



Wetland Vegetation Monitoring Protocol

Terrestrial Long-term Fixed Plot Monitoring Program

Regional Watershed Monitoring and Reporting

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Toronto and Region Conservation for The Living City®

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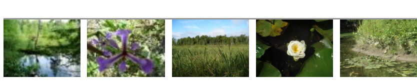


Table of Contents

page

1.0 INTRODUCTION 4

2.0 STUDY DESIGN 4

3.0 EQUIPMENT & MATERIALS 5

4.0 PLOT SET-UP METHODOLOGY 6

4.1 WETLAND TRANSECT SET-UP 6
4.1.1 50 m Transect Line Set-up 6
4.1.2 Woody Vegetation Subplot Set-up 7
4.1.3 Ground Vegetation Subplot Set-up 7

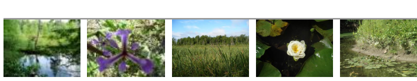
5.0 MONITORING FREQUENCY AND VARIABLES COLLECTED 9

6.0 DATA COLLECTION METHODOLOGY 10

6.1 TRANSECT LINE (0-50 m) DATA COLLECTION METHODOLOGY 10
6.2 WOODY VEGETATION SUBPLOT (2 m x 2 m) DATA COLLECTION METHODOLOGY 10
6.3 GROUND VEGETATION SUBPLOT (1 m x 1 m) DATA COLLECTION METHODOLOGY 11

7.0 DATA MANAGEMENT AND ANALYSIS 11

8.0 REFERENCES 14



List of Tables

Table 1: List of required equipment and materials for transect/subplot set-up and data collection . 5
Table 2: Wetland vegetation monitoring variables and frequency 9

List of Figures

Figure 1: Wetland transect design 8
Figure 1: Collapsible quadrat-cross 11

List of Appendices

Appendix A: Wetland tree and soil data sheet 15
Appendix B: Wetland woody vegetation data sheet 16
Appendix C: Wetland ground vegetation data sheet 17

1.0 INTRODUCTION

Wetlands are defined as areas "where the water table is at, near or above the surface". These areas are either seasonally or permanently inundated with water leading to the development of hydric soils (water-altered) and the establishment of obligate and facultative wetland flora and fauna species. In Ontario, wetlands are classified, according to the Canadian Wetland Classification System, into one of five categories: fens, bogs, swamps, marshes or shallow waters. Each category can be further sub-divided into a series of sub-categories (i.e. treed bog versus open bog). Distinctions between each wetland type are based on soil characteristics, water type, water morphology, surface patterns, surface morphology, and vegetation communities (Environment Canada 2010).

Wetlands provide many valuable ecological services; in addition to providing habitat for a variety of species, both common and rare. They regulate water movement, control sedimentation and filter pollutants such as fertilizers from the surrounding water and land. By monitoring wetlands, potentially significant changes in hydrology, soils, species composition and structure can be detected; thus enabling problems within the wetland or watershed to be recognized and addressed (Environment Canada 2010). The methodology used by the Toronto and Region Conservation Authority (TRCA) for long-term monitoring of wetland ecosystems is a modified version of the wetland protocols used by Credit Valley Conservation (CVC 2008a, b).

2.0 STUDY DESIGN

Ensuring a sample size that is appropriate to detect region wide trends is the primary objective of the monitoring program. However, with additional funds and resources in the future, it will also be desirable to increase the sample size in order to have the ability to look at differences between three land-use zones (urban, urbanizing and rural).

Objective(s):

- To determine the health of wetlands in the TRCA jurisdiction.
- To determine if the population and abundance of flora species of concern are changing over time.
- To determine the floristic quality of the site.

An *a priori* power analysis was conducted in 2008 (Zorn 2008) to determine the appropriate number of monitoring plots needed to achieve sufficient power. In 2015, a further power analysis (retrospective) was conducted to ensure the appropriate number of plots are monitored for assessing spatial and temporal trends in floristic quality index (FQI), the number of L1-L3 flora species and % native flora species. The sample sizes used in this power analysis were based on sample sizes used in TRCA (2015a).

Power was sufficient (>80%) for all analyses comparing the rural and urban zones (10 rural, 9 urban). Temporal trends for floristic quality index (FQI), the number of L1-L3 species and % native flora species were not analyzed due to suspected artificial increases in these parameters since plot set-up. This is a common situation when starting monitoring programs and in scientific studies and it is expected that these values will plateau at a point when all species have been identified (Grandin 2011).

Also in 2015, an additional review of plot location was completed to ensure that various wetland types are appropriately represented in the monitoring program. This analysis concluded that three meadow marsh (MAM) plots should be added in the rural zone and two meadow marsh (MAM) plots should be added in the urban zone. In addition to meadow marsh, the analysis concluded that two deciduous swamp (SWD) plots should be added in the rural zone and one deciduous swamp (SWD) plot should be added in the urban zone.

3.0 EQUIPMENT & MATERIALS

Different materials and equipment are needed depending on whether the plot is being set-up for the very first time or if visited for seasonal monitoring (Table 1).

Table 1. List of required equipment and materials for transect/subplot set-up and data collection. Asterisks (*) items needed for 5 year visits (**) items are needed for plot maintenance or in the event of plot disturbances such as vandalism.

Equipment	Set-up	Transect Line	Woody Vegetation Subplot	Herbaceous Vegetation Subplot
Map showing plot location	X	X	X	X
Prism (for prism sweep)	X*			
Compass	X	X	X	X
Clipboard, data sheets, pencils	X	X	X	X
Previous years' data		X	X	X
18 – 1 ½ m white PVC pipes	X			
GPS unit	X	X	X	X
Permanent ink writing markers	X	X**	X**	X**
30 m measuring tape	X	X	X	X
4 m2 quadrat cross	X	X	X	X
3 – 5 pieces of ½ m rebar	X	X**		
Pigtail marking stakes	X	X		
Waders	X	X	X	X
Camera	X	X	X	X
Soil auger	X			
Muriatic acid solution (diluted)	X			
Post pounder	X	X**	X**	X**
Bug spray	X	X	X	X

4.0 PLOT SET-UP METHODOLOGY

4.1 WETLAND TRANSECT SET-UP

Each wetland monitoring station is comprised of a 50 m transect with 6 centre-posts positioned at 10 m interval from 0 m – 50 m. Perpendicular to the transect, and offset 5 m to either side of a centre post is a 2 m x 2 m ($4m^2$) woody vegetation subplot and a 1 m x 1 m ($1m^2$) herbaceous subplot nested within (Figure 1). The numbering of the subplots is standardized. Posts are numbered from left to right; starting at the 0 m post and continuing to the 50 m post (Figure 1). At set-up, crews ideally consist of four people; one person recording and two to three setting up transect line and subplots (can be done with 2 to 3 but more time involved). In this instance, one team assesses the vegetation subplots while the second team collects the data for the transect line. Less time is needed to collect the transect line data (soil, water and prism sweep data), so after its collection, the second team can rejoin the first team allowing one team to assess the woody vegetation subplots (2 m x 2 m) while the other assesses the herbaceous vegetation subplot (1 m x 1 m). Teams also have the option of either assessing subplots separately, leap-frogging from one subplot to the next. On average each plot takes 3½ - 4 hours for set-up.

4.1.1 50 m Transect Line Set-up

The transect line is perpendicular to the edge of the wetland running in toward the centre of the wetland. The transect line is comprised of six centre posts each separated by 10 m. Transect centre posts are positioned according to the wetland's hydrological gradient. The 0 m post is placed at the drier end of the transect-line while the 50 m is placed at the wetter end. The first two subplots are therefore usually positioned within non-wetland vegetation or on the border between wetland and upland.

To begin, the entire transect length is measured out in 10 m increments with a 50 m measuring tape. Holding one end of the measuring tape, one crew member stands at the 0 m mark with a compass set to the appropriate bearing and then directs a second person, holding the other end of the tape, on how to maintain a straight line on that determined compass bearing. The 3rd crew member follows along behind and installs a 5 ft PVC pipe with the aid of a post-pounder at each 10 m interval. To reduce the likelihood of the posts shifting due to freeze/thaw, wind or wave action they are hammered down 0.5 to 1 m into the substrate.

PVC pipes are labelled using permanent ink marker and identified with the plot and transect number as well as a brief descriptive header (i.e. TRCA Wetland Monitoring Plot). Two photos of the transect line are taken for documentation purposes. The first is taken from the 0 m mark towards the 50 m. The second is taken from the 50 m mark towards the 0 m. Plots are geo-referenced by taking GPS readings at the 0 m and the 50 m posts. By geo-referencing the sites, plots can easily be relocated in subsequent visits.

Note(s):

1. If the soil is too compacted to allow the installation of a PVC pipe, then rebar is used in its place. This typically only occurs in the drier sections of the transect-line (i.e. at the 0 m mark and subplots 1 and 2).Where rebar is used the posts are tagged with metal tags.

2. If the vegetation along a transect-line is particularly thick, then the first crew member will move up the transect line after each 10 m so that they keep a clear line of sight.

4.1.2 Woody Vegetation Subplot Set-up

A total of 12 woody vegetation subplots are installed in each wetland plot. A subplot centre is situated 5 m perpendicular to each side of the main transect centre line post (see Figure 1). To obtain the correct orientation and direction for each subplot, the horizontal plane of the cross is adjusted so that each quadrant (within the cross) forms a 90 degree angle. Once achieved, this angle is locked in position. One crew member then walks 5 m in the direction indicated by the cross. The 5 m point marks the centre of the woody vegetation subplot. A PVC pipe labelled with the wetland plot number and the subplot number using the permanent ink marker is then installed at this location using a post pounder. When setting up the subplot, special care is taken to avoid unnecessary vegetation trampling both within the plot and the immediate surrounding area. The outer rear quarter of the subplot, which will be used for herbaceous monitoring (see “C” below), will require extra care. **Note:** The boundary of each subplot is defined by the quadrat cross when it is fully extended.

4.1.3 Ground Vegetation Subplot Set-up

The 1 x 1 m ground vegetation subplot is nested within the larger 2 x 2 m woody vegetation subplot. As such, the two share a common reference point. Depending on whether or not the subplot is located to the left of right of the main transect line, the centre point of the 2 x 2 m subplot is also the upper left or upper right corner of the 1 x 1 m subplot (see Figure 1). Wetland ground vegetation 1 x 1 m subplots are always on the rear outer side of 2 x 2 m (woody vegetation) subplots.

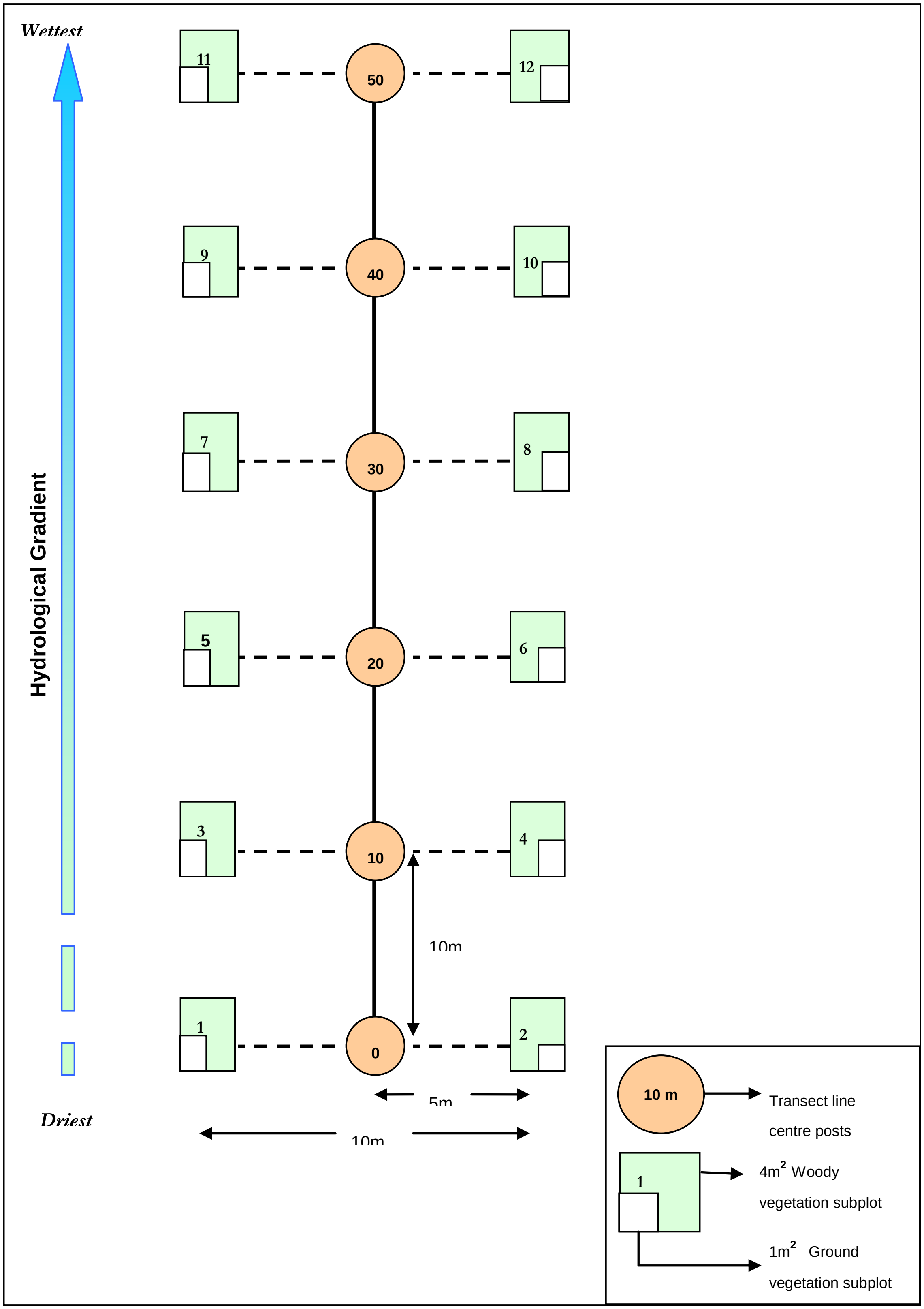


Figure 1: Wetland transect design (*Not to scale*)

5.0 MONITORING FREQUENCY AND VARIABLES COLLECTED

This section provides detailed information on the variables collected for each of the indicators chosen for the long-term monitoring plots including the frequency with which they are collected. Variables are collected on an annual or 5 year basis during a single site visit. Transect visits are carried out in the mid-late summer months (July- early September) to coincide with the peak growing season of the majority of wetland plants. Many of the key diagnostic features needed to accurately identify a species are only visible during this time. It is preferable to gather all the necessary data in one visit but depending on the site and/or the time of day a plot is visited, this may not be possible. If subsequent visits are required, they should be carried out within a reasonable timeframe from the first visit to prevent changes in the quality of data collected (i.e. 1 – 2 days later). Annual visits are completed around the same time each year to allow a better comparison from year to year. Table 2 summarizes the frequency with which each indicator variable is collected. Further details on the variables collected are provided in this section.

Table 2. Wetland Vegetation Monitoring Variables and Frequency

Variable	Details	Frequency
Water depth	Measured along the transect at 0 m, 30 m, and 50 m posts	Annually
Soils	Depth of organics and presence of carbonates at 0 m, 30 m, and 50 m posts	Every 5 years
Tree count	Prism sweep at 20 m post along transect (provides a count by species, of the total number of trees that living or dead)	Every 5 years
Shrubs and saplings	Complete inventory of woody species ≥16 cm tall and <10 cm dbh present within each subplot (dbh measured at 1.3 m) Estimate of cover for each species originating within subplot Tally of number of woody stems, by tree species occurring within each height class (16-95 cm, 96-200 cm, and >200 cm)	Annually
Ground vegetation	Complete inventory of non-woody species <16cm tall and present within each subplot Percent cover for each species originating within 1 x 1 m subplots (overhang is counted)	Annually

6.0 DATA COLLECTION METHODOLOGY

Navigational aids such as GPS units, site maps, and compasses are used (as needed) to locate and access all sites. A written description of all access routes to the including photos are noted. When approaching a site, special care is taken to avoid trampling within subplots. Data collection begins at the 0 m transect post and proceeds forward in numerical order, from left to right until the entire transect is completed. The data collection is best achieved using one team of two. Before leaving the site, all data is checked to ensure that it was collected completely and correctly.

6.1 TRANSECT LINE (0-50 m) DATA COLLECTION METHODOLOGY

Using an auger, soil samples (maximum depth, 120 cm) are taken along the transect line. A few drops of muriatic acid are then placed along the soil core to determine the presence or absence (and depth of occurrence) of carbonates and the depth at which they begin to occur. Non-calcareous soil will not react to acid (i.e. does not fizz), while calcareous soil will react (i.e. fizz). If a complete soil sample cannot be taken (i.e. the sample does not go to 120 cm), then the actual depth reached is recorded and a note that soil did not react is made. If an organic layer is present in the soil sample, then its thickness is measured and recorded. If required, a prism sweep is performed at the 20 m mark. To do this, a prism is extended in one hand, a crew member looks through the prism and while turning around in a circle, records number and species of any trees ≥10 cm dbh that fall within its radius. Appendix A shows a sample data sheet.

6.2 WOODY VEGETATION SUBPLOT (2 m x 2 m) DATA COLLECTION METHODOLOGY

The subplot boundaries are defined by a collapsible quadrat cross (Figure 2). The closed cross is placed over the middle of the centre post and adjusted until it is stabilized. When fully extended it opens into a 2 x 2 m subplot that further separates into four 1 x 1 m quadrants. Crews position themselves around the cross, in such a way as to avoid trampling. The quadrat is surveyed and the stems of all species ≥16cm tall and <10cm dbh within the subplot are identified, counted and recorded according to one of three height classes: 16-95 cm, 96-200 cm and >200 cm. The final stem counts within each height class are tallied, by species, and combined to create a total count for the entire subplot. The percent cover for each species (again based on stems originating within the subplot) is then estimated. Appendix B shows a sample data sheet. **Note:** Some species (e.g. *Cornus stolonifera*) have what appear to be multiple single stems however, the surveyor must confirm that each stem is not in fact attached at the base to a larger plant.

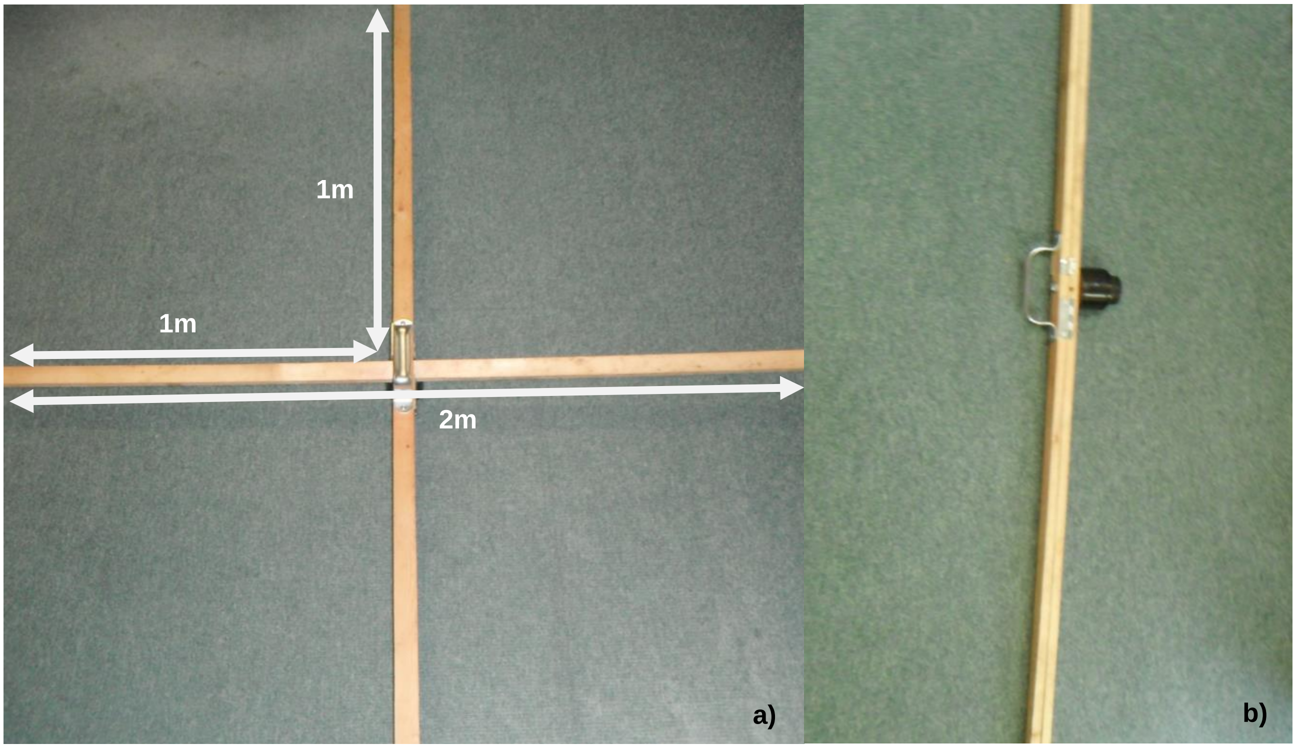


Figure 2: Collapsible quadrat-cross in an opened (a) and closed (b) position.

6.3 GROUND VEGETATION SUBPLOT (1 m x 1 m) DATA COLLECTION METHODOLOGY

Ground vegetation subplots are nested within the larger woody vegetation subplots. Looking forward, towards the 50 m post, subplots are always situated on the outer rear quadrant (Figure 1). Crew members are carefully positioned around the subplot to avoid trampling. All non-woody species and any woody plant seedlings <16 cm tall are identified and recorded. Plants are not counted but solitary species within the subplot is noted and percent cover of each species is estimated. Appendix C shows a sample data sheet.

7.0 DATA MANAGEMENT AND ANALYSIS

Data Management

At the end of each field season all data collected are entered into a corporate TRCA access database and all field collection forms are stored in a corporate filing system.

Data Analysis for the 2015 Terrestrial Long-term Monitoring Program Report (TRCA 2015a)

The TRCA Natural Heritage Monitoring database was queried using the 'Species List - Complete' button and selecting regional wetland plots in all years. 'Species List – Complete' provides an automatic summary of all the species found at the site. In step 1 of selecting species in the database query: bare soil, algae, Chara, dead/live wood, grasses, lichens, liverworts, mosses, N/A, open water/area submerged, seedling, unknown sp., wood, and species identified as non-vascular were excluded. Hybrids and sub-species were included as new species.

Coefficient of conservatism values and L-ranks are automatically exported from the database for each species. If a species could only be identified to the genus level it is labelled with the genus name and ".sp" follows the genus name. If a species with the same genus name as the ".sp" was already found in the species list for that site in that year, the ".sp" was excluded to be conservative (likely not a new species). If a ".sp" was a new genus for that list it was assigned an L-rank and cc value matching the species in the same genus with the lowest L-rank and cc value found in the jurisdiction (conservative). If a ".sp" had genera that were a mix of native and non-native species it was excluded from the analysis because native/exotic status could not be determined.

Data were then arranged into sheets by site and sorted by year. Variables (floristic quality index (FQI), # L1-L3 species and % native species) were calculated for each site in each year between 2008 and 2014. Non-native species were considered to be those ranked L+ and L+?. Data were then transferred to excel tables with the site name shown in each row and year running across the top as columns.

For both temporal and spatial analysis, summary tables with site as row and year as column were used. For temporal analysis, data analysis attempted to maximize the number of years with the same list of sites consistently surveyed each year. This often resulted in limiting the number of sites included because new sites were added in more recent years. Keeping the same group of sites studied in each year allows for valid comparisons among years. The current baseline year for the temporal data is 2008 but in future years a later baseline year may be used in order to increase the number of sites included in the analysis. When analyzing the temporal data for forest vegetation there was a significant increase in species richness over time. This is a common problem when starting monitoring programs and could be caused by either increased observer ability or increased observer knowledge of species already found at the site as time progresses. It is assumed that eventually there will be a plateau and tracking temporal trends can begin at that point. Even though wetland vegetation did not show this same trend, temporal trends for wetland vegetation will begin to be tracked in the same year as forest vegetation stabilizes.

Temporal trends can be statistically analyzed using Mann-Kendall tests in an established Microsoft Excel™ spreadsheet provided by the Ministry of Natural Resources and Forestry. The Mann-Kendall test is a non-parametric test for identifying monotonic trends in time series data. This test is favourable over traditional regression analyses because the data do not meet the assumption of independent samples required for regression analyses. When analyzing time-series data, data collected at the same site from one year to the next are not independent. This makes the Mann-Kendall test the best option. The Mann-Kendall test uses the S statistic to determine an associated p-value. If the value of S is zero, there is no trend in the data. If a data value from a later time period is higher than a data value from an earlier time period, S is incremented by one. On the other hand, if a data value from a later time period is lower than a data value sampled earlier, S is decremented by one. The net result of all such increments and decrements yields the final value of S (TRCA 2011). For example, a very high positive value of S is an indicator of an increasing trend, and a very low negative value indicates a decreasing trend (TRCA 2011). A p-value of less than 0.05 denotes a significant trend (increasing or decreasing) and a p-value of greater than 0.05 indicates that there is no increase or decrease over time and that the variable of interest is stable.

For spatial analysis, data analysis attempted to maximize the number of sites. This often resulted in using more recent years of data because new sites were added in more recent years. Often the most recent 2-4 years of data were used because they contained a consistent set of sites in each year. An average value across the selected years was calculated for each site and this single value per site was used for analysis. The list of sites and years included for the spatial analysis can be found in the appendix of TRCA (2015a).

Spatial trend analysis was conducted using SAS JMP statistical software (SAS Institute Inc. 2008). Differences between urban and rural land use zones were analyzed using independent t-tests. An independent t-test is a parametric test that compares the mean value between two groups (e.g. urban and rural land use zones). This test is reported using the test statistic, t, and an associated p-value where a p-value of less than 0.05 indicates a difference between groups. A p-value of greater than 0.05 indicates that there is no difference between groups. Before performing t-tests, all data were checked for normality and homoscedasticity because these are two assumptions of using parametric statistics. If these assumptions were not met, data transformations were attempted to improve normality or heteroscedasticity. If data transformations were not effective, a Wilcoxon test was conducted (Z-statistic). This is the non-parametric version of an independent t-test and is the appropriate test to proceed with if the data do not meet assumptions. For TRCA (2015a), an independent t-test was used but this may not be the appropriate test to use in the future if the data violate the assumptions of using parametric statistics listed previously.

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APPENDICES

APPENDIX A: WETLAND TREE AND SOIL DATA SHEET

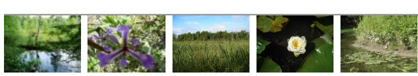
Site Name:____ Transect #_____ GPS______________________

Date (d/m/y):_______________________ Observers:____

WATER DEPTH AT 0m:_______10M_______20M_______30M_______40M_______50M________

DEPTH OF ORGANIC HORIZON (in cm)	CALCAREOUS	additional soil notes
0m__________	YES / NO	__________________________________
30m_________	YES / NO	__________________________________
50m_________	YES / NO	__________________________________

Tree Species Name	Total count		Notes
	Living	Dead	

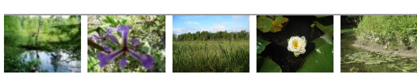


APPENDIX B: WETLAND WOODY VEGETATION DATA SHEET

Site Name:____ TRANSECT #_______________

Date (d/m/y):____________________ Observers:____

Subplot #	Species Name	Shrub/Sapling Stem Count (per height class)			Total Count	% Cover	Comments (e.g. photos)
		16-96 cm	96 -200 cm	>200 cm			



APPENDIX C: WETLAND GROUND VEGETATION DATA SHEET

Site Name:____ Plot #_______

Date (d/m/y):______________________ Observers:____

Subplot #	Species (full species name)	Solitary (check only when applicable)	% Cover	Comments (e.g. collected, photo, etc.)