Toronto and Region
Terrestrial Volunteer Monitoring Program
Monitoring Results
2002 - 2007

June 2008





Watershed Monitoring and Reporting
Ecology Division

TORONTO AND REGION Conservation
for The Living City

ACKNOWLEDGEMENTS

This monitoring program would not be possible without the dedication to environmental conservation exhibited by our many volunteer and landowner participants. Volunteers invest considerable time in training and surveying. They conduct the surveys according to the protocols, even when this means surveying at a time, or under conditions, that may be less than ideal for their convenience or comfort. Their concern for the quality of the data they collect, along with their long-term participation, enhances the scientific value of the monitoring effort. A special thanks is due to volunteers Kerry Adams, Adelle Leaney-East, Guangdong Liu, Bernie Taylor and Chris Watson for their added contribution in reviewing this report. The private landowners who participate allow volunteers to traverse their properties at various times of the day including early mornings and late evenings. They continue to be very accommodating to our efforts and interested in the results. Their ongoing involvement is very much appreciated and critical to our success.

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1.0 EXECUTIVE SUMMARY

The Toronto and Region Conservation Authority's (TRCA) Terrestrial Volunteer Monitoring Program (TVMP) has been collecting indicator species data on fixed monitoring sites distributed throughout the Toronto region since 2002. The program was designed to provide information on the condition of the terrestrial ecosystem in the region, with a focus on its forest, wetland and meadow habitats, to evaluate differences between zones defined on the basis of the degree of urbanization within them, and to track change over time. This information, when considered in conjunction with the Terrestrial Natural Heritage System Strategy, and the jurisdictional Species of Conservation Concern data set provides a basis for recommendations for TRCA land and watershed management, restoration and recovery planning and monitoring, as well as development planning enhancements to meet our objectives for regional biodiversity.

Volunteers are trained and work in pairs to conduct the biological surveys, visiting assigned sites 10 times each year to survey for the presence of a selected set of indicator species. Species were chosen as indicators based on their ecological needs and sensitivities, with the full complement of 56 species providing the ability to evaluate various aspects of ecosystem function across the region. Tables 1 and 2 on pages 15 and 16 summarize the species surveyed, the observation methods used and the schedule of site visits. Appendix C highlights the information indicated by the presence of each species as well as potential interpretations for its absence from a habitat type that it might be expected to occupy.

Data analysis to date has compiled results from sites for the monitoring period to evaluate overall indicator species richness (the number or percent of indicator species found) as well as species richness for subgroups within the indicator species list, i.e. jurisdictional Species of Conservation Concern, amphibians (frogs/toad), breeding birds, flora, and lichens. The data for sites were grouped by land-use zone (i.e. urban, urbanizing and rural) and by major habitat type (forest, wetland, meadow) and compared. Analysis of change over time and investigation of temporal trends will be conducted once 10 years of data has been collected.

Not surprisingly for an urban and urbanizing region, the terrestrial ecosystem showed a considerable degree of degradation. The indicator species richness mean (average) for the region was 39%. In a fully functional system comprised of native forest, wetland and meadow habitat, this number would be much higher. The indicator Species of Conservation Concern group demonstrated a low species richness averaging 6 of a possible 28 species. The indicator amphibian group mean was 3 of a possible 8 species found. Breeding birds averaged 4 of a possible 14 species, and the porcupine was found on just 6% of sites. In the past, this species would have been widespread in the region's forests.

Landscape analysis of 2002 aerial photography, combined with regional planning information, showed the urban zone occupying approximately 60% of the regional jurisdiction, with the rural zone at 30% and the urbanizing zone 10%. Statistically significant differences were evident in the average indicator species richness and number of Species of Conservation Concern found on sites in the urban versus the rural zone, with the urbanizing zone being very close to the rural one for the time period analyzed. Within the rural zone, comparisons were

made between sites located on the Oak Ridges Moraine and those located off the moraine, with no significant differences found between the two groups.

The monitoring results infer a considerably reduced level of structure and function within the remaining natural cover in the urban zone, as compared to the other zones. Its overall indicator species richness was 31%, and its mean for Species of Conservation Concern found was 4 of a possible 28 species. For fauna Species of Conservation Concern the mean was 1 of a possible 17, with the majority of the urban sites having none of these species present.

The urbanizing zone was intermediate between the urban and rural zone on most measures, and in most cases not significantly different from the rural zone. The similarity between these 2 zones relates to the fact that much of the urbanizing zone was in fact still rural during the period of study. A large portion of the urban zone was developed at a time when regional biodiversity was not considered in the planning process. Today, an improved process builds in greater habitat protection and buffering, yet we continue to see reduced biodiversity following development. Application of the systems approach presented in the Terrestrial Natural Heritage Systems Strategy will help to further ameliorate the negative effect of development on the remaining ecosystem by protecting sufficient habitat in a connected system to support a higher level of biodiversity. If a Terrestrial Natural Heritage System is not implemented in some jurisdictions, the ecosystem in those parts of the urbanizing zone would be expected to decline to the level of the recently developed parts of the urban zone. Results from the TVMP suggest additional factors that are likely important, and improved controls that might be helpful, such as applying best practice methods to minimize the potential for road salt to contaminate natural wetlands. The existing TVMP baseline data for this zone will support the ability to provide a quantitative assessment of ecosystem change as development occurs and monitoring continues.

TVMP monitoring sites are located on both public and private lands, with sites on many TRCA conservation properties, within municipal parks and in Rouge Park. The monitoring results are available for public sites and can be used in management planning. In the case of private properties, an individual landowner report has been prepared for each and distributed to the landowner. Private property data is used by TRCA only in the group analyses to arrive at the mean values presented.

The baseline data set and interpretation of the TVMP monitoring results is of value not only for ongoing TRCA monitoring and analysis; it can also be used for reference by others planning local site monitoring. If the TVMP protocol, or a subset of it, is used for such monitoring projects, the local site results can provide better information on how healthy the site is relative to the land-use zone or region. Where monitoring of the entire TVMP indicator species set would be too onerous, the amphibians are recommended as the most informative group on which to base monitoring efforts. This is due to their need for both aquatic and terrestrial habitat, their need for connections between these habitats and their sensitivity to contamination of either. If an existing site without wetland is to be monitored, the set of TVMP fauna indicator Species of Conservation Concern is a recommended alternative group.

A gap analysis of the TVMP monitoring effort, along with the results for flora species indicates a need for the modification of protocols under the current program to address invasive flora species distribution and rate of spread throughout the jurisdiction and the concurrent impact on native species. In addition, the results for monitoring of the Northern leopard frog, combined with continental concerns regarding its decline, suggest a need for a modified monitoring protocol, whether under this program or other TRCA monitoring, to better understand its distribution and population status, as well as relevant impacts to this species in the Toronto region.

The Terrestrial Volunteer Monitoring Program continues to be an extremely valuable contributor to the TRCA's data collection efforts. The quality of the data is evident both during the quality assurance process and through the analysis presented here. The quantity of data collected is clearly much higher than could be achieved at reasonable cost using staff field teams. The opportunity for interested community members to participate and build their knowledge of the terrestrial ecosystem and biodiversity issues is an added benefit. Multiple volunteers, particularly students and recent immigrants with an environmental background, have progressed from participating in the terrestrial monitoring program to employment within the environmental sector, some of them with TRCA.

2.0 INTRODUCTION

The Toronto and Region Conservation Authority's (TRCA) Terrestrial Volunteer Monitoring Program (TVMP) has been collecting data on terrestrial ecosystem condition in the Toronto region since April 2002. This is the first in a series of technical reports that will summarize findings and relate the results to complementary TRCA projects such as the Species of Conservation Concern scoring and ranking system, the landscape analysis model output and the Terrestrial Natural Heritage System Strategy. It interprets results to provide information for internal and external requirements, including those of conservation land and watershed management, partner municipalities, other agencies and organizations, and citizen stewards.

2.1 Terrestrial Volunteer Monitoring Program Background

The TVMP monitors the health of the terrestrial ecosystem throughout the Toronto region to track changes over time, and to build our understanding of how a variety of characteristics of the landscape (Appendix A) are helpful in explaining the observed condition. An additional goal is to engage citizens within the watersheds to learn more about the ecosystem and, with training, to be active participants in the collection of scientifically valid data. Landowners participate by allowing surveys to be carried out on their properties. Data are maintained, quality controlled, analyzed and reported on by the TRCA. Monitoring sites are 10 hectares in size, located in natural cover on both public and private lands, and distributed across the nine watersheds of the TRCA jurisdiction (Figure 1).

The Terrestrial Volunteer Monitoring Program was designed to inform decision making and target setting relative to the TRCA's *Terrestrial Natural Heritage System Strategy* (TRCA, 2007) for the region. Both the strategy and the monitoring program are built upon a foundation of earlier work that included the development of a regional Species of Conservation Concern ranking system. This system scores native flora and fauna species on several ecological criteria to assign a local level of conservation concern rank (L rank). Species ranked L1 to L3 are Species of Conservation Concern throughout the jurisdiction; additionally, L4 species are of concern within the urban zone. The L5 ranked species are considered secure throughout the region (TRCA, 2006). Ongoing maintenance of the species scores and ranks according to the protocol is key to the analysis of terrestrial monitoring program data results.

2.2 Study Area

The area monitored encompasses the existing terrestrial ecosystem throughout the 9 watersheds of the TRCA jurisdiction. These include Etobicoke Creek, Mimico Creek, Humber River, Don River, Highland Creek, Rouge River, Petticoat Creek, Duffin’s Creek and Carruther’s Creek, along with Frenchman’s Bay, the Toronto Islands and the Lake Ontario waterfront within the jurisdictional boundaries. The total area is approximately 250,000 hectares in size and includes the entire city of Toronto, significant portions of the regional municipalities of York, Durham, and Peel as well as a small area of Mono-Adjala.

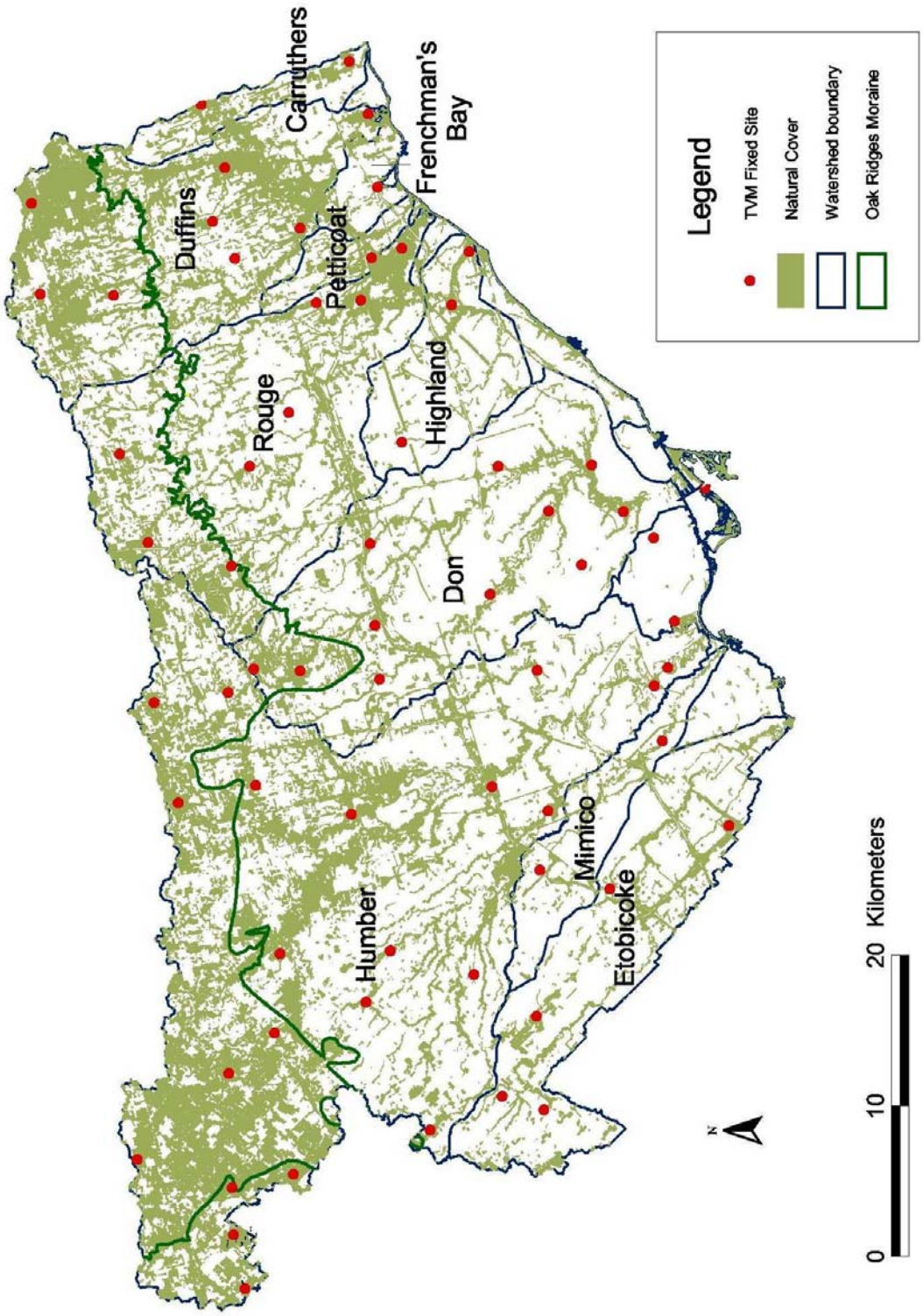


Figure 1: Toronto region natural cover, watersheds and TVMP fixed sites

Physiographic features within the region include part of the Oak Ridges Moraine, the morainal south slope, Peel plain, and old Lake Iroquois shoreline.

The Toronto region lies in an ecological transition zone between the Great Lakes-St. Lawrence forest to the north and the Carolinian forest to the south. Terrestrial natural cover is primarily deciduous and mixed forest, interspersed with smaller tracts of wetland, native meadow and Great Lakes coastal habitats (TRCA, 2007). Approximately 63,350 hectares (25%) of the Toronto regional landscape was under natural cover in 2002, as determined by landscape level analysis of 2002 aerial photography.

The region is highly urbanized but does have a large zone of rural/agricultural land use, primarily in the north, and a zone in transition from rural to urban land use. Areas not urban as of 2002, but identified in regional official plans as committed for future urban use are referred to as the urbanizing zone in this report. The urbanizing zone occupies 10% of regional area. The rural zone includes lands under rural/agricultural use in 2002 whether designated to remain so (i.e. greenbelt), or with undetermined planning status, and makes up 30% of regional area. The urban zone refers to all areas urbanized by 2002, as determined from aerial photography, and covers 60% of the total area.

2.3 Monitoring Questions

The monitoring program was designed to answer the following questions across a spatial scale of the TRCA jurisdiction and a temporal scale of multiple decades:

1. What is the overall condition of the terrestrial ecosystem in the Toronto region, including its forest, wetland and meadow habitats and the transition zones between them?
2. How is the condition of the terrestrial ecosystem changing over time? Are there identifiable trends?
3. Are there differences between the condition of the terrestrial ecosystem in the urban, urbanizing and rural zones of the region, and how are these changing over time?
4. What characteristics of the landscape are helpful in explaining or predicting differences, if any, between zones or over time?

As one element of a larger Terrestrial Natural Heritage Program, the TVMP results are also analyzed to investigate whether they are in agreement with the Terrestrial Natural Heritage System Strategy's landscape analysis and the Species of Conservation Concern ranking and scoring system, or if there are differences.

The answers to the monitoring questions will provide information for use in the Terrestrial Natural Heritage System Strategy implementation, in planning other terrestrial ecosystem protection and enhancement activities at a variety of scales, and in the identification of additional research needs or opportunities. Analysis of the monitoring results will also guide ongoing program development as determinations are made with respect to how well interpretation of the data collected provides answers to the monitoring questions.

The question of how climate change is, or is not, affecting the terrestrial ecosystem over time was not considered in the original planning of the protocols. Analysis of both the timing and results from the amphibian surveys may help to track a climate change effect, and overall temporal trends may provide additional information. Modification of the protocol could be undertaken to more specifically address this question, but other TRCA Terrestrial Natural Heritage program elements are expected to be more effective in collecting data for this purpose.

3.0 STUDY DESIGN and METHODS

3.1 Indicator Species

The utilization of a well-selected set of indicator species provides advantages to monitoring programs by limiting the natural variability or “noise” in the data. This improves the program's ability to recognize differences and trends. It also reduces the time and cost invested in training, and increases its effectiveness. The application of an indicator species approach enhances the TVM program's ability to collect high quality monitoring data using trained volunteer observers.

The TVMP indicator set includes 56 native species, with representation by amphibians, birds, mammals, plants and lichens. Species were chosen to include a range of habitat requirements within forests, wetlands, meadows and the transition zones between them, as well as varying degrees of specialization on specific habitats, and sensitivities in several areas. The indicator species L ranks range from L1 through L5, with 28 of the 56 being the L1 to L3 ranked regional Species of Conservation Concern. Appendix B lists the indicator species selected for monitoring along with their scores and L ranks.

Hutcheson *et al*. (1999) discuss the value of indicator species in monitoring studies, noting that species richness data must be integrated with knowledge of the individual species requirements and sensitivities to be useful. It is with this concept in mind that the set of indicators were selected for the current monitoring program. The presence of an indicator species provides specific information about conditions on the site where it is found. If absent, knowledge of its requirements and sensitivities suggests factors which should be considered when interpreting the absence result. Appendix C summarizes the information provided about the ecosystem within a site by virtue of the indicator species found as well as some factors which may explain the absence of others. In the latter case, one factor may be causative, several may act together, or there may be additional undetermined factors of importance in preventing occupation of the site by the species in question.

3.2 Site Selection

The sample size of 63 sites at 10 ha each, together represented just under 1% of the natural cover in the Toronto region in 2002, a proportion selected to support statistical analysis and extrapolation from the sampled area to the region as a whole. Three control sites were added to

provide for comparisons with urban manicured parkland, suburban residential and agricultural land.

The 63 non-control sample sites were initially allocated among watersheds according to watershed area, with a minimum of 2 sites for each. Next, specific site locations were chosen randomly within available natural cover of at least 10 hectares. Where possible, boundaries were established to include some forest, wetland, riparian and meadow habitat within each site, using aerial photography as a guide. Where the inclusion of all target habitats was not possible, a higher priority was placed on forest, followed by wetland. No preference was made with respect to public versus private lands, although the subsequent inability to obtain approval from some private landowners resulted in the adjustment of 10 site boundaries to exclude a property for which permission was not given, and has prohibited data collection on 8 sites. For these sites, the plan has always been to find alternate locations, but as the size of the volunteer contingent has not quite reached the point where every available site is consistently filled, adding sites has remained secondary to recruitment to this point. Following initial site visits, final adjustments to boundaries were made on 3 sites to enhance the safety of volunteers, i.e. by eliminating potentially dangerous water crossings, and an extreme slope.

When the program was established, the rural and urban land-use zones had been mapped. In the interim, updates to regional plans have designated areas to be urbanized, and development has been ongoing in many parts of the region. To more accurately reflect land-use, a third zone has now been mapped, described as the urbanizing zone. The urban zone covered approximately 60% of the region in 2002, the rural zone 30% and the urbanizing zone 10%. Landscape analysis will be conducted periodically and updated information used for the monitoring program as it becomes available.

Figure 1 depicts the TRCA jurisdiction, showing terrestrial monitoring fixed site locations along with mapped landscape level natural cover as of 2002 and watershed boundaries; Figure 2 shows the fixed sites in relation to land-use zones and municipal boundaries.

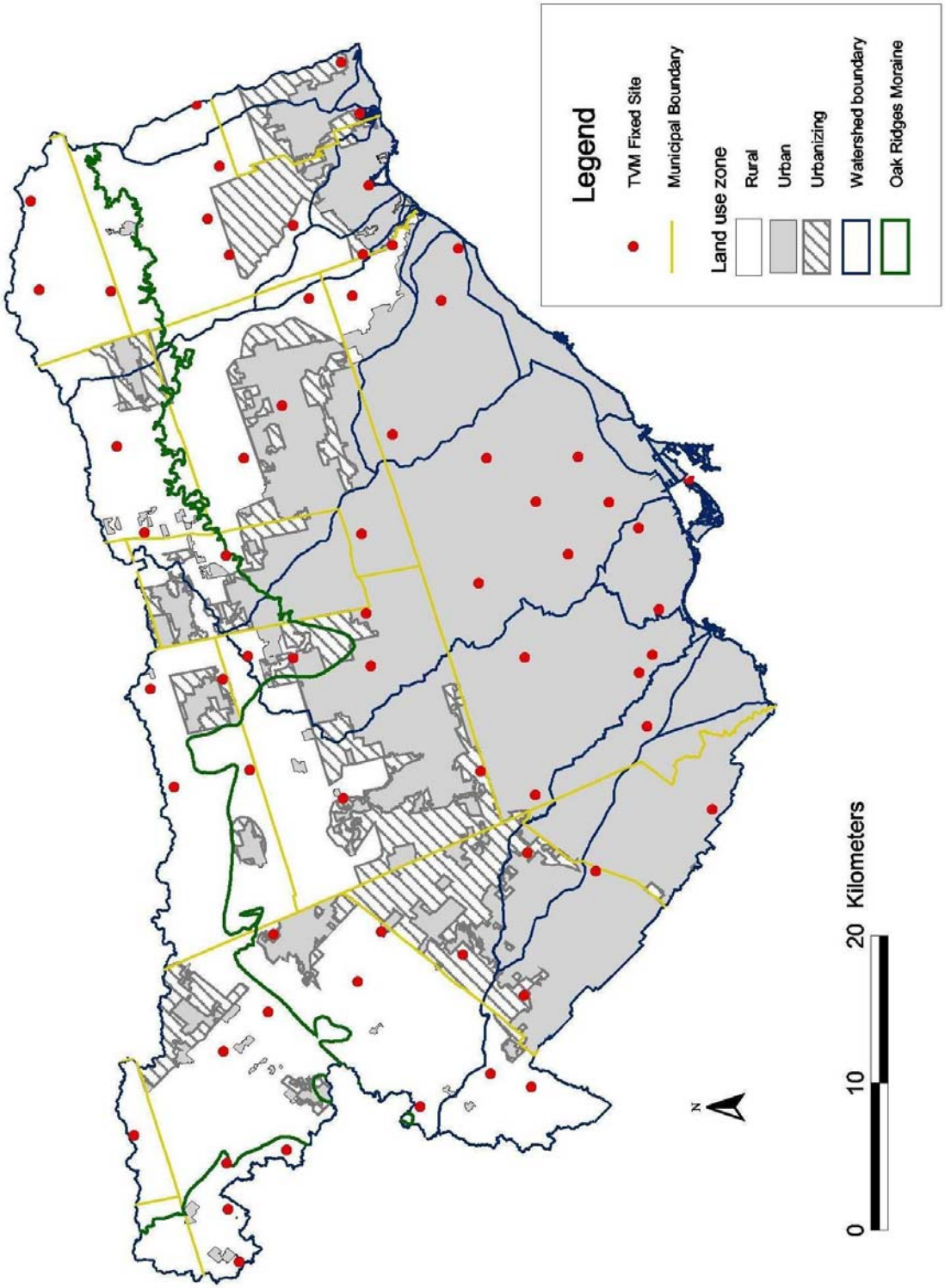


Figure 2: Toronto region land use zones, municipal boundaries and TVMP fixed sites

3.3 Survey Protocol

Survey and other program protocols were designed to facilitate the collection of scientifically valid species presence/absence data by trained volunteer observers. The volunteers work in pairs, surveying an assigned site during ten visits, distributed throughout all four seasons, each year. Each visit is conducted within a specific date range and time of day and is focused on searching for and identifying a subset of the indicator species list. For each target species there are a set of primary, secondary, and in some cases, tertiary identification characteristics that are individually recorded if observed (Appendix D). Depending upon the species, observation criteria may be visual, auditory or both. Visual and audio aids are included in the monitoring kit and seasonal training is provided. One of the two volunteers conducting any visit must have completed the training for that season and is considered the survey leader.

The survey protocol is designed to determine not only whether species found on the surveys are present there at a moment in time, but rather whether the site is providing habitat or resources critical to the reproduction or survival of the species found. Most of the fauna species are surveyed during seasonal time periods when they would be expected to be courting or breeding. Observers look for the porcupine during the winter since food supply at this time is an important determinant of whether a habitat is suitable for this species. Table 1 summarizes the general timing and survey method for species/groups, while Table 2 outlines the survey schedule along with the species surveyed during each visit.

Table 1: Timing of survey and observation method used for indicator species/groups of species

Species/group	Timing	Observation method
Porcupine	Winter morning	visual identification with trails as aid in locating an individual
Mink	Winter morning	visual or track/trail identification
Ruffed grouse	Winter morning	visual or track/trail identification
Eastern screech-owl	March evening	response to recorded call playback, visual identification
American woodcock	April evening	auditory of courtship flights, visual identification
Flora (25 species)	various	visual identification
Anurans (frogs/American toad – 8 species)	April & June evenings	mating call identification
Pileated woodpecker, wood duck	May morning	visual identification
Migratory songbirds (6 species)	early & late June evening	response to recorded song playback, visual identification
Green heron, bobolink, Eastern meadowlark	early and late June evening	visual identification
Lichens	October daytime	visual identification with aid of hand lens magnifier
Eastern chipmunk	October daytime	visual identification

3.4 Survey Effort

In order to standardize effort, the protocol for each site visit outlines not only the month and time of day, but also the maximum length of time for the survey. In the unlikely event that all of the target species for the visit are observed within less than the defined visit time, observers discontinue the survey at that point.

Survey time is adjusted for non-survey activities on site, with appropriate explanatory comment entered on data sheets. Some examples include communicating with landowners or other people encountered during the survey, boundary locating or marking, or navigating around obstacles.

The maximum effort per site per year is 16 hours (Table 2). Adherence to the survey effort for each visit is verified through the quality assurance process.

Table 2: Annual Data Collection Schedule for Volunteer Monitored Fixed Sites

		Indicator	
Season	Month	Fauna/Trails	Flora/Lichens
Winter	January or February (one 1½ hr. visit)	▪ porcupine ▪ mink ▪ ruffed grouse	▪ eastern hemlock ▪ white pine ▪ eastern white cedar
	March (one ½ hr. visit)	▪ eastern screech-owl	
Spring	April (two 1 hr. visits)	▪ American woodcock ▪ spring peeper ▪ wood frog ▪ western chorus frog ▪ northern leopard frog ▪ American toad	
	May (one 2 hr. visit)	▪ pileated woodpecker ▪ wood duck	▪ marsh marigold ▪ white trillium ▪ Jack-in-the-pulpit ▪ narrow-leaved spring beauty ▪ foam flower ▪ star flower
Summer	June (two 2 hr. fauna visits) July & August (one 1½ hr. flora visit each month)	▪ eastern wood-pewee ▪ ovenbird ▪ scarlet tanager ▪ swamp sparrow ▪ Virginia rail ▪ green heron ▪ bobolink ▪ savannah sparrow ▪ eastern meadowlark ▪ green frog ▪ grey treefrog ▪ bullfrog	▪ Michigan lily ▪ riverbank wild rye ▪ turtlehead ▪ black-eyed Susan ▪ swamp milkweed ▪ spotted Joe-pye weed ▪ barber-pole bulrush ▪ greater bur-reed ▪ big bluestem ▪ spreading dogbane ▪ common arrowhead ▪ fireweed ▪ white oak
Fall	October (one 3 hr. visit)*	▪ eastern chipmunk ▪ trail mapping*	▪ Christmas fern ▪ winterberry ▪ zigzag goldenrod ▪ mealy rosette lichen ▪ candleflame lichen ▪ hooded sunburst lichen ▪ rough speckled shield lichen ▪ common greenshield lichen ▪ hammered shield lichen

* trail mapping may be conducted on a separate visit depending on the number of trails on the site and surveyor preference

3.5 Data Management and Quality Assurance

Along with survey dates, times and environmental data, observation data for the species found are recorded in the field on paper data sheets and subsequently entered online into an MS Access database. The data sheets are also submitted, with a number of them selected at random for comparison with the online data.

Observations of a species are recorded on data sheets by checking boxes for the primary, secondary and/or tertiary characteristics observed (Appendix D). Where the observer is confident of the species identification, but a characteristic is not observed, they add an explanatory comment, but do not check the characteristic. An example would be the observation of a flora species when it is not in bloom. The comment would explain how the observer knows it is indeed the target species without observing the flower. Similarly, if the observer is unsure of a characteristic identification, it is entered only as a comment. Where observed characteristics are incomplete, those checked for each species, along with a staff review of the comments are used to verify species observations. Where possible, a sample or photo may be taken to assist in determination of identifications about which an observer is unsure, and an additional comment entered. Common sampling includes collecting leaves or acorns of an oak, taking one leaf of a Christmas fern, or collecting a piece of a lichen. Removal of entire individuals is avoided.

Species are recorded as not observed on a survey visit simply by leaving all of the required observation characteristics boxes for that species blank on the data sheet (Appendix D).

In addition to the species observation data collected on sites by volunteer observers, site characteristic data has been compiled by overlaying the TVMP fixed site GIS layer on 2002 ortho-rectified aerial photography, along with land-use zones, roads, volunteer mapped trails, 2002 natural cover patch scoring and ecological land classification (ELC) data layers in the ArcView 3.2 GIS system. The following data was tabulated for sites (Appendix A):

1. land-use zone, i.e. one of three defined zones:
   a) urban as of 2002
   b) urbanizing, i.e. under development in 2002 or planned for development based on regional official plans
   c) rural/agricultural, defined as land actually under a rural use in 2002 and not committed for urban use in current regional official plans
2. landscape level habitat types existing on site (forest, meadow, wetland, riparian)
3. area of forest, wetland and meadow (ha) within the natural cover patch on which the site is located
4. site location in relation to the Oak Ridges Moraine (site on or off the moraine)
5. distance from site boundary to nearest road (m)
6. road density (length of roads in km) within a 2 km radius of the site centroid
7. area of forest, wetland and meadow (ha) within a 2 km radius of the site centroid
8. watershed
9. mixed patch total score for natural cover patch on which site is located (weighted average of contiguous scored patches in the GIS layer)

10. mixed patch matrix score for natural cover patch on which site is located (simple average of contiguous scored patches in the GIS layer) (Fig. 1)
11. length of human-use trails on the site (m)

The natural cover patch total and matrix scores used (Appendix A) were derived from the 2002 scores in the regional landscape analysis conducted relative to the *Terrestrial Natural Heritage System Strategy* (TRCA, 2007). This process interpreted aerial photography to categorize natural cover into coarse habitat type patches (wetland, forest, meadow, beach/bluff). Each of these patches was then scored through the landscape analysis model to rate them relative to each other with respect to their potential ability to support a diversity of species. The model is a simplification that allows a coarse evaluation of this potential across the ecosystem of the region as a whole. Scores are reported for the matrix influence experienced by the patch, where matrix influence estimates the combined positive, negative and neutral ecological influences exerted on the scored patch by surrounding natural cover, agricultural and urban land use. Total patch scores are also calculated. These combine the matrix influence measure with patch size and shape. Larger patches have a higher potential to support a diversity of species and larger population sizes and so score higher than smaller ones. Rectangular or circular shaped patches are more resistant to negative "edge" effects such as invasion by exotic species, and score higher than long narrow patches of a similar size.

For the TVMP data analysis, in order to explore relationships between the species found on fixed sites and patch scoring metrics, it was necessary to derive a mixed patch score that took into account the scores for the forest, wetland and meadow habitat patches on which the site is located. This was done for both total score and matrix influence score. For the total score, where size is an important criterion, a mean total score weighted for area was calculated for the mixed patch. For the matrix score, which differs very little between the component patches in immediate proximity to each other, a simple mean score was determined for the mixed patch. The derived mixed habitat patch scores were then used in the linear regression analyses.

Data were quality controlled with the assistance of a data validation module. This software tool compares data to a series of templates for survey protocol, habitat types present on sites, and species observation characteristics. Data that do not fully conform with template parameters are flagged for a manual staff review. The standardized manual process includes reviewing data comments, photos and/or samples, direct communication with the observer and, where necessary, a site visit to attempt to verify an observation.

3.6 Sources of Error

The flagged species presence records that could not be verified and were therefore recorded as absences are a potential source of error. It is possible that a target species was indeed observed in one or more of these cases.

In any monitoring effort, species absence records have a greater error potential than species presence records. Many fauna species are elusive and may not be observed though present. Flora and lichen species that are rare on the site may be missed by the surveyor. There is a lower likelihood of a trained observer recording a species as present that is, in fact, not there.

Continued non-recording of a species on multiple visits to a given site over time increases the level of confidence in recording it as absent for the period in question.

The monitoring program's visit timing and training protocols maximize the likelihood of finding a species, if present. The potential for misidentification of a species is minimized through the training, the provision of visual and audio aids, the observation protocol (e.g. calling out birds), and the recording of individual characteristics to compile a positive observation rather than simply having observers check off a species as observed.

There is also a potential for recording a species that was actually observed outside of the site boundaries, an error that would reduce the validity of comparisons between sites. This source of error is minimized through training in the use of aerial photographs and ecological land classification maps to navigate the site and on the importance of boundaries. The use of GPS units to find boundaries, and flagging tape to mark them in the field, also reduces this potential. Observers are asked to note observations of target species found outside the site boundaries in the comments section of the data sheet.

To date no identifiable long term bias is evident in the sources of error. Any one of them could occur with equal likelihood on any site over time. In any given year, a site with an inexperienced observer will have a greater error potential than one with a more experienced observer. Observer related records, including volunteer start and end dates with the program and training attendance, are maintained and can be reviewed should the species data on a given site over time raise questions. The three year minimum commitment asked of prospective volunteers during recruitment helps in maximizing the overall observer experience level.

4.0 RESULTS

Where results are referred to as significant, the term is used in the statistical sense. The threshold used for establishing significance was an alpha or p-value lower than 0.05. This simply means that the likelihood of the observed result being due to chance alone is less than 5%, and conversely, that there is an over 95% likelihood that the observed effect is real. The smaller the p-value reported, the higher the confidence that the effect is indeed a real one. Results for values of p lower than 0.01 are described as very, or highly, significant.

Tests for significant differences and regression analysis were carried out where a statistically significant result would potentially be of ecological significance. Linear regression testing compared the values of a data variable (e.g. number of species found on a site) to the values of an independent variable (e.g. the size of a natural cover patch) to determine if there was a statistically significant relationship between them, and if so, how strong it was. An example would be the test to investigate whether the number of species on a site (species richness) increased on average as the size of natural cover patch increased, and if so, by how much. Where the two variables increased together the relationship is referred to as a positive correlation. Where the data variable decreased as the independent variable increased, the relationship is described as a negative correlation. The R^2 value, always a number between 0 and 1, describes how strong the correlation is. A value for R^2 of 0.34 for example, indicates

that 34% of the variability in the data variable can be mathematically accounted for by the variability in the independent variable. If interpretation supports the ecological significance of this effect, then the independent variable discussed is an important factor, but not the only one determining the observed result. Ecosystems are very complex and there will always be a multitude of factors affecting an observed result, some more than others, some working in concert and some working in opposition to each other.

Linear regression testing was carried out for variables that have a range of possible values (e.g. species richness, value of calculated indices). Logistic regression is a different method used to explore relationships in a similar way for data such as presence versus absence of a particular species on sites. The results of the logistic regression analyses presented indicate whether the probability of a species being present increases or decreases with the increase in an independent variable, or if a significant relationship is not evident.

4.1 Data Collection and Quality Assurance

There have been 1,805 site visits and 14,532 species presence/absence (P/A) observation records made by the TVMP volunteers throughout the region from April 2002 to October 2007. Of this total, 3,088 are presence records, i.e. observations of an indicator species during the survey for that species. The balance are records of species not found during the affected survey. Species absence from a site is determined using the latter records for the time period analyzed. In the current analysis, if a species was not found on any of the surveys for that species conducted from April 2002 to October 2007, then it was recorded as absent.

Over the period, 48 sample sites have had surveys completed for all indicator species. Eight sites have not been monitored due to permission being withheld, and 7 have not been monitored consistently. The agricultural control site was not monitored due to lack of permission. The residential control site presented difficulties with respect to full coverage of the 10 hectare area, since a complete survey would require the volunteer to traverse the front and back yards of many private properties. Data from these two control sites is not included in the analysis for these reasons. The urban manicured park control site (Queen's Park) has been monitored with consistency and is discussed in the analysis. Figure 3 shows the distribution of the sites included in the analysis.

The data validation process was able to resolve all data records flagged for survey timing or effort variances. Of the 296 flagged species observation records, 91% either passed quality assurance and were included in the analysis, or were determined to be in error and the characteristic records removed from the database. The balance remain flagged. These 31 records represent 1% of the species present observations, and 0.2% of the total species records. They are treated as species not found on the affected visit, since one or more of the observation characteristics required by the protocol are missing.

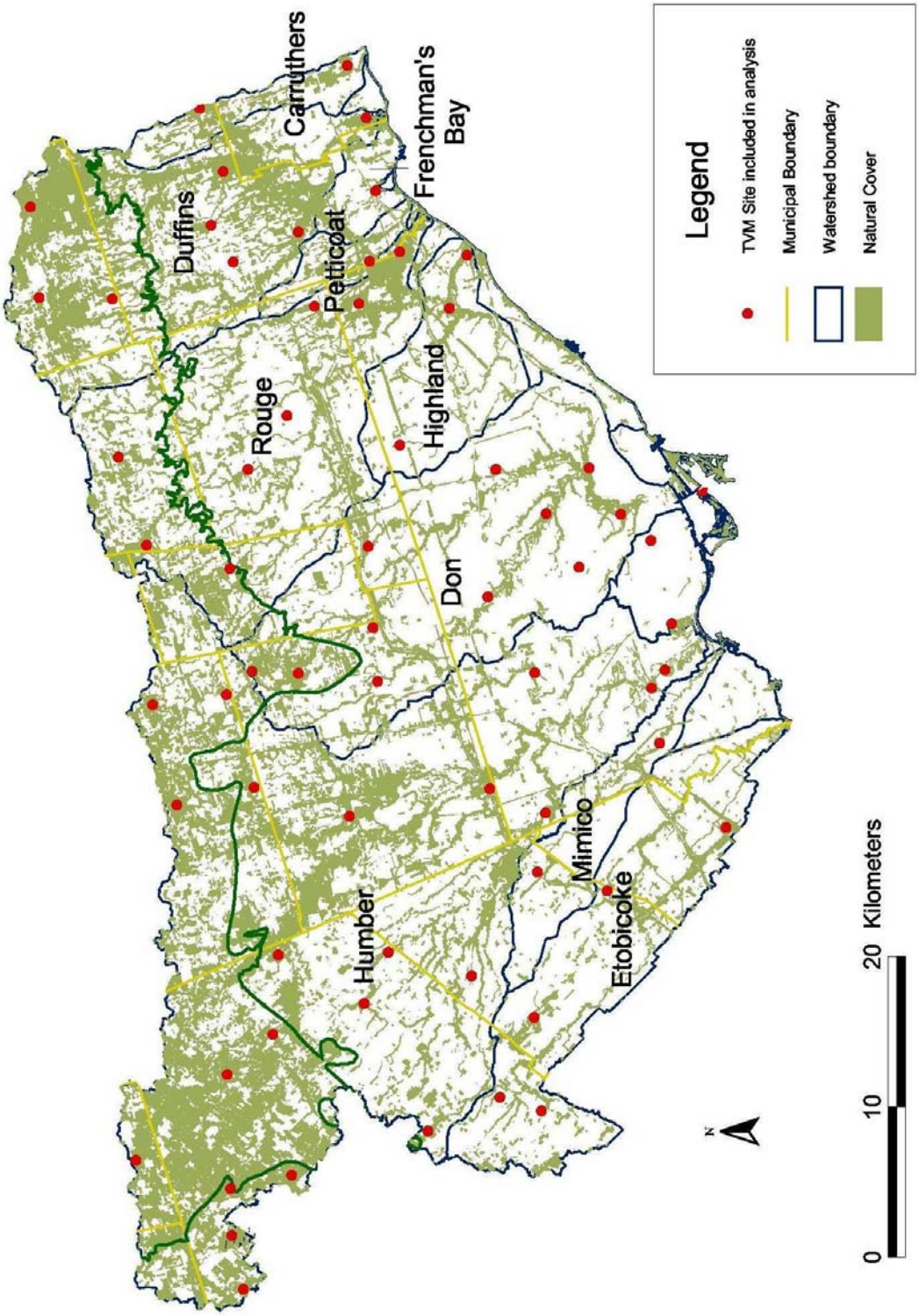


Figure 3: Distribution of TVMP fixed sites included in the analysis

4.2 Indicator Species Indices

Species Richness Index (SR)

Species richness, or the number of species found to be inhabiting an area, is a basic measure of ecosystem health. Our species were selected for their ability to demonstrate various aspects of ecosystem function across the wider region. Indicator species richness as a measure of health is therefore most useful when evaluated for the region as a whole, when used to compare land use zones, or in other grouped analyses. The full range of habitats present in the region would not be expected to exist on any single site and so a healthy site would not be expected to have 100% of the indicator species found. The indicator species richness index score reported is a count of the total number of indicator species found on the site expressed as a percentage of the total number of indicator species (Appendix E).

Species richness scores on non-control sites (Table 3) ranged from 14% to 68%, with a mean of 39% regionally on the total number of 48 sites (i.e. n=48). When grouped by land use zone (Figure 2), the rural zone with a mean of 45% (n=20) was very significantly higher in species richness than the urban zone with a mean of 31% (n=21). The rural zone did not differ from the urbanizing zone (n=7), the latter also having a mean of 45%. The difference between the urban and urbanizing zone was significant however (Table 3). Appendix E tabulates the scores for all sites included in the analysis.

The urban manicured park control site had an SR score of 13%.

Species richness was positively correlated with total patch score and matrix score at a highly significant level (R^2=0.22 in both cases).

The set of 56 indicators includes 25 fauna, 25 flora and 6 lichen species. Fauna therefore comprise 45% of the total number of species. As the number of indicator species found declined across the range of sites, fauna tended to disappear first. While 8 sites had a proportion of fauna to flora/lichen indicator species present at or higher than 45%, the great majority (40 sites) had fauna as a proportion of the total indicator species found of 40% or lower, with 25 sites below 30%, 9 below 20% and 1 site with 9 indicator species present having none of them fauna indicators. The latter result was very close to the urban manicured park control site which had 7 indicators, none of them fauna species.

Table 3: Summary of Mean Species Richness (SR), Habitat Dependence (HD), Area Sensitivity (AS), Mobility Restriction (MR) and Sensitivity to Development (SD) Index scores for the region, and land-use zones. The urban and rural zones differed significantly on all indices, as did the urban and urbanizing zones.

Index	Region		Land-use zone			Urban Control Site
	Range	Mean	Urban	Urbanizing	Rural	
SR	14 - 68%	39%	31%	45%	45%	13%
HD	12 - 64%	35%	28%	38%	40%	8%
AS*	0 - 75%	25%	14%	33%	35%	0%
MR*	0 - 81%	28%	17%	35%	38%	0%
SD	12 - 64%	34%	27%	39%	41%	10%

* Where AS & MR scores are 0%, none of the 25 fauna indicators were found on the site

Habitat Dependence Index (HD)

The habitat dependence index is a measure of how well the site is providing for the full range of habitat related requirements of the indicator species. It is the total of the habitat dependence scores for the species found on the site, expressed as a percentage of the total of the habitat dependence scores for the flora and fauna indicator species set (Appendix B).

Habitat dependence index sample site scores ranged from 12% to 64% across the region, with an overall mean of 35%, and the control site scoring 8%. The rural zone mean at 40% was very significantly higher than the urban zone mean of 28%. The means for the rural and urbanizing zones at 40% and 38% respectively were not statistically different, while the apparent difference in means between the urban and urbanizing zones was similarly not significant. Table 3 summarizes the scores, while Appendix E lists them for individual sites.

Habitat dependence scores were positively correlated with patch total score at a significant level and with patch matrix score at a very significant level.

Area Sensitivity Index (AS)

The area sensitivity index is a measure of how well the site and its surroundings are providing the area of natural cover needed to meet the needs of the fauna indicators. It is the total of the area sensitivity scores for the species found on the site, expressed as a percentage of the total of the area sensitivity scores for the fauna indicator species set (Appendix B).

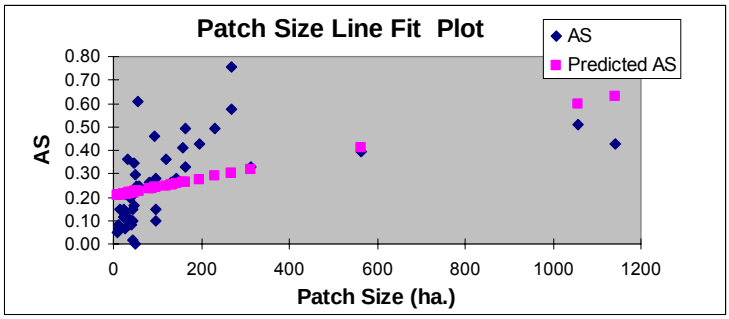
Area sensitivity scores ranged from 0% to 75% with an overall mean of 25%. A score of 0% occurred where none of the 25 fauna species were present. The rural mean of 35% was very significantly higher than the urban mean of 14%, while the rural and urbanizing zones were

not significantly different. The urbanizing zone at 33% was significantly higher than the urban zone. The Queen's Park control site scored 0% (Table 3). Appendix E lists AS scores by site.

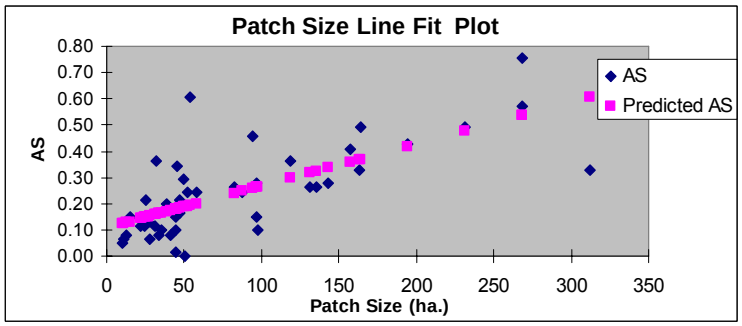
Area sensitivity index scores were correlated with total patch size (R^2=0.24) at a very significant level, and were more strongly correlated with total score (R^2=0.36) and matrix score (R^2=0.34) at an even higher degree of confidence. Exploration of data residuals led to regression testing of the AS score to patch area with three outlier points, i.e. sites located on patches over 350 hectares, removed. The correlation was much stronger and very significant for patches up to 350 hectares in size (R^2 =0.51). Figure 4 depicts the line fit plots for the two analyses of area sensitivity score and area of total patch.

Figure 4: Line fit plots for Area Sensitivity Index score vs. area of patch on which site is located

a) all data



b) data for sites located on patches up to 350 ha in size



Mobility Restriction Index (MR)

The mobility restriction index is a measure of how well the site and its surroundings are providing for fauna species that are restricted in their ability to move across the landscape. It is the total of the mobility restriction scores for the species found, expressed as a percentage of the total of the mobility restriction scores for the fauna indicator species set (Appendix B).

Mobility restriction scores ranged from 0 to 81% with a mean of 28% regionally on non-control sites, and the urban control scoring 0%, reflecting the fact that none of the 25 fauna species

were present. The rural mean of 38% was very significantly higher than the urban mean of 17%. The rural and urbanizing means were not significantly different, while the urbanizing mean of 35% was significantly higher than the urban (Table 3). Appendix E lists the MR scores for individual sites.

Sensitivity to Development Index (SD)

The sensitivity to development index is a measure of how well the site is providing for indicator species sensitive to development (e.g. disturbance to their habitat). The more highly sensitive of these will quickly disappear from the landscape when development occurs nearby. The index score is the total of the sensitivity to development scores for the species found expressed as a percentage of the total of the sensitivity to development scores for the flora and fauna indicator species set (Appendix B).

Scores on the SD index ranged from 12% to 64% on sample sites, with the urban control scoring 10%. The rural zone mean of 41% was very significantly higher than the urban mean of 27%. The rural and urbanizing zones did not differ significantly, while the urbanizing zone at 39% scored higher than the urban at p=0.056, slightly above the p=0.05 threshold (Table 3). Appendix E contains the SD scores for all sites.

Comparison of sites located on and off the Oak Ridges moraine

No significant differences were found in any of the foregoing indices when the 11 sites located on the Oak Ridges Moraine were compared to the 37 sites off the moraine.

When the ORM sites in the rural zone were compared with the non-ORM rural zone sites (n=10 for both) again no significant differences were found, with the high p-values ranging from 0.75 to 0.93 supporting a conclusion of similarity rather than difference (Table 4).

Table 4: Mean Species Richness (SR), Habitat Dependence (HD), Area Sensitivity (AS), Mobility Restriction (MR) and Sensitivity to Development (SD) Index scores for ORM and non-ORM sites in the rural zone. Differences were not significant.

Index	Rural Zone	
	Rural ORM	Rural non-ORM
SR	44%	46%
HD	39%	41%
AS*	36%	35%
MR*	37%	39%
SD	40%	42%

4.3 Species of Conservation Concern (SOCC)

This group includes the 17 fauna and 11 flora indicator species ranked from L1 to L3 and considered to be of conservation concern throughout the TRCA jurisdiction (Appendix B). In addition to scoring the total SOCC set, 2 subgroups were also evaluated; the fauna component alone, and the most sensitive L1 to L2 fauna grouping.

Species richness scores for the total SOCC set ranged from 1 to 17 of the possible 28 species, with a mean of 6.4. For fauna alone, SR scores were from 0 to 13, with the mean at 3.3, while the urban control site had 1 flora and 0 fauna species of concern (Table 5).

Testing of difference in means between sites in the urban (n=21), urbanizing (n=7) and rural (n=20) land-use zones showed species richness for both total SOCC and the fauna SOCC group to be very significantly higher in the rural versus the urban zone. The urbanizing zone had significantly higher species richness than the urban for both total SOCC and fauna SOCC, while it did not differ significantly from the rural.

SOCC species richness was positively correlated with total score (R^2=0.34) and matrix score (R^2=0.35).

The L1 and L2 ranked fauna indicator group scores were very low overall with 15 of the 21 urban sites, 2 of the 7 urbanizing sites and 7 of the 20 rural sites having none of these species present. Scores ranged from 0 to 5 regionally of a possible 6 species.

SR scores for Species of Conservation Concern and L1-L2 ranked fauna are summarized in Table 5.

Table 5: Regional Species of Conservation Concern species richness scores for region and by land-use zone. See text for significance of differences.

SOCC Group	# Indicator Species	Urban Control Site	Regional Range	SOCC Indicator Species Richness Mean			
				Region	Urban	Urbanizing	Rural
L1 – L3 Flora & Fauna	28	1	1 - 17	6.4	4.0	7.4	8.7
L1 – L3 Fauna	17	0	0 - 13	3.3	1.1	4.7	5.1
L1 – L2 Fauna	6	0	0 - 5	1.4	.3	1.7	2.2

4.4 Amphibians

The amphibian indicator species group includes 8 native anurans (frogs and toads) known to have been present throughout the regional jurisdiction historically (Appendix F). Data for amphibians are included only for sites containing wetlands, including vernal pools (Figure 5).

Amphibian species richness scores were from 0 to 6 on the 42 sites having wetland, with a mean of 2.7. The rural zone (n=20) was significantly richer with a mean of 3.5 as compared to the urban zone (n=15) at 1.3. The urbanizing zone (n=7) had a mean of 3.1, significantly higher than the urban zone, but not significantly different from the rural. Rural Oak Ridges Moraine sites (n=8) had a higher mean of 4.1, but not significantly so when compared with rural non-ORM sites (n=12) at 3.1 (Table 6). Just 1 of the ORM wetland sites was within the urban zone.

Amphibian species richness was positively correlated with both patch total score (R^2=0.39) and patch matrix score (R^2=0.38) to a very significant degree.

Species richness was also positively correlated with forest area within 2 km of the site centroid at a highly significant level (R^2=0.25), and less strongly with wetland area within 2 km (R^2=0.12). When 3 forest area outliers were removed (forest area equal to or greater than 650 ha), the former relationship strengthened (R^2=0.30) and the confidence increased.

A highly significant negative correlation was found between species richness and road density (length of road within 2 km of the site centroid) (R^2=0.28), as well as a less strong but highly significant positive correlation between species richness and distance to the nearest paved road (R^2=0.17).

Forest area within 2 km, wetland area within 2 km and road density when taken together were strongly correlated with amphibian species richness (multiple R=0.67).

The L2 wood frog (*Rana sylvatica*) presence/absence showed differences between land-use zones, with just 2 of 15 wetland sites in the urban zone reporting it at least once over the six years, 4 of 7 urbanizing zone sites and 13 of 20 in the rural zone doing so (Table 6). Logistic regression analysis demonstrated that these differences were significant. Wood frog presence/absence was also negatively correlated with road density, and positively correlated with total patch score. No correlation was found with either forest or wetland area within 2 kilometres.

The L3 northern leopard frog (*Rana pipiens*) was found on 10 of 42 wetland sites during the period, far fewer than the 19 sites found to support the wood frog. Leopard frog presence/absence was not significantly different between land-use zones (Table 6) and there was no correlation with road density or with total score. There was a significant positive relationship with matrix score.

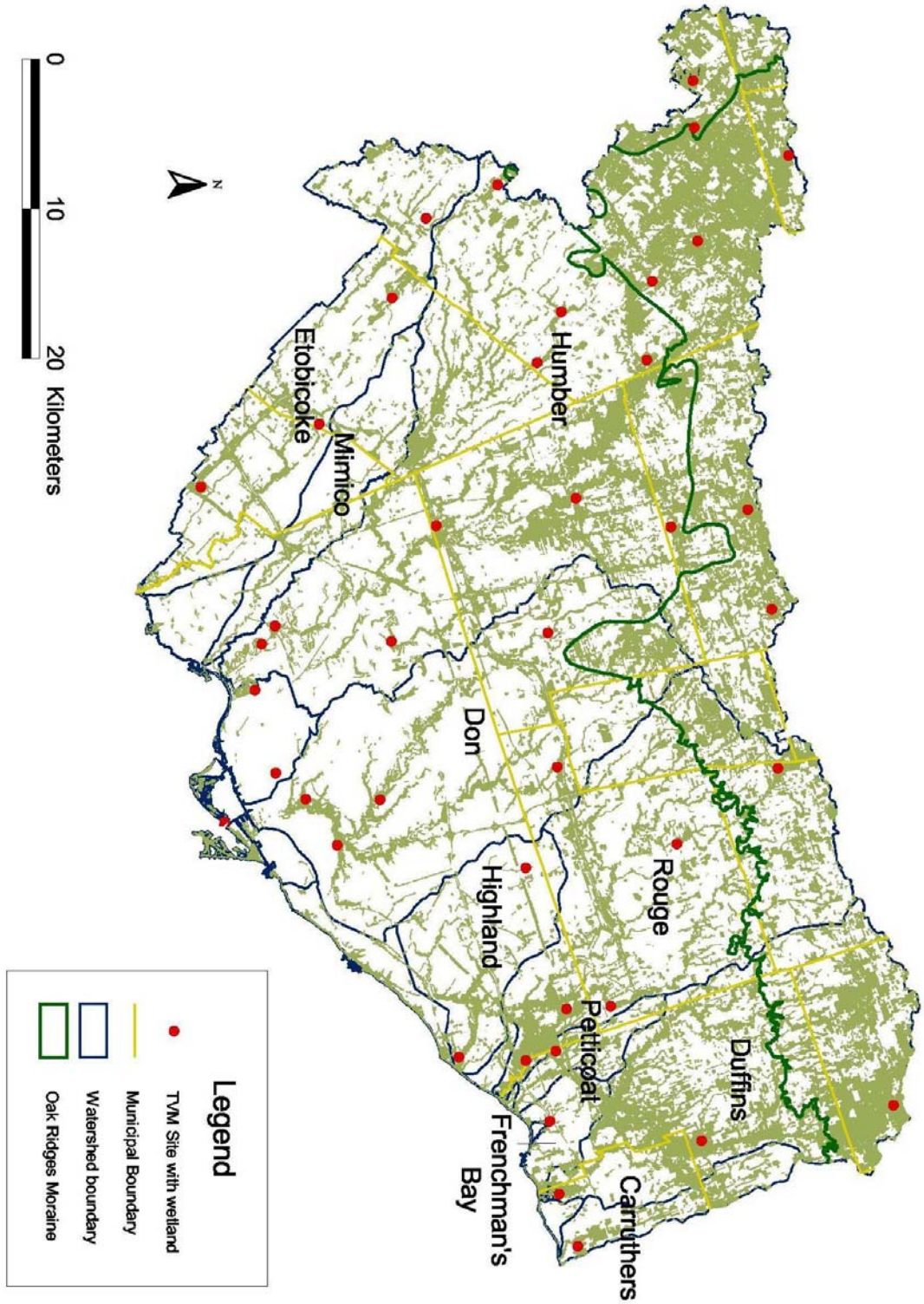


Figure 5: Distribution of TVMP fixed sites with wetland

4.5 Breeding Birds

This group includes 14 species that breed within the Toronto region, with representation by both year-round residents and migratory species (Appendix F).

Regional bird species richness ranged from 0 to 10 of a possible 14, with a mean of 3.8. The rural zone (n=20) was very significantly richer than the urban (n=21) at 4.5 versus 2.6. The urbanizing zone (n=7) was significantly richer than the urban zone, but not significantly different than the rural. The rural ORM sites (n=10) were not significantly different from the rural non-ORM (n=10) sites, with means of 4.2 and 4.8 respectively (Table 6).

Species richness showed a weak but significant correlation with both total score (R^2=0.12) and matrix score (R^2=0.11).

Table 6: Mean Species Richness scores by species group and percentage of sites reporting presence of selected species for the region, by land-use zone and for rural zone ORM and non-ORM sites. See text for significance of differences.

`	# Species in Group	Region		Land-use zone Mean Scores			Rural Zone Mean Scores	
		Range	Mean	Urban	Urbanizing	Rural	Rural ORM	Rural non-ORM
Amphibians	8	0-6	2.7	1.3	3.1	3.5	4.1	3.1
Birds	14	0-10	3.8	2.6	5.1	4.5	4.2	4.8
Flora	25	4-21	10.5	9.4	11.0	11.4	11.2	11.6
Spring Flora	5	0-5	2.5	2.0	2.4	2.9	3.2	2.7
Lichens	6	1-6	4.5	3.8	5.4	5.0	4.9	5.0
		Proportion of sites reporting species						
Wood frog	1	45%		13%	57%	65%	75%	58%
N. leopard frog	1	24%		13%	29%	30%	13%	42%
Porcupine	1	6%		0%	0%	14%	10%	17%
Mink	1	14%		18%	0%	14%	10%	17%
E. chipmunk	1	49%		32%	43%	68%	60%	75%

4.6 Mammals

The porcupine (*Erithizon dorsatum*), an L2 species, was found on just 3 of 51 sites during the monitoring period. All 3 sites were in the rural zone on natural cover patches containing forest areas of 984 ha, 206 ha and 101 ha. The mink (*Mustela vison*), an L3, was recorded at 7 sites, and the Eastern chipmunk (*Tamias striatus*), an L4, occurred at 25 sites including 32% of urban sites, 43% of urbanizing and 68% of rural. These differences were significant. The apparent difference in ORM (75%) versus non-ORM (60%) sites reporting the chipmunk was not significant when tested (Table 6).

The winter visit protocol for mink initially required a visual observation of the animal. It was recognized at the outset that it might be difficult for observers to find a mink during the 1-1/2 hour survey, even if present on a site, with the result that presence data would likely be understated. Following 4 years of data collection with just 2 mink recorded for the region, the protocol was changed beginning winter 2007 to include training on, and the recording of, mink tracks observed on snow or ice as an observation characteristic. During 2007, 6 sites recorded mink for the first time based on verifiable mink tracks. At this point insufficient data has been collected under the new protocol for confident estimation of the probability of detection given mink presence on a site. For this reason no further analysis was carried out on the mink presence/absence records. Future analysis will reassess and report accordingly.

4.7 Flora

The flora indicator group includes 25 species ranked from L2 through L5 and native to a range of habitats and moisture regimes (Appendix B, C and F).

Flora species richness had a minimum of 4, maximum of 21, and a mean of 10.5 out of a possible 25, for the sites overall (Table 5). Flora did not show a significant difference in species richness between land-use zones, nor did this measure correlate with total or matrix score.

4.8 Spring flora

This group includes 5 species of spring blooming forest ground flora, including the ephemerals narrow-leaved spring beauty (*Claytonia virginica*) and foam flower (*Tiarella cordifolia*) along with white trillium (*Trillium grandiflorum*), Jack-in-the-pulpit (*Arisaema triphyllum*) and star flower (*Trientalis borealis ssp. borealis*) (Appendix F).

Species richness scores for the group ranged from 0 to 5 across all of the sites, with a mean of 2.5. While the rural zone mean at 2.9 was significantly higher than the urban at 2.0, the urbanizing zone mean of 2.4 was not significantly different from either the urban or rural zone (Table 6).

No significant correlation was found between species richness and total score or matrix score. Species richness was not correlated with the length of trails on the site.

4.9 Lichens

Lichen species richness ranged from 1 to 6 with a mean of 4.5 out of a possible 6 species for the sites overall.

Lichen SR mean scores were very significantly different between the urban (mean 3.8) and rural (mean 5.0) zones. The urban and the urbanizing (mean 5.4) zones also differed very significantly. The urbanizing zone mean however, did not differ from the rural zone mean, and no difference was found with respect to whether the site was on or off the Oak Ridges Moraine in the rural zone (Table 6).

There was a highly significant correlation between lichen SR score and both patch total score and patch matrix score (R^2=0.24 and R^2=0.18 respectively).

An apparent weak negative relationship between lichen SR and road density was not significant. When 4 outlier points for values of road density over 100 km within a 2 km radius were removed however, the correlation strengthened (R^2= 0.20) and was highly significant for road densities up to 100 km.

4.10 Wetland habitat species

Of the 56 indicator species, the 21 that require wetland habitats for part or all of their life cycle, or are primarily associated with wetland habitat, were grouped and their species richness measured as an indicator for wetlands in the region. The group includes all of the amphibians along with 4 bird, and 9 plant species (Appendix F). Figure 5 shows the distribution of wetland sites. Three sites analyzed for the amphibian group, but missing data collection for some of the other wetland species, were not included in the wetland habitat analysis.

Wetland species richness ranged from 1 to 15 with a regional mean of 6.9. The rural zone had significantly higher species richness with a mean of 7.7 versus the urban zone mean of 5.3. No differences in species richness were found between the urban and urbanizing, rural and urbanizing and rural ORM versus rural non-ORM groups (Table 7).

Wetland SR showed a significant but weak positive correlation with both patch total score and patch matrix score (R^2=0.12 and R^2=0.13 respectively).

A correlation with total wetland area within a 2 km radius of the site centroid was not established at the p=0.05 threshold used, even when outliers with over 50 ha of wetland area were removed. There was no correlation with total natural cover area or forest area within a 2 km radius.

Table 7: Forest, wetland & meadow species richness for region, by land-use zone and ORM versus non-ORM location for rural zone sites. See text for significance of differences.

Habitat	# Sites	# Indicator Species	Region		Land-use zone			Rural zone	
			Range	Mean	Urban Mean	Urbanizing Mean	Rural Mean	ORM Mean	non-ORM Mean
Wetland	40	21	1 - 15	6.9	5.3	7.6	7.7	7.4	7.9
Forest	49	21	2 - 16	9.1	7.1	9.3	11.1	11.5	10.7
Meadow	32	8	0 - 5	2.2	1.8	3.4	2.1	1.0	2.4

4.11 Forest habitat species

The forest habitat indicator is a measure of species richness for 21 species that require forest or are primarily associated with forest habitats. From the amphibian group, the wood frog and northern spring peeper (*Hyla crucifer*) are included in both the wetland and forest groupings. The forest group also includes mammals, birds and flora (Appendix F).

Forest species richness ranged from 2 to 16 with a mean of 9.1 (n=49). A comparison by land use zone showed the rural zone (n=21) with a mean of 11.1, having a very significantly higher species richness than the urban (n=21), which had a mean of 7.1. A comparison between the urban and urbanizing zones indicated the urbanizing (n=7, mean 9.3) was not significantly higher in richness at the p=0.05 threshold, although it was at p=0.06. The rural and urbanizing zones were not significantly different at that threshold but were at p=0.101. The rural Oak Ridges Moraine versus rural non-Oak Ridges Moraine sites were not significantly different (Table 7).

Forest species richness had a weak positive correlation with patch total score and patch matrix score at very significant levels (R^2=0.18 and R^2=0.16 respectively). It showed a strong and very significant correlation with forest patch size for patches up to 225 ha in size (R^2=0.41).

4.12 Meadow habitat species

Species requiring or primarily associated with meadow habitat were grouped. This group includes 4 birds and 4 flora species (Appendix F).

Regional species richness ranged from 0 to 5 with a mean of 2.2 for sites containing meadow habitat (Figure 6). There was no significant difference in SR between the urban (n=17) and rural (n=10) zones, but there was a difference between the urbanizing zone (n=5) and the others, with the urbanizing zone (mean 3.4) having a significantly higher richness than either the urban (mean 1.8) or rural (mean 2.1). There was no difference between the rural ORM (n=2, mean = 1.0) and rural non-ORM (n=8, mean=2.4) sites (Table 7).

There was no correlation found between meadow SR and either total score or matrix score.

Meadow species richness was positively correlated with meadow patch size (R^2=0.18) and this relationship both strengthened and increased in confidence when 3 outliers having over 50 ha of meadow were removed from the test (R^2=0.24). SR was also positively correlated with meadow area within 2 km (R^2=0.19).

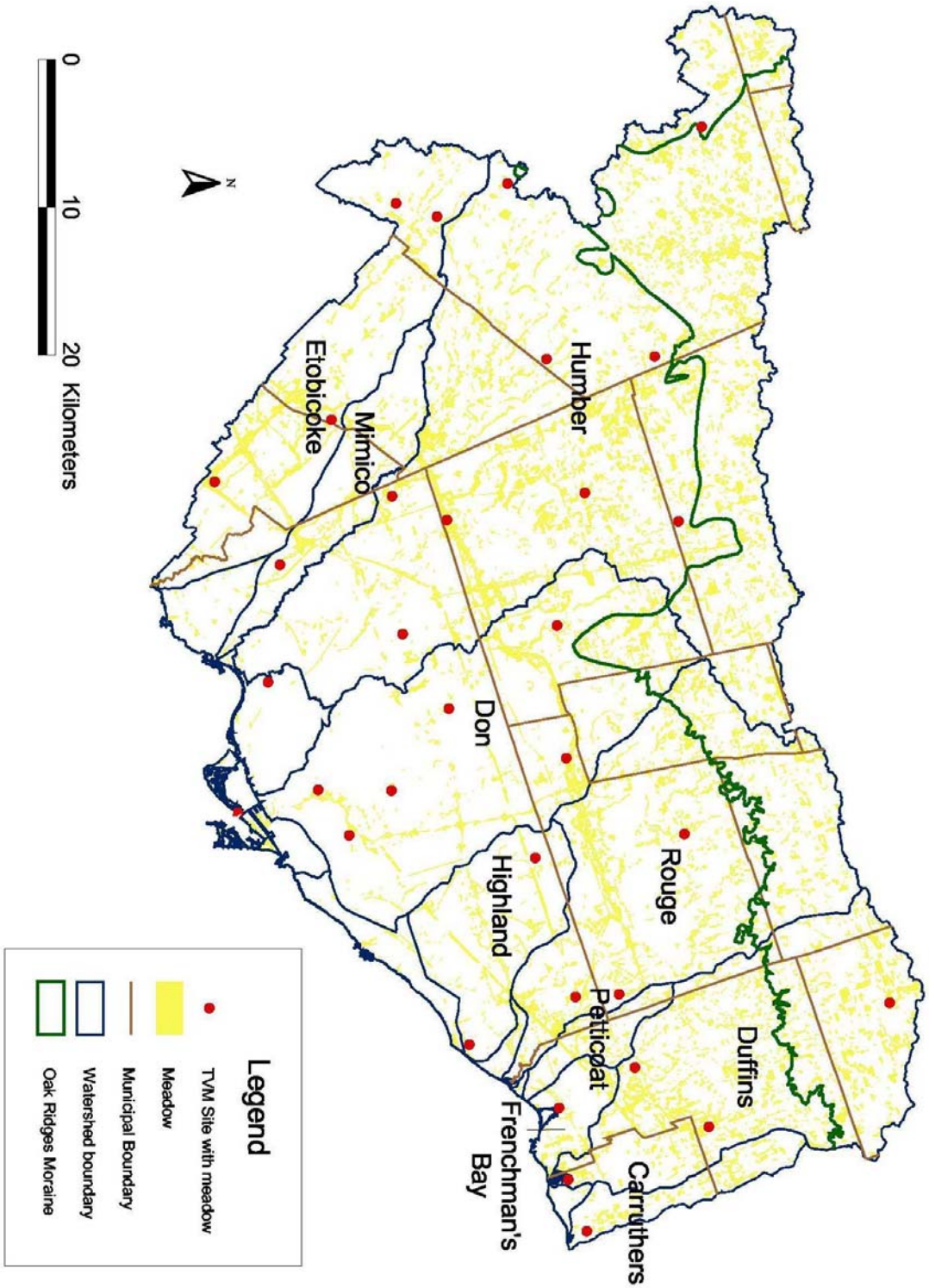


Figure 6: Regional meadow habitat and distribution of TVMP fixed sites with meadow

5.0 DISCUSSION

To determine whether an ecosystem is healthy, one needs to evaluate the degree to which both the structure and the function of the system is intact, i.e. whether it is capable of "supporting and maintaining a balanced, integrated, adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of the natural habitat of the region" (Karr and Dudley, 1981). While there are a multitude of characteristics that are diagnostic of a healthy ecosystem, this discussion will focus on just a few fundamental criteria of health or ecosystem integrity that are directly relevant to the indicators measured and analyzed by the monitoring program.

In a healthy ecosystem, the diversity of native species will be high, and the species composition will include native species understood to be sensitive to/intolerant of the types of stressors that occur very rarely or not at all in a natural condition. Species diversity will be expressed not only in an overall larger number of species, but in representation by a wide range of different taxa. There will be an efficient transfer of energy from primary production (plant photosynthesis) through a series of higher trophic levels (e.g. herbivores, carnivores). While natural variability will be high across sites and habitats, the ecosystem as a whole can be considered healthy only if the major habitat components native to the region remain in a healthy state.

A key characteristic of a degraded or stressed ecosystem is a reduced diversity in native species as the specific habitat needs of some of them are no longer being met. When the system is placed under a single stress, those species most sensitive to that stressor will be affected and, if it continues, lost from the system. Under continuing, and/or multiple stressors, a greater number of native species will be impacted, resulting in a more pronounced reduction in biodiversity. Eventually, larger taxonomic groups that were native may no longer be represented. At the same time, opportunistic native and exotic species will begin to take advantage of habitat openings where they exist, expanding their populations in the absence or reduction of competition.

Presence/absence data on a set of indicator species represents a coarse level of detail with respect to what is occurring to species on the landscape. While such a data set would not provide a good understanding of status and degree of change in an ecosystem that is close to optimum health, i.e. minimally impacted by unusual stress, it does provide ample evidence of changed structure and reduced function in the terrestrial ecosystem of an urban and urbanizing region. The results presented here show clear differences between the number of indicator species found on average across the region and what would be expected in a healthy state. Further differences are apparent between the less impacted rural zone as compared to the more highly impacted urban one. For a few of the measures, even the less distinct differences between the urbanizing zone and the other two zones were found to be statistically significant, and this with a small number of 7 sites in the urbanizing zone to be analyzed.

The very close agreement between the species actually found on sites with specific landscape characteristics and what would be expected based on the L ranks assigned to those species, demonstrates the value of the fauna and flora ranking system as a predictive and conservation

management tool. It similarly validates the scores applied through the current methodology for the Toronto region.

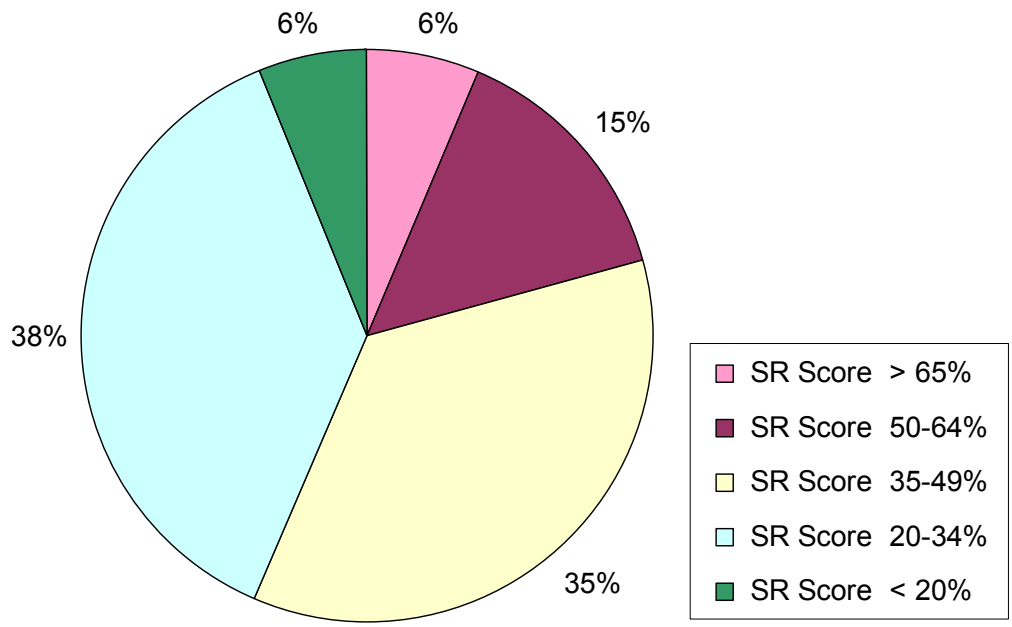
The majority of the species richness group measures and other indices were significantly, and in some cases highly significantly, correlated with the derived mixed patch total and matrix scores at varying relationship strengths. This result supports the patch scoring method as a very useful simplification for system analysis at a watershed or regional scale. Patch scores do not, and are not meant to, take into account the finer resolution differences between sites when observed at the site level. Nevertheless, the degree of agreement found increases confidence in the predictive value of the scoring system even at this finer scale. In most cases the strongest positive predictive relationship was with total score, and in all but one case (northern leopard frog presence/absence), if a positive relationship was found with either score it was found with both.

Notably, the meadow species richness data did not correlate with either total or matrix score. The scoring system does not appear to provide the same level of predictive value for meadow habitat in the region as it does for forests and wetlands. However, current regional meadow habitat is primarily of cultural origin, resulting from historical clearing for agriculture and subsequent abandonment, and hydro corridors. There is very little of what could be called native meadow in any zone in the region. The scoring system may well be a better predictor for native meadow than it is for old fields and hydro right-of-ways.

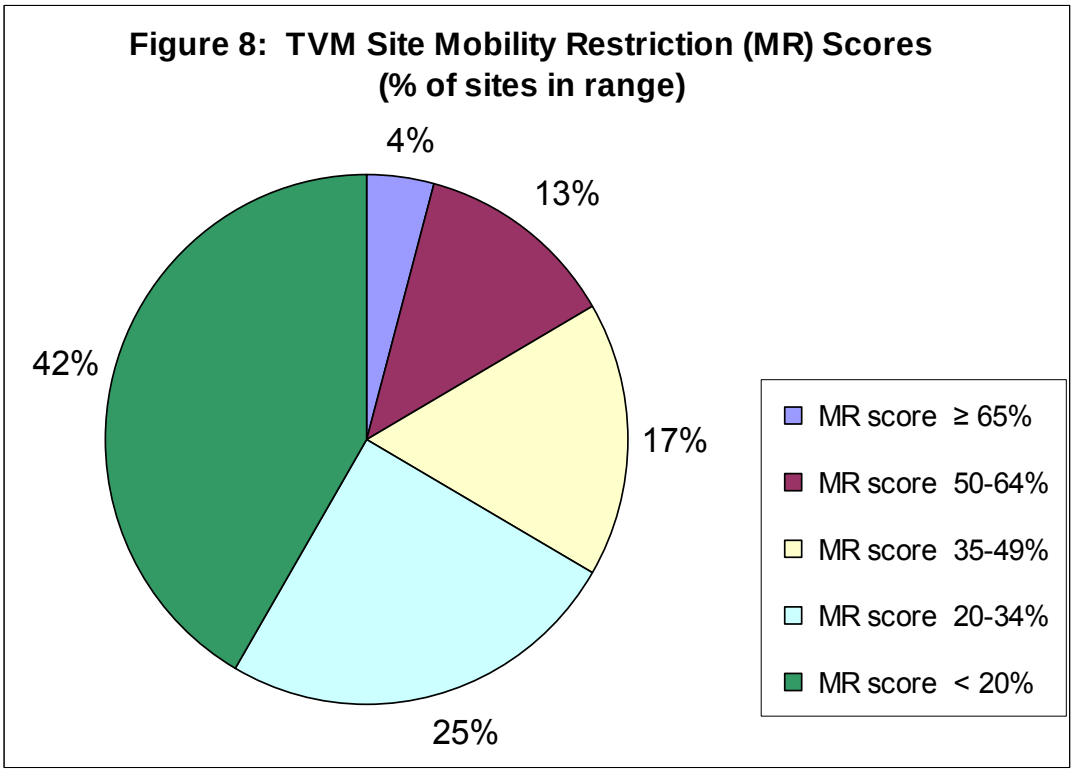
5.1 Regional Terrestrial Ecosystem Health

The data results from the period of 2002 to 2007 across the TRCA jurisdiction illustrate the characteristics of a degraded system. When species richness is the measure, the range is from 14% of the indicator species found to a maximum of 68% with an average of 39%. Since the indicators were specifically selected to encompass a wide range of habitat requirements, no single 10 hectare site is likely to contain habitat for every one of them. The maximum score of 68% could therefore be considered a fairly healthy result. The average however, was far below that, with just 21% of sites having more than 50% of the species, while 73% had fewer than 35% of the indicator species during the study period (Figure 7).

Figure 7: TVM Site Indicator Species Richness (SR) Scores (% of sites in range)



The sites' area sensitivity and mobility restriction scores highlight the fragmentation of the terrestrial ecosystem in the region. These two scores were very close to each other for any given site, reflecting the fact that isolation of natural cover patches and smaller patch size tend to happen together on the landscape. One urban sample site in the Mimico watershed scored 0 for both of these measures, reflecting that it did not support the presence of any of the 25 fauna species. As natural cover areas become too small and separated from each other, they can no longer support viable populations of many fauna species. While this site was the extreme, 30 of the 48 sites had scores below 30% on these two measures, and just 2 scored over 60% on both. Figure 8 charts the mobility restriction scores for the sites.

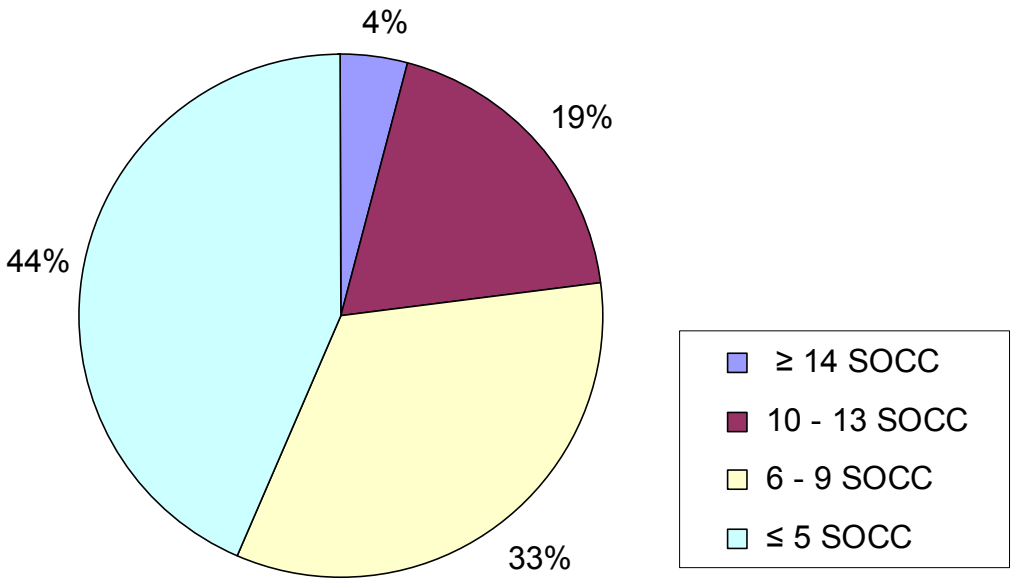


The habitat dependence scores reflect the degree to which the required habitat characteristics are simply not available for species across much of the region, resulting in many native species being absent. Just 4 sites scored over 60% based on the provision of the habitat requirements to support the indicator species, while 21 sites scored 30% or lower on this measure.

While it is not surprising that species diversity is reduced in an urban and urbanizing region such as the greater Toronto area, these numbers help to illustrate that gaps in the physical system visible at the landscape level are not the whole picture. The casual observer might expect that remaining natural cover patches support most of the same species that inhabited such areas prior to removal of adjacent habitat, but the monitoring results clearly show that this is not the case. This point is further illustrated by the proportionally lower fauna presence in the landscape as compared to flora and lichens. Vegetation, being the underlying structure that we recognize as natural cover, may be present in a general sense, while many of the sensitive native flora species are missing and even fewer of the expected native fauna species are supported.

The low regional average species richness for Species of Conservation Concern at 6.4 of a possible 28, leads to the conclusion that indeed sensitive species richness is very much reduced as predicted in a degraded ecosystem. This is true whether we consider the full complement of SOCC indicator species, the SOCC fauna alone or the most sensitive fauna ranked L1 or L2. Only 4% of sites supported 14 or more of the 28 Species of Conservation Concern monitored, while 44% reported 5 or fewer.

Figure 9: Number of Species of Conservation Concern (SOCC) found on TVM Sites (% of sites in range)



5.2 Land-Use Zones

With the exception of the total flora component, the measures analyzed showed clear and significant differences between the rural and the urban zone, with the urban zone being much more highly impacted by negative influences/stresses. No urban sites had 14 or more of the 28 Species of Conservation, while 76% had 5 or fewer (Figure 10). In contrast 5% of the rural zone sites had 14 or more of the 28 Species of Conservation Concern with 35% recording 5 or fewer (Figure 11). While it achieved better scores than the urban zone, these numbers still reflect a degraded condition within the rural or "best" regional zone.

Figure 10: Number of Species of Conservation Concern on Urban Sites (% of sites in range)

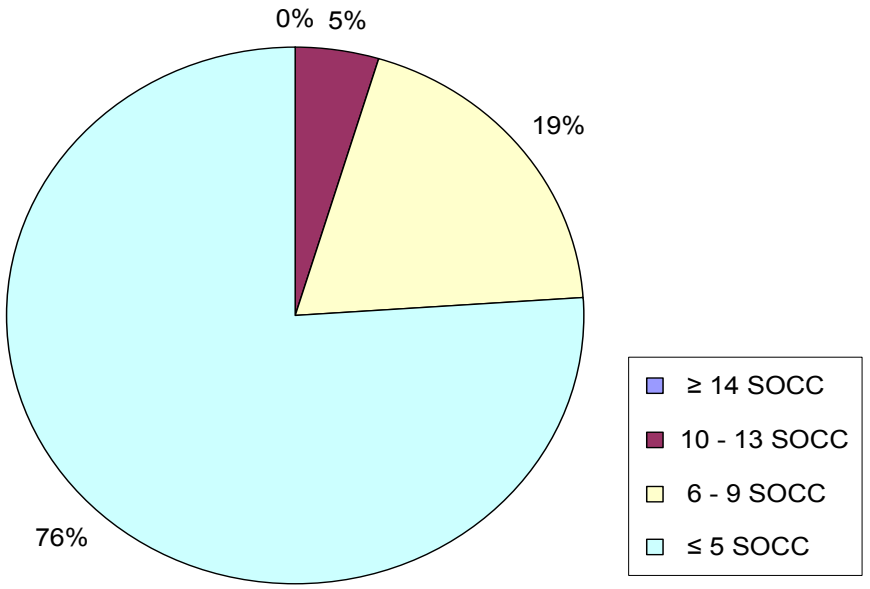
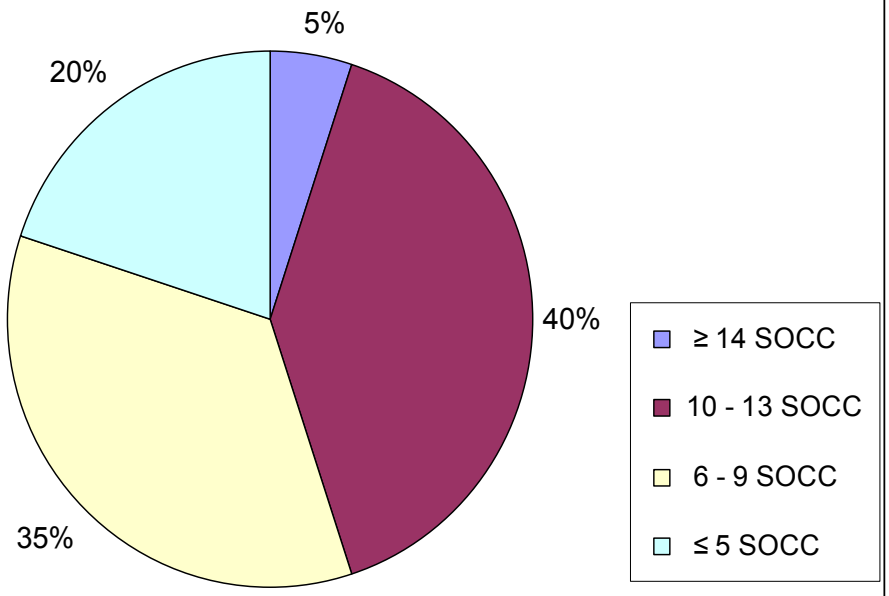


Figure 11: Number of Species of Conservation Concern on Rural Sites (% of sites in range)



The urbanizing zone was intermediate between the two with respect to most measures in scoring, but in most cases not significantly different from the rural zone statistically. This result likely reflects the fact that until urbanization actually occurs, this zone can support a level of diversity similar to the rural zone. A large portion of the urban zone was developed at a time when regional biodiversity was not considered in the planning process. Today, an improved process builds in greater habitat protection and buffering, yet we continue to see reduced biodiversity following development. Application of the systems approach presented in the Terrestrial Natural Heritage Systems Strategy will help to further ameliorate development impact on the remaining ecosystem by protecting sufficient habitat in a connected system to support a higher level of biodiversity. If a Terrestrial Natural Heritage System is not implemented in some jurisdictions, the ecosystem in those parts of the urbanizing zone would be expected to decline to the level of the recently developed parts of the urban zone. Results from the TVMP suggest additional factors that are likely important, and improved controls that might be helpful, such as applying best practice methods to minimize the potential for road salt to contaminate natural wetlands. The existing TVMP baseline data for this zone will support the ability to provide a quantitative assessment of ecosystem change as development occurs and monitoring continues.

5.3 Amphibians

In addition to the clear differences in species richness between the urban and rural land use zones, the amphibian group had the strongest positive correlation with total and matrix score, and a strong negative correlation with road density. They further exhibited a strong positive relationship with forest size. The requirement for wetlands connected with forest and meadow habitat, along with their need to travel across the landscape and their susceptibility to contamination are important determinants for where they will occur. Fragmentation of habitat patches combined with high road density and contaminated water are greatest in the urban zone and the sparseness of the amphibian group reflects this. It is worth noting that while much has been published regarding amphibians and their susceptibility to being killed on roads, only quite recently have studies looked at the impact of road salt contamination of wetlands on amphibian survival and species richness. A study in Thunder Bay, Ontario exploring this question found that road salts had toxic effects on wood frog tadpoles at environmentally realistic concentrations with potentially far-ranging ecological impacts. The authors further concluded that their investigations of amphibian species richness in both northwestern and southwestern Ontario suggested that road salts are having an effect on amphibian community structure (Sanzo and Hecnar, 2006). Studies in Nova Scotia (Chaisson and Russell, 2003 and Collins and Russell 2007) concluded that pond salinity and proximity to salted highways are major factors influencing amphibian species richness and distribution and reported that chloride concentration significantly influenced amphibian species richness in the ponds they studied. Multiple reports have documented increased chloride concentrations in aquatic systems linked to road salt contamination (Environment Canada, 2001, TRCA, 1999), while the Canadian Environmental Protection Act includes road salt in its list of priority toxic substances (Environment Canada, 2001). It is very likely that road salt contamination of wetlands is a determining factor with respect to amphibian species richness in the Toronto region.

The strong overall positive correlation of species richness with wetland and forest area within 2 km, combined with a negative correlation with road density is in agreement with the results of other studies, including the work done by Findlay and Houlahan (1997) in southeastern Ontario.

The forest dependent wood frog's occurrence did not correlate with either forest area or wetland area within 2 km, even though overall amphibian species richness was correlated with both, and contrary to results found by others including Porej *et al*. (2004). This, combined with the fact that its presence/absence did correlate with road density, leads to the conclusion that road related impacts along with water quality and other anthropogenic influences are critical factors for this species in the Toronto region. While it requires forest and wetland habitat, our results suggest that it will not be present in them if other factors to which it is sensitive are present. Since high road density occurs along with all other urban factors, we cannot conclude that road kills or road runoff containing contaminants are the primary cause where it is absent, but high chloride concentrations and other contaminants have been demonstrated as toxic to wood frogs (Sanzo and Hecnar, 2006). Further elevated chloride levels have been recorded in Toronto region aquatic systems through the TRCA's Regional Watershed Monitoring (TRCA, 1999 and TRCA, unpublished data).

The lower occurrence of the northern leopard frog, an L3 species, compared to the L2 wood frog is initially surprising. However our sites were selected with a preference for inclusion of forest and wetland habitat over meadow, which would suggest that they are biased toward wood frog versus leopard frog habitat. Further, northern leopard frogs do not call in unison to the extent that wood frogs do, their calls are less continuous, and they will begin calling from underwater when coming out of hibernation, in which situation their calls can be heard from only a few metres away (Seburn *et al.*, 1997). The combination of these factors suggest a lower likelihood of detection for the leopard frog as opposed to the wood frog. Thus, our numbers do not unequivocally show a difference between the two species' representation in the region. In light of concerns regarding northern leopard frog decline in many areas, an enhanced method for monitoring occurrence, abundance and population trend for this species throughout the region is desirable.

5.4 Breeding Birds

The breeding bird group includes representatives of forest, wetland and meadow habitats and both resident and migratory species. Species of Conservation Concern ranks are L3 and L4 for the various species. The mean species richness of 3.8, or just 27% of the indicator birds, reflects a high degree of degradation in the system regionally. As a group, birds scored more poorly than the amphibians, initially surprising considering their lower average scoring with respect to sensitivity. The greater mobility of birds however, allows them to adjust more easily to changing conditions, whether of natural origin or related to human activity. Subject to its availability on the landscape, they will select alternate habitat as previously utilized patches degrade over time. They will vacate degrading habitat more quickly, and similarly return to improving habitat following restoration.

The wide range of nesting requirements of these bird species demands a range of structure within forests and wetlands such as snags, dense understory, undisturbed ground layer, etc. which may be limited or unavailable in many of the region's disturbed forests. In the case of species such as the pileated woodpecker and scarlet tanager in the forest and the bobolink in meadows, area sensitivity comes into play, with small patches being unable to support them. The fragmentation of natural cover within the region increases the difficulty for all birds in finding suitable nest sites and mates, while the additional time, effort and therefore energy, expended in the search will impact the potential for breeding success. Food supply is also a concern. Programs to eradicate or limit the populations of a variety of insects reduces a key food source for many bird species. Predation by cats, especially of young birds, is an added stress on populations for many species in urban areas. Additional impacts external to the natural system, and in some cases, the region, are of importance and not measured under this program. These include the added dangers posed to migrating birds by tall buildings and other structures and the loss or degradation of the winter habitat utilized in other distant jurisdictions by migratory species that breed here.

5.5 Mammals

The low number of porcupine, an L2 species, found during monitoring surveys illustrates how few areas there are in the jurisdiction having sufficient connected habitat. Being slow moving animals with large home ranges, porcupines are also vulnerable to being killed on roads. They would benefit from wildlife crossings where large areas of natural vegetative cover exist along with roads.

The mink, an L3 species, can survive well in urban areas as long as natural cover along streams (riparian corridors) is maintained or restored, and the water quality is sufficient to provide the aquatic component of its food supply. One of the sites on which it has been verified through identification of tracks and trails (including "slides" through the snow), is in an urbanized part of the Don watershed within the city of Toronto. Additional data collection for mink will allow for a wider analysis of regional trends, and provide a measure for evaluating riparian corridors. In degraded riparian zones where restoration is planned, monitoring for this species before and after restoration may be helpful in measuring success. Appendix D highlights several factors that support the presence of mink as well as factors that may be tied to its absence.

The results for the L4 eastern chipmunk demonstrate just what we would expect based on that rank, which defines a species that is currently secure in the rural areas, and present in the overall urban envelope, but absent from the most urbanized areas, and reduced in others. Just 32% of urban sites supported it, while 68% of rural sites did. Impacts in the urban zone include contraction of habitat to areas simply too small and/or disconnected to support viable populations, competition from an increased population of grey squirrels (which benefit from living in close proximity to humans), and predation or harassment from free-roaming pets. The chipmunk, being a "ground squirrel" is more susceptible to this stress than the grey squirrels which spend a much greater proportion of their time higher in trees.

5.6 Flora

The species richness for the flora indicator species on sites was low at 10.5 of a possible 25, a further indicator of degradation at the regional scale.

The lack of clear differences in flora SR between land use zones and lack of correlation with patch scoring metrics, in contrast to all of the other species groupings, leads to a conclusion that presence/absence data for the selected indicator flora are not sufficient for the monitoring of flora species in our region. If abundance were considered, differences might become clearer. A major reason for this is that flora tend to persist longer in disturbed ecosystems than fauna do. While sensitive fauna may disappear very quickly in response to disturbance, flora will generally decline in numbers over a longer time period, and may continue to be present in small populations. White oak (*Quercus alba*), an L2 species, is an extreme example of this, found rarely at our sites and mainly as a remnant from pre-development, but nevertheless found at some of the more degraded sites, including the urban control. Even in the case of annual or biannual plants, a long-lived seed bank in soil may allow for sporadic appearances for years before the plant disappears.

A review of data which appeared initially surprising also resulted in an understanding that several of our study sites on public lands have been targeted for restoration plantings that included some of the L3 indicator species on our list. These efforts, while valuable to the ecosystem, do tend to confound the monitoring results, particularly when the sites are viewed as representative of a larger area in the analysis.

Flora native species monitoring needs to incorporate some measure of abundance and focus on more sensitive species to be more effective. Further, volunteer data sheet comments, as well as staff biological inventory surveys completed over the past several years, indicate a need to monitor the expansion of invasive exotic flora species in the region. Reducing the list of native species monitored, and adding some indicator invasive exotic species, along with a method to estimate percent cover or dominance for the indicator flora might provide better value from observer effort. Such monitoring should include dog-strangling vine (*Cynanchum nigrum*), garlic mustard (*Alliaria petiolata*), common reed (*Phragmites australis),* and European buckthorn (*Rhamnus cathartica*) along with a reduced set of native species in order to document both the status and spread of the exotic invasives and the resulting displacement of native species.

5.7 Wetland Habitat and Species

The mean score for wetland indicator species richness in the region, being 7 species of a possible 21, or 33% reflects degraded habitat overall. Again significant differences were evident between the rural and urban zones, although notably even the rural zone's mean score was quite low at 38% of the possible species richness. The correlation for wetland fauna with wetland area and forest area within 2 km points to habitat loss as a key issue for this group. The negative correlation of fauna SR with road density may also suggest factors beyond simple

habitat loss, although habitat loss and increased road density are likely to be correlated with each other. Road kills, particularly for the most wide ranging frogs, along with water contamination through urban runoff are likely suspects. While the ability of wetlands to reduce the contamination of surface runoff prior to its entering streams and lakes is often mentioned as an ecological service, there are effects of such contamination on species in the wetlands themselves. Invasive exotic flora species in wetlands, such as common reed (*Phragmites australis*) and purple loosestrife (*Lythrum salicaria*), will also reduce native flora diversity, although this program has not specifically monitored invasives on the TVMP sites. TRCA water quality data shows an increase in chlorides in urban areas (TRCA, 1999 and later unpublished data). The common reed is a salt tolerant species (Ehrenfeld, 2001) and may be better able to compete with more sensitive native species in such waters. The impact of purple loosestrife in southern Ontario has been reduced considerably since the release of two species of chrysomelid beetles as biological control agents during the 1990's (Corrigan and MacKenzie, 2003).

5.8 Forest Habitat and Species

Forest habitat scored the highest in regional indicator species richness with a mean of 43% of the total possible. This value is still low and reflective of very degraded habitat regionally.

The rural zone's higher richness reflects healthier forests than the urban, with this difference clearly tied to size of the forest habitat and its connection with additional natural cover in the landscape. Contrary to the result for some other measures, the urbanizing zone was not significantly better than the urban for this group, indicating that urbanizing zone forests have already declined to the level of urban forests. Since they are located close to urban areas and are attractive for recreational pursuits, they likely experience a higher level of impact from human activity sooner than meadows or wetlands as the urban envelope expands.

The correlation with total score, matrix score and the much stronger and highly significant correlation with forest patch size emphasize the value in pursuing implementation of the Terrestrial Natural Heritage System Strategy target system which aims to maximize these parameters regionally.

5.9 Meadow Habitat and Species

Based on the results from TVMP sites, meadow habitat across the region shows a poorer condition than either forest or wetland with a mean of just 28% of the possible meadow indicator species present. Relating this current condition to earlier time periods however, needs to take into account the fact that until European colonization, the natural ecosystem in the region was mainly forest with some wetland and very little in the way of meadow habitat. Forestry and forest clearing for agriculture during colonial times opened up considerably more meadow habitat, particularly where cleared land was subsequently found to be unsuitable for growing crops and was abandoned. Ongoing anthropogenic change is now reversing the earlier trend as meadows not under agricultural land use are targeted for urbanization.

The rural zone scored no better on meadow species richness than the urban zone, a result quite different from that observed for the forest and wetland habitats. This is not surprising since there is no conservation priority to protect meadow habitat. In the urban zone meadow land is targeted for development, and where agriculture is the primary land use, meadows become cultivated, in either case removing such land from the natural system. While agricultural fields such as hayfields and pastures do provide habitat for some species, frequent disturbance through grazing or mowing make them far from ideal for many. In the case of the bobolink, an area sensitive grassland bird, hayfields are often selected by breeding pairs early in the season as the largest areas with the preferred vegetation height. However, if fields are mowed earlier than mid July, many nests are destroyed before the young have fledged (Nocera *et al*., 2007).

It is interesting to note that the urbanizing zone was significantly richer than either of the others, a result that could be explained by areas of "abandoned" or old field habitat awaiting development that is potentially less disturbed than rural hayfields and pastures. This would be a temporary situation as fields in the urbanizing zone are eventually developed and the habitat lost entirely.

In addition to the physical habitat loss from development, the structure of meadow habitat increases the meadow community's susceptibility to human impact as compared to those of forest and wetland. Species in the meadows are more closely tied to the ground and do not have the refuge in trees that many forest species do, or the protection by virtue of the deterrent of water that wetland species have. This is true even for meadow birds. While adults can escape ground disturbance, nests placed on the ground or in low shrub vegetation leave the eggs and young vulnerable to human and pet disturbance.

The 2002 TRCA landscape analysis illustrates the limited and fragmented nature of meadow habitat, particularly in the southern half of the jurisdiction, with the major hydro corridors being clearly visible on mapping as some of the largest "meadow" habitat spaces remaining (Figure 6).

The increase in species richness with larger meadow patch size, and area of total meadow within 2 km is not surprising and points to meadow habitat loss and fragmentation as key drivers of the reduced species richness we're seeing in the region. Size seems to be very important for meadow quality, which has implications for recovery planning and terrestrial natural heritage system design.

5.10 Qualitative overview of example sites

The quantitative analysis looks at the region as a whole, as well as the primary land-use zones, and considers many factors impacting the terrestrial ecosystem throughout the region. It is also informative to view individual sites in a qualitative sense, wherein some of the reasons for the indicator species being found or not found and the positive and negative influences on the system can be understood. The following describes three sites selected to be representative of the range of ecosystem condition found within the Toronto region. It explores some common

themes with respect to the stresses and positive influences on the ecosystem observed through the monitoring process that are not directly measured or reflected in the quantitative analysis.

a) Rural headwaters site

This rural site on public conservation land in the northern part of the region, had high scores on most of the measures. Looking at the landscape in which it is located and the site itself, there are several characteristics that help to explain its good condition. The site is located not far downstream of a headwaters area in the Humber watershed on a large patch of natural cover that includes a large wetland area, native mixed forest and coniferous plantations. The wetland is varied, with swamp forest, thicket swamp, shallow aquatic and cattail marsh components. Beaver dam building activity is evident and important in maintaining both the high water levels and large extent of the wetland. While there are human-use trails close by, none traverse the site itself. Figure 12 is an aerial view of the site and its immediate surroundings.

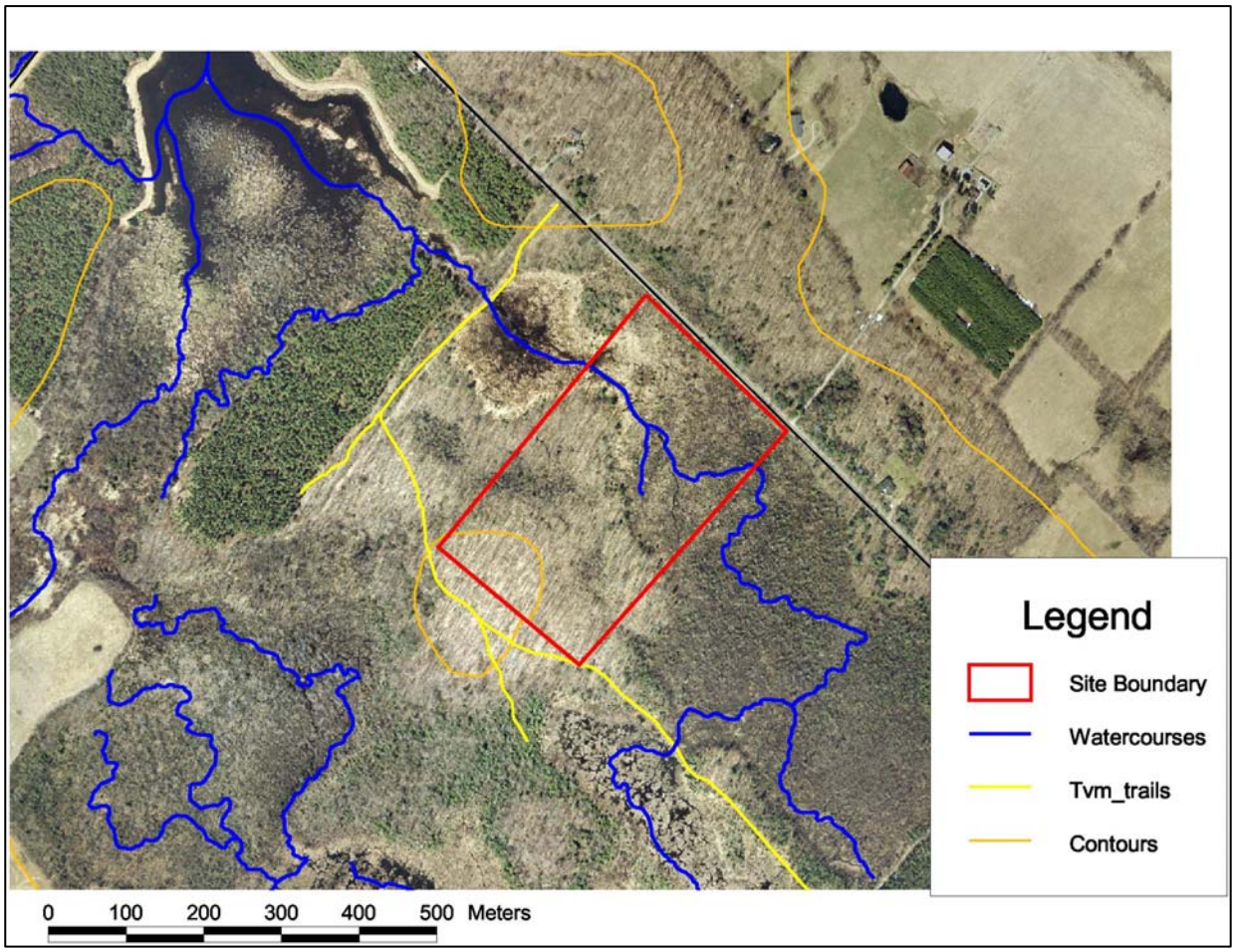


Figure 12: Aerial view of site in rural, headwaters area

The surrounding area is primarily rural residential with many large properties incorporating additional natural cover, helpful to the site's habitat quality in the sense that there is little in the way of direct impact on the site by its surroundings, relative to the majority of sites in the region. It does not see many visitors. A large part of the site is wetland and the wetland directly abuts the road, making access to the forest that lies behind difficult, or at least unappealing. Many residents in the area have dogs, but they also have large properties, so dog walking doesn't occur to any great degree. There are both high species richness overall and a high abundance of the more sensitive frogs, which can be heard calling throughout the spring season. Wood frogs, grey treefrogs, spring peepers, northern leopard frogs, and green frogs have all been recorded here. Road density within 2 km is quite low, but the road adjacent to the site was recently paved, resulting in much higher traffic speeds observed by volunteers, along with an increase in finds of road killed amphibians and reptiles. A dead porcupine was also found at roadside the spring following the paving. It remains to be seen whether there will be a resulting increase of road salt entering the wetland and to what degree it will impact the amphibians breeding there.

b) Recently developed urban site

A patch of publicly owned forest and swamp forest with groundwater seeps that is just slightly larger than the 10 ha site itself was protected when residential development went in to this area approximately 15 years ago. However it has no connection to other larger natural cover areas, being surrounded on all sides by roads and suburban residential properties (Figure 13). Trail planning has kept all trails to one side of the site and away from the most sensitive areas, and on a recent early morning winter visit, people out walking were keeping to the designated trails. However during the one and one half hour survey 5 off-leash dogs were encountered. They, unlike their owners, did not remain on the trails and traversed much of the total site. The volunteers knew that porcupine were unlikely due to the isolated nature and small size of the forest, and realized during the visit that the dog traffic meant that they probably would not observe the ruffed grouse they were looking for, even though the forest block seemed to offer appropriate habitat. They did not find grouse or their tracks. During a weekday evening survey that involved playing the eastern screech-owl call and listening for a response, the degree of noise penetrating the site from passing trains and traffic noticeably interfered, prompting a comment on the data sheet.

Wetlands and forest are both present on the site, and while several of the indicator flora have been found, few of the fauna native to these habitats have been recorded. Most are not likely to be able to recolonize the site, due to its lack of connection with other natural cover. Although the nearest additional natural cover is less than 1 km distant, it is not feasible to create even a narrow connection at this point since the intervening area is comprised of residential properties.

The best opportunity to enhance the habitat within the site at this point in time would appear to be improvement of public education with respect to the free roaming pets and the impact they have on natural systems, and enforcement of existing regulations. With this, some additional bird species may be able to return to utilize the improved habitat, although this might depend on whether the noise level is constant, or only high at certain periods of the day.

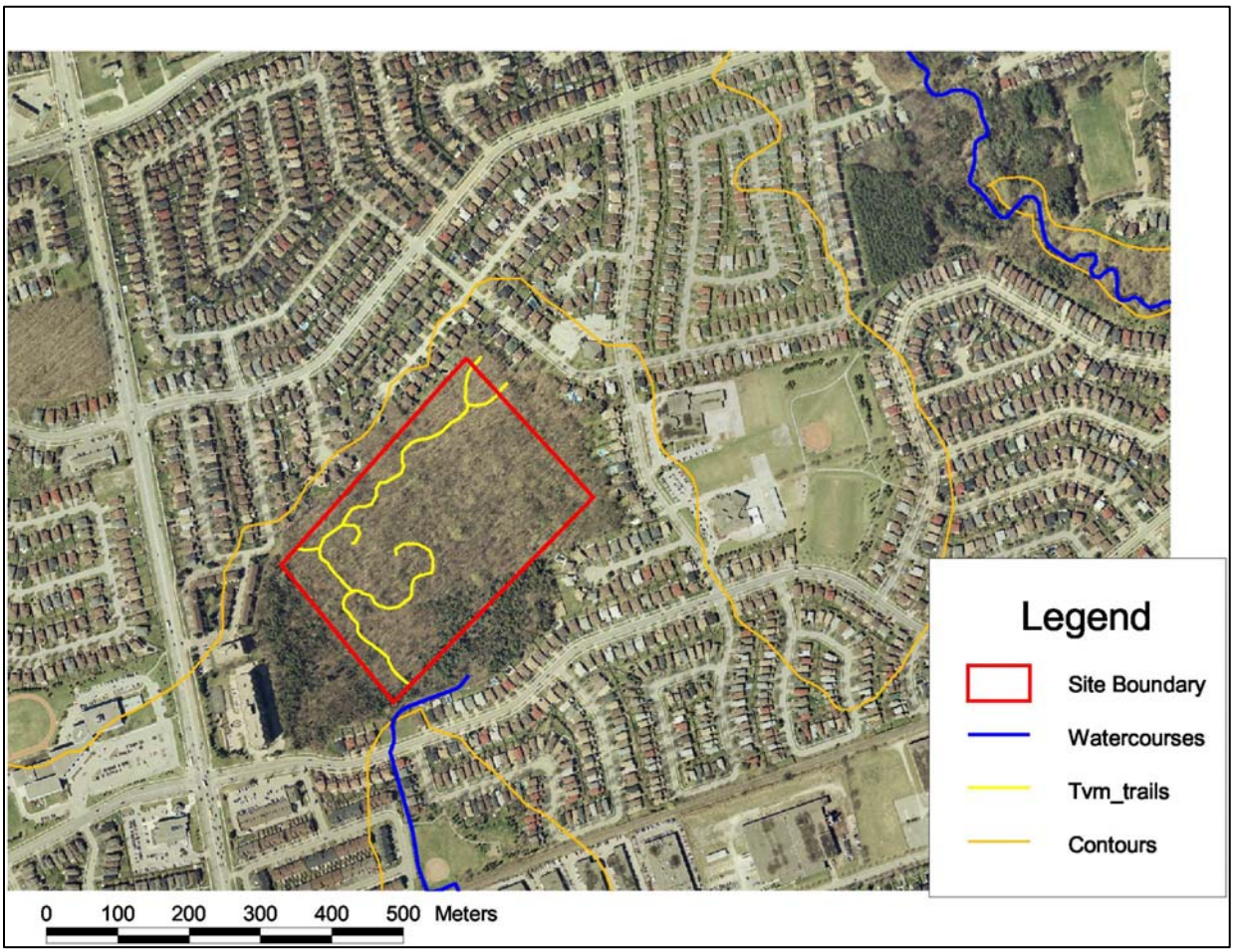


Figure 13: Aerial view of site located in a recently developed urban area

c) Established urban site

A publicly owned site located in an area of Toronto that has long been urbanized and was developed well before there was any understanding of the value in integrating natural cover into urban zones, has a very small area of forest, some meadow and wetland. There is high road density in the surroundings including 2 major highways immediately adjacent to the site (Figure 14). It has been the target of restoration plantings that have resulted in several of the indicator flora species found during the monitoring period, but the wetlands have no breeding frogs or toads, and in fact, none of the fauna indicator species have been found on this site to date. Its continued presence in the landscape could lead to an impression of greater value for biodiversity than it truly has. Monitoring the species composition within it demonstrates its degraded structure and function.

There are no designated trails on the site, but it does see usage by ATV's and trail bikes.

This site's position between the highways means it is no longer possible to increase its size or connectivity to other natural cover or accomplish more than the native flora plantings to enhance the condition of this site.

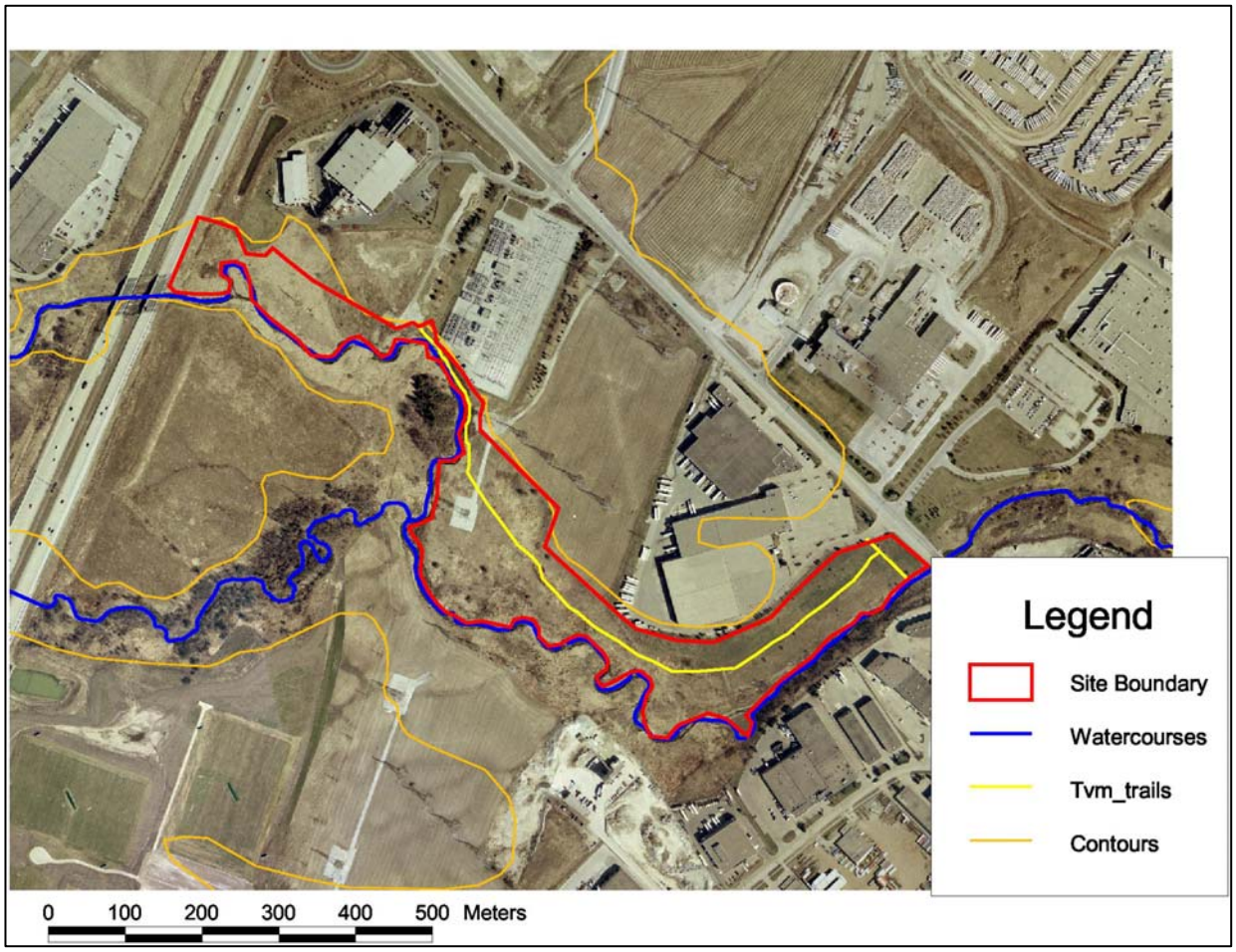


Figure 14: Aerial view of site located in an established urban area

6.0 CONCLUSIONS and RECOMMENDATIONS

Monitoring results from the TVM sites are useful at a range of scales. Recognizing the paramount importance and value in implementing the Terrestrial Natural Heritage System Strategy, the TVMP results and analysis support both the regional approach and the development of smaller scale practical recommendations.

The correlation of species richness with natural cover patch size demonstrates the value of localized restoration and recovery efforts that focus on increasing the size of natural cover patches wherever feasible. Even at the low end of the patch size scale, the positive relationship between species richness and size is clear and continuous. It predicts an improved ability for species to utilize the habitat with every increase in size, meaning any restoration that expands existing patches has value.

Individual sites provide valuable information at a local scale. Of note are sites located in conservation properties and parks, particularly those with active stewardship groups. There are established sites at Heart Lake, Albion Hills and Greenwood Conservation Areas, the Glen Major tract, Bolton resource management tract, Caledon tract, and at the Humber Arboretum, all TRCA properties. Large municipal parks with sites include High Park, Morningside Park, and Sunnybrook Park, and several other municipal properties also contain sites. Rouge Park has 4 sites within its boundaries. At the watershed scale, all watersheds are represented according to their size, and have data collection for the 2002 - 2007 period. Both raw data and individual site scores for the metrics analyzed herein on public lands are available and may be used to assist in evaluating the condition of the ecosystem in an area of interest. Data for private properties is shared with the owners, while being used by TRCA only in the grouped analyses.

Where an individual site is the focus, it is not possible to carry out statistical analysis. It is however helpful to compare the results for the site to those for the region or the land-use zone to which the site belongs. Such comparisons may be made to the mean or the best scores to determine whether the site of interest appears to be in better or worse condition than the applicable zone or the region, with respect to the various species richness and index measures. Appendix C provides details on what the presence or absence of individual species may indicate about the site, and is helpful in interpreting the results. Where restoration is planned, the applicable best scores for the region presented in table 8 could be viewed as targets, and scores for the site tracked over time to monitor progress.

In the instance where lands without TVM sites are targeted for restoration or recovery planning, and monitoring is desired, the complete TVM protocol, or a subset of it, could be implemented. This approach would once again provide the opportunity to compare results from the site to regional scoring for the time period of interest. Table 8 highlights the means and ranges for key scoring elements from tables 3 to 7 considered to be most valuable for such comparisons. It is important to note however, that monitoring activity on a site is a source of disturbance that can have a negative impact on flora and fauna. It should occur only where truly of value, and operate according to a well developed plan that includes training for observers and focuses on minimizing impact.

Determining which of the species, groups and/or measures to select as a monitoring set should be driven by the location, size, habitat and other characteristics of the site to be evaluated. It is likely not necessary to implement the entire protocol in order to provide sufficient information for action planning.

Amphibians are the ideal group as monitoring subjects for sites or properties that contain wetland. They are sensitive to change in their environment and respond quickly to changes as they occur. This is a result of having permeable skins through which they are directly exposed to their immediate environment, as well as their dependence upon both aquatic and terrestrial habitats and need to move safely between them. As the results of this study demonstrate, analysis of the amphibian group provides the best information for how the terrestrial ecosystem is faring in the region, and the best indication of what factors on the landscape are likely important in determining the results we see.

Table 8: Summary of regional indicator species richness scores for TVMP sites in the TRCA Toronto regional jurisdiction for the period 2002 - 2007, expressed as percent of indicator species in group found.

	Regional Scores		
Indicator Group & Measure	Minimum	Maximum	Mean
Species Richness (SR)	14%	68%	39%
Species of Conservation Concern SR	4%	61%	22%
Amphibian (Anuran) SR	0%	75%	34%
Breeding Bird SR	0%	71%	27%
Lichen Species Richness	17%	100%	75%
Wetland Habitat Species Richness	5%	71%	33%
Forest Habitat Species Richness	10%	76%	43%
Meadow Habitat Species Richness	0%	63%	28%

Future monitoring by the Authority should incorporate protocols designed to track the effects of climate change on the terrestrial system, as well as to compile better information on the occurrence and population trend for the northern leopard frog, since both of these are identified gaps in the current monitoring. New protocols currently being implemented by staff are expected to address these needs.

Based on the TVMP flora monitoring results and the current lack of monitoring for exotic invasive flora species, a simple invasive species monitoring protocol element should be developed to be implemented into the ongoing volunteer monitoring program. This protocol could also be made available to interested community/stewardship groups and individuals. This requirement will be considered in upcoming program enhancement planning.

The Terrestrial Volunteer Monitoring Program continues to be an extremely valuable contributor to the TRCA's data collection efforts. The quality of the data is evident both during the quality assurance process and through the analysis presented here. The quantity of data

collection, seasonal coverage and temporal replication is clearly much higher than could be achieved at reasonable cost using staff field teams. The opportunity for interested community members to participate and build their knowledge of the terrestrial ecosystem and biodiversity issues is an added benefit. Multiple volunteers, particularly students and recent immigrants with an environmental background, have progressed from participating in the terrestrial monitoring program to employment within the environmental sector, some of them with TRCA.

TVMP monitoring and data analysis is continuing. Future reporting will consider whether there are identifiable trends occurring over time. It is currently expected that 10 years of data collection will provide sufficient data to report on temporal results.

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8.0 Appendices

Appendix A: Landscape level data for TVMP sites used in the analysis

Site	Area of Natural Cover Patch on which site is located (ha.)				Mixed Patch Scores		Length of trails (m)	Dist. to road (m)	Road density (km)	Area of Habitat within 2 km. (ha.)*			Land Use Zone			ORM	Watershed
	Total	Forest	Wetl.**	Mead.	Total	Matrix				Forest	Wetl.	Mead.	Urban	U'izing	Rural		
2	268	206	59	3	11.9	4.4	2	2	14	425	79				X		Humber
3	194	163	1	31	11.5	4.6	1108	1517	13	381	4				X	X	Humber
4	564	492	3	69	12.3	4.8	541	579	12	650	9	126			X		Humber
5	231	175	16	40	10.9	4.4	1193	791	21	443	45				X	X	Humber
7	143	129	0	13	10.4	4.4	135	24	12	450	16				X	X	Humber
8	157	132	0	25	10.1	3.8	1089	299	41	428	2	119		X			Humber
9	1058	984	10	64	12.1	4.4	1145	1914	9	695	18				X	X	Humber
10	164	134	19	11	10.7	4.4	1011	444	18	334	22				X	X	Humber
11	163	129	6	28	11.0	4.4	911	765	16	310	10	63			X		Humber
13	88	67	0	21	9.4	3.6	422	170	14	109	4					X	Humber
14	119	101	0	18	10.2	3.8	690	171	13	188	11	32				X	Humber
15	45	35	2	8	9.4	3.6	0	2	18	61	5	88			X	X	Humber
16	312	219	0	93	10.7	4.4	470	25	25	378	4	181		X			Humber
17	50	30	0	20	9.1	3.6	373	403	12			68			X		Etobicoke
18	23	16	0	7	9.2	3.6	0	2	13	102	1	117			X		Etobicoke
19	135	108	15	12	9.4	3.0	809	2	66	154	38			X			Etobicoke
20	25	4	0	21	7.2	1.8	990	5	32	15	3	131	X				Etobicoke
22	38	12	0	26	7.8	2.5	0	40	59	146	4	203		X			Humber
24	94	45	4	45	7.6	2.0	661	31	66			121	X				Humber
25	41	35	3	3	7.6	1.6	926	70	93	114	3	47	X				Humber
26	51	13	1	36	7.6	1.8	0	29	83	30	2	185	X				Etobicoke
27	34	21	0	13	6.8	1.5	1131	38	96			57	X				Mimico

Site	Area of Natural Cover Patch on which site is located (ha.)				Mixed Patch Scores		Length of trails (m)	Dist. to road (m)	Road density (km)	Area of Habitat within 2 km. (ha.)*			Land Use Zone			ORM	Watershed
	Total	Forest	Wetl.**	Mead.	Total	Matrix				Forest	Wetl.	Mead.	Urban	U'izing	Rural		
28	25	24	0	1	7.4	1.6	1119	82	102	127	1		X				Humber
29	22	22	0	0	7.1	1.6	886	34	109	145	1		X				Humber
30	48	48	0	0	8.9	2.0	755	2	109	109	1	7	X				L. Ontario
31	11	5	1	6	10.7	4.8	3380	775	5	51	7	86	X				L. Ontario
32	44	33	1	11	7.3	1.7	530	25	121	158	62	53	X				Don
33	28	19	0	9	7.7	1.9	1696	2	86	182	1	64	X				Don
34	13	13	0	0	6.0	1.4	2625	2	79				X				Don
35	97	92	1	4	7.8	1.8	1486	127	73	250	2	10	X				Don
36	45	40	0	5	7.8	1.6	2305	35	90			31	X				Don
37	83	34	0	49	8.8	2.1	1403	111	80	86	1	168	X				Don
38	31	31	0	0	10.7	2.4	809	51	65				X				Don
39	27	17	0	10	7.0	1.9	185	15	48	67	6	135	X				Don
43	98	63	5	30	10.2	4.4	440	20	18	226	35				X	X	Rouge
44	32	31	0	0	10.4	4.4	685	149	13	254	7				X	X	Rouge
45	47	27		20	8.9	3.6	1185	261	31	109	19	91			X		Rouge
46	17	17	0	0	9.4	1.8	1010	28	89	63	4		X				Rouge
47	10	8	0	1	8.4	1.2	1967	2	115	14	4	78	X				Highland
48	45	37	0	8	10.2	4.4	0	526	19	186	3	83			X		Rouge
49	32	20	0	13	10.4	4.4	0	2	32	340	19	179			X		Rouge
50	97	92	0	5	10.4	3.2	0	333	68	431	6				X		Rouge
51	74	73	1	0	9.5	2.2	0	86	79	95	3		X				Highland
52	35	34	1	0	9.3	3.6	1368	38	50	149	8	49	X				Highland
53	132	39	0	93	11.4	4.4	279	279	39	373	17			X			Petticoat
54	15	6	6	3	7.8	2.3	548	16	86	41	22	52	X				L. Ontario

Site	Area of Natural Cover Patch on which site is located (ha.)				Mixed Patch Scores		Length of trails (m)	Dist. to road (m)	Road density (km)	Area of Habitat within 2 km. (ha.)*			Land Use Zone			ORM	Watershed
	Total	Forest	Wetl.**	Mead.	Total	Matrix				Forest	Wetl.	Mead.	Urban	U'izing	Rural		
55	54	31	10	14	9.1	3.2	1490	51	49	108	30	281		X			Duffin's
56	166	88	0	78	10.4	4.5	0	28	17	325	6	167			X		Duffin's
58	269	142	0	127	10.9	4.7	1178	627	21	336	7	266			X		Duffin's
59	93	29	2	62	10.0	3.8	0	458	19	94	22				X		Duffin's
60	69	57	0	12	10.8	4.4	0	191	16	264	17				X	X	Duffin's
61	52	22	0	30	10.7	4.5	1081	705	15			159			X	X	Duffin's
62	1142	1018	5	119	13.1	5.0	975	2337	8	890	4				X	X	Duffin's
63	58	39	0	19	10.8	3.6	0	2	54	169	11	118		X			Carruther's

* Forest and wetland area within 2 km. recorded for wetland sites, meadow area within 2 km. recorded for sites with meadow.

** Sites with wetland were included in the analysis regardless of the size of wetland they contained. Where wetland area on the site was less than .5 ha, it shows as 0 ha here due to rounding.

Appendix B: TRCA Species of Concern Scores and Ranks for Terrestrial Volunteer Monitoring Program Indicator Species

TRCA FAUNA SCORES & RANKS											
Common Name	Scientific Name	LO	PTn	PTt	HD	AS	MR	SD	AP	Total	L-Rank
American toad	*Bufo americanus*	0	2	2	1	1	2	4	0	12	L4
American woodcock	*Scolopax minor*	0	2	3	2	3	2	4	0	16	L3
bobolink	*Dolichonyx oryzivorus*	0	3	2	2	3	1	4	0	15	L3
bullfrog	*Rana catesbeiana*	4	4	3	3	2	3	5	1	25	L1
eastern chipmunk	*Tamias striatus*	0	2	2	1	2	2	3	0	12	L4
eastern meadowlark	*Sturnella magna*	0	3	2	2	3	2	3	0	15	L4
eastern screech-owl	*Megascops asio*	1	2	2	3	1	2	3	0	14	L4
eastern wood-pewee	*Contopus virens*	0	4	2	1	2	2	2	0	13	L4
green heron	*Butorides virescens*	2	2	2	2	2	2	3	0	15	L3
green frog	*Rana clamitans*	0	2	2	1	1	2	4	0	12	L4
grey treefrog	*Hyla versicolor*	2	2	3	2	3	3	5	1	21	L2
mink	*Mustela vison*	3	2	2	1	3	2	4	0	17	L3
northern leopard frog	*Rana pipiens*	0	3	2	2	1	2	5	1	16	L3
northern spring peeper	*Hyla crucifer*	1	2	3	3	3	2	5	1	20	L2
ovenbird	*Seiurus aurocapillus*	0	2	3	3	4	2	4	0	18	L3
pileated woodpecker	*Dryocopus pileatus*	1	2	2	3	4	2	3	0	17	L3
porcupine	*Erethizon dorsatum*	3	2	3	3	4	2	4	0	21	L2
ruffed grouse	*Bonasa umbellus*	1	3	2	1	3	2	5	1	18	L3
savannah sparrow	*Passerculus*	0	3	1	2	1	1	3	0	11	L4
scarlet tanager	*Piranga olivacea*	1	2	3	3	4	2	3	0	18	L3
western chorus frog	*Pseudacris triseriata*	3	2	3	2	2	5	5	2	24	L2
swamp sparrow	*Melospiza georgiana*	0	1	2	2	1	2	5	1	14	L4
Virginia rail	*Rallus limicola*	1	2	2	2	2	3	4	0	16	L3
wood duck	*Aix sponsa*	2	1	1	3	3	1	4	0	15	L3
wood frog	*Rana sylvatica*	0	2	3	4	3	2	5	1	20	L2

LO - Local Occurrence PTn - continental population trend PTt - population trend TRCA jurisdiction HD - habitat dependence
AS - area sensitivity MR - mobility restriction SD - sensitivity to development AP - additional points

TRCA FLORA SCORES & RANKS							
Common Name	**Scientific name**	LO	PTn	HD	SD	Total	L-Rank
		1-5	1-5	0-5	0-5	Score	
marsh marigold	*Caltha palustris*	2	4	3	4	13	**L4**
Jack-in-the-pulpit	*Arisaema triphyllum*	1	3	3	4	11	**L4**
narrow-leaved spring beauty	*Claytonia virginica*	3	4	4	4	15	**L3**
white trillium	*Trillium grandiflorum*	1	4	4	5	14	**L3**
foam-flower	*Tiarella cordifolia*	2	3	3	4	12	**L4**
star-flower	*Trientalis borealis ssp. borealis*	2	4	4	5	15	**L3**
Michigan or Turk's cap lily	*Lilium michiganense*	3	4	3	5	15	**L3**
turtlehead	*Chelone glabra*	3	3	4	4	14	**L3**
swamp milkweed	*Asclepias incarnata ssp. incarnata*	2	3	4	3	12	**L4**
spotted Joe-Pye weed	*Eupatorium maculatum ssp. maculatum*	1	2	3	3	9	**L5**
barber-pole bulrush	*Scirpus microcarpus (S. rubrotinctus)*	2	2	4	3	11	**L4**
giant or great bur-reed	*Sparganium eurycarpum*	3	4	5	4	16	**L3**
common arrowhead	*Sagittaria latifolia*	2	2	5	4	13	**L4**
black-eyed Susan	*Rudbeckia hirta (R. serotina)*	2	4	4	3	13	**L4**
spreading dogbane	*Apocynum androsaemifolium*	3	3	3	3	12	**L4**
fire-weed	*Epilobium angustifolium*	4	4	4	4	16	**L3**
white oak	*Quercus alba*	3	5	4	5	17	**L2**
big bluestem	*Andropogon gerardii*	4	2	4	4	14	**L3**
riverbank wild rye	*Elymus riparius*	2	2	5	2	11	**L4**
Christmas fern	*Polystichum acrostichoides*	2	3	5	5	15	**L3**
zig-zag goldenrod	*Solidago flexicaulis*	1	1	3	2	7	**L5**
winterberry	*Ilex verticillata*	3	4	4	5	16	**L3**
eastern hemlock	*Tsuga canadensis*	1	4	3	5	13	**L4**
white pine	*Pinus strobus*	1	4	3	4	12	**L4**
white cedar	*Thuja occidentalis*	1	4	1	5	11	**L4**

LO - Local Occurrence PTn - continental population trend HD - habitat dependence SD - sensitivity to development

Appendix C: Information provided by presence or absence of individual indicator species

Indicator species	L rank	Presence indicates:	Absence may indicate one of more of:
Mammals			
Eastern chipmunk (*Tamias striatus*)	L4	• at minimum, 1 ha deciduous or mixed forest patch connected to other patches by hedgerows or meadow with protective cover • available food supply of tree seeds/nuts, berries, mushrooms, invertebrates, eggs & nestling birds etc. • leaf litter & fallen logs etc. intact, soil type & moisture content appropriate for burrowing • available food supply for predators such as weasels, hawks, owls, foxes, coyotes, snakes	• forest fragments too small or isolated • tree seed/nut production insufficient for food requirements • ground layer cleared or insufficient to provide cover from predators • predation by free roaming pets or natural predators where supply of available prey is reduced by ecosystem stresses • invasive species dense in ground layer • high competition from grey squirrels • too many trails/high trail usage/off-trail human activity high
Mink (*Mustela vison*)	L3	• vegetated riparian habitat zone 1+ km in length to provide cover and terrestrial prey species • water quality high enough to support aquatic prey species • undisturbed riparian areas for denning sites	• riparian zone insufficiently protected/buffered from development • riparian vegetation cleared • too much disturbance along stream banks to allow successful denning • contaminated water or otherwise degraded stream/wetland habitat • lack of sufficient aquatic or terrestrial food (could result from other impacts beyond riparian zone)
Porcupine (*Erithizon dorsatum*)	L2	• relatively undisturbed contiguous or connected coniferous or mixed forest & meadow/successional patches of size over 100 ha of which at least 10 ha is forest • road density in habitat area low or wildlife corridors available	• forest fragments too small for critical winter habitat • contiguous natural cover area too small for summer home range • tree species assemblages within forest insufficient for food requirements • road kill rate too high • human/pet impact within forest too high • dense cover by invasives such as dog-strangling vine
Amphibians			Note: Frogs & toads are an important food supply for wetland birds and other fauna. If missing, other groups will be reduced or missing as well. There is also a global concern with respect to increases in viral and fungal diseases of amphibians. Where populations are already stressed, such diseases will have greater impacts on populations. Movement from pond to pond and mass breeding activity facilitate the spread of such diseases.

Indicator species	L rank	Presence indicates:	Absence may indicate one or more of:
Wood frog (*Rana sylvatica*)	L2	• at minimum, some area of deciduous or mixed forest with connectivity to fishless wetlands/vernal pools • undisturbed forest floor with intact litter layer • few to no roads between forest & wetland/breeding ponds or wildlife corridor bypasses them • uncontaminated water	• fishless wetlands/vernal pools missing or dry out too early in season • wetland and forest isolated or separated by barriers such as busy roads • water contaminated by road salt, pesticides or other toxins
Northern spring peeper (*Hyla crucifer*)	L2	• at minimum, some area of forest with connectivity to fishless wetlands/vernal pools • relatively undisturbed forest floor with litter layer intact • breeding wetlands not contaminated	• fishless wetlands/vernal pools missing or dry out too early in season • forest or wetland missing or separated by barriers such as roads • wetland lacking aquatic vegetation • water contaminated by road salt, pesticides or other toxins
Western chorus frog (*Pseudacris triseriata*)	L2	• at minimum, some area of contiguous fishless wetland with meadow, successional or forest habitat • uncontaminated water	• fishless wetlands missing or isolated from terrestrial habitat • riparian zone cleared of vegetation • wetland lacking aquatic vegetation • water contaminated by road salt, pesticides or other toxins Note: The very low occurrence of this previously common species in the Toronto region suggests a higher sensitivity to one or more of the above as compared to the other frogs, or the existence of another, so far unidentified, sensitivity or impact.
Northern leopard frog (*Rana pipiens*)	L3	• at minimum, some area of meadow/ successional habitat with connectivity to fishless wetland (home range larger than chorus frog's) • low road density over large area or wildlife corridors available • uncontaminated water • sufficient food supply (primarily insects) available	• fishless wetlands missing or isolated from terrestrial habitat, riparian zone cleared of vegetation • wetland lacking aquatic vegetation • water contaminated by road salt, pesticides or other toxins • food supply reduced through other ecosystem impacts • hunting/collecting
American toad (*Bufo americanus*)	L4	• at minimum, some area of meadow/ successional/forest/parkland/lawn or garden habitat with connectivity to wetland • uncontaminated water • road density not too high in habitat area	• water contaminated by road salt, pesticides or other toxins • road density/traffic volume or speeds high • pesticides in terrestrial habitat • insufficient food supply (primarily insects) as a result of other impacts
Green frog (*Rana clamitans*)	L4	• wetland/pond/lake with aquatic vegetation & riparian cover • permanent water deep enough for overwintering tadpoles • uncontaminated water	• lack of permanent deep water; natural riparian &/or aquatic vegetation cleared • water contaminated by road salt, pesticides or other toxins • hunting/collecting

Indicator species	L rank	Presence indicates:	Absence may indicate one or more of:
Bullfrog (*Rana catesbiana*)	L1	• large wetland/pond or lake with aquatic vegetation & riparian cover; permanent water deep enough for overwintering tadpoles • sufficient supply of invertebrate and small vertebrate prey • uncontaminated water.	• lack of permanent deep water • natural riparian &/or aquatic vegetation cleared • water contaminated by road salt, pesticides or other toxins • hunting/collecting
Grey treefrog (*Hyla versicolor*)	L2	• thicket/deciduous/mixed swamp or deciduous/mixed forest connected with breeding wetlands • wetlands with emergent vegetation • uncontaminated water	• fishless wetlands missing or isolated from terrestrial habitat • riparian zone cleared of vegetation • wetland lacks aquatic emergent vegetation • water contaminated by road salt, pesticides or other toxins
Birds			Note: Many birds return to the same nesting sites year after year with their young eventually establishing territories in the immediate vicinity. As habitat is lost within our region, birds returning to affected areas will often be unable to find an unoccupied alternate location to breed.
American woodcock (*Scolopax minor*)	L3	• meadow/successional habitat patch close to forest/swamp patch or forest with openings • undisturbed ground (ground nester) • understory & ground layer intact (fallen logs etc.) • sufficient soil invertebrate food supply, especially earthworms	• meadows cleared/developed • human disturbance (flushing) in courting or nesting areas • predation by free roaming pets, especially in nesting areas • increased predation by natural predators where overall supply of prey is reduced
Ruffed grouse (*Bonasa umbellus*)	L3	• deciduous or mixed forest/swamp usually with aspen • understory & ground layer intact, including leaf litter & fallen logs • undisturbed ground (ground nester) • supply of variable foods throughout all seasons (catkins, buds, twigs, seeds, berries, fruit, forbs, insects), especially winter (aspen)	• forest clearing or forestry activities, logs/snag removal • disturbance & flushing by human activities/pets • predation by free roaming pets • hunting
Eastern screech-owl (*Megascops asio*)	L4	• mature deciduous forest or swamp or woodland with dead standing trees • existing tree cavities or nest boxes • sufficient supply of variety of prey foods (wide variety of invertebrate & small vertebrate prey to the size of a chipmunk)	• forest clearing or forestry activities, removal of snags • forest that supports great horned owls • depletion of local prey supply

Indicator species	L rank	Presence indicates:	Absence may indicate one or more of:
Wood duck (*Aix sponsa*)	L3	• mature deciduous forest close to wetland with aquatic vegetation, or swamp with dead standing trees & intact downfall • existing tree cavities or nest boxes • sufficient supply of fruits, seeds, herbaceous water plants and aquatic invertebrate prey	• forest clearing or forestry activities, removal of snags & fallen logs especially around swamps • wetland removal or separation of forest from wetland • removal of aquatic vegetation • disturbance (flushing) by human or pet activity
Pileated woodpecker (*Dryocopus pileatus*)	L3	• large mature forest area (40 ha or more), or multiple mature forest patches amounting to high coverage across the landscape • intact forest structure, i.e. snags & fallen logs including tall snags (for nest cavity building) • sufficient dead wood with carpenter ants & other wood boring insects for food (size of forest area needed depends on availability of food supply) • likely presence of other hole-nesting birds, including other woodpeckers and secondary cavity nesters such as wood duck & some owls	• forest clearing or forestry activities, removal of snags & fallen logs • mature forest missing or patches too small or far apart to provide food supply and nest sites
Eastern wood-pewee (*Contopus virens*)	L4	• deciduous or mixed forest or woodland with relatively open understory of at least 4 ha • sufficient supply of flying insect food	• excessive understory growth of invasives such as species of buckthorn • predation by increased populations of grey squirrels in urban environments • predation by free roaming cats
Ovenbird (*Seiurus aurocapillus*)	L3	• mature deciduous or mixed forest patch greater than 4 ha, most likely over 6 ha & having interior habitat (more than 100m from edge) • intact leaf litter layer with sufficient supply of insect food • undisturbed ground layer (ground nester)	• forest patches too small or isolated • dense stands of understory invasives such as dog-strangling vine • forest ground layer cleared • predation and disturbance by free roaming pets • forest disturbance through heavy trail use or off trail human activity
Scarlet tanager (*Piranga olivacea*)	L3	• mature mixed or deciduous forest patch large enough to have some interior habitat (more than 100m from edge) • sufficient supply of insect & other foods available, especially lepidoptera larvae (caterpillars) during breeding season, berries/seeds late summer • likely presence of other area sensitive forest species	• forest patches too small or overall forest cover too low in the landscape • high level of nest predation & brood parasitism (i.e. cowbirds) • high level of forest disturbance & noise - heavy trail use or off trail human activity • reduced insect population through spraying programs for pests

Indicator species	L rank	Presence indicates:	Absence may indicate one or more of:
Swamp sparrow (*Melospiza georgiana*)	L4	• marsh, thicket swamp, swamp, fen or bog/peatland • sufficient food supply, insects during breeding and berries/seeds prior to migration	• wetland removal or hydrology changes impacting wetlands • chemical pesticides or other contaminants
Green heron (*Butorides virescens*)	L3	• isolated swamp forest/thicket swamp not disturbed by human activity • sufficient supply of food especially amphibians, invertebrates	• removal of wetlands, hydrology changes resulting in drying out of wetlands • food supply missing through other impacts such as water contamination, especially reduction of amphibians
Virginia rail (*Rallus limicola*)	L3	• shallow cattail marsh, meadow marsh or thicket swamp • water depth less than 15" in nesting area • food supply of aquatic invertebrates & wetland plant seeds	• removal of wetlands • hydrology changes resulting in drying out of wetlands or flooding during summer nesting period
Bobolink (*Dolichonyx oryzivorus*)	L3	• grassland, meadow, pastureland, grain or hayfields larger than 10 ha • undisturbed ground (ground nester) • food supply of insects and grass/grain seeds	• meadows too small or missing • disturbance in meadows - human activity, free roaming pets • hayfields mowed earlier than mid-July
Eastern meadowlark (*Sturnella magna*)	L4	• grassland, meadows & pastures larger than 5 ha • undisturbed ground (ground nester) • food supply of insects	• meadow habitat loss • disturbance in meadows - human activity, free roaming pets
Savannah sparrow (*Passerculus sandwichensis*)	L4	• meadow, grassland, old fields, early successional habitat • food supply of insects & seeds	• meadow habitat loss • disturbance in meadows - human activity, free roaming pets
Flora			
Marsh marigold (*Caltha palustris*)	L4	• swamp, thicket swamp or meadow marsh • ground water input	• competition from invasive species such as purple loosestrife • altered hydrology; reduction or elimination of wetland swamps & meadow marshes
Jack-in-the-pulpit (*Arisaema triphyllum*)	L4	• moist coniferous or mixed forest	• forest floor disturbance through heavy use • invasive species such as garlic mustard, dog-strangling vine
Narrow-leaved spring beauty (Claytonia virginica)	L3	• mature deciduous forest	• forest floor disturbance • past agricultural disturbance • invasives such as garlic mustard, dog-strangling vine
White trillium (*Trillium grandiflorum*)	L3	• upland deciduous/mixed forest • intact soil	• forest floor disturbance • invasive species • collecting/picking by people • increased herbivory by overpopulation of white-tailed deer

Indicator species	L rank	Presence indicates:	Absence may indicate one or more of:
Foam flower (*Tiarella cordifolia*)	L4	• moist coniferous or mixed forest or swamp	• forest floor disturbance • altered hydrology, especially decreased moisture from urban heat island effect/climate change • invasive species
Star flower (*Trientalis borealis ssp. borealis*)	L3	• mature moist coniferous or mixed forest or swamp • intact soil and litter layer	• forest floor disturbance • altered soil chemistry due to fill, nutrient loading or past land uses • invasive species
Michigan lily (*Lilium michiganense*)	L3	• moist/wet meadow, floodplain	• reduction/clearing of vegetation along streams • collection/picking • introduced Asian lily beetle • invasives such as dog-strangling vine & Japanese knotweed
Turtlehead (*Chelone glabra*)	L3	• wetland, meadow marsh, floodplain • ground water input	• reduction/clearing of vegetation along streams • invasive species such as common reed
Swamp milkweed (*Asclepias incarnata ssp. incarnata*)	L4	• thicket swamp, meadow marsh, floodplain	• removal of wetland, hydrology changes • reduction/clearing of vegetation along streams • invasive species such as reed canary grass
Spotted Joe-pye weed (*Eupatorium maculatum ssp. maculatum*)	L5	• thicket swamp, meadow marsh, floodplain	• removal of wetland, hydrology changes • reduction/clearing of vegetation along streams
Barber-pole bulrush (*Scirpus microcarpus*)	L4	• shallow marsh, meadow marsh	• removal of wetland • reduction/clearing of vegetation along streams • increased herbivory - e.g. Canada geese
Greater bur-reed (*Sparganium eurycarpum*)	L3	• shallow marsh	• removal of wetland, hydrology changes • increased herbivory by geese • invasive species such as common reed
Common arrowhead (*Sagittaria latifolia*)	L4	• shallow marsh, streamside habitat intact	• removal of wetland, hydrology changes • increased herbivory by geese • possibly water quality deterioration
Black-eyed Susan (*Rudbeckia hirta*)	L4	• dry meadow, old fields (may be included in restoration plantings)	• removal of meadows • invasive species such as dog-strangling vine • shading due to succession (increased tree cover)
Spreading dogbane (*Apocynum androsaemifolium*)	L4	• upland forest openings & edges, successional habitat	• invasive species such as dog-strangling vine, garlic mustard, & buckthorns

Indicator species	L rank	Presence indicates:	Absence may indicate one or more of:
Fireweed (*Epilobium angustifolium*)	L3	• dry meadow, old field, disturbed ground, roadsides, railways	Note: fireweed is naturally rare in the Toronto region • elimination of natural fires in landscape • invasive species such as dog-strangling vine
White oak (*Quercus alba*)	L3	• dry forest, savannah, woodland or restoration potential for these habitats (existing white oaks often remnant pre-development trees)	• elimination of natural fires in landscape • invasive species • increased herbivory by high grey squirrel population
Big bluestem (*Andropogon gerardii*)	L3	• dry sandy soils, savannah, prairie (often included in restoration plantings) • if planted, will persist in less than ideal habitat	• reduction of prairie/savannah • elimination of natural fires in landscape • invasive species
Riverbank wild rye (*Elymus riparius*)	L4	• floodplain (often included in restoration plantings)	• hydrology - reduction of natural flooding • removal of riparian vegetation • invasive species such as dog-strangling vine
Christmas fern (*Polystichum acrostichoides*)	L3	• mature to old growth forest	• heavy trail/off trail use - trampling • invasive species such as garlic mustard • history of past cattle grazing in woodlot
Zig-zag goldenrod (*Solidago flexicaulis*)	L5	• forest	• trampling off trails • soil not original but fill
Winterberry (*Ilex verticillata*)	L3	• thicket swamp, deciduous swamp, bog	• wetland removal or high silt loading • hydrology changes • contamination of water
Eastern hemlock (*Tsuga canadensis*)	L4	• mature moist coniferous, mixed forest or swamp	• changes in hydrology and surface water (drying out, sediment loading) • surface contamination • increased herbivory
White pine (*Pinus strobus*)	L4	• upland coniferous, mixed forest or plantation (often included in restoration plantings)	• historical logging eliminated most of population • continuing forestry • surface contamination • invasive species preventing regeneration
White cedar (*Thuja occidentalis*)	L4	• coniferous forest or swamp, (often included in restoration plantings)	• surface contamination • hydrology changes • invasive species preventing regeneration

Indicator species	L rank	Presence indicates:	Absence may indicate one or more of:
Lichens			Note: Lichens obtain their moisture and nutrients from the air and the surface on which they attach. As a group they are susceptible to high levels of air pollutants and to drying out.
Candleflame (*Candelaria concolor*)	NA	• hardwood trees, dead trees and wood posts in open areas • high level of nutrients in air or substrate • near roads & agricultural fields	• removal of snags • heavy traffic related and industrial air pollution • dry or low light (shaded) conditions
Mealy rosette (*Physcia millegrana*)	NA	• hardwood trees, dead trees and wood posts in open areas • high level of nutrients in air or substrate • near roads & agricultural fields	• removal of snags • heavy traffic related and industrial air pollution • dry conditions
Common greenshield (*Flavoparmelia caperata*)	NA	• moist deciduous forests, swamps, thicket swamps • clean air	• removal of snags • roads too close • traffic related and other air pollution • dry conditions
Hammered shield (*Parmelia sulcata*)	NA	• moist deciduous forests, swamps, thicket swamps, open areas	• removal of snags • heavy traffic related and industrial air pollution • dry conditions
Hooded sunburst (*Xanthoria fallax*)	NA	• hardwood trees, dead trees and wood posts in open areas • high level of nutrients in air or substrate • near roads & agricultural fields	• removal of snags • heavy traffic related and industrial air pollution • dry or low light conditions
Rough speckled shield (*Punctelia rudecta*)	NA	• moist deciduous forests, swamps, thicket swamps • clean air	• removal of snags • roads too close • traffic related and other air pollution • dry conditions

Spring Data Sheet
Flora Species

Observer:
Site Number:

Date: Visit #1 .....
Visit #2 .....
Visit #3 .....

Survey Start Time:	#1	#2	#3
Survey End Time:	#1	#2	#3
Temperature (0C):	#1	#2	#3
% cloud cover:	#1	#2	#3
Precipitation:	#1	#2	#3

	#1	#2	#3
marsh marigold			
primary: waxy yellow flowers like large buttercups	☐	☐	☐
secondary: large roundish or kidney-shaped, shiny leaves	☐	☐	☐
tertiary: found in wetlands	☐	☐	☐
Jack-in-the-pulpit			
primary: flower stalk has over-arching hood, hood has purplish stripes	☐	☐	☐
secondary: leaves are three-parted (like a trillium)	☐	☐	☐
narrow-leaved spring beauty			
primary: low-growing plant with leaves strap-like or grass-like	☐	☐	☐
secondary: pink lines on white or pink petals	☐	☐	☐
tertiary: found in moist deciduous forests	☐	☐	☐
white trillium			
primary: leaves and flower parts in threes	☐	☐	☐
secondary: flowers white - or pale pink when aging	☐	☐	☐
foam-flower			
primary: hairy leaves, maple-leaf shape, at ground level only	☐	☐	☐
secondary: white flower clusters on leaf-less stalk	☐	☐	☐
tertiary: found in moist mixed forests and cedar swamps	☐	☐	☐
star-flower			
primary: small plant with one whorl of leaves	☐	☐	☐
secondary: small white flowers	☐	☐	☐
tertiary: found in coniferous or mixed forests - swampy or dry	☐	☐	☐

Comments:

Appendix E: Index scores for sites

	Index Scores				
Site #	Species richness	Habitat dependence	Area sensitivity	Mobility restriction	Sensitivity to Development
2	66%	57%	75%	81%	64%
3	45%	41%	43%	46%	44%
4	30%	23%	39%	40%	27%
5	57%	54%	49%	54%	56%
7	48%	48%	28%	23%	40%
8	36%	25%	41%	37%	30%
9	46%	39%	51%	52%	42%
10	54%	46%	49%	58%	51%
11	63%	63%	33%	35%	56%
13	39%	32%	25%	23%	33%
14	50%	48%	36%	38%	47%
15	30%	27%	10%	15%	27%
16	55%	54%	33%	29%	49%
17	38%	33%	30%	27%	30%
18	14%	14%	15%	12%	13%
19	38%	30%	26%	29%	33%
20	34%	34%	21%	25%	34%
22	34%	23%	20%	21%	24%
24	46%	43%	46%	56%	49%
25	30%	29%	8%	12%	29%
26	16%	12%	0%	0%	12%
27	21%	21%	8%	8%	21%
28	39%	36%	11%	19%	34%
29	29%	21%	11%	17%	22%

	Index Scores				
Site #	Species richness	Habitat dependence	Area sensitivity	Mobility restriction	Sensitivity to Development
30	46%	42%	21%	25%	37%
31	23%	12%	7%	13%	17%
32	30%	23%	15%	12%	22%
33	21%	21%	7%	10%	20%
34	16%	17%	8%	8%	15%
35	64%	64%	28%	35%	59%
36	23%	22%	2%	4%	19%
37	41%	36%	26%	27%	35%
38	21%	14%	11%	12%	13%
39	30%	29%	13%	12%	27%
43	23%	21%	10%	12%	23%
45	43%	37%	16%	21%	35%
47	27%	20%	5%	8%	17%
48	46%	40%	34%	40%	42%
49	61%	54%	36%	52%	58%
50	34%	32%	15%	15%	31%
52	39%	36%	10%	12%	33%
53	41%	32%	26%	33%	34%
54	29%	27%	15%	19%	23%
55	66%	62%	61%	63%	63%
58	68%	60%	57%	67%	64%
61	34%	23%	25%	19%	25%
62	48%	41%	43%	46%	41%
63	46%	41%	25%	31%	41%
64 - control site	13%	8%	0%	0%	10%

Appendix F: Indicator species groupings used in the analysis

Taxonomic Group	Habitat Group	Additional Group	Common name	Scientific name	L Rank
Amphibian	Wetland		American bullfrog	*Rana catesbeiana*	L1
Amphibian	Wetland		American toad	*Bufo americanus*	L4
Amphibian	Wetland		Green frog	*Rana clamitans*	L4
Amphibian	Wetland		Grey treefrog	*Hyla versicolor*	L2
Amphibian	Wetland		Northern leopard frog	*Rana pipiens*	L3
Amphibian	Wetland		Northern spring peeper	*Hyla crucifer*	L2
Amphibian	Wetland		Western chorus frog	*Pseudacris triseriata*	L2
Amphibian	Wetland		Wood frog	*Rana sylvatica*	L2
Bird	Forest		Eastern screech-owl	*Megascops asio*	L4
Bird	Forest		Eastern wood-pewee	*Contopus virens*	L4
Bird	Forest		Ovenbird	*Seiurus aurocapillus*	L3
Bird	Forest		Pileated woodpecker	*Dryocopus pileatus*	L3
Bird	Forest		Ruffed grouse	*Bonasa umbellus*	L3
Bird	Forest		Scarlet tanager	*Piranga olivacea*	L3
Bird	Meadow		American woodcock	*Scolopax minor*	L3
Bird	Meadow		Bobolink	*Dolichonyx oryzivorus*	L3
Bird	Meadow		Eastern meadowlark	*Sturnella magna*	L4
Bird	Meadow		Savannah sparrow	*Passerculus sandwichensis*	L4
Bird	Wetland		Green heron	*Butorides virescens*	L3
Bird	Wetland		Swamp sparrow	*Melospiza georgiana*	L4
Bird	Wetland		Virginia rail	*Rallus limicola*	L3
Bird	Wetland		Wood duck	*Aix sponsa*	L3
Mammal	Forest		Eastern chipmunk	*Tamias striatus*	L4
Mammal	Forest		Porcupine	*Erethizon dorsatum*	L2
Mammal	Riparian		Mink	*Mustela vison*	L3
Flora	Forest	Spring flora	Foam-flower	*Tiarella cordifolia*	L4
Flora	Forest	Spring flora	Jack-in-the-pulpit	*Arisaema triphyllum*	L4

Flora	Forest	Spring flora	Narrow-leaved spring beauty	*Claytonia virginica*	L3
Flora	Forest	Spring flora	Star-flower	*Trientalis borealis ssp. borealis*	L3
Flora	Forest	Spring flora	White trillium	*Trillium grandiflorum*	L3
Flora	Forest		Christmas fern	*Polystichum acrostichoides*	L3
Flora	Forest		Eastern hemlock	*Tsuga canadensis*	L4
Flora	Forest		White cedar	*Thuja occidentalis*	L4
Flora	Forest		White oak	*Quercus alba*	L2
Flora	Forest		White pine	*Pinus strobus*	L4
Flora	Forest		Zig-zag goldenrod	*Solidago flexicaulis*	L5
Flora	Meadow		Big bluestem	*Andropogon gerardii*	L3
Flora	Meadow		Black-eyed Susan	*Rudbeckia hirta*	L4
Flora	Meadow		Fire-weed	*Epilobium angustifolium*	L3
Flora	Meadow		Spreading dogbane	*Apocynum androsaemifolium*	L4
Flora	Riparian		Riverbank Wild Rye	*Elymus riparius*	L4
Flora	Wetland		Barber-pole bulrush	*Scirpus microcarpus*	L4
Flora	Wetland		Common arrowhead	*Sagittaria latifolia*	L4
Flora	Wetland		Greater bur-reed	*Sparganium eurycarpum*	L3
Flora	Wetland		Marsh Marigold	*Caltha palustris*	L4
Flora	Wetland		Spotted Joe-pye Weed	*Eupatorium maculatum spp. maculatum*	L5
Flora	Wetland		Swamp Milkweed	*Asclepias incarnata ssp. Incarnata*	L4
Flora	Wetland		Turtlehead	*Chelone glabra*	L3
Flora	Wetland		Winterberry	*Ilex verticillata*	L3
Flora			Michigan Lily	*Lilium michiganense*	L3
Lichen			Candleflame	*Candelaria concolor*	
Lichen			Common Greenshield	*Flavoparmelia caperata*	
Lichen			Hammered Shield	*Parmelia sulcata*	
Lichen			Hooded sunburst	*Xanthoria fallax*	
Lichen			Mealy Rosette	*Physcia millegrana*	
Lichen			Rough speckled shield	*Punctelia rudecta*	