Terrestrial Fixed Plot Monitoring

Regional Baseline Conditions Report

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TORONTO AND REGION Conservation for The Living City

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Executive Summary

The Toronto and Region Conservation Authority (TRCA) conducts a long-term Regional Watershed Monitoring Program that is designed to assess the health of the region's watersheds and natural heritage features. Under this program fish, geomorphology, water quality and benthic invertebrates are being assessed annually. In 2008, this program was augmented with the addition of a number of terrestrial long-term fixed plots. The purpose of these plots is to detect spatial and temporal trends in the vegetation, breeding bird, amphibian and Plethodontid salamander communities within the TRCA jurisdiction.

In 2008, TRCA biologists' established forest vegetation and forest bird fixed plots across the jurisdiction. In 2009, additional regional plots were set-up to monitor wetland vegetation, wetland birds, frogs, Plethodontid salamanders and meadow birds. More plots will continue to be added where possible. Through the use of standardized scientific data collection protocols, the response of the terrestrial system to various landscape changes such as increased natural cover through reforestation efforts or to increased use of the natural area due to recent nearby urbanization can be quantitatively documented. The assessment of changes in these natural systems can then be used to better guide management actions on site with the aim of improving overall biodiversity.

Flora and fauna communities in the TRCA jurisdiction have been characterized using data collected between 2008 and 2010. This time frame allows for three years of data collected for forest vegetation and forest birds and two years of data for all wetland indicators (vegetation, birds and frogs), Plethodontid salamanders and meadow birds. The data collected will represent the baseline conditions. As the purpose of monitoring is to detect change, several years of data (at least five) are required in order to have a data set that is large enough to conduct analysis and to start to identity any trends. The longer term goal of the monitoring project is to have a large enough sample size in order to not only detect trends across the jurisdiction but also to be able to compare results between three land-use types; urban, urbanizing and rural. Although, presently the sample size is not large enough for this analysis, there is a sufficient sample size for most of the measures in order to compare data collected in the urban and rural land-use zones (Table 1).

Table 1. Number of plots in each land-use zone for each terrestrial monitoring indicator

Monitoring Indicator	Land-use Zone			
	Urban	Urbanizing	Rural	Total Number of Plots
Forest				
Forest vegetation	12	3	9	24
Forest birds	14	3	10	27
Plethodontid salamanders	9	2	8	19
Wetland				
Wetland vegetation	7	1	10	18
Wetland birds	7	2	9	18
Amphibians	7	2	9	18
Meadow				
Meadow birds	4	4	6	14

The monitoring methodology employed by TRCA is very closely based on that which is used by Environment Canada in its Ecological Monitoring and Assessment Network (EMAN) and the Credit Valley Conservation Authority (CVC) (EMAN 2004a, EMAN 2004b, CVC 2010). By implementing the same monitoring protocols as other agencies, especially those nearby, a larger data set is available for comparison. This is truly advantageous as the data collected in the TRCA jurisdiction can be validated by being placed into a larger context in the Greater Toronto Area or south-central Ontario which could strengthen data analysis for certain applications. For further details on the monitoring methodology used by TRCA for its forest, wetland, and meadow stations refer to Section 3.0.

Health of TRCA Forests

Vegetation

The age distribution of trees in the TRCA forest plots (11 in the rural and 13 in the urban land-use zone) is close to that of normal distribution. Older trees over 100 years of age have a distinct presence but are not common. The composition of the forests was found to be dominated by sugar maple (*Acer saccharum* ssp. *saccharum*) with white cedar (*Thuja occidentalis*), bur oak (*Quercus macrocarpa*), and eastern hemlock (*Tsuga canadensis*) as co-dominant trees. The forest canopy was generally healthy with minimal crown die-back detected (<10%). Few species are represented in the regeneration / sapling layer and with low numbers. Sugar maple accounts for the majority of all saplings that are regenerating along with white ash (*Fraxinus Americana)*. Choke cherry (*Prunus virginiana*) and European buckthorn (*Rhamnus cathartica*) constitute the second and third-most abundant species across all of the forest plots. Ground vegetation overall seemed to be reasonably healthy with native species dominating the ground layer in both rural and urban land-use zones, although the latter had somewhat more exotic. The relative scarcity of exotic species in the ground layer was actually an unexpected result. Nonetheless, the higher level of invasion in urban forest stands did provide a flag for a potential threat in the future. The three main species recorded: dog-strangling vine (*Cynanchum rossicum)*, garlic mustard (*Alliaria petiolata*), and European buckthorn are all serious threats to our forests (Knight *et al*. 2007). They are constantly encountered in TRCA biological inventories, but invasion is perhaps a bit slower in the forest stands included in the set of monitoring plots.

What appears to be missing in the forests however is the number of dead standing trees or “snags”. Compared to typical eastern North American forest stands, the number of dead trees found was well below the average. Only 14% was observed in comparison to 25% that are generally found in healthy forest systems. In addition, within the urban land-use zone the number drops substantially to only 8%. Rather than this being an indicator of low tree mortality and exceptional forest health, it is more likely the result of human removal of dead trees. In urban and near-urban areas frequented by people, the clearing of “hazard trees” is a growing concern. Dead and near-dead trees can also be culled during forest management for wood production. The paucity of snags is actually a potential ecological problem in that they represent a significant habitat feature for other species, including native birds, insects and fungi.

TRCA results show mortality rates may be elevated among certain species: American elm, *Ulmus americana* (55% of which were dead), ironwood, *Ostrya virginiana* (26% dead), white ash (25%), and beech, *Fagus grandifolia* (15%). Dutch elm disease has been attacking elm for decades so the high rate of mortality in this species is not surprising. The high prevalence of dead white ash – even in the absence of emerald ash borer (*Agrilus planipennis*) observations, is concerning and requires further investigation. Is there a serious ash yellows disease problem or is it natural mortality due to succession (white ash is somewhat of a pioneer species though less so than poplars)? The high prevalence of dead trees among the ironwood is even stranger and the reason for this is unclear at this point and further data is required. Beech bark disease is having a severe impact in much of eastern North America so closer attention to the presence of the canker infection will be needed. The fact that many of the beech trees in TRCA plots currently seem to have a full leaf canopy even while affected by beech scale is reassuring, but this may be temporary and infected trees may go into decline if another stressor is added, such as drought.

Although there is evidence for some gradual deterioration in the urban zone, species richness is relatively high in the TRCA forest plots and completes the picture of fair to good forest ecosystem health in the jurisdiction. There seems to be a degree of stability in forest ecosystem so long as the original canopy and other vegetation layers remain intact. This supports the idea that identification and protection of native forest communities is worthwhile and can be successful, at least for flora conservation.

Forest Birds

For the region as a whole there was a combined total of 24 breeding forest species reported from all stations with urban stations registering 12 species and rural stations registering 22 species. A large difference between the abundance of forest species in the two land-use zones was noted with a total of 530 individuals at the rural stations and 245 individuals at the urban stations. The most commonly encountered species across the region was red-eyed vireo (*Vireo olivaceus*). In the rural zone, the second most commonly encountered species was eastern wood-pewee (*Contopus virens)* while wood thrush (*Hylocichla mustelina)* and ovenbird (*Seiurus aurocapillus*) were tied for the third commonly encountered species*.* In the urban zone, eastern wood-pewee again was the second commonly encountered species while hairy woodpecker (*Picoides villosus)* was the third most common. The difference in the species most commonly encountered in the rural and urban land-use zones supports the results found through the TRCA's biological inventories, in that, the more sensitive species are generally not found in urban settings. In particular, wood thrush and ovenbird are species that nest on or close to the ground and therefore are not found in areas where there is a high amount of disturbance. Whereas species such as eastern wood-pewee and hairy woodpecker nest higher in the canopy so are not as impacted by associated urban disturbances.

Forest Salamanders

Red-backed salamanders (*Plethodon cinereus)* were reported from 17 of the 22 plots, with animals present at 9 urban plots and 8 rural plots. Among those stations that reported salamanders, a slightly higher proportion of the rural plots (50%) reported abundances greater than 20 (averaging the maximum counts from both years), but surprisingly the station that reported the greatest abundance was an urban station. The highest average maximum count in the urban land-use zone was 63 individuals whereas in the rural land-use zone it was 34.5 individuals. This may simply be a result of there being fewer natural cover objects available within the urban forest and hence a higher number of animals being attracted to the artificial cover objects that this project provided.

Health of TRCA Wetlands

Vegetation

Wetlands in the rural land-use zone are more likely to have had an organic horizon over 40cm deep. Deep organic soils are indicative of long-term stable wetland conditions. On the other hand, the urban set of transects had more evidence of carbonates; there presence is a sign of disturbance (usually either dumping of subsoil fill or erosion of the surface layers). These results are expected, given the increased amount of disturbance in urban areas.

Non-treed wetlands are most prevalent in the TRCA's sample. Of the woody vegetation regeneration recorded, shrubs outnumber trees and also have a higher cover. Treed swamps have a relatively low representation in the TRCA jurisdiction wetland transects, especially in the urban zone. Wetland ground vegetation had more exotic invasion than any of the other vegetation layers examined in this study (forest tree, regeneration and ground layers; and wetland tree and regeneration layers). In the rural land-use zone, 28% of the vegetation was exotic compared to the urban land-use zone which had 69%. The elevated coverage of exotic ground species in the urban wetlands versus the rural was statistically significant at the 95% confidence level even given the relatively and short time period of this baseline study. Hybrid cattail (*Typha* x *glauca*) was largely responsible for the dominance of exotic cover in the urban zone; however, several other exotic species were observed, including purple loosestrife (*Lythrum salicaria*), reed canary grass (*Phalaris arundinacea*), common reed (*Phragmites australis* ssp*. australis*), and giant manna grass *Glyceria maxima*, all of which are considered high-priority invasive species (Catling and Mitrow 2005; OMNR 2011). The similarity of the invasive hybrid cattail in its structure to the native broad-leaved cattail *(Typha latifolia)* means that it still provides habitat function for native fauna, in contrast to common reed and purple loosestrife.

There were 76 flora species of regional concern (TRCA rank L1 to L3) observed in all the wetland transects over the 2008-10 period: 67 in the rural land-use zone and 23 in the urban zone. This difference in the number of sensitive species and low number of exotic species found in the rural land-use zone versus the urban suggests a difference in the quality of wetlands found between these two areas. Again, this data supports data collected through the biological inventories; the clear distinction between the types of species that can be observed in these two contrasting environments.

TRCA wetlands are showing some of the same matrix influence stresses as the forests, but the impacts are if anything more accentuated. The results suggest that wetland communities are easily damaged and tend to be replaced by low-diversity stands of hybrid cattail, common reed, and other invasive species. The examples of WV-2 (Kenpark) and WV-10 (East Don Parklands) suggest that successful protection of natural communities should be possible given enough knowledge of the site, good planning, and political will.

Birds

For the jurisdiction as a whole, there was a combined total of 12 wetland-associated species reported from all stations with urban stations registering 8 species and rural stations registering 10 species. The most commonly encountered species found in the jurisdiction was swamp sparrow (*Melospiza Georgiana),* followed by common yellowthroat (*Geothlypis trichas)* and Canada goose (*Branta canadensis).* These same three species were the most common in the urban land-use zone as well however Canada goose was the second most encountered followed by common yellowthroat. The rural land-use zone had similar results to the region except Virginia rail (*Rallus limicola)* was the third most common species as opposed to Canada goose.

There was a considerable difference between the abundance of wetland-associated birds in the two land-use zones, with 46 individuals counted from the urban stations, and 96 individuals counted from the rural stations. Surveyors are just as likely to encounter swamp sparrows at urban as at rural stations, but the occurrence of the more sensitive species such as Virginia rail, sora (*Porzana carolina*) and common yellowthroat are weighted towards the rural stations.

Frogs

Six frog and toad species occur at a level of abundance across the jurisdiction that allows for effective monitoring. All six of these species were reported from the 18 sites (21stations) over the course of the 2 years of preliminary monitoring. No single site reported all six species but the rural stations consistently supported a higher number of species than the urban counterparts. All 11 of the rural stations reported frog or toad activity at some point over the initial 2 years whereas only 7 of the 10 urban stations reported activity. Green frog (*Lithobates clamitans*) was reported from the highest proportion of stations, both urban and rural. This species was present at 100% of the rural stations. Wood frog (*Lithobates sylvatica*) was the next most frequently encountered species at the urban stations while grey treefrog (*Hyla versicolor*) and spring peeper (*Psuedacris crucifer*) were both more likely to be reported from the rural stations.

Health of TRCA Meadows

A total of just 8 meadow-associated bird species were reported from the 21 stations. The most frequently encountered meadow bird species was savannah sparrow (*Passerculus sandwichensis*), occurring at 76% of the 21 stations across the region. Of the eight species, six species are ranked as L4, with one species each ranked as L3 and L2 (bobolink, *Dolichonyx oryzivorus*; and grasshopper sparrow, *Ammodramus savannarum*, respectively).

Although meadow habitat is not lacking in the jurisdiction, large sized meadows are. Meadow species of regional conservation concern such as bobolink and grasshopper sparrow are no longer found in the urban land-use zone due to the fact that large meadows have been developed and are no longer available as breeding habitat.

Next Steps

The most important step to take is to ensure that annual monitoring continues using the same protocol(s). A minimum of five years of data are needed in order to start seeing meaningful results. The following are a few possible temporal trends we should be looking for in particular, while continuing the overall monitoring program:

- Changes in the proportion of native to exotic species cover in the forest and wetland vegetation plots. These could result from natural succession and competitive pressures; intensification of land use, climate change, etc.

- Changes in species richness and Floristic Quality Index in the forest and wetland vegetation plots

- Changes in bird species richness and representation recorded from the forest, meadow and wetland stations, changes in Plethodontid representation, and changes in frog species richness and representation from the wetland stations

- Region wide changes in populations (richness and representation) of bird species with more southern and more northern affinities in response to climate change

- Impacts of emerald ash borer, or any other pests or pathogens that may irrupt

In addition, steps should be taken to further improve the set of monitoring plots and analyses of data as follows:

- Determine through further analysis if the sample size (number of plots and transects) should be increased.

- Focus on including better representation of under-represented vegetation communities, for example, disturbed lowland forests and tableland deciduous swamps.

- The statistical power of the TRCA dataset could be improved by pooling the data with other GTA CAs, government and non-government organizations that use the same or similar monitoring methodologies.

1.0 Introduction

The Toronto and Region Conservation Authority (TRCA) has developed and is implementing a long-term Regional Watershed Monitoring Program (RWMP) that is designed to assess the health of the region's watersheds and natural heritage features. In 2008, this program was augmented with the addition of a number of terrestrial long-term fixed plots. The long-term monitoring plots represent an addition to our other projects: the systematic natural heritage inventory and assessment information that maps comprehensive vegetation community, flora and fauna species data across the landscape, which began in the late 1990s (TRCA 2007); and the terrestrial volunteer monitoring program (started in 2002) that focuses on occurrences of a limited number of indicator species.

TRCA biologists' established forest vegetation and forest bird fixed plots across the jurisdiction beginning in 2008. In 2009, additional regional plots were set-up to monitor wetland vegetation, wetland birds, frogs, Plethodontid salamanders and meadow birds (Figure 1). Plots were placed in forest, wetland and meadow habitat types using the TRCA's Long Term Monitoring Project (LTMP) protocol (TRCA 2011c). In contrast to the systematic natural heritage inventory, which provides a one-time picture of the flora and fauna, the purpose of the LTMP is to detect regional spatial and temporal trends in the vegetation, breeding bird, amphibian, and Plethodontid salamander communities. Through the use of standardized scientific data collection protocols, the response of the terrestrial system to various landscape changes such as increased natural cover through reforestation efforts or to increased use of the natural area due to recent nearby urbanization can be quantitatively documented. The assessment of changes in these natural systems can then be used to better guide management actions on site with the aim of improving overall biodiversity.

This report characterizes the health and condition of the fauna and flora communities in the TRCA jurisdiction at the time of initial plot set-up and with data collected between 2008 and 2010. This time frame allows for three years of data collected for forest vegetation and forest birds and two years of data for all wetland indicators (vegetation, birds and frogs), Plethodontid salamanders and meadow birds. The data collected will represent the baseline conditions from which future change will be measured. As the purpose of monitoring is to detect change, several years of data (at least five) are required in order to have a data set that is large enough to conduct analysis and to start to identity any trends. At present, there is a sufficient sample size for most of the measures in order to compare data collected in two land use zones: urban and rural, along with detecting region-wide trends. In the longer term the LTMP should have a large enough sample size in order to include results in the urbanizing zone as well. This is the zone currently not developed but which is planned for imminent development. At present, sites in this zone are considered rural based on existing land use.

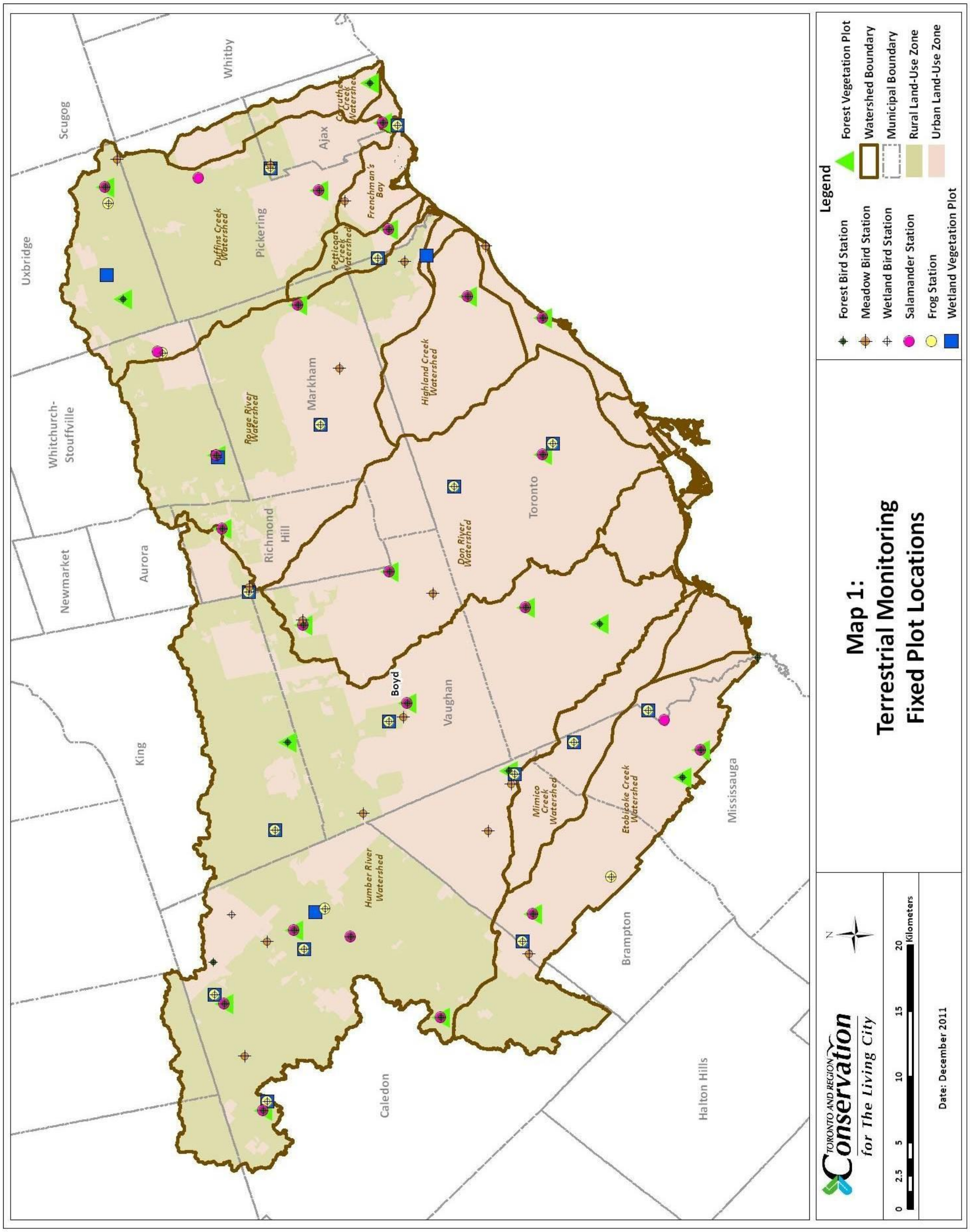


Figure 1. Terrestrial Monitoring Plots in the TRCA Jurisdiction, 2010

3.0 Methodology

The monitoring methodology employed by TRCA is very closely based on that which is used by Environment Canada in its Ecological Monitoring and Assessment Network (EMAN) and the Credit Valley Conservation Authority (CVC) (EMAN 2004a, EMAN 2004b, CVC 2010). By implementing the same monitoring protocols as other agencies, especially those nearby, a larger data set is available for comparison. This is truly advantageous as the data collected in the TRCA jurisdiction can be validated by being placed into a larger context in the Greater Toronto Area or south-central Ontario which could strengthen data analysis for certain applications. For the full monitoring methodology used by TRCA for its forest, wetland, and meadow stations refer to TRCA (2009).

For the purposes of this report, the TRCA jurisdiction has been divided into *rural* and *urban* zones, based on the existing land-use patterns observed during the three-year baseline period (2008-2010) and interpretation of 2007-2008 aerial ortho-photos. This is to enable comparison of ecosystems between the two land-use zones. For the majority of the long-term monitoring plots it is immediately obvious as to which of the two zones they are located within (Appendix 1). However, there are several borderline locations (generally "urbanizing" locations) that might currently be considered either rural or urban. To eliminate any arbitrary categorization of such plots a GIS exercise was developed to identify rural or urban plots based on percent urban and percent natural cover within a 2 km radius of the plot.

3.1 Selection of Site Quality Indicators

Long-term monitoring plots were established to identify the health and condition of key biological communities (i.e. vegetation, bird, frog, plethodontid etc.) associated with forest, wetland and meadow habitat features and to track changes in their condition over time. Ecosystem health can be measured with various indicators, including tree health, flora and fauna species richness, the representation of native versus exotic species, and the presence and abundance of sensitive species (those of conservation concern). Objectives based on such indicators, specific to each habitat type, are outlined below.

Forest monitoring plots were designed to:

- Determine the health of forests in the TRCA jurisdiction
- Determine regeneration rate and species composition of understorey saplings and shrubs
- Determine if the population and abundance of flora species, including those of conservation concern, are changing over time
- Determine the floristic quality of the site
- Determine the rate of spread of selected invasive species, and
- Determine if non-native invasive species are replacing native species
- Facilitate identification of any regional trends in the status of forest-associated bird species, and in particular to identify any changes in the proportions of variously ranked suites of species present at forest sites in both rural and urban zones.
- Track region-wide changes in the status of Plethodontids

Wetland monitoring plots were designed to:

- Determine the health of wetlands in the TRCA jurisdiction (rural and urban zones)
- Determine if the population and abundance of flora and fauna species, including those of conservation concern, are changing over time
- Determine the floristic quality of the site
- Determine the rate of spread of selected invasive species
- Determine if non-native invasive species are replacing native species.

Meadow monitoring plots were designed to:

- Assess overall trend in meadow bird species richness and abundance in the TRCA region

Indicators were selected in accordance with these monitoring objectives prior to plot set-up. Table 1 provides an overview of the indicators chosen to interpret site quality.

Table 1. List of monitoring high-level indicators chosen for long-term monitoring program

Habitat type	Monitoring Indicator(s)	Description
Forest	Tree health	Proportion healthy trees
	Mean floristic quality index (FQI)	Proportion of habitat sensitive species
	Flora species richness	Number of plant species
	Flora species abundance	Proportion of different L-ranked species
	Bird species richness	Presence of forest guild species
		Proportion of different L-ranked species
	Plethodontid abundance	Count of red-backed salamanders
Wetland	Mean floristic quality index (FQI)	Proportion of habitat sensitive species
	Flora species richness	Number of plant species
	Flora species abundance	Proportions of different L-ranked species
	Bird species richness	Presence of wetland guild species
		Proportions of different L-ranked species
	Amphibian species richness	Presence of frog and toad species
Meadow	Bird species richness	Presence of meadow guild species
		Proportions of different L-ranked species

The assessment of tree health provides a wealth of information on the condition and resilience of forest communities. Variables such as tree mortality and crown vigour are measures of tree health that are standard monitoring variables used throughout the world. While there is a long history of assessing tree health, the measurement and interpretation of species richness and biodiversity are a more recent development and some clarification is provided here.

Species richness (i.e. the number of different species) and the relative dominance of native or exotic species are important indicators of ecosystem health. A closer look at the native flora and fauna present at any given site reveals that they vary in their degrees of tolerance to disturbance.

Some are indicators of high-quality remnant habitat, thus of successful preservation or restoration efforts. They are of greater regional conservation concern. Others occur in a wide range of disturbed habitats. Various methods of assessment can be used to interpret any observed changes in composition of plants or animals. TRCA has developed a local ranking system for flora and fauna species; this ranking system was designed to reflect the ability of each species to thrive in the changing landscape of the Toronto region. The ranks range from the extremely sensitive species (L1) to the largely urban tolerant species (L5), with an additional L-rank for exotic (non-native) species (L+). Ranks are reviewed annually and subject to updates (TRCA 2010). Species with ranks of L1 to L3 are considered to be of concern throughout the TRCA jurisdiction, while those ranked L4 are of intermediate sensitivity and are of conservation concern within urban and suburban landscapes.

An additional ranking system for plants, the coefficient of conservatism (CC) was used for calculating Floristic Quality Index (FQI) of the plots. The CC is assigned to native plants and is a measure of a plant's fidelity to high-quality remnant habitats (with 10 being the most sensitive score and 0 the lowest). This system is used for various regions across North America (Masters 1997). It therefore provides us with a continent-wide standard for assessing site biodiversity and quality. The CC values used by the TRCA are those assigned for southern Ontario plants by Oldham *et al*. (1995).

Breeding bird diversity is tracked by referring to habitat guild-groupings; these guild groupings are listed in Appendix 2 and were produced primarily through staff biologists' understanding of the various species' nesting requirements.

3.2 Forest Monitoring Methodology

3.2.1 Vegetation Plots

Forest plots were set up according to standards developed by Environment Canada's Ecological Monitoring and Assessment Network (EMAN 2004a, EMAN 2004b, Roberts-Pichette and Gillespie 1999), with slight modifications. This protocol is almost identical to that used by the Credit Valley Conservation in its forest vegetation plot monitoring, although there are differences in sapling assessment (CVC 2010).

Detailed information on plot set-up can be found in TRCA (2009). In summary, each forest vegetation plot consists of one 20 x 20 m square plot (i.e. 400 m^2) for monitoring tree health; and five 2 x 2 m subplots (i.e. 4 m^2) for monitoring woody regeneration (tree saplings, shrubs and woody vines). Four of the subplots are placed 1 m outside the perimeter of the 20 x 20 m tree health plot, and the fifth is located in its centre. Ground vegetation is measured in a 1 x 1 m subsection (1 m^2) of each subplot at its southwest quarter (Figure 2). Two visits are conducted per year: in the spring and in early-to-mid summer.

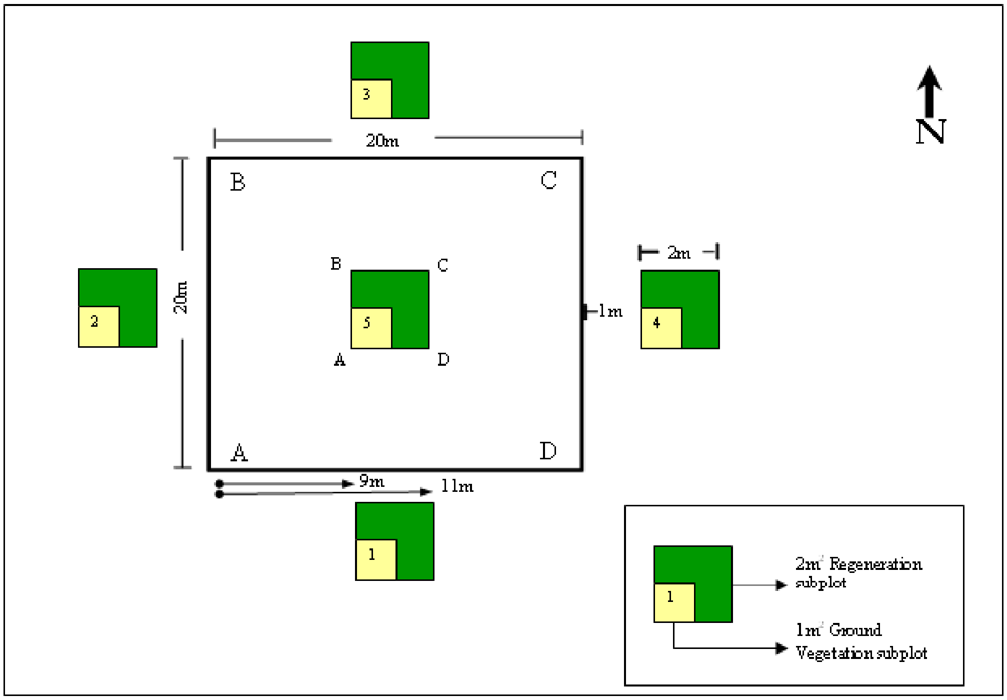


Figure 2. Forest plot design (not to scale)

There was a total of 24 forest plots set up: 21 of them in 2008 and an additional 3 in 2010. Plots were distributed across the TRCA jurisdiction and divided between two land-use zones: rural and urban. As of 2010, there were 11 plots located in the rural land-use zone and 13 in the urban. Plot locations are listed with UTM co-ordinates in Appendix 1 and shown on Figure 1.

Variables Monitored and Monitoring Frequency

Tree health is assessed in early-to-mid summer (late June to early August) when trees are in full leaf but prior to the onset of any late summer natural senescence. Tree health is monitored in the 400 m^2 plot. All trees >10 cm diameter at breast height (dbh) are assessed. Tree health assessment includes a variety of measures including; age, tree height, tree diameter, condition, crown class, crown vigour and stem defects. A detailed summary of the measures taken and their frequency is shown in Table 2.

Table 2. Forest vegetation monitoring variables and frequency

Indicator	Variable	Details	Frequency
Tree Health	Age of Stand	Cores taken from 5 trees outside plot	Once at plot set-up
	Tree Height and Diameter	Height as measured with range-finder and diameter at breast height	At plot set-up, then every 5 years; new recruits as they appear
	Tree Status and Condition	Living/dead/damaged/leaning etc.	Annually
	Crown Class	Dominant, co-dominant, intermediate, suppressed	Annually

	Crown Vigour	Fullness of canopy, presence of dieback	Annually
	Stem Defects	Wounds, scars, seams, decay, disease, insect damage	Annually
Tree Regeneration	Stem Counts	By species in 6 height classes	Annually
	% Cover by Species	Based on all stems that originate within the subplots	Annually
Shrubs and Woody Vines	Stem Counts	By species in 6 height classes	Annually
	% Cover by Species	Based on all stems that originate within the subplots	Annually
Ground Vegetation	% Cover	Cover estimates including overhang for all species found in 1 m^2 subplot	Twice annually (spring and summer)
All Vascular Plants	Total Species Richness	All species recorded in main tree health plot plus subplots	Annually (pool both visits)
	# Native versus Exotic	Separation of species identified into native (L1-L5) and exotic (L+)	Annually
	Occurrence of Species of Regional Conservation Concern	Native species are subdivided into species of regional concern (L1-L3), species of urban concern (L4), and species not of concern (L5)	Annually

Tree regeneration and shrub assessment is done during the main early-to-mid summer visit (late June to early August). Assessments are undertaken in each of the 4 m^2 subplots and include all woody plants (including vines) that are over 16 cm in height but less than 10 cm dbh. Stem counts by 6 height classes (16-35, 36-55, 56-75, 76-95, 96-200 cm and over 2 m) are recorded for each species. In addition, surveyors obtain a percentage cover estimate based on those stems that originate within the subplot.
Tree saplings and shrubs are measured at the same time but are separated for analysis purposes because saplings represent the future tree canopy, while shrubs always remain in the understorey. Woody vines are counted with the shrubs in this baseline report but future analyses allow for their separation.

Ground vegetation assessment is conducted twice per year. The first visit in May captures spring ephemerals, while the second assessment in summer at the same time as the sapling and shrub assessment captures herbaceous species that emerge more slowly and remain visible through the growing season. Ground vegetation measurements in the 1 m^2 subplots include percentage cover of vascular plants by species and also mosses and liverworts as groups. Cover assessment includes overhanging leaves as well as stems originating from within the subsection.

Finally, a total list of all vascular plant species is taken every year for each plot. This includes all types and sizes found within the 400 m^2 tree health plot as well as the subplots. The species list yields the following information:

- Total species richness (number of species)
- Number of native versus exotic species
- Occurrence of species of regional (or urban) conservation concern (ranks L1 to L3 (L4))
- Mean coefficient of conservatism – see Masters (1997) for explanation
- Floristic Quality Index (FQI) – calculated from native species richness and mean coefficient of conservatism (TRCA 2009).

A photo of the forest plot is taken for documentation purposes. It is taken from the southwest corner of the tree health plot (post A) diagonally toward the northeast (post C). GPS co-ordinates for the plot were taken (Appendix 1).

Statistical Tests

Two variables were selected for statistical tests based on assessing differences between rural and urban land-use zones: percentage cover of exotic species in the ground layer and floristic quality index based on the total species lists. The test used was a t-test at two confidence levels: 95% as is the standard for most scientific literature; and 80% as suggested for monitoring projects to identify likely trends and potential areas of concern (Zorn 2008).

3.2.2 Forest Bird Stations

Forest birds were monitored using the Ontario Forest Bird Monitoring Program (FBMP) protocol designed by the Canadian Wildlife Service. This protocol was originally developed for use in large forest patches across the province where plots are generally centred at least 100 m inside the edge of the forest patch in order to target forest bird species. Despite a relatively high degree of historic forest loss and fragmentation across the region (especially in the urban zone) the majority of forest bird stations were successfully located in situations where this criterion was satisfied.

The centre of each plot is marked with a piece of rebar hammered into the ground (with the top 2-5 cm remaining above ground) in order to be able to repeat the monitoring from exactly the same location in future visits. This location is referenced using a GPS unit to ensure repeatability at that location (see Appendix 1 for the UTM coordinates of each station).

The forest bird stations are monitored twice per year at times considered optimum for recording forest bird breeding species. The first count is conducted between May 24th and June 17th; the second count is conducted no sooner than 10 days after the first visit and between the dates June15th and July10th. Many species that are recorded before the first week of June may still be passing through the area as migrants, therefore registering a second observation in late June or July supports the indication of a territorial and likely breeding individual. All counts are completed between 05:00 a.m. and 10:00 a.m. The second visit is completed at the same time of day as the first visit and an attempt is made to maintain the same timing schedule of visits in subsequent years.

Counts are conducted in weather conditions that optimize the detection of songbird species. Ideally there should be very little to no wind, and precipitation should be at most a light rain. Overnight rainfall will also potentially have considerable impact on the ability of the recorder to hear bird song and calls since the noise from dripping trees may be enough to mask quieter species.

The FBMP requires the biologist to plot every individual bird observed and heard within a 100 m circle centred on the point station over a 10 minute period. In addition, any birds identified at distances beyond the 100 m circle are mapped at their approximate position. The count period is divided into two 5 minute segments with the observations divided between them. The following metadata are recorded on the field forms: date and start time of count period, weather conditions (wind speed and direction, cloud cover and precipitation), and observer.

For the purposes of analysis it was decided to consider only those individuals and species located within the 100 m count circle. By doing this it will be possible to diminish the effect of any variation in observer ability over the years, the implication being that all observers should be able to effectively document any birds singing within the smaller count area. Two further data filters were imposed so as to reduce any “noise” in the analysis. All species and individuals in the swallow (*Hirundinidae)* family plus chimney swifts (*Chaetura pelagica*) were omitted from this and all other analyses (i.e. wetland and meadow). These species are exclusively aerial foragers and as such they move over very large areas in search of food. Part of the analysis will concentrate on species identified as forest-guild species in the TRCA’s list of habitat-use guilds (Appendix 2); this additional data filter will incidentally exclude the aforementioned swallows and swift.

The abundance of all species was averaged across the three years so as to acquire a baseline for abundance to which future count results can be compared. This calculation was performed for the region as a whole and then for the two sub-sets: the urban sites and the rural sites.

3.2.3 Plethodontid Salamander Plots

Plethodontid salamanders are represented in the TRCA region by just one species, the eastern red-backed salamander (*Plethodon cinereus*). Due to its particular life history traits (i.e. entirely terrestrial – therefore not effected by any local wetland declines) this is an excellent species for assessing and monitoring the condition of forest ecosystems. Local populations of Plethodontids are monitored by establishing grids of 40 artificial cover boards at forest stations across the jurisdiction. The cover boards are left in place for the entire year in order to “weather” before monitoring begins. Monitoring occurs over a 5 week period shortly after spring thaw (late April and early May) when frost is no longer a threat. Data collected over and above each board’s salamander count include the presence or absence of black or red ants at the board, the disturbance of soil beneath the cover board (e.g. small mammal tunnels), any disturbance of the boards themselves (either by animal or human), weather conditions (wind speed and direction, cloud cover and precipitation), indication of precipitation within the previous 24 hours, and air and soil temperatures. The following metadata are recorded on the field forms: date and start time of count period, cover board type (double or single), cover board installation year, and observer (TRCA 2011b).

Six Plethodontid stations were already in operation prior to 2008 and these were augmented by an additional 16 stations in 2009, bringing the jurisdictional total to 22. These stations are distributed fairly evenly across the region with 10 located in the rural zone and 12 in the urban zone (using the same criteria as established for monitoring birds).

3.3 Wetland Monitoring Methodology

3.3.1 Vegetation Transects

Wetland vegetation is monitored along a 50 m transect, capturing a gradient of conditions (terrestrial to aquatic) that occur in most wetlands. Where possible, the transect starts immediately outside the wetland in an adjacent terrestrial system, while the remainder of the transect lies within the wetland proper.

Posts (lengths of white polyvinyl chloride or “PVC” pipe) are placed at 10 m intervals along the transect, and vegetation monitoring subplots occur 5 m on either side of each post. Thus, there are paired subplots at the 0, 10, 20, 30, 40 and 50 m points along the transect: 12 in total. Subplots for woody regeneration (tree saplings, shrubs and woody vines) are 2 x 2 m (4 m^2), while the rear outer quarter (1 x 1 m subplot) of each 4 m^2 subplot is used for ground vegetation) (Figure 3). Detailed information on wetland transect layout can be found in TRCA (2009).

As of 2010, there were 18 transects that were set up to capture the range of wetland types present in the TRCA jurisdiction. There are 10 in the rural land-use zone and 8 in the urban land-use zone. Transect locations were mapped with GPS readings (Appendix 1; Map 1).

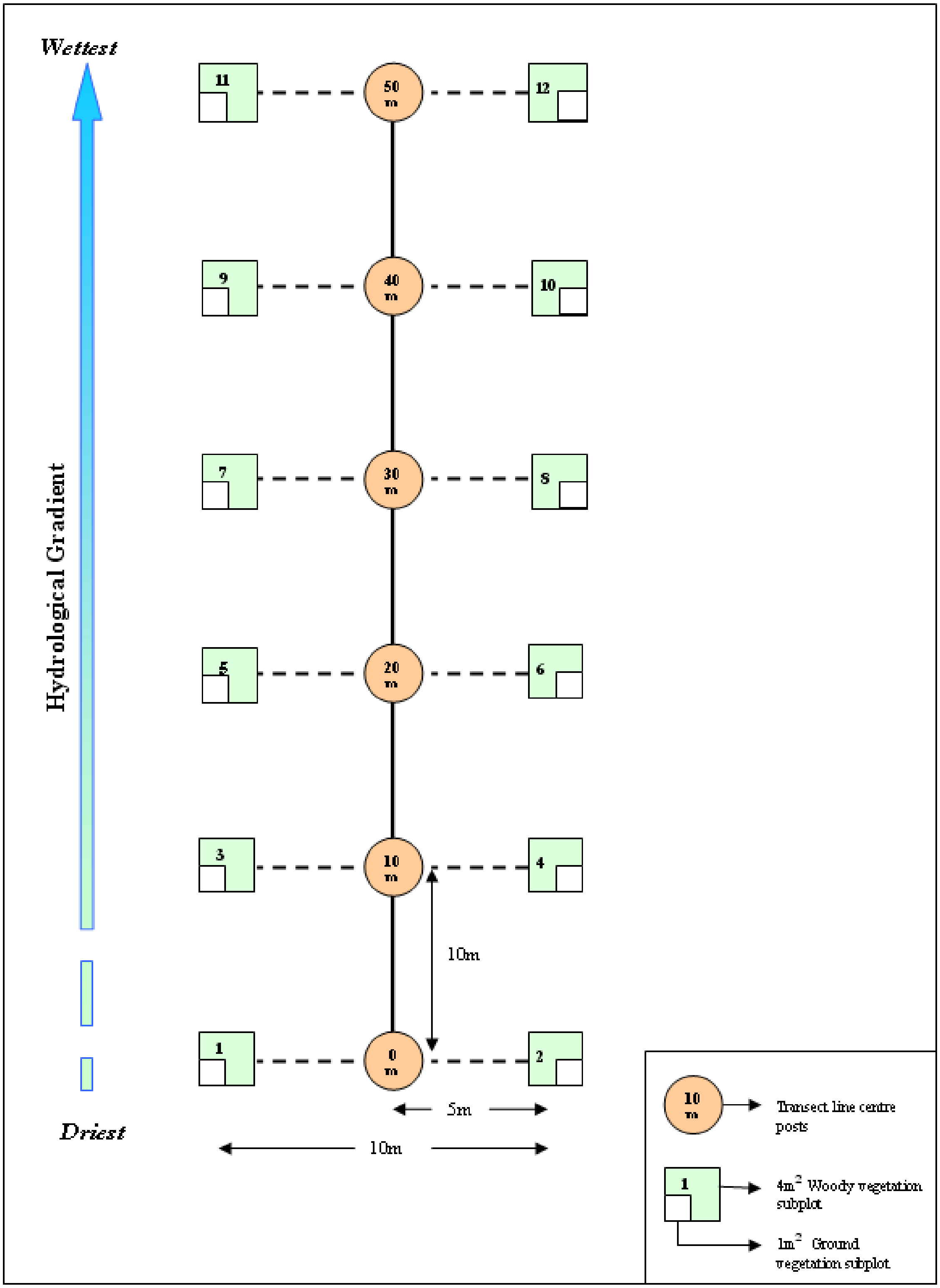


Figure 3. Wetland transect design (not to scale)

All wetland vegetation data are collected concurrently, in mid-to-late summer (late July to mid-September). This corresponds with full vegetation expansion before autumnal die-back and with relatively low water levels. The timing also harmonizes with the schedule for the forest plots, which are sampled earlier in the season.

Variables Monitored and Monitoring Frequency

Physical characteristics are assessed along with various vegetation parameters on the transect (see Table 3). Water depth is measured yearly at each of the 10 m intervals on the transect (0 to 50 m). Soils are sampled at 3 of the 10 m intervals along the transect (0 m, 30 m, 50 m) on a 5-year rotation. The depth of the organic horizon (peat or muck, if any) is recorded, as well as the presence of carbonates. Carbonates are detected by the fizzing reaction when the soil sample is treated with muriatic acid.

Trees are sampled at the 20 m post of each wetland plot. The data are simply a count of stems (living or dead) that are greater than 10 cm diameter at breast height (dbh). Tree data are collected every five years. Surveyors use a forestry prism to record tree stems.

Tree saplings, woody vines, and shrubs are counted in each of the twelve 4 m^2 subplots if they are >2 m in height but less than 10 cm dbh. However, only 3 height classes are taken: 16-95 cm, 96-200 cm and over 2 m. Cover estimates (percentage) of all species (using those stems that originate within the plot) are also taken. This is done annually.

Data on herbaceous plants (and woody seedlings <16 cm in height) are recorded within the 1 m^2 subsections of each of the 12 subplots (Figure 2). Percent cover estimates are taken for each vascular species, as well as mosses, liverworts, and algae by group.

The total list of vascular plants includes all woody and non-woody plants found within the subplot surveys plus any trees captured by the prism sweep. Species richness, proportion of native and exotic species, coefficients of conservatism, and floristic quality indices are derived from the species list.

Table 3. Wetland vegetation monitoring variables and frequency

Indicator	Variable	Details	Frequency
Physical Environment	Water depth	At 10 m intervals along the transect	Annually
	Soil organic layer	Depth of organic horizon at 0, 30, 50 m post on transect	Every 5 years
	Soil carbonates	Presence of calcium carbonate at 0, 30, 50 m post on transect	Every 5 years
	Cover	Based on all stems that originate within subplots	Annually
Herbaceous Plants	Cover	Cover estimates including overhang for all species found in 1 m^2 subplot	Annually
All Vascular Plants	Total Species Richness	All species recorded in prism sweep plus subplots	Annually
	# Native versus Exotic	Separation of species identified into native (L1-L5) and exotic (L+)	Annually
	Occurrence of Species of Conservation Concern	Native species are subdivided into species of regional concern (L1-L3), species of urban concern (L4), and species not of concern (L5)	Annually

Statistical Tests

As with the forest plots, a t-test was used to assess differences between rural and urban land-use zones for percentage of exotic cover in the ground layer and floristic quality index. This test was performed at the 95% and 80% confidence levels.

3.3.2 Wetland Bird Stations

Monitoring stations were set-up following the Marsh Monitoring Program (MMP) protocol that was established by Bird Studies Canada (BSC). This protocol provides a convenient method for conducting long-term monitoring of birds in marshes of a wide variety of size and quality (BSC, 2008).

Plot set-up involves the placement of a permanent marker (e.g. iron rebar, or wooden stake) at the centre of the long axis of the mapped count-semi-circle. This location is geo-referenced using a GPS unit (See Appendix 1 for list of UTM coordinates). There is a requirement in the protocol for all bird-stations on a route to be distanced at least 250 m from each other.

Observations and counts are undertaken in a semi-circle from the station marker since in general, stations are located at the edge of the wetland. It is therefore important to ensure that the orientation of the semi-circle is constant from visit to visit. Orientation is documented using a compass (see Appendix 1 for the orientation of each wetland station). The wetland stations are monitored twice per year at times considered optimum for recording wetland bird breeding species. The first count is conducted between May 20th and July 5th; the second count is conducted no sooner than 10 days after the first visit (TRCA 2011d).

Counts are conducted in weather conditions that optimize the opportunity for the biologist to hear and observe wetland bird species. Ideally, there should be no wind (very light wind is acceptable), and precipitation should be light rain at the very most. The surveys are conducted in the morning hours a half hour before sunrise and end by 10:00 a.m. during appropriate weather conditions for bird activity.

The MMP counts are conducted in a similar manner to the protocol used in the forest habitat. There are two main differences: first, a small suite of focal species (birds that rely on marshes as breeding habitat, i.e. obligate marsh breeders) are mapped separately. This is simply to aid in the tracking of these particular species at the broader continental scale since the MMP is an international project. Second, individuals observed beyond the 100 m count boundary, are merely noted by species and neither counted nor mapped individually. Two additional items of metadata are recorded on the field forms: a measure of background noise and the orientation of the count semi-circle.

The field protocol for monitoring wetland birds requires counts to be made of individuals located only within the 100 m count semi-circle. This should effectively diminish the effect of any variation in observer ability over the years, the implication being that most observers should be able to effectively document any birds singing within the smaller count area. The same data filters that were applied to the forest data were applied to the wetland data with all *Hirundinidae* and chimney swift records being excluded from the analysis. Only species identified as wetland-guild species in the TRCA's list of habitat-use guilds (Appendix 2) were considered in the analysis.

3.3.3 Frog Stations

Frogs are an effective monitoring indicator since they are habitat dependent and respond relatively rapidly to changes in environmental quality. Furthermore, the fact that they advertize their presence using vocalizations during a very specific time period means that as a group they are well suited to long-term monitoring.

Plots were set-up and monitored following the MMP in the same manner as wetland birds. The frog stations are 100 m semi-circles with orientation noted and maintained on each visit; these frog stations need to be at least 500 m apart. The determination of the appropriate time to conduct amphibian surveys is primarily dictated by local weather and temperature conditions. Surveys are conducted on relatively warm and moist nights that have little to no wind (based on the Beaufort Wind Scale).

Not only will strong winds dry out the skin of the amphibian causing them to remain under water and hinder calling activity but it will also impair the ability of the observer to effectively listen to any calling/singing.

Temperature guidelines change with each visit. For the first visit in the spring, night temperatures should be above 5°C, at least 10°C for the second visit and at least 17°C for the third and final visit. Surveys begin one half hour after sunset and end before midnight. When deciding on the date to conduct a survey, night air temperatures and lack of wind are the most important factors to consider (BSC, 2008).

The same metadata are collected on the field data forms for frogs as for wetland birds. However, reporting and mapping of the frogs themselves is entirely different. A point is mapped on the field sheet representing the position of separate choruses audible from the station. These choruses are mapped both within and beyond the count semi-circle. The intensity of each chorus is indicated by a number-code associated with each observation:

1. Code 1 indicates that activity is very low with individual calls readily differentiated with no overlap.
2. Code 2 indicates that activity is moderate with enough individuals calling such that calls overlap with each other, but not to the extent that the number of individuals cannot be distinguished.
3. Code 3 indicates a full chorus; so many individuals are calling that an accurate count is not possible.

Monitoring for frogs and toad species are done three times annually during the peak breeding times for the individual species. The early breeders (chorus frog, *Pseudacris triseriata;* wood frog, *Rana sylvatica*; and spring peeper, *Pseudacris crucifer*) are captured during April visits, the mid-breeders (American toad, *Bufo americanus*; northern leopard frog, *Rana pipiens*; and pickerel frog, *Rana palustris*) during May visits and the late breeders (gray treefrog, *Hyla versicolor*; mink frog, *Rana septentrionalis*; green frog, *Rana clamitans*; and bullfrog, *Rana catesbeiana*) during June visits. Each visit is separated by at least 15 days. It should be noted that 4 of the 10 frog and toad species that occur in the TRCA jurisdiction (chorus frog, American bullfrog, mink frog and pickerel frog) are too rare in the landscape to be effectively monitored using the set number of plots, however, any reports of these species will be fully documented in the TRCA database.

3.4 Meadow Monitoring Methodology

Only one parameter – bird population - is used to document change over time in the meadow ecosystem within the study area.

Meadow Bird Stations

In the absence of any bird monitoring protocols designed specifically for meadow habitat it was decided to simply use the FBMP protocol and to adjust the suite of target species during analysis

(TRCA 2011a). Meadow habitat bird species tend to acquire territories and nest a little earlier than forest habitat species, therefore the timing of the two visits is likewise earlier. Each station is sampled twice per year with the first visit occurring between May15th and May 30th, and the second visit between May 30th and June 15th, with at least 10 days between visits. Counts are conducted between 05:00 a.m. and 10:00 a.m., and at approximately the same time of day on subsequent visits from year to year.

The field protocol for monitoring meadow birds is adapted from the forest bird protocol which requires counts to be made of individuals located both within and beyond the 100 m count circle. For the analysis of results, as with the forest and wetland results, it was decided to consider only those individuals and species located within the 100 m count circle. Furthermore, the same data filters were applied again to the meadow-data whereby all species and individuals in the *Hirundinidae* family plus chimney swifts were omitted. The same metadata and variables are collected on the field data forms for the meadow sites as for the forest sites.

4.0 Results

The findings documented in this report cover the first 3 years of monitoring: 2008 to 2010. Therefore, what is presented here represents the baseline conditions for the fixed plot monitoring in the TRCA jurisdiction. Statistical analysis can commence when there is a sufficient timeline of data (5 years). At present, our data can be compared roughly with regional results collected by the nearby Credit Valley Conservation Authority monitoring program (CVC 2010).

4.1 Forest Monitoring

4.1.1 Vegetation

Stand Age and Character

The majority of the forest stands in which plots were placed are in the mid-aged to early mature age range. Based on the sampling of trees in the vicinity of the plots, the dominant age cohorts (as of 2010) in the set of regional forest vegetation plots were 31-60 years and 61-100 years (Figure 4).
The overall distribution of age across the set of forest plot sites loosely resembles a classic bell curve, with smaller numbers of trees in the under-30 years of age and over-100 years of age cohorts.

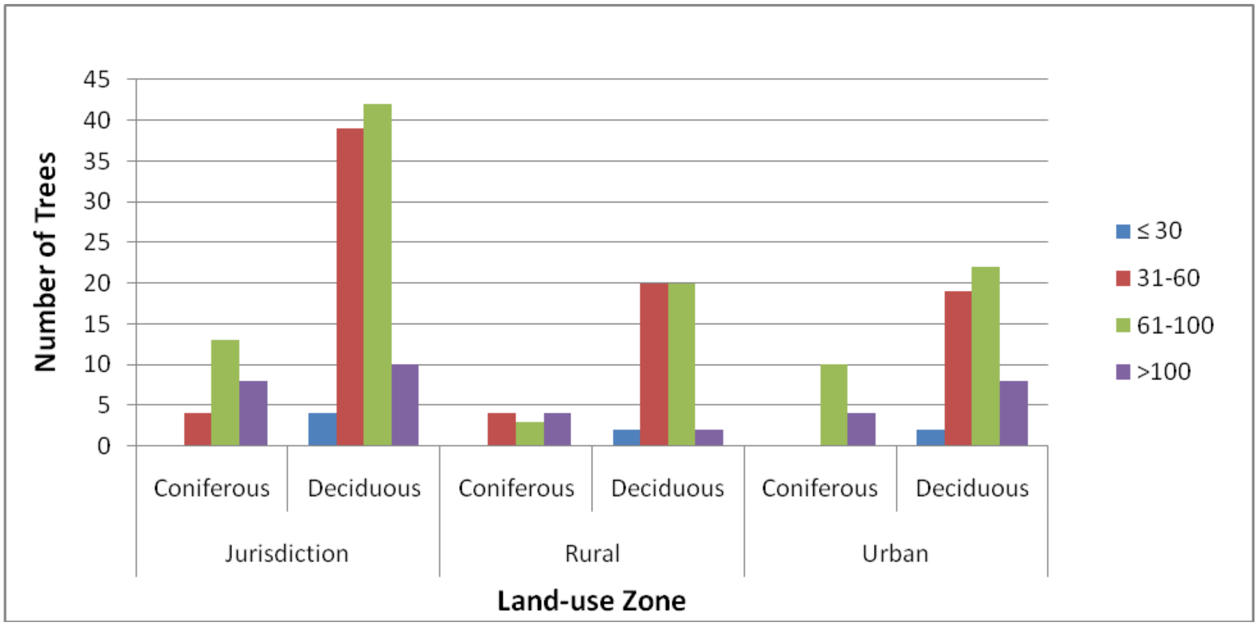


Figure 4. Age classes (by year) of trees in TRCA forest plots, (2010)

A closer look suggests there are some small differences between the urban versus rural zone and between coniferous and deciduous trees, though the sample size is not sufficient for statistical testing. Plots in the urban zone seem to be slightly weighted toward older trees, and conifers are more restricted to older cohorts. No conifers sampled were 30 years of age or younger; and in the urban zone, none were younger than 60 years.

Size

The average height of trees in the TRCA forest vegetation plots was 17-19 m, both in the urban and rural zones (Table 4). All height classes (i.e. Dominant, co-dominant, intermediate and suppressed) were factored into this figure; if the latter 2 groups were excluded a higher average canopy height would result. The tallest trees were in the 30-35 m height range.

Table 4. Tree heights in TRCA forest vegetation plots*, (2008-2010)

Land-use Zone	Height(m)	Stn dev. (m)
Jurisdictional average (n = 542)	18.0	± 6.43
Rural average (n = 225)	18.9	± 6.2
Urban average (n = 317)	17.4	±6.53

*Excludes height data for 9 trees within the dataset which were not collected at the time of this report.

Diameter at breast height ranged from 10 cm (the smallest size incorporated into our sampling protocol) to 89.7 cm (a black cherry, *Prunus serotina*, at Morningside Park on Highland Creek).

Tree Composition

In 2010, the 24 regional tree health plots contained a total of 551 *live* trees of ≥10 cm dbh (numbers were slightly lower in the previous two years because only 21 plots were monitored - three new regional plots were added in 2010). There were 254 trees in the rural zone and 297 in the urban zone. Across the whole set of plots, there were 30 species of trees encountered (Figure 5). Sugar maple (*Acer saccharum* ssp. *saccharum*) was by a wide margin the most common tree, comprising 183 trees (33.2% of the total, i.e. relative abundance). Other prominent species included white cedar (*Thuja occidentalis*) – 74 trees (13.4% of the total), bur oak (*Quercus macrocarpa*) – 50 trees (9.1% of the total), and eastern hemlock (*Tsuga canadensis*) – 48 trees (8.7% of the total).

Note that the composition of trees sampled for stand age (shown earlier in Figure 4) is slightly different because these trees are a different set, not located within the 20 x 20 m tree health plots.

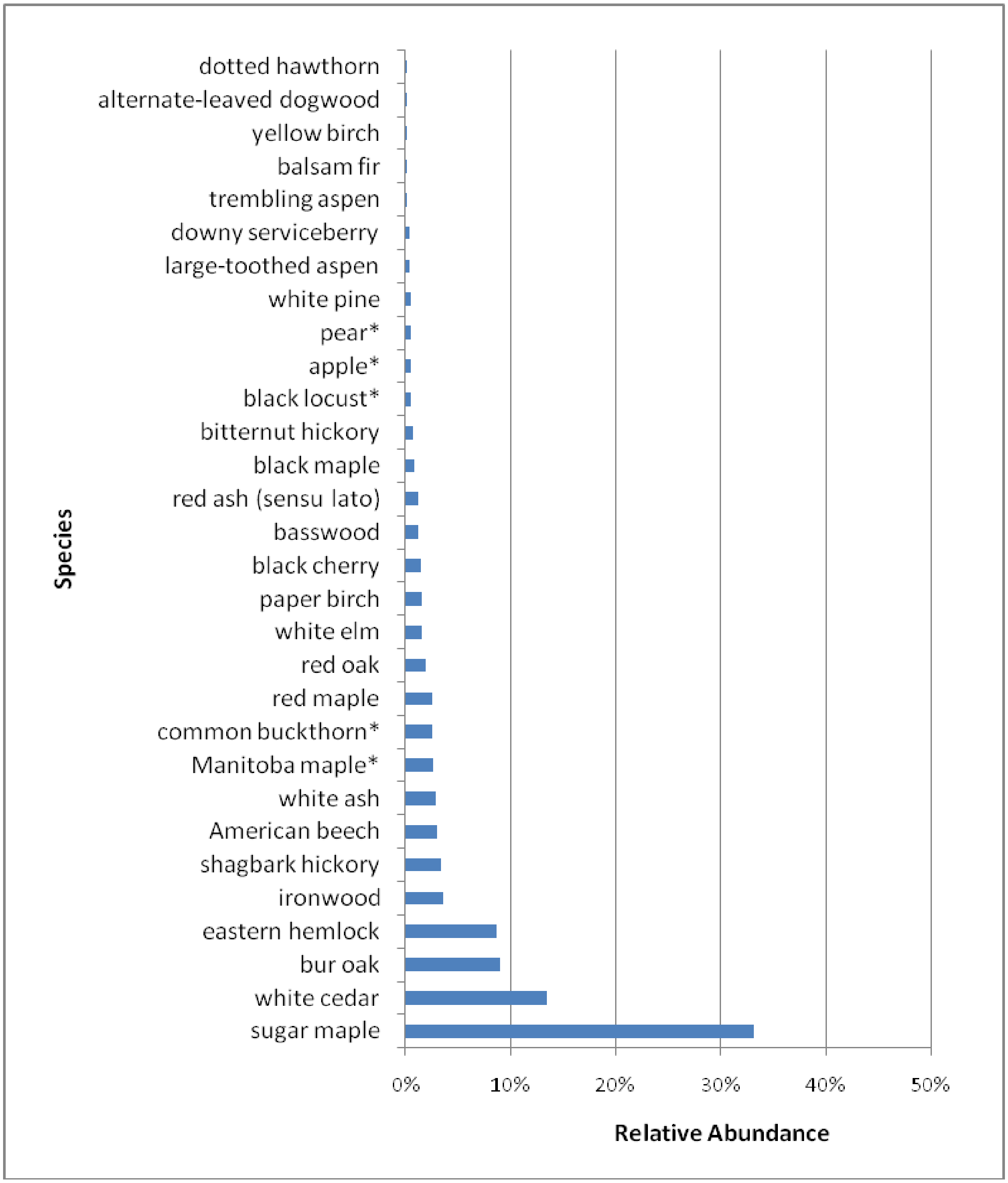


Figure 5. Tree species relative abundance in the entire set of regional tree health plots, (2010). Exotic species are indicated by an asterisk (*)

The species composition of trees in the urban and rural zones showed some differences. While sugar maple was the dominant species across plots in both zones, the remaining top four species were different (Figure 6).

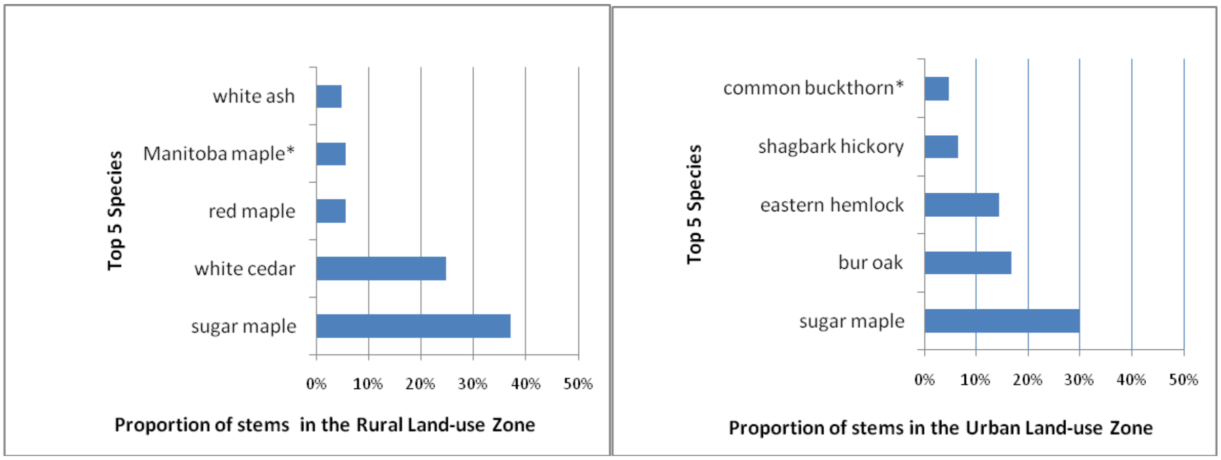


Figure 6. Five most abundant tree species in the rural and urban land-use zones, (2010). Exotic species are indicated by an asterisk (*)

White cedar was the second-most common tree in the rural zone plots, and bur oak in the urban zone plots. Neither species was in the top five in the other zone. Hemlock was third most abundant in the urban zone plots, with shagbark hickory (*Carya ovata*) and buckthorn (*Rhamnus cathartica*) fourth and fifth. In the rural zone, red maple (*Acer rubrum*), Manitoba maple (*Acer negundo*), and white ash (*Fraxinus americana*) were roughly tied for third place, but well behind white cedar.

Deciduous trees outnumbered conifers overall by about four to one (76% deciduous: 24% coniferous), with the rural zone having 71% deciduous: 29% coniferous and the urban zone 81% deciduous: 19% coniferous respectively (Figure 7).

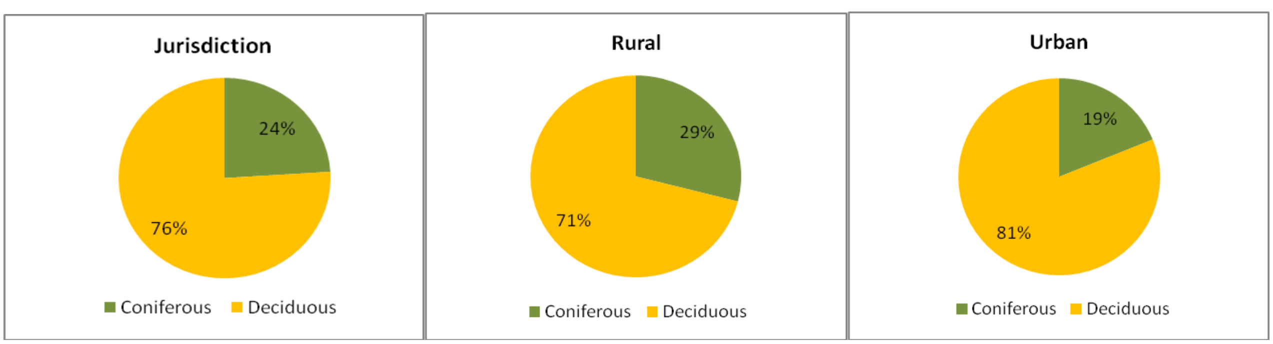


Figure 7. Proportion of coniferous and deciduous trees in forest plots, (2008-2010)

With 93% of the jurisdictional total, native species made up the overwhelming majority of trees sampled in the forest plots (Figure 8). Results in rural and urban land-use zones were virtually identical. The major exotic tree species were common buckthorn and Manitoba maple, with very small numbers of black locust (*Robinia pseudoacacia*), apple (*Malus pumila*), and pear (*Pyrus communis*) (see Figure 5).

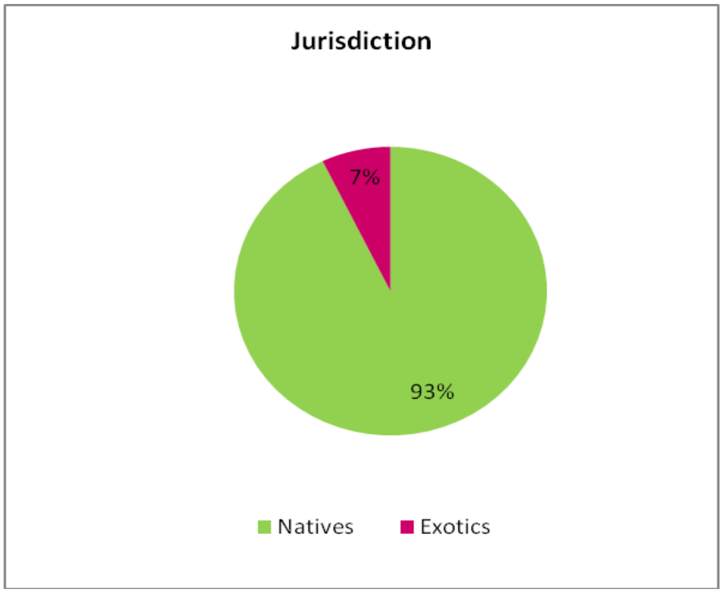


Figure 8. Proportion of native and exotic trees across the entire set of plots, (2008-2010)

Mortality

Dead trees (snags) made up 10% of the total in the entire set of plots over the period of 2008-2010. The proportion of snags was 8% in the urban zone and 14% in the rural zone (Figure 9).

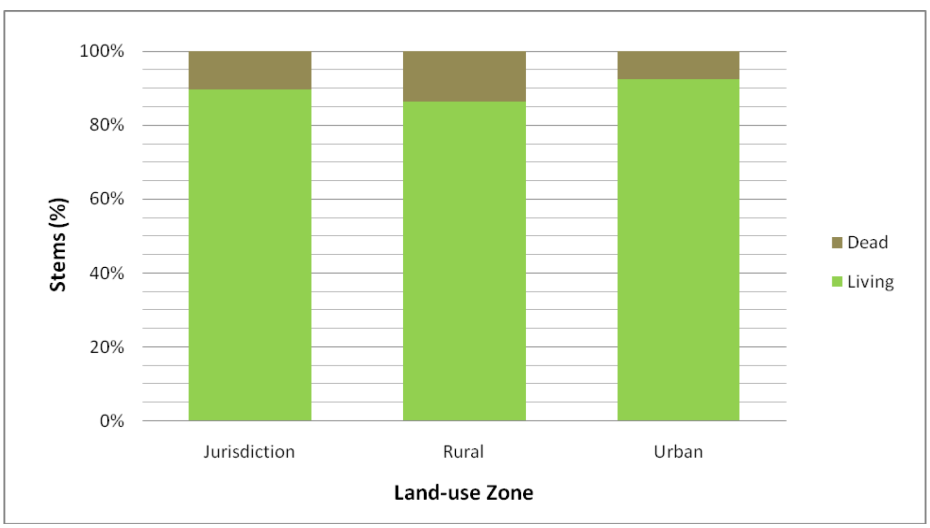


Figure 9. Proportion of snags versus live trees in TRCA plots by land-use zone, (2008-2010)

The three-year period covered by this baseline report is insufficient to determine mortality rates, only what is already dead. In 2010, American elm (*Ulmus americana*) made up the largest share of snags (15.1%) in the whole set of plots; while there was a range of other species represented (Table 5).

Table 5. Composition of snags observed in TRCA plots: six most abundant species per zone

Jurisdiction Total		Rural Zone		Urban Zone	
American elm	15.1%	balsam poplar	15.9%	ironwood	24.1%
sugar maple	9.6%	apple	13.6%	American elm	20.7%
ironwood	9.6%	sugar maple	13.6%	American beech	10.3%
balsam poplar	9.6%	white cedar	11.4%	common buckthorn	10.3%
white ash	6.8%	American elm	11.4%	white ash	6.9%
white cedar	6.8%	red maple	9.1%	eastern hemlock	6.9%

Balsam poplar (*Populus balsamifera*), apple, and sugar maple are the most abundant snags in the rural zone, while ironwood (*Ostrya virginiana*), American elm, and American beech (*Fagus grandifolia*) are the most abundant in the urban zone.

Possibly a clearer indicator of mortality would be the proportion of each species (or tree type: deciduous or coniferous) that is dead. The condition of all tree species observed in both land-use zones is shown in Appendix 3; and includes dead trees as well as the various crown vigour levels of living trees. Many species are present in very low numbers, but of those with 20 or more individuals recorded in our set of regional plots, American elm has the highest proportion of dead trees at 55%. Ironwood was 26% dead, white ash was 25% dead and American beech 15% dead. Other species with a high proportion of dead individuals (for example, all the balsam poplar stems observed were dead), were present as fewer than 20 trees.

Overall, both conifers and deciduous trees have a low proportion of dead trees in both land-use zones (Table 6). This measure may show slightly less mortality among coniferous species and in plots within the urban land-use zone.

Table 6. Percentage of conifers and deciduous trees which were dead, (2008-2010)

Tree Type	Jurisdiction	Rural	Urban
Coniferous	7.2%	8.5%	5.4%
Deciduous	11.5%	15.2%	8.4%

Crown Vigour

Crown die-back in over 80% of the trees surveyed in forest plots across the TRCA jurisdiction was minimal (i.e. <10%) in 2008-2010 and indicated a generally healthy forest canopy (Figure 10). Results from the rural and urban land-use zones were virtually identical. The average proportion of healthy crowns was 83% in the rural zone and 85% in the urban zone (Appendix 3). The proportion of trees with light to moderate crown die-back (10-50%) or severe die-back (>50%) was low, ranging from 1 to 5%.

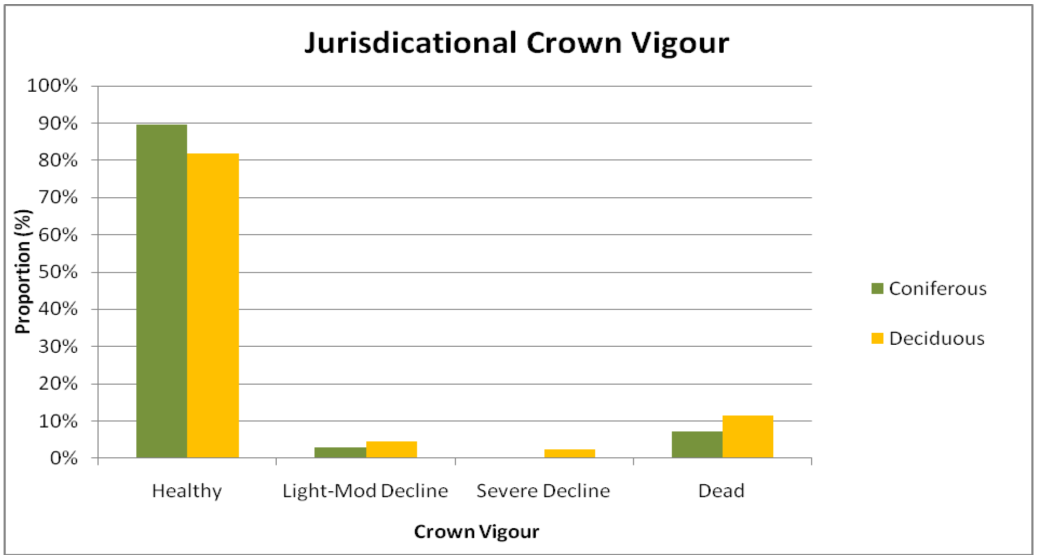


Figure 10. Crown vigour of coniferous and deciduous trees in TRCA plots, (2008-2010)

Conifers, although much less abundant in the forest plots than deciduous trees, seemed to show slightly lower levels of crown die-back. Across the jurisdiction, 90% of conifers had <10% die-back, while 82% of deciduous trees had <10% die-back.

Eight species of trees, all of them deciduous, seem to show at least slightly elevated levels of die-back compared to the average: yellow birch (*Betula alleghaniensis*), paper birch (*Betula papyrifera*), American beech, white ash, red ash (*Fraxinus pennsylvanica*), trembling aspen (*Populus tremuloides*), bur oak, and common buckthorn (Appendix 3). However, of these only the American beech, white ash, and bur oak were represented by at least 20 trees across the set of regional plots. Ten percent of the beech and white ash had light-to-moderate crown die-back (10-50%), while the 6% of the bur oak were in the light-to-moderate die-back category. An additional 8% of the bur oak showed severe (>50%) die-back. Those trees with evidence of crown die-back were more often in the more shaded crown classes. Of the trees that had severe die-back, 70% were in the intermediate or suppressed crown class, receiving little or no direct sunlight; 57% of the trees with light-to-moderate die-back were in the intermediate or suppressed crown class, and 36% of the healthy trees were in these lower crown classes (Figure 11).

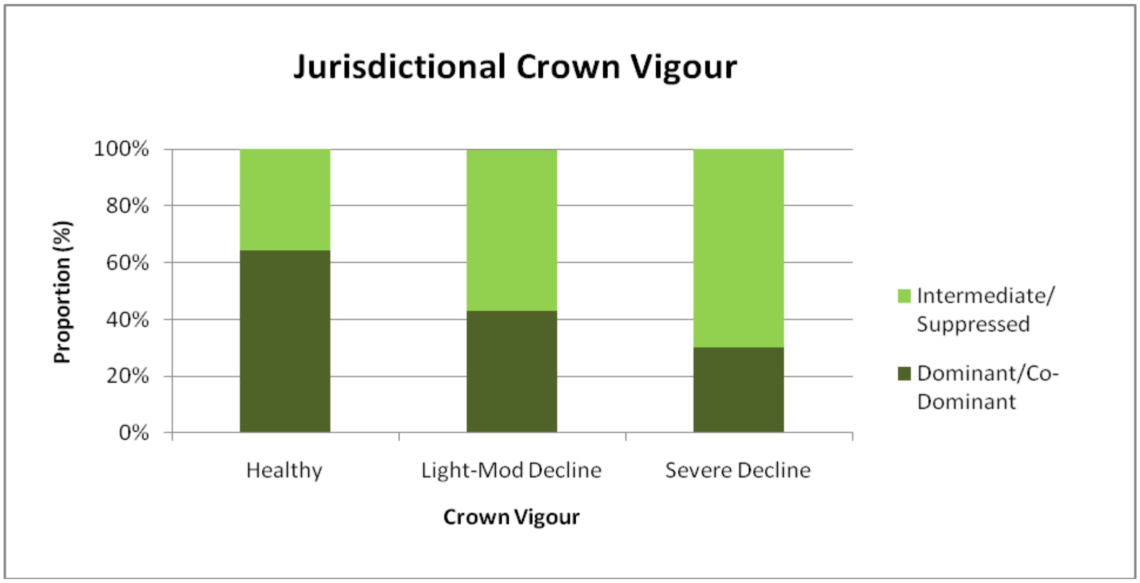


Figure 11. Crown classes of trees according to crown vigour rating in forest plots, (2008-2010)

Stem Defects

Stem defect data in 2008 and 2009 were excluded from data analysis due to inconsistencies in field collection. For this reason, only 2010 data are discussed. Somewhat fewer than half of all the trees surveyed in the TRCA plots in 2010 had noticeable stem defects. The proportion of trees affected was virtually identical in the rural and urban land-use zones (Figure 12).

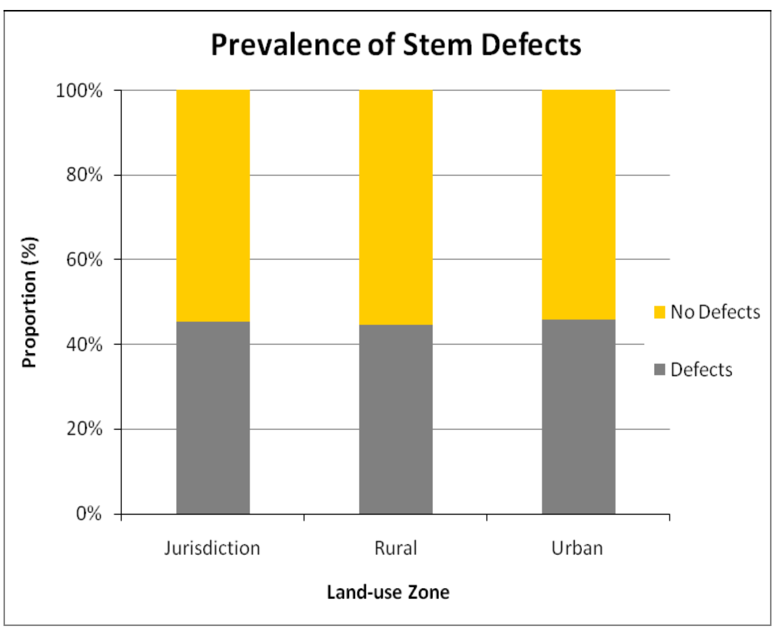


Figure 12. Proportion of trees affected by stem defects in 2010 by land-use zone

The most common stem defects were open and closed wounds. A total of 190 open wounds and 79 closed wounds were observed in 2010 (Figure 13). (The number of trees actually affected would be slightly lower given that some trees had more than one wound). There was a much lower incidence of other types of stem defects, although 30 occurrences of canker and 29 of insect damage were noted. Animal damage (e.g. deer rub or sapsucker holes) was observed only 3 times, while decay fungus was seen 13 times. Incidence of any stem defect type within the rural and urban land-use zones was similar (note that there are a slightly larger number of stems in the urban zone; and the percentage of affected trees is almost the same in both zones, Figure 13).

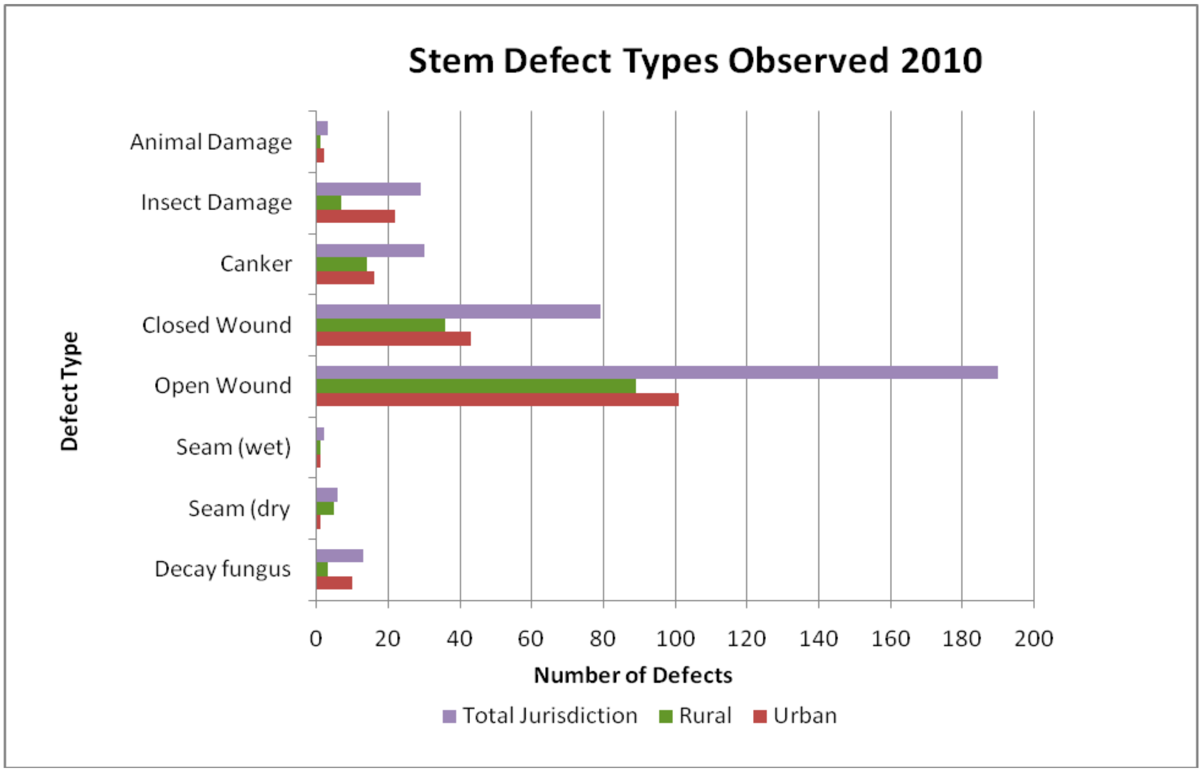


Figure 13. Occurrences of stem defects in TRCA forest vegetation plots, (2010)

Pests and Diseases

Of the numerous pathogens that can affect trees in the region, three main ones are tabulated based on reliable identification in 2010 and potential seriousness. Ash yellows affect only ash trees. It is a mycoplasmic disease whose symptoms are similar to Dutch elm disease: blockage of the vascular system followed by deformed branching, crown dieback and death of the tree (Pokorny and Sinclair 1994, Gillman 2005). Beech bark disease is composed of a combination of beech scale (*Cryptococcus fagisuga*) and *Nectria* cankers, causing decline and often death of the tree after several years. Gypsy moth (*Lymantria dispar*) is periodically a major defoliator of numerous tree species, especially oak.

Ash yellows was identified on one tree in the rural land-use zone, although there were a number of declining ash that may have been infected. Beech scale was present on every beech tree in the rural land-use zone and every beech but one in the urban zone. The secondary and more damaging component of the disease, *Nectria* canker, was not assessed consistently. Gypsy moth was observed on only two trees each in the two land-use zones (Table 7). Gypsy moth was observed as a few egg cases and dead caterpillars; there was no visible damage to the trees. Dutch elm disease (*Ceratocystis* sp.) was not observed, although there was a large number of already-dead elm.

Table 7. Occurrence of three identified pest(s) and/or disease(s) in TRCA forest plots, (2010)

	Land-use Zone	**Rural**			**Urban**		
Pest/Disease	Species affected by pathogen	# stems affected	total # stems	% stems affected	# stems affected	total # stems	% stems affected
ash yellows	*Fraxinus* spp.	1	12	8.3%	0	11	0.0%
beech scale	*Fagus grandifolia*	4	4	100.0%	12	13	92.3%
gypsy moth	many spp.	2	254	0.8%	2	297	0.7%

Forest Sapling and Shrub Composition

Total Quantity of Woody Regeneration

Density of woody regeneration varied enormously across the TRCA woody regeneration (tree sapling, shrub and woody vine) subplots. The most dense plot was Portage Trail (FV-3) in the Lower Humber subwatershed, which had 247 tree, shrub, and woody vine stems irrespective of species in 2008 (49 per 4 m^2 subplot), 289 stems in 2009 (58 per subplot), and 345 stems in 2010 (69 per subplot). One plot: FV-17 (Reesor Road – Hwy 7), in the Little Rouge subwatershed, had no live woody regeneration recorded over the period 2008-10. The average density over the two land-use zones as a whole was about the same: 9.3 stems per 4 m^2 subplot in the urban and 9.5 stems in the rural zones.

Woody Regeneration Species Composition

An average of 36 species of woody plants was observed each year in the woody regeneration subplots from 2008-10 (Table 8). This ranged from 31 in 2008 to 44 in 2010. By land-use zone, the average was 22 woody species in the rural plots and 29 in the urban plots. The average number of species per plot was 4.2 in the rural zone and 4.8 in the urban zone.

Table 8. Number of woody species in regeneration subplots by land-use zone and year

	Number of species per year			
Land-use Zone	**2008**	**2009**	**2010***	**Average**
Whole Jurisdiction	31	34	44	36
Rural all plots	16	21	30	22
Urban all plots	26	30	31	29
Rural average/plot	3.8	3.8	5.0	4.2 (±3.7)
Urban average/plot	4.3	5.0	5.0	4.8 (±3.7)

*Three additional forest vegetation plots were added in 2010, two in the rural zone and one in the urban
Standard deviation is shown in brackets

The most dominant woody regeneration species in the whole set of TRCA forest plots was sugar maple according to two measures of assessment: relative abundance (i.e. proportion of total stems) and relative cover (proportion of total twig and foliage cover). Next were choke cherry (*Prunus virginiana*) and European buckthorn. Relative cover showed a heavier skew in favour of the dominant species than relative abundance; sugar maple had 37.4% of the total relative cover but 27.0% of the total relative abundance. The vast majority of species contributed less than 2% each to relative abundance or cover.

A closer look at the results by land-use zone reveals some differences, especially in the relative abundance measure (Figure 14). Sugar maple ranks first in relative abundance in the rural zone, but choke cherry ranks first in the urban zone. Choke cherry was ranked seventh in the rural zone. Buckthorn was very common in both zones, and white ash and wild black currant (*Ribes americanum*) fairly common.

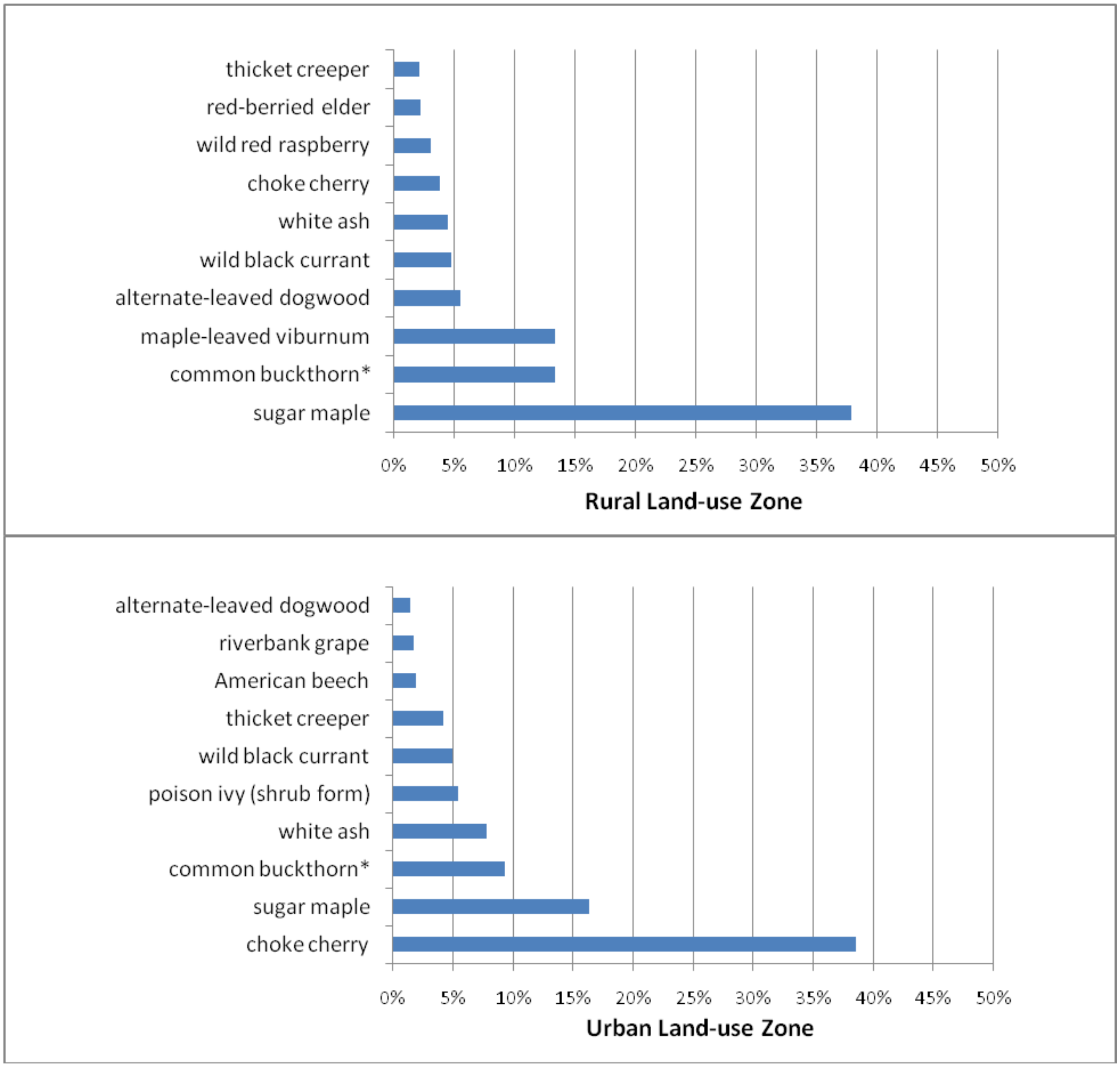


Figure 14. Relative abundance of 10 most common woody species by land-use zone, (2008-2010). Exotic species are indicated by an asterisk (*)

Sugar maple retains its dominance in both land-use zones when relative cover is considered (Figure 15). However, choke cherry, while having the second-highest cover in the urban zone, is absent from the top ten species in the rural zone. European buckthorn ranks third in both zones, while white ash and wild black currant are in the top ten for cover in both zones.

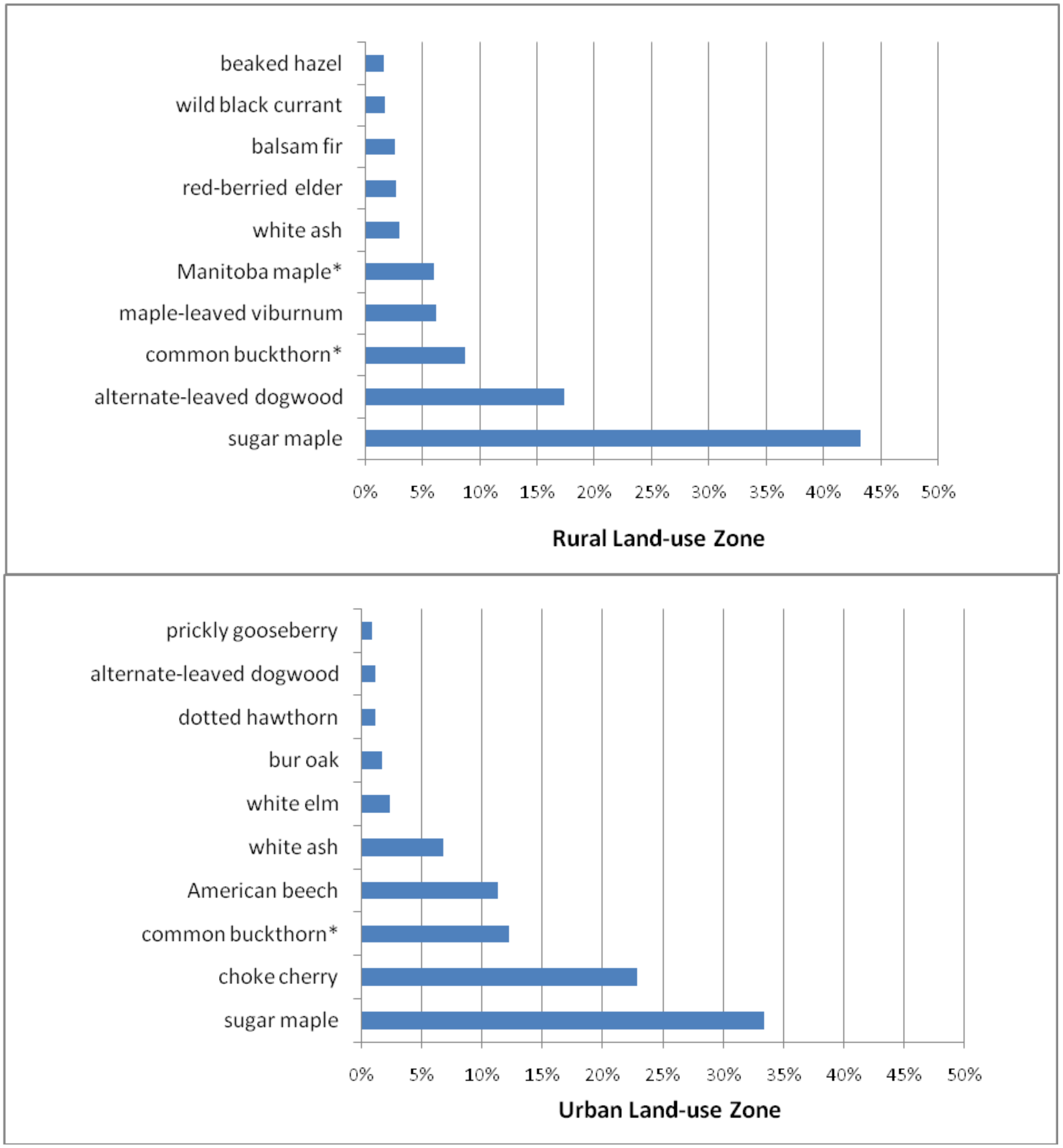


Figure 15. Average percent relative cover of Top 10 woody species by land-use zone, (2008-2010). Exotic species are indicated by an asterisk (*)

Native species dominate the woody regeneration in the TRCA forest plots with well over 80% of both relative abundance and relative cover measures (Table 9). Native woody species dominate in both land-use zones; if anything, the urban zone is slightly higher.

Table 9. Relative abundance (based on stem counts)and cover of native and exotic sapling and shrub species, (2008-2010)

Zone	Rural		Urban	
Measure	Relative Abundance	Relative Cover	Relative Abundance	Relative Cover
Native	82.4%	85.3%	88.7%	87.3%
Exotic	17.6%	14.7%	11.3%	12.7%

Forest Regeneration Composition by Growth Form

When woody regeneration is divided into growth form (i.e. tree, shrub, woody vine), it was found that the number of tree species generally was higher than the number of shrub species, which in turn was much higher than the number of woody vine species (Figure 16). There were, however, more species of tree sapling recorded in the urban zone, which averaged 17 species per year than the rural, which averaged 9 species per year. (Total species counts over the 3 year period, i.e. any species that occurred in at least one of the years, were 13 in the rural zone and 19 in the urban zone).

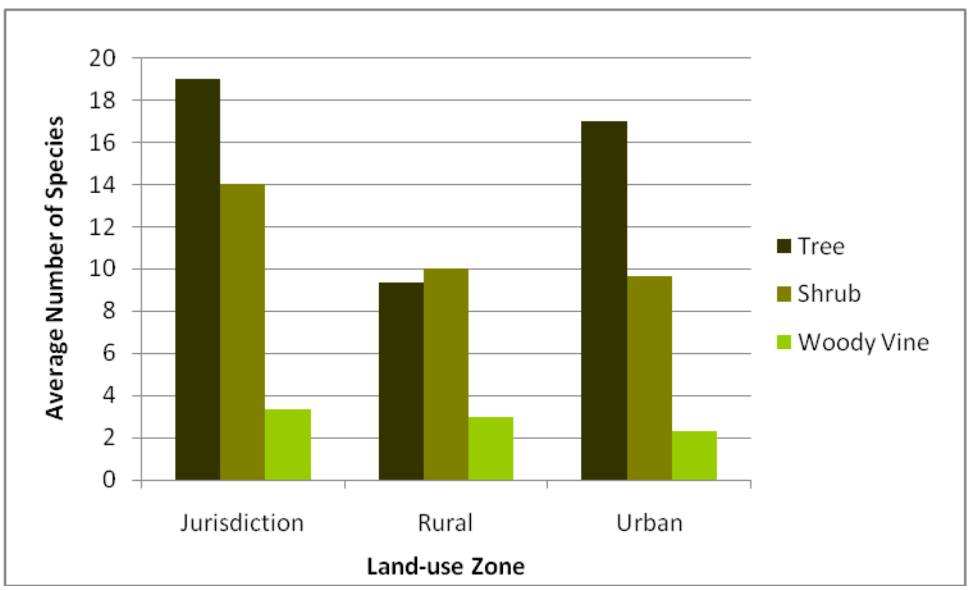


Figure 16. Average species richness tree saplings, shrubs, and woody vines by land-use zone, (2008-2010)

In terms of dominant plant type in the understorey layer, shrubs had a slightly higher relative abundance (more stems), especially in the urban land-use zone where tree saplings made up less than a third of the total abundance (Figure 17). Woody vines had a relative abundance of 3% in the rural zone and 6% in the urban zone.

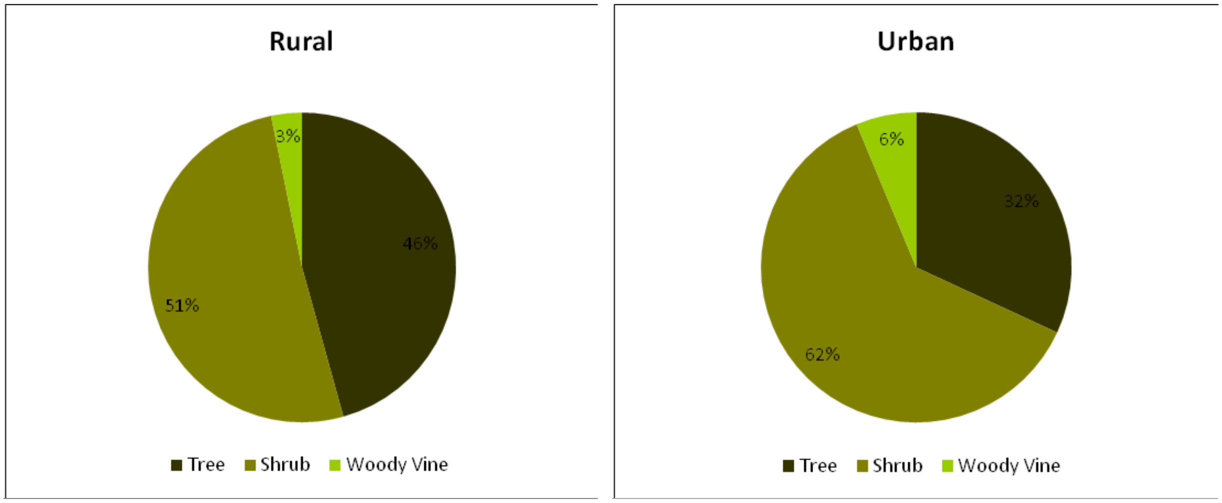


Figure 17. Relative abundance of tree saplings, shrubs, and woody vines, (2008-2010)

However, tree and shrub figures were reversed for cover, with greater cover of tree saplings than shrubs in both the rural and urban zones. Woody vine cover was very low (Figure 18).

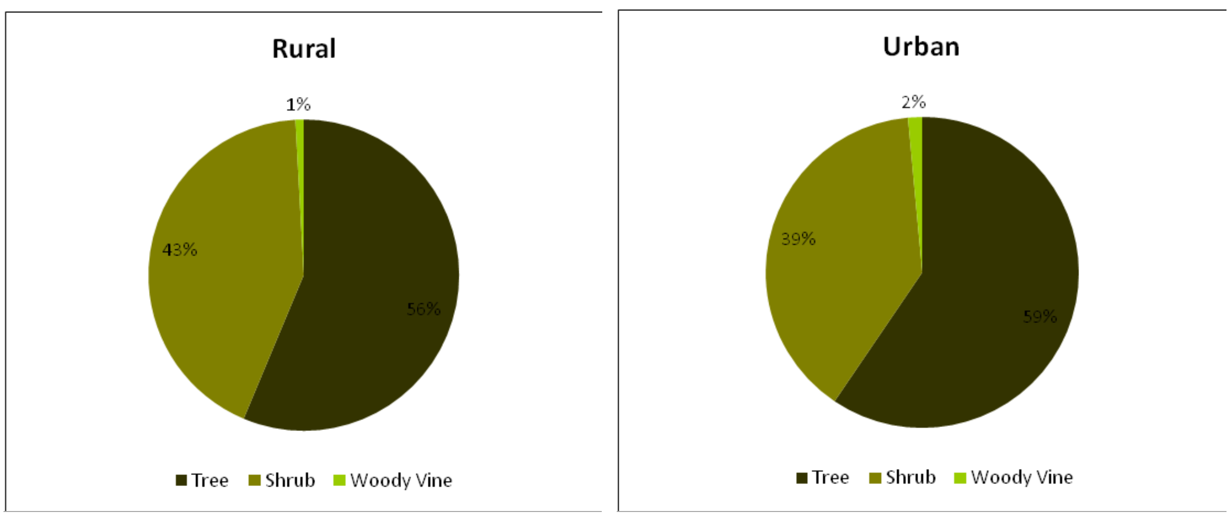


Figure 18. Relative cover of tree saplings, shrubs and woody vines, (2008-2010)

A total of 22 species of tree saplings were recorded in the forest plots over the 3-year period 2008-2010. There were 13 species in the rural zone plots but 19 in the urban zone plots (Figure 19). Sugar maple overwhelmingly dominated the tree sapling populations (relative abundance), especially in the rural zone, where this single species comprised more than 80% of all the stems. White ash was the second-most abundant species in both zones, although it was more abundant in the urban zone. Beech was a distant third in the urban zone and very scarce in the rural zone.
Conifers were almost absent in the understorey: they were represented by a single balsam fir (*Abies balsamea*) sapling in the rural zone and by two white cedar saplings in the urban zone.

Four exotic tree species were found in the sapling layer: Norway maple (*Acer platanoides*), Manitoba maple, apple, and European mountain-ash (*Sorbus aucuparia*). The latter two species were found only in the urban zone. In total, eight tree sapling species were found only in the urban zone and three tree sapling species found only in the rural zone.

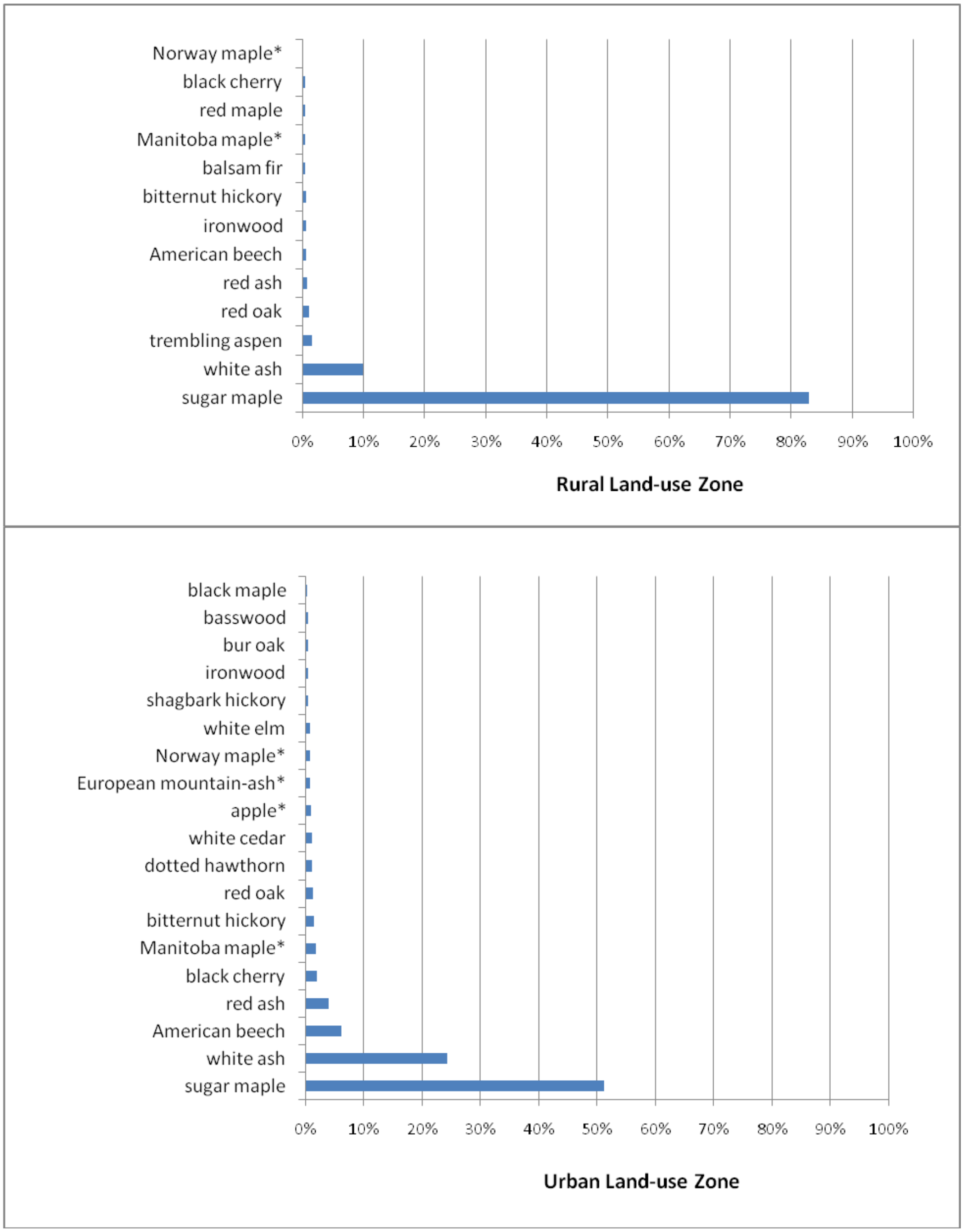


Figure 19. Relative abundance of tree sapling species in the two land-use zones, (2008-2010). Exotic species are indicated by an asterisk (*)

Shrubs and woody vines, considered together, were represented by 21 species in the rural zone (16 shrubs, 5 woody vines) and by 16 species in the urban zone (13 shrubs, 3 woody vines) (Figure 20). Choke cherry had the highest relative abundance in the urban zone, about 57% of the total number of stems. However, in the rural zone, this species ranked fifth, with about 7% relative abundance. The two most abundant species in the rural zone were European buckthorn and maple-leaved viburnum (*Viburnum acerifolium*), with relative abundance of about 24% each. Eleven species of shrub or woody vine were found only in the rural zone, and six only in the urban zone. Three exotic shrub and woody vine species occurred in the rural zone, although only buckthorn had a strong presence. There were six exotic species in the urban zone.

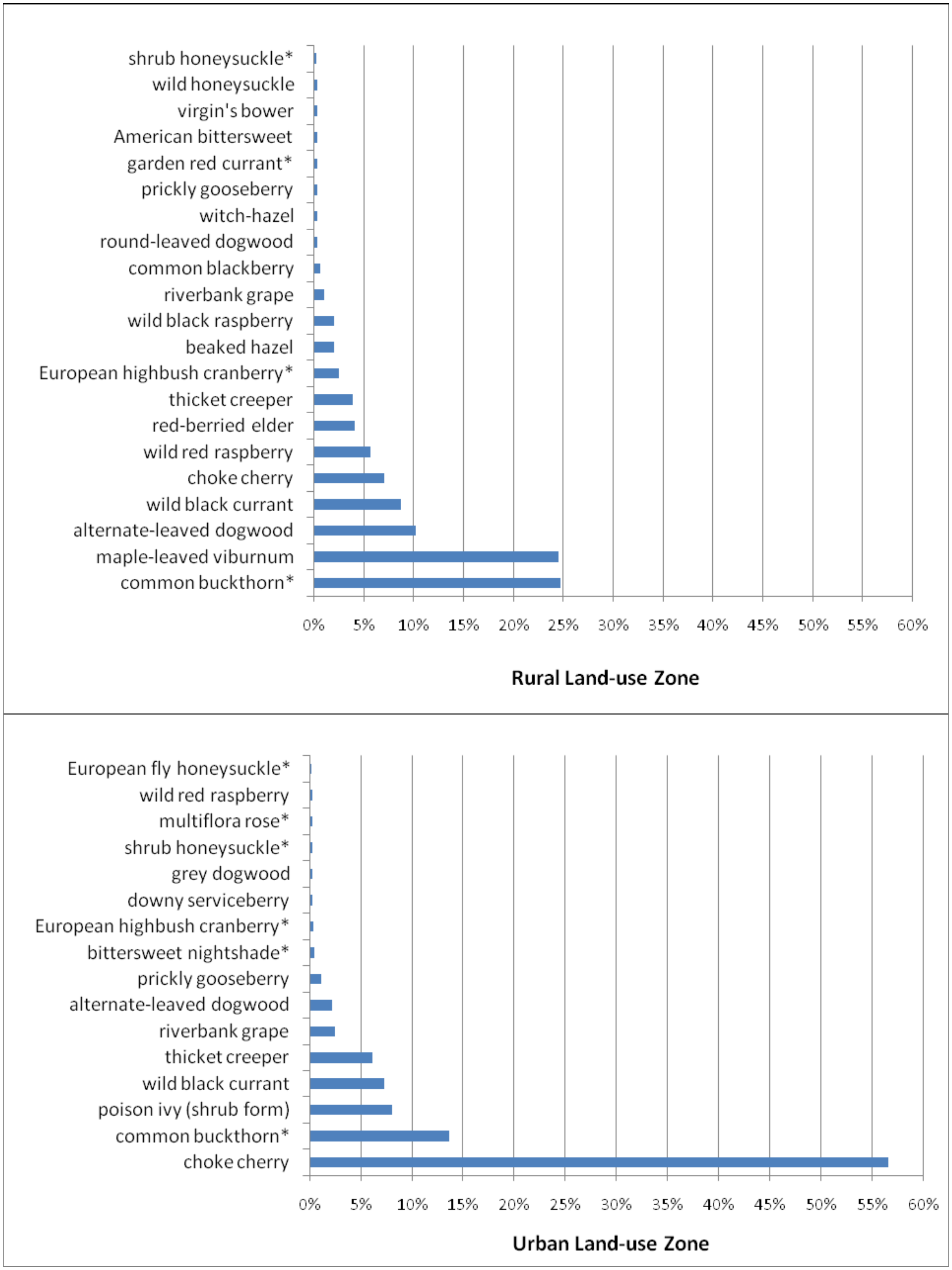


Figure 20. Relative abundance of shrub and woody vine species in the two land-use zones. Exotic species are indicated by an asterisk (*).

Forest Ground Vegetation Composition

An average of 112 species of ground layer species was observed each year in the TRCA 1 m^2 forest ground vegetation subplots from 2008-10 (Table 10). This ranged from 87 in 2008 to 137 in 2010. By land-use zone, the highest overall average number of species (77) was observed in urban subplots while the rural zone (13.9) had the highest number of species per plot.

Table 10. Number of species in ground vegetation subplots by land-use zone and year

	Number of species per year			
Land-use Zone	**2008**	**2009**	**2010***	**Average**
Whole Jurisdiction	87	111	137	112
Rural all plots	51	66	95	71
Urban all plots	67	77	88	77
Rural average/plot	8.7	11.3	15.1	13.9 (±8.5)
Urban average/plot	9.6	12.8	13.8	12.1 (±7.4)

*Three additional forest vegetation plots were added in 2010, two in the rural zone and one in the urban
Standard deviation is shown in brackets

Ground vegetation diversity varied greatly. Plot FV-17 (Reesor Road and Hwy 7) averaged only two ground layer species and FV-2 (Heart Lake) and FV-13 (Baker's Woods) had an average of four. On the other hand, FV-24 (Palgrave) had the largest number of species in the ground vegetation subplots, a total of 30 (2010 data only). Plot FV-18 (Shoal Point) had an average of 29 ground vegetation species. The total quantity of ground vegetation (i.e. the proportion of ground with cover versus bare soil) was not assessed.

Ground vegetation was more evenly distributed among a wider representation of species than was woody regeneration, which was heavily skewed toward sugar maple, choke cherry, and buckthorn. No single species contributed to more than 11% of the total relative cover (Figure 21). Fifteen species in the urban zone each contributed more than 1% of the total relative cover, and 16 species in the rural zone each had more than 1% of the total. The top four species in terms of cover (ranging from 5-11% of the total) in the rural zone were ostrich fern (*Matteucia struthiopteris*), white trillium (*Trillium grandiflorum*), orange touch-me-not (*Impatiens capensis*), and Pennsylvania sedge (*Carex pensylvanica*). The top four species in the urban zone were long-styled blue cohosh (*Caulophyllum giganteum*), Virginia waterleaf (*Hydrophyllum virginianum*), yellow trout-lily (*Erythronium americanum*), and orange touch-me-not. Over the entire jurisdictional set of plots, the top four species were ostrich fern, long-styled blue cohosh, white trillium, and orange touch-me-not.

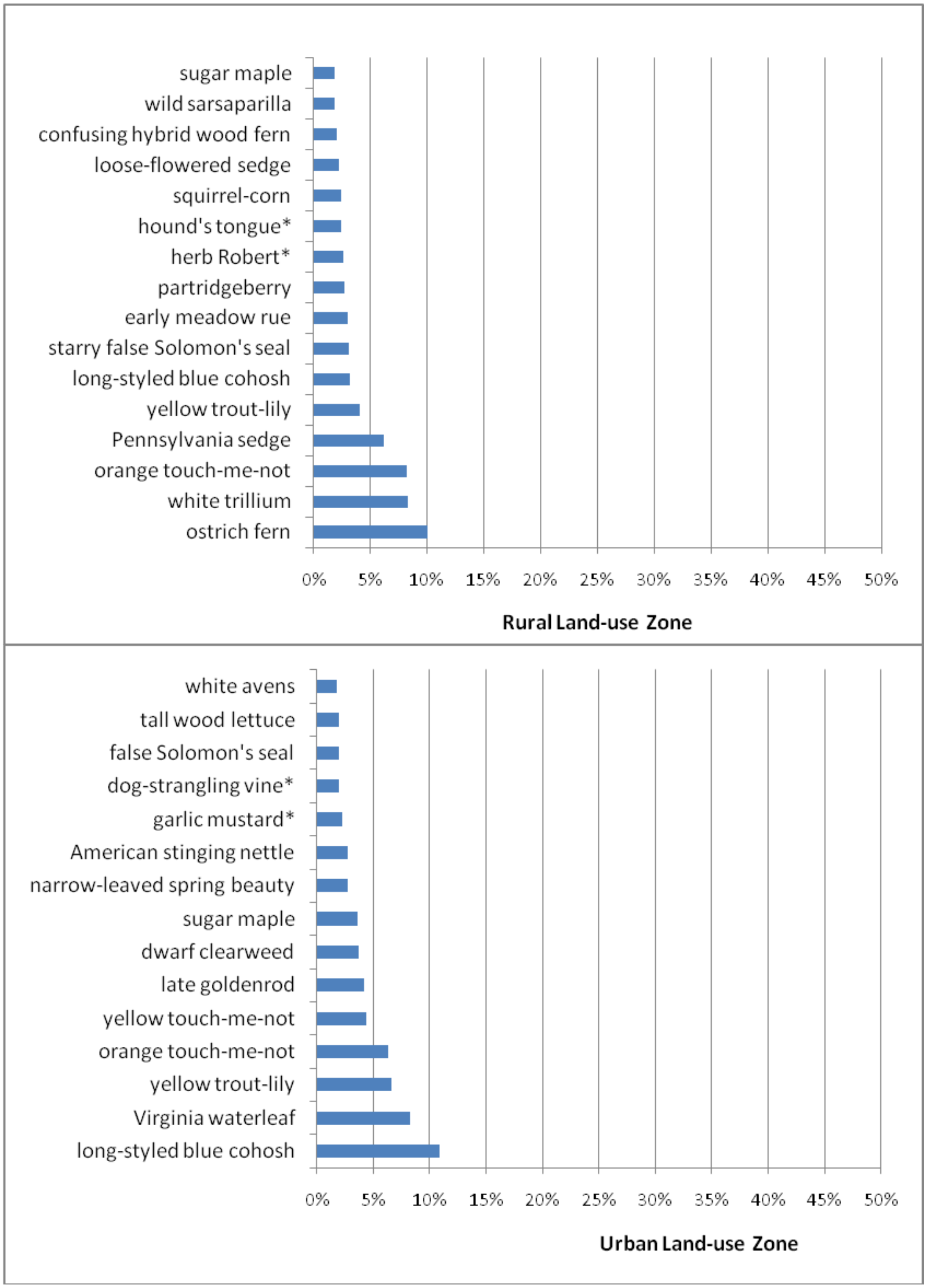


Figure 21. Relative cover of ground vegetation species having more than 1% of total, (2008-2010). Exotic species are indicated by an asterisk (*).

The *frequency* of occurrence (i.e. the number of times in which a species was found over the set of plots over the three-year period) yielded different results from cover. The most frequently-encountered species in the ground layer was sugar maple (as seedlings). Trout-lily was the second-most frequent in the rural zone and third-most frequent in the urban. Jack-in-the-pulpit *(Arisaema triphyllum)* was the second-most frequent in the urban zone and third-most frequent in the rural. The fourth-most frequent species was white ash in the rural zone and buckthorn in the urban. As was the case with trees and woody regeneration, exotic species comprised a relatively small proportion of the total cover (Figure 22). Natives occupied 90% of the total relative cover in the rural zone and 86% in the urban zone. The difference in proportion of exotic cover between land-use zones was not statistically significant at the 95% confidence level, but was at the 80% confidence level ($t=1.56$; $p<0.20$).

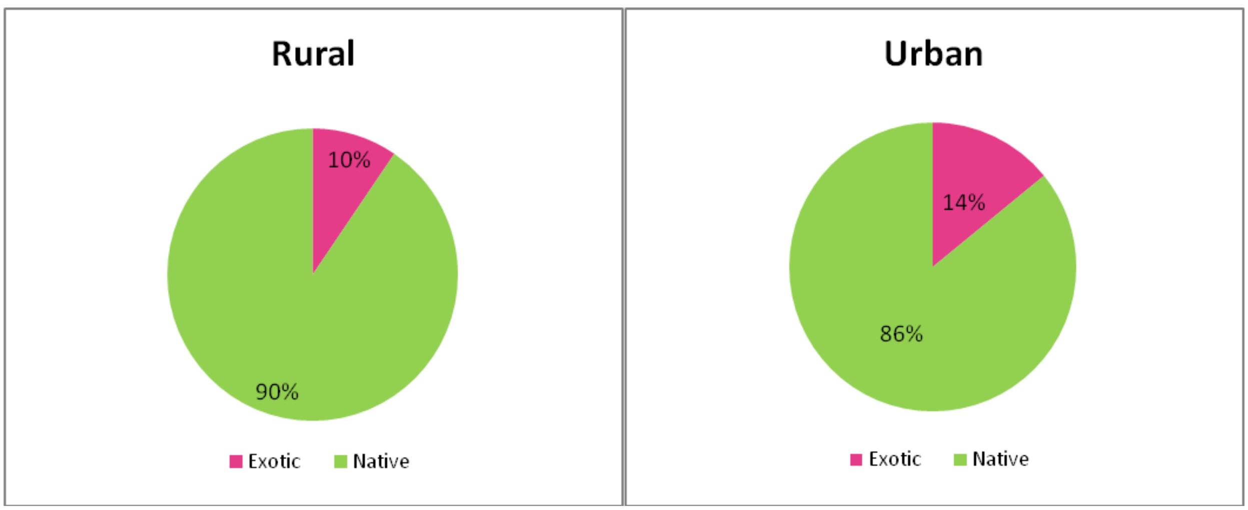


Figure 22. Relative cover of native and exotic ground vegetation by land-use zone, (2008-2010)

The main exotic ground layer species were garlic mustard (*Alliaria petiolata*), which ranked 11th in relative cover and 3rd in frequency in the urban zone, dog-strangling vine (*Cynanchum rossicum*), ranked 12th in relative cover in the urban zone, and European buckthorn, which ranked 4th in relative frequency in the urban zone. Exotic species were only a minor component of the rural ground layer.

Forest Ground Vegetation Composition by Growth Form

When ground vegetation is divided into growth form (e.g. tree, shrub, forbs etc.), it was found that the main cover was composed of forbs, especially in the urban land-use zone (Figure 23). Tree seedlings such as sugar maple, although frequent and widespread, had much less cover. The rural zone had a small but significant component of graminoids (i.e. grass-like plants), especially sedges. Ferns, mostly ostrich fern, also had a noticeable presence in the rural zone.

Spring ephemerals, especially trout-lily were an important component of the forbs in both land-use zones. Narrow-leaved spring beauty (*Claytonia virginica*), toothwort (*Cardamine* spp.), and squirrel-corn (*Dicentra canadensis*), were also noted occasionally.

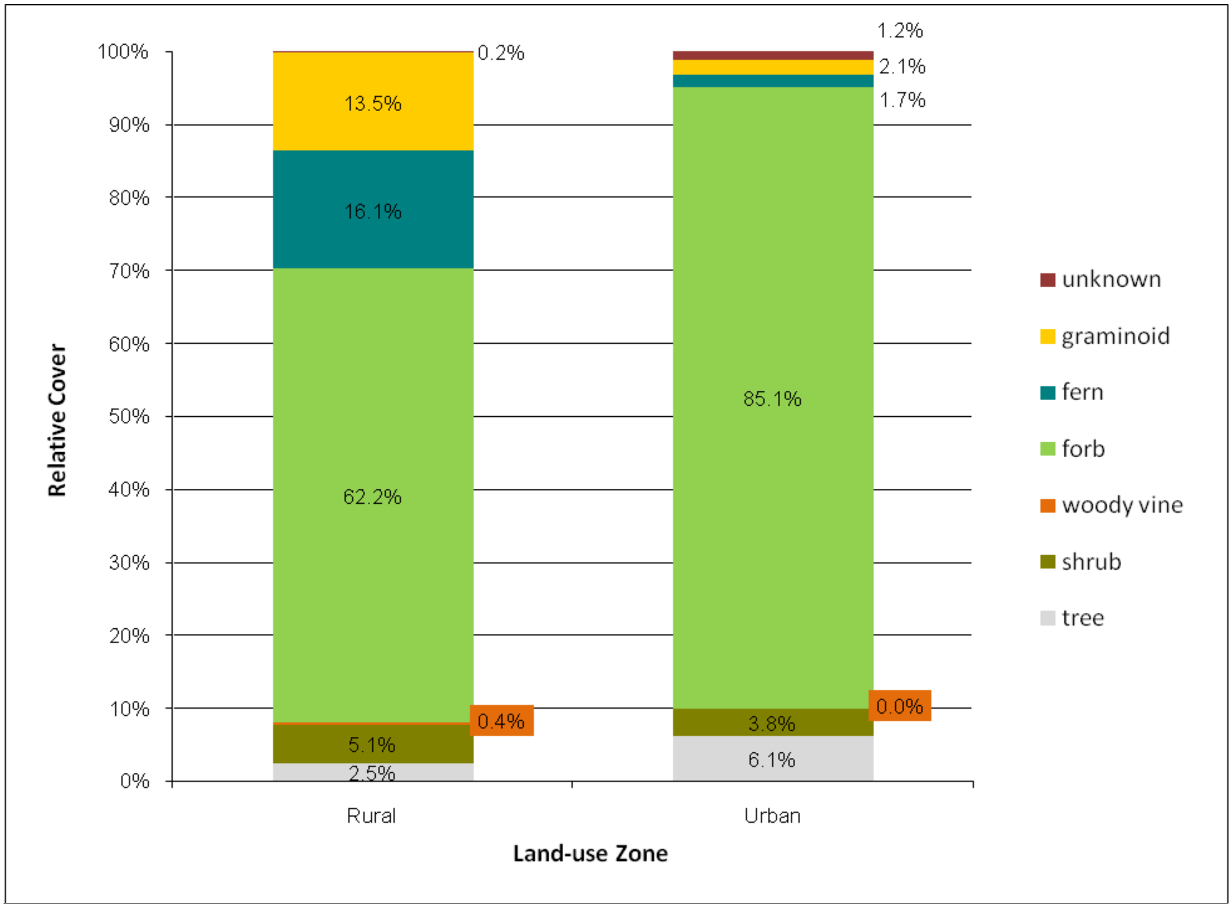


Figure 23. Relative cover of growth forms in forest ground vegetation subplots, (2008-2010)

Most of the forbs were species that emerge in the spring and persist through part of the summer, e.g. long-styled blue cohosh, false Solomon's seal *(Maianthemum racemosum* ssp*. racemosum),* and white trillium. Another group are more aggressive species that grow through the growing season and often flower in summer, e.g. orange touch-me-not, late goldenrod (*Solidago gigantea*), and Virginia waterleaf. These were more common in the urban zone.

Forest Species Richness and Floristic Quality

Floristic quality, based on the species list for the whole plot (tree health plot plus subplots), was revealed by several indicators: species richness and proportion of native species; the presence and number of species of regional conservation concern (TRCA L-rank L1 to L3); the mean coefficient of conservatism (CC) of the native species found within the plot, and the plot Floristic Quality Index (FQI) derived from native species richness and mean CC.

Total cumulative species richness for the set of TRCA forest vegetation plots (i.e. all species observed during 2008-10) was 239 (Table 11; Appendix 4). There were 192 native species and 47 exotics observed; the proportion of native species was 80.3%.

Table 11. Floristic quality measurement results at TRCA forest vegetation plots

Floristic Measure	Year	Rural	Urban	Jurisdiction
Total Species Richness	2008	113	133	169
	2009	130	149	192
	2010*	162	151	215
	cumulative 2008-10	186	171	238
	average 2008-10	135 (±25)	144 (±10)	192 (±23)
Native Species Richness	2008	95	103	137
	2009	111	115	154
	2010*	136	118	174
	cumulative 2008-10	153	133	192
	average 2008-10	143 (±21)	112 (±8)	155 (±19)
Plot Average Co-efficient of Conservatism (CC)	2008	4.7 (±0.4)	4.4 (±0.6)	4.5 (±0.6)
	2009	4.5 (±0.5)	4.4 (±0.6)	4.5 (±0.6)
	2010*	4.8 (±0.4)	4.5 (±0.6)	4.7 (±0.6)
	average 2008-10	4.7 (±0.4)	4.4 (±0.6)	4.6 (±0.5)
Plot Average Floristic Quality Index (FQI)	2008	21.9 (±4.7)	18.6 (±4.9)	20.0 (±5.0)
	2009	25.0 (±5.8)	21.2 (±5.3)	22.8 (±5.7)
	2010*	27.3 (±4.7)	21.3 (±5.5)	22.9 (±5.6)
	average 2008-10	26.2 (±6.4)	20.6 (±5.2)	23.2 (±5.9)
Number of L1-L3 species	cumulative 2008-10	35	21	44

*Three additional forest vegetation plots were added in 2010, two in the rural zone and one in the urban.
Standard deviation is shown in brackets.

The rural land-use zone had 186 species (of which 153 were native) over the period 2008-2010, while the urban zone had a total of 144 species (133 of them native). There seemed to be an incipient trend toward increasing species richness over the three-year period of observation. Average species richness (and native species richness) was a little higher in the rural zone.

The plots with the highest species richness and FQI were in the rural land-use zone: the highest plot average species richness was 68 and FQI 36.5. One plot in the urban zone averaged 53 species with an FQI of 28.1. At the other extreme, one plot in the rural zone had only 11 species with an FQI of 12 and one in the urban zone had 12 species and an FQI of 11.4.

The average CC for native plants was remarkably consistent across land-use zones and years, with averages ranging from 4.4 to 4.7. Floristic quality index, which takes into account both native species richness and coefficient of conservatism, followed more the pattern of species richness with increasing values toward the rural and recent surveys (Figure 24).

The lowest average was 18.6 for the urban zone in the earliest year, 2008; and the highest was 27.3 in the rural zone in the most recent year, 2010. The difference in the FQI between forest plots in the two land-use zones was statistically-significant at the 95% confidence level ($t=2.35$; $p<0.05$).

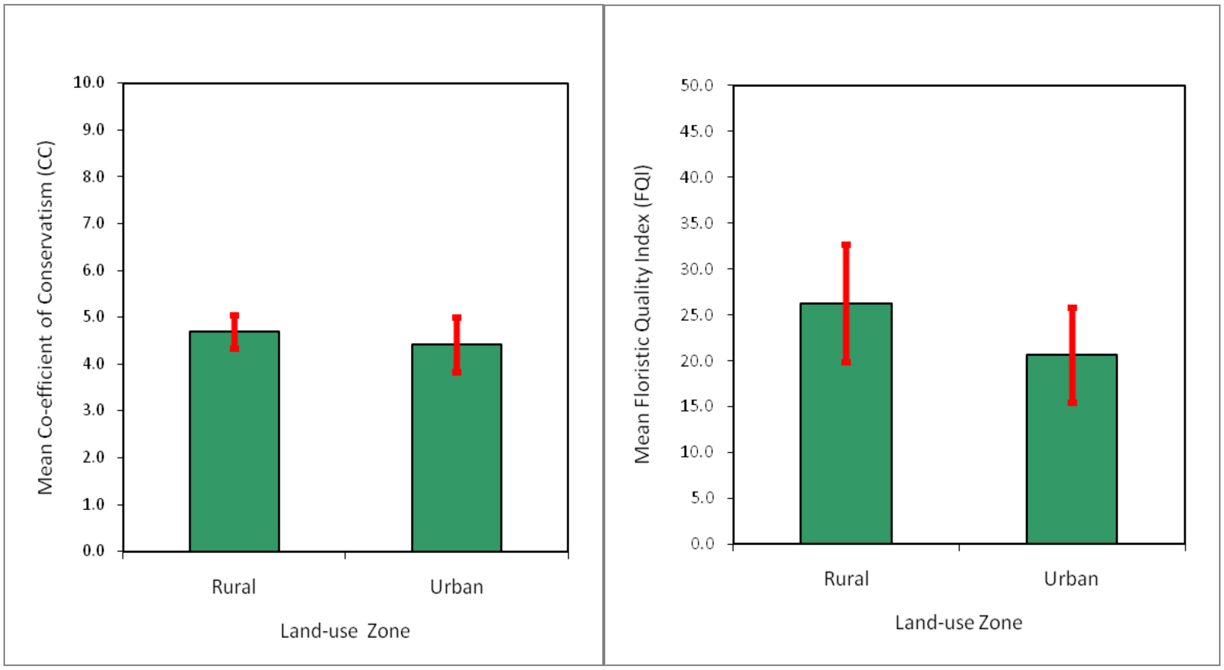


Figure 24. Average CC and FQI in the TRCA forest plots by land-use zone, (2008-2010). Standard deviation is shown by the red bars.

There were 44 flora species of regional conservation concern (TRCA rank L1 to L3) observed in all the plots over the three-year period: 35 in the rural land-use zone and 21 in the urban zone. The most sensitive species by all accounts was ginseng (*Panax quinquefolia*), observed once in the rural zone. This plant has a rank of L2. Ginseng had the highest coefficient of conservatism: 9 out of a possible 10; and is also listed as an endangered species. There were also three plants with a coefficient of conservatism of 8 in the rural zone plots. The highest coefficient of conservatism noted in the urban zone plots was 7; there were 12 species with that CC (Appendix 4).

4.1.2 Forest Birds

For the region as a whole there was a combined total of 24 forest species reported from all stations with urban stations registering 12 species and rural stations registering 22 species (Appendix 5). A large difference between the abundance of forest species in two land-use zones was noted with a total of 530 individuals at the rural stations and 245 individuals at the urban stations. The average station bird count by station was higher in the rural zone for the majority of these species (Figure 25). There were, however, five forest species which had a higher likelihood of being encountered at an urban station than at a rural station: blue-grey gnatcatcher (*Polyoptila caerulea*) and eastern screech-owl (*Megascops asio*) (neither of which were reported from any rural stations), hairy woodpecker (*Picoides villosus*), white-breasted nuthatch (*Sitta carolinensis*) and pine warbler (*Dendroica pinus*). The most commonly encountered species across the region and in both land-use zones was red-eyed vireo (*Vireo olivaceus*) (Tables 12, 13 and 14).

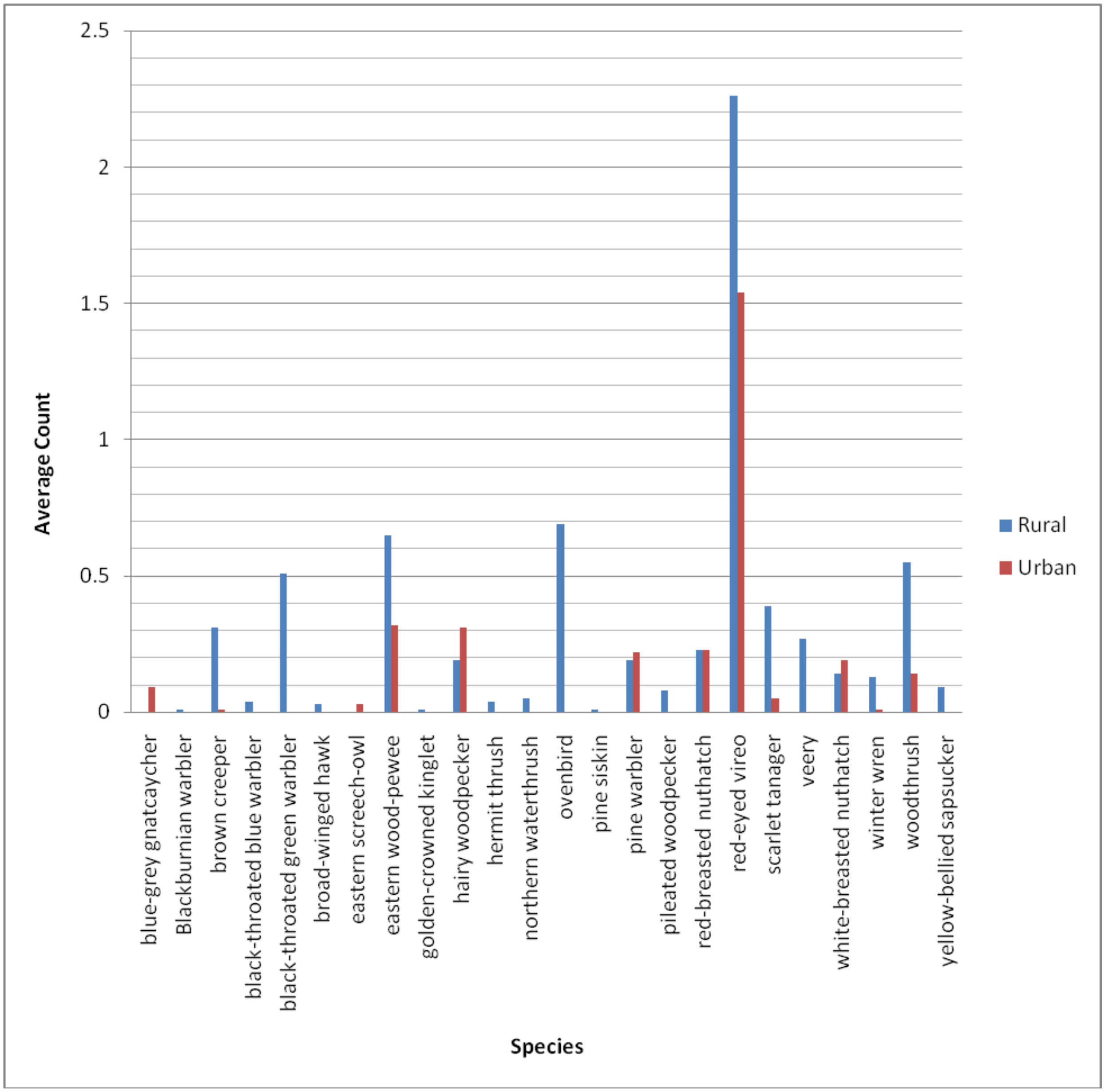


Figure 25. Average station counts for all forest-bird guild species

Table 12. Ten most abundant forest-associated species at all forest stations across the TRCA jurisdiction

Species	Scientific Name	Average Station Count	Local-rank
red-eyed vireo	*Vireo olivaceus*	1.90	L4
eastern wood-pewee	*Contopus virens*	0.48	L4
wood thrush	*Hylocichla mustelina*	0.34	L3
ovenbird	*Seiurus aurocapillus*	0.34	L3
hairy woodpecker	*Picoides villosus*	0.25	L4
black-throated green warbler	*Dendroica virens*	0.25	L3
red-breasted nuthatch	*Sitta canadensis*	0.23	L4
scarlet tanager	*Piranga olivacea*	0.22	L3
pine warbler	*Dendroica pinus*	0.21	L3
white-breasted nuthatch	*Sitta carolinensis*	0.17	L4

Table 13. Ten most abundant forest-associated species at all forest stations in the urban land-use zone

Species	Scientific Name	Average Station Count	Local-rank
red-eyed vireo	*Vireo olivaceus*	1.54	L4
eastern wood-pewee	*Contopus virens*	0.32	L4
hairy woodpecker	*Picoides villosus*	0.31	L4
red-breasted nuthatch	*Sitta canadensis*	0.23	L4
pine warbler	*Dendroica pinus*	0.22	L3
white-breasted nuthatch	*Sitta carolinensis*	0.19	L4
wood thrush	*Hylocichla mustelina*	0.14	L3
blue-grey gnatcatcher	*Polioptila caerulea*	0.09	L4
scarlet tanager	*Piranga olivacea*	0.05	L3
eastern screech-owl	*Magascops asio*	0.03	L4

Table 14. Ten most abundant forest-associated species at all forest stations in the rural land-use zone

Species	Scientific Name	Average Station Count	Local-rank
red-eyed vireo	*Vireo olivaceus*	2.26	L4
ovenbird	*Seiurus aurocapillus*	0.69	L3
eastern wood-pewee	*Contopus virens*	0.65	L4
wood thrush	*Hylocichla mustelina*	0.55	L3
black-throated green warbler	*Dendroica virens*	0.51	L3
scarlet tanager	*Piranga olivacea*	0.39	L3
brown creeper	*Certhia Americana*	0.31	L3
veery	*Catharus fuscescens*	0.27	L3
red-breasted nuthatch	*Sitta canadensis*	0.23	L4
pine warbler	*Dendroica pinus*	0.19	L3

Having filtered the data from each site and station across the two land-use zones throughout the region as described, the results were then sorted by local rank. The rural land-use zone was generally evenly split between L3 and L4 species, with just one L2 ranked species reported (broad-winged hawk, *Buteo platypterus*), whereas the urban land-use zone consisted mainly of L4 species (Figure 26).

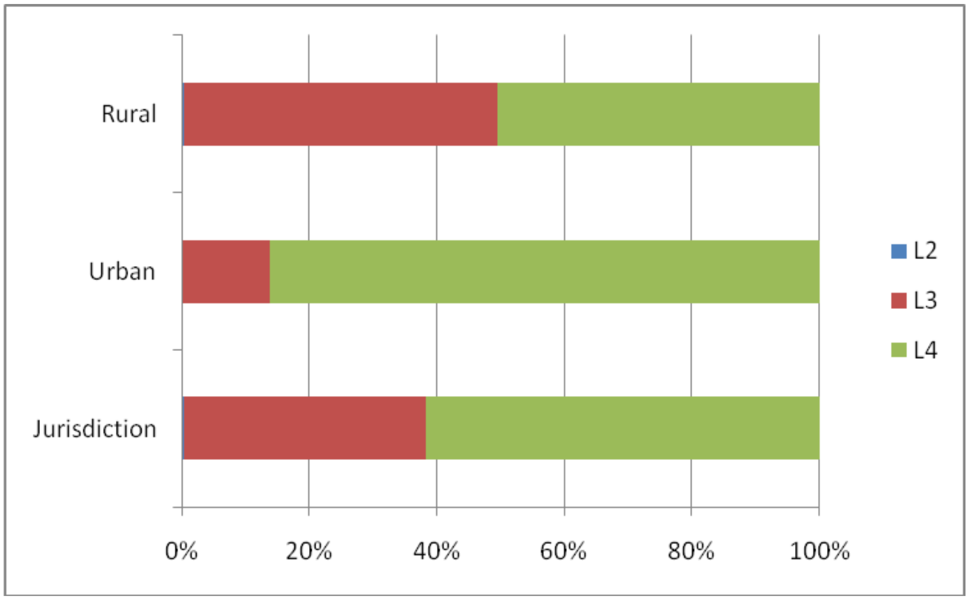


Figure 26. Ranks and relative abundance of all forest species, throughout jurisdiction and in the two land-use zones of urban and rural

The occurrence of L3 species at the urban stations is restricted to just three species, which in turn become an even less significant element of the urban forest system when representation rather than richness is considered. Two of the urban L3s occur in very low numbers, and the only species that shows any significant presence is pine warbler, a reflection perhaps of the number of mature pines within the urban forest matrix.

Together with richness – i.e. presence or absence of a particular species at a station – it is important to consider abundance or representation, since the two criteria are not necessarily mutually inclusive, e.g. one species may occur at all stations but only as single territories whereas another species may occur in large numbers but at fewer stations. Across the region as a whole the most frequently encountered forest-associated species was red-eyed vireo, occurring at 89.5% of all stations with a total of 294 points mapped over the 3 year period. This species is ranked as an L4 species. The more sensitive L3 ranked species were considerably less abundant and widespread with wood thrush (*Hylocichla mustelina*) and ovenbird (*Seiurus aurocapillus*) tying with a total of 53 points mapped over the 3 year period, occurring at just 35% and 26.3% of all stations. If these totals are broken down further, then the percent occurrence of these two higher ranked species illustrates the very large gap between urban and rural forest avian-quality (Figure 27). There were no reports of ovenbird from any of the urban stations over the 3 year period, while wood thrush occurred at just 14% of the urban stations in contrast to 55% of the rural stations.

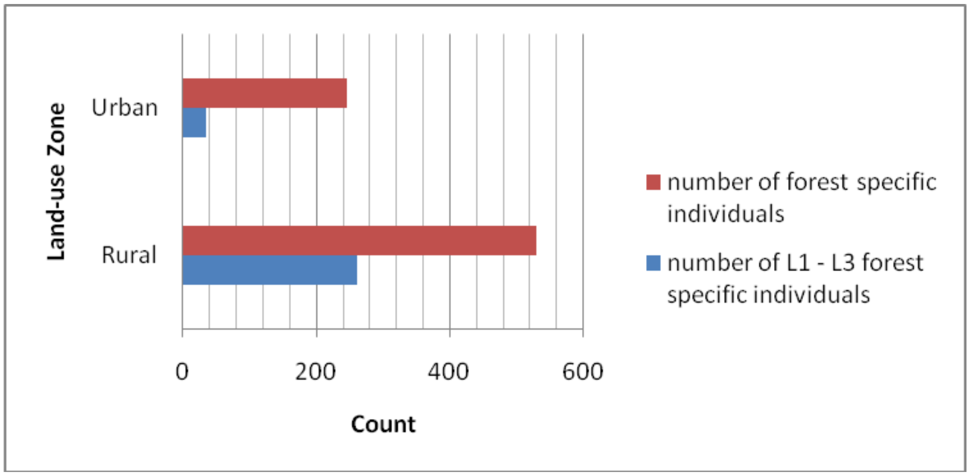


Figure 27. Variation in sensitive bird species representation across the two land-use zones at forest stations

4.1.3 Forest Plethodontids

Red-backed salamanders (RBSA) (*Plethodon cinereus)* were reported from 17 of the 22 plots, with animals present at 9 urban plots and 8 rural plots. Among those stations that reported salamanders, a slightly higher proportion of the rural plots reported abundances greater than 20 (averaging the maximum counts from both years), but surprisingly the station that reported the greatest abundance was an urban station (Table 15 and Appendix 6). This latter result may be due to the comparative lack of suitable natural cover opportunities in the vicinity at this particular urban station.

Table 15. Representation and abundance for Plethodontid salamanders recorded at monitoring plots, (2009-2010)

	Urban	Rural	Jurisdiction
Percent stations with no RBSA	25 %	20 %	22.7 %
Percent stations with mean max count greater than 20	44.4 %	50 %	47.1 %
Highest mean max count	63	34.5	63

4.2 Wetland Monitoring

4.2.1 Wetland Soil

Wetland Transect Soil Conditions

Organic soils over 40 cm deep are present in seven wetland transects in the rural land-use zone and in two of the urban transects (Table 16). Carbonates were also present in seven of the rural wetland transects, but two of these only had carbonates at the terrestrial end of the gradient. All of the eight urban wetland transects had carbonates, one of which only had carbonates at the terrestrial end of the gradient.

Table 16. Soils data in wetland transects, (2008-2010)

Land-use Zone	Number of Plots	Number (and %) of Transects with Organics >40 cm	Carbonate Presence (and %)
Rural	10	7 (70%)	7 (70%), (2 were at the 0 m post only)
Urban	8	2 (25%)	8 (100%), (1 was at the 0 m post only)
Jurisdiction	18	9 (50%)	15 (83%), (3 were at the 0 m only)

4.2.2 Wetland Vegetation

Wetland Tree Cover

Slightly more than half of the wetland transects had live trees as recorded by a prism sweep. These results were equal between the two land-use zones. The rural zone had more snags (Table 17).

Table 17. Live trees and snags found in TRCA wetland transects, (2008-2010)

	Rural		Urban	
	Count	Percentage *(based on 10 plots)*	Count	Percentage *(based on 8 plots)*
Number of Transects with Live Trees	5	50%	5	63%
Number of Transects with Snags	5	50%	2	25%
Number of Tree Species	9		14	

There were nine species of trees recorded by the prism sweep in the rural land-use zone; one of these, winterberry holly (*Ilex verticillata*) is actually a tall shrub. Of these transects, white cedar was the most commonly encountered species. Most trees were found in transects that included coniferous or mixed swamps; one transect: WV-11 (Finch and Pickering Townline) was a deciduous swamp with silver maple (*Acer saccharinum*).

There were 14 species of trees recorded in the urban zone wetland transects. One of these, mountain maple (*Acer spicatum*) is also more of a tall shrub than a tree. With the exception of one transect, WV-10 (East Don Parkland, a mixed conifer swamp), the trees found are representative of the edge of the wetland only, and in fact are often in the terrestrial vegetation community adjacent to the wetland rather than in the wetland itself. A good example is the red oak (*Quercus rubra*) recorded at WV-9 (E.T. Seton Park / Ontario Science Centre).

Wetland Sapling and Shrub Composition

Total Quantity of Woody Regeneration

Density of woody regeneration varied across the TRCA wetland transects and was primarily dependant upon the wetland community type (i.e. marsh, aquatic or swamp). The most dense transect was Caledon Tract (WV-5) in the upper Humber watershed, which had 624 stems in 2009 (averaging 52 per subplot), and 469 stems in 2010 (39 per subplot). Shrub and sapling presence was low in WV-7 (Radio Tower Wetland, a largely aquatic transect) and WV-9 (E.T. Seton Park / Ontario Science Centre, a low-diversity cattail marsh), with a total of eight stems each in 2009 (WV-9 had 10 stems in 2010). The average density over the two land-use zones as a whole was slightly higher in the rural land-use zone than the urban: 7.7 stems per 4 m^2 subplot in the rural and 5.8 stems in the urban zones.

Wetland Woody Regeneration Species Composition

An average of 50 species of woody plants was observed each year in the wetland subplots from 2008-10 (Table 18). This ranged from 48 in 2008 to 54 in 2010. By land-use zone, the average was 37 woody species in the rural transects and 35 in the urban transects. The average number of species per transect was about the same in the two zones: 7.9 in the rural zone and 7.8 in the urban.

Table 18. Number and average of woody species in wetland subplots by land-use zone

	Number of species per year			
Land-use Zone	**2008**	**2009**	**2010***	**Average**
Whole Jurisdiction	48	49	54	50
Rural all transects	35	36	39	37
Urban all transects	32	34	38	35
Rural average/transect	6.9	8.5	8.4	7.9 (±5.4)
Urban average/transect	7.0	8.1	8.1	7.8 (±5.5)

*Three additional wetland vegetation transects were added in 2010, two in the rural and one in the urban zone
Standard deviation is shown in brackets

The most dominant woody regeneration species in the jurisdiction wetland transects were red osier dogwood (*Cornus stolonifera*) and speckled alder (*Alnus incana* ssp*. rugosa*) according to two measures of assessment: relative abundance (i.e. proportion of total stems) and relative cover (proportion of total twig and foliage cover). Red osier dogwood accounted for 25% of the stem total and 17% of the relative cover. It was found in 9 of the 18 wetland transects, and was exceptionally abundant in Caledon Tract (WV-5). Speckled alder accounted for just 8% of the stem count but 18% of the relative cover. It was found in five wetland transects.

A closer look at the results by land-use zone shows that the dominance of red osier dogwood is more evident in the rural zone where it ranks first in relative abundance and second in relative cover (Figures 28, 29). Balsam fir ranks first in relative cover.

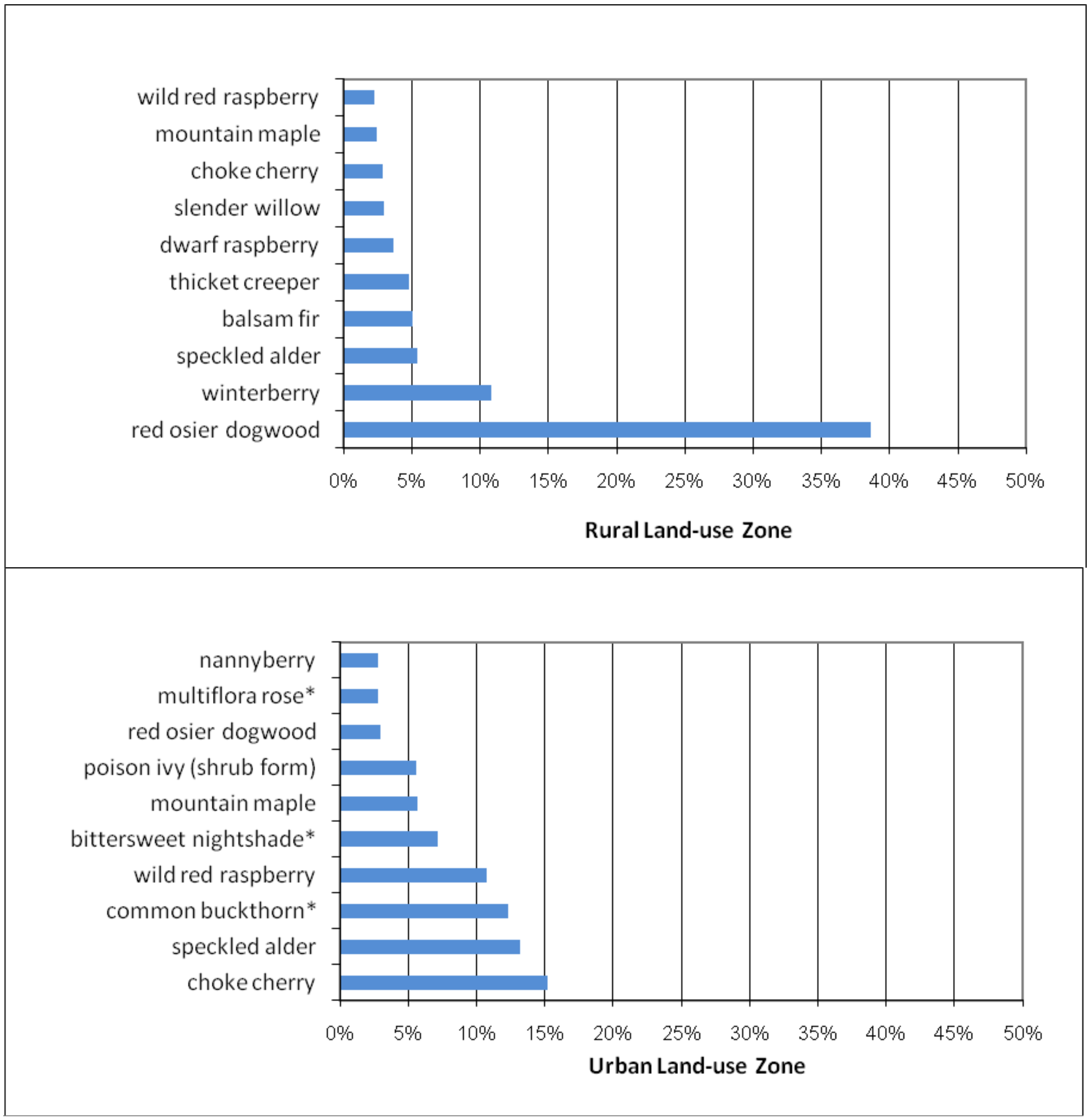


Figure 28. Relative abundance of the 10 most common woody species by land-use zone, (2008-2010). Exotics species are indicated by an asterisk (*).

In the urban zone, choke cherry ranks first in relative abundance, but has fairly low cover. Speckled alder ranks second in relative abundance but first by a wide margin in relative cover. Buckthorn ranks third in both measures.

Overall, the 4 species red osier dogwood, speckled alder, winterberry holly and choke cherry account for just under 50% of the total stem count in the jurisdictional wetland transects; and speckled alder, red osier dogwood, and balsam fir account for just over 50% of the total cover.

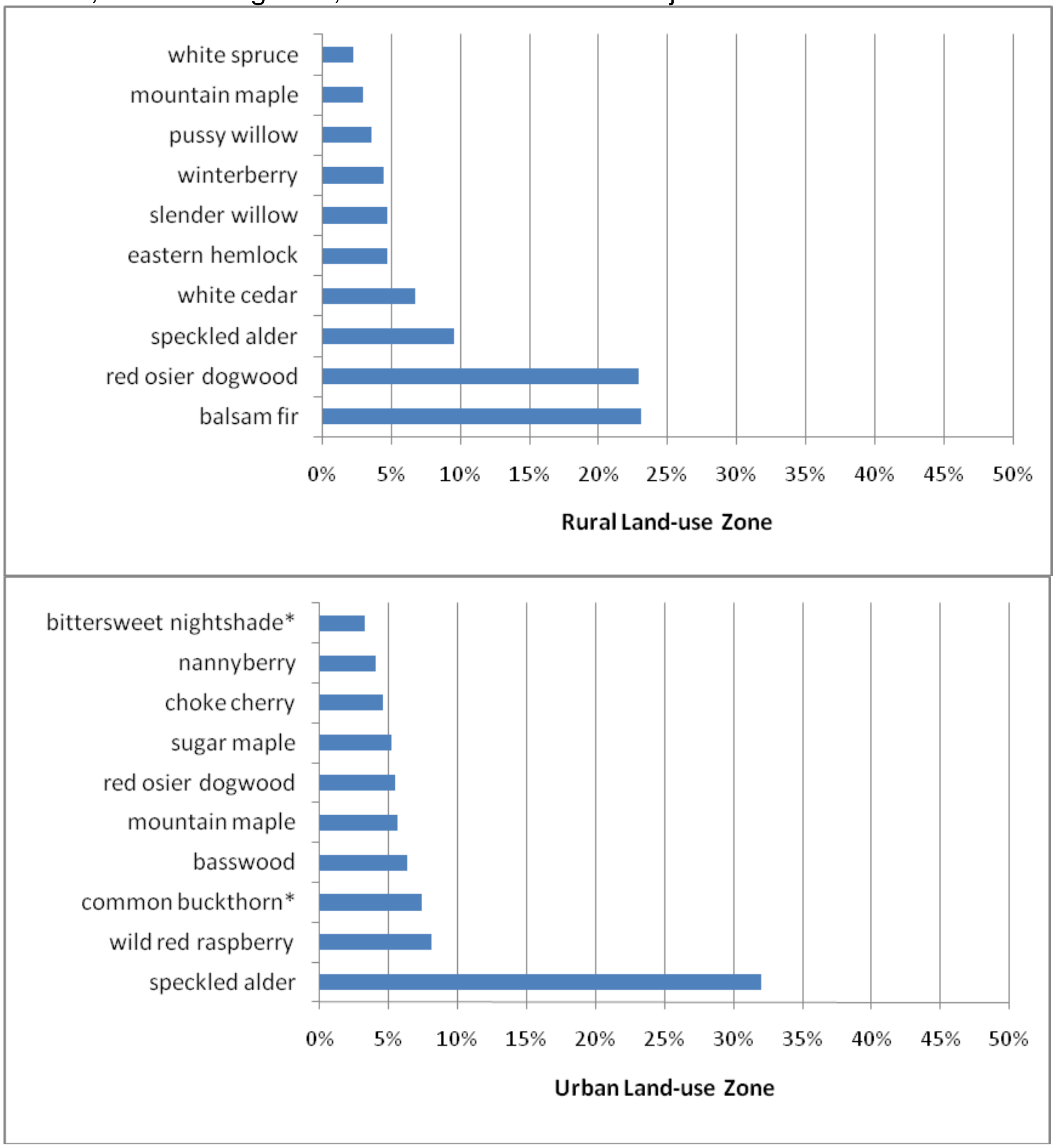


Figure 29. Relative cover of the top 10 woody species by land-use zone, (2008-2010). Exotic species are indicated by an asterisk (*).

Native species overwhelmingly dominate the woody regeneration in the TRCA wetland transects making up well over 90% of both relative abundance and relative cover measures in the rural land-use zone (Table 19). Exotic species do have a noticeably greater presence in the urban zone, but are still a small minority in terms of dominance measures. Native species dominance was higher with the cover measure than with the abundance (stem count) measure, with only 0.4% of the total rural relative woody cover being exotic.

Table 19. Relative abundance and cover of native and exotic sapling and shrub species, (2008-2010)

Zone	Rural		Urban	
Measure	**Relative Abundance**	**Relative Cover**	**Relative Abundance**	**Relative Cover**
Native	96.0%	99.6%	73.8%	86.0%
Exotic	4.0%	0.4%	26.2%	14.0%

Wetland Woody Regeneration Composition by Growth Form

When woody regeneration is divided into growth form (i.e. tree, shrub, woody vine), it was found that the number of shrub species generally was higher than the number of tree species, which in turn was much higher than the number of woody vine species (Figure 30). Species richness in the two land-use zones was similar, with slightly more shrub species (average 21) in the urban wetland transects than the rural (19). More tree species were found in the rural transects (15) than the urban (11).

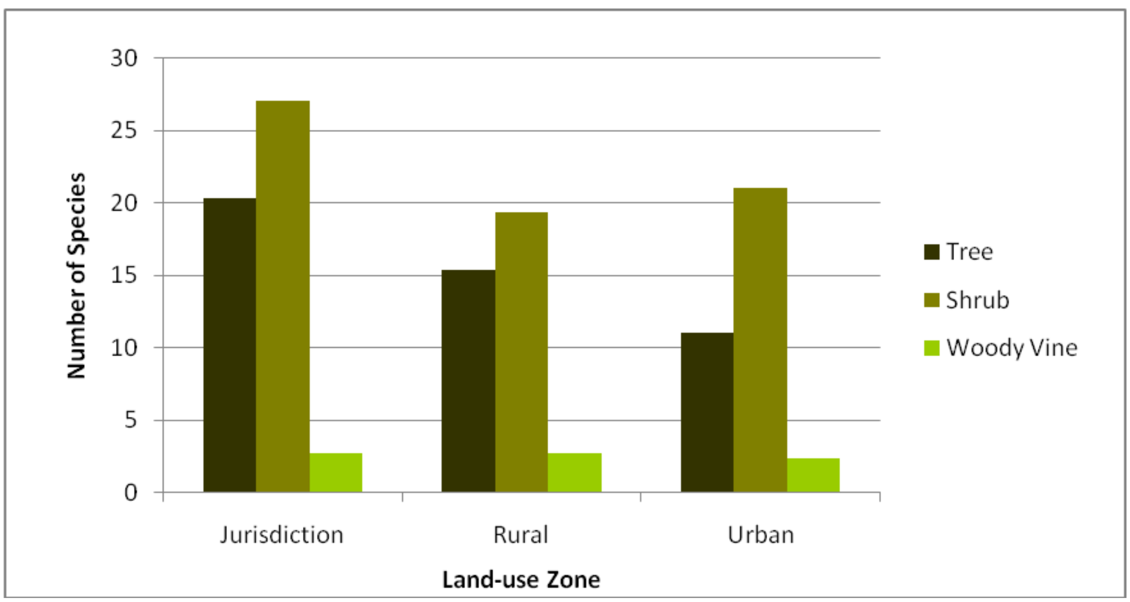


Figure 30. Average species richness for tree saplings, shrubs and woody vines by land-use zone, (2008-2010)

In terms of dominant plant type in the understorey layer, shrubs had a much higher relative abundance (more stems), especially in the urban land-use zone where tree saplings made up only

7% of the total abundance (Figure 31). Woody vines had a relative abundance of 7% in the rural zone and 10% in the urban zone.

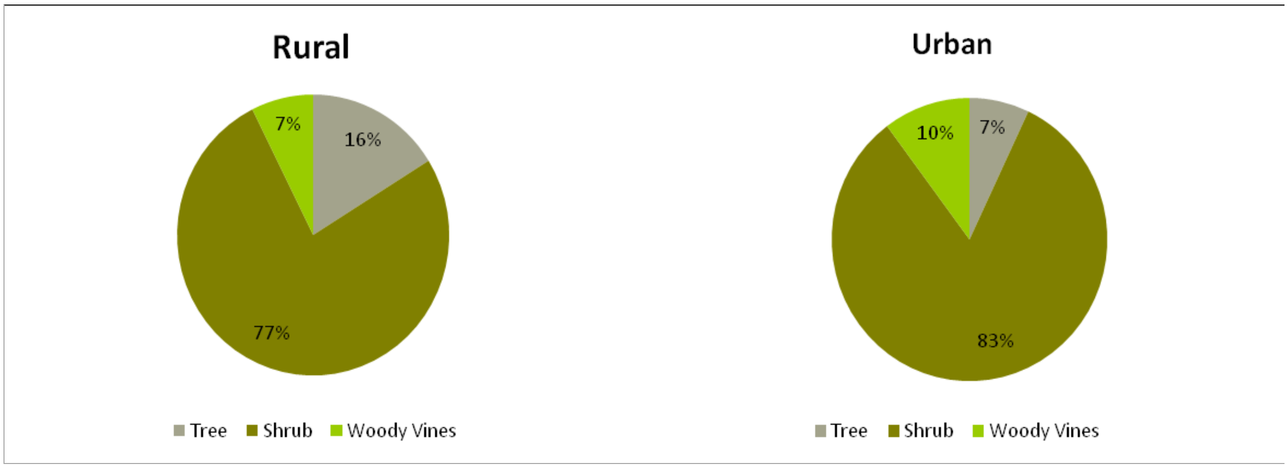


Figure 31. Relative abundance of tree saplings, shrubs and woody vines by land-use zone, (2008-2010)

Relative cover is more evenly balanced between trees and shrubs, at least in the rural zone where 46% of the total relative cover is composed of tree species (Figure 32). Woody vine cover is low.

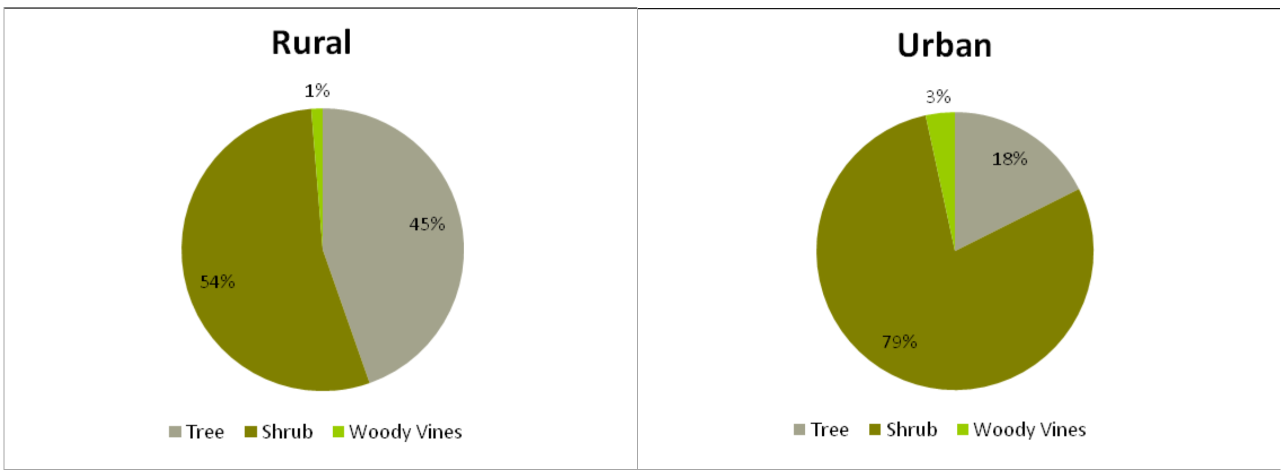


Figure 32. Relative cover of tree saplings, shrubs and woody vines by land-use zone, (2008-2010)

There were 23 species of tree represented in the regeneration subplots of the TRCA wetland transects: 18 in the rural zone and 12 in the urban zone. The most striking difference in species composition is the strong presence of conifers in the rural zone transects and their absence from the urban transects (Figure 33). This difference may in large part be due to the wetland type used in the monitoring within each zone. Balsam fir and white cedar are the two most common tree saplings recorded from the rural zone, and conifers account for about half the total. The most common tree sapling in the urban zone transects is basswood (*Tilia americana*), and most of the species in that zone are more typical of upland than wetland sites.

Transect WV-10 (East Don Parkland) accounts for a large share of the tree saplings in the urban zone wetlands. Deciduous swamp trees such as silver and red maple, and green ash *(Fraxinus pennsylvanica ssp. subintegerrima)*, are scarce.

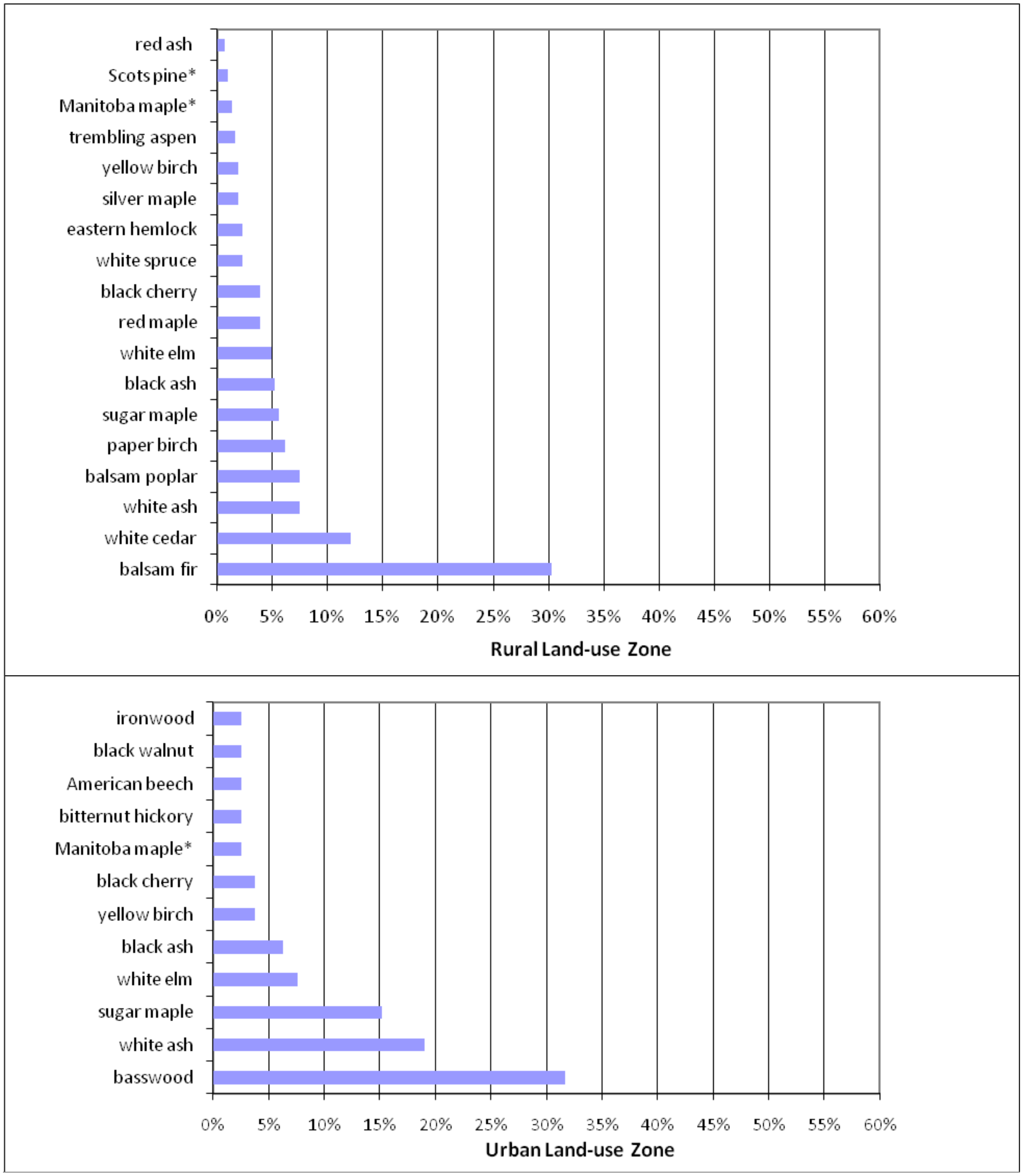


Figure 33. Relative abundance of tree sapling species in the two land-use zones, (2008-2010).

Shrubs and woody vines comprise 35 species across the TRCA jurisdiction set of transects, with 25 species in the rural zone and 27 in the urban zone. Three species of woody vine are included: riverbank grape, thicket creeper (*Parthenocissus inserta*), and climbing nightshade (*Solanum dulcamara*), occurring in both zones. Red osier dogwood accounts for almost half the total shrubs in the rural zone (Figure 34). The abundance distribution among species is much more even in the urban zone, but generalist species such as choke cherry, red raspberry, and poison ivy *(Rhus radicans ssp. rydbergii)*; and the invasive buckthorn have a higher representation. Rare and unusual shrubs such as mountain holly (*Nemopanthus mucronatus*) can be found in both zones.

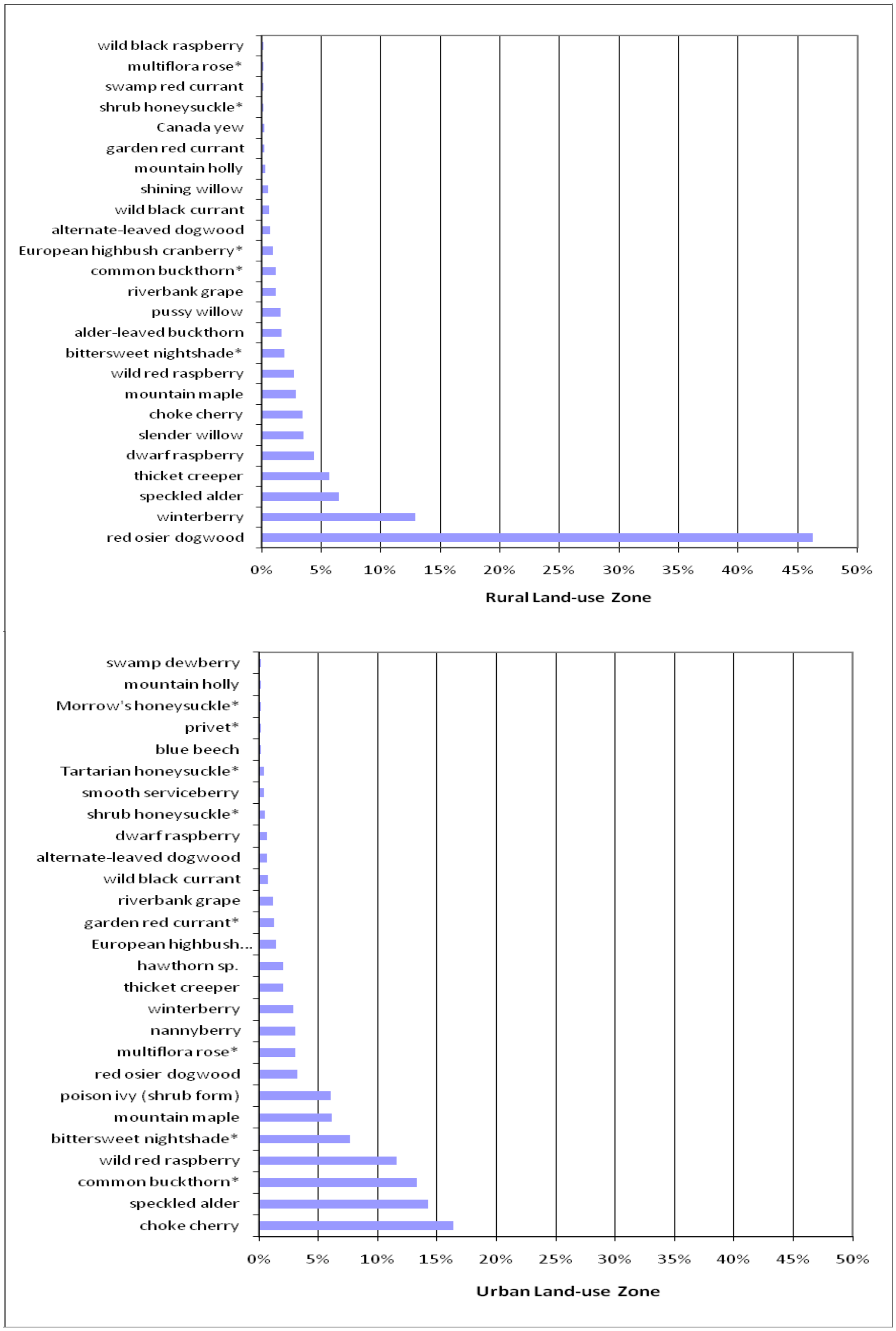


Figure 34. Relative abundance of shrub and woody vine species in the two land-use zones, (2008-2010). Exotic species are indicated by an asterisk (*)

Among the woody vines, the low-growing, barely woody, and slightly invasive climbing nightshade is the most common in the urban zone, while the medium-to-high-growing thicket creeper is the most common in the rural zone. Riverbank grape has a minor presence in both zones.

Wetland Ground Vegetation Composition

An average of 237 ground layer species was observed each year in the TRCA 1 m^2 ground vegetation subplots from 2008-10 (Table 20). This ranged from 230 in 2008 to 244 in 2010. By land-use zone, the average was 167 species in the rural transects and 154 in the urban transects. The average number of species per plot was 33.8 in the rural zone and 28.2 in the urban zone.

Table 20. Number of species in ground vegetation subplots by land-use zone and year

	Number of species per year			
Land-use Zone	**2008**	**2009**	**2010***	**Average**
Whole Jurisdiction	230	237	244	237
Rural all plots	160	162	180	167
Urban all plots	149	156	158	154
Rural average/transect	33.3	34.5	33.8	33.8 (±15.1)
Urban average/transect	27.6	30.6	28.4	28.2 (±16.0)

*Three additional wetland vegetation transects were added in 2010, two in the rural and one in the urban zone
Standard deviation is shown in brackets

Ground vegetation diversity varied greatly between transects but not so strongly between zones. Low counts were observed at WV-8 (Toogood Pond) in the urban zone (average 11 species) and at WV-11 (Finch and Pickering Townline) in the rural zone (12 species). On the other hand, the rural transect WV-5 (Caledon Tract) had the largest number of species in the ground vegetation subplots, an average of 60. In the urban zone, WV-10 (East Don Parkland) had an average of 56 species. The total quantity of ground vegetation (i.e. the proportion of ground with cover versus bare soil) was not assessed.

Composition of ground cover was very different in the rural and urban land-use zones. Hybrid cattail (*Typha* x *glauca*) accounted for one-third of the total cover in the urban zone transects (Figure 35). Reed canary grass (*Phalaris arundinacea*) ranked second and common duckweed (*Lemna minor*) third. Six of the nine species that each contributed over 1% of the total cover were exotic. A greater balance was found in the rural zone, with 17 species each contributing over 1% of the total cover. Common duckweed had the highest relative cover value, followed by common reed (*Phragmites australis* ssp*. australis*) and then two pondweed species (*Potamogeton zosteriformis* and *P. natans*).

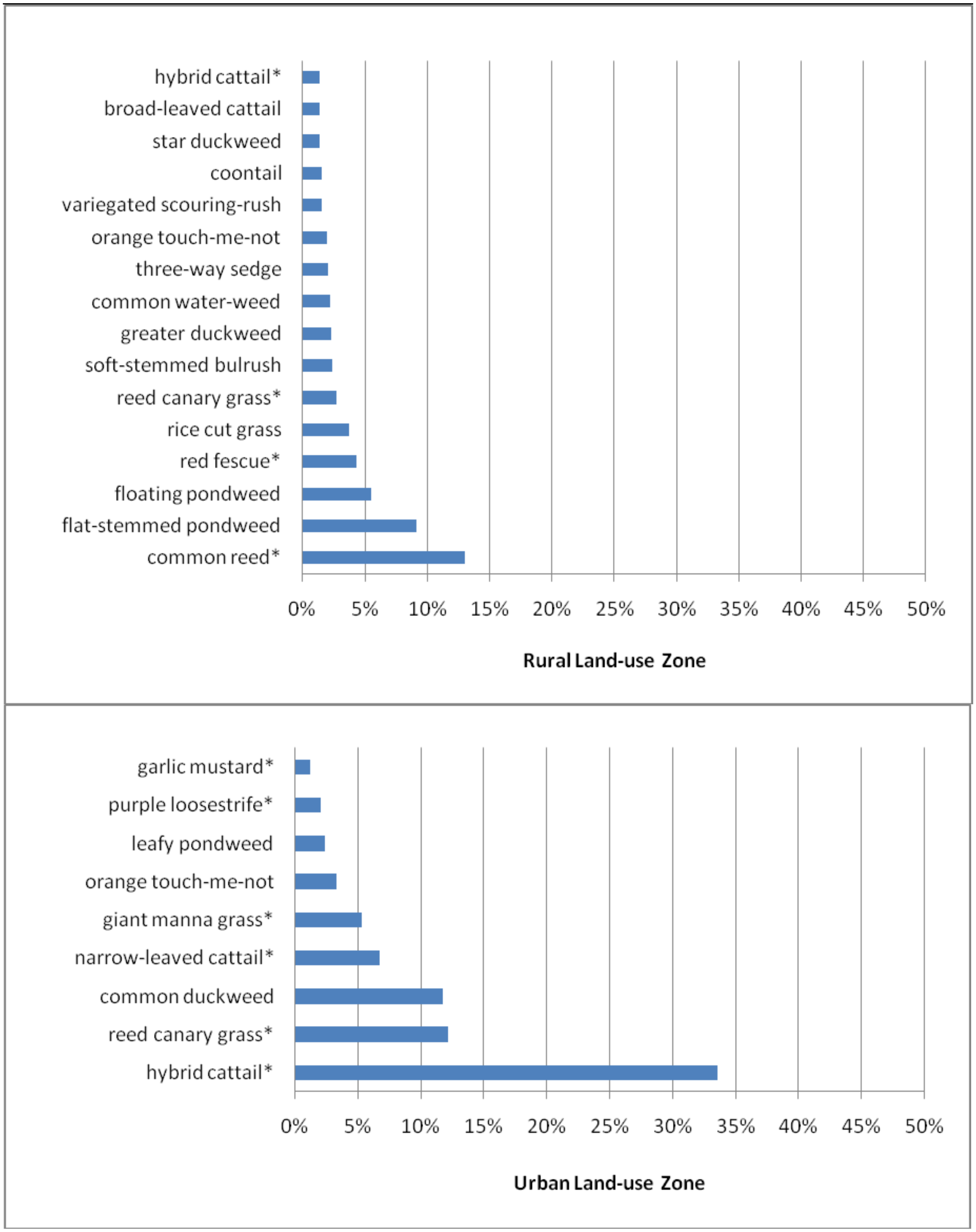


Figure 35. Relative cover of ground vegetation species having more than 1% of total, (2008-2010). Exotic species are indicated by an asterisk (*)

If the jurisdiction is taken as a whole, hybrid cattail still ranked first in ground vegetation cover, followed by common duckweed and reed canary grass.The frequency of occurrence (i.e. the number of plots in which a species was found over the three-year period) mostly followed the relative cover results, with some exceptions. The most frequently encountered species in all wetland transects was common duckweed, found in an average of 11 out of the total 18 transects. Hybrid cattail was second, being found in an average of 10 out of 18 transects; it was in every one of the urban transects. In the rural transects, no single species was found in more than half of the rural transects (i.e. 5 of the 10). Species with the highest occurrences included: common duckweed, orange touch-me-not, dandelion (*Taraxacum officinale*), common buckthorn, and spinulose wood fern (*Dryopteris carthusiana*). On the other hand, common reed, which ranked second-highest for relative cover in the rural zone, was only found in one transect, WV-14 (Greenwood), where it dominated.

Exotic species strongly dominated the ground vegetation cover in the urban zone, taking up 69% of the total relative cover there (Figure 36). Four of the five top species were exotic. The two most frequent species in the urban zone were exotic: hybrid cattail and purple loosestrife (*Lythrum salicaria*). Exotic cover was moderate in the rural transects; exotic species made up 28% of the total relative cover. Two of the five most frequently-encountered species were exotic. When the confidence value was tested at 95%, the difference in proportion of exotic versus native ground cover between the rural and urban land-use zones was statistically significant ($t=3.19$; $p<0.05$).

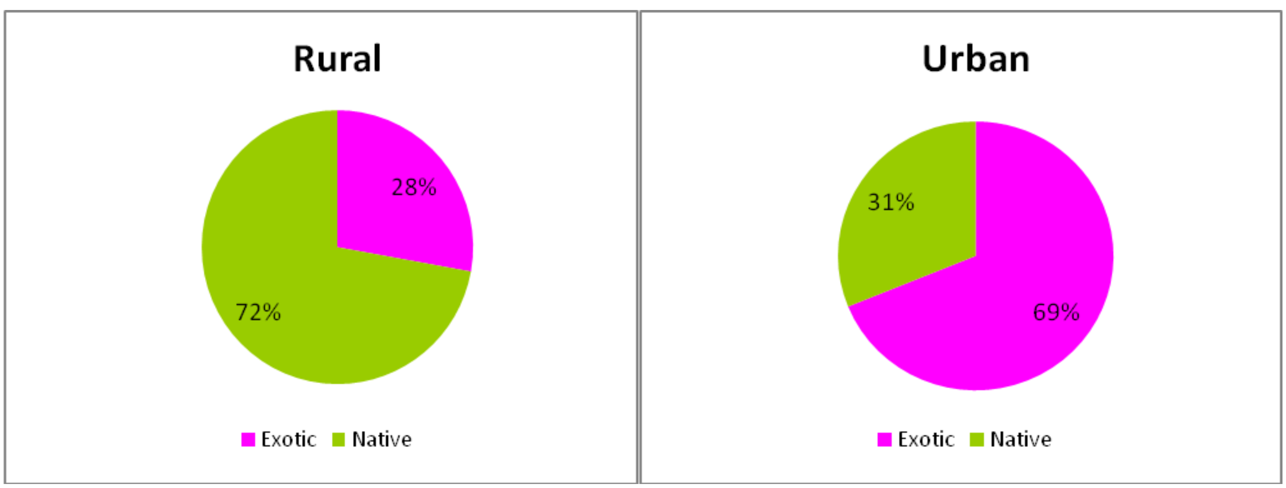


Figure 36. Relative cover of native and exotic ground vegetation by land-use zone, (2008-2010)

Major invasive exotics included hybrid cattail, as well as purple loosestrife, reed canary grass, and common reed, although the latter was confined to one transect. Others included giant manna grass (*Glyceria maxima*), also found at one plot (WV-9, E.T. Seton Park / Ontario Science Centre), and garlic mustard, at the terrestrial end of the gradient of several transects.

Wetland Ground Vegetation Composition by Growth Form

Forbs – defined as any broad-leaved plant including wildflowers, cattails, and floating and submerged aquatics, accounted for 58% of the total cover in the rural zone and 75% in the urban zone. Graminoids (grasses, sedges, and rushes) accounted for most of the remainder (37% in the rural zone and 22% in the urban zone) (Figure 37). Ferns and woody plant seedlings accounted for a negligible proportion of total cover.

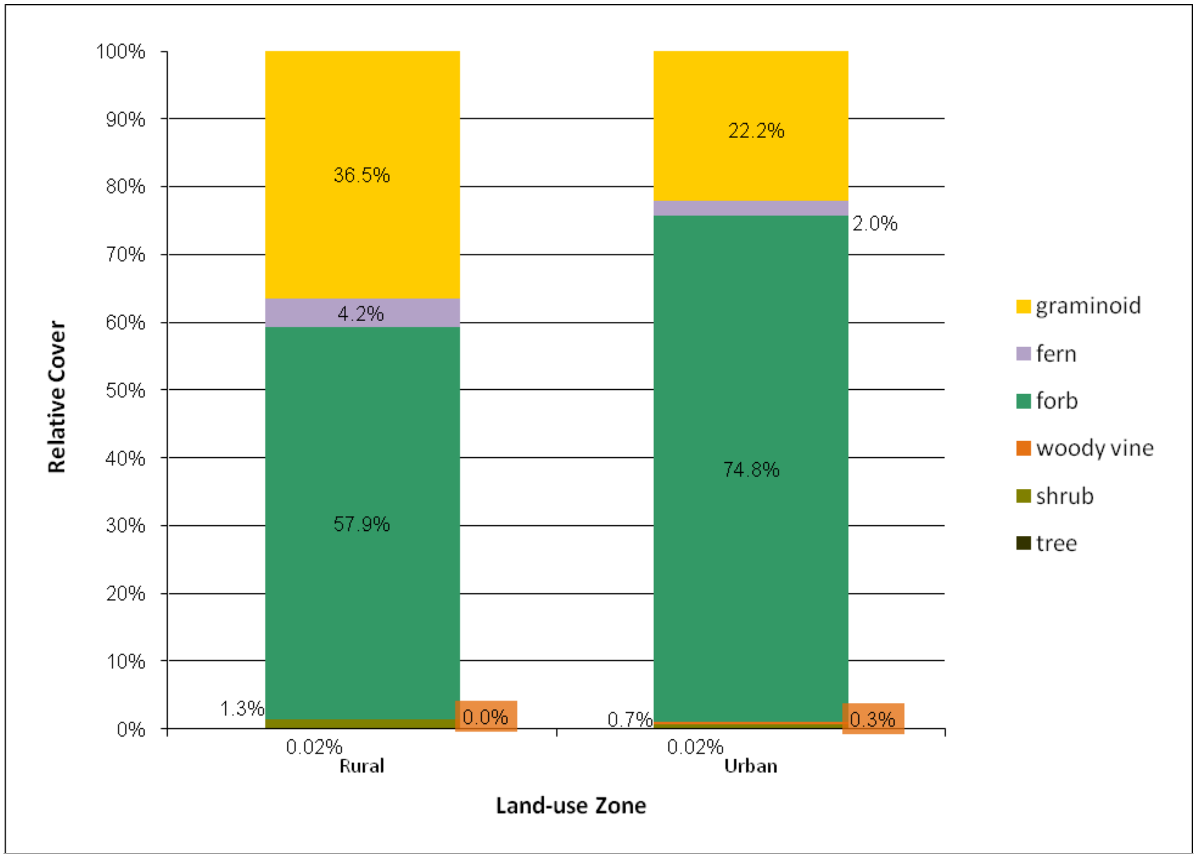


Figure 37. Relative cover of growth form in wetland ground vegetation subplots, (2008-2010)

Most of the forb cover is accounted for by hybrid cattail, common duckweed, and a few submerged pondweeds and similar species. The graminoids are heavily dominated by grass species over sedge species (grasses comprise 24% of the total jurisdictional relative cover and sedges just 4%). As noted, reed canary grass, rice cut-grass (*Leersia oryzoides*) and locally, giant manna grass and common reed are important species.

Wetland Species Richness and Floristic Quality

Floristic quality, based on the species list for the whole transect (subplots plus prism sweep trees), was revealed by the same indicators as used for the forest plots: native species richness and proportion of native species; the presence and number of species of regional conservation concern (TRCA L-rank L1 to L3); the mean coefficient of conservatism (CC) of the native species found within the plot, and the plot Floristic Quality Index (FQI) derived from native species richness and mean CC. Total cumulative species richness for the set of TRCA wetland transects (i.e. every species observed anytime during the 2008-10 period) was 310 (Table 21; Appendix 4). There were 233 native species and 77 exotics observed; the proportion of native species was 75.2%.

Table 21. Floristic quality measurement results at TRCA wetland vegetation transects

Floristic Measure	Year	Rural	Urban	Jurisdiction
Total Species Richness	2008	195	141	249
	2009	189	137	250
	2010*	207	149	261
	cumulative 2008-10	245	186	310
	average 2008-10	197 (±9)	142 (±6)	253 (±7)
Native Species Richness	2008	153	101	187
	2009	147	104	193
	2010*	165	109	200
	cumulative 2008-10	192	131	233
	average 2008-10	155 (±9)	105 (±4)	193 (±7)
Zone Average Co-efficient of Conservatism (CC)	cumulative 2008-10	4.5	4.3	4.6
Plot Average Co-efficient of Conservatism (CC)	2008	4.3 (±0.9)	3.4 (±0.9)	3.8 (±0.9)
	2009	4.3 (±1.0)	3.5 (±0.7)	4.0 (±0.0)
	2010*	4.2 (±1.1)	3.4 (±0.8)	3.9 (±1.0)
	average 2008-10	4.3 (±0.9)	3.4 (±0.7)	3.9 (±0.9)
Plot Average Floristic Quality Index (FQI)	2008	22.5 (±8.8)	15.5 (±10.2)	19.3 (±9.8)
	2009	22.9 (±8.2)	16.5 (±10.5)	19.9 (±9.6)
	2010*	22.8 (±8.0)	15.9 (±10.2)	19.8 (±9.4)
	average 2008-10	23.2 (±7.7)	15.7 (±9.8)	19.9 (±9.3)
Number of L1-L3 species	cumulative 2008-10	67	23	76

*Three additional wetland vegetation transects were added in 2010, two in the rural and one in the urban zone
Standard deviation is shown in brackets

The rural land-use zone had 245 species (of which 192 were native) over the period 2008-10, while the urban zone had a total of 186 species (131 of them native). There seemed to be a slight incipient trend toward increasing species richness over the three-year period of observation. Average species richness (and native species richness) was higher in the rural zone.

The transects with the highest species richness and FQI were in the rural land-use zone: WV-5 (Caledon Tract) was the single highest-quality transect in both measures: average 2008-10 species richness of 71 and average FQI of 36.3. Two urban land-use zone transects had an FQI of

over 25: WV-2 (Kenpark) and WV-10 (East Don Parklands). At the other extreme, the least floristically diverse transect was WV-8 (Toogood Pond) with an average of 14 species found. The lowest FQI of 4.9 was at WV-1 (Centennial Park). Both these transects are in the urban zone.
The average CC for native plants was consistent across the three-year period, but was higher in the rural land-use zone, at least at the plot level (Table 21; Figure 38). Plot average CC was 4.3 in the rural zone and 3.4 in the urban zone. Differences in mean CC were lower when comparing the whole species list for each zone.

Floristic Quality Index, which takes into account both native species richness and coefficient of conservatism, was also higher for the rural plots (Figure 38). The lowest plot FQI average was 15.5 for the urban zone in 2008; and the highest was 22.9 in the rural zone in 2009 (Table 21). The difference in FQI between rural and urban wetland transects was not statistically-significant at the 95% confidence level but was significant when the confidence was lowered to 80% ($t=1.78$; $p<0.20$).

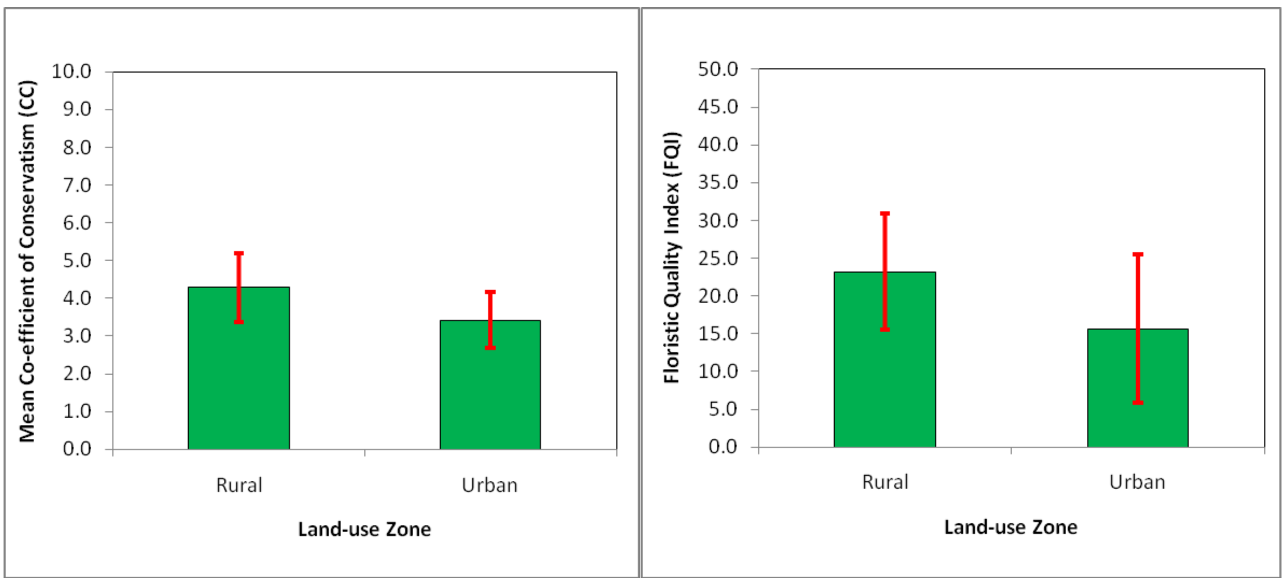


Figure 38. Average CC and FQI in the TRCA wetland transects by land-use zone, (2008-2010). Standard deviation is shown by the red bars.

There were 76 flora species of regional conservation concern (TRCA rank L1 to L3) observed in all the wetland transects over the 2008-10 period: 67 in the rural land-use zone and 23 in the urban zone (Appendix 4). The rural transects included two L1 species: small bladderwort (*Utricularia minor*) found at two sites; and daisy-leaved grape-fern (*Botrychium matricariifolium*), found at the terrestrial end of the gradient at one site. The highest L-rank in the urban zone was L3, shared by three species at one transect: swamp dewberry (*Rubus hispidus*), water arum (*Calla palustris*), and mountain-holly. The swamp dewberry is the only known location for this species in the TRCA jurisdiction.

Three species in the rural zone had a CC of 10, the highest possible score: mud sedge (*Carex limosa*), stunted sedge (*Carex magellanica* ssp. *irrigua*), and one-flowered pyrola (*Moneses uniflora*). (It is possible that the *C. limosa* observed in the first year was actually *C. magellanica*). The plant with the highest CC in the urban zone was sky-blue aster (*Aster oolentangiensis*) with a score of 9 (although this score seems to be an outlier based on the observed behaviour of the species). There were four species with a CC of 8 in the urban zone.

4.2.2 Wetland Birds

The abundance of all wetland species was averaged across the two years so as to indicate a baseline for abundance to which future count results can be compared. This calculation was performed for the jurisdiction as a whole and then for the two land-use zones (urban and rural). For the jurisdiction as a whole there was a combined total of 12 wetland-associated species reported from all stations with urban stations registering 8 species and rural stations registering 10 species (Tables 22, 23 and 24).

Table 22. Abundance of wetland bird species at all wetland stations across the TRCA jurisdiction, (2009-2010)

Species	Scientific Name	Average Station Count	Local-rank
swamp sparrow	*Melospiza georgiana*	1.0	L4
common yellowthroat	*Geothlypis trichas*	0.86	L4
Canada goose	*Branta canadensis*	0.68	L5
Virginia rail	*Rallus limicola*	0.46	L3
mallard	*Anas platyrhynchos*	0.32	L5
sora	*Porzana carolina*	0.27	L3
marsh wren	*Cistothorus palustris*	0.05	L3
hooded merganser	*Lophodytes cucullatus*	0.05	L3
alder flycatcher	*Empidonax alnarum*	0.05	L4
least bittern	*Ixobrychus exilis*	0.03	L2
common moorhen	*Gallinula chloropus*	0.03	L3
American coot	*Fulica americana*	0.03	L2

Table 23. Abundance of wetland bird species at all wetland stations in the urban land-use zone, (2009-2010)

Species	Scientific Name	Average Station Count	Local-rank
swamp sparrow	*Melospiza georgiana*	0.94	L4
Canada goose	*Branta canadensis*	0.69	L5
common yellowthroat	*Geothlypis trichas*	0.50	L4
mallard	*Anas platyrhynchos*	0.25	L5
Virginia rail	*Rallus limicola*	0.19	L3
sora	*Porzana carolina*	0.13	L3
marsh wren	*Cistothorus palustris*	0.13	L3
American coot	*Fulica americana*	0.06	L2

Table 24. Wetland bird species at all wetland stations in the rural land-use zone (2009-2010)

Species	Scientific Name	Average Station Count	Local-rank
common yellowthroat	*Geothlypis trichas*	1.14	L4
swamp sparrow	*Melospiza georgiana*	1.05	L4
Virginia rail	*Rallus limicola*	0.67	L3
Canada goose	*Branta canadensis*	0.67	L5
sora	*Porzana carolina*	0.38	L3
mallard	*Anas platyrhynchos*	0.38	L5
hooded merganser	*Lophodytes cucullatus*	0.10	L3
alder flycatcher	*Empidonax alnarum*	0.10	L4
least bittern	*Ixobrychus exilis*	0.05	L2
common moorhen	*Gallinula chloropus*	0.05	L3

There was a considerable difference between the abundance of wetland-associated birds in the two land-use zones, with 46 individuals counted from the urban stations, and 96 individuals counted from the rural stations. For the six species which occurred at both the urban and the rural sites, only Canada goose (*Branta canadensis*) showed a higher occurrence at the urban stations. Four wetland species occurred at the rural sites which did not turn-up at urban sites, while two species occurred exclusively at the urban sites. Unfortunately, these species occurred at such low levels that differences in distribution that are shown by these results are likely insignificant. Surveyors are just as likely to encounter swamp sparrows at urban as at rural stations, but the occurrence of Virginia rail (*Rallus limicola*), sora (*Porzana carolina*) and common yellowthroat (*Geothlypis trichas*) is certainly weighted towards the rural stations (Figure 39).

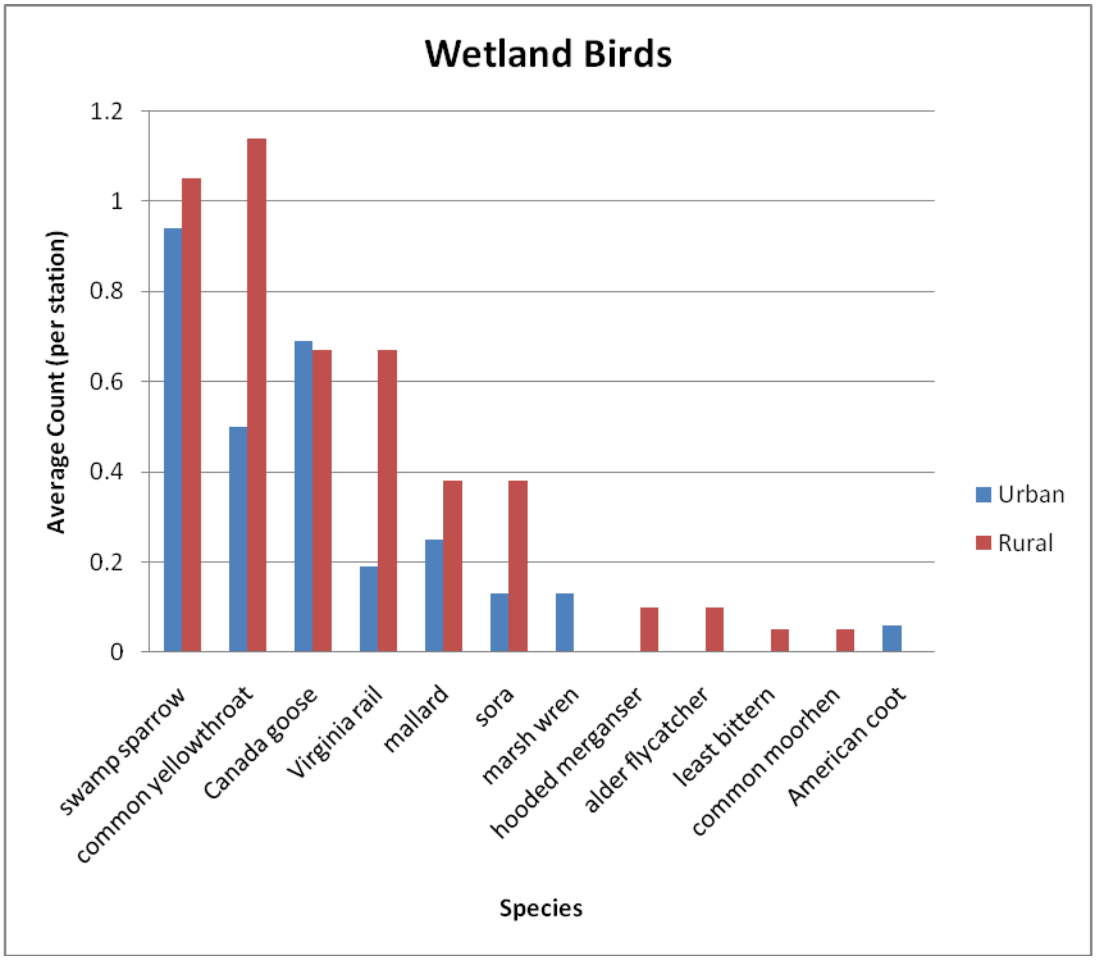


Figure 39. Average bird counts at wetland stations throughout the jurisdiction

Wetland habitat accommodates an avifauna which, although comprising fewer species than forest habitat, includes a greater diversity of TRCA L-ranks. Thus species ranked as L2 to L5 are represented within this habitat type. Although species richness is still maintained in the urban sites the representation of higher ranking wetland species is somewhat reduced in comparison to the rural sites (Figure 40). Virginia rail is the third most abundant wetland species at the rural sites with a station count average of 0.67; the same species places a respectable fifth in the urban sites but with a station count average of just 0.19. Nevertheless, as Figure 41 illustrates, the relative abundances of different ranked wetland associated species (both the sensitive L2 and L3 species and the more resilient L4 and L5 species) are pretty consistent between the urban and rural categories.

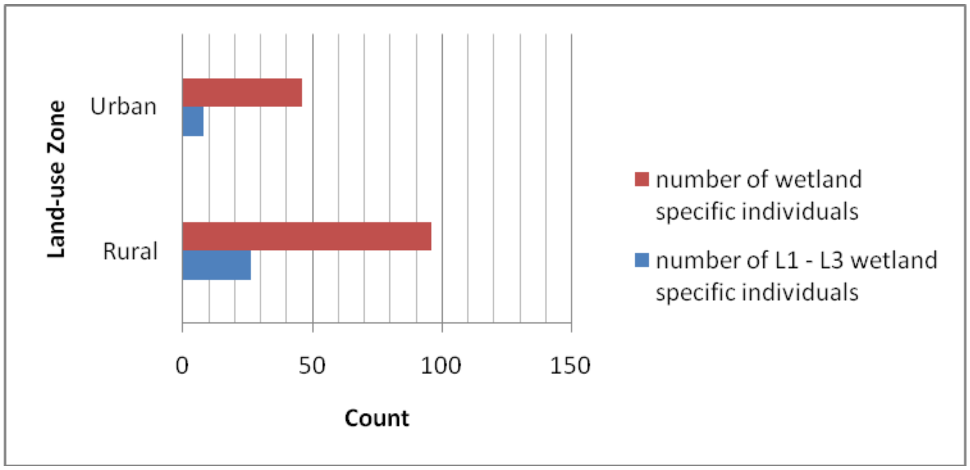


Figure 40. Variation in sensitive species representation across the two land-use zones at wetland stations

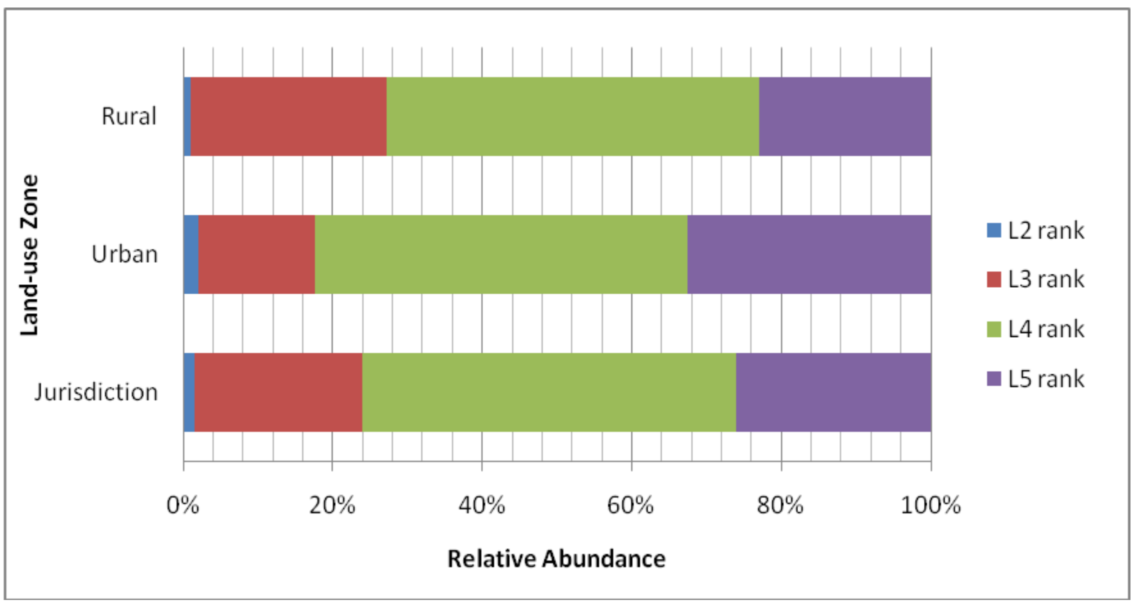


Figure 41. Ranks and relative abundance of wetland bird species by land-use zones

4.2.3 Frogs

Six frog and toad species occur at a level of abundance across the jurisdiction that allows for effective monitoring. All six of these species were reported from the 18 sites (21stations) over the course of the 2 years of preliminary monitoring. No single site reported all six species but the rural stations consistently supported a higher number of species than the urban counterparts. All 11 of the rural stations reported frog or toad activity at some point over the initial 2 years whereas only 7 of the 10 urban stations reported activity (Figure 42).

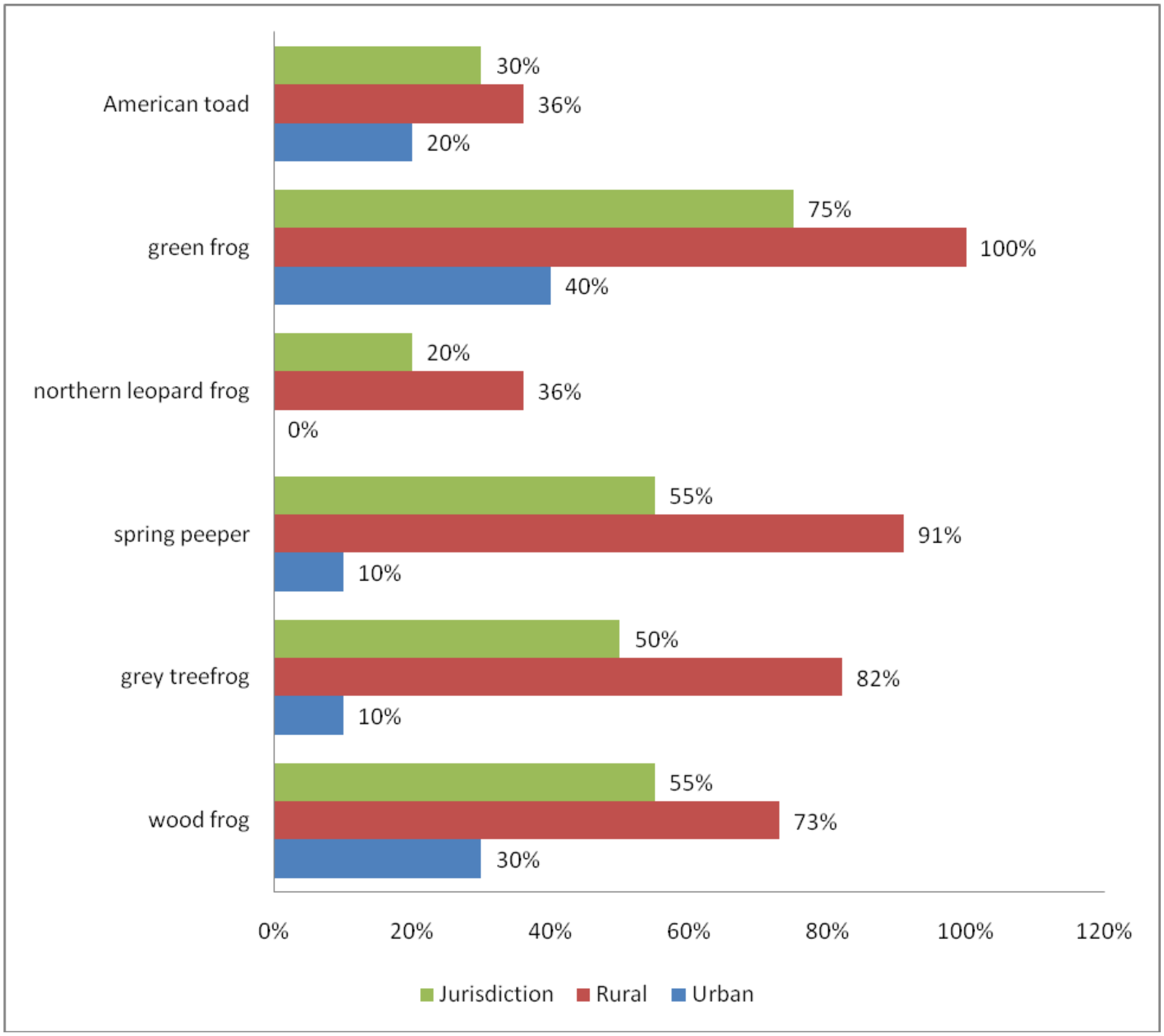


Figure 42. Percent occupancy of the six frog and toad species at stations across the jurisdiction and within the two land-use zones, (2009 – 2010)

Of the six species reported in the two years of monitoring, green frog (*Lithobates clamitans)* was reported from the highest proportion of stations, both urban and rural. This species was present at 100% of the rural stations. Wood frog (*Lithobates sylvatica*) was the next most frequently encountered species at the urban stations while grey treefrog (*Hyla versicolor*) and spring peeper (*Psuedacris crucifer*) were both more likely to be reported from the rural stations.

4.3 Meadow Monitoring

4.3.1 Meadow Birds

Since the number of meadow stations currently falls below the sample size needed for statistical analysis (Zorn, 2008) only meadow species richness can be analysed at this point. Furthermore, the low number of meadow sites and the limited number of meadow-dependent bird species precludes any comparison between the rural and urban categories.

A total of just 8 meadow-associated bird species were reported from the 21 stations (across a total of 14 plots). The most frequently encountered meadow bird species was savannah sparrow (*Passerculus sandwichensis*), occurring at 76% of the 21 stations across the region (Figure 43). Of the eight species, six species are ranked as L4, with one species each ranked as L3 and L2 (bobolink, *Dolichonyx oryzivorus*; and grasshopper sparrow, *Ammodramus savannarum*, respectively).

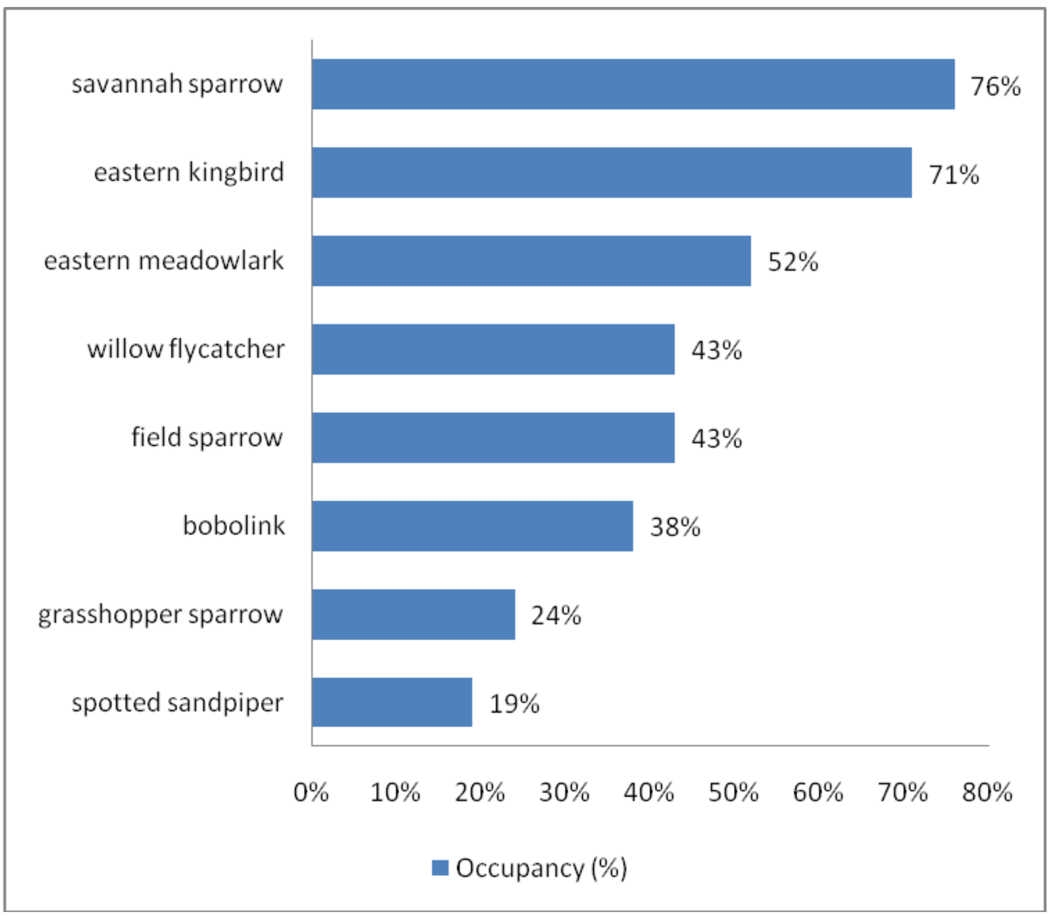


Figure 43. Percent occupancy of meadow species at the monitoring stations, (2009 - 2010)

5.0 Discussion

5.1 Forest Vegetation

5.1.1 Trees

Age and Composition

The age distribution of trees in the TRCA forest plots is close to that of a normal distribution (i.e. a "bell curve"). Older trees over 100 years of age have a distinct presence but are not common, indicating that these forest plots are generally not in old-growth stands. Along with an almost ubiquitous history of selective logging in Toronto-area woodlots, other factors opposing true old-growth status would include habitat fragmentation (with resulting edge effects), heavy trail use, sugar bush management, and the removal of snags and deadwood due to aesthetics or "hazard tree" concerns. On the other hand, the presence of these older trees indicates that there is a surprising amount of near old-growth. Many of these trees would be close to or at the "age of onset" for old-growth designation. Most deciduous and coniferous trees in southern Ontario have an old-growth age of onset between 110-140 years (Uhlig *et al*. 2001). Retention of woodlots would have been aided by the presence of steep ravines making some stands difficult to reach for logging. Selective logging, unlike agricultural clearing, leaves some original trees available for recruitment, along with understorey and seed bank.

The possible (but not statistically-verifiable) tendency for older age profiles in urban (versus rural) and coniferous (versus deciduous) trees is interesting. In the former case, this may be due to cessation of selective logging after urbanization; timber harvest is predominantly a rural activity. In the latter case, it may reflect greater longevity of conifers or reduced recruitment in the past several decades leading to the loss of a younger cohort.

Composition

The dominance of sugar maple in the TRCA forest monitoring plots is not surprising. The 33.2% of the total is comparable with the 41% in the Credit Valley Conservation Authority's jurisdiction (CVC 2010). Sugar maple is characteristic of this part of North America, both in the Great Lakes – St. Lawrence and Carolinian life zones. A late successional species, it is shade tolerant and has not so far been subject to introduced pests and diseases. Woodlot management has also favoured sugar maple through direct selection for sugar production, and through creation of favourable conditions for regeneration. Important secondary species include white cedar, bur oak, and eastern hemlock. The secondary species in the rural and urban land-use zones, however, are quite different: white cedar being a clear secondary dominant in the rural zone, and bur oak and eastern hemlock in the urban zone. In turn, these results also appear to be different from those of the Credit watershed, where white ash, paper birch, beech, and white pine are the secondary dominants. Overall, the TRCA jurisdiction plots seem to have slightly more conifers.

It is too early to make any statistical inferences here, given the small sample sizes available for individual tree species. However, the TRCA jurisdiction straddles the boundary between the Carolinian and Great Lakes – St. Lawrence life zones. This boundary also roughly corresponds to the land-use zone boundary. Hence, differences due to land-use zone may be confounded with the more natural life zone gradient. For example, white cedar is scarce in south-western Ontario (while rapidly becoming very common just to the north in south-central Ontario); and shagbark hickory is more abundant in the southwest (though there is a strong eastern Ontario population separated from the one in south-western Ontario). These distributions are reflected in the TRCA jurisdiction, where shagbark hickory dominates the south-westernmost forest plot (FV-1: Hwy 401 & 403), and white cedar is concentrated to the northeast (e.g. at FV-17: Reesor Road & Hwy 7). The ratio of coniferous to deciduous trees is also lower in the urban land-use zone as compared to the rural; again, this could be a compound of natural life zone and urban heat island effects. Plot site selection could also be a factor affecting some of the results: white cedar is scarce in Credit watershed forest plots, but is abundant in the riparian plots set up by CVC (CVC 2010). TRCA does not have a separate network of riparian plots, and any non-wetland treed areas are included in the forest sample.

Native trees also overwhelmingly dominate TRCA forest plots. This result would appear to contradict a widely-held perception that invasive exotics are threatening our forests. However, there may also be plot site selection and sample size issues, as no plots were located in typical floodplain stands of Manitoba maple; the plots that were placed in valleys and lowland forests actually ended up being other communities; for example, FV-3 (Portage Trail) in the lower Humber, is a bur oak stand; and FV-18 (Shoal Point) is dominated by red ash. In addition, in plots that have an established population of sugar maple, this tree is a formidable competitor with other species, even invasive exotics; as this species combines shade tolerance with relative tolerance for weather extremes. Barring catastrophic attack by a pest such as Asian long-horn beetle or dramatic acceleration of climate change, sugar maple stands appear to be stable and robust against invasion by invasive tree species. However, the shrub and ground layers also need to be considered with regard to exotic species.

Tree Health

The TRCA forest plots have a reduced number of dead trees compared to typical eastern North American forest stands. Snags typically account for close to 25% of stems (Sajan 2006). In contrast, the TRCA rural zone forest plots have 14% snags and within the urban land-use zone only 8%. Rather than this being an indicator of low tree mortality and exceptional forest health, it is more likely the result of human removal of dead trees. In urban and near-urban areas frequented by people, the clearing of “hazard trees” is a growing concern. Dead and near-dead trees can also be culled during forest management for wood production. The paucity of snags is actually a potential ecological problem in that they represent a significant habitat feature for other species, including native birds, insects and fungi. The somewhat less urbanized Credit watershed has a more normal presence of snags: about 21% of stems (CVC 2010).

TRCA results show mortality rates may be elevated among certain species: American elm (55% of which were dead), ironwood (26% dead), white ash (25%), and perhaps beech (15%). Dutch elm disease has been attacking elm for decades. Elm has a high regeneration and growth rate, but new strains of the disease appear periodically, potentially keeping ahead of the development of resistant trees. The native elms in the TRCA jurisdiction still need to be considered to be stressed species. American elm, the only elm species observed in our plots, is ranked L5 (secure even in disturbed urban forests) but now is far from being a dominant tree species. The more scarce rock elm (*Ulmus thomasii*) and slippery elm (*U. rubra*) are currently ranked L3.

The frequency of dead white ash – even in the absence of emerald ash borer (*Agrilus planipennis*) observations, is also concerning and requires further investigation. Ash is a major component of many TRCA jurisdiction forests, especially young to mid-aged ones, although it is not as prevalent in our set of plots as it is in that of CVC. Is there a serious ash yellows disease problem or is it natural mortality due to succession (white ash is somewhat of a pioneer species though less so than poplars)? Ash yellows are a subtle disease, not discovered until the 1980s (Pokorny and Sinclair 1994, Gillman 2005). The fact that ash is showing possible signs of weakness even as emerald ash borer is just beginning to show up in the TRCA jurisdiction is ominous. The loss of most ash trees in our area is considered to be imminent based on the impact of emerald ash borer in the U.S. Midwest and south-western Ontario.

The high prevalence of dead trees among the ironwood is even stranger. This species is not normally considered to have serious health problems, although there may be some difficult-to-detect stem and butt rots (Fehrenbach 198-, US Forest Service 198-). Sample size and time period are still too small to draw clear conclusions.

Tree decline as measured by crown die-back was generally low across the TRCA set of forest plots; over 80% of all trees were in the minimal decline category with under 10% crown die-back. This is below the 25% (i.e. 25% of trees showing die-back) threshold of concern established by EMAN (Sajan 2006). The fact that most of the trees showing die-back were in the intermediate and suppressed crown classes is to be expected given the impact of competition and reduced light on such trees. Unlike the CVC, TRCA forest plots did not show increased decline among conifers (CVC, 2010). Even the three deciduous species (beech, white ash, and bur oak) that showed slightly elevated incidence of crown die-back were below the 25% threshold of concern (Appendix 3).

While various uninfected wounds detected as stem defects (open, closed, frost cracks and seams) are generally the result of physical damage (e.g. wind, the fall of neighbouring trees), the presence of cankers, decay fungi, or insect damage is more of interest. The occurrences of canker (30), decay fungi (13), and insect damage (29) across 551 live trees sampled are below the threshold of concern of 10% (CVC 2010). While the overall incidence of pathogens was low, a few potential problems with particular species need to be noted. Dutch elm disease has already been alluded to; the fact that it was not recorded on individual living trees is likely due to the fact that death often occurs quickly after symptoms begin. Hence at baseline, Dutch elm disease is reflected in the high proportion of already-dead trees rather than as records of the disease itself. As monitoring continues, it is likely that cases of the disease will be noted.

Beech bark disease is having a severe impact in much of eastern North America. Closer attention to the presence of the canker infection (rather than only the beech scale insect) will be needed. The fact that many of the beech trees in TRCA plots currently seem to have a full leaf canopy even while affected by beech scale is reassuring, but this may be temporary and infected trees may go into decline if another stressor is added, such as drought. The three years of this baseline report (2008-10) have all had plentiful rain during the growing season (Environment Canada 2011). In addition, the proportion of dead beech trees may be slightly elevated.

Gypsy moth was present in only low numbers during the baseline period. Similarly, other significant insect defoliators (such as fall cankerworm - *Alsophila pometaria*) were not evident over this time. Nonetheless, population spikes of these insects can be expected to occur in the future.

Asian long-horned beetle (*Anoplophora glabripennis*) could have the potential to become a devastating pest on sugar maple and several other species of trees. Fortunately, quarantine and control measures seem to be having some success, unlike the case with emerald ash borer. Nonetheless, constant vigilance will be required to ensure that it does not reappear.

Some pests and diseases known to be in the TRCA jurisdiction were not recorded in the plots because of the absence or scarcity of the host species in the plots. For example, there were no butternut (*Juglans cinerea*) in any of the plots and therefore no butternut canker (*Ophiognomonia clavigignenti-juglandacearum*, Broders and Boland 2010) was recorded. Butternut is mapped during our wide-ranging systematic inventory surveys, and brief notes on health and disease are recorded. Most butternuts in the TRCA jurisdiction do have symptoms of butternut canker. White pine blister rust (*Cronartium ribicola*) was not recorded in the regional plots, and only a few (mature) white pine were found. However, denser younger stands of white pine in the special project monitoring plots at Duffins Heights do have white pine blister rust.

Several other pests and diseases, such as the hemlock woolly adelgid (*Adelges tsugae*) are present in eastern North America and are likely to reach the Toronto area in the coming years.

The generally good health of the forest canopy over the past couple of years has also been noted by CVC (2010) and is likely due to favourable growing conditions (above-normal summer rainfall) from 2008-2010. This may be masking some longer-term problems that stress would reveal. The last dry summer in the TRCA jurisdiction was in 2007, prior to the initiation of the long-term monitoring plot program. Additionally, wetter conditions may favour a parasitic fungus (*Entomophaga maimaiga*) that controls gypsy moth (CVC 2010).

5.1.2 Saplings and Shrubs

There was a wide variation of sapling and shrub density across the TRCA plots; some plots had little or no woody regeneration, whereas others had hundreds of stems. Reasons for this variation cannot be ascertained on the basis of available data; however, factors such as stand maturity, canopy density, and light availability seem likely enough explanations. Species richness is fairly high but the understorey is heavily dominated by large numbers of only a few species: sugar maple among the tree saplings, choke cherry and European buckthorn among the shrubs.

Tree sapling data are of particular interest because these have the potential of forming the future tree canopy whereas this is not the case with shrubs or woody vines. Shrubs appear to have a higher relative abundance compared to tree saplings but tree saplings have a higher relative cover. Thus, there are fewer tree saplings but they have a larger canopy "footprint". This makes sense given that saplings by definition grow larger than shrubs; and that the TRCA protocol includes saplings of up to 10 cm dbh.

The composition of tree regeneration differs from that of the canopy. Firstly, there are slightly fewer species of tree regenerating than are currently in the larger size classes of 10 cm dbh or greater. This is true in both land-use zones, and also reflects the findings of CVC (2010). Secondly – and probably of even greater concern is the fact that very few species are represented in the regeneration/sapling layer in any numbers. Sugar maple accounts for the majority of all saplings. Meanwhile the second-most abundant species, white ash, is facing imminent challenges to the emerald ash borer. Other tree species have a low to negligible presence.

A good deal of the explanation could be that sugar maple is a shade-tolerant late-successional species that relies for recruitment on large numbers of persistent suppressed small saplings that would be expected in a shaded understorey; whereas many of the others require more light with larger canopy gaps or edges for recruitment. After all, the forest plots were set up in forest stands with mostly-closed canopies; this alone would dictate more representation by shade-tolerant species in the regeneration layer.

However, if this were the only reason, there should be a greater presence of other shade-tolerant species, especially beech and hemlock. Beech saplings were virtually absent from the rural land-use zone, and weakly represented in the urban land-use zone. Meanwhile, hemlock was entirely absent from the regeneration in any of the TRCA forest vegetation plots. Beech bark disease is causing serious decline in recruitment of this tree species; stressed trees may fail to produce much viable seed. The beech in TRCA plots that showed signs of beech scale but had reasonably full canopies over the 2008-2010 period may still be failing to produce viable seed crops. Instead, saplings are produced from root suckers. In addition, the restriction of regeneration to clonal suckering only means that there is no opportunity for genetic recombination that may result in resistant trees.

The observed failure of hemlock – and conifers generally, to reproduce is supported by the older age profile of conifers in the forest stands containing the TRCA forest vegetation plots. The overall picture is of an aging population, and a long-standing decrease in conifer regeneration. There do not appear (yet) to be any emergent pathogens affecting hemlock in the Toronto area. Explanations could range from climate change exacerbated by urban heat island and edge effects resulting in decreased atmospheric humidity and high temperatures, and air pollution to subtle changes in soil structure, metabolism and chemistry resulting from nitrate deposition and earthworm activity, and herbivory.

Three species of shrub account for more than half of the total, although representation is better distributed among the shrub species than among the trees, especially in the rural land-use zone Choke cherry heavily dominates the urban zone shrubs, and together with European buckthorn constitute the second- and third-most abundant and highest-cover woody species across the whole set of plots. The relatively high cover of maple-leaved viburnum in the rural zone is attributable entirely to one plot: FV-27 (Kirby and Keele). This suggests that a third measure of plant dominance – relative frequency (i.e. the proportion of the plots in which a species occurs) be added to relative abundance and relative cover.

Choke cherry was also the most abundant shrub observed by CVC (2010), comprising 62% of the total. Casual observations (e.g. through ELC surveys) seem to suggest that choke cherry is characteristic of more disturbed forests; at any rate, it has been found to have a high survival rate in urban plantings (Jack-Scott 2009).

Total invasive woody regeneration in the TRCA plots was relatively low, but European buckthorn accounted for almost the entire total, showing that it seems able to successfully invade established forest stands at least to some extent. Buckthorn fruits heavily and the seed is dispersed by birds. It exhibits rapid growth, high photosynthetic rates, and appears to alter soil chemistry with its nitrogen-rich leaf litter (Knight *et al*. 2007). This results in rapid leaf-litter decomposition, bare soil, and more suitable conditions for its own germination as well as that of other invasive species. We can perhaps see here a synergistic interaction of increased nutrient loading, reduced native biodiversity, and more invasions. If due to pathogens or other reasons there is an increase in tree mortality, buckthorn is well-poised to take advantage of canopy openings.

Woody vines, especially the native riverbank grape and thicket creeper have also been casually noted during TRCA ELC surveys as being extremely abundant in areas of declining or disturbed forest, for example, where Dutch elm disease has heavily depleted an elm-rich stand. Invasive woody vines such as kudzu (*Pueraria lobata*), oriental bittersweet (*Celastrus orbiculatus*), and Japanese honeysuckle (*Lonicera japonica*) are devastating to urban forest remnants in the eastern USA, where they are preventing regeneration of tree species (Sauer 1998). There is some evidence that woody vines are increasing in many types of forest, especially warm temperate and tropical forest, perhaps in response to increased carbon dioxide and nitrates (Allen *et al*. 2007, Schnitzer and Bongers 2011). However, woody vines remain as only a minor component of the TRCA forest vegetation plots, perhaps because of the mostly intact tree canopy at our sites so far. Some exotic woody vine species are present in the TRCA jurisdiction (e.g. oriental bittersweet, Japanese honeysuckle, and English ivy – *Hedera helix*), but heavy infestations are local, while opportunistic natives such as riverbank grape are still much more common. It will be very important to keep monitoring the forests of the TRCA jurisdiction to see whether woody vines (whether invasive exotic or opportunistic native species) gain ascendency. A helpful way to further monitor woody vine invasion would be to record their presence in the crowns of trees during tree health surveys.

5.1.3 Ground Vegetation

Ground vegetation overall seemed to be reasonably healthy in the TRCA forest vegetation plots over the 2008-2010 period. Native species dominated the ground layer in both the rural and urban land-use zones, although the latter had somewhat more exotic. Species richness within the ground layer subplots (a three-year average of 112) is almost exactly the same as the results observed by CVC (2009). A wide array of species, plant types, and strategies were represented, including spring ephemerals. The urban land-use zone was perhaps more dominated by forbs, especially more generalist species that persist through the growing season, but sample size is probably too small to verify the difference.

Tree seedlings seemed to be a bit sparse and restricted once again mostly to sugar maple, reflecting the conditions of the woody regeneration layer.

The relative scarcity of exotic species in the ground layer was actually an unexpected result. Nonetheless, the higher level of invasion in urban forest stands, although it did not meet the conservative 95% confidence level standard for most scientific literature, did meet the 80% confidence level suggested for monitoring to flag potential trends or threats (Zorn 2008). The three main species recorded: dog-strangling vine, garlic mustard, and European buckthorn are all serious threats to our forests (TRCA 2008, Nuzzo 1999, Knight *et al*. 2007, Catling and Mitrow 2005). They are constantly encountered in TRCA biological inventories, but invasion is perhaps a bit slower in the forest stands included in the set of monitoring plots. These invasive species will have to be closely monitored. The ground layer with its high biodiversity and seedling trees is of critical ecological importance to the forests.

5.1.4 Floristic Quality

Apparent trends in floristic quality must be taken with caution at this early stage of the long-term monitoring plot program. One such trend is the apparent increase in species richness (and hence FQI) over the three-year period. Not only is the temporal trend too short to obtain a clear signal, but also it is likely that the increase in species recorded is simply due to cumulative effects. New species were found in 2009 and 2010 that had not been noted in the previous year. The fact that average CC remained consistent across the years and plots also fits this explanation, as this measure doesn’t involve changes in numbers of species.

The case is more robust for the higher species richness and FQI being recorded in the rural zone as compared to the urban. The difference was significant at the 95% confidence level. These results parallel those of CVC (2010) in which the highest values were found in the upper Credit watershed, more remote from urban areas. Various “matrix influence” effects that include increased trampling and recreational use, air pollution, dumping of fill or storm water runoff, high populations of herbivores ranging from white-tailed deer to slugs and invasive species could all be implicated. Another factor could simply be isolation. Isolated populations of sensitive flora species may be so small as to be non-viable and some would gradually disappear just through random population fluctuations with no nearby source for recruitment.

On the other hand, species richness and FQI values are relatively high overall. The total species richness across the TRCA forest plots was considerably higher than the 127 recorded by CVC (2010). The urban species richness alone was higher than the CVC total. FQI averaged 26.2 in the TRCA rural zone, 20.6 in the TRCA urban zone, and just 16.3 across the CVC set of plots (CVC 2010). Average CC was similar in both CVC (4.9) and TRCA (4.6), and the proportion of native species was also similar (although a bit higher in CVC at 89%). The higher species richness and FQI in TRCA is due to methodological differences in recording rather than to actually higher biodiversity. CVC has compiled its plot species lists strictly from its plot observations; i.e. herbaceous species were recorded only from the five 1 m^2 subplots, shrubs only from the five 4 m^2 woody regeneration subplots, and trees only from the 400 m^2 tree health plot. TRCA compiled its species lists from everything found in the 400 m^2 tree health plot (including herbaceous species) as well as the subplots. If one looks at the average CC and proportion of native species, then the results from CVC show the floristic quality in the Credit watershed to be the same or slightly higher than TRCA. This is consistent with the Credit watershed being somewhat less urbanized than TRCA.

If the TRCA forest plots are compared with floristic quality standards for oak savannah and prairie in the U.S. Midwest, the FQI and mean CC fall into the medium to slightly-above-medium quality range (Packard and Ross 1997). Of course, this comparison is approximate given the different habitats and probably site sizes involved. The relatively high species richness and FQI in the TRCA forest plots complete the picture of fair to good forest ecosystem health in the jurisdiction. Although there is evidence for some deterioration in the urban zone, the results as a whole are better than what might be expected. There seems to be a degree of stability in forest ecosystems so long as the original canopy and other vegetation layers remain intact. This supports the idea that identification and protection of native forest communities is worthwhile and can be successful, at least for flora conservation.

The forest plots were selected to be well-distributed across the watershed in a semi-random fashion; however, they were placed in locations with an intact canopy. Areas with a broken canopy resulting from tree death or other disturbance were avoided because they may not qualify as forest (>60% canopy cover). It also turned out that no plots ended up being in disturbed lowland forest types dominated by exotic or likely-exotic species such as Manitoba maple. The lowland sites that were selected ended up being dominated by red ash, bur oak, or a blend of species with exotics having a relatively modest presence. There are plenty of such disturbed treed sites in the TRCA jurisdiction that have been encountered during ELC vegetation mapping; however, they were somehow missed during the plot selection process. This represents a data gap that should be filled once there are sufficient resources to do so.

The evidence for reduced floristic diversity in the urban land-use zone is a cause for concern. The most sensitive plant species even in large nature reserves with extensive nearby urban land-uses are still at risk of disappearing on a scale of decades. This has been noted in the Rouge Park (TRCA 2011) and in the eastern USA (Primack *et al.* 2009). Careful control of disturbances related to urban "matrix influence" will need to be exercised in order to maintain and protect biodiversity and floristic quality in TRCA forests.

The small sample size imposes statistical limitations. Specifically, it prevents the attainment of a power level of 90%. Therefore, even if some trends have been detected at a high level of confidence (minimizing Type I error), others may have been missed (Type II error) (Zorn 2008). This could be addressed in future by increasing sample size either by increasing the number of TRCA forest plots or in some cases by pooling our data set with nearby monitoring projects using the same protocol in the Greater Toronto Area, such as CVC (2010).

It will be very important to continue to monitor these forest plots. Will they remain intact or will some species of tree succumb to pests and diseases, altering the species composition and allowing invasive exotics to colonize? Will there be a continued gradual attrition of the most conservative, high L-rank species, or is it possible to arrest or reverse this trend through application of conservation biology to the regional natural heritage system?

5.2 Wetland Vegetation

5.2.1 Soil Conditions

Deep organic soils are indicative of long-term stable wetland conditions, where they have had a chance to accumulate. Overall, the wetlands in the rural land-use zone are more likely to have had an organic horizon over 40 cm deep, with seven of the nine showing such an organic horizon. On the other hand, carbonates in the surface horizons indicate the presence of unweathered calcareous parent material and are a sign of disturbance (usually either dumping of subsoil fill or erosion of the surface layers). The urban set of transects had more evidence of carbonates, with five of the nine showing this even into the wetland end of the gradient. These results are to be expected, given the increased amount of disturbance in urban areas.

5.2.2 Tree Presence

Although just over half (5/9) of the wetland transects in each zone had trees recorded through prism sweep, many of the trees, especially in the urban zone, were on the terrestrial margin of the wetland and were even upland species. In addition, while five rural transects had snags captured by the prism sweep, only two of the urban transects had snags. Hence trees are probably a significant feature among slightly fewer than half of the wetland transects overall.

Overall, this seems to indicate that non-treed wetlands are somewhat predominant among the TRCA's sample. These are marshes, vegetated aquatic, and some thicket swamps that have shrub but little tree cover. Treed swamps are particularly vulnerable to hydrological changes, and may be diminishing in favour of more open wetlands; however a long time period of monitoring will be required to ascertain this.

Snags are an important habitat feature in wetlands, providing nesting habitat for birds and, when they have fallen, resting habitat for reptiles and amphibians. They seem to be less available in the urban set of wetlands as they are in the urban forests, perhaps due to a combination of hazard removal as well as a lack of treed swamp communities overall.

5.2.3 Saplings and Shrubs

Saplings and shrubs are found in both land-use zones, while they tend to be more restricted to the terrestrial end of the gradient in many of the urban transects, which include more open marshes.

Of the woody vegetation regeneration recorded, shrubs outnumber trees and also have a higher cover. This supports the evidence given by the prism sweep that treed swamps have a relatively low representation in the TRCA jurisdiction wetland transects, especially in the urban zone. Conifer saplings prevail in the rural zone transects, which include several headwater conifer or mixed swamps (e.g. WV-6: Cold Creek, WV-12: Bruce's Mill, and WV-15: Secord). Tree saplings in the urban zone transect are entirely deciduous, largely upland or generalist species, with basswood occupying first rank.

Shrubs follow a similar pattern of distribution in that there is a more consistent presence of wetland shrubs in the rural zone, although the urban zone also includes some conservative or specialist wetland shrubs. The urban zone has more invasive exotic or generalist native shrubs. Choke cherry is the most abundant shrub, and buckthorn is the third-most abundant shrub. Many of these would be located toward the terrestrial end of the gradient of open marsh transects.

Woody vines are currently a minor component of the TRCA wetland transects, as they are with the forest plots. The urban zone has more woody vines, although the most common species there is climbing nightshade, which is of low stature and is a mildly invasive exotic. Woody vines will need to be monitored in the wetland transects as in the forests to see if there is an increasing trend.

The main concern, however, is the lack of woody species generally in the urban wetlands and the lack of deciduous swamp trees from the jurisdiction as a whole. Mature deciduous swamps featuring trees such as silver maple, red ash, elm and bur oak are not well-represented in the TRCA wetland transects. In fact, only one regional wetland transect: WV-11, Finch and Pickering Townline, fits this description well. (The forest plot FV-18 at Shoal Point is transitional between lowland forest and deciduous swamp). This kind of vegetation community was most prominent on poorly-drained tablelands such as the Peel Clay Plain. This area has been drained and cleared for agriculture, and is now undergoing urbanization with very little greenbelt protection. Most of the remaining hardwood swamp woodlots are on private land.

Development – both agricultural and urban land-uses, can alter the hydrology of wetlands and disrupt the more sensitive woody species. Ditches, storm water drains, and tile drainage lower the water table and convey water away from the site. On the other hand, increased impervious surface from urbanization in the vicinity can lead to increased runoff and more concentration of water in remaining natural areas, resulting in more extreme fluctuations in water level and longer periods of inundation. Roads are a particularly disruptive factor (Noss 1995).

It will be important to monitor whether there is in fact a decline in woody species, especially trees, in the TRCA wetland transects. Are changes in hydrology leading to the loss of moderately wet vegetation communities (thus being replaced either by wetter types such as marsh or aquatic or by drier disturbed forests occupied by generalist and invasive species)?

5.2.4 Ground Vegetation

Wetland ground vegetation had more exotic invasion than any of the other vegetation parameters examined in this study (forest tree, regeneration and ground layers; and wetland tree and regeneration layers). The elevated coverage of exotic ground species in the urban wetlands versus the rural was statistically-significant at the 95% confidence level even given the relatively small sample size (and short time period) of this baseline study.

Hybrid cattail was the main exotic species observed. Five of the wetland transects (all of them in the urban zone) could be characterized as being largely hybrid cattail marsh. This species was largely responsible for the dominance of exotic cover in the urban zone; however, several other exotic species were observed, including purple loosestrife, reed canary grass, common reed, and giant manna grass, all of which are considered high-priority invasives (Catling and Mitrow 2005; OMNR 2011). The Eurasian subspecies of common reed is a very aggressive invasive species, so far found only at one of the TRCA wetland transects at Greenwood (WV-14) (although it is widespread in disturbed wetlands across the jurisdiction. At Greenwood, it forms a virtual monotypic stand along most of the transect. Similarly, giant manna grass dominates part of the Science Centre wetland (WV-9). This invasive species is currently very local but also seems to show the ability to form very dense monotypic stands, under slightly drier conditions than hybrid cattail. Most of these invasions were described by Galatowitsch *et al.* (1999) as being the result of large-scale disturbance and dispersal patterns in which hydrological alterations, increased nutrient and road salt inputs, and adaptations such as increased competitive ability and hybridization have all played a role. These disturbances are most obviously present in urban wetlands, which have usually been disturbed by construction and storm water runoff. The Greenwood transect is in the rural zone but was formed partly by aggregate extraction in the mid-twentieth century. An additional factor in coastal wetlands such as Duffins Marsh might be the stabilization of Lake Ontario water levels following the construction of the St. Lawrence Seaway in the mid-twentieth century. Protected kettle wetlands and ground water fed headwater swamps with fewer such external inputs, have a more native-dominated flora. These are mostly associated with the rural zone and the Oak Ridges Moraine in particular.

The high cover of exotics in the urban wetlands even compared to urban forests also reflects the accumulation of silt, nutrients, and contaminants in low-lying areas, while upland forests are more likely to receive fewer of these disturbances. Supporting evidence for disturbance is provided by the soils data, which show less organic matter and more carbonate in the urban wetlands. Given the long-term alteration of such sites, exotic-domination is not likely to be successfully reversed; even if inputs are curtailed, many decades would need to elapse before the contaminants are sequestered or removed naturally. Protection of existing high-quality wetlands from disturbance therefore must be the first priority over restoring degraded ones. Small and localized invasions may be contained or removed in otherwise high-quality wetlands.

The plant type is also an important structural feature to be investigated in wetland monitoring. This study used the designations provided by Bradley and Lee (2009). This classification is upland-oriented, with all non-woody, non-graminoid seed plants considered as "forbs". Future examination of wetland vegetation should distinguish between various kinds of emergent, floating-leaved, and submergent plant types, perhaps following more the designations of the Ontario Wetland Evaluation System (OWES) (OMNR 2002). For example, cattails are designated as "robust emergents", to distinguish them as a particular form of emergent plant – a tall, fleshy and somewhat slender monocot that is neither a forb nor a graminoid. The similarity of the invasive hybrid cattail in its structure to the native broad-leaved cattail (*Typha latifolia*) means that it still provides habitat function for native fauna, in contrast to common reed and purple loosestrife. Therefore it is in some respects a less serious invasive.

5.2.5 Floristic Quality

Species richness and floristic quality in the TRCA wetland transects was about the same or slightly lower than recorded by CVC (2010). Species richness in TRCA averaged 253 over the 2008-2010 period, while CVC recorded 274. The average CC was 4.0 in CVC and 3.9 in TRCA. While the FQI averaged 24.6 in the CVC wetland transects but only 19.9 in TRCA. Comparisons between CVC and TRCA are robust because, unlike forest plots, wetland transect species lists were compiled using the same methodology. The wetlands at CVC show slightly higher floristic quality, probably because the watershed as a whole is less urbanized than the TRCA jurisdiction. When comparing the TRCA forests and wetlands, species richness was higher in the TRCA wetland transects than in the forest plots, but average CC and FQI tended to be a bit lower, especially in the urban zone.

There was a large difference in floristic quality between wetland transects in the rural and urban land-use zones. Rural FQI averaged about 23, while urban FQI was about 16. This difference was partially offset by the high variability within each zone; standard deviation was about half the magnitude of the mean across TRCA and even higher in the urban zone. Therefore, the difference was statistically significant only at the 80% confidence level – still enough to elicit concern for degraded floristic quality in the urban zone. If compared with standards for tallgrass prairie and savannah sites in the Midwestern USA, the TRCA wetland transects show mostly fair floristic quality, tending toward poor in the urban land-use zone (Packard and Ross 1997).

A closer look reveals that two urban wetland transects retain a relatively high floristic quality. Kenpark (WV-2) is a natural kettle associated with the Heart Lake wetland complex, even though it is surrounded by residential development. Part of the transect is occupied by hybrid cattail, although the furthest end remains in a more natural thicket swamp condition with several sensitive species recorded. The transect at East Don Parkland (WV-10) is largely fed by ground water and retains some headwater swamp characteristics with high species richness and moderate conservatism or sensitivity. These two transects appear to have been relatively insulated from inputs of storm water, silt, or nutrients. The reduction in floristic quality of urban wetlands appears to be less advanced than the ground layer results; this suggests that native species can persist in low numbers even though exotic species may strongly dominate the total cover.

TRCA wetlands are showing some of the same matrix influence stresses as the forests, but the impacts are if anything more accentuated. There is a stronger presence of exotic species and lower floristic quality. This is probably because wetlands are at the receiving end of disturbances such as runoff bearing road salt, silt, excess nutrients, and weed seed. The results suggest that wetland communities are easily damaged and tend to be replaced by low-diversity stands of hybrid cattail, common reed, and other invasive species. Runoff and drainage can also alter the hydrology, by increasing net water input and high water levels or by lowering the water table. It is very important to firmly sequester urban runoff from existing natural wetlands, and to preserve their hydrological balance. The examples of WV-2 (Kenpark) and WV-10 (East Don Parklands) suggest that successful protection of natural communities should be possible given enough knowledge of the site, good planning, and political will. In addition, the catchment area of high floristic-quality wetlands should be converted to natural cover where possible. Even agricultural runoff (assuming conventional agriculture rather than alternatives such as permaculture or organic farming) can degrade wetlands. Subtle changes have been revealed in kettle wetlands in the Oak Ridges Moraine Corridor Park / West Gormley area (OMNR 2000, Watchorn *et al*. 2008).

Some wetland community types are poorly-represented to date in the monitoring program with only one tableland deciduous swamp included (WV-11: Finch and Pickering Townline). It is difficult to find such communities accessible on public land, as most of them have been lost to development (the unprotected Peel Clay Plain had the best conditions for these swamps). This data gap should be addressed in the selection of any new wetland vegetation transects.

5.3 Fauna

5.3.1 Birds

The presence of habitat-specific fauna species indicates that a particular station is situated on a site that is functioning – at least at the fauna level – appropriately as wetland, meadow or forest. By applying the species guilds to the baseline data it is possible to assess the regional sites and stations. It is important to consider the different interpretation of results depending on whether one considers species richness (the number of species) or species representation (the number of individuals of each species).

Species richness

Using a combination of the local-rank and the guild-based approach, it would seem that the largest and most consistent difference between the two land-use zones - urban and rural – is presented by the forest stations. The proportion of higher ranked bird species is considerably higher in the rural versus the urban zone. Species ranked L3 and L2 constitute 77.3% of the forest-guild species recorded in the rural forests, whereas these same ranks make up only 41.7% of forest-guild species in the urban zone. This is pretty much as expected since forest ecosystems function through several different structural layers (ground, understory and canopy) and it is speculated that the lower of these structural layers is very much compromised within the urban matrix. There were no L2 ranked species reported from any of the urban stations (albeit this rank only featured at a very low percentage even in the rural zone forests).

Of the five forest-associated species which had a higher chance of being encountered at the urban rather than at the rural stations the most surprising was pine warbler, a species which until fairly recently was considered quite area sensitive, requiring extensive stands of conifers. In more recent years the species has undergone what has been described as explosive population growth in the province (Cadman, 2007). Both hairy woodpecker and white-breasted nuthatch are resident forest-associated species which habitually visit backyard bird-feeders throughout the winter (as do red-breasted nuthatches, a species that was as likely to be encountered at the urban as at the rural stations).

To some extent, wetlands possess an inherent buffer against many (but by no means all) of the negative impacts associated with the urban matrix. This being the case it might be expected that higher ranked wetland species (i.e. more sensitive species) will occur in urban wetlands more so than in the other two habitat-types within the urban zone, perhaps approaching equality with the rural wetlands. To date the wetland component of the long-term monitoring project has only been run for two years (as opposed to three years for forest and meadow) and the sample size is too small to come to any conclusions. Nevertheless, it does appear that L3 species richness is nearly equal across the two land-use zones, and, perhaps more significantly, single L2 species were reported from both urban and rural sites.

A similar comparison cannot be made for the meadow habitat since currently the sample size lies below the threshold given in the power analysis. The number of species considered in the meadow analysis is very limited – only eight species in all - any real differences may only be revealed with a larger sample size (i.e. over a longer period of sampling or with a higher number of stations and sites).

Species representation

A similar comparison of the numbers of individuals of each species occurring at the different stations returned a very similar result to the species richness - the forest stations had a large gap between the higher ranked species' (L1 to L3) representation in the rural (49.4%) versus the urban (13.9%) land use zones. Species representation results from the wetland stations also begin to show a greater difference between the two land-use zones (27.1% for rural wetlands, 17.4% for urban wetlands). Nevertheless, as should be expected, the difference is still slightly smaller in the wetland category where the urban matrix appears to have a somewhat smaller affect on the breeding bird population. At this early stage of monitoring, such differences between the forest and wetland habitats might, however, simply be a reflection of the considerably smaller selection of species that are considered to be wetland-associated species.

These apparent patterns fit with the idea that the urban matrix has its most negative impact on the lower strata of the natural habitat. The majority of individuals belonging to those species more sensitive to disturbances associated with the urban landscape are ground-nesting species and although even these sensitive species may be represented by the occasional breeding pair at urban locations, they are far better represented in the rural locations.

The comparison between the results for species richness and species representation illustrates the importance of considering both values; species richness alone can be highly misleading in interpreting results. Furthermore, although species representation helps considerably in assessing the condition of a habitat, this value does not indicate success (productivity) within the habitat. To assess productivity would be a highly labour-intensive process. It is expected that an effective surrogate for such a detailed assessment will be provided by the current monitoring project as the database grows over the years: if productivity is poor within any one habitat then in due course this will be reflected in persistent declines as time passes.

5.3.2 Plethodontid salamanders

After just two seasons of monitoring any discussion of the results is highly speculative. However, even at this stage it is quite apparent that of the 12 urban stations there were 3 that failed to register any salamanders over the 2 seasons. Rather unexpectedly, 2 of the 10 rural stations also registered no salamander sightings in either of the 2 years monitored. The implication of this is that these sites – or at least the forest floor in close proximity to the grid – do not currently support populations of red-backed salamanders. If this absence is true for the entire forest block then it is highly unlikely that salamanders will appear at any time in the near future since red-backed salamanders are generally rather sedentary with little likelihood of recruitment into isolated fragments of forest (unless assisted by humans). This being the case, than the sites that have failed to register any salamanders need to be removed from the project and any further analysis. The protocol calls for a confirmation that red-backed salamanders are present within the study area.

The two years of baseline data suggest a feast or famine scenario whereby there are no stations that register a medium count – either the count is very low or very high. In the urban zone there were no average counts between 5 and 20, and in the rural zone there was only one average count between 5 and 15. This discontinuity may diminish over the years but currently it makes it rather difficult to decide on the appropriate number of Plethodontid monitoring sites that are required for proper analysis. Discounting the five stations that registered no salamanders, the average count for the each of the two years across the entire region was 20.1 and 15.6 respectively.

5.3.3 Frogs

Discussion based on such a comparatively small sample – just 2 years of monitoring at fewer than 20 sites – is somewhat premature since frog populations are very dynamic and subject to considerable variation due to local weather conditions. The affects of this variation on any underlying population trend will diminish over time as the sample size increases. Four of the six species reported seem to be maintaining their presence throughout the rural areas but at this stage the absence of what are considered two of the more common species in our region – American toad and northern leopard frog - from so many of both the rural and urban stations makes analysis rather difficult; further data is required.

Northern leopard frog was not reported from any of the urban stations in either of the two survey years. This absence may be due to the particular types of wetlands that were selected for the project; leopard frogs tend to prefer more open wetlands with access to nearby terrestrial foraging opportunities in meadows. It may be that such wetlands make up a larger proportion of the rural sample than of the urban sample, in fact such open-country wetlands may be entirely absent from the urban zone. Alternatively, it is possible that, so far, monitoring visits have not coincided with peak calling periods for either leopard frog or American toad.

American toad is a second species that appears to be under-represented at the project stations throughout the region. This species is generally considered to be as resilient as green frog and it is therefore very surprising that initial results show the species as absent from a large proportion of both the urban and rural stations. Again, this may simply be due to a site selection issue. American toads and wood frogs rarely share the same breeding ponds (wood frog tadpoles are voracious predators on toad eggs and hatchlings, Petranka, 1994) and this may go some way to explain the rural absence since wood frogs were found in 73% of the rural wetlands. This does not, however, explain the urban absence. This species is one that may need to be watched very carefully, although song activity is highly weather dependant and it may be that these first two years did not allow for the optimal survey conditions.

6.0 Next Steps

The most important step to take is to ensure that annual monitoring continues using the same protocol(s). A minimum of five years of data are needed in order for trends to become apparent, allowing for more robust analysis and interpretation. The following are a few possible temporal trends we should be looking for in particular, while continuing the overall monitoring program:

- Changes in the proportion of native to exotic species cover in the forest and wetland vegetation plots. These could result from natural succession and competitive pressures; intensification of land use, climate change, etc.
- Increases in woody vines, especially in the forest plots. *Monitoring woody vine invasion would be strengthened by including it as a component of tree health assessment: are there woody*

vines present in the crown of the tree? Currently, they are captured only in the 4 m^2 regeneration plots and this does not reveal whether they are present in the tree canopy.

- Changes in species richness and Floristic Quality Index in the forest and wetland vegetation plots
- Changes in bird species richness and representation recorded from the forest, meadow and wetland stations, changes in Plethodontid representation, and changes in frog species richness and representation from the wetland stations
- Changes in representation of the different L-ranks in bird communities in the three habitat types in rural and urban locations
- Region wide changes in populations (richness and representation) of bird species with more southern and more northern affinities in response to climate change
- Population trends in particular individual native flora species of concern (e.g. northern manna grass) or invasive species (e.g. common buckthorn, dog-strangling vine or common reed)
- Any incursion or colonization by additional invasive species not yet observed in the plot or transects (e.g. oriental bittersweet or water soldiers, *Stratiotes aloides*)
- Impacts of emerald ash borer, or any other pests or pathogens that may irrupt
- The resilience of trees affected by pests and diseases already present: will elm and American beech continue to decline, or will they gain resistance and recover?
- Changes due to any restoration efforts undertaken in the vicinity of plots or transects.
- Comparison between trends observed through the TRCA's regional Long Term Monitoring Project and those at individual special projects (e.g. Duffins Heights and Oak Ridges Moraine Corridor Park).
- Further investigation might also incorporate an indication of the preferred nest-height for each bird species. This is done to provide a surrogate indication of sensitivity, it being assumed that ground-nesting species are generally more prone to the negative impacts of human disturbance than those species nesting in the higher levels of the specific habitat type. At this juncture no attempt has been made to analyse this baseline data from the first three years of the project according to nest-height. Appendix 6 also indicates a third and fourth consideration that may be used in future analyses: cavity-nesting species and aerial-feeding species. The latter has been included in order to pre-empt possible future declines in aerial feeding insectivores, a group of species that has already been identified as exhibiting persistent population declines across the continent over recent years.

In addition, steps should be taken to further improve the set of monitoring plots and analyses of data as follows:

- Determine through further analysis if the sample size (number of plots and transects) should be increased, with an aim to keep a reasonable balance between rural and urban sites.

- There should be a focus on including better representation of under-represented vegetation communities, for example, disturbed lowland forests in the forest plots and tableland deciduous swamps in the wetland transects.

- The statistical power of the TRCA dataset could be improved by pooling the data with nearby monitoring projects that use the same or similar methodology. For example, CVC (2010) has a set of forest and wetland monitoring plots immediately to the west of TRCA, and it may be possible to combine the TRCA tree health data with the results of the forest plot tree health data in some applications.

- Further comparisons and combinations of shrub and ground vegetation data are possible: for example, a combination of relative frequency (number of plots in which a species occurs), relative abundance (stem count), and relative cover can yield importance values and distinguish species that are dense but localized from those that are widespread across the set of plots.

- Discontinue any Plethodontid plot that shows no evidence of Plethodontid presence within three years. Relocate Plethodontid plots to sites where presence of red-backed salamanders is confirmed (e.g. by searching of nearby natural cover objects).

7.0 Glossary of Terms

Avifauna: The birds of a particular region, habitat or geological period

Cohort: A group of individuals that share a common factor (e.g. age)

Crown vigour: A measure of the degree of die-back (e.g. dead branches) present in the crown

Spring ephemeral(s): Early blooming wildflowers that emerge in the early spring and go dormant by mid-summer. Typically, they flower, seed and disappear in a two month period

Forbs: Any herbaceous plant that is not grass

Graminoids: Grasses and grass-like plants which includes sedges and rushes

Guild: A group of diverse species that occupy a common niche in a given community, characterized by exploitation of environmental resources in the same way

Indicator(s): A substance or being that is used by observers to determine how various conditions in an environment have changed over time.

Matrix influence: A measure of the positive and negative impacts from the surrounding land-use

Metadata: Data that provides information about one or more aspects of data such as the date of collection and name of collector

Monocot: A group of flowering plants that is characterized by having one cotyledon (seed leaf) in the seed

Noise (statistical): Unexplained variation in a sample

Obligate species: Those species are only capable of functioning or surviving in a particular condition or by assuming a particular behaviour

Pioneer species: The first species to establish in an area where nothing is growing-or in an area that has been devastated by natural and non-natural forces (i.e. fire, flood, plowing etc.)

Senescence: the growth phase in a plant or plant part (as a leaf) from full maturity to death

Snag(s): A dead standing tree

Species representation: The number of individuals (or breeding pairs) of each species in a given area.

Species richness: The number of different species in a given area

Strata: Layers

Strategies: Behaviours evolved and exhibited by a living organism to accomplish a goal (e.g. foraging strategy)

8.0 References

Allen B.P., Sharitz R.R. and Goebel P.C. 2007. ***Are lianas increasing in importance in temperate floodplain forests in the southeastern United States?*** Forest Ecology and Management 242: 17-23.

BSC 2008. Bird Studies Canada. ***Marsh Monitoring Program – Amphibian surveys***. Available on-line at: http://bsc-eoc.org/mmpfrogs.html [Accessed 6 January 2010].

Bradley D. and Lee H. 2009. ***Standardized Plant Species List for Southern Ontario***. Peterborough: Ontario Ministry of Natural Resources Southern Region Information Management and Spatial Analysis Unit.

Broders K.D. and Boland G.J. 2010. ***Reclassification of the butternut canker fungus*, Sirococcus clavigignenti-juglandacearum, *into the genus* Ophiognomonia**. Fungal Biology 115: 70-79.

Cadman, M.D., D.A. Sutherland, G.G. Beck, D. Lepage, and A.R. Couturier (eds.). 2007. ***Atlas of the Breeding Birds of Ontario, 2001 – 2005***. Bird Studies Canada, Environment Canada, Ontario Field Ornithologists, Ontario Ministry of Natural Resources, and Ontario Nature, Toronto, xxii + 706pp.

Catling P.M. and Mitrow G. 2005. ***A prioritized list of the invasive alien plants of natural habitats in Canada***. Canadian Botanical Association Bulletin 38(4): 55-57.

CVC 2010. ***Credit Valley Conservation Integrated Watershed Monitoring Program 2008 Summary Draft Report.*** Credit Valley Conservation. January 2010*.*

EMAN 2004a. ***Tree Health – EMAN Monitoring Protocols and Standards.*** Ecological Monitoring and Assessment Network (EMAN). Environment Canada. Available on-line at: http://eman-rese.ca/eman/ecotools/protocols/terrestrial/tree_health/tree_health.pdf [Accessed 6 January 2010].

EMAN 2004b. ***Regeneration and Sapling Survey – EMAN Monitoring Protocols and Standards.*** Ecological Monitoring and Assessment Network (EMAN), Environment Canada. Available on-line at: http://eman-rese.ca/eman/ecotools/protocols/terrestrial/sapling/sapling.pdf [Accessed 6 January 2010].

Environment Canada 2011. ***Canadian Climate Data Search***. Available on-line at http://www.climate.weatheroffice.gc.ca/climateData/canada_e.html [Accessed 7th April 2011].

Fehrenbach W.E. 198-. **Ostrya virginiana: *characteristics and potentials of a little-known native***. Kirtland, Ohio: Holden Arboretum. Available on-line at http://www.ces.ncsu.edu/fletcher/programs/nursery/metria/metria04/m410.pdf [Accessed 4th April 2011].

Galatowitsch S., Anderson N. and Ascher P. 1999. ***Invasiveness in wetland plants in temperate North America.*** Wetlands 19 (4): 733-755.

Gillman D.H. 2005. ***Ash yellows***. Amherst, MA: University of Massachusetts Extension Landscape, Nursery and Urban Forestry Program. Available on-line at: http://www.umassgreeninfo.org/fact_sheets/diseases/ash_yellows.pdf [Accessed 5th April 2011].

Jack-Scott E. 2009. ***Survival and Growth Factors Affecting Community-1 Planted Urban Street Trees***. Yale University School of Forestry and Environmental Studies. Available on-line at: http://environment.yale.edu/hixon/files/pdf/2009_Emily_JackScott.pdf [Accessed 11th April 2011].

Knight K.S., Kurylo J.S., Endress A.G., Sewart R. and Reich P.B. 2007. ***Ecology and ecosystem impacts of common buckthorn* (Rhamnus cathartica)*: a review***. Biological Invasions 9: 925-937.

Masters L.A. 1997. ***Monitoring vegetation***. In Packard S. and Mutel C.F. (eds) 1997. ***The Tallgrass Restoration Handbook***. Washington, Island Press, pp. 279-301.

Noss R. 1995. ***The ecological effects of roads***. Wildlands CPR. Available on-line at: http://www.wildlandscpr.org/ecological-effects-roads [Accessed 19th April 2011].

Nuzzo V.A. 1999. ***Invasion pattern of the herb garlic mustard* (Alliaria petiolata) *in high quality forests***. Biological Invasions 1: 169-179.

Oldham M.J., Bakowsky W.D. and D.A. Sutherland. 1995. ***Floristic Quality Assessment System for Southern Ontario***. Natural Heritage Information Centre, Ontario Ministry of Natural Resources, Peterborough.

OMNR 2000. ***Inventory of five areas of natural and scientific interest (ANSIs) on the Oak Ridges Moraine, Town of Richmond Hill, Ontario.*** Ontario Ministry of Natural Resources, Aurora District.

OMNR 2002. ***Ontario Wetland Evaluation System: Southern Manual, Third Edition***. Ontario Ministry of Natural Resources.

OMNR 2011. ***Invasive* Phragmites *– Best Management Practices***. Ontario Ministry of Natural Resources, Peterborough, Ontario. Version 2011. 17p.

Packard S. and Ross L.M. 1997. ***Restoring Remnants***. In Packard S. and Mutel C.F. (eds) 1997. ***The Tallgrass Restoration Handbook***. Washington, Island Press, pp. 63-88.

Petranka, James W., Mark E. Hopey, Barton T. Jennings, Shannon D. Baird and Sarah J. Boone. 1994. **Breeding Habitat Segregation of Wood Frogs and American Toads: The role of interspecific tadpole predation and adult choice.** Copeia. Vol. 1994, No.3, Aug.17, 1994.

Pokorny J.D. and Sinclair W.A. 1994. ***How to identify and manage ash yellows in forest stands and home landscapes***. St. Paul MN: USDA Forest Service Document NA-FR-03-94. Available on-line at: http://www.na.fs.fed.us/pubs/howtos/ht_ash/ash_yell.pdf [Accessed 5th 2011].

Primack R.B., Miller-Rushing A.J., and Dharaneeswaran K. 2009. ***Changes in the flora of Thoreau's Concord***. Biological Conservation 142: 500-508.

Roberts-Pichette P. and Gillespie L. 1999. ***Terrestrial vegetation biodiversity monitoring protocols: Ground Vegetation Biodiversity Monitoring Protocols***. Ecological Monitoring and Assessment (EMAN) Occasional Paper Series. Report Number 9. 142 pp. Available on-line at: http://www.eman-rese.ca/eman/ecotools/protocols/terrestrial/vegetation/e_veg_protocol.pdf [Accessed 6 January, 2010].

Sajan R. 2006. ***Tree Health Data Analysis – EMAN Monitoring Protocols and Standards. Ecological Monitoring and Assessment Network.*** Environment Canada. Available on-line at: http://www.eman-rese.ca/eman/ecotools/protocols/terrestrial/tree_health/Tree%20health%20threshold_final.pdf [Accessed 6 January 2010].

Sauer, Leslie, 1998. ***The Once and Future Forest***. Washington, DC: Island Press.

Schnitzer and Bongers F. 2011. ***Increasing liana abundance and biomass in tropical forests: emerging patterns and putative mechanisms***. Ecology Letters 14: 397-406.

TRCA 2006. ***Oak Ridges Corridor Park Management Plan.*** Toronto Region Conservation Authority.

TRCA 2007. ***Terrestrial Natural Heritage Program Data Collection Methodology***. Toronto Region Conservation Authority.

TRCA 2008. ***Dog-strangling vine* – Cynanchum rossicum *(Kleopow) Borhidi: a review of distribution, ecology and control of this invasive plant***. Toronto and Region Conservation Authority and Rouge Park

TRCA 2009. ***Terrestrial Fixed Plot Monitoring: Regional Watershed Monitoring Program Protocols***. Toronto Region Conservation Authority.

TRCA 2010. ***Vegetation Community and Species Ranking and Scoring Method***. Toronto Region Conservation Authority.

TRCA 2011. ***Rouge Park South of Steeles Avenue: Terrestrial Biological Inventory and Assessment***. Toronto Region Conservation Authority.

TRCA 2011a. **Meadow Bird Monitoring Protocol -Terrestrial Long-term Fixed Plot Monitoring Program – Regional Watershed Monitoring and Reporting.** Toronto and Region Conservation Authority.

TRCA 2011b. **Plethodontid Monitoring Protocol - Terrestrial Long-term Fixed Plot Monitoring Program – Regional Watershed Monitoring and Reporting.** Toronto and Region Conservation Authority.

TRCA 2011c. **Terrestrial Long-term Fixed Plot Monitoring Program – Regional Watershed Monitoring and Reporting.** Toronto and Region Conservation Authority

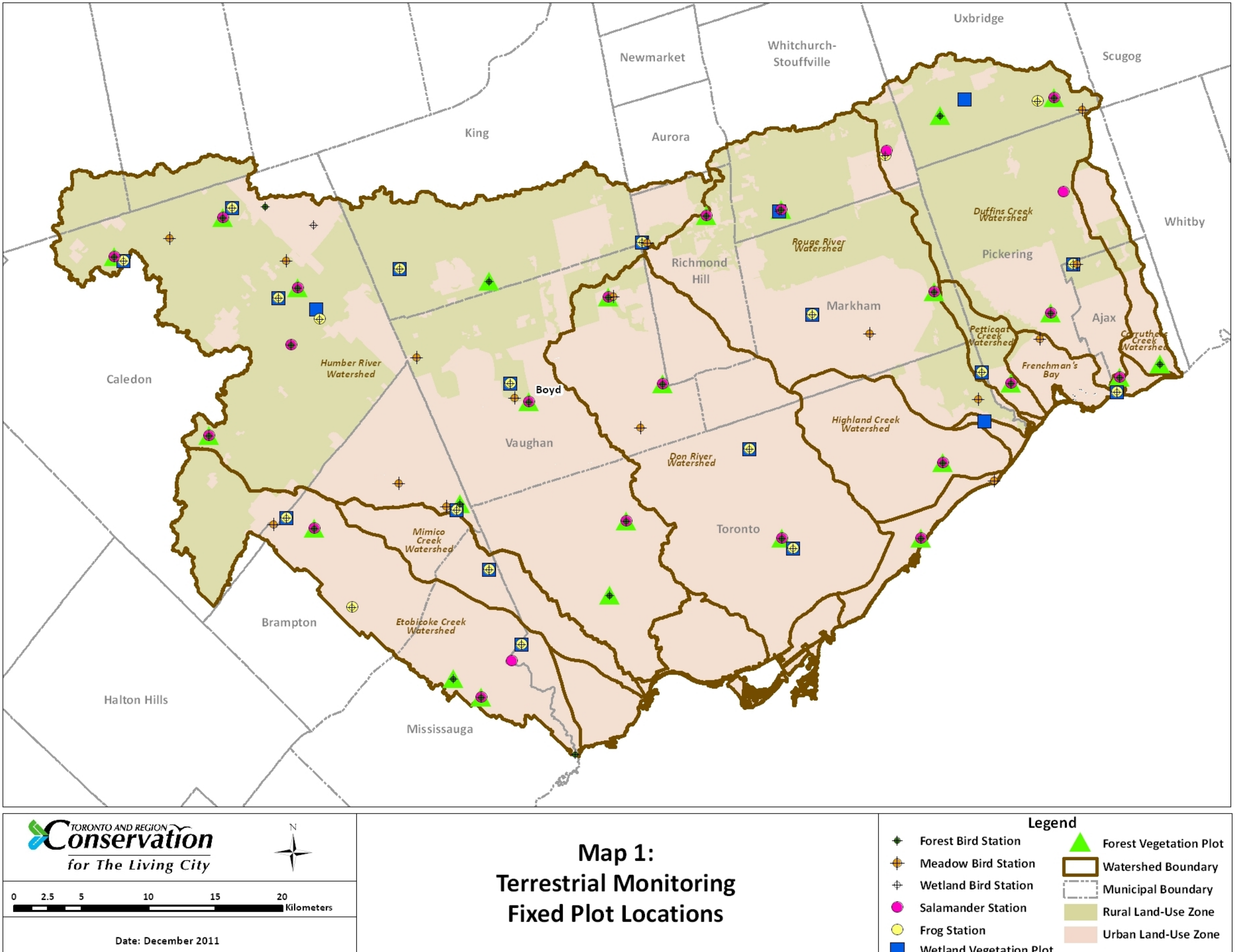
TRCA 2011d. **Wetland Bird Monitoring Protocol - Terrestrial Long-term Fixed Plot Monitoring Program – Regional Watershed Monitoring and Reporting.** Toronto and Region Conservation Authority

Uhlig, P., A. Harris, G. Craig, C. Bowling, B. Chambers, B. Naylor and G. Beemer 2001. ***Old growth forest definitions for Ontario***. Ont. Min. Nat. Res., Queen's Printer for Ontario, Toronto, ON. 53 p.

U.S. Forest Service 198-. ***Eastern hop-hornbeam*** **(Ostrya virginiana).** Available on-line at: http://www.discoverlife.org/mp/20q?search=Ostrya+virginiana&guide=Trees&cl=US/WI/Ozaukee/UWM_Field_Station#http://www.na.fs.fed.us/spfo/pubs/silvics_manual/volume_2/ostrya/virginiana.htm [Accessed 4th April 2011].

Watchorn M.A. Hamilton P.B. Anderson T.W. Roe H.M. and Patterson R.T. 2008. ***Diatoms and pollen as indicators of water quality and land-use change: a case study from the Oak Ridges Moraine, Southern Ontario, Canada***. J Paleolimnology 39:491–509.

Zorn P. 2008. **A Priori *Power Analysis for Toronto Region Conservation Authority's Regional Watershed Monitoring Program***. Report prepared for TRCA. Ottawa, ON.



TORONTO AND REGION Conservation for The Living City

Date: December 2011

Map 1: Terrestrial Monitoring Fixed Plot Locations

Appendix 1: Locations of Regional Monitoring Plots and Stations (2010)

Monitoring Plot / Transect / Station Type	Plot	Plot Name	UTM co-ordinates (m) NAD-83		˚N	Land-use
			Easting	Northing		
Forest Vegetation	FV-1	Hwy 401 & 403	608310	4832183		urban
	FV-2	Heart Lake	597921	4843397		urban
	FV-3	Ukranian Canadian Memorial Park	619989	4838386		urban
	FV-4	Downsview Dells	621179	4843951		urban
	FV-5	Claireville	608786	4845211		urban
	FV-6	Boyd	613934	4852805		urban
	FV-7	TVM Site #14	590071	4850311		rural
	FV-8	Caledon Tract	582995	4863642		rural
	FV-9	Bolton Tract	596693	4861345		rural
	FV-10	Humber Trails Forest & Wildlife Area	610956	4861772		rural
	FV-11	West Gormley	627169	4866688		rural
	FV-12	Wilket Creek Park	632676	4842583		urban
	FV-13	Baker's Sugar Bush	623892	4854181		urban
	FV-14	Cudia Park	643163	4842615		urban
	FV-15	Morningside Park	644819	4848290		urban
	FV-16	Altona Forest	649877	4854197		urban
	FV-17	Reesor Rd & Hwy #7	644171	4861027		rural
	FV-18	Shoal Point Woodland	661010	4855666		urban
	FV-19	Duffin Heights	652835	4859433		rural
	FV-20	Goodwood	644589	4874178		rural
	FV-21	Glen Major	653006	4875501		rural
	FV-22	Duffin Marsh Woodland	657973	4854677		urban
	FV-24	Palgrave	not available	not available		rural
	FV-27	S. of Kirby & E. of Keele	619439	4861008		rural
Forest Bird	FB-1	401/403	608186	4832338		urban
	FB-2	HLCA	597918	4843334		urban
	FB-3	Portage	620073	4838139		urban
	FB-4	Downsview Dells	621023	4844194		urban
	FB-5	Claireville	608843	4845198		urban
	FB-6	Boyd	613906	4852765		urban
	FB-7	TMV #14	590133	4850323		rural
	FB-8	Caledon Tract	583018	4863702		rural
	FB-9	BRMT	596784	4861335		rural
	FB-10	Humber Trail	611046	4861794		rural
	FB-11	West Gormley	626660	4866083		rural
	FB-12	Wilket Creek	632632	4842899		urban
	FB-13	Baker's Sugarbush	623565	4854168		urban
	FB-14	Cudia	643179	4842653		urban
	FB-15	Morningside	644541	4848579		urban
	FB-16	Altona	649659	4854861		urban
	FB-17	Reesor Road	644184	4861036		rural
	FB-18	Shoal Point	661098	4855703		urban
	FB-19	Duffins Heights	652843	4859443		rural
	FB-20	Goodwood	645127	4874277		rural
	FB-21	Glen Major	653148	4875591		rural
	FB-22	Duffin's Marsh Woods	657954	4854632		urban
	FB-23	Bruce's Mill	632577	4867159		rural
	FB-24	Palgrave	591487	4866700		rural
	FB-27	Kirby and Keele	619805	4860529		urban
	FB-28	Eglinton and Tomken	610394	4830793		urban
	FB-29	Marie Curtis Park	617399	4826526		urban

Appendix 1: Locations of Regional Monitoring Plots and Stations (2010)

Monitoring Plot / Transect / Station Type	Plot	Plot Name	UTM co-ordinates (m) NAD-83		˚N	Land-use
			Easting	Northing		
Forest Salamander	FS-1	401/403	608186	4832338		urban
	FS-2	HLCA	597812	4843464		urban
	FS-4	Downsview Dells	621171	4843966		urban
	FS-5	Claireville	608767	4845214		urban
	FS-6	Boyd	613860	4852610		urban
	FS-7	TMV #14	590072	4850297		rural
	FS-8	Caledon Tract	582961	4863669		rural
	FS-9	BRMT	596735	4861336		rural
	FS-11	West Gormley	627164	4866681		rural
	FS-12	Wilket Creek	632658	4842571		urban
	FS-13	Baker's Sugarbush	623886	4854181		urban
	FS-14	Cudia	643160	4842594		urban
	FS-15	Morningside	644954	4848776		urban
	FS-16	Altona	649831	4854062		urban
	FS-17	Reesor Road	644252	4861279		rural
	FS-19	Duffins Heights	652836	4859429		rural
	FS-20	Goodwood	644582	4874178		rural
	FS-21	Glen Major	652943	4875543		rural
	FS-22	Duffin's Marsh Woods	657995	4854625		urban
	FS-23	Bruce's Mill	632721	4867107		rural
	FS-24	Palgrave	591187	4866629		rural
	FS-27	Kirby and Keele	619873	4860559		urban
Wetland Vegetation	WV-1	Centennial Park	613400	4834756		urban
	WV-2	Kenpark	595840	4844156		urban
	WV-3	Claireville	608541	4844778		urban
	WV-4	Kortright	612526	4854226		rural
	WV-5	Caledon Tract	613389	4834708		rural
	WV-6	Cold Creek	604283	4862754		rural
	WV-7	Radio Tower	646494	4875414		rural
	WV-8	Too Good Pond	635049	4859355		urban
	WV-9	Ontario Science Ctr	623179	4865648		urban
	WV-10	Don Parkland	630364	4849304		urban
	WV-11	Finch & Pickering	654512	4863094		rural
	WV-12	Bruce's Mill	583587	4863207		rural
	WV-13	Duffin's Marsh	not available	not available		urban
	WV-14	Greenwood	654561	4863099		rural
	WV-15	Secord	646454	4875450		rural
	WV-16	Palgrave	591781	4867278		rural
	WV-20	Bolton Tract	595270	4860603		rural
	WV-22	Wildwood	610976	4840326		urban
Wetland Bird	WB-1	Centennial	613388	4834717	77˚	urban
	WB-2	Kenpark	595784	4844136	121˚	urban
	WB-3	Claireville	608435	4844752	42˚	urban
	WB-4	Kortright	612588	4854260	293˚	rural
	WB-5	Caledon Tract	583491	4863170	228˚	rural
	WB-6	Cold Creek	604677	4863773	72˚	rural
	WB-7	ORMCP (Radio Tower)	622524	4864555	284˚	rural
	WB-8	Too Good	635096	4859360	315˚	urban
	WB-9	ETSeton Park/OSC	633682	4841763	307˚	urban
	WB-10	East Don	630350	4849329	73˚	urban
	WB-11	Finch/Pickering Townline	647693	4855143	350˚	rural
	WB-13	Duffin's Marsh	657761	4853618	na	urban
	WB-14	Greenwood	654514	4863129	96˚	rural
	WB-16	Palgrave	591740	4867275	348˚	rural
	WB-17	Albright	651854	4875242	228˚	rural
	WB-20	BRMT	595281	4860592	198˚	rural
	WB-21	South of Queen	600723	4837495	112˚	urban
	WB-22	Wildwood	610971	4840328	335˚	urban

Appendix 1: Locations of Regional Monitoring Plots and Stations (2010)

Monitoring Plot / Transect / Station Type	Plot	Plot Name	UTM co-ordinates (m) NAD-83		˚N	Land-use
			Easting	Northing		
Wetland Frog	WF-1	Centennial	613388	4834717	77˚	urban
	WF-2	Kenpark	595784	4844136	121˚	urban
	WF-3	Claireville	608435	4844752	42˚	urban
	WF-4	Kortright	612588	4854260	293˚	rural
	WF-5	Caledon Tract	583491	4863170	228˚	rural
	WF-6	Cold Creek	604677	4863773	72˚	rural
	WF-7	ORMCP (Radio Tower)	622524	4864555	284˚	rural
	WF-8	Too Good	635096	4859360	315˚	urban
	WF-9	ETSeton Park/OSC	633682	4841763	307˚	urban
	WF-10	East Don	630350	4849329	73˚	urban
	WF-11	Finch/Pickering Townline	647693	4855143	350˚	rural
	WF-13	Duffin's Marsh	657761	4853841	na	urban
	WF-14	Greenwood	654514	4863129	96˚	rural
	WF-16	Palgrave	591740	4867275	348˚	rural
	WF-17	Albright	651854	4875242	228˚	rural
	WF-20	BRMT	595281	4860592	198˚	rural
	WF-21	South of Queen	600723	4837495	112˚	urban
	WF-22	Wildwood	610971	4840328	335˚	urban
Meadow Bird	MB-2	Claireville	607803	4845040		urban
	MB-3	Boyd North	612860	4853148		urban
	MB-4	UPSA	605553	4856138		rural
	MB-5	BRMT	595920	4864076		rural
	MB-6	407 and Keele	622326	4851118		urban
	MB-7	Kirby and Keele	620191	4860666		urban
	MB-8	ORMCP	622701	4864689		urban
	MB-9	East Point	648623	4846965		urban
	MB-10	Twyn Rivers Hydro Corridor	647424	4853037		rural
	MB-11	Milne Reservoir	639824	4858237		urban
	MB-12	Duffin's Trail	652043	4857541		rural
	MB-13	Greenwood	654766	4863085		rural
	MB-14	Glen Major	655174	4874595		rural

Note: for plots that involve muliple stations, only coordinates for the first station are listed

Appendix 2: Local-ranks and Habitat Guilds for Breeding Birds Detected at Plots, 2008 - 2010.

Common Name	Code	L-Rank	forest	wetland	meadow	cavity	low	mid	upper	aerial	guild
Blackburnian warbler	BLBW	**L3**									C
black-throated blue warbler	BTBW	**L3**									B
black-throated green warbler	BTNW	**L3**									C
blue-grey gnatcatcher	BGGN	**L4**									C
broad-winged hawk	BWHA	**L2**									C
brown creeper	BRCR	**L3**									B
eastern screech-owl	EASO	**L4**									C
eastern wood-pewee	EAWP	**L4**									C
golden-crowned kinglet	GCKI	**L3**									C
hairy woodpecker	HAWO	**L4**									C
hermit thrush	HETH	**L3**									A
ovenbird	OVEN	**L3**									A
pileated woodpecker	PIWO	**L3**									C
pine siskin	PISI	**L3**									C
pine warbler	PIWA	**L3**									C
red-breasted nuthatch	RBNU	**L4**									C
red-eyed vireo	REVI	**L4**									B
scarlet tanager	SCTA	**L3**									C
veery	VEER	**L3**									A
white-breasted nuthatch	WBNU	**L4**									C
winter wren	WIWR	**L3**									A
wood thrush	WOTH	**L3**									B
yellow-bellied sapsucker	YBSA	**L3**									C
alder flycatcher	ALFL	**L4**									E
American coot	AMCO	**L2**									D
Canada goose	CANG	**L5**									D
common moorhen	COMO	**L3**									D
common yellowthroat	COYE	**L4**									D
hooded merganser	HOME	**L3**									F
least bittern	LEBI	**L2**									D
mallard	MALL	**L5**									D
marsh wren	MAWR	**L3**									E
sora	SORA	**L3**									D
swamp sparrow	SWSP	**L4**									D
Virginia Rail	VIRA	**L3**									D
bobolink	BOBO	**L3**									G

Appendix 2: Local-ranks and Habitat Guilds for Breeding Birds Detected at Plots, 2008 - 2010.

Common Name	Code	L-Rank	forest	wetland	meadow	cavity	low	mid	upper	aerial	guild
eastern kingbird	EAKI	**L4**									I
eastern meadowlark	EAME	**L4**									G
field sparrow	FISP	**L4**									G
grasshopper sparrow	GRSP	**L2**									G
savannah sparrow	SAVS	**L4**									G
spotted sandpiper	SPSA	**L4**									G
willow flycatcher	WIFL	**L4**									H
northern waterthrush	NOWA	**L3**									J

note that the given habitat is that in which the species places the nest.

ground = on or very near to ground-level. <0.5m = low level

undrstry = lower shrub layer (in forest), or generally in shrubs (open country). 0.5 to 3m = mid level

canopy = middle or upper canopy in forest habitat - small to large trees. > 3m = upper level

Guild descriptions:

A) forest low-level nester
B) forest mid-level nester
C) forest upper-level nester
D) wetland low-level nester
E) wetland mid-level nester
F) wetland upper-level nester
G) meadow low-level nester
H) meadow mid-level nester
I) meadow upper-level nester
J) swamp low-level nester

Appendix 3: Crown Vigour of Tree Species in TRCA forest plots, 2010

	2010 whole TRCA jurisdiction									
	Crown Vigor Rating - count of stems					Crown Vigour Rating - percentage of each species				
Tree Species	Healthy	10-50% Dieback	>50% Dieback	Dead	Grand Tot	Healthy	10-50% Dieback	>50% Dieback	Dead	Grand Total
Abies balsamea	1	0	0	0	1	100%	0%	0%	0%	100%
Acer negundo	15	0	0	0	15	100%	0%	0%	0%	100%
Acer rubrum	13	0	1	4	18	72%	0%	6%	22%	100%
Acer saccharum ssp. *nigrum*	5	0	0	0	5	100%	0%	0%	0%	100%
Acer saccharum ssp. *saccharum*	182	1	0	7	190	96%	1%	0%	4%	100%
Amelanchier arborea	2	0	0	0	2	100%	0%	0%	0%	100%
Betula alleghaniensis	0	1	0	1	2	0%	50%	0%	50%	100%
Betula papyrifera	8	1	0	1	10	80%	10%	0%	10%	100%
Carya cordiformis	4	0	0	0	4	100%	0%	0%	0%	100%
Carya ovata	19	0	0	1	20	95%	0%	0%	5%	100%
Cornus alternifolia	1	0	0	0	1	100%	0%	0%	0%	100%
Crataegus punctata	1	0	0	0	1	100%	0%	0%	0%	100%
Fagus grandifolia	15	2	0	3	20	75%	10%	0%	15%	100%
Fraxinus americana	13	2	0	5	20	65%	10%	0%	25%	100%
Fraxinus pennsylvanica	6	0	1	1	8	75%	0%	13%	13%	100%
Malus pumila	3	0	0	6	9	33%	0%	0%	67%	100%
Ostrya virginiana	20	0	0	7	27	74%	0%	0%	26%	100%
Pinus strobus	3	0	0	1	4	75%	0%	0%	25%	100%
Populus balsamifera ssp. *balsamifera*	0	0	0	7	7	0%	0%	0%	100%	100%
Populus grandidentata	2	0	0	0	2	100%	0%	0%	0%	100%
Populus tremuloides	0	0	1	1	2	0%	0%	50%	50%	100%
Prunus serotina	8	0	0	1	9	89%	0%	0%	11%	100%
Pyrus communis	3	0	0	0	3	100%	0%	0%	0%	100%
Quercus macrocarpa	43	3	4	1	51	84%	6%	8%	2%	100%
Quercus rubra	11	0	0	1	12	92%	0%	0%	8%	100%
Rhamnus cathartica	9	2	2	3	16	56%	13%	13%	19%	100%
Robinia pseudoacacia	3	0	0	1	4	75%	0%	0%	25%	100%
Thuja occidentalis	72	2	0	5	79	91%	3%	0%	6%	100%
Tilia americana	7	0	0	1	8	88%	0%	0%	13%	100%
Tsuga canadensis	47	1	0	4	52	90%	2%	0%	8%	100%
Ulmus americana	9	0	0	11	20	45%	0%	0%	55%	100%
Grand Total	**525**	**15**	**9**	**73**	**622**	**84%**	**2%**	**1%**	**12%**	**100%**

Appendix 3: Crown Vigour of Tree Species in TRCA forest plots, 2010

	2010 Rural Land-use Zone									
	Crown Vigor Rating - count of stems					Crown Vigour Rating - percentage of each species				
Tree Species	**Healthy**	**10-50% Dieback**	**>50% Dieback**	**Dead**	**Grand Tot**	**Healthy**	**10-50% Dieback**	**>50% Dieback**	**Dead**	**Grand Total**
Acer negundo	14	0	0	0	14	100%	0%	0%	0%	100%
Acer rubrum	13	0	1	4	18	72%	0%	6%	22%	100%
Acer saccharum ssp. *saccharum*	94	0	0	6	100	94%	0%	0%	6%	100%
Amelanchier arborea	2	0	0	0	2	100%	0%	0%	0%	100%
Betula alleghaniensis	0	1	0	1	2	0%	50%	0%	50%	100%
Betula papyrifera	7	0	0	1	8	88%	0%	0%	13%	100%
Carya cordiformis	3	0	0	0	3	100%	0%	0%	0%	100%
Fagus grandifolia	4	0	0	0	4	100%	0%	0%	0%	100%
Fraxinus americana	11	1	0	3	15	73%	7%	0%	20%	100%
Malus pumila	0	0	0	6	6	0%	0%	0%	100%	100%
Ostrya virginiana	6	0	0	0	6	100%	0%	0%	0%	100%
Populus balsamifera ssp. *balsamifera*	0	0	0	7	7	0%	0%	0%	100%	100%
Populus tremuloides	0	0	1	1	2	0%	0%	50%	50%	100%
Prunus serotina	6	0	0	0	6	100%	0%	0%	0%	100%
Quercus rubra	10	0	0	1	11	91%	0%	0%	9%	100%
Robinia pseudoacacia	3	0	0	1	4	75%	0%	0%	25%	100%
Thuja occidentalis	61	2	0	5	68	90%	3%	0%	7%	100%
Tilia americana	4	0	0	1	5	80%	0%	0%	20%	100%
Tsuga canadensis	5	0	0	2	7	71%	0%	0%	29%	100%
Ulmus americana	5	0	0	5	10	50%	0%	0%	50%	100%
Grand Total	**248**	**4**	**2**	**44**	**298**	**83%**	**1%**	**1%**	**15%**	**100%**

Appendix 3: Crown Vigour of Tree Species in TRCA forest plots, 2010

	2010 Urban Land-use Zone									
	Crown Vigor Rating - count of stems					Crown Vigour Rating - percentage of each species				
Tree Species	**Healthy**	**10-50% Dieback**	**>50% Dieback**	**Dead**	**Grand Tot**	**Healthy**	**10-50% Dieback**	**>50% Dieback**	**Dead**	**Grand Total**
Abies balsamea	1	0	0	0	1	100%	0%	0%	0%	100%
Acer negundo	1	0	0	0	1	100%	0%	0%	0%	100%
Acer saccharum ssp. *nigrum*	5	0	0	0	5	100%	0%	0%	0%	100%
Acer saccharum ssp. *saccharum*	88	1	0	1	90	98%	1%	0%	1%	100%
Betula papyrifera	1	1	0	0	2	50%	50%	0%	0%	100%
Carya cordiformis	1	0	0	0	1	100%	0%	0%	0%	100%
Carya ovata	19	0	0	1	20	95%	0%	0%	5%	100%
Cornus alternifolia	1	0	0	0	1	100%	0%	0%	0%	100%
Crataegus punctata	1	0	0	0	1	100%	0%	0%	0%	100%
Fagus grandifolia	11	2	0	3	16	69%	13%	0%	19%	100%
Fraxinus americana	2	1	0	2	5	40%	20%	0%	40%	100%
Fraxinus pennsylvanica	6	0	1	1	8	75%	0%	13%	13%	100%
Malus pumila	3	0	0	0	3	100%	0%	0%	0%	100%
Ostrya virginiana	14	0	0	7	21	67%	0%	0%	33%	100%
Pinus strobus	3	0	0	1	4	75%	0%	0%	25%	100%
Populus grandidentata	2	0	0	0	2	100%	0%	0%	0%	100%
Prunus serotina	2	0	0	1	3	67%	0%	0%	33%	100%
Pyrus communis	3	0	0	0	3	100%	0%	0%	0%	100%
Quercus macrocarpa	43	3	4	1	51	84%	6%	8%	2%	100%
Quercus rubra	1	0	0	0	1	100%	0%	0%	0%	100%
Rhamnus cathartica	9	2	2	3	16	56%	13%	13%	19%	100%
Thuja occidentalis	11	0	0	0	11	100%	0%	0%	0%	100%
Tilia americana	3	0	0	0	3	100%	0%	0%	0%	100%
Tsuga canadensis	42	1	0	2	45	93%	2%	0%	4%	100%
Ulmus americana	4	0	0	6	10	40%	0%	0%	60%	100%
Grand Total	**277**	**11**	**7**	**29**	**324**	**85%**	**3%**	**2%**	**9%**	**100%**

Appendix 3: Flora Species observed in Long-term Monitoring Plots 2008-2010

Scientific Name	Common Name	Rank TRCA (03/2009)	Co-efficient of Conservatism	Forest Landuse Zone(s) Rural Plots	Forest Landuse Zone(s) Urban Plots	Wetland Landuse Zone(s) Rural Plots	Wetland Landuse Zone(s) Urban Plots
Botrychium matricariifolium	daisy-leaved grape fern	L1	7			x	
Utricularia minor	small bladderwort	L1	8			x	
Calla palustris	water arum	L2	8			x	x
Carex limosa	mud sedge	L2	10			x	
Carex magellanica ssp. *irrigua*	stunted sedge	L2	10			x	
Coptis trifolia ssp. *groenlandica*	goldthread	L2	7			x	
Cornus canadensis	bunchberry	L2	7			x	
Dulichium arundinaceum	three-way sedge	L2	7			x	
Lindernia dubia var. *dubia*	false pimpernel	L2	7			x	
Moneses uniflora	one-flowered pyrola	L2	10			x	
Najas flexilis	bushy naiad	L2	5			x	
Nemopanthus mucronatus	mountain holly	L2	8			x	x
Panax quinquefolius	ginseng	L2	9	x			
Panicum columbianum var. *siccanum*	Columbia panic grass	L2	6			x	
Potamogeton berchtoldii	least pondweed	L2	4			x	
Potamogeton zosteriformis	flat-stemmed pondweed	L2	5			x	
Ranunculus aquatilis var. *longirostris*	white water crowfoot	L2	5			x	
Rubus hispidus	swamp dewberry	L2	6				x
Solidago uliginosa	bog goldenrod	L2	9			x	
Utricularia vulgaris	common bladderwort	L2	4			x	
Abies balsamea	balsam fir	L3	5	x	x	x	
Agrostis scabra	ticklegrass	L3	6			x	
Alnus incana ssp. *rugosa*	speckled alder	L3	6			x	x
Anemone acutiloba	sharp-lobed hepatica	L3	6	x	x		
Anemone quinquefolia var. *quinquefolia*	wood-anemone	L3	7		x		
Aquilegia canadensis	wild columbine	L3	5	x			
Aralia racemosa ssp. *racemosa*	spikenard	L3	7			x	
Aster ontarionis	Ontario aster	L3	6			x	
Aster umbellatus var. *umbellatus*	flat-topped aster	L3	6				x
Bidens discoideus	small beggar's-ticks	L3	6			x	
Cardamine concatenata	cut-leaved toothwort	L3	6	x	x		
Carex albursina	white bear sedge	L3	7	x			
Carex atherodes	awned sedge	L3	6			x	
Carex canescens ssp. *canescens*	silvery sedge	L3	7			x	
Carex comosa	bristly sedge	L3	5			x	
Carex disperma	two-seeded sedge	L3	8			x	
Carex hitchcockiana	Hitchcock's sedge	L3	6	x	x		
Carex interior	fen star sedge	L3	6			x	
Carex laevivaginata	smooth-sheathed sedge	L3	8			x	
Carex leptalea ssp. *leptalea*	bristle-stalked sedge	L3	8			x	
Carex leptonervia	few-nerved wood sedge	L3	5	x		x	
Carex trisperma var. *trisperma*	three-seeded sedge	L3	9			x	
Carya ovata	shagbark hickory	L3	6		x		
Caulophyllum thalictroides	blue cohosh	L3	6	x			
Celastrus scandens	American bittersweet	L3	3	x			
Ceratophyllum demersum	coontail	L3	4			x	
Chrysosplenium americanum	golden saxifrage	L3	8				x
Cicuta bulbifera	bulblet-bearing water-hemlock	L3	5			x	x
Circaea alpina	smaller enchanter's nightshade	L3	6			x	
Claytonia caroliniana	broad-leaved spring beauty	L3	7	x	x		
Claytonia virginica	narrow-leaved spring beauty	L3	5		x		
Cystopteris tenuis	Mackay's fragile fern	L3	6	x			
Deparia acrostichoides	silvery glade fern	L3	8	x			
Desmodium glutinosum	pointed-leaved tick-trefoil	L3	6	x			
Dicentra canadensis	squirrel-corn	L3	7	x			
Dryopteris clintoniana	Clinton's wood fern	L3	7			x	
Dryopteris cristata	crested wood fern	L3	7			x	
Eleocharis smallii	Small's spike-rush	L3	6			x	
Euonymus obovata	running strawberry-bush	L3	6		x	x	
Galium boreale	northern bedstraw	L3	7		x		
Galium tinctorium	stiff marsh bedstraw	L3	5				x
Galium trifidum var. *trifidum*	small bedstraw	L3	5			x	
Glyceria borealis	northern manna grass	L3	8			x	
Gymnocarpium dryopteris	oak fern	L3	7			x	
Hamamelis virginiana	witch-hazel	L3	6	x			
Ilex verticillata	winterberry	L3	5			x	x
Iris versicolor	blue flag	L3	5		x	x	x
Lemna trisulca	star duckweed	L3	4			x	x
Lilium michiganense	Michigan lily	L3	7	x	x		
Liparis loeselii	Loesel's twayblade	L3	5			x	
Lonicera canadensis	fly honeysuckle	L3	6	x			
Lonicera dioica	wild honeysuckle	L3	5	x			
Ludwigia palustris	water purslane	L3	5			x	
Lysimachia thyrsiflora	tufted loosestrife	L3	7			x	x
Mitchella repens	partridgeberry	L3	6	x	x	x	
Mitella nuda	naked mitrewort	L3	6			x	x
Monotropa uniflora	Indian-pipe	L3	6		x		
Oryzopsis asperifolia	white-fruited mountain-rice	L3	6	x			
Osmorhiza longistylis	smooth sweet cicely	L3	6		x		
Osmunda cinnamomea	cinnamon fern	L3	7			x	x
Picea glauca	white spruce	L3	6			x	
Pilea fontana	spring clearweed	L3	5				x
Poa alsodes	grove meadow grass	L3	7	x			

Appendix 3: Flora Species observed in Long-term Monitoring Plots 2008-2010

		Rank		Forest		Wetland	
		TRCA	Co-efficient of	Landuse Zone(s)		Landuse Zone(s)	
Scientific Name	Common Name	(03/2009)	Conservatism	Rural Plots	Urban Plots	Rural Plots	Urban Plots
Poa languida	languid spear grass	L3	8	x			
Polygonum cilinode	fringed black bindweed	L3	2	x			
Polystichum acrostichoides	Christmas fern	L3	5	x	x		
Potamogeton foliosus	leafy pondweed	L3	4			x	x
Potamogeton natans	floating pondweed	L3	5			x	
Prenanthes alba	white wood lettuce	L3	6				x
Pyrola elliptica	shinleaf	L3	5	x			
Ranunculus hispidus var. *caricetorum*	swamp buttercup	L3	5			x	
Rhamnus alnifolia	alder-leaved buckthorn	L3	7			x	
Ribes triste	swamp red currant	L3	6			x	
Sagittaria cuneata	arum-leaved arrowhead	L3	7			x	
Salix lucida	shining willow	L3	5			x	
Scirpus cyperinus	woolly bulrush	L3	4			x	
Scirpus fluviatilis	river bulrush	L3	7				x
Solidago patula	rough-leaved goldenrod	L3	8				x
Sparganium emersum ssp. *emersum*	green-fruited bur-reed	L3	5			x	x
Sparganium eurycarpum	great bur-reed	L3	3				x
Spirodela polyrhiza	greater duckweed	L3	4			x	x
Streptopus roseus	rose twisted-stalk	L3	7	x	x		
Taxus canadensis	Canada yew	L3	7	x		x	
Trientalis borealis ssp. *borealis*	star-flower	L3	6	x		x	
Triosteum aurantiacum	wild coffee	L3	7		x		
Uvularia grandiflora	large-flowered bellwort	L3	6	x	x		
Viburnum acerifolium	maple-leaved viburnum	L3	6	x	x		
Viola affinis	Le Conte's violet	L3	6	x	x	x	
Viola blanda	sweet white violet	L3	6			x	x
Viola canadensis	Canada violet	L3	6	x			
Viola rostrata	long-spurred violet	L3	6	x			
Viola selkirkii	Selkirk's violet	L3	8	x			
Acer rubrum	red maple	L4	4	x	x	x	x
Acer saccharinum	silver maple	L4	5		x	x	
Acer saccharum ssp. *nigrum*	black maple	L4	7		x		
Acer spicatum	mountain maple	L4	6		x	x	x
Actaea pachypoda	white baneberry	L4	6	x			
Allium tricoccum	wild leek	L4	7	x	x		
Amelanchier arborea	downy serviceberry	L4	5	x	x		
Amelanchier laevis	smooth serviceberry	L4	5		x		x
Amelanchier sp.	serviceberry sp.	L4					x
Antennaria howellii ssp. *howellii*	Howell's pussytoes	L4	2				x
Asarum canadense	wild ginger	L4	6	x			
Aster macrophyllus	big-leaved aster	L4	5	x	x		
Aster oolentangiensis	sky-blue aster	L4	9				x
Betula alleghaniensis	yellow birch	L4	6	x		x	x
Betula papyrifera	paper birch	L4	2	x	x	x	x
Bidens tripartitus	three-parted beggar's-ticks	L4	4			x	x
Boehmeria cylindrica	false nettle	L4	4			x	x
Calamagrostis canadensis	Canada blue joint	L4	4			x	
Caltha palustris	marsh marigold	L4	5			x	x
Cardamine diphylla	broad-leaved toothwort	L4	7	x	x		
Cardamine pensylvanica	bitter cress	L4	6			x	
Cardamine x maxima	hybrid toothwort	L4	0	x			
Carex arctata	nodding wood sedge	L4	5	x	x		
Carex aurea	golden-fruited sedge	L4	4			x	
Carex communis	fibrous-rooted sedge	L4	6	x	x		
Carex deweyana	Dewey's sedge	L4	6	x	x		
Carex gracillima	graceful sedge	L4	4	x		x	
Carex hirtifolia	hairy wood sedge	L4	5		x		
Carex intumescens	bladder sedge	L4	6	x			
Carex lacustris	lake-bank sedge	L4	5				x
Carex laxiflora	loose-flowered sedge	L4	5	x	x		
Carex peckii	Peck's sedge	L4	6	x	x		
Carex pedunculata	early-flowering sedge	L4	5	x	x	x	x
Carex pensylvanica	Pennsylvania sedge	L4	5	x		x	
Carex pseudo-cyperus	pseudocyperus sedge	L4	6			x	x
Carex sprengelii	long-beaked sedge	L4	6		x		
Carex stricta	tussock sedge	L4	4			x	
Carpinus caroliniana ssp. *virginiana*	blue beech	L4	6		x		x
Carya cordiformis	bitternut hickory	L4	6	x	x		x
Caulophyllum giganteum	long-styled blue cohosh	L4	6	x	x		
Cornus rugosa	round-leaved dogwood	L4	6	x			
Corylus cornuta	beaked hazel	L4	5	x			
Crataegus pedicellata	scarlet hawthorn	L4	4		x		
Cuscuta gronovii	swamp dodder	L4	4			x	x
Cystopteris bulbifera	bulblet fern	L4	5	x			
Dryopteris intermedia	evergreen wood fern	L4	5	x	x	x	
Dryopteris marginalis	marginal wood fern	L4	5	x			
Dryopteris x triploidea	confusing hybrid wood fern	L4	5	x	x		
Elodea canadensis	common water-weed	L4	4			x	
Elymus hystrix	bottle-brush grass	L4	5		x		x
Elymus riparius	riverbank wild rye	L4	7				x
Epifagus virginiana	beech-drops	L4	6		x		
Epilobium coloratum	purple-leaved willow-herb	L4	3			x	x
Equisetum variegatum ssp. *variegatum*	variegated scouring-rush	L4	5			x	

Appendix 3: Flora Species observed in Long-term Monitoring Plots 2008-2010		Rank		Forest		Wetland	
		TRCA	Co-efficient of	Landuse Zone(s)		Landuse Zone(s)	
Scientific Name	Common Name	(03/2009)	Conservatism	Rural Plots	Urban Plots	Rural Plots	Urban Plots
Fagus grandifolia	American beech	L4	6	x	x		x
Fraxinus nigra	black ash	L4	7		x	x	x
Galium aparine	cleavers	L4	4	x	x		
Galium asprellum	rough bedstraw	L4	6	x	x	x	x
Geranium maculatum	wild geranium	L4	6		x		
Glyceria grandis	tall manna grass	L4	5			x	
Impatiens pallida	yellow touch-me-not	L4	7	x	x		
Juncus nodosus	knotted rush	L4	5			x	
Lycopus americanus	cut-leaved water-horehound	L4	4		x	x	
Lycopus uniflorus	northern water-horehound	L4	5			x	x
Maianthemum canadense	Canada May-flower	L4	5	x	x	x	x
Myosotis laxa	smaller forget-me-not	L4	6			x	x
Osmorhiza claytonii	woolly sweet cicely	L4	5	x			
Panicum acuminatum var. *acuminatum*	hairy panic grass	L4	2			x	
Penthorum sedoides	ditch stonecrop	L4	4				x
Pinus strobus	white pine	L4	4	x	x		x
Polygonatum pubescens	downy Solomon's seal	L4	5	x	x		
Polygonum amphibium	water smartweed	L4	5			x	x
Populus grandidentata	large-toothed aspen	L4	5	x	x		
Potamogeton pectinatus	sago pondweed	L4	4			x	
Prunella vulgaris ssp. *lanceolata*	heal-all (native)	L4	5	x		x	
Prunus pensylvanica	pin cherry	L4	3	x			
Pteridium aquilinum var. *latiusculum*	eastern bracken	L4	2	x			
Quercus macrocarpa	bur oak	L4	5		x		x
Quercus rubra	red oak	L4	6	x	x		x
Rorippa palustris ssp. *fernaldiana*	Fernald's marsh cress	L4	3			x	x
Rorippa palustris ssp. *hispida*	hispid marsh cress	L4	3			x	x
Rosa blanda	smooth wild rose	L4	3		x		
Rubus pubescens	dwarf raspberry	L4	4			x	x
Sagittaria latifolia	common arrowhead	L4	4			x	
Salix discolor	pussy willow	L4	3			x	
Salix petiolaris	slender willow	L4	3			x	
Schizachne purpurascens ssp. *purpurascens*	purple melic grass	L4	6	x			
Scirpus validus	soft-stemmed bulrush	L4	5			x	
Sium suave	water-parsnip	L4	4			x	
Solidago rugosa ssp. *rugosa*	rough-stemmed goldenrod	L4	4			x	x
Thelypteris palustris var. *pubescens*	marsh fern	L4	5			x	
Thuja occidentalis	white cedar	L4	4	x	x	x	
Tiarella cordifolia	foam-flower	L4	6			x	x
Trillium erectum	red trillium	L4	6	x	x		
Trillium grandiflorum	white trillium	L4	5	x	x		
Tsuga canadensis	eastern hemlock	L4	7	x	x	x	x
Typha latifolia	broad-leaved cattail	L4	3			x	x
Veronica americana	American speedwell	L4	6				x
Waldsteinia fragarioides	barren strawberry	L4	5	x			
Wolffia columbiana	Columbia water-meal	L4	4			x	x
Acer saccharum ssp. *saccharum*	sugar maple	L5	4	x	x	x	x
Achillea millefolium ssp. *lanulosum*	woolly yarrow	L5	0			x	
Actaea rubra	red baneberry	L5	5	x	x	x	x
Agrimonia gryposepala	agrimony	L5	2		x		
Alisma plantago-aquatica	water-plantain	L5	3			x	
Ambrosia artemisiifolia	common ragweed	L5	0			x	
Amphicarpaea bracteata	hog-peanut	L5	4		x		x
Anemone canadensis	Canada anemone	L5	3	x	x	x	x
Anemone virginiana	common thimbleweed	L5	0		x	x	x
Aralia nudicaulis	wild sarsaparilla	L5	4	x		x	x
Arisaema triphyllum	Jack-in-the-pulpit	L5	5	x	x	x	x
Asclepias syriaca	common milkweed	L5	0			x	x
Aster ericoides ssp. *ericoides*	heath aster	L5	4			x	x
Aster lanceolatus ssp. *lanceolatus*	panicled aster	L5	3	x	x	x	x
Aster lateriflorus var. *lateriflorus*	calico aster	L5	3	x	x	x	x
Aster novae-angliae	New England aster	L5	2			x	x
Aster puniceus var. *puniceus*	swamp aster	L5	6	x		x	x
Athyrium filix-femina var. *angustum*	northeastern lady fern	L5	4	x	x	x	x
Bidens cernuus	nodding bur-marigold	L5	2			x	x
Bidens frondosus	common beggar's-ticks	L5	3	x	x	x	x
Bidens sp.	beggar's ticks sp	L5	3			x	
Carex blanda	common wood sedge	L5	3	x	x		x
Carex cristatella	crested sedge	L5	3			x	x
Carex granularis	meadow sedge	L5	3			x	
Carex radiata	straight-styled sedge	L5	4	x	x	x	
Carex rosea	curly-styled sedge	L5	5	x	x	x	
Circaea lutetiana ssp. *canadensis*	enchanter's nightshade	L5	3	x	x	x	x
Clematis virginiana	virgin's bower	L5	3	x			
Cornus alternifolia	alternate-leaved dogwood	L5	6	x	x	x	x
Cornus foemina ssp. *racemosa*	grey dogwood	L5	2		x		
Cornus stolonifera	red osier dogwood	L5	2			x	x
Crataegus punctata	dotted hawthorn	L5	4		x		
Crataegus sp.	hawthorn sp.	L5					x
Dryopteris carthusiana	spinulose wood fern	L5	5	x	x	x	x
Echinocystis lobata	wild cucumber	L5	3	x	x	x	x
Elymus virginicus var. *virginicus*	Virginia wild rye	L5	5				x
Epilobium ciliatum ssp. *ciliatum*	sticky willow-herb	L5	3		x	x	x

Appendix 3: Flora Species observed in Long-term Monitoring Plots 2008-2010

Scientific Name	Common Name	Rank TRCA (03/2009)	Co-efficient of Conservatism	Forest Landuse Zone(s) Rural Plots	Forest Landuse Zone(s) Urban Plots	Wetland Landuse Zone(s) Rural Plots	Wetland Landuse Zone(s) Urban Plots
Equisetum arvense	field horsetail	L5	0	x	x	x	x
Equisetum hyemale ssp. *affine*	scouring-rush	L5	2			x	
Erigeron annuus	daisy fleabane	L5	0	x			x
Erythronium americanum ssp. *americanum*	yellow trout-lily	L5	5	x	x		
Eupatorium maculatum ssp. *maculatum*	spotted Joe-Pye weed	L5	3			x	x
Eupatorium rugosum	white snakeroot	L5	5	x		x	x
Euthamia graminifolia	grass-leaved goldenrod	L5	2			x	
Fragaria vesca ssp. *americana*	woodland strawberry	L5	4		x		x
Fragaria virginiana	wild strawberry	L5	2		x	x	x
Fraxinus americana	white ash	L5	4	x	x	x	x
Fraxinus pennsylvanica	red ash (sensu lato)	L5	3	x		x	x
Fraxinus pennsylvanica var. *pennsylvanica*	red ash	L5	3	x	x		
Fraxinus pennsylvanica var. *subintegerrima*	green ash	L5	3	x	x		
Galium palustre	marsh bedstraw	L5	5			x	x
Galium triflorum	sweet-scented bedstraw	L5	4	x		x	
Geum canadense	white avens	L5	3	x	x	x	x
Glyceria striata	fowl manna grass	L5	3	x		x	x
Hackelia virginiana	Virginia stickseed	L5	5	x	x	x	x
Heracleum lanatum	cow-parsnip	L5	3		x		
Hydrophyllum virginianum	Virginia waterleaf	L5	6	x	x		
Impatiens capensis	orange touch-me-not	L5	4	x	x	x	x
Juglans nigra	black walnut	L5	5				x
Juncus articulatus	jointed rush	L5	5			x	
Juncus dudleyi	Dudley's rush	L5	1			x	
Laportea canadensis	wood nettle	L5	6	x		x	
Leersia oryzoides	rice cut grass	L5	3			x	x
Lemna minor	common duckweed	L5	2			x	x
Lysimachia ciliata	fringed loosestrife	L5	4	x	x		x
Maianthemum racemosum ssp. *racemosum*	false Solomon's seal	L5	4	x	x		
Maianthemum stellatum	starry false Solomon's seal	L5	6	x	x	x	x
Matteuccia struthiopteris var. *pensylvanica*	ostrich fern	L5	5	x			x
Mentha arvensis ssp. *borealis*	wild mint	L5	3			x	x
Muhlenbergia mexicana var. *mexicana*	common muhly grass	L5	1			x	
Onoclea sensibilis	sensitive fern	L5	4	x		x	x
Ostrya virginiana	ironwood	L5	4	x	x		x
Oxalis stricta	common yellow wood-sorrel	L5	0		x		x
Parthenocissus inserta	thicket creeper	L5	3	x	x	x	x
Phryma leptostachya	lopseed	L5	6	x			
Pilea pumila	dwarf clearweed	L5	5		x	x	x
Plantago rugelii	red-stemmed plantain	L5	1			x	
Poa palustris	fowl meadow-grass	L5	5			x	
Podophyllum peltatum	May-apple	L5	5	x	x		
Polygonum lapathifolium var. *lapathifolium*	pale smartweed	L5	2			x	
Populus balsamifera ssp. *balsamifera*	balsam poplar	L5	4			x	
Populus tremuloides	trembling aspen	L5	2	x		x	
Potentilla anserina ssp. *anserina*	silverweed	L5	5				x
Prenanthes altissima	tall wood lettuce	L5	5	x	x		
Prunus serotina	black cherry	L5	3	x	x	x	x
Prunus virginiana ssp. *virginiana*	choke cherry	L5	2	x	x	x	x
Ranunculus abortivus	kidney-leaved buttercup	L5	2	x	x		
Ranunculus recurvatus var. *recurvatus*	hooked buttercup	L5	4		x		
Ranunculus sceleratus	cursed crowfoot	L5	2				x
Rhus radicans ssp. *rydbergii*	poison ivy (shrub form)	L5	0	x	x		x
Rhus typhina	staghorn sumach	L5	1			x	
Ribes americanum	wild black currant	L5	4	x	x	x	x
Ribes cynosbati	prickly gooseberry	L5	4	x	x		
Rubus allegheniensis	common blackberry	L5	2	x	x		
Rubus idaeus ssp. *melanolasius*	wild red raspberry	L5	0	x	x	x	x
Rubus occidentalis	wild black raspberry	L5	2	x	x	x	
Rubus odoratus	purple-flowering raspberry	L5	3		x		
Salix eriocephala	narrow heart-leaved willow	L5	4			x	
Sambucus racemosa ssp. *pubens*	red-berried elder	L5	5	x			
Sanguinaria canadensis	bloodroot	L5	5	x	x		
Scirpus atrovirens	black-fruited bulrush	L5	3			x	
Scutellaria galericulata	common skullcap	L5	6			x	x
Scutellaria lateriflora	mad-dog skullcap	L5	5			x	x
Smilax herbacea	carrion-flower	L5	5	x	x		
Solidago altissima	tall goldenrod	L5	1	x	x	x	x
Solidago caesia	blue-stemmed goldenrod	L5	5	x	x		
Solidago canadensis var. *canadensis*	Canada goldenrod	L5	1	x			
Solidago flexicaulis	zig-zag goldenrod	L5	6	x	x		x
Solidago gigantea	late goldenrod	L5	4	x	x	x	x
Solidago nemoralis ssp. *nemoralis*	grey goldenrod	L5	2			x	
Thalictrum dioicum	early meadow rue	L5	5	x	x		
Thalictrum pubescens	tall meadow rue	L5	5	x	x	x	
Tilia americana	basswood	L5	4	x	x		x
Ulmus americana	white elm	L5	3	x	x	x	x
Urtica dioica ssp. *gracilis*	American stinging nettle	L5	2		x	x	
Viburnum lentago	nannyberry	L5	4	x			x
Viola conspersa	dog violet	L5	4	x		x	
Viola pubescens	stemmed yellow violet	L5	5	x	x		
Viola sororia	common blue violet	L5	4	x	x		x
Vitis riparia	riverbank grape	L5	0	x	x	x	x

Appendix 3: Flora Species observed in Long-term Monitoring Plots 2008-2010							
		Rank		Forest		Wetland	
		TRCA	Co-efficient of	Landuse Zone(s)		Landuse Zone(s)	
Scientific Name	Common Name	(03/2009)	Conservatism	Rural Plots	Urban Plots	Rural Plots	Urban Plots
Fragaria virginiana ssp. *virginiana*	common wild strawberry	LU	2			x	x
Acer negundo	Manitoba maple	L+?		x	x	x	x
Atriplex patula	halberd-leaved orache	L+?					x
Geranium robertianum	herb Robert	L+?		x	x	x	
Phalaris arundinacea	reed canary grass	L+?				x	x
Phragmites australis	common reed	L+?				x	
Polygonum hydropiper	water-pepper	L+?				x	x
Prunella vulgaris	heal-all	L+?				x	x
Acer platanoides	Norway maple	L+		x	x		
Agrostis gigantea	redtop	L+				x	
Alliaria petiolata	garlic mustard	L+		x	x	x	x
Alnus incana ssp. *incana*	grey alder	L+					x
Arctium lappa	great burdock	L+					x
Arctium minus ssp. *minus*	common burdock	L+			x		x
Barbarea vulgaris	winter cress	L+			x		x
Berberis thunbergi	Japanese barberry	L+			x		
Bromus inermis ssp. *inermis*	smooth brome grass	L+				x	x
Cardamine hirsuta	hairy bitter cress	L+			x		
Carduus acanthoides	plumeless thistle	L+					x
Carduus nutans ssp. *nutans*	nodding thistle	L+					x
Carex spicata	spiked sedge	L+			x		
Cerastium fontanum	mouse-ear chickweed	L+				x	
Chenopodium album var. *album*	lamb's quarters	L+					x
Chrysanthemum leucanthemum	ox-eye daisy	L+				x	x
Cirsium arvense	creeping thistle	L+		x	x	x	x
Cirsium vulgare	bull thistle	L+		x			x
Convallaria majalis	lily-of-the-valley	L+		x			
Crataegus monogyna	English hawthorn	L+			x		
Cynanchum rossicum	dog-strangling vine	L+		x	x	x	x
Cynoglossum officinale	hound's tongue	L+		x			
Dactylis glomerata	orchard grass	L+				x	
Daucus carota	Queen Anne's lace	L+		x		x	x
Dipsacus fullonum ssp. *sylvestris*	teasel	L+					x
Echium vulgare	viper's bugloss	L+				x	
Elymus repens	quack grass	L+				x	x
Epilobium parviflorum	small-flowered willow-herb	L+				x	x
Epipactis helleborine	helleborine	L+		x	x	x	
Euonymus europaea	European spindle-tree	L+			x		
Festuca pratensis	meadow fescue	L+				x	
Festuca rubra ssp. *rubra*	red fescue	L+				x	x
Galeopsis tetrahit	hemp-nettle	L+			x		
Geum urbanum	urban avens	L+		x	x	x	x
Glechoma hederacea	creeping Charlie	L+		x			
Glyceria maxima	giant manna grass	L+					x
Hesperis matronalis	dame's rocket	L+		x	x		
Hydrocharis morsus-ranae	European frog-bit	L+					x
Hypericum perforatum	common St. Johnswort	L+				x	x
Impatiens glandulifera	Himalayan balsam	L+		x			
Iris pseudacorus	yellow flag	L+					x
Lactuca serriola	prickly lettuce	L+			x	x	
Lapsana communis	nipplewort	L+		x	x		
Leonurus cardiaca ssp. *cardiaca*	motherwort	L+		x			
Ligustrum vulgare	privet	L+					x
Linaria vulgaris	butter-and-eggs	L+				x	
Lithospermum officinale	Eurasian gromwell	L+					x
Lonicera morrowii	Morrow's honeysuckle	L+			x		x
Lonicera tatarica	Tartarian honeysuckle	L+					x
Lonicera x *bella*	shrub honeysuckle	L+		x	x	x	x
Lonicera xylosteum	European fly honeysuckle	L+			x		
Lotus corniculatus	bird's foot trefoil	L+				x	
Lycopus europaeus	European water-horehound	L+					x
Lysimachia nummularia	moneywort	L+					x
Lythrum salicaria	purple loosestrife	L+		x		x	x
Malus pumila	apple	L+		x	x		
Medicago lupulina	black medick	L+					x
Medicago sativa ssp. *sativa*	alfalfa	L+				x	
Melilotus alba	white sweet clover	L+				x	x
Mycelis muralis	wall lettuce	L+		x			
Myosotis scorpioides	true forget-me-not	L+				x	x
Nasturtium microphyllum	small-leaved watercress	L+				x	
Nepeta cataria	catnip	L+					x
Pinus sylvestris	Scots pine	L+				x	
Poa compressa	flat-stemmed blue grass	L+				x	x
Poa nemoralis	woodland spear grass	L+		x	x		
Poa pratensis ssp. *pratensis*	Kentucky blue grass	L+		x	x	x	x
Polygonum persicaria	lady's thumb	L+				x	
Potamogeton crispus	curly pondweed	L+				x	
Potentilla recta	sulphur cinquefoil	L+				x	
Pyrus communis	pear	L+			x		
Ranunculus acris	tall buttercup	L+			x	x	x
Rhamnus cathartica	common buckthorn	L+		x	x	x	x
Ribes rubrum	garden red currant	L+		x	x	x	x
Rosa multiflora	multiflora rose	L+			x	x	x

Appendix 3: Flora Species observed in Long-term Monitoring Plots 2008-2010							
		Rank		Forest		Wetland	
		TRCA	Co-efficient of	Landuse Zone(s)		Landuse Zone(s)	
Scientific Name	Common Name	(03/2009)	Conservatism	Rural Plots	Urban Plots	Rural Plots	Urban Plots
Salix x rubens	European tree willow	L+				x	
Scrophularia nodosa	European figwort	L+				x	
Solanum dulcamara	bittersweet nightshade	L+		x	x	x	x
Sonchus arvensis ssp. *arvensis*	glandular perennial sow-thistle	L+				x	
Sonchus oleraceus	annual sow-thistle	L+					x
Sorbus aucuparia	European mountain-ash	L+		x	x		x
Stachys palustris	marsh hedge-nettle	L+					x
Syringa vulgaris	common lilac	L+			x		
Taraxacum officinale	dandelion	L+		x	x	x	x
Taxus cuspidata	Japanese yew	L+			x		
Torilis japonica	hedge-parsley	L+			x		
Tussilago farfara	coltsfoot	L+				x	
Typha angustifolia	narrow-leaved cattail	L+				x	x
Typha x glauca	hybrid cattail	L+				x	x
Veronica officinalis	common speedwell	L+		x	x	x	
Viburnum lantana	wayfaring tree	L+					x
Viburnum opulus	European highbush cranberry	L+		x	x	x	x
Vicia cracca	cow vetch	L+				x	x
***Aster* sp.**	aster species	n/a		x			x
***Carex* sp.**	sedge species	n/a		x		x	x
***Cirsium* sp.**	thistle species	n/a			x		
***Eleocharis* sp.**	spike-rush species	n/a				x	
***Epilobium* sp.**	willow-herb species	n/a					x
***Juniperus* sp.**	juniper species	n/a					x
***Lonicera* sp.**	honeysuckle species	n/a				x	
***Salix* sp.**	willow species	n/a					x
Stachys sp.	hedge-nettle species	n/a					x

Appendix 5: Details of number of stations per site for fauna monitoring project.

Forest birds were monitored at a total of 27 sites (20 in 2008 and 2009, and 27 in 2010). These sites vary considerably both in quality and size, the larger sites being able to accommodate a larger number of stations. Thus, the sites range from the single station sites (the majority of sites – 11 in all) to the largest multi station site, Glen Major, which accommodates a total of 5 stations. In general, larger forest blocks are situated within the rural zone and accordingly the sites with the highest number of stations are likewise designated as rural sites. However, a surprisingly high proportion of the urban sites are able to accommodate three stations and this has resulted in a fairly even spread of stations between the two zones: the 11 rural sites comprise a total of 2.4 stations per site, whereas the 16 urban sites have an average of almost 2 stations per site. The allocation of rural versus urban was conducted using GIS. Table A shows the breakdown of sites and stations by urban versus rural zones.

Table A: Breakdown of Forest Bird Monitoring Sites by Urban vs. Rural Zones

Year	2008		2009		2010	
Land-Use Zone	Urban	Rural	Urban	Rural	Urban	Rural
number of sites	11	9	11	9	16	11
total sites	20		20		27	
5-station sites	0	1	0	1	0	1
4-station sites	0	1	0	1	0	1
3-station sites	7	2	7	2	7	2
2-station sites	1	3	1	3	1	4
1-station sites	3	2	3	2	8	3
total stations	26	23	21	28	31	26

Wetland birds and frogs were monitored at a total of 18 sites: 15 sites were monitored in 2009 but one of these was omitted in the following season. An additional three sites were then added in 2010 for a season total of 17 sites, but a two year total of 18 sites. All but two of these sites are single station sites, there being just one rural site with three stations and one urban site with two stations (Table B).

Table B: Breakdown of wetland bird monitoring sites by urban and rural land-use zones

Year	**2009**		**2010**	
Land-Use Zone	urban	rural	urban	rural
number of sites	7	8	8	9
total sites	15		17	
3-station sites	0	1	0	1
2-station sites	1	0	0	0
1-station sites	6	7	8	8
total stations	8	10	8	11

Meadow birds were monitored at a total of 13 sites (constant through 2008 to 2010). These sites vary considerably in quality and size, the larger sites being able to accommodate a larger number of stations. Other than one particularly extensive rural site which is able to accommodate three stations, the sites – both urban and rural – are evenly split between those supporting one and two stations. Table C shows the breakdown of sites and stations by urban versus rural zones.

Table C: Breakdown of Meadow Bird Monitoring Sites by Urban vs. Rural Zones

Years	2008, 2009 and 2010	
Land-Use Zone	urban	rural
number of sites	7	6
total sites	13	
3-station sites	0	1
2-station sites	4	2
1-station sites	3	3
total stations	11	10

Appendix 7: Peak counts for each year (2009 and 2010) at Plethodontid long term monitoring stations.

Site	PlotID	year	peak count	land-use
Heart Lake	FS-2	2009	23	urban
Heart Lake	FS-2	2010	18	urban
Downsview Dells	FS-4	2009	81	urban
Downsview Dells	FS-4	2010	45	urban
Boyd	FS-6	2009	32	urban
Boyd	FS-6	2010	32	urban
TVM #14	FS-7	2009	3	rural
TVM #14	FS-7	2010	3	rural
Caledon Tract	FS-8	2009	2	rural
Caledon Tract	FS-8	2010	5	rural
Bolton Tract	FS-9	2009	14	rural
Bolton Tract	FS-9	2010	19	rural
West Gormley	FS-11	2009	24	rural
West Gormley	FS-11	2010	26	rural
Wilket Creek Park	FS-12	2009	1	urban
Wilket Creek Park	FS-12	2010	1	urban
Baker's Sugar Bush	FS-13	2009	33	urban
Baker's Sugar Bush	FS-13	2010	33	urban
Morningside Park	FS-15	2009	5	urban
Morningside Park	FS-15	2010	3	urban
Altona Forest	FS-16	2009	2	urban
Reesor Rd & Hwy #7	FS-17	2009	38	rural
Reesor Rd & Hwy #7	FS-17	2010	15	rural
Glen Major A	FS-21	2009	38	rural
Glen Major A	FS-21	2010	31	rural
Duffins Marsh Woodland	FS-22	2009	2	urban
Duffins Marsh Woodland	FS-22	2010	3	urban
Bruces Mill	FS-23	2009	26	rural
Bruces Mill	FS-23	2010	28	rural
Palgrave	FS-24	2009	16	rural
Palgrave	FS-24	2010	2	rural
Kirby & Keele	FS-27	2009	1	urban
Kirby & Keele	FS-27	2010	2	urban