CITY OF TORONTO NATURAL HERITAGE STUDY—FINAL REPORT

A Project in Partnership

between

City of Toronto

and

Toronto and Region Conservation Authority

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EXECUTIVE SUMMARY

In the year 2000 the Toronto and Region Conservation Authority was commissioned by the City of Toronto to undertake a study of natural heritage features and their status within the newly amalgamated City. The goal was to provide a preliminary framework in support of the natural heritage policies of the new City of Toronto Official Plan. This included:

- Providing an inventory of ecological information;
- Informing the development of natural heritage policies; and
- Providing a tool to identify a natural heritage system within a functional framework that is designed to address biodiversity and ecosystem needs, while recognizing urban context and multiple-use values.

The inventory was developed by a combination of "desktop" exercises such as literature review and aerial photography interpretation and supplemented with field investigation. A "Made in Toronto" approach was adopted, through which a natural heritage system was defined by combining terrestrial, aquatic, geophysical, and hydrological data layers using geographical information systems (GIS) software. A complete list of these data layers is found in Section 4 of the report. It is recognized that the data layers have some limitations, and that there is as yet no system available for an integrated evaluation of all of them. Furthermore, field surveys have not been undertaken at many sites. It should therefore be recognized that lack of data does not imply lack of significance. As a result, the "Made in Toronto" approach proposes that the natural heritage system should be seen as a functional framework that will continue to evolve over time as new information or evaluation systems become available.

Two products have been produced as deliverables. The first is this report, which summarizes the study methodology and results and outlines some key directions for natural heritage protection and restoration. Maps included in the report are designed to illustrate study results and the types of data collected, but are not of a scale which allows for close examination of details. This ability is provided through the second product, which is a series of GIS data sets and a user access tool delivered in laser disc format (see Figure 1). This allows the user to view and overlay natural heritage and land use data layers in any combination at scales ranging from the entire city to individual sites. The tool also includes a template for transferring on screen data to printed map format.

APPROACH

Using a comprehensive evaluation system already devised, the terrestrial study is the largest component of the inventory. The methodology applied is the Toronto and Region Conservation Authority's (TRCA) Terrestrial Natural Heritage Approach which scores and ranks biodiversity at landscape, vegetation community and species levels.

The landscape analysis evaluates habitat patch conditions related to size, shape, and the surrounding landscape matrix, as well as total habitat cover and distribution. The landscape analysis is also applied to one hypothetical modelled scenario (Appendix E) in order to illustrate how the data can be used to evaluate a multitude of possible future scenarios for increasing habitat values.

Detailed information on the individual vegetation community types within habitat patches is provided for approximately 60 percent of the city's known natural areas by a combination of digitized new and older life science study information. Approximately half of this coverage is provided through field inventories conducted in 2000, using the Ecological Land Classification System (ELC). Information utilized from previous studies is translated to ELC categories in order to maintain a consistent data standard. Flora and fauna species of concern are included in the vegetation communities coverage.

The aquatic component of this report used a variety of information sources to describe and evaluate the condition of the aquatic ecosystem, with much of the information presented being obtained from watershed fisheries management plans. A classification of aquatic habitats was used to describe the historic function of the aquatic habitats and was compared to existing fish communities. The existing communities were then evaluated using the Index of Biotic Integrity (IBI) and recent fish community survey data. The historic and current distribution of species of concern was also used as a measure of the integrity of the aquatic system.

Other measures to evaluate the aquatic system included the presence of in-stream barriers to fish passage as an indicator of connectivity within the system. A functional definition of a riparian zone was developed, applied, and its condition evaluated using land use and vegetation cover data sets. Overall, the information presented on the aquatic ecosystem was used to describe historic and existing conditions, evaluate conditions based on data available, and identify potential management activities for consideration.

Hydrological features have been included in the natural heritage system as a series of data layers, including watershed boundaries, known watercourses, and the valley and stream corridors and waterfront regulation zone as defined by the TRCA. The fact that there is limited information and no comprehensive evaluation system currently available for hydrologic features does not imply that they are not important components of the natural heritage system. Hydrology is a vital consideration with respect to ecosystem function and needs to be assessed accordingly.

Geophysical features have also been included as a series of data layers only because there is currently no evaluation system available for them. They consist of soil types and physiography, significant features such as the Lake Iroquois Shoreline/Shorecliff, and locations of Earth Science Areas of Natural and Scientific Interest.

RESULTS AND CONCLUSIONS

The terrestrial landscape analysis results indicate that there are currently some 8,595 hectares of natural habitat in the City of Toronto, covering some 13.5 percent of the total city area. This habitat is unevenly distributed, with most of the larger patches located in the Rouge River and Highland Creek watersheds. The largest habitat patch is 127 hectares in size; however, the majority of patches are less than five hectares. Furthermore, patches tend to be convoluted rather than simple in shape, in part because most are restricted to valley and stream corridors. The relatively low values for size and shape mean that forest interior, an indicator of quality habitat, is rare in the city. The dominance of the urban matrix surrounding habitat patches suggests considerable negative pressures, which lead to habitat disturbance and degradation.

As a whole, Toronto maintains a good coverage of terrestrial natural habitat for an urban area, primarily as a result of the extensive valley land network where development has been restricted. However, in terms of total cover, the presence of the Rouge Park has disproportionately elevated the existing conditions results for the rest of the city. In general, habitat patches in the city tend to be relatively small and convoluted in shape, which suggests a limited capacity to support viable populations of sensitive species and a high exposure to negative external influences, such as heavy recreational use, pollutants, and an increase in predation by such urban tolerant fauna as crows, foxes, raccoons, etc.

A total of approximately 240 vegetation communities have been identified within the City of Toronto based on the Ecological Land Classification System for Southern Ontario. Although most are common for the region, some rarities are still represented within the city, including tallgrass prairie and savannah remnants, and several rare coastal communities. Numerous provincially rare flora species can still be found within these communities and in some of the more pristine forested areas. Unfortunately, many of these are threatened by invasive exotic plants and an overall decline in ecosystem health. Regionally rare vertebrate species also persist in Toronto, with the majority of these concentrated in the extensive habitats of the Rouge watershed. In other areas remaining small populations are at risk due to isolation of habitat patches and disturbance.

While Toronto does not have a completely healthy terrestrial natural heritage system, the total area of natural habitat and the persistence of numerous vegetation communities and flora and fauna species of concern is impressive for a large urban area. Nevertheless, maintaining and improving these conditions will require continued protection and restoration efforts.

In general, the aquatic habitats and fish communities within the City of Toronto are highly impacted. The Index of Biotic Integrity (IBI) suggests that aquatic ecosystems are in poor to fair condition. The fact that 45 percent of the defined riparian zone is made up of forest, successional, or wetland habitats suggests a fair condition. In general, conditions are best in areas experiencing less urban development both in Toronto and upstream from the city (such as the Rouge and Humber watersheds and the coastal marshes along Lake Ontario).

Aquatic habitat condition can be improved through better management, such as by protecting and improving riparian areas, and through improved management of streams to facilitate the passage of fish. Stormwater management efforts should mimic the natural water cycle, and a combination of source, conveyance and end-of-pipe controls should be used to improve water quality. Natural habitats within the defined riparian zone should be increased to at least 75 percent natural cover, with most of this made up of woody vegetation. Finally, there is a need to develop an approach to integrate the evaluation of the aquatic and hydrological features with that of the other natural heritage system components.

Because no accepted evaluation system exists, the condition of hydrological and geophysical features has not been assessed through this study. However, these components of the natural heritage system have been provided as GIS data layers, and the user access tool provides the opportunity to overlay these with terrestrial, aquatic, and land use features in any combination to inform the decision making process in relation to protection and management.

DEFINING A NATURAL HERITAGE SYSTEM

Natural heritage systems are often defined as a network of protected significant features. The approach in this study builds upon the traditional approach to begin integrating features and functions.

The City of Toronto's natural heritage system is defined using terrestrial, aquatic, hydrological and geophysical data layers. The system is viewed as a "mosaic", composed of the following features and functions:

- terrestrial natural habitat;
- known watercourses and hydrological features;
- major landforms and physical features;
- riparian zones;
- valley and stream corridors;
- waterfront zone;
- provincially significant features;
- vegetation communities and species of concern; and
- significant aquatic features.

In the future it may be possible to develop a fully integrated natural heritage study approach that would communicate an understanding of the dynamics and functions of ecosystems, hydrology, and landscape processes. For now, the system definition is viewed as a "snapshot" of natural heritage features based on current information. However, given the number of features to consider in a natural heritage system and the many disparate data sources available, it is recognized that some of this information may be inaccurate or incomplete. Therefore, the natural heritage system as defined should not be interpreted as a fait accompli. Rather, it should be considered an evolving system that is more accurately evaluated and defined as data sources improve and further field investigation is undertaken.

POSSIBLE NEXT STEPS

1) The study provides approximately 60 percent field coverage for Toronto based on digitizing in-file studies and collecting new field data. In order to complete the remaining 40 percent at a similar level of detail, additional field work will be required.

2) Site inventory studies should be updated on a regular basis, and at least once every ten years. Additional natural heritage information should be added to the database as it becomes available.

3) Due to inevitable oversights when digitizing, some natural areas may be missing from the mapping provided with this study. These habitats should be incorporated in future mapping.

4) As ongoing ravine and other studies identify new sites and features such as groundwater discharge areas and watercourses, or result in revisions of subwatershed boundaries, the database and mapping should be updated accordingly.

5) Riparian habitats may be undervalued in the study. There is a need to better define the ecological and hydrological functions of riparian habitat as part of the natural heritage system, and to develop an evaluation method which better represents their status and condition.

6) This study identified a major gap in information coverage related to wetlands. A comprehensive wetland inventory should be completed to clearly map wetlands in the field.

7) Additional natural heritage information should be added to the database as it becomes available. This includes updated information from the Ministry of Natural Resources, such as ANSI and Classified Wetland studies.

8) A system should be developed to determine the values of natural areas for migratory species, for example as stopover areas.

9) A natural heritage evaluation system that integrates terrestrial, aquatic, hydrological and geological components should be developed.

10) Property ownership data should be kept up-to-date to allow for the development of acquisition, stewardship and management programs and for future modelling.

11) Responsibilities for natural heritage data collection and management, as well as data access and sharing issues must be identified and resolved. A Memorandum of Understanding should be developed between the TRCA and the City of Toronto as soon as possible to address this issue.

SECTION 1: STUDY INTRODUCTION

BACKGROUND

The City of Toronto is developing a new Official Plan (OP) for the amalgamated city. As part of this process, the recently published report, Toronto at the Crossroads: Shaping Our Future, identified five campaigns to improve the quality of life within the city. Specific to the environment is the Campaign to Green Toronto, an important component of which is to identify and to understand the natural heritage of Toronto.

The importance of Toronto's natural heritage is recognized in the City Council's Environmental Plan: Clean, Green and Healthy, which identifies the city's green spaces as our "green infrastructure." The city's natural heritage system is as important to the city's continuing health and vitality as its transportation, water and sewage systems. The Environmental Plan recommends the development of a natural heritage strategy to ensure the protection, restoration and linkages of this system.

The Toronto and Region Conservation Authority (TRCA) was commissioned by the City of Toronto to undertake a natural heritage inventory and strategic directions study early in 2000. Representatives from the TRCA and three City departments—Urban Development Services, Economic Development, Culture and Tourism, and Works and Emergency Services—formed a technical work group to oversee the study, which extended over one year between June 2000 and June 2001.

STUDY PURPOSE

The purpose of the City of Toronto Natural Heritage Study is to provide an inventory of information about ecological systems as a basis for developing natural heritage policies for the City's new Official Plan. The project provides a tool to assist in identifying a natural heritage system within a functional framework that is designed to address biodiversity and ecosystem needs, while recognizing urban context and multiple-use values.

WHAT IS NATURAL HERITAGE?

Natural Heritage is the basic fabric of the landscape including: Land (landform, soils, geology); Water (surface and ground); and Life (plants and animals). It includes the physical, chemical and biological elements and interactions of our environment that constitute what is often termed "Nature."

A Natural Heritage System is a way of interpreting and visualizing the critical interactions and dependencies between and among the features and functions of our natural heritage.

A Natural Heritage Strategy describes how human activity can be managed in order to protect, restore, or enhance the natural heritage system.

The study combines landscape level and field level data into a Geographic Information Systems (GIS) database. GIS software is then used to map and analyze the information, as well as provide the ability to overlay a variety of natural heritage and land use data layers in order to define protection or restoration opportunities or direct management activities.

This product does not preclude the possibility for further study. The Terms of Reference recognize that this project represents a "first phase" and that "more detailed later phases" may be incorporated into future budget cycles. More detailed site assessments will be needed to design specific management level projects and to assess future development proposals.

The project was undertaken as a joint City/TRCA partnership to provide the following benefits:

- a consistent science-based approach to evaluating natural heritage;
- a shared framework for coordination of conservation and restoration efforts;
- a regularly updated database on the status of species, communities and habitat cover;

- an enhanced partnership between key natural heritage players.

"MADE IN TORONTO" APPROACH

The "Made in Toronto" approach incorporates and adapts the TRCA's terrestrial natural heritage methodology into a comprehensive ecosystem information base. This information base (inventory) includes terrestrial, hydrological, aquatic, earth science and cultural information, incorporated into a Geographic Information Systems (GIS) database. This approach provides an important step towards an integrated approach to defining, assessing and maintaining ecological function.

It should be pointed out that, because there is no evaluation system currently in place for hydrological and geological features, this report may appear to place a higher value on terrestrial features. This is not the intention. The hydrological and geological, as well as the aquatic features, are all vital components of an integrated natural heritage system and should, therefore, be given equal attention. It should also be noted that field inventories have not yet been undertaken in many natural areas throughout the city, and that there are many gaps in site level data as reflected on existing maps and in the database. Lack of data should not be interpreted as lack of significance, because many of these sites could have important functions in the natural heritage system. The need to continue field inventories to collect additional data is another reason why the "Made in Toronto" approach views the natural heritage system definition and evaluation as an ongoing process.

The primary tool used to generate and analyze all natural heritage information considered in this study is ArcView Software. The GIS product is an innovative user access program that allows users to display, overlay and interpret the relationships between ecosystem resource information for planning or management purposes. However, although it serves a useful purpose in providing this capacity, the database does not in itself set priorities for management in relation to the many features it can display. In cases where there is an apparent conflict between management priorities it will have to be determined which features and functions are most important under the specific circumstances. It is also important to have qualified individuals available to interpret relationships between components of the natural heritage system when comparing data layers and to recognize where important data gaps may exist at a site level. For example, the hydrological values of terrestrial natural cover on a site may not be immediately apparent if data is missing, or persons not aware of these potential relationships are using the tool.

The City of Toronto Natural Heritage Study provides a GIS database compilation of the best resource information available to date—a "living inventory" of the natural heritage system. The products from this study include:

- a GIS User Access Program designed for City staff, which allows for the desktop access, overlay and interpretation of the data layers generated from this study;

- a detailed terrestrial study that synthesises and analyzes old and new information using numerical interpretation indices and GIS;

- an analysis of aquatic habitat conditions using existing information collected as part of watershed fisheries management plans, and accompanying maps;

- a variety of additional data layers, crossing the elements of earth sciences (landforms, geology and physiography), hydrology (watercourses, watershed boundaries, TRCA regulated areas) and cultural (land use, property ownership, etc.)

STUDY AREA

In 1998, the City of Toronto was amalgamated to encompass 2.4 million people within a land base of 635.5 square kilometres. With forecast growth of 540,000 people and the possibility of up to one million new residents added to the city by 2030, maintaining the city's green space will be critical to providing a high quality of life in Toronto.

The City of Toronto is situated in a biophysical region (see Figure 2) that is bordered to the north by the Oak Ridges Moraine and to the south by Lake Ontario. The Oak Ridges Moraine is a significant geological landform that is the source area for five of the six major watersheds found in the city, including Etobicoke and Mimico Creeks, Humber River, Don River, and the Rouge River. The sixth major watershed is the Highland Creek, most of which is contained within the City boundary. Several smaller watersheds flow directly into Lake Ontario.

The City of Toronto lies in the transition area between the Carolinian Floristic Zone, more common further south in Ontario, and the Great Lakes-St. Lawrence Forest Region, common to mid-Ontario. Lake Ontario and the Lake Iroquois Shoreline/Shorecliff provide ecological interfaces, adding to a particularly biologically rich and diverse study area. From beach/bluff, to remnant prairie/savannah habitats, to lush riparian areas and mixed upland forest blocks, the City of Toronto is a unique urban setting requiring a unique study and planning approach.

SECTION 2A: TERRESTRIAL INTRODUCTION

ECOLOGICAL AND HISTORICAL CONTEXT

When the first European settlers arrived in the geographic region that is now the Greater Toronto Area (GTA), the landscape consisted almost entirely of rich deciduous and mixed forests, dominated by maple, beech and hemlock. Although the forests were the dominant feature, the variety of landform and soil types, coupled with natural disturbances and the activities of aboriginal people, created a mosaic of many other ecosystems (Riley and Mohr, 1994). Low lying wet areas were covered by forest and shrub swamps and with marshes and meadows associated with lake and river systems. Dry sites on sandy soils featured rich prairies and oak savannahs. Naturally occurring fires, extensive flooding and tree downfalls created habitats for fast-growing, opportunistic species. The majority of the forest, however, would have consisted of mature and old- growth stands. Because the landscape was essentially unbroken, strong connections existed among all community types and their associated flora and fauna. Natural processes of energy, matter and gene flow maintained a healthy, ecologically diverse system in a dynamic equilibrium of all of its components.

Within 200 years of its inception, the old City of Toronto grew from a population of 241 in an area covering less than 1 km^2 to a population of 635,400 covering approximately 100 km^2 (Kalbach, 1999). During this period, urban areas were expanding rapidly, replacing agricultural lands that, themselves, had displaced the original forests. Remaining natural cover was largely limited to valley lands and occasional tableland woodlots. The area of the newly amalgamated City of Toronto now supports a population of 2.4 million people in an area of 635.5 km^2.

Direct loss of natural habitat profoundly changes biogeophysical interactions, with resulting impacts on ecosystem health. For example, reduction in forest and wetland cover changes the hydrological regime, resulting in less water retention and more flooding while eliminating the valuable water filtering capacity of these habitats. Groundwater recharge and discharge patterns are altered when habitat, particularly wetlands, is removed. Both forests and wetlands are also important for soil formation, a process which is essentially halted when they are removed. At a larger scale, forests and wetlands have a vital role to play in climate regulation because they absorb solar radiation and act as carbon sinks.

Historical and current land use patterns in southern Ontario have resulted in a significant loss of biological diversity, and are contributing in their own way to the global "biodiversity crisis". Direct loss of habitat is the most dramatic and significant factor in the global, regional and local decline of biodiversity because it impacts all four biodiversity levels. At the landscape level, disappearance of habitats leads to increased fragmentation and isolation of the remaining patches; at the ecosystem level, habitats lose their representation and the remaining patches become degraded; at the species level, native species populations become smaller and more vulnerable to invasions of alien species or simply disappear; and at the genetic level, species lose their genetic fitness and opportunities for free gene flow. This situation is more pronounced in urban landscapes such as Toronto.

CURRENT ECOLOGICAL ISSUES

The concept of habitat fragmentation relates to the breaking up of contiguous habitat into smaller parcels. Fragmentation is one of several spatial land transformation processes affecting habitat patches. The parcels are often of convoluted shapes, which lowers the amount of potential interior habitat. The type of surrounding land uses (matrix) also affects the structure, composition and function of ecosystems.

Plant and animal populations have been profoundly impacted by habitat fragmentation. Dispersal capacities of many species are reduced by isolation from adjacent habitats or potential mates (Primack, 1993). For example, animals that require cover for movement are unable to cross open agricultural areas between forest patches due to the risk of predation. Barriers, such as roads and urban areas, can be formidable and dangerous obstacles to animal movement (Forman, 1995; Saur, 1998). For some species, loss and fragmentation of habitat can disrupt migratory patterns or breeding cycles. Many amphibians reside in upland forests, but require wetlands for breeding. If one of these habitats disappears or becomes disconnected, the local population is at risk.

Restriction of dispersal opportunities results in isolated populations, which are not only more vulnerable to unpredictable natural disturbances such as floods or fires, but which can also suffer loss of genetic fitness due to inbreeding. Studies of white-footed mice in Ontario indicate that even this normally common and prolific species is disappearing from small woodlots (Merriam and Wegner, 1992). The situation may be similar for other species as well. Since small animals can be vital for the dispersal of seeds or as a food source for larger animals, their loss can have a profound effect on ecosystem health. The mere presence of an animal or plant species in a habitat patch does not guarantee its continued existence. Without regular recruitment of individuals, pollen or seed from adjacent populations, the few remaining individuals may be destined to local extinction (Merriam, 1999).

Small forest fragments frequently have a high perimeter-to-area ratio and a large proportion of edge habitat. In a general sense, areas of interface between two different habitat types tend to support a high diversity of species because species characteristic of both situations can usually exploit them, e.g., forest birds and meadow birds. Edges are also frequented by "generalist" species that make use of a variety of habitats and, therefore, have proliferated in a fragmented landscape.

However, edge habitats also have many characteristics that pose concerns for biodiversity conservation. These include increased wind damage of trees, drought, susceptibility to invasion by exotic species, and increased risk of predation of birds and small animals by such generalist species as raccoons, skunks, foxes, etc., all of which tend to have artificially inflated populations due to their tolerance of settled areas. The brown-headed cowbird, a brood parasite, is abundant in agricultural landscapes and regularly penetrates forest fragments to access nests of native songbirds (Robinson et al., 1995).

Forest edges are a stark contrast to the cool, shaded and damp environment of interior forest. Some birds that are dependent on interior forest habitat (e.g., thrushes) are experiencing dramatic population declines, and are now of considerable conservation concern (Robbins et al., 1989, Terbourgh, 1992). Several birds and other vertebrates are also "area-sensitive"; that is, they require large expanses of forest, meadow, or wetland. These species cannot breed in small habitat patches.

Large forested areas have the capacity to influence local climate and hydrology, and fragmentation greatly decreases their ability to do so. Typically, there is greater diversity of habitats in larger patches, which helps to maintain biodiversity. Fragmentation limits or eliminates the extent of natural processes or disturbances, such as fire, which can be both beneficial to many species and important to maintain age structure and species diversity. Fire is vital for maintaining prairies and savannahs.

Habitat fragments, especially those in or near urban areas, are also subject to disturbance and degradation by humans. Uncontrolled recreation leads to trampling and erosion, and facilitates the introduction and spread of invasive plants. Wildflowers are picked to be transplanted in people's gardens; amphibians and reptiles are collected as pets; and house cats hunt for birds and small mammals. Dumping of refuse in natural areas remains a common practice, while pesticides, pollutants and dust can drift in and affect sensitive species. Even noise from backyards, traffic, industry or construction can disrupt the activities of species, especially birds and mammals. The impact of urbanization on wildlife and natural areas has been well documented (e.g., Adams and Dove, 1989, Friesen et al., 1995).

Protecting only the best or most representative of natural areas will not in itself preserve biodiversity or ecosystem health. A more ecologically sound strategy is required to evaluate natural features as a functioning system across the landscape, and to work towards protection and restoration of those functions. In order to avoid the expense and risks involved in crisis management, the approach must be preventative rather than reactive. To a large degree, the approach developed by the TRCA (TRCA, 2001) evolved as a result of the failure of traditional tools to protect biodiversity within a rapidly developing landscape, such as the Greater Toronto Area, and because of the need to develop an approach that applies conservation biology and landscape ecology principles.

SECTION 2B: TERRESTRIAL METHODS

In the mid-1990s the Toronto and Region Conservation Authority (TRCA) began developing a methodology for identifying and evaluating terrestrial natural heritage features (woodlands, wetlands, meadows etc.) in order to help protect, enhance and promote ecosystem health within its jurisdiction.

The main function of the TRCA's terrestrial natural heritage approach is to inform land use and resource management decisions. The goal is to provide a methodology for the evaluation of terrestrial natural habitat function within a systems context, and to direct protection and restoration efforts to where they can maintain and improve this ecological function. It considers three main levels of information: landscape, vegetation community, and species (flora and fauna), each of which correspond to recognized levels of biodiversity. Landscape measures are used to evaluate, score, and rank habitat patches based on spatial characteristics. Vegetation communities and species are scored and ranked according to criteria related to abundance and sensitivity.

The landscape analysis used in the approach includes a modelling component to help determine potential conditions under plausible scenarios. The habitat scoring system can then be used to set incremental targets for ecological improvements. Landscape spatial characteristics, vegetation community quality, and species composition all provide indicators of current condition. Current values can be used as baseline to monitor change over time.

The "Made in Toronto" approach combines the TRCA's terrestrial natural heritage approach with additional natural heritage information layers discussed in Section 4 of this report. In the Toronto application, the methodology incorporates information related to earth sciences, hydrology, aquatic, and cultural information, such as property ownership and land use.

LITERATURE REVIEW

The first step towards undertaking the system evaluation was to compile existing information and to look for information gaps. A call for relevant documents was circulated within City departments and the TRCA. Documents containing information on fauna, flora, vegetation communities, and geological features, including consultant reports, ESA and ANSI studies, municipal planning documents, watershed reports, and documents from the Toronto Field Naturalists, were all of interest to the terrestrial study component. The purpose of the literature review was to gather and incorporate all relevant existing data, to identify information gaps, and to avoid duplication of effort in the field data collection. Documents reviewed for this purpose are listed in Appendix A.

Existing mapping of vegetation communities was gathered from sources such as City and TRCA files, and consultant reports. It was then screened for compatibility with the Ecological Land Classification System for Southern Ontario (ELC). Where possible, information was translated to the habitat categories used in the ELC, based on the presence of dominant species. The information was then digitized for use in the City and TRCA natural heritage databases. Fauna and flora species records older than 15 years were not incorporated because of possible changes in habitat due to land use and ecological succession. Relevant information, such as date, breeding status (i.e., breeding versus migrant bird) and exact location were included where available. This existing information on communities and species provided the basis for identifying data gaps and field data collection priorities.

LANDSCAPE ANALYSIS

In defining a natural heritage system, the terrestrial natural heritage approach commences with a landscape analysis of habitat patch characteristics and their landscape context. This tool can be used to both evaluate existing conditions and to undertake a "modelling" exercise to look at a variety of scenarios to determine potential conditions. A detailed description of the methodology is included in Appendix D.

The landscape analysis requires that land use types and natural areas be simplified into general categories. The land use surrounding natural areas is classified as either urban or agriculture, while natural habitats are divided into basic categories of forest, wetland, meadow, successional, or beach/bluff (coastal communities).

Mapping of each of the major habitat types is based on polygon definition through digitization using ArcView GIS software. In order to maximize accuracy, mapping should be based on the most recent information possible. In this case, existing mapping of forest, wetland, meadow, successional and beach/bluff habitat polygons was digitally updated using 1999 digital orthographic air photos taken during the spring. This involves carefully demarcating habitat polygons using the ortho photos as a base. Habitat patches (polygons) were demarcated by obvious changes in habitat type, and by clear breaks in habitat, such as roads, railways and wide rivers.

Polygon boundaries for forest were made where there was a clear and consistent break in the canopy, such as roads, wide trails, or wide rivers. Since natural ecosystems seldom have well-defined borders, it can often be difficult to discern a precise community (polygon) edge, for example, between successional habitat and forest.

Very small or extremely narrow patches were not always mapped because of the study scale, and the abundance of such sites. This explains why, for example, the strip of meadow found along the channelized portion of the lower Don River was not mapped. This area tends to be less than the width of two tree canopies, which would not be enough to define a patch of forest, while the width of meadows here would be less than many naturalized backyards or small strips of habitat along roadsides. The study time frame and priorities did not permit this level of detailed review and analysis for very small features.

In addition to measuring total cover of each of the major habitat types for the city, the landscape analysis measures three numerically evaluated criteria in relation to individual habitat polygons: size, shape, and matrix influence (adjacent land use).

This analysis is applied to forest (with which successional is combined in the analysis) and meadow patches that are over 0.5 hectares, and all known wetlands and beach/bluff habitats, regardless of size. The minimum size ensures that the calculation is not skewed towards smaller forest and meadow patches over larger ones, which, fundamentally, have greater ecological value. However, since wetlands and coastal habitats are relatively rare compared to forest and meadow, and because wetlands tend to have higher ecological values at a fraction of a hectare, all known patches of these were included in the calculation. Wetlands were given additional weighting in the size scoring because they not only tend to be smaller than the other major habitats, but they can have higher functional values relative to their size. For example, a small pond may be the only available breeding area for amphibians that spend the rest of the year in a large adjacent forest patch. The analysis does not consider riparian habitat as a separate category. These areas were incorporated into terrestrial habitat (forest, meadow, or wetland) polygons for the landscape evaluation. Because riparian habitats are relevant to stream function they are considered in the Aquatic section of this report. However, it should be pointed out that the lack of a separate evaluation system for riparian areas suggests that there is a risk that these areas may be undervalued.

The resulting scores allow for a relative comparison of individual patch values. Each major habitat type polygon is given a reference number and its attributes for habitat type, size, shape, and matrix are recorded in the GIS database.

Maps depicting the ranking of habitats based on the size, shape, and matrix measures, as well as the sum of the scores of each of these, are produced to graphically illustrate the landscape values of habitat patches on colour maps. Thus, green represents the highest score range, and red the lowest. Because the numerical values are actually precise enough to provide a range of score values within each colour category, a series of hues within each colour can be produced, if desired, to illustrate a finer scale of differences between patch scores.

The landscape analysis can also be used to calculate forest interior, a specific type of high-quality forest habitat that is rare in agricultural and urban landscapes. Forest interior contains the damp, dark, cool conditions preferred by some songbirds, and is buffered from negative edge effects, such as wind, predation, exotic species. Generally, the forest edge, where these negative effects can penetrate, is defined as a minimum of 100 metres. Thus, only forest that is found in blocks over 200 metres across on all sides can contain forest interior. Successional habitat is included in interior calculations because this is generally on its way to becoming forest.

As a remote evaluation of habitat patches and land use represented by geometric figures, the GIS landscape analysis does not, in itself, provide an accurate depiction of habitat quality (although the matrix influence calculation is designed to provide some indication of condition). Habitat condition can be better determined through the data collected on site for vegetation communities and species.

VEGETATION COMMUNITIES

The next level of detail used to describe terrestrial natural heritage is the vegetation community. Vegetation communities are associations of plant species. They are mapped as GIS polygons based on the Ecological Land Classification System (ELC) for Southern Ontario (Lee et al., 1998). Although it is still being refined, this system is now the provincial standard for field data collection. It divides communities into a series of classes from general (i.e., "forest") to very specific (i.e., "fresh-moist oak-maple deciduous forest").

Vegetation community mapping existed in TRCA/City files for approximately 30 percent of the city's natural cover, based on previous studies. This was translated into ELC categories and entered into the GIS database. This existing mapping helped to determine where field work to collect community data would be undertaken to fill gaps in coverage. It should be noted that much of the existing mapping is based on field studies that occurred during the 1980s, and this, combined with the fact that it was translated to the ELC, makes it less accurate than the mapping which occurred during the 2000 field work. It is recommended that sites with old mapping be revisited prior to making management decisions that might negatively affect vegetation communities.

During the 2000 field season, vegetation communities were documented for an additional 30 percent coverage of the known natural areas in the city (for a total of approximately 60 percent). Communities were classified to the "ecosite" category of the ELC as a minimum level of detail. However, in most cases the finer level of detail provided by "vegetation type" was recorded. Detailed soil analysis was not incorporated into the definition of each polygon because of study time constraints, although core samples of soils were taken when wetlands were encountered to determine if they were on mineral or organic soils, or when confirmation of any other vegetation type was required.

Vegetation community polygons were transcribed directly onto 1:2000 colour orthographic photos while researchers were in the field. These photos were georeferenced in advance and were digitized by GIS staff when field biologists returned to the office. Each hand-drawn vegetation community polygon was numbered so that more detailed data related to community condition could be recorded separately and have a reference point.

Many of the vegetation types found in urban areas are not included in the current version of the Ecological Land Classification System for Southern Ontario (ELC). Some of these are highly disturbed associations dominated by exotic species such as black locust or Norway maple, although a few are native-dominated natural communities which are ranked as being of conservation concern. The unclassified natural communities include some distinctive coastal associations along the waterfront as well as a mixed red ash and eastern hemlock swamp, which is a distinct ecosite.

Communities not currently defined by the ELC, but found in Toronto, were assigned loose designations at the ecosite level in the field, and dominant species were recorded. Later, tentative vegetation type descriptions were developed for use as working designations. Tentative vegetation types are identified by an alphabetic rather than a numeric code in the GIS database. Natural vegetation types have an upper-case letter, while disturbed/exotic types were given a lower case letter. They will be easy to locate in the database and to reassign to official vegetation type designations in any future revisions to the ELC regime. For example, a dry-fresh ironwood deciduous forest is assigned the code FOD4-A, while a dry-fresh Norway maple deciduous forest is assigned the code FOD4-d.

The evaluation system for defining vegetation communities of concern is currently based on two criteria—local (TRCA jurisdiction) distribution and geophysical requirements. Communities of concern are those which have a local rank of L1 to L3. A list of vegetation communities of concern found in Toronto is provided in Appendix C.

FAUNA AND FLORA SPECIES

The third level of detail in the terrestrial study is species—both flora and fauna. Data collection focussed on "species of concern", as defined through the TRCA Natural Heritage Approach scoring and ranking methodology (TRCA, 2001). Existing records for fauna and flora species of concern within the boundary of the City of Toronto were supplemented with new records made during the field inventory in 2000.

The TRCA methodology scores and ranks species based on a number of criteria related to their abundance and sensitivity. The result is a list of species that includes not only those which are of concern nationally or provincially, but also those which are disappearing locally due to land use intensification. The premise is that all indigenous flora and fauna are important parts of healthy functioning ecosystems.

The system designates local status (ranks) for fauna and flora species in a range of L1 to L5. It is modelled after the method developed by The Nature Conservancy (TNC) for use in Conservation Data Centres, such as the Ministry of Natural Resources' Natural Heritage Information Centre in Peterborough. That system, which designates a global rank (G1 to G5) and a provincial or sub-national rank (S1 to S5), is now the standard. In the TRCA system, L1 species are the rarest and most sensitive, while L5 species tend to be abundant habitat generalists that are either tolerant of, or directly benefit from, urbanization.

The TNC and TRCA ranking systems go beyond federal or provincial listings of Vulnerable, Threatened, or Endangered species, in part because all species receive a status rank, and because many species identified as rare on the TNC list have yet to be added to federal or provincial lists. The federal and provincial lists are based on population status by large-scale political jurisdictions and do not consider local population status or species sensitivity.

Incremental loss of local populations of sensitive species can eventually lead to vulnerability at the provincial or federal level, but if recognition of the problem does not occur until that time, protection options and recovery can be severely limited and expensive. The TRCA system is designed to ensure that local populations are maintained to ensure healthy ecosystem function. By recognizing species sensitivity to development, it also attempts to be pro-active in achieving that goal.

Within the TRCA region, species which rank L1, L2, or L3 are considered to be species of concern. Given that the City of Toronto is an almost completely urbanized landscape that has a limited capacity to support sensitive species, L4 species were also considered to be of potential concern within the city's context, and were recorded in the field unless they were obviously abundant. An example of an exception to this rule is certain tree species, such as white pine and hemlock, which are too common and well distributed throughout much of the City of Toronto to record individuals each time they are encountered. The reason that they are of some concern is that they are not regenerating well, not because they are currently rare. Thus the methodology anticipates negative trends allowing for appropriate management before a crisis situation develops. For these species, a record was made where there was good regeneration, and this was entered into the database as additional information. Appendix C contains flora and fauna species of concern lists.

For the purpose of this study, only vertebrate fauna that breed in the City of Toronto were considered (i.e., mammals, birds, reptiles, amphibians). Migrating birds have not been included as there is no current system for evaluating the significance of natural areas for these species within the TRCA jurisdiction, nor have any comparative studies been undertaken.

Table 1 summarizes the criteria used to score and rank the three levels of detail: habitat patches (landscape scale), vegetation communities, and species. The criteria are designed to reflect the relationship between landscape condition and the status of communities and species. The ranking system allows for a comparison of habitat patch values, providing a tool to set protection and restoration priorities. As the basis for target setting for improved ecological health, the criteria can be used to measure change at each of the three levels.

Table 1: Terrestrial Ranking Criteria

LANDSCAPE	COMMUNITY	FLORA SPECIES	FAUNA SPECIES
	Local Occurrence	Local Occurrence	Local Occurrence
		Local Population Trends	Local Population Trends
	Geophysical Requirements	Habitat Dependence	Habitat Dependence
Size and Shape			Area-sensitivity
Connectivity*			Mobility
Matrix Influence		Sensitivity to Development	Sensitivity to Development

* A connectivity measure for the TRCA's landscape analysis is currently being developed.

SELECTION OF SITES FOR FIELD INVESTIGATION

The initial landscape analysis used to set field investigation priorities was based on habitat mapping derived from 1993 air photo interpretation and, thus was undertaken prior to the digital update to 1999 digital orthographic photos. This allowed for sites to be identified at the beginning of the season, in time to undertake inventories of breeding birds. Once the landscape analysis was completed, the process for defining which sites were to be investigated through field visits included the following steps:

1) A base map was produced showing the major habitats (polygons) in the City of Toronto on a large format map. The landscape analysis was undertaken to provide comparable patch values based on size, shape and matrix influence.

2) Landscape score ranges for the habitat polygons were colour-coded. The resulting patch scores (high, medium, or low) were reviewed by the technical work group. Forest patches that scored in the top five range of values, meadow patches scoring in the top three range of values, and all wetlands were short-listed. In this process, meadows were given a lower priority for inventorying than forests or wetlands if they were old fields because these tend to have lower biodiversity, significance and vegetation quality values than forests or wetlands. "Sites" where field investigations were conducted are shown as "cross-hatched" areas on Map 1. To maximize benefits of field research these generally included habitats beyond those of the evaluated habitat patch, including portions of parks, entire parks, or other adjacent lands.

3) A "gap analysis" was applied to the short-listed sites to identify where vegetation community mapping and flora and fauna records were not yet available.

4) Most of the highest-scoring sites were located in the Rouge and Highland Creek watersheds in the east end of the city. To ensure more even field data collection coverage across the city, sites that scored in the upper medium range in the landscape analysis were selected in the Don and Humber watersheds. No sites were selected in the Etobicoke or Mimico Creek watersheds because of the low habitat patch scores.

5) Sites suggested by the work group were added in a priority sequence, beginning with coastal/waterfront sites and those related to the Lake Iroquois Shoreline/Shorecliff features, followed by smaller remnant woodlots.

In total, 43 sites, ranging from individual woodlots to large sections of valley and stream corridors, were thoroughly investigated through field research. A list of these is provided in Table 2 and their locations are shown on Map 1: Priority Sites for Data Collection. These sites represent a first phase for field inventories to address sites with the greatest need for detailed field documentation due to their potential to support high-quality habitat. It is recognized that to achieve complete coverage of all natural heritage area within the city future field seasons will be needed. Field investigations in areas of Highland Creek and Rouge Community Park were undertaken by the City's Urban Forestry Services group as a contribution to the study.

FIELD DATA COLLECTION PROTOCOLS

Field data collection commenced in June 2000. During the early breeding bird surveys, fauna and some flora records were marked directly on maps carried by field researchers, with supplementary information made in field notes. These records were digitized as point data to the GIS database. Later in the season, field data was collected using a hand held Compaq PC portable computer that uses ArcPad software obtained specifically for the City of Toronto study. This device, tested in this study, proved to be a successful new tool for recording field data.

1999 digital orthographic air photos were loaded onto the device prior to field work. Vegetation community and species records were entered directly onto the device, using the photo image as a base. Vegetation community boundaries and ELC codes were recorded either on paper air photos first, then digitized at the office, or were recorded directly in the field on the device (Figure 3).

A series of pull-down menus was designed for the Compaq PC unit to address field recording needs. Information such as date, weather conditions, observer, species names, and various breeding codes were all incorporated into the device. Sample menus are provided on Figure 4. The ArcPad software allowed for the direct transfer of field data and accompanying fields into the ArcView software database on return from the field.

A digital camera was also taken into the field to record species and communities of concern, or to make visual records of noteworthy site conditions. Photos taken were noted in the pull-down menu so that they would be referenced by the point data. While photos were not taken at every field location, additional photos can be incorporated into the database over time.

Like most urban areas, habitats in Toronto are subject to a wide range of disturbances. These include trampling, erosion, disturbance or predation of wildlife by dogs and cats, collecting of plants or animals by people, dumping of refuse, and invasive exotic plants. These disturbances are relevant to note, both for their impact on biodiversity and habitat quality, and for consideration in relation to setting management goals. For these reasons, particular disturbance types, such as exotic plant invasions, erosion zones or dumping sites, were recorded during the field visits when they were having a clearly negative impact. Notes were also made when particularly high quality habitat was encountered during field visits, such as where there was good regeneration of native trees or features related to old growth such as downed woody debris and high-quality soils. Additional information on drainage, erosion, or other features related to site conditions was marked on the ortho photos and recorded on a separate field form added later. (Figure 4)

The timing of field visits is a vital consideration for observation of flora and fauna. For example, many spring ephemeral wildflowers—which tend to be sensitive and species of concern—blossom in April or May, and all evidence of their presence can disappear by mid or late summer. Amphibians, whose wetland breeding habitats may be ecologically significant, call from April to June, depending on the species. In contrast, the best time to record breeding birds is in June, when the spring migration is over and males are singing in territories. The June start date for this study meant that some amphibians and spring wildflowers were not recorded. Fortunately, many records already existed in previous studies for these species, and have been included in the data base and report.


Figure 3
Vegetation Communities
Mapping
Sample Area.
Legend
Community Boundary
FOD7-a
ELC Community Code
30 0 30 60 Meters
Toronto
Toronto and Region Conservation

Figure 4: ArcPad Data Collection Forms

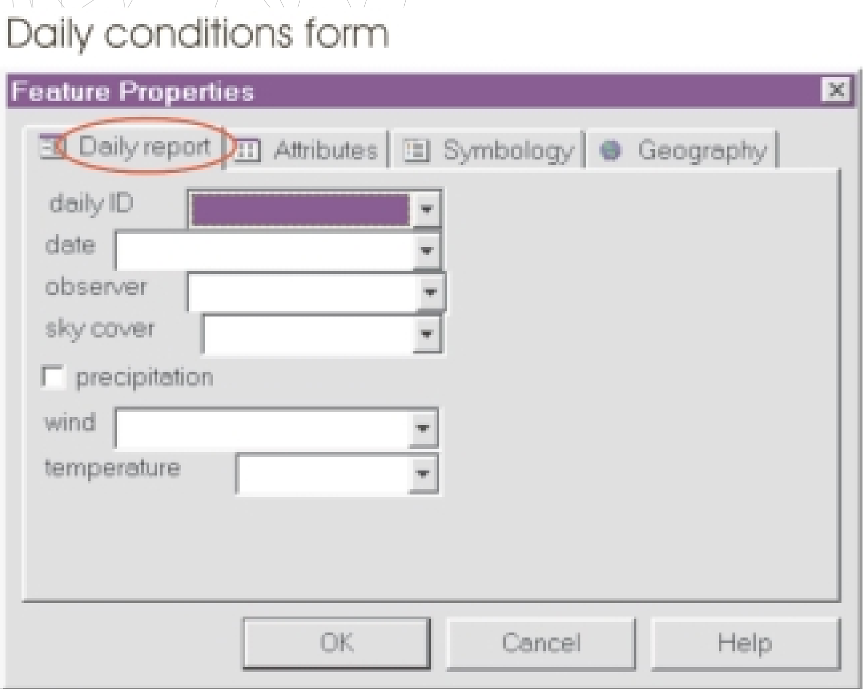


Figure 4: ArcPad Data Collection Forms (cont'd)

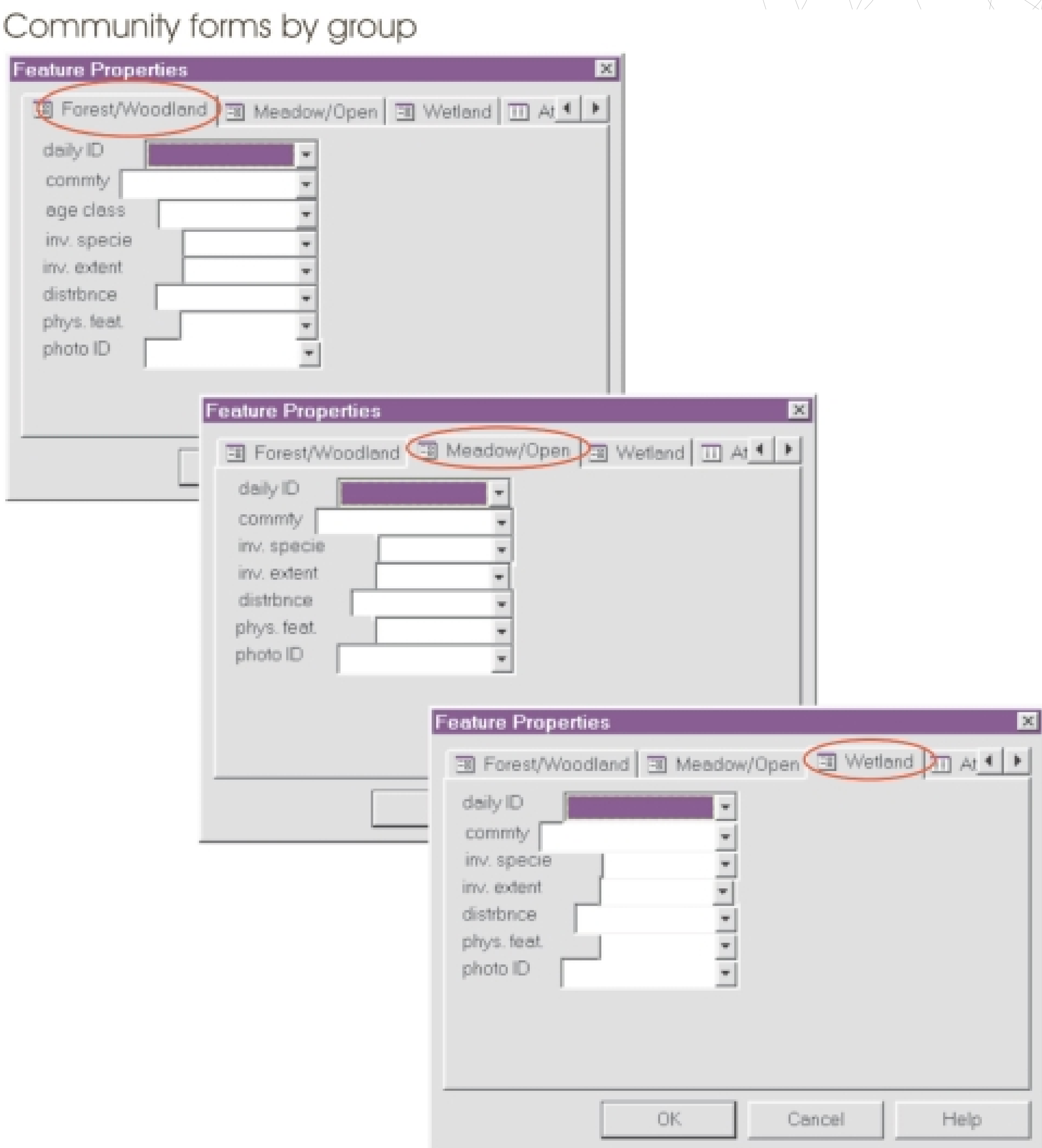


Figure 4: ArcPad Data Collection Forms (cont'd)

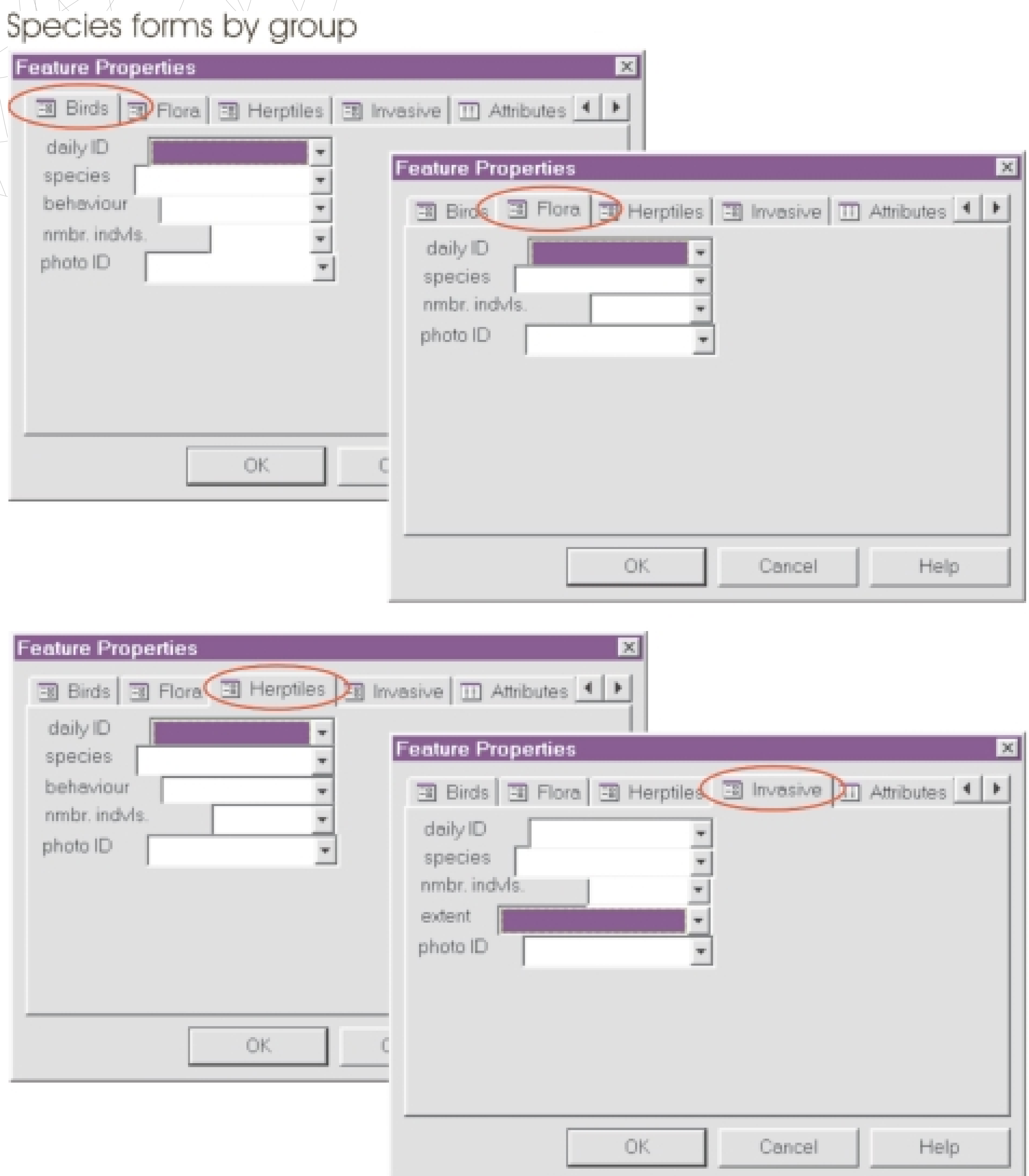


Table 2: Sites* for Field Investigation and Data Collected

SITE NO.	SITE NAME	FAUNA	FLORA	VEGETATION COMMUNITIES	SIZE (ha)
1	Humber Arboretum	x	x	x	74.04
2	Roundtree Mills Park	x	x		101.48
3	Bluehaven Park	x			64.19
4	York University Woodlots**	x	x	x	12.99
5	Derrydowns Park	x	x		30.44
6	Downsview Dells	x	x	x	66.09
7	Lambton Woods	x			30.08
8	Magwood Park	x	x	x	35.61
9	Humber Marshes area	x			36.00
10	High Park	x			166.70
11	G. Ross Lord Park	x	1/2	x	33.92
12	Hinder Property & adjacent slopes**	x	x	x	37.44
13	Earl Bales Park area**	x			33.06
14	East Don Parkland north	x	x		38.94
15	East Don Parkland south	x			123.51
16	Betty Sutherland Trail north	x		x	11.18
17	Betty Sutherland Trail south	x	x		46.50
18	Glendon/Sunnybrook complex	x	x		169.56
19	Charles Sauriol Reserve north	x	x	x	65.80
20	Charles Sauriol Reserve south	x	x	x	69.05
21	Crothers Woods	x		x	23.59
22	Moore Park Ravine	x		x	31.41
23	Park Drive Ravine/Craigleigh Gardens	x		x	39.63
24	Rosedale Ravine Lands	x		x	30.77
25	Portions of Toronto Island Park	x		x	35.10
26	Thomson Memorial Park	x	x		14.20
27	Hague Park	x	x		16.44
28	Morningside Park/Highland Creek complex***	x	x	x	305.75
29	Military Trail Park area**	x	x	x	67.78
30	Scarborough College property**	x	x	x	94.10
31	Colonel Danforth Park/Lower Highland Creek***	1/2	x	x	100.27
32	Woodgrove/Beechgrove Ravines area	x	x	x	5.28
33	East Point Park	x		x	69.64
34	Guildwood Park	x		x	39.63
35	Rouge Community Park***	x	x	x	14.78
36	Scarborough Transportation Corridor (Phase IV site)		x	x	8.85
37	Toronto Hunt Club**		x	x	9.43
38	Sylvan Park/Bluffs			x	88.85
39	Tommy Thomson Park			x	236.79
40	Gerrard Prairie			x	16.14
41	Passmore Forest (L'Amoreaux Park North)			x	6.88
42	Brimley Woods			x	7.36
43	Milliken Park Woodlot			x	2.80

*These "sites" typically include numerous GIS defined polygons in addition to the one which scored high in the TRCA landscape analysis. They may include all, or a portion of the parks as identified in the table. "X" indicates data collected to fill an information gap. Those designated "1/2" have partial coverage for the particular data type. Sites in the Rouge Park were not considered priorities due to the presence of existing data.
** Sites that are entirely or partially on private land.
***Sites where vegetation community mapping was undertaken by the City of Toronto Urban Forestry Services.

SECTION 2C: EXISTING TERRESTRIAL CONDITIONS

LANDSCAPE ANALYSIS

The landscape analysis is performed on the major habitat type polygons that were digitized for the study using colour orthographic photos. Results of the landscape analysis are summarized and interpreted in this section by the individual landscape measures. A discussion of the total cover of major habitat types is followed by a summary of the measures for individual patch characteristics, i.e., size, shape, matrix influence, and forest interior.

Total Cover (Map 2)

Table 3 and Map 2: Major Habitat Types: Existing Conditions, summarize the currently known conditions for the total cover of major habitat types in the City of Toronto.

The total amount of known natural cover found in the City of Toronto (1999) is just over 8,595 hectares (13.5 percent). This figure does not include street and yard trees or manicured parkland areas, which, although they may contribute to overall canopy cover, are not considered natural habitat. It is also possible that some small natural areas were missed in the mapping process. The total is somewhat less than the 17 percent cover for the TRCA region, but is fairly good for a large urban area. Of this total, forest cover has been calculated at 4,384 ha, which amounts to 6.9 percent of the city's land base of 63,550.9 hectares. Much of this is concentrated in the east end, with the Rouge Park accounting for the largest single contribution. The Great Lakes Remedial Action Plan (Environment Canada et al. 1998) suggests a minimum of 30 percent forest (not including urban canopy) cover as a target for an ecologically healthy landscape. However, the RAP makes no distinction between urban and rural landscapes, and while it is desirable to have an increase in forest cover to improve ecological function, it may not be possible to achieve this target in urban areas.

According to the GIS mapping, of the total area of natural habitat currently found in Toronto, forest cover represents 51 percent of all of the major habitat types. If successional habitat is included, this figure rises to 55.9 percent. This is probably much lower than pre-European settlement forest cover relative to other habitat types.

The total mapped area of successional habitat in the city amounted to approximately 417.7 hectares. A small portion of this may be thicket swamp because of the difficulty in discerning between the two in air photo interpretation. Also, when mapping major habitat types, savannah was classified as successional habitat. Native tallgrass communities such as savannah and prairie are, however, recognized at the vegetation community level.

The total amount of meadow habitat, most of which is old field and a very small amount native prairie, is approximately 3,553.7 hectares, representing 5.6 percent of the city. This represents 41.3 percent of the total natural habitat area within the city, which translates into a high ratio of meadow to forest cover (5.6 percent to 6.9 percent respectively). The exact portion of meadow which is actually natural tallgrass communities is not known, given that a thorough survey of the city has not been undertaken for these habitats. However, a number of these have been included in the vegetation community mapping.

The calculation of total area for wetlands is the least accurate of the major habitat types, and will require revision over time. Relying solely on aerial surveys is not accurate for these habitats because: 1) many sites are too small to be detected; 2) some sites that look like meadow may be meadow marsh; and 3) swamps generally appear as forests or successional habitat because, by definition, they are dominated by trees or shrubs. As new field data is added to the inventory database over time, wetland areas can be more accurately defined.

Ideally, a distinction should be made between natural and constructed wetlands, in part because, depending on the circumstances, the latter may not have been established long enough to provide full wetland functions, such as an accumulation of organic soils and complex

Table 3: Existing Cover of Major Habitat Types in the City of Toronto

HABITAT TYPE	TOTAL AREA (HA)	% OF CITY LAND BASE	AVERAGE PATCH SIZE (HA)**
Forest*	4384.2	6.90	3.50
Successional	417.71	0.66	1.27
Meadow	3553.69	5.59	1.05
Wetland*	258.18	0.40	0.36
Beach/Bluff	133.18	0.21	3.17
Total Cover	8595.06*	13.52	2.35

*Known swamp cover (151.9 ha) is measured twice under forest and wetland, but included only once in the total. Forest cover does not include urban canopy (street and backyard trees).

**Average patch size is slightly lower than reality because some convoluted polygons that straddle the city boundary are cut into more than one piece when defining the city boundary.

interactions between species. However, a distinction could not be made for this study using air photo interpretation. Knowing the type of wetland, for example swamp or marsh, is also important, both from a functional perspective, and for definition as a vegetation community type. Although it was beyond the capacity of this study to do so, it is recommended that a thorough inventory of Toronto's wetlands be undertaken to establish a baseline, and that the accompanying database be structured to distinguish between the various wetland types.

Given the above considerations, the current total cover for wetland has been conservatively calculated at 258.2 hectares which represents 0.4 percent of the city's total cover. The Remedial Action Plan's suggested guideline for wetland cover is ten percent. However, since wetland distribution is based on the physiography, hydrology, and climate of a particular landscape, setting a target for additional wetland cover will require the development of a different modelling process. In the meantime, 10 percent wetland cover can be used as a general guideline.

The total area of beach and bluff habitats in the City of Toronto was calculated as 133.2 hectares or 0.21 percent of the city's total area. These habitats are naturally rare relative to forest, meadow, and wetland because they are restricted to coastal areas. Most of the beach areas have been heavily used for recreation over decades, and it may be argued that they are now human artifacts more than natural areas. Nevertheless, some degraded beach/dune habitats remain at Toronto Island Park, and these could be subject to ecological restoration. Breakwater structures have further reduced the natural quality of many beaches and parts of the Scarborough Bluffs by halting normal geological processes.

Forest Interior (Map 2)

Because most of Toronto's remaining forests are in valley lands that are long and narrow, and because these valley lands are used heavily for recreation, both forest interior and its associated species tend to be rare. This study indicates that the amount of existing forest interior within Toronto, based on total area that is beyond a 100-metre edge, is 138.6 hectares, or 0.22 percent of the total city area. While this is probably a large amount of this habitat for an urban area, given that the entire landscape was once dominated by interior forest, it is no surprise that the species associated with this habitat tend to be rare in the GTA.

Most of the remaining forest interior in Toronto exists due to the protection of large forest blocks in Rouge Park and Morningside Park. Nevertheless, small amounts of interior are also found in the Don and Humber watersheds. As will be discussed below, the fauna species composition of some of these areas reflects the presence of this habitat feature; that is, birds associated with forest interior habitat tend to be concentrated here.

Size (Map 3)

Within the regional context, the habitat patches (GIS polygons) in the City of Toronto are small. The average sizes of each of the major habitat types is shown in Table 3. Studies in conservation biology have indicated that larger patches are likely to have a better representation and diversity of both vegetation communities and species, and are, therefore, more likely to have a healthy ecosystem function.

The largest forest patch is 127 hectares in size, the second largest is 99.9 hectares, and the third 77.5 hectares. The first two of these are found in the Rouge watershed, while the latter is part of the Glendon/Sunnybrook complex in the Don watershed. It is important to note that this calculation incorporates successional habitats into the total forest area. Generally speaking, forest patch size has a tendency to increase from west to east, with the largest patches occurring in the Rouge Park.

The largest meadow patch is actually the Beare Road landfill site, which measured 81.1 hectares. This patch was considerably larger than all others, with the second and third largest at approximately 36 hectares and 34 hectares respectively, both of which are also in the Rouge watershed. Given that it probably cannot be converted to forest, the value of the Beare Road Landfill's potential may best be reflected in its capacity as a perpetual meadow. If the other large meadow sites are to be considered for restoration potential, then restoration efforts could greatly increase forest and forest interior area. However, in general, the values of large forests and their potential to support area-sensitive species must be weighed against the value of large meadows for doing the same.

Wetlands receive a higher weighting in the landscape analysis because they tend to be smaller by nature and because small wetlands can have crucial biodiversity values. The large Rouge Marsh was the highest-scoring wetland site, while parts of the Humber Marsh and wetlands at the mouth of Highland Creek scored in the middle-value range. Such larger sites are of particular importance because they may not only support more individuals of the same species than smaller wetlands support, but also feature area-sensitive wetland species, such as American bittern and black tern (for which records exist at the Rouge Marshes). Other known wetland areas, such as the East Don Valley Swamp, tended to score low because they are very small.

Size for coastal habitats, such as beach, dune, and bluff, is probably of less overall relevance for area-sensitive species than for supporting populations of rare plant species that are specific to these naturally limited habitats. As it stands, most of the natural beach and dune areas are very small; thus, plants that depend on these, such as Sea Rocket, may always be rare in Toronto.

Shape (Map 4)

Shape is measured because it determines the amount of edge relative to patch (polygon) area and thus, determines its degree of exposure to negative edge effects in relation to the amount of interior habitat. Round or square-shaped patches score highest for shape. The habitat patches in the City of Toronto scored relatively evenly in the middle range. Those that scored highest tend to be small tableland patches. This is because most tableland patches are bordered by roads, and there is a natural tendency for smaller patches to have less convoluted shapes.

Those habitat patches that scored very low for shape tend to be of three types: 1) highly convoluted; 2) very long and thin; and 3) patches which are both convoluted and contain gaps and holes in the canopy. Predictably, most of the patches with very low shape scores reflect topography, and are found in valley lands and along the Lake Ontario coastline, where natural areas tend to be more linear in shape (refer to Map 4: Existing Conditions: Shape Scores).

In the literature, negative edge effects and habitat shape are usually a focus of concern for forest habitat. However, in a heavily developed landscape, there are many negative external influences, even on open habitats such as meadows, for which compact shape could be of benefit—especially for larger patches. These external influences are measured more specifically by the matrix influence criterion.

Matrix Influence (Map 5)

Matrix influence measures the effect of surrounding land use on a habitat patch (polygon), based on a 2 km radius from the outside edge of the patch. While shape is a measure of the amount of exposed edge a patch has, matrix influence measures type and extent of external pressures on the habitat edge.

It is not surprising that most patches scored at the low end of the scale for matrix influence, considering that the surrounding areas tend to be urban. This is expected to have a predominantly negative impact. Using Map 5, the highest scores (5+) were gained by habitats at the Toronto Island Park and Tommy Thomson Park, despite the relatively small size of these areas. The reason is that much of the 2 km radius that is applied around the outside edge of the patch for this calculation contains open water. In comparing the relative amount of land use type within the radius and its potential effects, open water is considered to have a benign influence, while urban has a negative influence. For these patches, there is more of the former. Other areas along the waterfront, such as the Scarborough Bluffs and East Point Park, scored in the next highest value ranges (4+ and 3+) also because of this lake influence.

Habitat patches in the Rouge Park area also tended to score high for matrix influence. This is because much of the surrounding area is made up of either other natural areas (benign influence), or agriculture (low negative influence). If these agricultural fields were to be reforested, the values of existing patches would increase (as demonstrated by the modelling exercise outlined in Appendix E).

Another interesting result of the matrix influence score is that habitats in valley and stream corridors that are in close proximity to confluence points where tributaries come together tend to score higher. This emphasizes the value of such areas, not only for featuring habitat that may be in better condition because of a reduced negative external influence, but also for providing better opportunities for wildlife dispersal because of their proximity. In essence, then, these patches have a higher degree of connectivity.

Total Landscape Score (Map 6)

In general, when size, shape and matrix influence scores are summed, the highest-scoring habitat patches are those in the Rouge Park area. This result is based on a combination of larger size and lower matrix influence. Several patches along the waterfront, notably on the Toronto Islands, also were among the highest scoring. The positive matrix influence resulting from the close proximity of the lake has had the largest positive impact on these scores, since open water is considered to have a benign influence in the analysis.

The apparent lack of red patches reflecting the lowest score range is due in part to the very small size of these and the scale of the map. However, this is also a reflection of an adjustment that was made in the landscape analysis to better reflect the value of smaller patches, as requested by the City. This adjustment, which involved a change in the scoring system for shape, was tested on the TRCA region as a whole, and appears to more accurately reflect small patch values while not reducing the scores of larger patches.

The lowest scoring sites, not surprisingly, are small, narrow remnant habitat patches that are completely isolated from other natural areas and are surrounded by urban development. Species composition and condition of these sites reflects this situation. In short, in their current condition they tend to support only common species, and may be quite degraded. However, if maintained and improved, these patches can make a substantial contribution to the natural heritage system in terms of their ability to act as stepping stones or stopover areas for animals on the move. If poorly scoring patches were to be removed because they were considered insignificant, this would change the matrix influence on nearby patches, possibly reducing their total score. Furthermore, lower-scoring meadow sites that are adjacent to, or surrounded by forest may turn out to be of particular value in relation to restoration potential, as shown by the modelled conditions that occur in the next phase of the landscape analysis. Lower quality sites also have the potential to have their quality improved through site management.

Habitat patches in valley lands did not always score in the lowest range, despite the linearity of these features. In part this is because most valley lands are currently a mosaic of many individual forest, meadow and wetland patches, rather than a few long, linear patches. Those patches which do tend to be highly convoluted, also tend to be larger. Also, the matrix influence around individual patches always includes adjacent natural areas in the valley; therefore, the score tends to be higher than isolated sites where the matrix is entirely urban.

With the exception of the Rouge watershed, the majority of habitat patches in the city scored in the medium to low range in the landscape analysis, as depicted by yellow and blue on the map. This suggests that, from a landscape perspective, patch values tend not to be as high as many of those in rural areas, such as the Oak Ridges Moraine, due largely to the restrictions on size and the matrix influence inherent in an urban landscape. However, the importance of ravine systems in Toronto for sustaining habitat values is clearly demonstrated by the fact that there are not more red, low-scoring patches in the landscape. In short, the situation could be much worse, and undoubtedly is, in cities that do not have protected ravine systems.

VEGETATION COMMUNITIES (MAPS 7 AND 8)

The combination of old and new mapping from previous studies and from the 2000 field surveys provides a total of 5,199.8 hectares of mapped vegetation communities within the City of Toronto. This represents 60.5 percent of the total amount of natural habitat cover of 8,595 hectares based on the major habitat type mapping (Map 2). For reference purposes, the database includes the year in which each community polygon was mapped. Since many of the historical maps are from the 1980s, these should be updated as soon as possible to ensure accuracy.

The community mapping is based on the Ecological Land Classification System for Southern Ontario (Lee et al., 1998). It was undertaken at least to the ecosite level of that system but, more typically, to the more detailed vegetation type level.

A total of about 240 vegetation communities have been identified within the City of Toronto, based on the vegetation type level of the ELC. A number of the “cultural” communities that occur in disturbed urban areas are not found in the ELC; therefore, new community types were defined for these, based on the ELC community code formula. A list of these has been provided to the ELC workgroup for consideration, since they are currently involved in a similar definition process to revise the system. The most abundant vegetation community type in the city is cultural meadow (CUM1), which is essentially old field habitat. This is distributed throughout the city and is the typical habitat found in hydro corridors. The second and third most abundant community types respectively are dry-fresh sugar maple deciduous forest (FOD5-1) and fresh-moist willow lowland deciduous forest (FOD7-3). The former is perhaps the most characteristic tableland and slope forest type for clay plains in the Toronto area; thus, its continued dominance is not surprising. The reason for the latter being so abundant is that this is a typical forest type of valley lands and riparian areas, which is where the majority of the remaining habitat in the city is concentrated.

Incomplete mapping of vegetation communities across the city makes it impossible to accurately discuss how much land area is covered by high-concern natural vegetation communities versus more degraded or resilient types. Nevertheless, this study has revealed that Toronto continues to support a very rich diversity of natural heritage, as expressed through vegetation communities. The diversity of vegetation communities is related to the variety of geophysical features in the study area, including soil type, slope aspect and hydrological conditions. Many of the more sensitive vegetation communities are associated with the Iroquois Sand Plain and the current Lake Ontario shoreline. Toronto’s extensive ravine system contributes to a diverse landscape; for example, soil type, slope aspect and groundwater seepage are associated with different vegetation types.

A number of high-concern communities (L1, L2 or L3) are located in the study area. Along the waterfront, these include the provincially rare Cottonwood Treed Sand Dune (ELC SDT1-1), as well as several bluff and beach communities, some of which are not yet recognized by the ELC but for which we have provided provisional codes. These were also ranked.

Other communities of concern include the tallgrass prairie, black oak savannah and tallgrass woodland communities found at East Point Park, Toronto Island Park, the Gerrard Street Prairie; along the railway line in Weston, as well as at High Park and Lambton Prairie. In total, these communities cover some 44 hectares. All of these are associated with the Lake Iroquois Sand Plain or are located in the immediate vicinity of Lake Ontario. Tallgrass remnants may be very small, but are of high provincial and global, as well as local concern. For example, according to Bakowsky (1996), Fresh-Moist Tallgrass Prairie (TPO2-1) and Dry Black Oak Tallgrass Savannah (TPS1-1) are extremely rare provincially (designated S1) and globally (designated G2 and G3 respectively). Unfortunately, some of these, such as the prairie remnant at East Point Park, are under threat from invasive plants.

By total area covered and by virtue of its being found in only one location, the broad-leaved sedge organic shallow marsh (MAS3-4) that is found in Sherwood Park can be considered the rarest known community type for the City of Toronto. Map 8 and Appendix C summarize known vegetation communities of concern. It is possible that others may exist at sites that have yet to be surveyed.

It will be possible to determine the area, in hectares, of any given GIS polygon for a community of concern in any area that has ELC mapping. These can then be added up for a total. However, if there is a low amount of coverage, it may be related as much to geophysical requirements as it is to direct loss or degradation of the community. For example, tallgrass communities are extremely rare, not only because of impacts from development, but also because the suite of conditions necessary for them is highly limiting (sandy soils, fire).

Various high-quality forest and wetland communities are found in river valleys, such as the Don River and Highland Creek, and at points along the Scarborough Bluffs. Valley rims, and particularly ridges, provide drier, exposed sites that support such vegetation types as Dry-Fresh Mixed Oak Deciduous Forest (FOD1-4) in Moore Park Ravine, and Dry- Fresh Hickory Deciduous Forest (FOD2-3) at Bluffers Park. Lower pockets may contain wetlands, such as an Alder Organic Thicket Swamp (SWT3-1) along the Betty Sutherland Trail. The above-named examples all have a local rank of L2 in the TRCA system. Bear Swamp in Morningside Park along Highland Creek is a relatively intact wetland complex associated with groundwater that contains a wide array of unusual vegetation types, including organic swamps.

FAUNA AND FLORA SPECIES

During the field work for this study, a total of 35 sites were investigated for fauna species and records of flora were made at 26 sites. The data collected in 2000 has been combined with previous records already within the TRCA database, and with additional records found through the literature search. Previous records exist for the Rouge Park area based on surveys conducted by the Ontario Ministry of Natural Resources; however, these are currently unavailable in digital form.

Map 9 shows the distribution of known species of concern—both fauna and flora—in the City of Toronto, minus records made for the ecological survey for the Rouge Valley Park (Varga et al. 1991), which are currently not available in digital form. The map does not indicate which species each point represents. This information is available in the database which accompanies this report. Lists of species of concern found in the City of Toronto are found in Appendix C. Extensive records of species found during the preliminary studies for the Rouge Park were not available digitally, and will be added to the database at a later date.

Fauna

Highlights of fauna records for the 2000 field work include an unexpected number of area-sensitive and forest interior birds. The Rouge Park features ovenbird, veery, and wood thrush, each of which rank L2 in the TRCA system. The first two of these are forest interior specialists, and this may be the only location where it is possible for them to breed in the city. The wood thrush is considered to be a forest interior species in much of the literature, but can be found in small woodlands if the cool, damp conditions it requires are found along with a good understorey. The fact that it is slightly less sensitive than other interior species is emphasized by the fact that this wood thrush was recorded at a number of sites in ravines across the city during the 2000 field season. This is a good sign, considering that this bird is experiencing population declines throughout its range.

Clearly, along with the Rouge Park, Morningside Park on Highland Creek is one of the most important areas for forest birds in Toronto. Several wood thrushes, northern waterthrush (rank L3), mourning warbler (rank L4) and scarlet tanager (rank L3) were recorded as probable breeders here. The northern waterthrush and mourning warbler both prefer high-quality swamp habitat, which reflects one of the important features of this park, while the scarlet tanager is area-sensitive and found only in locations where there is a large quantity of high-quality forest. Records for numerous forest birds of concern were included in the Ecological Survey of the Rouge Valley Park (Varga et al., 1991). These include winter wren, American redstart, eastern towhee, and white-throated sparrow. Because of the size and quality of forests, the Rouge Park may be the only location where these species breed in Toronto.

Area-sensitivity is not restricted to forest species. Some bird species of concern are typical of large open meadow habitats. The bobolink and eastern meadowlark are two such species that have been found in the City of Toronto. The bobolink is the most sensitive of the two, and has been found in unmowed transmission corridors. The eastern meadowlark can be found in sites that are less than 10 hectares and appears to be more widely distributed in the city.

Wetland birds of concern found in Toronto include common moorhen and green heron, which are known from more than one site in the city. The Rouge Marshes have also been known to support breeding pairs of least bittern and black tern, both of which require large, high-quality marshes.

Map 9 includes species that rank L1 to L3 due to spatial constraints. However, some L4 species may be of local interest as indicators of certain habitat types or quality. A list of these species has, therefore, been included in Appendix C. Typically, these are moderately sensitive species that are either very habitat-specific, or have a limited tolerance to disturbance. Thus, they tend to be restricted to natural areas within the urban context and are not generally "backyard" species. They include such species as great-crested flycatcher, eastern screech owl, and pileated woodpecker. All of these are cavity nesting birds that require mature forests to provide trees that are large enough for this purpose.

The presence of pileated woodpeckers in Toronto is particularly interesting. These spectacular birds require old growth, and the recent expansion of their populations throughout Toronto's ravine system attests to the presence of mature trees in many areas.

No mammals of concern were found during the 2000 field survey; however, previous records exist for some species. For example, a hairy-tailed mole, which prefers high-quality forests with sandy loam soils, was found in Sherwood Park. Another species, the meadow jumping mouse, was observed in abundance in the Humber Valley, just south of Finch Avenue in 1997. These two species have also been found in the Rouge Park, as have star-nosed mole, short-tailed shrew, pygmy shrew, and ermine.

Previous records of amphibians of concern include gray treefrog and wood frog. Both of these require high-quality forest and wetland habitats in close proximity, and tend to disappear as urbanization encroaches. Only a few isolated populations or individuals are likely to remain in Toronto, with the possible exception of parts of the Rouge Park area. The western chorus frog, eastern newt, and mudpuppy also have been recorded in the Rouge Park, although the current status of these species should be assessed.

Reptiles of concern include two turtle species—the Blandings turtle and the common map turtle. Both of these have been observed in Grenadier Pond in High Park, while the latter has also been seen in the Humber Marshes. It is possible that the Blanding's turtle was a former captive, as it is common for people to release pet turtles that were captured in central Ontario or were purchased in pet stores. The map turtle prefers large bodies of water, and it is possible that these individuals are part of a local population.

The smooth green snake and the northern redbelly snake are two snake species of concern found in Toronto. Records of the former exist in the lower Humber Valley. Other populations may survive in the city. However, this species is secretive and well camouflaged and, therefore, may go unnoticed. The tiny redbelly snake, a forest species, is known to occur in the Rouge Park. A northern water snake was observed in the Little Rouge Creek in 1990, but it is likely that this species is now extirpated from the city. The eastern milk snake is occasionally found in the ravines of Toronto, and should be considered a species of local concern. Its populations have probably declined due to collecting and road kills.

Flora

Previous records and the 2000 field study demonstrate that rare or highly-sensitive plants do occur within the City of Toronto, especially where inaccessibility or relatively large habitat patch size has restricted disturbance. Five of the species recorded during the field work have a local rank of L1 according to the current system, and approximately twenty are ranked L2. These include coastal, wetland and forest species. A few of these are ranked provincially rare (S3) such as bushy cinquefoil, a coastal plant. Some of the records of species of concern verified previous records: others were new localities for rare species.

Some highlights of the flora species (all ranking L1) include: sea-rocket (Cakile edulenta), which was located at four separate coastal sites; seaside spurge (Chamaesyce polygonifolia) at Bluffers Park; fringed gentian (Gentianopsis crinita) at East Point Park and Toronto Island Park (confirming previous records); partridge berry (Mitchella repens) at Thornton Creek and Serena Gundy Parks; and Pringle's aster (Aster pilosus var. pringlei) at Toronto Island Park.

The best conditions for significant flora occur in areas where access is somewhat restricted. Forest species, in particular, are often absent where there is a proliferation of trails and trampling. Coastal plants in their exposed environment are often more physiologically robust than forest spring flora, but the sheer volume of recreational use on a beach can be overwhelming. On the other hand, areas blocked off by steep slopes, wet soils, or fences sometimes support high-ranking plants, even if the habitat patch is small. Fences have helped to restrict or direct traffic at such places as Guildwood Park and the Toronto Hunt Club property, while much of the Charles Sauriol Conservation Reserve is wild and rugged and difficult to access. Nevertheless, such areas can be prone to unseen problems such as dumping and gully erosion.

In order to protect species of high concern from disturbance, collection or habitat degradation, access to information on exact location should be restricted to those who are involved in management of the site. This information should not be made available to the general public on demand or in the form of maps that might inadvertently be included in reports to which the public has access. This topic will require further discussion to determine under which circumstances restricted access should apply to information.

SECTION 2D: TERRESTRIAL CONCLUSIONS

EXISTING CONDITIONS

While a total natural cover of 13.5 percent may be encouraging, cover alone does not ensure ecological health. There is a very uneven distribution of natural cover within Toronto. Not only are most natural areas concentrated in valley lands (suggesting a poor representation of tableland habitats), but cover decreases substantially from east to west and from north to south in Toronto. Most of the forest cover is concentrated in the Highland Creek and Rouge River watersheds, and if it were not for the protection offered by the Rouge Park, the total cover for the city would be much lower.

The largest blocks of habitat containing uncommon forest interior are found in the Rouge River and Highland Creek watersheds to the east, although these features are occasionally found elsewhere in the city's ravine systems.

Overall, habitat shape scores tend to be low because most remaining habitats in the urban context are found in valley and stream corridors and tend to be too narrow and irregularly shaped to support a protected forest core. Low matrix influence scores are also the norm since many habitats are surrounded by development, indicating their high susceptibility to perturbations. Exceptions were patches along the shores of Lake Ontario and in the Rouge River watershed, where natural cover scored higher due to the proximity to open water.

The current high representation of open meadow habitats compared to other types, including forest and wetlands, may imply poorer ecosystem health—especially if these are disturbed areas containing lower quality vegetation. This emphasizes the importance of restoring forest as a priority in many of these areas in order to have a more natural distribution of habitats in the landscape.

Vegetation communities of concern occurring in the city include several rare coastal types, a number of savannah and prairie remnants, and occasional high-quality forest or wetland types, the majority of which are found in valley and stream corridors.

Flora species of concern were found in many areas, the most sensitive of these being associated with rare vegetation communities such as prairie, savannah, or coastal habitats.

The presence of fauna species of concern, in particular birds, reflects habitat size and shape values as well as available forest interior. Thus, the most sensitive species, including area-sensitive and forest interior specialists, are found in the Rouge Park and Highland Creek areas. A particularly positive sign is the presence of birds that require high quality forest habitat such as wood thrush and pileated woodpecker at numerous sites throughout the city's ravine system.

Good recent records do not exist for mammals, reptiles, and amphibians in Toronto, suggesting the need for an updated survey. The last thorough survey of amphibians and reptiles was undertaken almost twenty years ago, (Johnson 1983) and it is likely that several sensitive species have disappeared from within the city boundary since then.

Vegetation quality is an important issue, as reflected by the limited distribution of sensitive species. Although the presence of these is a very positive sign for some locations, without additional protection or restoration measures, many of these may be lost as land use and recreational pressures intensify.

Disturbance and habitat condition are key issues related to ecological health. Invasions by exotic plant species are rapidly changing the composition of plant communities within forests and, for reasons which are not entirely clear, some tree species such as hemlock, white oak, and American beech are not reproducing well. These and other issues related to condition are undoubtedly due to negative external influences that have a profound impact on ecosystem health and function.

Use and management of natural areas is an important determinant of condition. For example, heavy recreational use can lead to a number of negative effects. While management goals may include protection of natural features, many damaging activities still occur in sensitive areas.

In summary, Toronto maintains a good coverage of natural areas for an urban area, primarily as a result of the extensive ravine network where development has been restricted. However, the Rouge Park has disproportionately elevated the existing conditions results for the rest of the city. More even distribution of all aspects considered will be needed to provide equally healthy conditions across the study area. Vegetation quality and species composition are two other issues that will require an emphasis on management of the existing features and functions; otherwise, existing unique or sensitive communities and species may be lost to land use and recreational pressures.

MODELLED CONDITIONS

Given the low representation of natural areas in much of the city, a minimum goal of maintaining existing values should be considered inadequate. Wherever possible, values should be increased by regenerating the landscape. The landscape modelling provides direction with respect to where increases in values can be gained. Achieving improvements in habitat size, shape, matrix, forest interior and habitat distribution should result in eventual improvements in the representation of fauna, flora, and vegetation communities of concern.

The modelling scenario undertaken for this report (Appendix E) is just one example used to demonstrate how to look for potential improvements in terrestrial habitat values. Other scenarios should also be tested, but all of them must ultimately be assessed for real opportunities.

SECTION 3A: AQUATIC INTRODUCTION

The aquatic ecosystem is an integral component of the natural heritage system, and because of a relationship of interdependence, its health relies on the condition of the terrestrial and hydrologic systems.

A comprehensive evaluation of the aquatic system within the context of the larger watershed is recognized as an important step in aquatic systems analysis. However, without such a system currently in place, the best available information has been used to evaluate and communicate current and historic conditions.

In this report, information on the aquatic ecosystem is presented in several forms: a classification of aquatic habitats; an evaluation of fish community composition, including presence/absence of species at risk; the riparian zone; and in-stream barriers to fish passage. These data layers provide valuable information on the aquatic ecosystem in Toronto. Taken together, the knowledge provided by this information gives an indication of the general health of the aquatic ecosystem.

Much of the information presented is derived from the watershed fisheries management plans developed for watersheds in the Toronto area. The Fish Management Plans were prepared as a cooperative effort of the TRCA and the OMNR with input from the public and the watershed councils and alliances. The fisheries management plans are resource documents that identify the historic and current conditions based on data collection and a habitat classification system. The fisheries management plans provide direction for management and rehabilitation efforts, using the fish community as an important indicator of aquatic ecosystem health.

The aquatic information for this report is presented on Maps 10 and 11.

SECTION 3B: AQUATIC METHODS

HABITAT CATEGORIES (MAP 10)

Habitat categories were obtained from the fisheries management plans prepared for watersheds in the Toronto area. The categories are based on the fundamental or underlying characteristics of a watershed, including drainage basin surficial geology, drainage area, stream slope and historic fish communities. These categories are delineated based on broadly based and historical information and in some circumstances may not reflect all site specific conditions. The characteristics used allow one to look past existing conditions to understand how the basin would have historically functioned. Surficial geology is used as a surrogate for the flow regime in a watercourse since geology and soils tend to dictate runoff characteristics (including baseflow). Drainage area is used in many circumstances as a measure of the size of a watercourse, and stream slope tends to be a predictor of stream substrate.

The habitat categories represent an expectation of historic or underlying function for the watercourses, and thus provide a benchmark against which to measure health. The habitat categories, in conjunction with the IBI, details of fish community composition, and extent of existing impact, are used in the fisheries management plans to establish short- and long-term fish community targets.

To follow are descriptions of each habitat category.

Small Riverine Coldwater Habitat

Watercourses in this habitat category have drainage areas less than 10 km^2. This includes primarily first and second order tributaries, although a few third order watercourses do fall into this group. Some of these watercourses will be intermittent in their upper reaches, but the majority will have permanent flow. Coarse soils and associated groundwater inputs help to maintain low water temperatures. They also have relatively stable flows due to the high groundwater input and attenuated higher flows.

Some of the most sensitive species in the Toronto area would normally be found in this habitat category, including American brook lamprey, Atlantic salmon, brook trout, redside dace and mottled sculpin. The Atlantic salmon were extirpated from Lake Ontario around the turn of the century.

Small Riverine Warmwater Habitat

This habitat type is comprised of watercourses having drainage areas of less than 10 km^2. For the most part, this means first and second order tributaries draining from the Peel Plain, although there are some third order streams in this category. Due to the dominance of clay soils in the drainage catchment, infiltration rates are low, as are the rates of groundwater recharge to streams. As a result, many of these tributaries are either reduced to standing pools or completely dry up during the warmer summer months. As well, the low ratio of baseflow to average annual flow suggests that these tributaries have less stable flow regimes, with stream levels fluctuating after a rainfall. Water temperatures are likely to fluctuate and become quite warm during the summer.

Intermediate Riverine Coldwater Habitat

Included in this category are those watercourses whose headwaters drain the Oak Ridges Moraine and the Niagara Escarpment. These permanently flowing tributaries receive a proportionately high percentage of groundwater and, as a result, exhibit relatively high baseflow ratios and have relatively stable flows and water temperatures. Drainage areas for these watercourses range from approximately 10 km^2 up to 200 km^2. The majority of watercourses in this habitat category are third and fourth order streams, although some second and fifth order streams are also found. Historically, these habitats supported sensitive species such as American brook lamprey, Atlantic salmon, brook trout, redside dace, rainbow darter and mottled sculpin.

Intermediate Riverine Warmwater Habitat

This habitat category contains watercourses draining from the Peel Plain. Stream order classes in this category are mainly third and fourth order, although some are second and fifth order streams. The majority of these watercourses drain an area between 10 km^2 and 200 km^2. The flow regime and water temperatures tend to fluctuate due to low amounts of baseflow and high storm flows. Sensitive species that would normally be found here include redside dace and rainbow darter.

Large Riverine Habitat

Any watercourse with a drainage area greater than 200 km^2 was included in this category. Since it receives water from numerous large sub-basins, the flow regime can fluctuate greatly. Because of the width of the river, riparian vegetation is unable to effectively shade the stream and thus water temperatures may tend to fluctuate. American brook lamprey, Atlantic salmon, redside dace, rainbow darter and smallmouth bass are some of the most sensitive species historically found in this habitat category. This habitat category played a vital role in allowing the now extirpated Atlantic salmon access to headwater tributaries to spawn.

Estuarine Habitat

Estuarine, or coastal wetland habitat in Toronto extends from the mouth of rivers that enter Lake Ontario to the point upstream that is influenced by the water level in Lake Ontario. This habitat is characterized by very low slope (0.03 percent), slow moving, turbid water especially after a storm. The presence of coastal marshes in the Humber Highland and Rouge Rivers provides spawning, nursery and feeding areas for many normally lake resident species, such as northern pike, largemouth bass, yellow perch and many minnow species. As well, some of the species found in estuarine habitat only migrate through and do not live there. Trout, salmon and white sucker, for example, move through this habitat on their annual spawning runs.

FISH COMMUNITIES

The data on fish communities was collected between 1995 and 2000 by staff at the Toronto and Region Conservation Authority. Most data were collected in support of the development of Fisheries Management Plans, and the Regional Watershed Monitoring Program. Procedures used in collecting data followed Stanfield et al (1997).

Data for fish communities in the coastal marshes were obtained from the appropriate watershed Fisheries Management Plans.

The condition of fish communities is commonly used as an indicator of the overall condition of the aquatic ecosystem. The Index of Biotic Integrity (IBI) is one of the measures of fish community associations that is used to identify the health of the broader stream ecosystem. Steedman (1988) adapted the IBI to Southern Ontario streams, and it is an adaptation of his work that is used in this analysis.

The IBI developed by Steedman utilizes 10 measures of fish community composition to rate biotic integrity on a scale from 10 (poor) to 50 (very good). In our analysis, one of Steedman's measures was not available (the presence of black spot, a fish parasite); therefore, it was deleted from the IBI calculation. Steedman also used a measure of community structure that requires the number of all large piscivores to be summed (fish-eating fish with a body length greater than 20 cm). In our surveys, the total range in length for each species was measured rather than the length of individual fish. Therefore, Steedman's measure for the abundance of large piscivores could not be duplicated. To estimate the large piscivore variable, all fish (for piscivorous species) were summed if at least one individual was greater than 20 cm in length. This will tend to increase IBI scores slightly, but not significantly, based on our sensitivity analysis.

One limitation of the IBI was that it scored all streams as if they once supported brook trout. In our analysis, the scores were adjusted to reflect the habitat categories. Thus, the brook trout metric was dropped for small and intermediate warmwater categories of habitat and large watercourses, and the resulting score was adjusted to the 9 to 45 range of scores. Scores for all habitat categories were then transformed to a common scoring range:

IBI SCORE	STREAM QUALITY
9 - 18	poor
19 - 27	fair
28 - 36	good
37 - 45	very good

SPECIES AT RISK

Based on the recent report (November, 2000) by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC, 2000), there is one fish species in the Toronto area that is considered of "special concern" — the redside dace (Clinostomus elongatus). Species are given this designation because of characteristics that make them particularly sensitive to human activities or natural events. Recent and historic distributions of the redside dace were obtained from Erling Holm at the Royal Ontario Museum.

The redside dace inhabits pools and slow-moving areas of small streams where overhanging bushes and trees offer cover; where the bottom is composed of rocks, gravel or sand; and where the water is clear. The main factors which have adversely affected redside dace populations are: destruction and degradation of habitat through alteration of stream flow; siltation; removal of bank cover; and water quality deterioration. In Canada, there is no protection specific to the redside dace; however, the Federal Fisheries Act prohibits destruction of fish habitat. The redside dace is one of several fish species being addressed under a recovery plan (adapted from the Environment Canada Species at Risk website).

RIPARIAN ZONE (MAP 11)

There are almost as many definitions of riparian zone as there are practitioners of riparian management. This is due in part to the general nature of the term. For example, Webster's New Collegiate Dictionary defines riparian as: "relating to or living or located on the bank of a natural watercourse (as a river) or sometimes of a lake or tidewater."

For the most part, this definition is clear in that a riparian zone is the area associated with the bank of a river or lake or tidewater. The uncertainty arises from the term, "relating to." There are many ways in which the surrounding lands can relate to the river and, depending on the functions of interest, the width of the riparian area can vary tremendously. Therefore, when defining and delineating a riparian area, it is important to consider the functions that relate to the river that are of particular interest and how they are manifested in the field.

The riparian zone and its associated vegetation play an important part in the physical, chemical and biological function of the stream ecosystem. The vegetation found in this area can provide a number of critical functions, including filtering pollutants, nutrients and sediments from the water, detaining flows and evaporating water. Vegetation in the riparian zone provides organic material to the stream that starts the food chain for many higher organisms. Woody vegetation (trees and shrubs) in the riparian zone affects the shape of the channel and the quality of in-stream habitat. As well, it moderates water temperature by providing shade. The roots of vegetation and fallen woody debris also slow the rate of stream bank erosion.

The riparian zone provides an important area of land in which a watercourse can move through over time. This is a very important component of the riparian zone because the lateral movement of a watercourse is critical to the provision of in-stream habitat and for the generation of bed load that creates riffles and point bars in the stream.

The riparian zone also provides important habitat for many flora and fauna and acts as a movement corridor.

In general, the desired functions associated with the lands adjacent to watercourses that relate to watercourses can be placed in five categories. The riparian zone defined by the desired functions is delineated based on the area encompassed by the criteria identified in Table 4.

The criteria can be summarized as:

- the OMNR watercourse buffer (15m warmwater and 30m coldwater);
- the 25-year storm floodplain (riparian flows);
- plant communities associated with mesic soils; and
- the watercourse meander belt.

The first criterion has been applied based on the habitat categories derived from the fisheries management plans. Small and intermediate warmwater habitats, as well as large riverine and estuarine habitats, are buffered with 15m on either side of the watercourse, while the small and intermediate riverine coldwater habitats are buffered with 30m. The buffers were established from the centre of single line watercourses and from the stream bank on double lined watercourses.

Table 4: Categories of Riparian Function

CATEGORY	FUNCTION	DELINEATION CRITERIA
1. Water Quality and Quantity Improvement	Filtering, polishing, evaporating and attenuating surface waters	The greater extent of OMNR criteria for watercourse buffers (15m for warm water and 30m for cold water habitat—OMNR 1985), the 25yr storm floodplain and all plant communities associated with mesic soils.
2. Watercourse Structure	Provision of in-stream cover, channel structure, and resistance to erosion	OMNR criteria for watercourse buffers (15m for warm water and 30m for cold water habitat)
3. Food Supply	Organic material as food supply for the aquatic food chain	OMNR criteria for watercourse buffers (15m for warm water and 30m for cold water habitat)
4. Shade	Moderation of water temperature	OMNR criteria for watercourse buffers, (15m for warm water and 30m for cold water habitat)
5. Water-course Movement	Long term movement of watercourses and other geomorphic functions	The watercourse meander belt, the maximum lateral extent of meandering in a defined reach

The second criterion, the 25-year storm floodplain, is not available in digital form for application in this project, but could be included in the future. It will also be possible to apply this criterion on a site-specific basis for specific management decisions during implementation. The third criterion, plant communities associated with mesic soils, is also unavailable at this time. Plant community inventories must be completed in order to apply this criterion.

The fourth criterion, watercourse meander belt width, was determined for most watercourses through remote sensing using 1999 digital ortho photographs. The meander belt was delineated based on the maximum lateral extent of meandering within relatively homogeneous reaches. Where watercourses were altered, meander belt widths for similar watercourses were used as an estimate. For smaller, highly altered watercourses, a minimum meander belt width of 20m was applied. The appropriateness of this value was checked against calculated meander belt widths at several representative locations, using formulas presented in Parish (1999).

It should be noted that the meander belt widths identified in this study are accurate for the broad scale at which they were created. As such, for site-specific investigations, more detailed work would be required. A draft report is available from the TRCA outlining procedures for delineating meander belts on a site or reach basis in the TRCA jurisdiction (Parish, 2001).

In summary, there are four criteria recommended for delineating riparian zones based on the desired functions. At this time, data is only available for two of the criteria and they have been used to identify a riparian zone for all watercourses in Toronto. In the future, it is recommended that data be collected for the remaining two criteria and that the riparian zone be modified accordingly.

IN-STREAM BARRIERS

The inventory of in-stream barriers was derived from the work conducted in developing Fisheries Management Plans for the Toronto area. Potential barriers were identified from aerial photographs taken in 1993 and 1995. Many but not all of these barriers have been visited to confirm their size and condition. Due to the limitations of aerial photo interpretation, it is likely that there are more barriers than have been identified. For example, barriers obscured by tree canopy or bridges would have been missed. Hanging culverts would not have been visible and, thus, were also missed in the inventory.

EVALUATION OF AQUATIC CONDITION

The evaluation of the overall condition of the aquatic ecosystem is based on a subjective assessment of the weight of evidence provided by each component of the systems for which information is available. A score is derived from the IBI, which provides an indication of the health of the aquatic ecosystem.

A score was derived for the riparian habitat by applying the following scoring ranges; 0-25% forest, poor; 26-50% forest, fair; 51-75% forest, good; and 76-100% forest, excellent. These ranges are loosely adapted from the work of Steedman (1988).

SECTION 3C: AQUATIC EXISTING CONDITIONS

There are more than 400 km of watercourses in the City of Toronto. These watercourses have been classified into six categories of aquatic habitat (see Map 10); namely, small and intermediate riverine warm water, small and intermediate riverine cold water, large riverine, and estuarine.

The designation of habitat categories is based on underlying characteristics of the landscape; thus, they provide an indication of how the habitats function in the absence of significant impacts. The habitat categories provide an expectation of function against which to compare existing or future conditions in order to determine health or establish management targets. This is the process undertaken through the development of fisheries management plans.

Overall, aquatic habitats within the city are not meeting expectations (Map 10). Of the 87 sites surveyed for fish since 1995, 26 percent had no fish present. Although this is almost one third of all sites, these sites are centred on the Highland Creek and smaller tributaries in the Don watershed. Overall, fish communities have a median IBI score of “fair”. Sites scoring "good" are generally in the Humber and Rouge River systems.

In all, there are 73 species of fish that could have been found in the City of Toronto over time (Table 7). Only 31 species were found in the 2000 fish community survey of the city. More species would have been found; however, no sampling was conducted in the coastal marshes. The number of fish species present and the types of species differs across the city. In general, the more sensitive species, such as rainbow trout and rainbow darters, are encountered in the less urbanized Rouge and Humber watersheds (see fisheries management plans). The greatest species richness is found in the estuarine habitats of the Humber and Rouge Rivers. These areas are of particular significance because they provide habitats for many life stages of both river and lake species. The marshes at the mouth of Highland Creek also support a high species richness but not to the same degree of the other two, due to the impacts of urban land use.

Historically, the City of Toronto supported both cold and warm water habitats and associated fish species. In fact, 62 km (or 15 percent) of the watercourses in Toronto were historically cold water habitats, supporting trout and salmon. These coldwater species are highly dependant on a good supply of groundwater to cool water temperatures and moderate flows (see Fish Management Plans for more details on the importance of groundwater to the aquatic ecosystem). Today, trout and salmon still exist in limited numbers, but only because of fish stocking efforts.

Many of the more sensitive fish species have been lost, or their ranges have been greatly reduced. There are still three coastal marshes present, which play an important role in supporting a very high species richness and in providing a linkage between Lake Ontario and the watersheds (see Map 11).

Redside dace, a species considered of special concern based on a recent report from COSEWIC, was once widespread in the Toronto area. As recently as the 1980s, redside dace was found in all of the City of Toronto watersheds. In the 1990s, despite extensive sampling, it was only found in two locations—Morningside Creek in the Rouge watershed and Black Creek in the Humber watershed (Map 10).

In-stream barriers to fish passage have been identified in fisheries management plans as one of the important factors influencing the condition of fish communities in Toronto streams. In fact, in-stream barriers are likely the primary reason that Atlantic salmon were extirpated from Lake Ontario because they prevented adult fish from reaching spawning grounds. For this reason, rehabilitation efforts in recent years have focused on mitigating the negative effects of barriers that are specifically preventing the movement of migratory salmonids from Lake Ontario to spawning grounds near the Oak Ridges Moraine.

There are more than 187 in-stream structures that limit fish movement in the City of Toronto (see Map 11). These barriers vary in size from the G. Ross Lord Dam on the Don to the many small weirs throughout the watercourses in the city. Most of these barriers prevent the upstream movement of fish and a large number inhibit the movement of even jumping species such as migratory salmon. Rehabilitation efforts in recent years have targeted the modification of these barriers to improve passage for migratory salmon, as well as many other species. Approximately one dozen barriers have been modified since 1995, with many more modifications required to allow freer movement of the fish community. The location of these rehabilitation works are identified in the mapping.

The riparian zone plays an important role in the function of aquatic habitats. It influences water quality and quantity, provides physical structure, shade and a source of nutrients, as well as an area within which the stream may move over time. Based on the functional definition of riparian zone outlined earlier, the riparian zone encompasses approximately 3,596 hectares of land in the City of Toronto. Of this area, approximately 2,131 hectares (or 61 percent) consists of natural habitats such as forest, wetlands and meadows. The lowest values occur in the Etobicoke and Mimico Creek watersheds, with 41 percent and 46 percent of the riparian areas in natural habitats respectively. The best condition was found in the Rouge River watershed, where 73 percent of the riparian zone consists of natural habitats.

Of the natural habitats found in the riparian zone, the most important from a stream function standpoint are the forested, successional and wetland habitats. Overall, these habitats make up only 45 percent of the riparian zone. The lowest values again occur in the Etobicoke and Mimico watersheds, with 30 percent and 29 percent respectively. The best condition is again within the Rouge watershed.

Based on these results and a target of at least 75 percent of riparian zones in a natural state (preferably forest), riparian zones appear to be in fair condition.

As noted previously, the riparian zone is very important in providing for many aquatic functions. The zone is also an important part of the terrestrial system outlined earlier in this report. In fact, the riparian zone contains 26 percent of all of the natural habitats in the City of Toronto. Furthermore, if the remaining parts of the riparian zone that do not contain natural habitats were naturalized, it would increase the total coverage of natural habitats in the city from 13.5% to nearly 16 percent.

Table 5: Extent of Natural Habitat in Watershed Riparian Zones

Watershed	Percent Riparian Zone in Natural Habitats	Percent Riparian Zone in Forest, Successional, Beach/Bluff, or Wetland	Percent Riparian Zone in Meadow
Etobicoke	41	30	11
Mimico	46	29	17
Humber	57	44	13
Don	62	43	19
Highland	66	43	23
Rouge	73	60	13
TOTAL	61	45	16

N.B. Table based on GIS overlay of riparian and terrestrial data sets.

Table 6: Historic and Current Fish Species Found in the City of Toronto

Common Name	Historically Present	Present in 2000 Survey
LAMPREY FAMILY		
American brook lamprey	X	X
northern brook lamprey[5]	X	
sea lamprey[1,4]	X	
GAR FAMILY		
longnose gar[4]	X	
BOWFIN FAMILY		
bowfin[4]	X	
HERRING FAMILY		
alewife[2,4]	X	
gizzard shad[4]	X	
SALMON FAMILY		
chinook salmon[1,4]	X	
coho salmon[1,4]	X	
rainbow trout[1]	X	X
Atlantic salmon[3]	X	
brown trout[6]	X	
brook trout	X	
SMELT FAMILY		
rainbow smelt[2,4]	X	
PIKE FAMILY		
northern pike	X	
MUDMINNOW FAMILY		
central mudminnow	X	
SUCKER FAMILY		
white sucker	X	X
northern hog sucker	X	X
MINNOW FAMILY		
goldfish[2]	X	X
northern redbelly dace	X	
finescale dace	X	
redside dace[5]	X	
lake chub[4]	X	
common carp[2]	X	X
brassy minnow	X	
hornyhead chub	X	X
river chub	X	X
golden shiner	X	
emerald shiner	X	X
common shiner	X	X
blackchin shiner	X	
blacknose shiner	X	
spottail shiner[4]	X	
rosyface shiner	X	
spotfin shiner	X	X
sand shiner	X	
mimic shiner	X	X
bluntnose minnow	X	X
fathead minnow	X	X
blacknose dace	X	X
MINNOW FAMILY (cont'd)		
longnose dace	X	X
creek chub	X	X
pearl dace	X	
central stoneroller[4]	X	X
CATFISH FAMILY		
yellow bullhead	X	
brown bullhead	X	
channel catfish	X	
stonecat	X	X
FRESHWATER EEL FAMILY		
American eel[4]	X	
STICKLEBACK FAMILY		
brook stickleback	X	X
three-spine stickleback	X	X
TROUT-PERCH FAMILY		
trout-perch[4]	X	
TEMPERATE BASS FAMILY		
white perch[2]	X	
white bass[4]	X	
SUNFISH FAMILY		
rock bass	X	X
green sunfish[4]	X	
pumpkinseed	X	X
bluegill	X	X
smallmouth bass	X	X
largemouth bass	X	
black crappie	X	
PERCH FAMILY		
yellow perch	X	X
walleye	X	
rainbow darter	X	X
Iowa darter	X	
fantail darter	X	X
johnny darter	X	X
logperch	X	X
blackside darter	X	
river darter	X	
tessellated darter[4]	X	
DRUM FAMILY		
freshwater drum[4]	X	
SCULPIN FAMILY		
mottled sculpin	X	

1. Introduced species.
2. Naturalized species.
3. Extirpated species.
4. Found only in estuarine habitat.
5. Species at Risk—classified as "special concern" COSEWIC.
6. Resident brown trout are naturalized while migratory brown trout are introduced.

SECTION 3D: AQUATIC CONCLUSIONS

Overall, the aquatic habitats and fish communities within the City of Toronto are highly impacted. The Index of Biotic Integrity (IBI) suggests that aquatic ecosystems are in poor to fair condition. The data for riparian zones also suggests a fair condition. Conditions are best in areas experiencing less urban development, including parts of the Rouge and Humber watersheds and the coastal marshes along Lake Ontario.

Specific fish community targets for rivers in the Toronto area are available through the watershed Fisheries Management Plans prepared in conjunction with the public, the Ministry of Natural Resources and the watershed councils and alliances.

Based on the results of the fisheries management plans, in order to achieve healthier fish communities, it will be necessary to concentrate rehabilitation efforts in three key areas: improvement of stormwater management; protection and enhancement of riparian zones; and modification of in-stream barriers.

Stormwater management efforts should be focussed on providing water quality control and quantity control to better mimic the natural water cycle. A combination of source, conveyance and end-of-pipe controls should be used to improve runoff quality, as well as to infiltrate and attenuate flows. Management of groundwater flows and groundwater relative to overland flows is critical to the long term health of the aquatic ecosystem.

Improvement of the riparian zone along watercourses should focus on increasing the percentage of the zone that consists of natural habitats. Emphasis should be placed on providing a high percentage of woody riparian habitat (habitats containing trees and shrubs) in this zone. The current condition of the riparian zone should be improved to a level where at least 75 percent of the riparian zone consists of natural habitats, with the majority of that being woody riparian habitat.

The numerous in-stream barriers to fish passage prevent fish communities from accessing necessary habitats at critical times. Modification of existing in-stream barriers would allow better movement of species between desired habitats, such as spawning, feeding and over wintering areas. Modification of in-stream barriers will assist significantly in the reestablishment of migratory salmonid populations where suitable spawning habitats presently exist in headwater areas north of Toronto. Some barriers will need to remain to prevent species such as sea lamprey and other exotic invasive species from accessing appropriate habitats.

The aquatic ecosystem is an important component of the natural heritage system. Unfortunately, at this time, there is not an approach available for providing a comprehensive evaluation of the aquatic system within the context of the larger watershed.

In summary, aquatic habitats in the City of Toronto are highly impacted. In general, the aquatic ecosystem is in poor to fair condition as judged by the Index of Biotic Integrity (IBI) and the state of riparian habitats. Conditions are best in areas experiencing less urban development. Improvements in the condition of aquatic habitats and species will require rehabilitation efforts in stormwater management to control flows and water quality, rehabilitation of riparian habitats, and modification of in-stream barriers to improve fish passage. A regional reference approach to evaluating aquatic communities and habitats would assist in integrating aquatic management with the rest of the natural heritage system.

SECTION 4: ECOSYSTEM RESOURCE INFORMATION

Issues and topics reviewed for this study include terrestrial function, geology, hydrology, aquatic, riparian, and other interfacing habitats or ecosystem resources that were considered relevant to the City of Toronto context. The study provides a comprehensive database of ecosystem resource information categorized into five components: earth science, hydrological, aquatic, terrestrial and cultural. Table 7 lists the ecosystem resource information compiled or generated for this study as GIS digital information and summarizes how the information was used in this study. The compilation of this information into a database through this product is a major step towards the development of an integrated natural heritage system evaluation and modelling approach. A GIS User Access Program and users manual designed to access the resource information is provided as part of this study deliverable.

The partners worked to identify the best information sources available between the City of Toronto, TRCA and/or external data sources. Several draft lists of potential data layers were reviewed by the work group and GIS staff. They were selected with input from various departments on the basis that: they would supplement the terrestrial information, broaden the current definition of natural heritage, and/or assist in the development of both planning and management level strategies.

Each of the individual data layers are synthesized and evaluated to different levels, with the terrestrial component being the largest database, followed by the aquatic. Other layers are provided as supporting information.

The compilation of this information reveals future study needs, data gaps in the areas of ground water hydrology, wetland coverage and map quality, and accuracy issues regarding public land ownership and land use. These issues are identified in the Next Steps section of this report (under Section 5). The production of an integrated natural heritage evaluation model is beyond the scope of this project but should be developed in the future in order to incorporate all natural heritage functions.

The information compiled for each component are outlined to follow.

EARTH SCIENCE (MAP 12)

Soils, geology and physiography provide the basic abiotic information critical to an understanding of ecological functions. Physiography and soils information tend to be the most revealing in terms of hydrologic patterns or the biotic setting. The direct relationship between abiotic and biotic characteristics is well established. Soil type and moisture content are directly related to vegetation composition and provide the basis for the Ecological Land Classification (ELC) system used in this study. Vegetation distribution and composition is generally related to soil moisture, local climate, soil nutrients and disturbance. Therefore, this abiotic information has been included as GIS data layers as an integral component of the database.

Physiographic regions indicate the effects of the last glaciation 13,000 years ago and provide the transition between surficial geology and soil characteristics. Significant landforms were digitized from Geological Survey of Canada information. Also included are locations of Earth Science Areas of Natural and Scientific Interest (ANSIs) as identified by the Ministry of Natural Resources.

Slope information was provided by the City of Toronto from their digital elevation model and has been interpreted to show slopes greater than 10 degrees for this mapping product. Slopes are a landform that can affect vegetation composition. For example, steep slopes are commonly associated with seepage areas resulting in wetland features. Microclimatic effects can be present in sheltered slope areas. North-facing slopes provide cooler habitat for various plant associations. Steep slopes are prone to erosion, which can represent a hazard or be inhospitable to vegetation growth.

All of the earth science data layers are included as descriptive information necessary to fully understand other data layers and their interrelationships.

HYDROLOGY (MAP 13)

The hydrological information provided in the database integrates natural hazard and heritage-related features and functions. Watercourses provide the fundamental component of the hydrological system. Known watercourses, which included first, second, third and fourth order streams, regardless of size, are mapped and included in the GIS database deliverable. Major watershed boundaries are provided. In the City of Toronto, from west to east, six major watersheds are represented, including: Etobicoke-Mimico Creeks, Humber River, Don River, Highland Creek and the Rouge River. There are also a number of smaller watersheds that drain into Lake Ontario.

Valley and stream corridors are "the natural resources associated with river systems characterized by their landform" (TRCA, 1994). They are the physiographic landform connected to the river system. Valley corridors are distinguished from stream corridors by the presence of a distinct landform such as top of bank. Stream corridors are generally defined by the extent of floodplain. Therefore, valley corridors are defined using a number of criteria, including 10 metres from the top-of-bank or 10 metres from the predicted long-term stable slope. Stream corridors are defined using a 10-metre setback from the TRCA's regulatory floodplain or 10 metres from a predicted meander belt of the watercourse. In the TRCA's definition, where a significant natural heritage feature is directly adjacent to a valley or stream corridor, it is included in the valley and stream corridor. Thus, the valley and stream corridor area integrates a number of issues relating to floodplains and valley slopes (natural hazards), significant landforms, as well as some aquatic and terrestrial features. It should be noted, however, that some stormwater management and hydrological features may extend beyond the valley and stream corridors, and that these may not have been defined through this study due to limitations in both the availability of data and in the methodology used to identify such features.

The Waterfront Regulatory Zone is a hazard-related, regulatory line related to potential wave uprush resulting from a regulatory storm flood event. This regulatory line is defined and implemented by the TRCA pursuant to provincial floodplain policy. The line is based on the 100-year flood level, plus a 15-metre allowance for wave uprush from Lake Ontario. However, the Waterfront Regulatory Zone also represents an all-encompassing area of waterfront that can be used to define shoreline vegetation attributes including the coastal/beach barren habitats described in this study.

CULTURAL INFORMATION (MAP 14)

The terrestrial evaluation component of this study looks at natural features that provide a primarily ecological function to the city's overall natural heritage system. Other types of greenspace are included through the Land Ownership and Land Use data layers. It should be noted that the most current information on land ownership was incorporated into the inventory; however, a number of inaccuracies were noted that will require updates and amendments in the future.

The land use and property data identify recreational and other forms of greenspace that provide multiple-use values, such as parks, schoolyards, cemeteries, golf courses and hydro corridors. Where these properties are heavily manicured, they provide very limited ecological function. In contrast, the portions of public properties that are natural can provide linkage functions across the landscape by acting as "stepping stones" for wildlife on the move. Other types of greenspace have the potential to be naturalized, at least in part, in the future.

Information related to land use and ownership also provides detail about the composition and function, and multiple use values of the urban matrix. For example, recreational trails indicate the extent of existing trails and pressures on the current green space system. Trails information may assist in rerouting or designing new trails when viewed in association with sensitive features.

GIS USER ACCESS PROGRAM

The integration of the information base is accomplished by accessing the GIS database, which contains the data layers described in this section of the report.

To facilitate access to the digital data, the TRCA developed a custom User Access Program application using ArcView version 3.2. This program compiles the data layers into one database, allowing the user to display individual data layers or to overlay two or more data layers in order to address planning and management applications. The programming language used is "Avenue", which is the development environment for ArcView GIS (3.2).

Figure 5 shows some of the navigation features found in the User Access Program. The application allows the user to navigate around the study area using "zoom-in, zoom-to-previous" and other panning tools in order to locate an area of interest and view available data at that location. A detailed street network is visible at scales larger than 1:50,000 and a tool is available to assist in displaying road names and rivers as location benchmarks (screen 1). Coloured 1999 ortho photography can be turned on and off as the background, at any scale, to assist the user visually.

An outlining tool is provided to identify an area of interest (screen 2). Entering this area prompts the application to display a menu of available data layers found for that particular location. The user then selects which of these data layers they would like displayed, either individually or overlaid together. Another feature available to the user is the ID tool. This button marked "I" pulls up an information table about the source of the data layer and any other detailed information available. For example, species information would identify the species code, the field biologist, the site visit date and even the weather conditions. In the case of soils information, the mapping source would be provided.

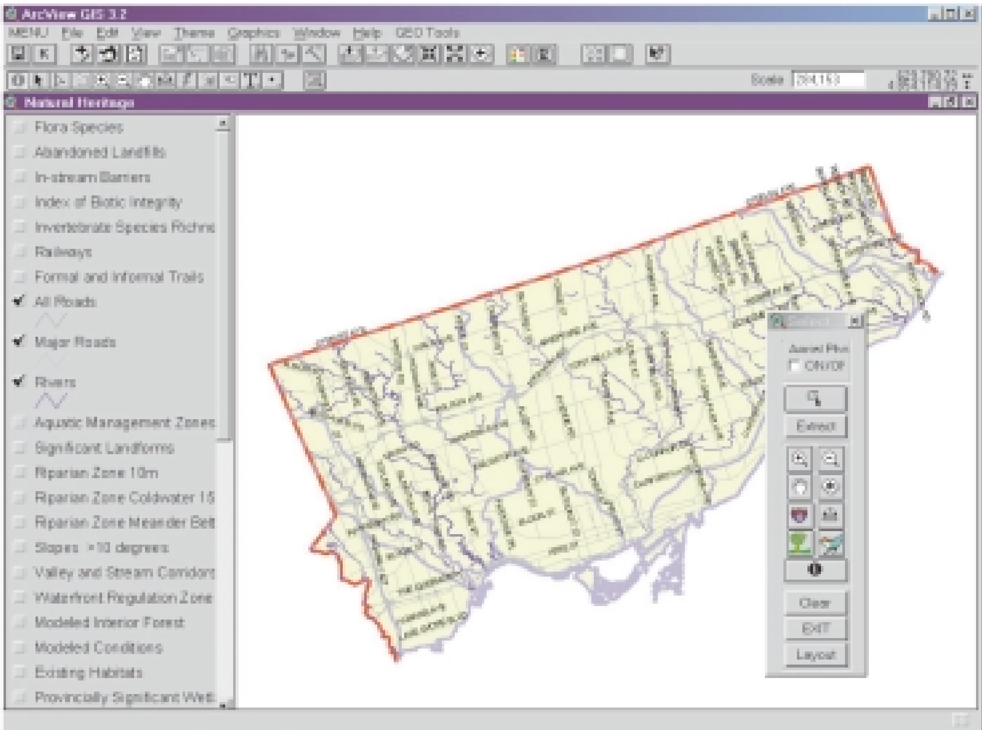
The layering of information (themes) can be modified to suit the user's needs for viewing, printing and exporting snapshots to other programs. For example, more detailed data layers, such as geology, cannot be overlaid on top of other information layers because the colour scheme and level of detail would hide some of the information. However, point data can be overlaid onto polygon data, e.g., species points on top of vegetation communities. As a general rule, more detailed information can be combined with more general information. The user must become familiar with combinations that work well through multiple applications.

Once the user selects the data layers to view, the extract button generates a picture of the data overlaid together (screen 3). In Figure 5 example, ELC vegetation communities, flora species, in-stream barriers, roads, rivers and watershed boundaries were combined. The user has the option of either exporting the information to another file or program for use in reports, etc. or printing the information (screen 4).

As a custom designed desk top tool, the User Access Program allows City staff to access the inventory of information compiled through this study. The ability to overlay information means that ecosystem resource issues are integrated to assist in comprehensive decision-making and in priority setting. Resource conflicts management issues, sensitive features and system boundaries can be identified.

Figure 5: GIS Custom User Access program

Screen 1



Screen 2

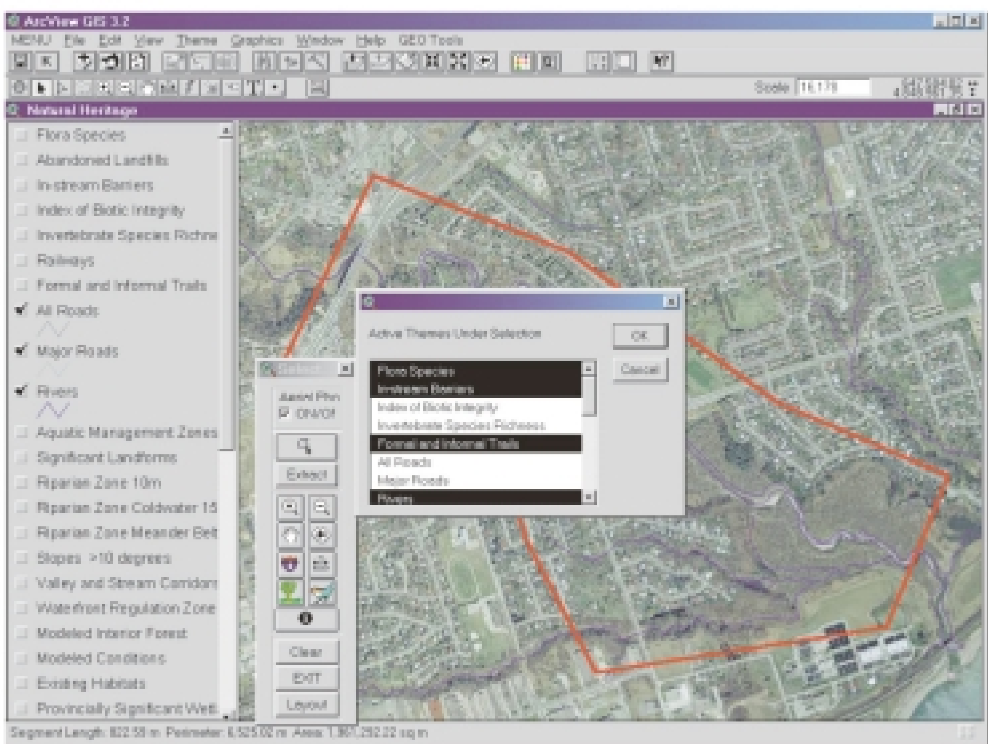
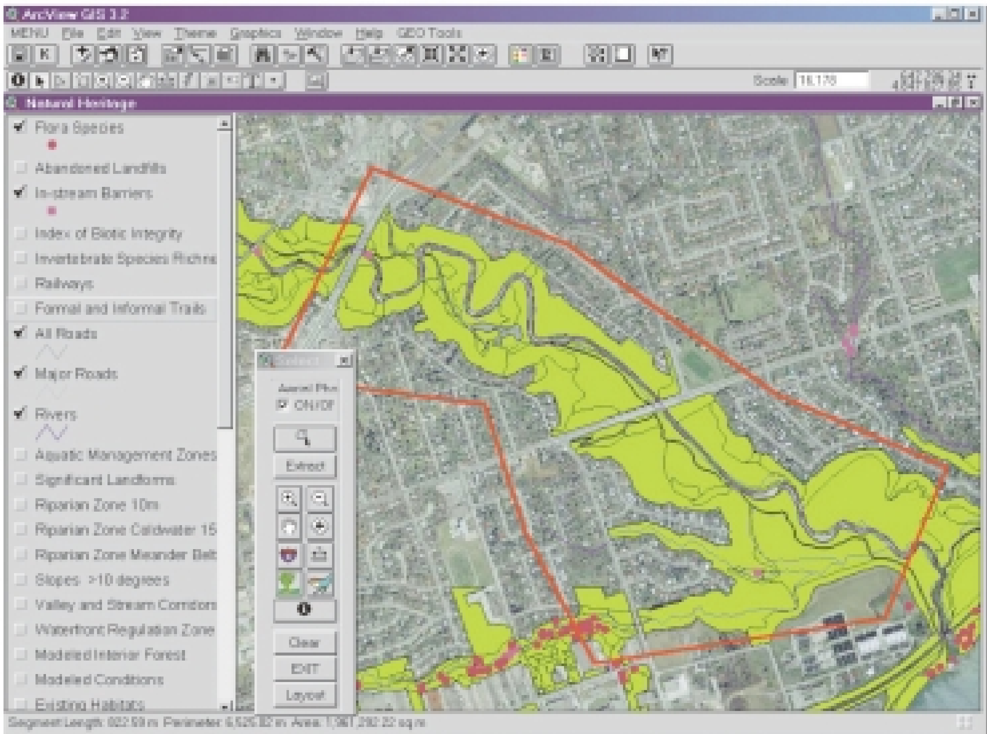


Figure 5: GIS Custom User Access program (cont'd)

Screen 3



Screen 4

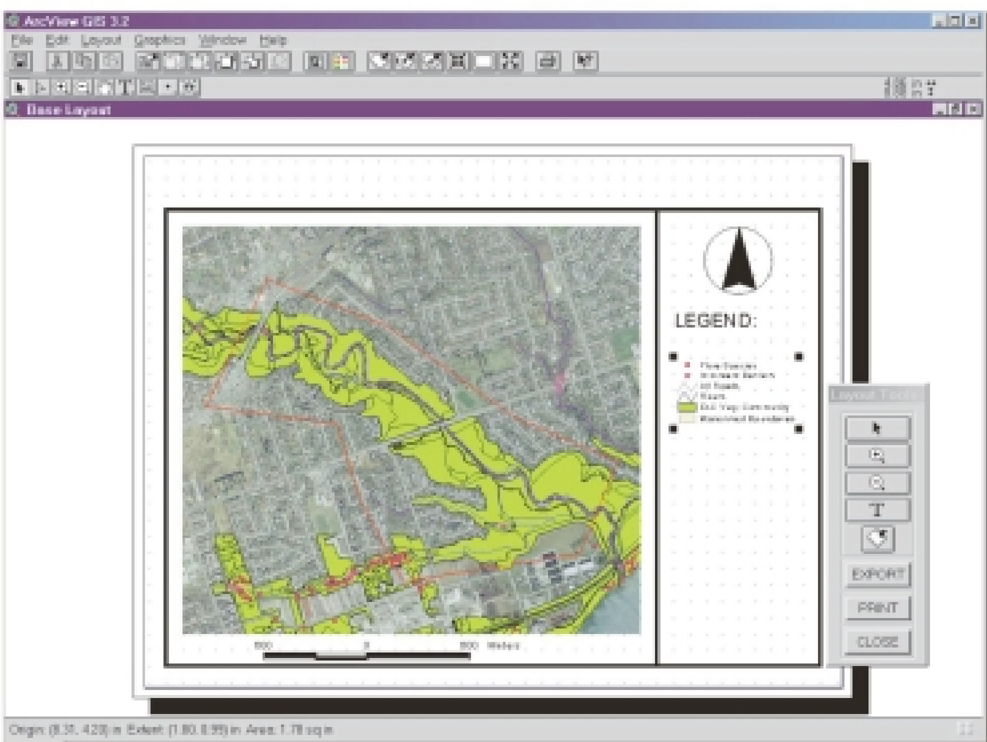


Table 7: City of Toronto Natural Heritage Study: Summary of Data Layers*

DATA CATEGORY Data Layer	Descriptive Information	Information Used to Evaluate Conditions	Information Used to Define the Natural Heritage System
EARTH SCIENCE			
Soils	•		
Geology	•		
Physiography	•		
Significant Landforms			•
Earth Science ANSIs	•		•
Slopes (DEM)*	•		
HYDROLOGICAL			
Watercourses	•		•
Watershed Boundaries	•		
Valley & Steam Corridors			•
Waterfront Regulatory Zone			•
AQUATIC			
Stream Habitat Categories		•	
Index of Biotic Integrity (Fisheries)		•	
Riparian Zone			•
In-stream Barriers		•	
TERRESTRIAL			
Major Habitat Types	•		•
Landscape Analysis		•	
- Size			
- Shap			
- Matrix			
- Total Score			
- Interior			
Vegetation Communities	•	•	
- ELC** Type			
- Age			
- Disturbance			
- Communities of Concern			
Fauna & Flora Species	•	•	
- Type			
- Number			
- Breeding Status (Birds)			
- Species of Concern			
Significant Features**			•
- Life Science ANSIs			
- ESAs			
CULTURAL			
Public Properties	•		
School Properties	•		
Cemeteries	•		
Golf Courses	•		
Hydro Corridors	•		
Landfill Sites	•		
Trails	•		
Railways	•		
Roads	•		

* For details regarding the individual data layers see the summary of data sources that accompanies the maps in the Appendices.
**DEM: Digital Elevation Model, ELC: Ecological Land Classification System, ANSI: Area of Natural or Scientific Interest, ESA: Environmentally Significant Area.

SECTION 5A: STUDY FINDINGS AND IMPLICATIONS

FROM FEATURES TO FUNCTIONS

Approaches for studying natural heritage have been evolving over the last two decades, along with draft provincial policies dealing with representative natural heritage elements. By the early 1980s, life science studies of significant natural features were being undertaken to follow provincial policy direction and respond to local concerns. Approaches for evaluating wetlands and Areas of Natural and Scientific Interest (ANSI's) had been developed by the Ministry of Natural Resources. Studies on locally significant features (Environmentally Significant Areas) were being undertaken in conjunction with area municipalities. The push to identify significant, representative features was underway in response to increasing degradation and loss of natural habitat in southern Ontario.

Ecosystem planning and watershed planning approaches became prevalent in the late 1980s. These approaches looked beyond feature boundaries towards trying to recognize and understand the ecosystem processes (functions). Examples of ecological functions could include groundwater recharge areas, stream baseflow, flood storage and habitat conditions. It is now recognized that comprehensive, long term planning and resource protection are required in order to adequately plan for cumulative pressures on, and changes in the environment.

Beyond the Wetlands Policy approved by the Province in 1989, resource managers began to identify gaps in the protection of features other than natural hazards or wetlands. The Comprehensive Set of Policy Statements (Ministry of Municipal Affairs, 1995) resulted from a thorough public consultation process undertaken in the early 1990s as part of a comprehensive review of planning and development in Ontario. Natural heritage protection policies born out of this process were later scaled back to form today's Provincial Policy Statement (Province of Ontario, 1997).

Today's Provincial Policy Statement moves natural heritage planning towards an ecosystem function-based approach, in that it promotes the protection of significant features and functions across the landscape. While policies are a critical protection tool, the challenge for natural heritage planning and policy is to understand and recognize the interdependencies of resource features and functions, and to recognize that locations across the landscape do not follow static boundaries. These systems are dynamic and continually undergoing and responding to change.

The shortfalls of past planning approaches in preserving significant features and functions is the driving force for looking towards more holistic approaches. The work towards the identification and protection of significant features may have seemed progressive in the 1980s; however, with the continual decline of habitat cover, diversity and quality, the protection of only the most significant features has not been enough to maintain a reasonable level of ecosystem health. Today's challenge is to regenerate the landscape, working with the natural heritage that remains. Multi-disciplinary, integrated planning approaches are the approach of the future, and policy needs to be devised to reflect these goals.

While the ecosystem approach to planning is now widely advocated, experts are still struggling with the definition of critical functions, multi-disciplinary integration and with developing dynamic strategies that balance human interactions with natural systems.

The City of Toronto Natural Heritage Study incorporates ecosystem resource information as part of the development of a multi-disciplinary "Made in Toronto" approach. This approach recognizes that the definition of a natural heritage system, that encompasses terrestrial, aquatic, geological and hydrological components, will require further refinement as new data is collected and new evaluation systems are developed.

THE VALUE OF UTILITY CORRIDORS IN THE NATURAL HERITAGE SYSTEM

Because of maintenance and access issues, utility and railroad companies actively prevent the growth of trees in hydro and rail corridors. As a result, old field habitats dominate these areas in southern Ontario. Numerous grassland birds, including bobolink and eastern meadowlark, and shrubland species such as brown thrasher and eastern towhee, are experiencing population declines in eastern North America. Therefore, maintaining some representation of open field and thicket habitat is important (while recognizing that this should be proportional to forest cover, which historically dominated the landscape). Hydro corridors, in particular, might help address this conservation concern.

If they are on well-drained sandy soils, hydro and railway corridors may provide opportunities to increase representation of native prairie habitat and associated rare plant species. Where conditions are suitable, hydro corridors may also provide opportunities to restore wet meadows and to increase the representation of plant and insect species associated with these.

The value of utility corridors to act as wildlife corridors, on the other hand, is limited. Only wildlife that depend on open meadow habitats and habitat generalist species are likely to make use of these sites. In the Toronto area, the former include grassland birds, including those mentioned above, small mammals such as the meadow vole, and one reptile in particular, the smooth green snake. Because birds have fixed territories and the ability to fly, they do not require corridors. Meadow voles and smooth green snakes can survive in single large habitat patches, and are not likely to move long distances. Single large meadow patches in hydro corridors may be sufficient to support populations of these; thus, the issue is not so much corridor function as patch size. Connectivity is also limited for small animals by the presence of roads, which act as barriers. On the other hand, flying insects such as butterflies that are meadow specialists, might benefit from this type of corridor function.

Habitat generalists that may use utility corridors in Toronto include raccoons, skunks, deer, foxes, and coyotes. The first two of these are regularly found in residential areas far from any natural habitat; thus, they do not actually require corridors. The other three species have larger foraging circuits and can cross roads, thus would likely benefit from utility corridors. However, none of these are of conservation concern and, in fact, they can conceivably present problems for biodiversity. For example, in many parts of southern Ontario, deer have become a problem because of over-grazing of native wildflowers, shrubs, and saplings. Foxes and coyotes readily prey on ground nesting birds and small animals, such as reptiles and amphibians. Because many of the food items of these generalists are forest species that are already sensitive to urbanization, it may not be wise from a biodiversity conservation perspective to actively promote linkages between utility corridors and forested areas such as river valleys unless, in the future, it becomes possible to plant the utility corridors with trees in order to provide forested corridors. This, however, is not to imply that such linkages should be severed where they already exist, or that they should not be promoted for other reasons such as human access or recreation.

In summary, by virtue of the fact that they are regularly bisected by roads, utility corridors have a limited biological corridor function in heavily developed landscapes. Those species which do use these areas for movement are not likely to be of conservation concern, and could even be problematic. In Toronto, the greatest value of utility corridors for biodiversity is probably their capacity to support populations of meadow and shrubland species of concern, and, where conditions exist, vegetation communities of concern.

ISSUES RELATED TO THE CORES AND CORRIDORS APPROACH

Life science studies have evolved from identifying and preserving key terrestrial features to a "cores and corridors" approach to define terrestrial natural heritage systems. This approach is not recommended for the City of Toronto. The rationale is explained below.

In the cores and corridors approach, core areas typically consist of existing protected areas, such as parks or reserves, or other natural areas that contain a range of significant features (i.e., natural areas that are large, are of high quality, high biodiversity representation, contain rare species, or provide breeding habitat for species of concern). The corridors are designed to allow for wildlife movement between the cores in order to ensure population viability by preventing inbreeding. This may be less relevant in a landscape with a low representation of natural areas because in this case all remaining habitats can be considered to be significant, whether or not they provide a "core or a "corridor" function. In this case to define core areas because they have particularly significant features could divert attention from the need to protect other habitat patches, including those that have been isolated by urban development and where corridor development is not feasible. The fact that these areas are not clearly part of a linked protected areas network should not diminish their contribution to the natural heritage system. For example, High Park is one of the most important natural features in Toronto, even though it is isolated from other natural areas.

In the urban setting cores and corridors may not only be difficult to define, their functions tend to converge because most remaining features—especially large ones that would normally be classified as cores—are already located in valley and stream corridors. This is due to aggressive land acquisition programs, which began in the valley systems in the 1950s in response to conservation objectives and flood events.

The value of corridors has been debated by some (Simberloff and Cox 1987, Simberloff et al. 1992), primarily because promoting corridors where they did not already exist can conceivably result in the introduction of predators, invasive plants, parasites, or disease into previously isolated natural areas. That the risk of such negative impacts is likely to be higher in urban areas (e.g., because of elevated populations of predators such as racoons, and the proliferation of exotic plants that results from disturbed habitat), suggests that corridor creation should not automatically be treated as an imperative in a heavily settled landscape, at least when biodiversity is a principal concern. High Park can again serve as an example. Many of the significant plant species and communities may still exist here largely because the site is isolated from these potential problems associated with urban wildlife corridors.

Natural areas in the urban setting are also prone to a high degree of human use and pressure. These areas tend to be more disturbed and lower in vegetative quality than their rural or wilderness area counterparts. Consequently, connections are not always recommended in the urban setting because more pristine areas can actually become more degraded by being physically connected and/or by being subject to increasing unmanaged recreational use through this connection. Invasive exotic plants, such as garlic mustard and dog strangling vine, are of particular concern because they are spread by recreational use (on foot or bike).

If a particular species of concern is identified as a target, and one that would benefit from creating a linkage (i.e., because it would increase the availability of resources), it may be valid to take this action. However, a risk assessment should be undertaken in order to identify the costs and benefits of connection to that species and others. This would involve identifying species and vegetation communities that are sensitive to disturbance and anticipating possible changes to habitats that would result from connections and the permitted human uses within them.

This discussion does not imply that corridors have no value in urban landscapes. Existing connectivity should be maintained in areas that clearly provide some current corridor function such as contiguous habitats in valley and stream corridors.

TORONTO'S NATURAL HERITAGE MOSAIC

Rather than being limited to a series of core protected areas and linkages between them, the spatial pattern and composition of the City of Toronto's natural heritage system is better described as a "mosaic" of landscape elements: remnant upland, wetland, meadow and coastal habitat types, valley and stream systems and the surrounding land use matrix. The Oak Ridges Moraine lies north of the City of Toronto and outside of the study area. The city's topography slopes gently to the Lake Ontario shoreline, with most of its major watersheds draining from the moraine. The Peel Plain, South Slope, and the Iroquois Shoreline/Shorecliff, and sand plain form the basic physiography of the study area from north to south. The edge of the matrix is marked by coastal habitats and beach bluffs along the Lake Ontario shoreline and Toronto Island Park.

Existing valley and stream systems, from the Etobicoke and Mimico system to the Rouge Valley in the east, comprise the majority of the natural heritage system. Tableland habitats are scattered and less predominant than the valley system habitats. Hydro corridors provide lateral connections between watersheds.

Total natural cover in the city is 13.5 percent, which is average in the mid-southern Ontario area. Essex County, an agricultural municipality in the southwest has 4 percent cover, while areas near the City of Guelph contain up to 30 percent. 13.5 percent may be atypical for a city region; however, the spatial pattern, in terms of most of this cover being found in its ravine systems, is expected in the urban setting. Healthy system targets are generally 30 percent or more cover.

Toronto's remaining habitat is extremely valuable from the standpoint of maintaining and increasing biodiversity in this region. The value of all remaining habitats should be recognized by planning policy, as should the need to increase total cover and to regenerate the system. Existing habitat values should be maintained and improved wherever possible.

The key difference between this natural heritage study approach and more traditional approaches is that, rather than focussing on identifying significance alone, the goal is to better understand current habitat values and the state of the ecosystem so that protection and regeneration take place across the broad landscape. All natural areas have some ecological function and a degree of quality that should be maintained and, wherever opportunities exist, improved.

At the landscape scale, total scores for the habitat patches on the site should not decrease due to changes in size, shape, or the matrix factors. At the species level, as a minimum, the most sensitive species should be maintained at any given site. For example, the most sensitive bird in a particular habitat patch may be a relatively common L4 species. This is some indication that the patch may not be seriously degraded, but neither is it of high quality. The goal would be to ensure that L4 species remain on the site, and, if modelling shows that the patch can be improved, then eventually more sensitive L3 species might become established as a result of implementing a restoration/ enhancement plan on available lands. If in future years, only L5 species can be found at this site, this would indicate that an undesirable change has occurred and remediation may be required. Thus, the scoring and ranking system applied in the terrestrial study component in Toronto is used both as a habitat evaluation tool as well as a monitoring tool to achieve desired system targets over time.

Rather than use a "no net loss" approach which is difficult to implement and evaluate, the City of Toronto may prefer to go a step further and adopt a "net gain" approach. For example a net gain can be the result of an increase in natural habitat area or alternatively an increase in the quality of existing habitat patches. This can be achieved by setting targets to regenerate the natural system. Continued representation of species and communities, especially those of concern, should be ensured. Based on modelling scenarios, potential improvements in the landscape values can be identified and used as targets (see Appendix E).

DEFINING THE NATURAL HERITAGE SYSTEM

In the traditional approach, natural heritage protection typically involves identifying the boundaries of significant features (ANSI's, wetlands and ESA's) and providing protection through both designation and management related policies. This study recommends a systems approach that recognizes the values, interactions and interdependencies among all of the natural features, including sites that are comparatively small. A true systems approach identifies the full natural heritage system and overlays different levels of protection, with the goal to maintain and increase the quality and function of natural areas. The natural heritage system, as it is defined through this study, supports the ecological features and functions that are identifiable today.

Therefore, the City of Toronto's natural heritage system is defined using the broad ecosystem components identified through the GIS database compiled in this study. The outermost boundaries of the system were mapped using these components. The detail regarding the individual system components can be viewed in their respective report sections and accompanying maps. Section 4 of this report describes each of these data layers, their sources and methodologies. The following components have been used to form the definition of Toronto's natural heritage system shown on Map 15.

1) Significant landforms and geological features, including drumlins and the Lake Iroquois Shoreline/Shorecliff.

2) Watercourses which collect the runoff from surrounding lands.

3) The Riparian Zone identifies a broad area of riparian/aquatic habitat function adjacent to the watercourse that is essential to healthy stream function.

4) The valley and stream corridor boundary provides the most encompassing boundary to define the valley landform and associated terrestrial features. It also includes potential hazard lands susceptible to erosion or flooding.

5) The Waterfront Regulatory Zone provides a reasonable boundary to contain coastal habitats. It also represents potential hazard lands related to flooding and erosion.

6) The terrestrial natural heritage system is mapped as the coverage of major habitat types; that is, all of the remaining (known) forest, wetland, successional, meadow, and coastal habitat patches, regardless of their variations in composition, structure or function.

7) Overlaid on this system are known significant biological features that are directly addressed by provincial policy. These include: significant aquatic features identified through this study (redside dace locations and coastal marsh communities); significant terrestrial features identified through this study (vegetation communities and species of concern); and Life Science Areas of Natural and Scientific Interest (ANSIs), Environmentally Significant Areas (ESAs) and wetlands.

Combined, this information defines the components of the City of Toronto's natural heritage system today (shown on Map 15). This study recommends that Toronto's Official Plan identify this system as a minimum (since some natural areas may not be mapped), and Official Plan policies should protect and restore these system components. It should also recognize the importance of other supporting features not considered in this study, such as the urban canopy (street trees, manicured parks, backyards). Beyond protection, this study recommends that Toronto move towards regeneration of its natural heritage system in the following ways:

- Habitat patches that coincide with significant landforms or geological features, such as drumlins and the Lake Iroquois Shoreline/Shorecliff, can provide opportunities to maintain visual representation of these features. Opportunities may be identified to extend a continuous habitat feature across the Lake Iroquois Shoreline/Shorecliff in the future.

- The riparian zone provides an opportunity to improve aquatic and terrestrial conditions simultaneously by enhancing these riparian systems with natural cover.

- Valley lands that extend beyond the riparian zone represent floodplains and slopes or other hazards should be protected, not only to maintain the valley landform, but also to enhance the ravine system and the corridor functions these systems provide.

- Remnant tableland features provide opportunities to enhance habitat diversity and species targets across the city. Upland features are the most threatened by development pressures and fragmentation. Tableland features represent priorities for enhancement as large, regularly shaped habitat blocks.

- Protection and enhancement of the waterfront and Toronto Island Park is important in providing unique coastal, beach/bluff and dune habitats and in providing habitat for migratory birds. Waterfront planning needs to recognize opportunities to protect and enhance these coastal features.

MANAGEMENT TOOLS

The highest quality areas may require additional levels of protection beyond what policy alone can provide. Management tools can include land acquisition, stewardship programs and management planning to preserve ecological features and functions.

Land securement via public ownership has typically been regarded as providing the highest level of protection, followed by policy (e.g., land designation), and private land stewardship. The land owner is regarded as ultimately key to the success of site-level management and protection, whereas policy objectives change over time. However, experience has shown that public ownership does not necessarily guarantee protection. In recent years, government cutbacks have caused public bodies to sell off lands to private ownership. In addition, public lands tend to be made available for public use, which can lead to higher degradation of these features than those that are privately-owned.

Therefore, a toolkit is needed to ensure protection and enhancement of important ecological features and functions. It should include policy protection and public acquisition as well as stewardship and management-scale options to address a variety of issues affecting ecosystem health.

Encroachment is recognized as a slow, incremental factor inhibiting habitat quality and protection. Encroachment includes attrition at habitat edges through development or neighbouring impacts (e.g., private trails, dumping, mowing into natural areas) by adjacent property owners. In urban areas, natural habitats are under constant pressure from development and from backyard encroachment. Addressing encroachments effectively will likely require a parkland monitoring and enforcement program.

Use and management of natural areas are important determinants of condition. Heavy recreational use can lead to trampling, erosion, accumulation of trash, spread of exotic plants, disturbance of wildlife, plant collection etc. Dumping, filling, and the construction of utilities, roads and trails can alter soils and hydrological patterns, introduce exotic plants, and disrupt sensitive vegetation communities and wildlife habitat. In short, policies and practices must reflect natural heritage conservation goals, while attempting to balance these with alternative uses. Passive activities may be permitted in sensitive areas, whereas active recreational pursuits would be directed to fewer sensitive parts of the natural heritage system. Because users are often unaware of the problems, public education is an important tool for achieving these goals.

The surrounding landscape also strongly influences the condition of natural areas; therefore, human behaviour and land use in the matrix is an important issue. Defining actions that will enhance, rather than degrade the value of the natural system, should precede education and outreach. Examples are: planting more native species; reducing pesticide use; promoting lawn substitutes; restricting use of invasive exotic street trees; disconnecting downspouts; and promoting permeable surfaces.

Maintaining and restoring natural heritage values on private lands will require private landowner cooperation and stewardship. A landowner contact program could be used to determine the level of interest in conservation or restoration. If the land owner is interested in protecting the features on the property, a stewardship agreement, if not a legal conservation easement, might be considered. Should the owner not be interested, or if an approved development plan is already in place, acquisition of the property or its development rights might be considered for higher priority features.

Habitat patch values, including the presence of species and/or vegetation communities of concern, combined with other ecological values (e.g., riparian zone, hydrological features etc.), can be used to identify a sequence of protection and management priorities. Alternatively, overlaying City-owned properties with the system definition or specific natural heritage components will reveal gaps in stewardship agreements, public ownership or management plans.

It should be noted that, while this study helps in the identification of management options, it is not intended that it substitute for the need to undertake full-scale site assessments where data is lacking. Detailed inventories provide information about site sensitivities and factors affecting site quality. Management plans provide a tool to comprehensively review human use impacts, compared with ecosystem values at a detailed level. They can contribute towards community-based strategies for dealing with multiple-use conflicts to ensure the long-term viability of a site.

It should further be noted that the contribution of some natural areas to the natural heritage system may not be fully recognized at this time, either because the patches were missed during the mapping exercise, or because the current methodology does not fully evaluate all components of the system. For example, stormwater and hydrological functions would extend beyond the defined boundaries of the valley and stream corridors that were used in part to define hydrological features for this study. Due consideration should be given to the significance of these areas for maintaining or enhancing hydrologic conditions. Development of an evaluation tool for hydrological function may be particularly important in this context.

FROM PROTECTION TO REGENERATION

The methodology used for this study provides a tool to compare existing and potential values of individual habitat patches within the system and to allow for measurable increments towards achieving that potential (see Section 2D). The inventory and evaluation of existing conditions through this study demonstrates a range of habitat patch values. Actions can be directed to the highest ranking patches first, and to patches containing species or communities of concern. This will ensure the preservation of priority features or functions through both planning and management-level actions.

Given the low representation of natural areas in the city, maintaining existing values should be seen as the minimum goal. Wherever possible, values should be increased through regeneration in areas where ecological potential can be maximized. This means achieving potential conditions as described by the landscape modelling process (See Appendix E).

The modelling tool is useful for establishing and evaluating terrestrial natural habitat targets based on total cover, forest interior, size, shape, matrix influence and improved connectivity. The improvements at the landscape scale should eventually be reflected in an increased presence of vegetation communities and of species of concern.

The modelled approach provides an opportunity for the City to evaluate the impacts of a variety of scenarios. The sample modelled scenario provided in this study reflects an increase in total cover to 17.8 percent from the current 13.5 percent. It would also improve existing conditions in terms of forest patch size, shape and forest interior. Riparian cover in the valley and stream systems is substantially increased through the model, providing more even distribution and cover across the study area.

Large tableland habitat blocks are created by reforesting available lands. The meadow-to-forest ratio is decreased to be more representative of preferred conditions.

Although the model is terrestrial-based, it would enhance many aquatic and hydrological issues, since vegetation cover relates to each of these components.

SECTION 5B: SUMMARY OF STUDY FINDINGS AND IMPLICATIONS

Table 8 provides a summary of the major study findings and translates these into strategic directions for the City of Toronto. Achieving these strategic direction is a shared responsibility on the part of the City government and other public agencies and institutions along with the private sector, community organizations, landowners and citizens.

Table 8: Study Findings and Implications

ISSUES	STUDY RESULTS/FINDINGS	IMPLICATIONS
TERRESTRIAL		
Habitat Cover	Average for southern Ontario but well below recommended healthy levels of 30%.	Protect all existing natural cover. Increase natural cover.
Distribution	Uneven, majority of cover in east Toronto (Rouge and Highland watersheds).	Improve cover distribution across watersheds.
Proportional Habitat Representation	Forest to meadow ratio is disproportionate. (7%:6% respectively)	Increase forest cover in available areas such as old field sites. Modelled system produces a proportionate ratio of 13%:3% respectively. Maintain and restore potential prairie or savannah types e.g., on Lake Iroquois Sand Plain. Maintain and enhance quality meadows and shrub thickets within hydro corridors and along railway lines as representative meadow habitat.
Habitat Size/ Forest Interior	Most of remaining habitat lies in valley and stream corridors. Largest blocks of habitat, including interior forest found mainly in Rouge/Highland watersheds.	Maintain existing large blocks of habitat. Create large blocks of habitat greater than 100 hectares in other possible locations across the city, such as those identified in modelled system (Appendix E).
Habitat Shape	Most of the city's habitat patches are convoluted in shape. Edge to area ratio is high.	Use habitat restoration to expand existing forest patches by filling in gaps and making them more regular shaped (circle shape is ideal to minimize edge).
Habitat Connectivity	Most connectivity is found within valley and stream corridors.	Maintain existing valley and stream corridor functions and habitat clusters on tablelands. Increase connectivity, within valley and stream corridors. Maintain habitat clusters and improve habitat patch proximity on tablelands.
Vegetation Communities of Concern	Rare coastal communities, prairie and savannah remnants and high quality forest and wetland types found. 60% of study area inventoried.	Protect existing vegetation communities of concern. Improve quality and size of habitats surrounding these features to ensure their resilience. Manage trail design, public use and access at these sites to maintain vegetation features and functions. Manage to mimic natural disturbance regimes where possible (e.g., prescribed burns in tallgrass communities). Continue to study remaining areas to increase data coverage of these features and to monitor change.
Species of Concern	Most sensitive fauna species found in Rouge/Highland watersheds. Some species found in city's ravine systems. Sensitive flora associated with vegetation communities of concern found across the city.	Protect associated features and functions required by these species e.g., forest interior, coastal & prairie habitats. Develop management and restoration plans to target species of concern (protection or attracting new species).
Habitat Quality and Disturbance	Limited distribution of sensitive species indicating lower vegetation quality. Problems associated with trampling, dumping, exotic species, etc.	Consider improvement of habitat quality as part of ecological restoration. Identify vegetation communities of concern that require rehabilitation. Devise a city-wide invasive species control program.
Significant Features	Areas of Natural and Scientific Interest (ANSIs), Environmentally Significant Areas (ESAs), Provincially and Locally Significant Wetlands, were identified and mapped where data was available.	Maintain quality of existing significant features, while recognizing that there are other features requiring mapping and protection.

Table 8: Study Findings and Implications (cont'd)

ISSUES	STUDY RESULTS/FINDINGS	IMPLICATIONS
AQUATIC		
Habitat Condition	Aquatic habitats are generally degraded with best conditions present in less urbanized watersheds.	Fisheries Management Plans identify work needed in three key areas in order to improve aquatic conditions: stormwater management, in-stream barriers and riparian zones.
Riparian Zones	Riparian zones, which are an important interface between terrestrial and aquatic systems, are degraded. Approximately 40% of riparian zones exhibit some use other than natural habitats. Desired forest or successional habitats make up less than 50% of the riparian zone.	Protect the form and function and the habitat of the riparian zone. Increase the amount of natural habitats in the riparian zone with emphasis on forest communities.
Fish Barriers	In-stream structures that prevent fish passage impact fish communities.	Modify barriers to fish passage as recommended in watershed fisheries management plans.
Coastal Marsh Habitat	Coastal marshes are an important aquatic habitat along Lake Ontario, providing important habitats for both riverine and lake species.	Protect existing coastal marshes, enhance where necessary and recreate historic coastal marshes where possible. Regulate lake filling and the placing of structures in the lake.
EARTH SCIENCE		
Features	Geological Features, physiography, soils, slopes, and significant landform mapping provided as additional data layers.	Maintain significant geological features such as the Lake Iroquois Shoreline/Shorecliff, Scarborough Bluffs, and drumlins. Sites with original topsoil should be protected. Recognize vegetation associated with these features. Restore to original conditions e.g., Prairie/Savannah where possible.
HYDROLOGIC		
Features	TRCA Valley & Stream Corridors identified and mapped. Boundaries address hydrological functions, hazard lands and TRCA regulated areas.	Maintain valley and stream corridors. Maintain watercourse baseflow and enhance natural watercourse function where possible. Recognize and enhance vegetation associated with the valley and stream corridor. Continue to promote the finalization of TRCA's fill line extension program. Protect surface water features, particularly wetlands.
CULTURAL		
Land Use	Land use mapping provided as additional data layer.	Recognize the opportunities provided by public spaces, remaining agricultural lands and other cultural features such as hydro corridors to meet immediate protection and restoration priorities.
Private Lands	Land ownership mapping provided as additional data layer. Many species and communities of concern as well as geological features are found on private lands.	Identify priority sites for acquisition or stewardship agreements. Undertake land owner contact program to promote private stewardship options. Where feasible, acquire lands of high significance.

SECTION 5C: NEXT STEPS

The City of Toronto Natural Heritage Study was developed as a first phase in addressing terrestrial ecosystem health and in developing an integrated natural heritage evaluation approach. Building on the current work the following next steps are envisioned:

1) This study provides approximately 60 percent field coverage of the mapped natural areas in Toronto based on digitizing in-file studies and collecting new field data. In order to complete the remaining 40 percent at a similar level of detail, further field inventories are required.

2) Because conditions in natural areas are subject to change, existing site inventory studies should be updated on a regular basis, and at least once every ten years. Additional natural heritage information should be added to the database as it becomes available.

3) It is recognized that due to inevitable oversights when digitizing, some natural areas may be missing from the mapping provided with this study. These habitats should be incorporated in future mapping.

4) As ongoing ravine and other studies identify new sites and features such as groundwater discharge areas and watercourses, or result in revisions of subwatershed boundaries, the database and mapping should be updated accordingly.

5) Riparian habitats may be undervalued in the study because they are not considered as a separate habitat category in the terrestrial evaluation methodology. There is a need to better define the ecological and hydrological functions of riparian habitat as part of the natural heritage system, and to develop an evaluation method which better represents their status and condition.

6) This study identified a major gap in information coverage as it relates to wetlands. A comprehensive wetland inventory should be completed to clearly map wetlands in the field. This would include even the smallest wetlands since they can provide important ecological functions. For example, vernal pools provide important amphibian breeding locations.

7) Additional natural heritage information should be added to the database as it is encountered or becomes available. This includes updated information from the Ministry of Natural Resources, such as ANSI and Classified Wetland studies.

8) Currently there is no system in place to evaluate the use of natural areas by migratory species such as birds and butterflies (e.g., Monarch). Important stopover areas in the city should be identified and mapped in order to help maintain populations and the important ecological functions of these species.

9) Currently a numerical evaluation system is only available for terrestrial natural heritage. There is a great need to develop evaluation systems for the hydrological and geological components of the natural heritage system and to integrate these into a comprehensive whole.

10) The property ownership data should be updated on a regular basis to allow for the development of acquisition, stewardship, and management programs, as well as for future modelling to find habitat restoration opportunities.

11) There is a need to promote and maintain consistent data collection protocols and data management related to natural heritage features. Responsibilities for data input and management, as well as data access and sharing issues must be identified and resolved. A memorandum of understanding should be developed and signed to address these issues as soon as possible.