridors and hydrologically sensitive features, landform protection in sensitive areas, and the requirement for municipalities to designate wellhead protection areas and areas of high aquifer vulnerability and prepare water budgets and water conservation plans on a watershed basis.

The success of the ORMCP in preventing cumulative effects will depend to a large extent on the effectiveness of these policies. Submissions made during the development of the Conservation Plan have already identified deficiencies in certain areas that may allow cumulative effects to continue and increase. For example:

- Natural Core and Natural Linkage areas that abut the Moraine boundary may not be adequately buffered from off-Moraine development.
- Although proposals for major recreation must meet stringent standards, there is no provision for long term agreements to ensure that the environment is protected.
- Infrastructure such as roads may still be permitted in Natural Core and Linkage Areas and significant natural heritage and hydrogeologically sensitive features under certain conditions. These requirements may not be sufficient to prevent residual effects.
- Setbacks from natural heritage features may not be sufficient to protect natural functions, such as foraging areas for amphibians.
- The requirement for municipalities to pass land alteration and tree cutting bylaws is at the discretion of the Minister. Some municipalities may not be required to pass such by-laws, and the bylaws themselves may have limitations that prevent them from being fully effective.
- Restrictions of impervious areas in landform protection areas may not be sufficient to protect groundwater resources.

4.4.4 Cumulative Effects in Relation to Development Proposals

By their nature, cumulative effects arise from the incremental effects of several or numerous developments and activities, and can therefore be difficult to consider in relation to individual development applications. It is also difficult to require proponents to study the effects of developments other than their own—especially those for which applications have not yet been submitted. Cumulative effects can be considered more effectively when planning takes place at a larger scale, such as a secondary plan, that incorporates a number of potential development proposals. At the same time, the boundaries for such plans likely will not reflect natural boundaries. In the ORMCP, municipalities are encouraged to adopt official plan policies and zoning provisions that support, complement, or exceed the policies of the Plan. Where an opportunity to consider cumulative effects is identified that goes beyond the provisions of the Plan, the policies can be supplemented to assist in achieving this objective.

4.5 Monitoring and Response

The ORMCP requires the Ontario Government, in consultation with municipalities, to identify performance indicators and, in partnership with appropriate stakeholders, to establish a monitoring framework. The framework would be used to assess changes in the ecological and hydrogeological integrity of the Moraine and the effectiveness of the policies of the Plan, and to help identify improvements.

Depending on the level of resources allocated and the timing of its implementation, this monitoring framework could be invaluable in identifying the health of natural processes on the Moraine, whether the policies are being enforced, and the extent to which they are effective. The indicators should include measures that reflect the cumulative effects of a wide range of developments and activities on basic natural processes, such as the quality and quantity of water in watercourses and aquifers, the extent and quality of critical habitats, and the direct effects of development on natural features. Many of the effects of development on the natural environment are still poorly understood, and the framework should be used to establish cause and effect where possible. There should be a clear decision making “loop” that enables the findings of monitoring studies to be incorporated into the consideration of individual development proposals, and the ten-year review of the Conservation Plan.

The monitoring framework should capitalize on the interest and enthusiasm that has been generated around the Moraine during the process of developing the Plan. There should be provision for monitoring by the public where appropriate, the monitoring results and analysis should be made freely available, and there should be public input to the review of the Plan. With the gradual enhancement of our understanding of the cumulative effects of activities and development on the environment of the Moraine, the policy framework can be improved and refined over time.

5. Conclusions: Lessons Learned and the Path Forward

The evolution of events in the Oak Ridges Moraine case demonstrates a number of important lessons:

- It is more than ten years since provincial government efforts were initiated to protect the Moraine with special policies through the Implementation Guidelines. For most of the intervening period many would have concluded that the natural heritage of the Moraine would never have strong and sustained protection, and that its qualities would be steadily eroded over time. It took considerable commitment and effort on the part of groups such as SRVS to expand the debate from the critical lands in Richmond Hill to encompass the Moraine as a whole, and to create a political climate that would enable the development of a robust Plan that provides much greater assurance that natural heritage will be protected over the long term. The process provides graphic confirmation of the ability of direct community action to overcome administrative and political hurdles to natural heritage conservation.
- Having generated the political will, follow up was important in the form of credible and well informed commentary and participation in the process, using experts who can engage the issues with their government peers. This was largely enabled by the City of Toronto through its support for SRVS, both at the hearing and in the development of the ORMCP. The Plan reflects many of the issues and incorporates many of the solutions put forward by the SRVS expert team. This reinforces the need for public access to expert assistance in developing a case that can survive debate among a number of competing interests.
- The outcome of the process represents a validation of the landscape ecology approach to natural heritage protection, including the need to examine issues in a broad regional context, and to emphasize connectivity as well as the protection of individual features.
- The Plan supports the need for adequate information in ensuring protection for natural heritage. Accurate, comprehensive natural heritage information must be obtained prior to formulating development plans. Guidelines for developers which clearly outline the expectations of the planning authority in meeting the Plan's requirements would best facilitate this.
- The Plan incorporates major advances in a growing awareness of the importance of hydrology and hydrogeology in ensuring protection of water resources, for both natural heritage conservation and public safety. The water safety issue was addressed concurrently with the development of the Plan by the enquiry into the Walkerton tragedy – the enquiry's recommendations also propose strong action in support of water resource protection. In future years measures such as watershed plans, wellhead protection areas, areas of high aquifer vulnerability and limits on the creation of impermeable areas will be more widely incorporated into land use policy.

Much remains to be done to advance the principles of Smart Growth as they apply to the Moraine. Issues raised by SRVS in its submissions that were not adequately reflected by Plan policies include:

- Protection in the Yonge East and West areas of the Moraine in Richmond Hill.
- Buffering of features on the edge of the Moraine and along downstream watercourses from development off the Moraine.

- Minimum areas of influence and vegetation protection areas that reflect the full range of potential effects of development on natural heritage.
- Applications which had already been received, and applications submitted before the development freeze took effect are given special status in the Plan, with reduced requirements. SRVS argued that these should be subject to the full requirements of the Plan. Also, although municipalities may impose more stringent policies than those provided for in the Plan, this is not the case for policies related to agriculture and aggregate extraction.
- Watershed plans, water conservation plans and water budgets require better coordination across the Moraine. The Plan requires implementation to be undertaken solely by individual municipalities.
- Infrastructure proposals are still permitted in Natural Core Areas and key natural heritage and hydrological features, under certain circumstances.
- The Plan does not require minimum standards of effluent from sewage treatment plants.
- Greater resources are required for environmental monitoring, and there should be coordination of monitoring across the Moraine, and a clear relationship between monitoring and the formulation of new policy.

Continued vigilance will be required to ensure the effective implementation of the Plan, and to further pursue these issues in relation to individual development applications, and in the future review of Plan policy.

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Appendix A

Convention on Biological Diversity, 5 June 1992

Preamble

The Contracting Parties,

Conscious of the intrinsic value of biological diversity and of the ecological, genetic, social, economic, scientific, educational, cultural, recreational and aesthetic values of biological diversity and its components,

Conscious also of the importance of biological diversity for evolution and for maintaining life-sustaining systems of the biosphere,

Affirming that the conservation of biological diversity is a common concern of humankind,

Reaffirming that States have sovereign rights over their own biological resources,

Reaffirming also that States are responsible for conserving their biological diversity and for using their biological resources in a sustainable manner,

Concerned that biological diversity is being significantly reduced by certain human activities,

Aware of the general lack of information and knowledge regarding biological diversity and of the urgent need to develop scientific, technical and institutional capacities to provide the basic understanding upon which to plan and implement appropriate measures,

Noting that it is vital to anticipate, prevent and attack the causes of significant reduction or loss of biological diversity at source,

Noting also that where there is a threat of significant reduction or loss of biological diversity, lack of full scientific certainty should not be used as a reason for postponing measures to avoid or minimize such a threat,

Noting further that the fundamental requirement for the conservation of biological diversity is the in-situ conservation of ecosystems and natural habitats and the maintenance and recovery of viable populations of species in their natural surroundings,

Noting further that ex-situ measures, preferably in the country of origin, also have an important role to play,

Recognizing the close and traditional dependence of many indigenous and local communities embodying traditional lifestyles on biological resources, and the desirability of sharing equitably benefits arising from the use of traditional knowledge, innovations and practices relevant to the conservation of biological diversity and the sustainable use of its components,

Recognizing also the vital role that women play in the conservation and sustainable use of biological diversity and affirming the need for the full participation of women at all levels of policy-making and implementation for biological diversity conservation,

Stressing the importance of, and the need to promote, international, regional and global cooperation among States and intergovernmental organizations and the non-governmental sector for the conservation of biological diversity and the sustainable use of its components,

Acknowledging that the provision of new and additional financial resources and appropriate access to relevant technologies can be expected to make a substantial difference in the world's ability to address the loss of biological diversity,

Acknowledging further that special provision is required to meet the needs of developing countries, including the provision of new and additional financial resources and appropriate access to relevant technologies,

Noting in this regard the special conditions of the least developed countries and small island States,

Acknowledging that substantial investments are required to conserve biological diversity and that there is the expectation of a broad range of environmental, economic and social benefits from those investments,

Recognizing that economic and social development and poverty eradication are the first and overriding priorities of developing countries,

Aware that conservation and sustainable use of biological diversity is of critical importance for meeting the food, health and other needs of the growing world population, for which purpose access to and sharing of both genetic resources and technologies are essential,

Noting that, ultimately, the conservation and sustainable use of biological diversity will strengthen friendly relations among States and contribute to peace for humankind,

Desiring to enhance and complement existing international arrangements for the conservation of biological diversity and sustainable use of its components, and

Determined to conserve and sustainably use biological diversity for the benefit of present and future generations.

Appendix B

Summary of Corridor Literature Citations

Author(s)	Year	Location	Cited By	Topic	Subject	Ecosystem	Empirical data
Aars & Ims	1999	Norway	Coleman	corridors	wildlife	grassland/ meadow	yes
Aars, Johannesen & Ims	1999	Norway	Coleman	corridors	wildlife	grassland/ meadow	yes
Adams & Dove	1989	n/a	n/a	corridors fragmentation	review	n/a	no
Anderson & Danielson	1997	n/a	Coleman	corridors	model	model	no
Beier & Loe	1992	n/a	Sharp '98	corridors	opinion	n/a	no
Beier & Noss	1998	review	Coleman	corridors	review	n/a	no
Bennet, Henein & Merriam	1994	Manotick, ON	Coleman Sharp '98	corridors	wildlife	agricultural/rural	yes
Bennett	1990	Victoria, Australia	Sharp '98	corridors	wildlife	woodlands	yes
Binford & Buchenau	1993	n/a	n/a	buffers/effect zone	hydrology	riparian	no
Burke & Nol	1998a	Peterborough County, Ontario	n/a	habitat fragmentation	wildlife	woodlands	yes
Burke & Nol	1998b	Peterborough County, Ontario	n/a	habitat fragmentation	vegetation	woodlands	yes
Cameron	1997	Nova Scotia, Canada	n/a	corridors	wildlife	woodlands	yes
Catterall, Green & Jones	1991	Brisbane, Australia	n/a	corridors matrix	wildlife	woodlands urban	yes
Clevenger & Waltho	2000	Alberta, Canada	n/a	corridors	wildlife	natural mixed	yes
Cole	1993	n/a	n/a	landscape matrix	opinion	n/a	no
Corbit, Marks & Gardescu	1999	New York, USA	Coleman	corridors	vegetation	agricultural/rural woodlands	yes
Croonquist & Brooks	1993	Pennsylvania, USA	Coleman Sharp '98	corridors	wildlife	riparian	yes
Dawson	1994	review	n/a	corridors	wildlife	n/a	no
Debinski & Holt	2000	review	n/a	habitat fragmentation	wildlife	review	review
Demaynadier & Hunter	1997	Maine, USA	Sharp '98	buffers/effect zone	wildlife	woodlands	yes

Author(s)	Year	Location	Cited By	Topic	Subject	Ecosystem	Empirical data
Dodd & Cade	1998	Florida, USA	Coleman Sharp '98	wetlands/swm ponds	wildlife	wetlands	yes
Fahrig & Paloheimo	1988	model	n/a	n/a	n/a	model	no
Fahrig, Pedlar, Pope, Taylor & Wegnar	1995	Ottawa, Ontario	Sharp '98	landscape matrix	wildlife	natural mixed	yes
Findlay & Houlihan	1997	Southeastern Ontario	Sharp '98	landscape matrix buffers/effect zone	wildlife vegetation	wetlands	yes
Forman	1991	review	Sharp '98	corridors	n/a	n/a	no
Freemark & Collins	1992	Ottawa, Ontario Illinois, USA Missouri, USA	Sharp '98	habitat fragmentation landscape matrix	wildlife	woodlands	yes
Gaines, Diffendorfer, Tamarin & Whittam	1997	several	Coleman	habitat fragmentation	wildlife	several	no
Gibbs	1993	Maine, USA	Sharp '98	wetlands/swm ponds landscape matrix	wildlife	model	yes
Grubb & Doherty	1999	Ohio, USA	Coleman	habitat fragmentation	wildlife	agricultural/rural woodlands	yes
Gustafsson & Hansson	1997	review	Coleman	corridors	wildlife vegetation review	n/a	no
Haas	1995	North Dakota, USA	Sharp '98	corridors	wildlife	woodlands agricultural/rural	yes
Haddad	1999a	South Carolina, USA	Coleman	corridors	wildlife	woodlands	yes
Haddad	1999b	South Carolina, USA	Coleman	corridors	wildlife	woodlands	yes
Haddad & Baum	1999	South Carolina, USA	n/a	corridors	wildlife	grasslands	yes
Hansen, Garman, Marks & Urban	1993	Oregon, USA	Sharp '98	landscape matrix	wildlife	n/a	no
Harris & Scheck	1991	review	n/a	corridors	review	n/a	no
Harrison	1992	review	Coleman Sharp '98	corridors	wildlife	review	no
Harrison & Fahrig	1995	review	n/a	landscape matrix	history	n/a	no

Author(s)	Year	Location	Cited By	Topic	Subject	Ecosystem	Empirical data
Henein & Merriam	1990	model	Coleman Sharp '98	corridors	wildlife	model	no
Hobbs	1992	n/a	Coleman	corridors	opinion	n/a	no
Holomuzki	1998	Kentucky, USA	n/a	wetlands	wildlife	wetlands	yes
Howard, Eyles, Smart, Boyce, Gerber, Salvatori & Doughty	1995	Oak Ridges Moraine, Ontario, Canada	n/a	landscape matrix	hydrology	agricultural/rural	no
Hunsaker, Graham, Suter, O'Neill, Barnthouse & Gardner	1990	n/a	n/a	n/a	opinion	n/a	no
Ims	1995	review	n/a	habitat fragmentation landscape matrix	review	n/a	no
La Polla & Barrett	1993	Ohio, USA	Coleman	corridors	wildlife	agricultural/rural grassland	yes
Laan & Verboom	1990	Limburg, The Netherlands	Sharp '98	wetlands	wildlife	wetlands	yes
Lindenmayer & Nix	1993	Victoria, Australia	Coleman	corridors	wildlife	woodlands	yes
MacDonald & Johnson	1995	Buckinghamshire, UK	Sharp '98	habitat fragmentation	wildlife	agricultural/rural	yes
Machtans, Villard & Hannon	1996	Alberta, Canada	Coleman Sharp '98	corridors	wildlife	riparian	yes
Mader	1984	Odenwald, West Germany	Sharp '98	habitat fragmentation landscape matrix	wildlife	agricultural/rural	yes
Mauritzen, Bergers, Andreassen, Bussink & Barendse	1999	Southern Holland	Coleman	corridors	wildlife	agricultural/rural	yes
Merriam	1991	review	n/a	corridors	wildlife	review	no
Merriam & Lanoue	1990	Ottawa, Ontario	Sharp '98	corridors	wildlife	agricultural/rural	yes
Monkkonen & Reunanen	1999	review	Coleman	landscape matrix habitat fragmentation		review	no
Naiman, Decamps & Pollock	1993	n/a	Sharp '98	corridors	opinion	riparian	no
Noss	1987a	n/a	Sharp '98	corridors	opinion	n/a	no
Noss	1987b	review	n/a	habitat fragmentation	review	n/a	no
Noss	1993	review	Sharp '98	corridors	review	n/a	no
Noss	1990a	opinion	n/a	n/a	opinion	n/a	no

Author(s)	Year	Location	Cited By	Topic	Subject	Ecosystem	Empirical data
Noss	1990b	opinion	n/a	n/a	opinion	n/a	no
Noss	1992	opinion	Sharp '98	habitat fragmentation corridors	landscape	n/a	no
Oxley, Fenton & Caromody	1974	South-eastern Ontario, Quebec, Canada	Sharp '98	habitat fragmentation	wildlife	woodlands	yes
Paton	1992	review	Sharp '98	habitat fragmentation	wildlife	woodlands	no
Robbins	1979	review	Sharp '98	habitat fragmentation	wildlife	woodlands	yes
Rosenberg, Noon & Meslow	1997	review	Coleman Sharp '98	corridors	n/a	review	no
Ruefenacht & Knight	1995	Wyoming, USA	Coleman	corridors	wildlife	woodlands	yes
Saunders & de Rebeira	1991	Kellerberrin district, Western Australia	Sharp '98	habitat fragmentation	wildlife	natural mixed	yes
Saunders, Hobbs & Margules	1991	review	Sharp '98	habitat fragmentation	review	review	no
Schmiegelow, Machtans & Hannon	1997	Alberta, Canada	Sharp '98	habitat fragmentation	wildlife	woodlands	yes
Schwab	1994	n/a	n/a	corridors	opinion	n/a	no
Simberloff & Cox	1987	n/a	Sharp '98	corridors	opinion	n/a	no
Simberloff, Farr, Cox & Mehlman	1992	n/a	n/a	corridors	opinion	n/a	no
Smallwood	1994	California, USA	Sharp '98	habitat fragmentation	wildlife	agricultural/rural urban grasslands	yes
Smith	1993	review	Sharp '98	corridors	review	riparian natural mixed urban	no
Soule	1990	n/a	Sharp '98	habitat fragmentation	opinion	n/a	no
Soule & Gilpin	1991	n/a	Sharp '98	corridors	model	n/a	no
Spackman & Hughes	1995	Vermont, USA	Sharp '98	corridors	wildlife vegetation	riparian	yes
St. Clair, Belisle, Desrochers, Hannon	1998	Alberta, Quebec, Canada	Coleman	corridors	wildlife	woodlands agricultural/rural	yes

Author(s)	Year	Location	Cited By	Topic	Subject	Ecosystem	Empirical data
Tiebout & Anderson	1997	review	Coleman Sharp '98	corridors	wildlife	natural mixed (transient successional)	no
Tischendorf & Wissel	1997	model	Coleman Sharp '98	corridors	wildlife	model	no
Verboom & Apeldoorn	1990	Twente, The Netherlands	Sharp '98 Coleman	habitat fragmentation	wildlife	woodlands	yes
Villard, Trzcinski & Merriam	1999	Ottawa, Ontario	Coleman	habitat fragmentation	wildlife	woodlands	yes
Wegner & Merriam	1979	near Ottawa, Ontario	n/a	landscape matrix	wildlife	woodlands agricultural/rural	yes
Wiens	1995	review	n/a	landscape matrix	landscape	review	no
Yanes, Velasco & Suarez	1995	Madrid, Spain	Sharp '98	habitat fragmentation	wildlife	natural mixed	yes

Appendix C
Summary Table of Literature on Suburban Impacts

	Type of Impact	Impact Factor	Zone of Impact (how far an impact extends from source)	Reference	Comments
1	Urban Predation	Free-ranging Cats (feral, stray, pet)	190 m (males) 140 m (females) (maximum home range distances)	Haspel and Calhoun, 1991	Actual levels of predation would vary with changes in population, density and available resources. Population size was proportional to the amount of shelter in a neighborhood. Males travelled perimeter of their home range more than females.
			One feral cat can range 1.4 km in a single day	Ogan and Jurek, 1997	Information based on Stallcup, 1991.
			(1) 30 - 40 ha home range for rural cat population. (2) Feral male cats had home ranges 2 - 4 km across.	Ogan and Jurek, 1997	Information based on Swedish study (Liberg, 1980).
				Coleman et al., 1997	Nationwide, ~ 30% of US households have cats. In rural areas, 60% have cats (based on 1990 data). Small mammals make up 70% of cat prey; Birds make up 20%. Free-ranging cats living in small towns each kill an average of 14 wild animals annually.
2	Urban Predation	Red Fox	Mean group home range size was 52 ha	Adkins and Stott, 1998	Distances travelled nightly by both sexes ranged from 2-20 km. Foes avoided adjacent medium-density housing areas.
3	Urban Predation	Raccoons	Average Home range is 0.42 km ²	Rosatte <i>et al.</i> , 1991	97% of radio-tagged Raccoons were recaptured within 1 km of the original capture site. This is a Toronto study.
4	Urban Predation	Skunks	Average Home range is 0.51 km ²	Rosatte <i>et al.</i> , 1991	98% of radio-tagged Skunks were recaptured within 1 km of the original capture site. This is a Toronto study.

	Type of Impact	Impact Factor	Zone of Impact (how far an impact extends from source)	Reference	Comments
5	Urban Predation	Birds (Blue Jays, American Crows)		Hogrefe et al., 1998	Ground-nesting breeding birds (Ruffed Grouse & Wild Turkey) appear to experience higher rates of nest loss with res. development. Densities of Crows, a major nest predator, were at least 3x higher at the suburban site compared to the rural site.
					Suburban study site was 49 ha in size & 75% was surrounded by residential development within 0.2-0.8 km of its borders. Rural study site was 688 ha in size and proximal to contiguous forest and agricultural land.
6	Salt Spray	Road salt application in winter	200 - 1500 m	Forman & Deblinger, 2000	Primary ecological effects of road salt were believed to be on shallow ponds, lakes & reservoirs, streams near roads & vernal pools (based on National Research Council, 1991). Visible damage to woody vegetation appeared to be localized to 10 m of roads.
7	Grassland Habitat Degradation	Road Noise	190 m +	Netherlands Min. of Transportation, 1995.	Based on motorway traffic at 10,000 cars/day. Zone of impact will increase with increased traffic speeds and volumes
			up to 930 m	Forman & Deblinger, 2000 (see <i>Comments section</i>)	Distance used is based on various studies from the Netherlands (van der Zande <i>et al.</i> , 1980; R. Reijnen, 1995; M. Reijnen <i>et al.</i> , 1995; and R. Reijnen <i>et al.</i> , 1996).
			480 m - 2000 m	van der Zande et al., 1980 as cited by Forman, 1995 & Trombulak <i>et al.</i> , 2000.	Netherlands data for highway with average of 54,000 cars/weekday.
			500 m		Netherlands data for 'quiet road' with 50 cars/day.

Type of Impact		Impact Factor	Zone of Impact (how far an impact extends from source)		Reference	Comments
8	Forest Habitat Degradation	Road Noise	120 m +		Netherlands Min. of Transportation, 1995.	Based on motorway traffic at 10,000 cars/day. Zone of impact will increase with increased traffic speeds and volumes
			up to 650 m		Forman & Deblinger, 2000	Pop density of the most sensitive forest-interior species is reduced (by one third) in woods up to 650 m from a main road (traffic volumes @ 40-50,000/day).
			100 m +		Ferris, 1979 as cited by Forman, 1995.	Forest birds density in Maine
9	Forest Habitat Degradation	Residential encroachment into woodlands	Variable (see comments)		Friesen et al., 1995	as # of adjacent homes increases, diversity and abundance of neotropical birds decreases; homes were within 100 m of woodlots.
					Merenlender & Heise, 2000	Effects of habitat fragmentation due to parcelization of rangelands was studied. Rangelands 300 acres in size, ranchettes on 10-40 acre lots, and 0.5-2.5 acre suburban lots were compared. Bird species richness did not vary between study stites. Species composition of bird communities changed from from site to site. % of neotropical migrant birds was significantly higher in undeveloped sites than at ranchettes or suburban lots.
10	Forest Habitat Degradation	Backyard Impacts	woodlands with road access	without road access		
	10a	- creation of wood piles	19 m	---	Matlack, 1993	study based on 40 forest fragments from 0.7 to 20 ha in size & surrounded by at least 10 detached residences within 100 m of the forest margin
	10b	- deposition of grass clippings	19 m	---	Matlack, 1993	
	10c	- discarded Christmas trees	34 m	---	Matlack, 1993	

	Type of Impact	Impact Factor	Zone of Impact (how far an impact extends from source)		Reference	Comments
	10d	- lawn extensions	38 m	---	Matlack, 1993	
	10e	- creation of leaf piles	38 m	---	Matlack, 1993	
	10f	- composting beyond lot lines				
	10g	- gardening beyond lot lines				
11	Forest Habitat Degradation	Recreation-related impacts	woodlands with road access	without road access		
	11a	- incidence of hacked trees	76 m	70 m	Matlack, 1993	study based on 40 forest fragments from 0.7 to 20 ha in size & surrounded by at least 10 detached residences within 100 m of the forest margin
	11b	- creation of children's huts	79 m	---	Matlack, 1993	
	11c	- creation of treehouse	107 m	---	Matlack, 1993	
	11d	- creation of campsites	114 m	67 m	Matlack, 1993	
	11e	- firewood gathering	130 m	69 m	Matlack, 1993	
	11f	- poaching/picking plants	area adjacent to subdivision		Dawson, 1991	
12	Loss of Wetland Function	Inadequate buffer zone	164.3 m protects 95% of pop.		Semlitsch, 1998	164 m = the width of terrestrial habitat that would be required to protect 95% of the pop. of pond-dwelling salamanders. Info based on 6 species, 2 of which occur in the ORM.

	Type of Impact	Impact Factor	Zone of Impact (how far an impact extends from source)	Reference	Comments
					The mean distance travelled by Spotted Sal. was 118 m (15-249 m) & 194 m for Jefferson's Sal. (15-625 m). Therefore in order to protect 95% of the pop. of these 2 species, the buffer would need to extend beyond 164 m.
13	Loss of Wetland Function	Runnoff from adjacent developments into bogs & fens	There is no 'zone of impact' per se, but impacts that result from lack of habitat that is preserved	Norman, 1996	The only way to ensure bogs & fens are protected from nutrient inputs is to maintain the entire catchment basin in a naturally vegetated state. Discussion refers to S. Ontario situation.
14	Loss of Ecological Functions	Innapropriate buffer width	vegetative buffers need to be at least 100 m in width to protect some neo-tropical bird species (assuming there is core habitat)	Norman, 2000	There are no sources quoted. The 100 m figure is given in relation to a buffer strip around a stream/wetland
			vegetative buffer needs to be at least 300 m wide to provide good habitat for neo-tropical bird species (assuming there is core habitat)		There are no sources quoted. The 300 m figure is given in relation to a buffer strip around a stream/wetland
15	Loss of Ecological Functions	Innapropriate buffer width	There is no 'zone of impact' per se, but impacts that result from lack of habitat that is preserved	Norman, 1996	If buffer strip is 200 m wide, approx 50% of Mallard nest should be protected. 300 m protects most nests. References are provided.
					Norman sites a Maryland study that recommended that riparian forest be at least 100 m wide to provide some nesting habitat for area-sensitive species.
					Norman reports that the OMNR has recommended that in forested areas a minimum of 50m on either side of river or lake be left uncut to protect raptors, cavity nesting birds and warblers. Refs are given.

	Type of Impact	Impact Factor	Zone of Impact (how far an impact extends from source)	Reference	Comments
16	Loss of Ecological Functions	Roads	ecological effects averaged just over 300 m	Forman & Deblinger, 2000	Therefore the average width of the road-effect zone for the suburban highway (4--50,000 cars/day) exceeded 600 m.
17	VARIOUS	VARIOUS (include: altered flow & reduced quality of waters passing through parks, acid rain, waste dumping, interference of cross-boundary wildlife migrations, poaching, pesticide and herbicide damage through drift)	areas adjacent to US National Parks	Dawson, 1991	"State of the Parks" report found that 50% of park threats arose outside the system boundaries.

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Appendix D

Profile of Road Crossing Technology for Wildlife (from Forman 1995)

Underpasses and Tunnels to Alter a Collision Course

"It 'takes guts' to hit the windshield of a moving vehicle, and knowledgeable fly fisherman look carefully at the insects smashed on vehicles. Road kill estimates for insects are limited 519, 1837, 520, 1339, but annual vertebrate numbers based on measurements of short sections of roads are impressive: 159 000 mammals and 653 000 birds in The Netherlands 821 cited in 1774, seven million birds in Bulgaria 1188 cited in 111, five million frogs and reptiles in Australia 437. One million vertebrates per day are road killed in the USA 914. The species range from wolves and deer to bats and platypus (Ornithorhynchus) 393, 736, 1757, 1479.

Many techniques have been tried to decrease road kills. Reflectors, mirrors, repellents, bait, various fencing types, one-way gates (to escape from fenced roadsides), wildlife crossing signs, and animated warning signs for motorists generally show modest or no success. 409, 1396, 1336, 467, 1397, 1828, 1497, 470

An alternative approach is to have animals cross over a road, either on a land-surface-level bridge over a sunken road, or on an overpass above the land surface, that arches over the road. A land-level grass-covered bridge, 15 m wide in the middle and 50 m wide at the ends, over a sunken highway was studied for faunal movements in The Netherlands (data of W. Nieuwenhuizen & R.C. Apeldoorn cited by H.D. van Bohemen, pers. commun.). Of 13 mammal species observed, 77% crossed the wildlife bridge. The same percentage that crossed in tunnels under highways. Three species, squirrel, hare, and deer (*Sciurus vulgaris*, *Lepus europaeus*, *Capreolus capreolus*) crossed on the land-level bridge, but not in tunnels. Overpasses, designed for wildlife and that arch over a road, apparently have not yet been evaluated for animal crossing. 902

However, underpasses and tunnels have been established and tested for use by animals in many countries. They are used by badgers in Britain 1386, mountain goats in Montana, USA 1566, 1296, toads in The Netherlands 1780, mountain pygmy-possums in Victoria 1042, desert tortoises in California, mule deer in Colorado 1398, 1395, 1828, and amphibians in Germany, Switzerland, The Netherlands, England, Wales, France and Massachusetts, USA. 1723, 1755, 918. Tunnels have been constructed under railroads in Australia 763, and an oil pipeline elevated for caribou and moose movement in the Arctic. 872, 346, 443 Standardized design, technology, and prefabricated structures are available for amphibian tunnels. 918 So far the most ambitious project is a series of 35 underpasses along 'alligator alley' highway in South Florida, through which panthers, bobcats, bears, alligators, (*Felis concolor*, *Lynx rufus*, *Ursus americanus*, *Alligator mississippiensis*) and numerous other species move daily. 685, 1035, 688

A tunnel or underpass system includes the essential accompanying fences. Walls, rock lines, earth berms, shrubs and/or trees. The accompanying structures act as drift fences to funnel animals to an underpass, as sound or visual screens, and as barriers to discourage movement over the road near an underpass. The heights, widths, lengths, angles, and locations of all structures are keyed to target species. It is appropriate to identify at least two types of target species, the largest animal of interest, and the species most sensitive to a road barrier. The underpass or tunnel system is then primarily designed around the behavioral requirements of these species. Success for these two species types should mean success for most other species. The underpass and tunnel approach will likely enhance movements of most terrestrial mammals, amphibians, and reptiles near roads. This approach also should reduce road kills of birds feeding on road kills. However, reduction of the impressive bird mortality on roads will require other techniques.

Today, mobile animals are threatened by a fixed road grid reinforced with moving vehicles. The solution may lie in porous roadbeds with tunnel and underpasses. In this manner, both natural and human processes are maintained, as 'happy animals cross under oblivious vehicles'. Land-level wildlife bridges are also in the repertoire."

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