July 26, 2023

Committee Chair
Rouge National Urban Park Study

Dear Committee Chair,

The Parks Canada 2016 “Operational Review of Potential Measures to Assess Condition of Natural Ecosystems in Rouge National Urban Park” (Operational Review) has been included in the background information package for committee members. The objective of the Operational Review is to provide recommendations on thresholds, methodology and sampling design for 10 potential measures to monitor and assess the condition of the natural ecosystems of the Rouge National Urban Park (RNUP). Although the Operational Review was intended to be an internal document, it has been included in the information package as it contains valuable context and background material that will be beneficial to the committee. When reviewing the Operational Review, it is important to note the following:

1. The report was written in 2016 and may not accurately reflect current ecological site conditions. The information and data included was the best available at the time.

2. The report lists ecosystems and measures that were relevant in 2016, at a time when the protection and maintenance of Ecological Integrity was not identified as one of the main goals of the RNUP in the *Rouge National Urban Park Act*.

3. The report was written at a time when there were no established monitoring programs in RNUP.

4. Although it is expected that all national parks will establish and implement monitoring and reporting programs, there were no requirements for the recommendations provided in the Operational Review to be implemented.

Thank you,

<Original signed by>

Katherine Cumming
Manager of Impact Assessment
Parks Canada

Operational Review of Potential Measures to Assess Condition of Natural Ecosystems in Rouge National Urban Park

MONITORING & ECOLOGICAL INFORMATION DIVISION 2016

Parks Canada Parcs Canada

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Executive Summary

The objectives of the operational review is to providing recommendations on thresholds, methodology and sampling design based on available information on 10 potential measures that have been identified for assessing the condition of the natural ecosystems of the Rouge National Urban Park (RNUP). Overview tables have also been prepared to facilitate the presentation of the program.

Review summary of the Landscape change measures in Forest and Wetland ecosystem, and Riparian cover type change measure in the Freshwater ecosystem

1) The proposed Forest Landscape Change measure has 3 sub-measures, the Wetland Landscape Change measure has 3 sub-measures, and the Riparian Landscape Measure has 2 sub-measures.
2) Thresholds are proposed for all sub-measures based on Environment Canada (2013) guidelines and expert opinion.
3) Ongoing implementation of this measure will require acquisition of new high-resolution imagery every 5 years.
4) Remote sensing expertise is necessary to process and classify each time step of imagery in order to implement the protocol. Once the imagery is classified geomatics operations are needed to extract the monitoring metrics. It is assumed this will require a combination of within-PCA capacity and outsourcing.

Review Summary of the Bird community measures in the Forest and Wetland ecosystems

The Monitoring and Ecological Information division (MEI division) recommend the following actions to complete the development of the measures:

1) Perform a power analysis with the TRCA bird database to determine if a sample of 15 sites can detect an acceptable rate of change at 80% confidence level in the RUNP.
2) Analyse the data collected by the TRCA in the Toronto area to determine how patch size influence the probability of occurrence of the each of the selected focal species for this measure, and if required adapt the sampling design accordingly.
3) Consider changing the measure name to “Status of Fragmentation-sensitive nesting bird species” to better describe the nature of the measure.

Review Summary of the Key Tree Species in the Forest ecosystem

The MEI division recommend the following actions to complete the development of the measure:

1) Implement a preliminary sampling design of 20 plots, i.e. 10 plots per general stand type category;

2) Conduct a power analysis once preliminary data have been collected to adjust the sample size if needed;

3) Review the data from the permanent forest plots network implemented by the TRCA to establish thresholds on growth rate, and complement the information with a dendrochronology study within the park.

Review Summary of the Deer Browsing measure in the Forest ecosystem

The MEI division recommend the following actions to complete the development of the measure:

1) If enough resources is available in the park, we recommend to implement the AGBR protocol as the measure obtained with this protocol will be more comprehensive and more directly linked to effect of deer browsing at the plant community level;

2) If resource is limited, we recommend to implement the WTMHL measure. A preliminary survey of 5 sites in spring 2016 would provide data that could help refine the protocol and sampling design.

Review Summary of the Amphibian Community measure in the Wetland ecosystem

The MEI division recommend the following actions to complete the development of the measure:

1) Adopt a monitoring metric based on a two-year moving average in PAO for the 6 amphibian species.

2) Adopt a monitoring question that incorporates the proposed metric and thresholds. A change in status or trend would occur based on the majority (3 of 6 species) of results. If no majority then the measure is stable.

3) Adopt initial thresholds based on 2sd and 3sd from baseline conditions. Baseline conditions should be derived from existing FrogWatch monitoring data that has been collected since 2009.

4) Adopt a trend assessment method that uses a GLMM that incorporates both PAO and Detection Probability.

5) Standardize a monitoring effort that consistently samples 20 wetland complexes every year. This is consistent with existing levels of effort and should be operationally sustainable.

6) Adjust the existing FrogWatch sampling design to reduce variability and improve representivity of large wetland complexes that occur in a range of Matrix Quality and Connectivity conditions.

7) Improve the data management for this measure such that all monitoring data is saved in a single flat file with PAO and Detection Probability included per species per year.

Review Summary of the Water Quality measure in the Freshwater ecosystem

The MEI division recommend the following actions to complete the development of the measure:

1) We recommend the park's EH monitoring program continues the same WQ field measurements of TRCA's Regional Watershed Monitoring Program as that for the WQ measure of the Freshwater ecosystem in RNUP.
2) We suggest that the sampling design, metrics, as well as the sampling frequency will be maintained for the 4 WQ sampling sites within the park as the minimum level. If the FU's capacity and budget may be feasible for doing more sites, we suggest considering more than the 6 sites (the 4 sites inside the park, plus the 2 sites just outside the park's boundary), as long as the FU may maintain its sustainable operation of the monitoring program.
3) We recommend the WQI to be assessed annually, and calculated based on the 7 parameters as recommended by PWQMN. In this report, we calculated the WQI values from 2002 to 2013, based on the available WQ data (See below for detail.)
4) We suggest to consider including the E. Coli data for calculating the annual WQI.
5) We recommend a statistical trend analysis of WQI changes to be assessed after 2015 year of WQ sampling, or 3 years of establishing of this Park's monitoring program.

Review Summary of the Fish community measure in Freshwater ecosystem

1) This measure is directly linked to health of ecological processes and biodiversity component of the freshwater ecosystem. The fish surveys / monitoring are part of the regional watershed fish management plan by TRCA.

2) The sampling is based on a random design, guided by the OSAP fish sampling protocol for the fish monitoring with 3-year sampling interval.

3) The protocol is well-documented and comprehensive. The 3-year sampling frequency for fish and 1-year sampling for benthos provide a representative portrait of the expected range of variability through time.

4) The fish community data collected are properly stored and managed by TRCA. OSAP's latest version provides updated standardized field sampling and data forms.

5) Should costs prove restrictive, the MEI division recommend that the Park consider using benthic macroinvertebrates as an alternative health measure for the freshwater ecosystem. This measure is relatively mature, and has been used for EI monitoring in numbers of Canadian national parks. The OBBN protocol for sampling of benthic macroinvertebrates has been widely adapted in watershed ecological and environment monitoring in Ontario and other regions.

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Introduction

According to the Rouge National Urban Park (RNUP) Act (Government of Canada 2015), the park was created "… for the purposes of protecting and presenting, for current and future generations, the natural and cultural heritage of the Park and its diverse landscapes, promoting a vibrant farming community and encouraging Canadians to discover and connect with their national protected heritage areas" (article 4). Also, the management plan of the park must "… take into consideration the protection of its natural ecosystems and cultural landscapes and the maintenance of its native wildlife and of the health of those ecosystems" (article 6).

These two articles of the act provides a framework that could be used to establish a monitoring program that will support the management planning process of the park. The landscape of the RNUP is covered by three main natural ecosystems of the park as well as by farmlands managed for agriculture production (figure 1). Prior to the operational review, preliminary work focus mainly on selecting measures that could be used to describe the change in the diversity and the functions in the natural ecosystems. Conceptual models were developed to underline the main natural and human-caused drivers that significantly influence the evolution and dynamics of the ecosystems (see appendix I). A list of 45 potential measures were afterward identified and prioritized using 7 criteria (see appendices II and III) that describe the capacity of a measure to represent changes in ecosystems in a cost-effective way. The top 5 measures were afterward selected in each ecosystem according to their priority scores (table 1).

Table 1: List of potential measures for monitoring natural ecosystems of the RNUP.

Ecosystem	Measures
Forest	Forest landscape change*
	Key tree species status*
	Bird community*
	Deer browsing*
	Invasive species
Wetlands	Wetland landscape change*
	Amphibian community*
	Bird community*
	Turtle community
	Invasive species
Freshwater	Aquatic connectivity
	Riparian cover type change*
	Water quality*
	Fish community*
	Invasive species

*Detailed review presented in the report

The goal of the operational review is to support the development of the monitoring program of the RNUP by:

- Providing recommendations on thresholds, methodology and sampling design based on available information for 10 measures (identified with * in table 1) that could potentially be used to assess the condition of the natural ecosystem of the RNUP ;

- Preparing overview tables that will be presented to the Chief Executive Office, as part of the performance expectation of the Agency for 2015-16.

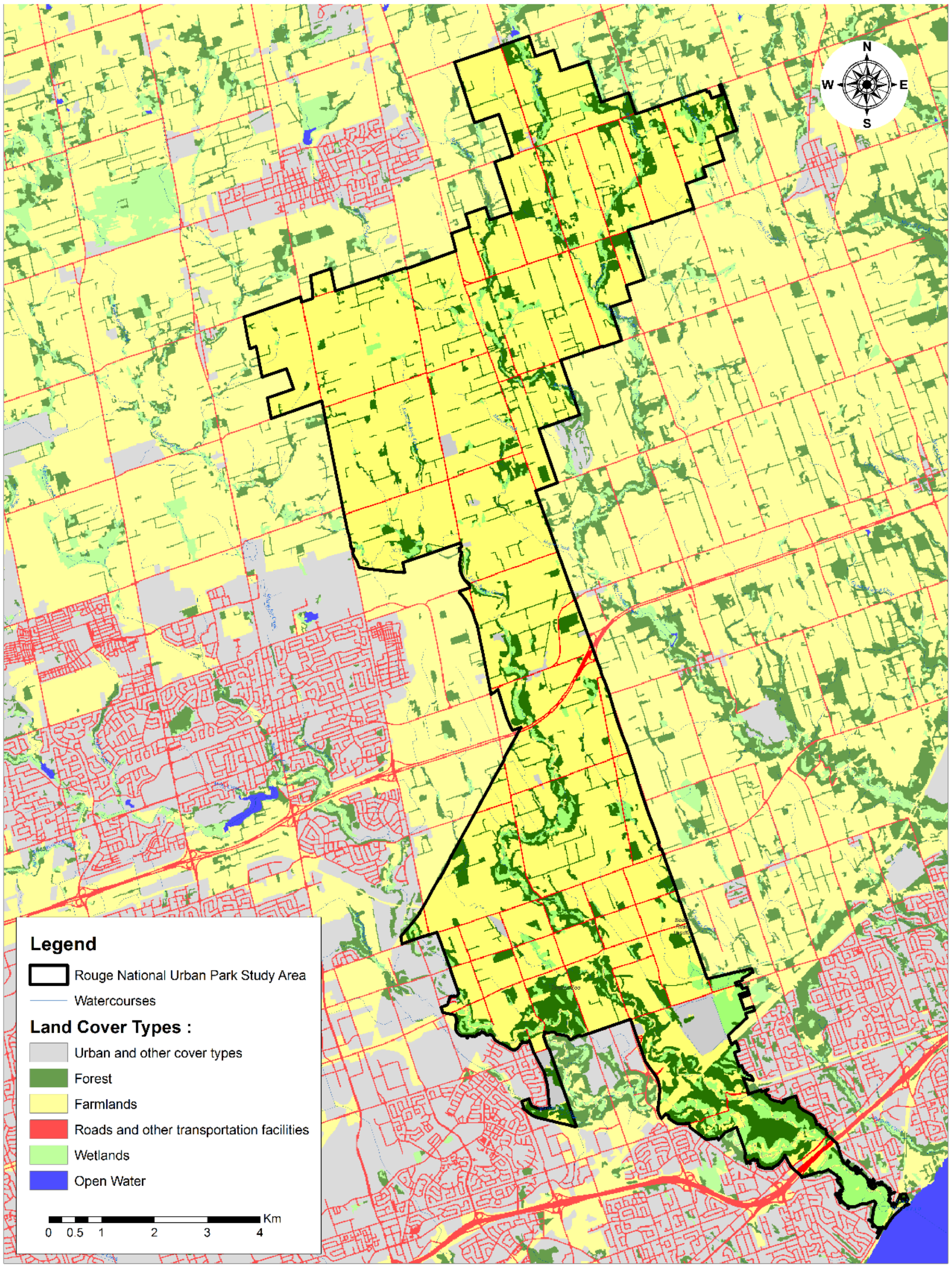

Figure 1 : Main cover types in the Rouge National Urban Park and the peripheral area.

Reference

Government of Canada. 2015. Rouge National Urban Park Act - S.C. 2015, c. 10. Published by the Minister of Justice at: http://laws-lois.justice.gc.ca

Detailed measure review

Common measures in different ecosystems

Landscape change in Forest and Wetland ecosystems, and Riparian cover type change in Freshwater ecosystems

<table>
<tr><td colspan="2">Ecosystem: Forest / Wetland / Freshwater</td></tr>
<tr><td colspan="2">Proposed Monitoring Metric
1. Forest: total amount, total core area, distance between patches
2. Wetland: total amount, total amount of natural cover intersecting core areas, total amount of interior area
3. Freshwater: total amount of natural vegetation in riparian zone, percent of stream length naturally vegetated</td></tr>
<tr><td colspan="2">Proposed Monitoring Question
"Has the metric changed by more than 3% (estimated effect size) at the scale of RNUP over a 10 year period?"</td></tr>
<tr><td>Threshold
See Table 4.</td><td>Frequency
10 years</td></tr>
<tr><td colspan="2">Assessment Method
Sub-measures are rolled up based on the "Logic Approach" from the "Options for Combining Field Measures" document on the MEI intranet site. This approach is based on the majority status of sub-measures. For Riparian Landscape Change, where there are only 2 sub-measures, if no majority then status is Yellow.
<u>Status</u>: Direct comparison of metrics to established thresholds.
<u>Trend</u>: If metric has changed by more than 3% from previous values then the metric has increased / decreased, otherwise the measure is stable.</td></tr>
<tr><td colspan="2">Review Summary
1. One landscape change measure is proposed for each of the Forest, Wetland and Freshwater ecosystems (total of 3 measures).
2. The proposed Forest Landscape Change measure has 3 sub-measures, the Wetland Landscape Change measure has 3 sub-measures, and the Riparian Landscape Measure has 2 sub-measures.
3. Thresholds are proposed for all sub-measures based on Environment Canada (2013) guidelines and expert opinion.
4. Ongoing implementation of this measure will require acquisition of new high-resolution imagery every 5 years. The anticipated cost of this imagery is $10k and 2 person days.
5. Remote sensing expertise is necessary to process and classify each time step of imagery in order to implement the protocol. Once the imagery is classified geomatics operations are needed to extract the monitoring metrics. It is assumed this will require a combination of within-PCA capacity and outsourcing. The anticipated cost for this $20k and 5 person days.
6. Total anticipated operational cost is $30k and 7PD every 5 to 10 years depending on monitoring frequency.</td></tr>
</table>

<u>What to Measure</u>

Recommendations on monitoring measures for Forest, Wetland, and Riparian Landscape are based on Environment Canada's guidelines presented in the document: "How Much Habitat is Enough?"[1] (see Appendix IV). These habitat guidelines are briefly reviewed and some

[1] Environment Canada. 2013. How Much Habitat is Enough? Third Edition. Environment Canada. Toronto, Ontario.

monitoring measures associated with them are suggested (table 2). The selections of these measures were guided by the following criteria:

- Landscape measures should be logically straightforward, easy to understand, and easy to communicate to a range of audiences (ie, not complicated landscape indices such as Fractal Dimension).
- Each landscape monitoring measure for Forest, Wetlands, and Riparian should be as concise as possible without too many sub-measures such that each measure is not too difficult to implement, interpret, and report.
- Landscape measures should be sensitive to changes in habitat amount and configuration (with priority being on habitat amount).
- Landscape measures must be operational sustainable and based on remotely-sensed data and analytical methods that are available and low cost.
- Landscape measures should be sensitive to changes at the scale of the park, as well as, sensitive to local scale restoration projects and other active management initiatives.
- Landscape measures should focus on major land cover types and not species-specific habitat requirements. These requirements are important but are not operational given available capacity. Species-specific needs should be the focus of targeted research partnerships.

How to Measure It

This review will discuss the 3 major steps (table 3) and associated costs for implementing the 8 recommended landscape monitoring sub-measures presented on the previous page. It will not, however, provide detailed protocols. Detailed protocols will have to be developed once RNUP selects its final set of landscape monitoring measures. All 8 measures are discussed as a set because all can be implemented using the same remotely-sensed data and analytical approaches.

1. Image Acquisition

Current values of the proposed monitoring metrics were derived from ELC data (2013 and 2015). In order to implement change over time in these metrics with sufficiently high spatial resolution, ELC-type maps need to be updated every 5 years, considering the priority that will be given to restoration projects, and the relatively fast change expected in the landscape of the rural area in the park. Two major imagery sources are recommended to accomplish this: spring leaf-off imagery from the Ontario Imagery Strategy obtained through Land Information Ontario (LIO) and summer leaf-on imagery of similar resolution (Worldview2 or Worldview3 satellite imagery). Ideally both leaf-off and leaf-on imagery can be attained to maximize the classification accuracy and delineation of forested, wetland, and riparian areas. The anticipated costs for Ontario Imagery Strategy data is approximately $5000 as is the estimated cost for Worldview imagery giving these measures a combined fixed imagery cost of $10,000 every 5 to 10 years. Acquisition of imagery does take some effort (~2 person days) to arrange orders, prepare area of interest shapefiles, etc. Support for imagery acquisition can be given by the Monitoring and Ecological Information Division (lead = Olivier Berard).

2. Imagery Classification

Once the imagery has been acquired it must be classified into relevant land cover types (likely at the ELC Community level with minimum 85% overall classification accuracy excluding open water). This will require dedicated remote sensing expertise in order to undertake image processing, supervised / unsupervised classification techniques, accuracy assessment, and metadata cataloguing. Parks Canada's capacity to do this kind of work is very limited and, therefore, this work will likely have to be outsourced. The estimated cost for this is approximately $20,000 and represents the largest fixed cost associated with implementing RNUP's proposed landscape change monitoring measures. Once updated imagery is acquired and classified, however, the mapping products can be used to a range of other applications including research, communications, media products, etc.

3. Metric Calculation

After new imagery has been classified according to a standardized legend and the per-class accuracy of the new map has been confirmed, then a range of geomatics operations is required to extract the relevant monitoring metrics and update the measures' status and trend assessments. Parks Canada should have the capacity to undertake this work on an ongoing basis either through the Field Unit or MEI. An estimated 5 person days is required to do this work. The set of geomatics operations needs to be captured within a set of detailed protocols that should be developed once RNUP has selected a finalized set of measures. The creation of these protocols is a substantial amount of work (approx. 20PD) and is not captured in the costs summarized in table 3.

Thresholds

Table 4 presents a set of suggested initial thresholds for each parameter, as well as their current status, and the current status of the measure in each ecosystem. Trend of the measure is unassessed since all data are derived from a single time period (ELC 2013/15). Maps showing the current spatial pattern of the different parameters in each ecosystem are presented in Appendix V.

The values of these thresholds are based on the "How Much Habitat is Enough" report, expert opinion (Paul Zorn, Monitoring Ecologist. PhD – Landscape Ecology. Over 20 years experience), current values from available ELC data, and a focus on Ecosystem Health appropriate for a national urban park. A detailed narrative explaining the thought process behind each of these thresholds is beyond the schedule provided for this operational review. For explanations associated with these thresholds, please contact Paul Zorn.

Table 2 : List of recommended landscape monitoring metrics for Forest, Wetland and Freshwater ecosystems. Based on habitat guidelines from Environment Canada's "How Much Habitat is Enough?"

	Parameter	*Comment*	*Metric [Metric Label]*
		FOREST	
✓	Percent forest cover	A change in the total amount of forest cover (regardless of forest type) is a primary measure of potential habitat within the park.	1. Total forest amount (ha) [F_AREA]
✓	Area of largest forest patch	Focus on total area of interior forest conditions (more than 100m from an edge).	2. Total forest core area (ha) [F_CORE]
	Forest shape	A relatively less important metric compared to forest amount.	
	Percent of watershed that is forest cover 100m from forest edge	Correlated with the metric selected for "Proximity to other forest patches".	
	Proximity to other forest patches	Forest patches are small but well dispersed. No forest patches are isolated (at 2km nearest neighbour distance).	
✓	Fragmented landscapes and the role of corridors	Forest nodes and linear connectors (ie, riparian forest corridors) can facilitate species movement and reduce the effects of landscape fragmentation if they are sufficiently wide.	3. Distance between forest patches with minimum 50m width (m) (1ha minimum size) [F_CORRIDOR]
	Forest quality – species composition and age structure	Attributes of forest community composition and age structure should be captured within RNUP's "Key tree species status" measure.	
		WETLAND	
✓	Percent wetlands in the watershed and sub-watershed	A primary measure of landscape-scale wetland health. Includes total wetland amount regardless of type (ie, marsh, swamp, bog, fen).	4. Total wetland amount (ha) [W_AREA]
	Wetland location in the watershed	Constrained by hydrology and surrounding land use patterns. Not a sensitive measure at the scale of the park.	
✓	Amount of natural vegetation adjacent to the wetland	Wetland context (surrounding Matrix Quality) can complement habitat of many species that require different aquatic and terrestrial resources to satisfy life cycle needs.	5. Total amount of natural cover intersecting wetland core areas within a 50m buffer (ha) [W_MATRIX]
	Wetland proximity	Correlated with "Amount of natural vegetation adjacent to wetlands"	
✓	Wetland area, shape and diversity	Extensive wetland complexes, comprised of swamps and marshes, with interior habitat conditions (greater than 50m from an edge) can support area-sensitive species.	6. Total amount of wetland interior area (ha) [W_CORE]
	Wetland restoration	Monitoring measures associated with restoration projects will be developed through active management initiatives.	
		FRESHWATER (RIPARIAN)	
✓	Width of natural vegetation adjacent to stream	Width (greater than 30m) of vegetated riparian zones is critical for the provision of aquatic habitat and stream bank stabilization.	7. Total amount of natural riparian vegetation greater than 30m wide (ha) [R_AREA]
✓	Percent of stream length naturally vegetated	Related to the above parameter [R_AREA] but focuses on stream length given any riparian width greater than 30m. Can be stratified on specific stream reaches across the entire park.	8. Percent of stream length naturally vegetation (%) [R_PCT]
	Percent of an urbanizing watershed that is impervious	An insensitive measure for RNUP as the landscape will not "urbanize" within park boundaries.	

Table 3: Major steps in performing change over time analyses on proposed landscape monitoring metrics.

Major Step	Comment	Approx. cost every 5 Years ($ and time)
1. Image Acquisition	➢ High resolution leaf-off (spring) imagery from the Ontario Imagery Strategy (~$5k). ➢ High-resolution leaf-on (summer) imagery from Worldview2/3 (~$5k). ➢ 2 person days for image ordering and data management.	$10k + 2PD
2. Image Classification	➢ Remote sensing image processing and classification and change vector analysis using new imagery with existing ELC/SOLRIS as training data. If done internally by PCA then ~20 person days or ~$20k if outsourced (assume outsourced for now).	$20k
3. Metric Calculation	➢ GIS applications to derive monitoring metrics from newly classified imagery. Assume done internally (approx. 5 person days).	5PD
	TOTAL	$30k + 7PD

Table 4: Proposed thresholds for the Landscape change measure in the Forest and Wetland ecosystems, and for the Riparian cover type change in the Freshwater ecosystem.

Ecosystem	Metric	Threshold: Poor	Threshold: Fair	Threshold: Good	Current value	Current status of parameters	Current status of measure
Forest	Total amount (km²)*	< 11.9 km²	11.9 - 23.8 km²	> 23.8 km²	15.3 km²	FAIR	FAIR
	Total core area (km²)**	< 4.0 km²	4.0 - 8.0 km²	> 8.0 km²	3.1 km²	POOR	
	Distance between forest patches (m)***	> 2000 m	1000 - 2000 m	< 1000 m	1405 m	FAIR	
Wetland	Total amount (km²)†	< 4.8 km²	4.8 - 7.9 km²	>7.9 km²	8.0 km²	GOOD	GOOD
	Total core area (ha)††	< 85 ha	85 - 95 ha	> 95 ha	97.2 ha	GOOD	
	Total amount of natural cover intersecting core areas (km²)†††	< 1.2 km²	1.2 - 1.8 km²	> 1.8 km²	1.5 km²	FAIR	
Freshwater	Proportion of natural vegetation in riparian area (%)‡	< 50%	50 - 75%	>75%	51.2%	FAIR	GOOD
	Proportion of stream length naturally vegetated (%)‡‡	< 50%	50 - 75%	>75%	64.4%	GOOD	

*Equivalent to the proportion of park area: Poor is <15%; Good is >30%; Current value is 19.3%.

**Equivalent to the proportion of park area: Poor is <5%; Good is >10%; Current value is 3.9%.

***Calculated by the 75th percentile in nearest neighbour distance between patches >50 m wide.

†Equivalent to the proportion of park area: Poor is <6%; Good is >10%; Current value is 10.1%.

††Equivalent to the proportion of park area: Poor is 10% decline from current value; Good is current value adjusted for classification error.

†††Surface area of are natural land cover in buffer zones (50m wide) surrounding wetland core areas: Poor is <50% of existing wetland core buffer zones area; Good is >75% of existing wetland core buffer zones area.

‡Riparian area defined with a 30 m buffer along stream; Thresholds based on guidelines from Environment Canada (2013).

‡‡Thresholds based on guidelines from Environment Canada (2013).

Bird community in Forest and Wetland Ecosystems

Monitoring Questions:

1) Was the average relative abundance and occupancy rate of ≥70% of species within ± 1 SD of the baseline during the last 5 years in the forest ecosystem?
2) Was the average relative abundance and occupancy rate of ≥70% of species within ± 1 SD of the baseline during the last 5 years in the wetland ecosystem?

Thresholds	*Sampling frequency*
The thresholds should be established by the statistical distribution (average ±1 SD) of the relative abundance and occupancy rate from a baseline. The data collected by the TRCA in the Toronto Region between 2008-2014 could be used to set thresholds, assuming that the baseline is representative of the current status of birds in the forest and wetlands ecosystems in RNUP. Thresholds could be revised with baseline values obtained after 5 years of monitoring.	Annual

Status and Trend Assessment Method

1) Status and trends of each species at the scale of RNUP should be analyzed with a Generalized Linear Mixed Model with Year as the fixed effect variable and Site as a random effect variable. Effect of other variables, such as the size of habitat patches, peripheral land use, and degree of connectivity, could be included in the model to refine the interpretation. Once the status of the each species have been established, the status of the measure should be establish using the 70th percentile approach (see detailed review).
2) For each species, determine if the trends in relative abundance and occupancy are significant at p<0.2 over the period of assessment. Assign a value of -1 or +1 to significant trends if the parameter respectively move away from or approach a Good condition, and a value of 0 to trends that are not significant. The trends of the measure will be judged based on the average trend value (see detailed review).

Review Summary

4) The proposed measure focus on common species selected to be representative of various guilds defined by habitat requirement in forest and wetland ecosystems.
5) The methodology based on point count that is currently used by the TRCA to survey bird is appropriate for the proposed measure.
6) A sampling design based on size of nesting habitat patches have been proposed. Results interpretation could be complemented by Generalize Linear Mixed Modelling that include variable describing the surrounding landscape. A minimum sample size of 15 sites in both ecosystems is recommended based on typical bird monitoring project in national parks, but the statistical power of such sample remains to be assessed.
7) Over a 5 year period, 15 person-days per year will be required to complete the data collection of each ecosystem. Data management and analysis would also require an additional 10 PD/5 year. Up to $1K per year can be also be allow to cover material and travel expenses in both ecosystem.

Recommendations:

1) A power analysis should be performed using the TRCA bird data base to determine if an acceptable rate of change can be detected with the recommended sample size at 80% power and confidence levels.
2) The patch size criteria used to elaborate the sampling design was arbitrarily selected to keep a minimum number of patches in the statistical population. We recommend to analyse the data collected by the TRCA in the Toronto Region to determine how patch size influence to probability of occurrence of the each of the selected focal species for this measure. The sampling design may need to be adapted according to the needs of some focal species.
3) The TRCA wetland bird data base should be analysed to establish a preliminary list of focal birds in each guild.

Detailed review

Rationale of the measure

Birds are conspicuous species, that are known to be affected by various ecological factors and conservation issues, and that could be easily monitored with field-tested protocols. Birds also generated large public interests and therefore have a high potential for citizen science integration in the monitoring program of the RNUP.

A large number of species can be detected during a monitoring project, and the purpose of this measure is to focus on common species, classified in guilds according to their habitat requirements. A special attention will also be given to species known to be sensitive to habitat fragmentation, a major issue in the park.

List of focal birds in the forest ecosystem

The TRCA conducted a bird survey in forest ecosystem from 2008-2014, and this extensive dataset could be used to determine which species could be included in the measure assuming that the bird community of the RNUP is relatively similar to the bird community in the forested areas of the region of Toronto. The list of species could be adjusted after 4 or 5 years of monitoring in the park.

The TRCA suggested to classify birds species in guilds according to the nesting behavior (TRCA 2011). Three guilds were identified based on the vertical location of the nest, i.e. on the ground (<0.5 m), in the understory (0.5 to 3.0 m), and in the canopy (>3.0 m). The species could also be distinguished according to their level of sensitivity to habitat fragmentation, based on the expertise of the CWS's National Wildlife Research Centre and Geomatics and Landscape Ecology Laboratory of Carleton University (P. Zorn comm. pers.).

A total of 63 species were observed during the survey. The ground nester guild represent 19% of the species (n=12), and two species of this guild are known to be sensitive to fragmentation (table 5). In comparison, the understory nester guild represent 20% of the total number of species (n=13), and only species of this group is known to be sensitive to fragmentation (table 6). Finally, the canopy nesters guild is the more diverse group with 60% of the total number of species (n=38), including 6 fragmentation sensitive species (table 7).

The suite of species in the forest community measure should be representative of the distribution of species in the three guild. The MEI div recommend to focus on at least 33% of the species in each guild. The most common species of each guild should be selected according to their average occupancy rate and relative abundance. Assuming that the same species observed in the Toronto region could be observed in the RNUP at a similar relative abundance and occupancy rate, the suite of species would include 4 ground nesting species, 4 understory nesting species, and 13 canopy nesting species, of which 9 species are known to be sensitive to habitat fragmentation (table 8).

Table 5: List of species in the ground nesters guild observed in the TRCA. Species are ranked according to their average occupancy rate and average relative abundance.

Species	Fragmentation sensitivity	Occupancy[1]			Relative abundance[2]			Total rank
		Average	Std	Rank	Average	Std	Rank	
Ovenbird	HIGH	0.20	0.04	1	0.31	0.71	1	2
Song Sparrow	LOW	0.15	0.02	2	0.20	0.52	2	4
Veery	HIGH	0.09	0.02	3	0.14	0.50	3	6
Mourning Warbler	LOW	0.07	0.02	4	0.08	0.31	4	8
Winter Wren	LOW	0.06	0.04	5	0.06	0.24	5	10
Northern Waterthrush	LOW	0.02	0.02	6	0.02	0.12	6	12
Hermit Thrush	LOW	0.02	0.02	7	0.02	0.12	6	13
Black-and-White Warbler	LOW	0.01	0.01	8	0.01	0.07	8	16
Eastern Towhee	LOW	0.00	0.01	9	0.01	0.07	8	17
Common Nighthawk	LOW	0.00	0.01	10	0.00	0.05	10	20
Nashville Warbler	LOW	0.00	0.01	11	0.00	0.05	10	21
White-Throated Sparrow	LOW	0.00	0.01	12	0.00	0.05	10	22

[1]Proportion of stations where the species was observed
[2]Number of bird/station

Table 6: List of species in the understory nesters guild observed in the TRCA. Species are ranked according to their average occupancy rate and average relative abundance.

Species	Fragmentation sensitivity	Occupancy[1]			Relative abundance[2]			Total rank
		Average	Std	Rank	Average	Std	Rank	
American Robin	LOW	0.69	0.06	1	1.16	1.05	1	2
Northern Cardinal	LOW	0.46	0.03	2	0.71	0.94	2	4
Wood Thrush	HIGH	0.22	0.03	3	0.36	0.76	3	6
Rose-Breasted Grosbeak	LOW	0.20	0.06	4	0.24	0.50	4	8
American Goldfinch	LOW	0.17	0.11	5	0.22	0.57	5	10
Brown Creeper	LOW	0.10	0.04	6	0.12	0.39	6	12
Gray Catbird	LOW	0.06	0.02	7	0.08	0.33	7	14
Indigo Bunting	LOW	0.06	0.02	8	0.08	0.34	8	16
Chipping Sparrow	LOW	0.05	0.03	9	0.06	0.28	9	18
Black-Throated Blue Warbler	LOW	0.02	0.01	10	0.02	0.12	10	20
Yellow-Billed Cuckoo	LOW	0.01	0.01	11	0.01	0.07	12	23
Chestnut-Sided Warbler	LOW	0.00	0.01	12	0.01	0.11	11	23
Eastern Phoebe	LOW	0.00	0.01	13	0.00	0.05	13	26

[1]Proportion of stations where the species was observed
[2]Number of bird/station

Table 7: List of species in the canopy nesters guild observed in the TRCA. Species are ranked according to their average occupancy rate and average relative abundance.

Species	Fragmentation sensitivity	Occupancy[1]			Relative abundance[2]			Total rank
		Average	Std	Rank	Average	Std	Rank	
Red-Eyed Vireo	HIGH	0.81	0.03	1	1.83	1.44	1	2
Black-Capped Chickadee	LOW	0.71	0.05	2	1.28	1.19	2	4
Blue Jay	LOW	0.48	0.07	3	0.68	0.86	3	6
Eastern Wood-Pewee	HIGH	0.44	0.10	4	0.58	0.74	4	8
Great Crested Flycatcher	LOW	0.22	0.05	5	0.28	0.58	5	10
Hairy Woodpecker	HIGH	0.21	0.03	7	0.24	0.49	7	14
Downy Woodpecker	LOW	0.22	0.05	6	0.23	0.44	8	14
American Crow	LOW	0.19	0.08	8	0.26	0.62	6	14
Pine Warbler	HIGH	0.18	0.05	9	0.21	0.50	9	18
Scarlet Tanager	HIGH	0.18	0.04	10	0.21	0.49	10	20
Red-Breasted Nuthatch	LOW	0.17	0.04	11	0.20	0.48	12	23
Black-Throated Green Warbler	HIGH	0.13	0.03	13	0.20	0.60	11	24
White-Breasted Nuthatch	LOW	0.16	0.03	12	0.19	0.47	13	25
Cedar Waxwing	LOW	0.12	0.07	14	0.17	0.49	14	28
Baltimore Oriole	LOW	0.09	0.04	15	0.10	0.36	15	30
Northern Flicker	LOW	0.08	0.04	16	0.09	0.34	16	32
Pileated Woodpecker	LOW	0.04	0.02	17	0.04	0.21	18	35
Blue-Gray Gnatcatcher	LOW	0.03	0.04	18	0.05	0.26	17	35
American Redstart	LOW	0.03	0.01	20	0.04	0.25	18	38
Warbling Vireo	LOW	0.03	0.02	19	0.03	0.17	21	40
Yellow-Bellied Sapsucker	LOW	0.03	0.03	21	0.03	0.23	20	41
Coopers Hawk	LOW	0.03	0.01	22	0.03	0.18	22	44
Mourning Dove	LOW	0.02	0.02	23	0.02	0.15	23	46
Yellow-Rumped Warbler	LOW	0.02	0.02	24	0.02	0.15	23	47
Red-Tailed Hawk	LOW	0.02	0.02	25	0.02	0.17	23	48
Ruby-Throated Hummingbird	LOW	0.02	0.02	26	0.02	0.13	26	52
Red-Bellied Woodpecker	LOW	0.02	0.02	27	0.02	0.13	26	53
Eastern Screech-Owl	LOW	0.01	0.01	31	0.02	0.16	28	59
House Wren	LOW	0.01	0.02	28	0.01	0.11	29	57
Broad-Winged Hawk	LOW	0.01	0.01	29	0.01	0.10	31	60
Great Horned Owl	LOW	0.01	0.01	30	0.01	0.10	31	61
Tree Swallow	LOW	0.01	0.02	32	0.01	0.15	29	61
Wood Duck	LOW	0.01	0.01	33	0.01	0.09	33	66
Blackburnian Warbler	LOW	0.01	0.01	34	0.01	0.07	34	68
Golden-Crowned Kinglet	LOW	0.00	0.01	35	0.01	0.07	34	69
Blue-Headed Vireo	LOW	0.00	0.01	35	0.01	0.07	34	69
Purple Finch	LOW	0.00	0.01	35	0.01	0.07	34	69
Pine Siskin	LOW	0.00	0.01	38	0.00	0.05	38	76

[1]Proportion of stations where the species was observed
[2]Number of bird/station

Table 8: Suite of species in the forest bird community measure, based on the relative abundance and occupancy rate observed in the Toronto region from 2008-2014.

Guild	Species	Fragmentation sensitivity
Ground nesters	Ovenbird	High
	Song Sparrow	Low
	Veery	High
	Mourning Warbler	Low
Understory nesters	American Robin	Low
	Northern Cardinal	Low
	Wood Thrush	High
	Rose-Breasted Grosbeak	Low
Canopy nesters	Red-Eyed Vireo	High
	Black-Capped Chickadee	Low
	Blue Jay	Low
	Eastern Wood-Pewee	High
	Great Crested Flycatcher	Low
	Hairy Woodpecker	High
	Downy Woodpecker	Low
	American Crow	Low
	Pine Warbler	High
	Scarlet Tanager	High
	Red-Breasted Nuthatch	Low
	Black-Throated Green Warbler	High
	White-Breasted Nuthatch	Low

List of focal birds in the wetland ecosystem

Moral et al. (2011) proposed a wetland bird guild classification based on foraging and nesting habitat zones. This classification include *Diving birds*, i.e. species who forage in deep open water, *Dabbling birds*, i.e. species who forage shallow open water, *Wading birds*, i.e. species dependent on mud flats and shallow emergent zones, and *Emergent-dependent birds*, i.e. species who forage and nest in emergent vegetation. These guilds are likely to regroup most common species found in the RNUP.

The TRCA data set describing the bird community observed in the wetland ecosystem of Toronto Region was not available in time to be analysed as part of this review. Once the database become available, all species observed should be ranked according to the average ± std of occupancy rate and relative abundance observed during the survey. As in the forest bird community measure, the suite of species in the wetland bird community should be representative of the distribution of species in the guilds. The MEI div also recommend to focus on at least 33% of the most common species in each guild.

Preliminary thresholds

During the first 5 years of the monitoring program, the preliminary thresholds for this measure could be established by baseline values from the 2008-2014 survey in the Toronto region area, assuming that these values are representative of the bird community in the RNUP. Over the long term, thresholds could be revised with baseline value specific to the park.

The status of a given bird species will therefore be considered Good, if both metrics, i.e. occupancy rate and relative abundance, are within 1 SD of the baseline (table 9). The status will become Fair if one metric is >±1 SD of baseline, and will become Poor if both metrics are >±1 SD of baseline.

Table 9: Status of a bird species according to the relative abundance and occupancy rate.

Relative abundance	Occupancy rate		
	> -1 SD	± 1 SD	> +1 SD
> -1 SD	Poor	Fair	Poor
± 1 SD	Fair	Good	Fair
> +1 SD	Poor	Fair	Poor

Monitoring questions

The status of the measure will be determined by the proportion of species of each guild that are within ± 1 SD of the baseline. The following monitoring questions are therefore suggested:

1) Was the average relative abundance and occupancy rate of ≥70% of species within ± 1 SD of the baseline during the last 5 years in the forest ecosystem?
2) Was the average relative abundance and occupancy rate of ≥70% of species within ± 1 SD of the baseline during the last 5 years in the wetland ecosystem?

Protocol and sampling design

The methodology based on point count that is currently used to survey bird (TRCA 2011) is appropriate for the proposed measure. Although the measure is centered on guilds of focal species, collecting data on other bird species do not represent a significant cost to the project. These data can also be useful to refine data analysis and interpretation or for other management needs.

Since the measure include habitat fragmentation sensitive species, sampling sites within RNUP should be selected based on the following criteria:

1) Forest patch size: ≥1 ha of interior habitat, i.e. located >100 m from the edge
2) Wetland patch size: ≥2 ha
3) Land Use: Urban vs Rural
4) Road Density: High vs Low, based on the median amount of roads within 1 km^2 neighbourhood
5) Connectivity: High vs Low, based on the median amount of “natural” land cover types (i.e. forest, wetland, hedgerows, etc.) that facilitate bird dispersal throughout a landscape even though it does not represent nesting habitat within 1 km^2 neighbourhood

A total of 19 forest patches and 57 wetland patches meet the criterion of patch size. All forest patches should be sampled with a least one point count site, and multiple sites can be implemented in larger patches. In the latter case, sampling sites should be located at a minimum distance of 250 m to avoid counting the same birds. A similar number of wetland patches should also be sampled. The landscape characteristics (land use, road density and connectivity) do not have to be included in the stratification of the sampling design, but will be considered in the data analysis.

In most national parks, typical bird monitoring projects are based on sample size of 10-20 sites/year. A sample size of 15 sites/year in both ecosystems is therefore suggested, with a rotating panel to cover all the habitat patches selected in the sampling design. A power analysis should be performed using the bird database of the TRCA to determine the detectable rate of change with such sample at a 80% power and confidence levels.

Status and Trends Assessment Method

Status and trends of each species at the scale of RNUP should be analyzed with a Generalized Linear Mixed Model (GLMM). A Poisson Link can be used with Year as the fixed effect variable and Site as a random effect variable. The average value of metrics will be calculated with this model and will be compared to threshold values. A 80% confidence interval around the average value will inform on the level of confidence that the metrics have crossed a threshold. Level of significance and degree of correlation of the fixed effect of Year variable will also inform on the strength of the trend through time. In order to determine if birds are exhibiting different trends within RNUP with respect to Land Use, Road density, or Connectivity, the variables can be added to the GLMM as fixed effect variables. An AIC approach would then be used to see if these factors, either individually or in combination, have an effect on bird abundance. If RNUP eventually invests in restoration efforts to increase the amount of connectivity, then a Before-After-Control-Impact design can be used using this data through the use of Analysis of Co-Variance model on the occurrence and abundance of fragmentation sensitive species.

Once the status of the each species have been established, the status of the measure should be establish using the 70th percentile approach. This approach consist of ordering the species from Good to Poor status, and the status of the measure is determined by the status of the species at the 70th percentile position (see table 10 for examples).

Since the number of species per guild is unbalanced, assessing the status of the measure based on the status of guilds would bias the results toward the guilds with low number of species. Nevertheless, the interpretation of the assessment could be complemented with the status of species within each guild, as well as with the status of fragmentation sensitive species.

Determining the trend in the condition of a composite measure is complex and involves the following steps:

1) For each species, determine if the trend in relative abundance and occupancy is significant at $p<0.2$ over the period of assessment. Trend is generally analyzed with a generalized linear mixed model.
2) Assign a value of -1 or +1 to significant trends if the parameter respectively move away from or approach a Good condition. Assign a value of 0 to trends that are not significant. When a parameter is already in Good condition, any significant trends should be interpreted according to the mid-value of the “two-tailed” thresholds.
3) Sum the value of trends for the two metrics to determine the overall trends of the species. The sum will vary from -2 (high condition decline) to + 2 (high condition improvement). Contradictory trends (-1 vs +1) will cancel each other, and will result as a “no overall trends” for the species.
4) Calculate the average overall trends of all species.

5) The trends of the measure will be judged as "Stable" if the average is between -0.6 and +0.6. If the average is <-0.6, the trends of the measure will be considered as "Declining", and it will be considered as "Improving" if the average is >+0.6.

Table 10: Examples of status assessment of a group of 10 species based on the 70th percentile approach.

Species rank	Case no.1	Case no.2	Case no.3	Case no.4	Case no.5
1	Good	Good	Good	Good	Good
2	Good	Good	Good	Good	Good
3	Good	Good	Good	Good	Good
4	Good	Good	Good	Good	Good
5	Good	Good	Good	Fair	Good
6	Good	Good	Fair	Fair	Good
7	Good	Fair	Fair	Poor	Poor
8	Good	Fair	Poor	Poor	Poor
9	Fair	Fair	Poor	Poor	Poor
10	Fair	Poor	Poor	Poor	Poor
Status	Good	Fair	Fair	Poor	Poor

Estimated cost

Assuming that a team of two technician can survey two sampling sites per day, about 8 person-days per year will be required to complete the data collection in each ecosystem. Another 2 PD/year will be required for data management, and 5 PD to analyse the data every 5 years. Up to $1K per year can be also be allow to cover material and travel expenses (about $0.5 K per year per ecosystem).

Cost will have to be adjusted if audio recording is used instead of direct observation. An expert may also have to be hire to analyse the recordings.

Recommendations

1) A power analysis should be performed using the TRCA bird data base to determine if an acceptable rate of change can be detected with the recommended sample size at 80% power and confidence levels.
2) The patch size criteria used to elaborate the sampling design was arbitrarily selected to keep a minimum number of patches in the statistical population. This is particularly true for the forest ecosystem where the interior habitat availability is limited in the park. Any more restrictive criteria would further reduced the number of patches that can be sampled. We therefore recommend to analyse the data collected by the TRCA in the Toronto Region to determine how patch size influence

to probability of occurrence of the each of the selected focal species for this measure. The sampling design may need to be adapted according to the needs of some focal species.

3) The TRCA wetland bird data base should be analysed to establish a preliminary list of focal birds in each guild.

List of references

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Forest ecosystem measures

Key tree species status

Monitoring Questions

The status of key tree species will be assessed by their mortality and growth rates. The following questions are suggested:

1) Was the annual mortality rate <3% during the last 5 years?
2) Was the growth rate less than 0.5 SD of the baseline during the last 5 years?

Thresholds

1) Annual Mortality Rate

Good	Fair	Poor
<3%	3-5%	>5%

2) Growth Rate

Growth rates (cm^2/yr) are compared with baseline values from data collected in permanent plots by the TRCA:

Poor	Fair	Good	Fair	Poor
- (≥0.8 SD)	- (0.5-0.8 SD)	<0.5 SD	+ (0.5-0.8 SD)	+ (≥0.8 SD)

Sampling frequency

5 years, with the possibility of a rotating panel

Assessment Method

1) For all proposed metrics, the average value will be compared to the thresholds and status will be determined depending on whether a threshold have been crossed or not;
2) Calculating the average value of metrics will require a generalized mixed modelling approach, considering that stems within a given plot are correlated with each other;
3) Generalized mixed models could also be used to determine if the average value change over time, and thus providing a trend assessment for the measure.
4) The status of the measure will be determined by the average status of dominance, mortality rate and growth rate.

Review Summary

4) Five key tree species have been identified based on the main stand types found in the RNUP according to the ecological land classification
5) Two general stand types have been identified for the purpose of the sampling design, and these stand types cover 50% of the natural forest ecosystem in the park.
6) Preliminary thresholds on mortality rate and growth rate were established based on review of similar protocols in national parks.
7) The EMAN protocol implemented by the TRCA is adequate to measure the proposed metrics, and should be continue to be used.
8) Cost of monitoring 20 plots is estimated to 55 PD and $5K over 5 years.

Recommendations:

1) Implement a preliminary sampling design of 20 plots, i.e. 10 plots per general stand type category;
2) Conduct a power analysis once preliminary data have been collected to adjust the sample size if needed;
3) Review the data from the permanent forest plots network implemented by the TRCA to establish thresholds on growth rate, and complement the information with a dendrochronology study within the park.

Detailed review

Rationale of the measure

Dynamics of the plant community is a major ecological aspect of the health of the forest ecosystem in the RNUP. It can be described with characteristics related to key tree species, i.e. tree species that define the stand types according to the ecological land classification (ELC). A total of 67 stand types can be found in the natural forest ecosystem of the RNUP (see Appendix VI), and these stand types have been grouped in 7 general stand type categories (table 11). We recommend focusing on the 2 most common stand types, i.e. Fresh-Moist Mixed, Dry-Fresh Sugar-Maple. These stand types cover a total of 54.4% of the surface area of the forest ecosystem. The list of key species was determined by the name of detailed stand types that cover at least 10% of the surface area within each category of general stand types (table 12; see also Appendix VI).

Table 11: Proportion of surface area of the RNUP covered by major stand types in the natural forest ecosystem.

General stand types	% of surface area in the natural forest ecosystem
Fresh-Moist Mixed	30.4%
Dry-Fresh Sugar-Maple	24.0%
Fresh-Moist Lowland Deciduous	14.0%
Fresh-Moist Sugar-Maple	11.1%
White Cedar, Pine & Hemlock	9.1%
Fresh-Moist Deciduous	8.3%
Dry-Fresh Deciduous Forests	3.1%

The following metrics can be used to describe the evolution of key tree species in the park:

1) Mortality rate, i.e. % of stems in canopy layer that died per year during a 5 year period, complemented with the proportion of live dominant and codominant trees with >50% crown decline
2) Growth rate, i.e. annual increase in diameter (mm/year) of stems in canopy layer over a 5 year period

Preliminary thresholds

1) Annual Mortality rate

Mortality rate of trees is monitored in some national parks (Giroux and Kehler 2006; Cabrera and Sabelli 2010; Patterson 2011; Saunders 2012), and annual mortality rate is expected to be <5% over a 5 year period. We recommend using this level of mortality as the threshold for Poor condition, and set the threshold for Good condition at <3%. The condition will be considered Fair when annual mortality rate is 3-5%.

2) Growth rate

Annual growth rate of key tree species is also monitored in some national park (Giroux and Kehler 2006; O'Grady and McCarthy 2013; Saunders 2012), and this metric is expected to vary within a range a

Table 12: List of key tree species for each general stand type in the RNUP.

General stand types	Detailed stand types	Key species				
		Sugar Maple	Red Oak	Beech	White Cedar	Hemlock
Fresh moist Mixed	Fresh-Moist Sugar Maple - Hemlock Mixed Fresh-Moist White Cedar - Hardwood Mixed Fresh-Moist White Cedar - Sugar Maple Mixed	X			X	X
Dry-Fresh Sugar maple	Dry-Fresh Sugar Maple - Beech Deciduous Dry-Fresh Sugar Maple - Oak Deciduous Dry-Fresh Sugar Maple Deciduous	X	X	X		

variability. Establishing this range will require a detailed analysis of data collected by the TRCA in permanent forest plots in the peripheral area. A dendrochronology study within the park could also provide valuable information for these thresholds. Indeed, historical data and trends on growth rate of trees can be obtained by the analysis of growth rings from tree core, and this methods have been successfully tested in an urban environment (Rogers et al. 2015). For the purpose of this review, the Good to Fair and Fair to Poor thresholds have been defined respectively with 0.5 and 0.8 SD difference below and above the TRCA baseline data.

Monitoring questions

The following questions are suggested, based on the proposed thresholds:

1) Was the annual mortality rate <3% during the last 5 years?
2) Was the growth rate within ±0.5 SD of the baseline during the last 5 years?

Protocol and sampling design

The EMAN protocol implemented by the TRCA is adequate to measure the proposed metrics, and should be continue to be used. Measurements related to DBH and condition of the trees, from seedlings to mature trees, should be kept, while measurements related to coarse woody debris and other plant species are not essential to this measure, and could be dropped. Measurements related to age and height of the trees are information useful for ELC mapping purpose and could be kept. There is currently only one permanent forest plot located within the park, and a minimum sample size of 10 plot per general stand type would be required to start the project (total n=20 plots). Once preliminary data has been collected, a power analysis should be conducted to determine if more or fewer plots are required. A rotating panel design could be used for this project if is more convenient from an operational perspective.

Status and Trends Assessment Method

For all proposed metrics, the average value will be compared to the thresholds and status will be determined depending on whether a threshold have been crossed or not. Calculating the average value of metrics will require a generalized mixed modelling approach, considering that stems within a given plot are correlated with each other. Generalized mixed models could also be used to determine if the average value change over time, and thus providing a trend assessment for the measure. The status of the measure will be determined by the average status of the three metrics, i.e. dominance, mortality rate and growth rate.

Cost estimation

Assuming that a team of 2 persons can survey 1 plot per day, and a rotating panel of 5 years (4 plots per year), the data collection will require 8 PD/year, and a total of 40 PD over 5 years. Data management may require up to 2 PD/year (10 PD over 5 years), and data analysis would require about 5 PD during a 5 year period. Cost for travel and material will likely be a maximum of $1K/year.

Recommendations

1) Implement a preliminary sampling design of 20 plots, i.e. 10 plots per general stand type category;

2) Conduct a power analysis once preliminary data have been collected to adjust the sample size if needed;

3) Review the data from the permanent forest plots network implemented by the TRCA to establish thresholds on growth rate, and complement the information with a dendrochronology study within the park.

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Saunders, D. 2012. Tree Health Monitoring Protocol Forest Permanent Sampling Plots (PSP) - Kouchibouguac National Park. Internal document (http://intranet/apps/ice/DownloadFile.aspx?id=3500&t=ICE_protocol)

Deer browsing

Monitoring Questions

The deer browsing measure can be based on two possible metrics, i.e. the Annual Growth Browse Rate (AGBR) and White Trillium Maximum Height to Leaf (WTMHL). The monitoring question of each metric could be the following:

1) "Was the average Annual Growth Browse Rate ≥60% during the last 5 years?"
2) "Was the average White Trillium Maximum Height to Leaf ≥190 mm during the last 5 years?"

Interim Thresholds

1) Annual Growth Browse Rate:

Good	Fair	Poor
≤60%	61%-80%	>80%

2) White Trillium Maximum Height to Leaf:

Poor	Fair	Good
≤150 mm	150-190 mm	≥190 mm

Sampling frequency

5 years

Measurements for both metrics could be achieved with a rotating panel design.

Status & Trends Assessment Method

1) For both proposed metrics, the average value will be compared to the thresholds and status will be determined depending on whether a threshold have been crossed or not;
2) Calculating the average value of both metrics will require a generalized mixed modelling approach, considering that stems within a given site, plot or patches are correlated with each other;
3) Generalized mixed models could also be used to determine if the average value change over time, and thus providing a trend assessment for the measure.

Review Summary

1) Deer population density can reach very high level in southern Ontario and cause major change in the composition and structure of vegetation communities. The white-tailed deer is a common species in the RNUP and play a significant role as a major browser in the forest and farmland ecosystem;
2) Two possible metrics can be used to monitor deer browsing, i.e. the Annual Growth Browse Rate (AGBR) and White Trillium Maximum Height to Leaf (WTMHL);
3) Thresholds have been proposed for both metrics based on various studies in southern Ontario;
4) The AGBR protocol would probably require a sample size of 4 plots per habitat type and 12 stems/plot (n=48 stems per habitat type) to meet the statistical power standard of the monitoring program. Up to 4 habitat types can be included in the sampling design.
5) A sample of 5-10 sites with n=25 stems/site would provide a representative and precise estimate of the mean WTMHL in RUNP. This sample size will also probably meet the statistical power standard of the monitoring program.
6) The AGBR measure would require 80 PD and $5K over 5 years. In comparison, the WTMLH measure would require 35 PD and $5K over 5 years

Recommendations:

1) If enough resources is available in the park, we recommend to implement the AGBR protocol as the measure obtained with this protocol will be more comprehensive and more directly linked to effect of deer browsing at the plant community level;
2) If resource is limited, we recommend to implement a WTMHL protocol, based on the protocol developed by Cabrera and Donley (2013). A preliminary survey of 5 sites in spring 2016 would provide data that could help refine the protocol and sampling design.

Detailed review

Rationale and potential metrics for a deer browsing measure

Deer population density can reach very high level in southern Ontario and cause major change in the composition and structure of vegetation communities (Koh et al. 2010; Cabrera and Donley 2013; Filazzola et al. 2014). The white-tailed deer is a common species in the RNUP and play a significant role as a major browser in the forest and farmland ecosystem. Deer management is a major issue the RNUP, and deer browsing monitoring is therefore essential to facilitate decision-making.

The Toronto and Region Conservation Authority (TRCA) have conducted a deer browse survey in 2008-09 which provided information on the Annual Growth Browse Rate (AGBR). This method is commonly used in Ontario to assess the level of use of the winter browse (Broadfoot et al. 1996).

Another approach developed in southern Ontario is based on the White Trillium Maximum Height to Leaf (WTMHL; Koh et al. 1996; 2010; Bazely et al. 1997). A protocol based on this approach was developed in Pointe-Pelee NP (Cabrera and Donley 2013).

Preliminary Thresholds

1) Annual Growth Browse Rate

Deer density is assumed to have reach the carrying capacity of the winter habitat when the AGBR is >60% (Broadfoot et al. 1996). For the purpose of the monitoring program, the condition of the measure will therefore be considered Good when the CABR is ≤60% (table 13). In areas with high deer density, deer browsing can be so high that overall winter browse availability can become very limited (Bazely et al. 1997). The Status Poor status threshold have therefore been set arbitrarily at 80% (table 13). No lower Good or Poor threshold have been proposed, assuming that low deer population is not an issue in the RNUP.

Table 13: Preliminary thresholds proposed for the Annual Growth Browse Rate.

Good	Fair	Poor
≤60%	61%-80%	>80%

2) White Trillium Maximum Height to Leaf

White Trillium is a preferred food plant species by deer, and Koh et al. (2010) have found that trillium height is correlated to deer density in Southern Ontario. Therefore monitoring change in trillium height can be used as an early-warning signal of high deer density issue, as well as to track change in the deer population (Cabrera and Donley 2013). The relationship between trillium height and deer density in Southern Ontario can be described by the following model (Koh *et al*. 2010):

$$Density = \frac{1590.0}{35.03 + e^{0.0254 \times H}}$$

Where *H* is the average maximum height to leaf measured in sampling plots.

Crop damage and high vehicle collision rates starts to occur at deer density ranging from 5 to 15 deer/km², while impacts on forest regeneration can be observed when the density reach 10 deer/km², and become severe when density reach 20 deer/km² (OMNR 2008). The preliminary thresholds for this metrics could be set to the trillium height corresponding to a density of ≤10 deer/km² and ≥20 deer/km², i.e. ≥190 mm and ≤150 mm for Good and Poor status respectively (figure 2). In comparison, the thresholds for Good and Poor EI condition in Pointe Pelee NP were set to ≥221 mm and ≤172 mm, which correspond to density of 5.2 and 14 deer/km² respectively (Cabrera and Donley 2013).

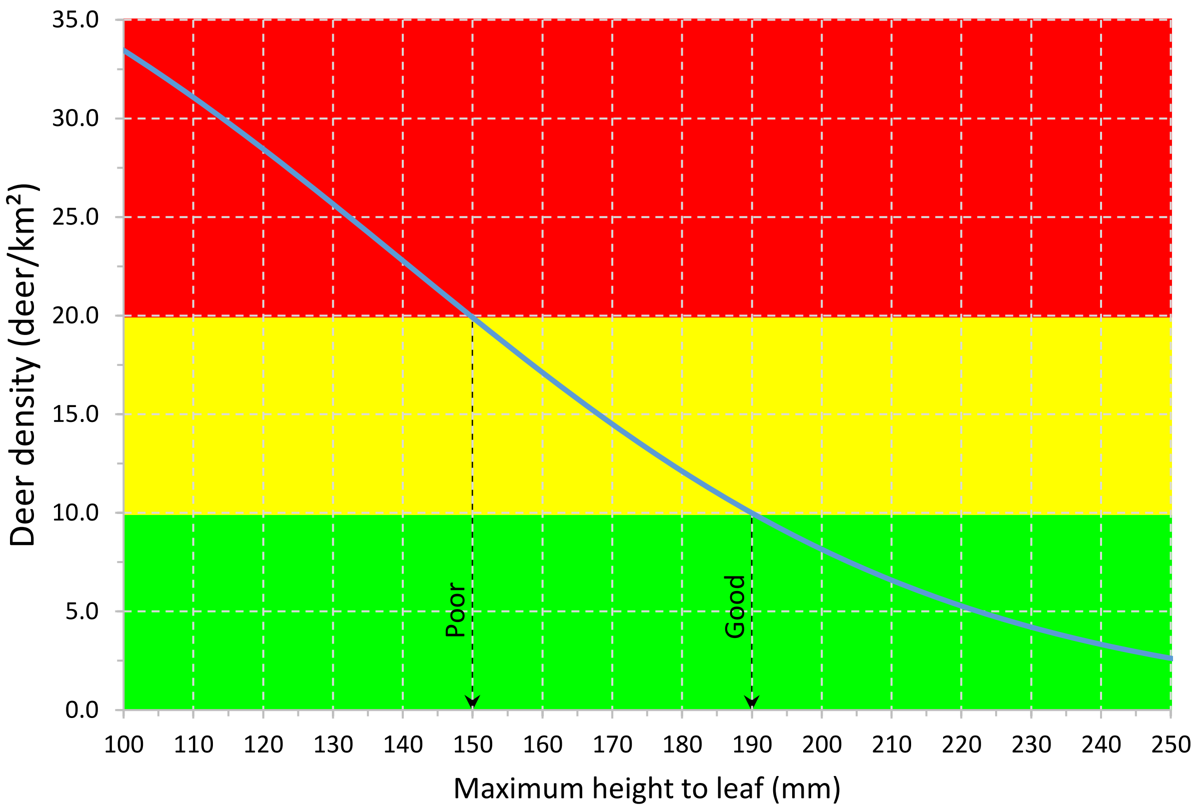

Figure 2: Relationship between deer density and maximum height to leaf of White Trillium in Southern Ontario (source: Koh et al. 2010). The arrows indicate Good and Poor status thresholds of the trillium height metric according to deer density.

Monitoring questions

The following questions are proposed for the two different metrics that can be used to measure deer browsing:

1) "Was the average Annual Growth Browse Rate ≥60% during the last 5 years?"

2) "Was the average White Trillium Maximum Height to Leaf ≥190 mm during the last 5 years?"

Protocol and sampling design

A rotating panel sampling design over a 5 year period could be used for both metrics, as the average annual value is not likely to vary much between years.

1) Annual Growth Browse Rate

The AGBR survey involve two field visits of each sampling plot, i.e. during fall and during the following spring (Broadfoot and Voigt 1996). In each visit the average annual growth/stem is estimated, and the difference between the two visits determine the browse rate.

The habitat is stratified in broad categories based on composition and canopy closure of forest stands. The survey conducted in 2008-09 in the RNUP included 4 habitat types with 8 plots each, for a total of n=32. Up to 20 stems can be sampled is each plot, which provide a sample of up to 160 stems in each habitat type. The annual growth of a total of 1195 stems was measured during the 2008-09 survey, i.e. 620 stems in fall and 575 stems in spring. This sampling design generated a large amount of data, and since the minimum detectable difference required for this measure is relatively high (60% decline in average annual growth between fall and spring), the statistical power obtained with this sample design probably exceed the standard of the program (80% power at 80% confidence level). A preliminary power analysis was performed with G*Power 3.1 software (Faul et al 2009) assuming that a one-tailed paired sample T-test could be used to compare the average annual growth between fall and spring in a given habitat type. Required sample size to detect a significant difference depends on the desired minimum detectable difference and the variability of the data. The mean and standard deviation of the annual growth measured in 2008-09 was 0.278 ± 0.571 g in fall and 0.255 ± 0.731 g in spring. Detecting a 60% difference at 80% power and confidence levels would require a sample size of 46 stems (Mean ± std: H0 = 0.278 ± 0.571 vs H1 = 0.111 ± 0.731; 0.5 correlation factor assumed). Therefore, the sample size could be reduced to 4 plots per habitat type (total n=16 plots) and 12 stems/plot, which would provide a total of 48 stems. This sample would probably provide enough statistical power to meet the program standard.

The current protocol focus on measuring the annual growth of a sub-sample of stems in sub-plots. A relevant complementary information would be to determine the density of stems providing available browse in the subplots. This can be done by noting the number of stems that provide browse within 1.5 m around the center of the sub-plot. Tracking change in the availability of browse will be useful to help interpreting trends in the deer browsing pressure (Bazely et al. 1997)

2) Trillium Maximum Leaf Height

White trillium is usually surveyed by using transects or plots (Koh et al. 2010; Cabrera and Donley 2013). However, distribution of trilliums can be patchy in some areas, so the plant may be efficiently sample with a randomized or systematic design. So patches of trillium could be localised by crossing suitable habitat (Maple-Ash-Beech stands) in transects and individual plants within patches could be sampled. For the purpose of the review, a preliminary power analysis was performed assuming that the observed mean of Trillium height can be compared to the thresholds with a one-tailed one sample T-test. The standard deviation of Trillium height measured in various area in southern Ontario is about ±20-22 mm according to Koh et al. (2010). Detecting a 5% difference in a given site at 80% power and confidence levels would only require a sample size of 18 stems for the Good status threshold (Mean H0 = 181 mm vs mean H1 = 190 mm; Std = ±22 mm) and a sample size of 29 stems for the Poor status threshold (Mean H0 = 143 mm vs mean H1 = 150 mm; Std = ±22 mm). A sample of 5-10 sites with n=25 stems/site will likely provide a representative and precise estimate of the mean WTMHL in RUNP. If the distribution of Trillium is relatively patchy in the sampled sites, up to 5-10 stems per patch could be measured, so 3-5 patches would be required to complete the sample.

Status and Trends Assessment Method

For both proposed metrics, the average value will be compared to the thresholds, and status will be determined depending on whether or not a threshold have been crossed. Calculating the average value of both metrics will require a generalized mixed modelling approach, considering that stems within a given site, plot or patches are correlated with each other. These models could also be used to determine if the average value is similar between the sites or habitat type. A 80% confidence interval around the average value could be calculated with these model, to inform about the confidence that the thresholds have been crossed or not. These models could also be used to determine if the average value change over time, and thus providing a trend assessment for the measure.

Cost estimate

The data collection of AGBR (2 field visits/plot/year) will require about 65 PD over a 5 year period, assuming that a team of 2 persons can survey 1 plot/day, and a rotating panel of 5 years (3-4 plots/year). In comparison, the data collection of WTMHL will require 20 PD over 5 year, assuming that a team of 2 persons can survey 1 site/day, a total sample size of 10 sites, and a rotating panel of 5 years.

For both metrics, data management may require up to 2 PD/year (10 PD over 5 years), and data analysis would require about 5 PD during a 5 year period. Cost for travel and material will likely be a maximum of $1K/year.

Recommendations

The AGBR protocol is more time-consuming than the WTMHL protocol, as 2 field visits of the same sites are needed to complete the sampling, and a larger number of sites is required to meet the program standards on statistical power. However, the AGBR protocol have been successfully tested and proven throughout Ontario by the provincial department of natural resources. Results obtained from this protocol in the RNUP could be therefore compared to results obtained elsewhere in Southern Ontario. The Trillium Maximum Leaf Height protocol have not been used yet to monitor long term trends in deer browsing. Nonetheless, in both case, enough information is available to set relatively solid interim thresholds for interpretation.

If enough resources is available in the park, we recommend to implement the AGBR protocol as the measure obtained with this protocol will be more comprehensive and more directly linked to effect of deer browsing at the plant community level. Indeed, in addition to the AGBR, other ancillary data are collected such as the proportion of stems browsed by plant species, and eventually the density of stems available to browsing. These information are valuable to facilitate the interpretation of the data.

If resource is limited, we recommend to implement a Trillium Maximum Leaf Height protocol, based on the protocol developed by Cabrera and Donley (2013). A preliminary survey of 5 sites in spring 2016 would provide data that could help refine the protocol and sampling design.

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Wetland indicator measure

Amphibian community

Proposed Monitoring Metric

Two-year moving average in proportion of areas occupied (PAO) in 6 amphibian species.

Proposed Monitoring Question

"Has the two year moving average in proportion of areas occupied (PAO) changed by >2 SD for ≥3 of 6 amphibian species in RNUP over a 10 year period?"

Threshold

Poor	Fair	Good	Fair	Poor
- (≥3 SD)	- (2-3 SD)	<2 SD of Baseline	+ (2-3 SD)	+ (≥3 SD)

Frequency

Annual

Assessment Method

<u>Status</u>: Direct comparison of species-specific two-year moving average in PAO to thresholds. A change in status occurs when a minimum of 3 in 6 species tracked by this measure cross a threshold.

<u>Trend</u>: Species-specific trend analysis using generalized linear mixed model (GLMM) with PAO as the response variable, Year as the fixed effect and Detection Probability as the random effect. A change in trend occurs when a minimum of 3 in 6 species show a significant trend *(P=0.2)* in the same direction.

Review Summary

1) This is a new measure for RNUP that is derived from existing FrogWatch monitoring. Overall this has the potential to become a strong measure for the assessment of ecosystem health as frogs are easy to monitor, are sensitive to a range of stressors, and possess standardized monitoring protocols that have been adopted by many agencies throughout the region.
2) The monitoring metric used by RNUP for FrogWatch monitoring since 2009 has been an ordinal scale based on visual inspection and chorus call intensity. MEI recommends the metric be changed to PAO as previous FrogWatch experience has concluded that the ordinal scale is insensitive to meaningful changes in frog abundance.
3) The number of FrogWatch sites monitored by RNUP since 2009 has been inconsistent every year ranging from 15 sites sampled in 2014 to 30 sites sampled in 2013. Variable sampling effort can confound trend analyses and reduce the value of monitoring information. Recommendations are provided on sampling effort (see Power Analysis).

Recommendation:

1) Adopt a monitoring metric based on a two-year moving average in PAO for the 6 amphibian species.
2) Adopt a monitoring question that incorporates the proposed metric and thresholds. A change in status or trend would occur based on the majority (3 of 6 species) of results. If no majority then the measure is stable.

3) Adopt initial thresholds based on 2sd and 3sd from baseline conditions. Baseline conditions should be derived from existing FrogWatch monitoring data that has been collected since 2009.
4) Adopt a trend assessment method that uses a GLMM that incorporates both PAO and Detection Probability.
5) Standardize a monitoring effort that consistently samples 20 wetland complexes every year. This is consistent with existing levels of effort and should be operationally sustainable.
6) Adjust the existing FrogWatch sampling design to reduce variability and improve representivity of large wetland complexes that occur in a range of Matrix Quality and Connectivity conditions.
7) Improve the data management for this measure such that all monitoring data is saved in a single flat file with PAO and Detection Probability included per species per year.

Review of RNUP's Existing Amphibian Community Monitoring Program

Table 14 summarizes available FrogWatch data collected by RNUP during a 6 year period between 2009 and 2014. These data recorded an index of relative abundance in these species as follows:

1. No frogs or toads seen or heard
2. Frog(s) or toad(s) seen but not heard
3. Individuals can be counted, calls not overlapping
4. Some individuals can be counted, other calls overlapping
5. Full chorus, calls continuous and overlapping.

These values were aggregated into "presence/not detected" values per species per site per year and used to calculate proportion of areas occupied (PAO -see Monitoring Metric). A total of 10 species have been observed during this time. Of these 10 species, four of them (bullfrog, chorus frog, mink frog, and pickerel frog) occur within the region very rarely and are not found consistently enough to represent useful species for monitoring purposes. Between 2009 to 2014 the monitoring effort has been inconsistent with a minimum of 15 sites monitored in 2014 and a maximum of 30 sites monitored in 2013.

Figure 3 displays the trends in PAO for the 6 species adequately tracked within the RNUP FrogWatch database. Using R3.2.0 a generalized linear model (GLM) was applied in order to determine if any of these trends are significantly different from zero (table 15; Note: a mixed model with a Site effect was not conducted because the sites sampled over time were inconsistent). Overall, <u>the trends in PAO for all species have been stable</u> (all P values > 0.2) with Year estimates close to zero with relatively large standard errors.

Table 14: Proportion of areas occupied (PAO) by amphibians monitored in RNUP between 2009 and 2014. Detection probability rates are shown in parentheses.

species	2009	2010	2011	2012	2013	2014	mean	sd	Sd trimmed*
American Toad	0.56 (0.22)	0.33 (0.15)	0.62 (0.22)	0.15 (0.05)	0.20 (0.07)	0.40 (0.18)	0.38	0.19	0.15
Bullfrog	*0.06 (0.02)*	*0.00 (0.00)*	*0.00 (0.00)*	*0.00 (0.00)*	*0.00 (0.00)*	*0.00 (0.00)*	*0.01*	*0.02*	*N/A*
Chorus Frog	*0.00 (0.00)*	*0.00 (0.00)*	*0.00 (0.00)*	*0.00 (0.00)*	*0.00 (0.00)*	*0.00 (0.00)*	*0.00*	*0.00*	*N/A*
Gray Tree Frog	0.72 (0.41)	0.54 (0.19)	0.50 (0.26)	0.38 (0.17)	0.63 (0.27)	0.80 (0.44)	0.60	0.15	0.10
Green Frog	0.61 (0.31)	0.58 (0.21)	0.54 (0.18)	0.58 (0.26)	0.57 (0.30)	0.73 (0.36)	0.60	0.07	0.02
Leopard Frog	0.17 (0.06)	0.25 (0.08)	0.23 (0.09)	0.15 (0.06)	0.17 (0.06)	0.13 (0.04)	0.18	0.05	0.03
Mink Frog	*0.06 (0.04)*	*0.00 (0.00)*	*0.00 (0.00)*	*0.00 (0.00)*	*0.00 (0.00)*	*0.00 (0.00)*	*0.01*	*0.02*	*N/A*
Pickerel Frog	*0.06 (0.02)*	*0.00 (0.00)*	*0.00 (0.00)*	*0.00 (0.00)*	*0.00 (0.00)*	*0.00 (0.00)*	*0.01*	*0.02*	*N/A*
Spring Peeper	0.17 (0.06)	0.17 (0.08)	0.35 (0.13)	0.08 (0.03)	0.07 (0.03)	0.13 (0.07)	0.16	0.10	0.04
Wood Frog	0.67 (0.22)	0.21 (0.07)	0.15 (0.05)	0.08 (0.03)	0.13 (0.04)	0.13 (0.04)	0.23	0.22	0.04
#sites monitored	18	24	26	26	30	15			

*Sd trimmed is the temporal standard deviation in PAO with the highest and lowest values removed.

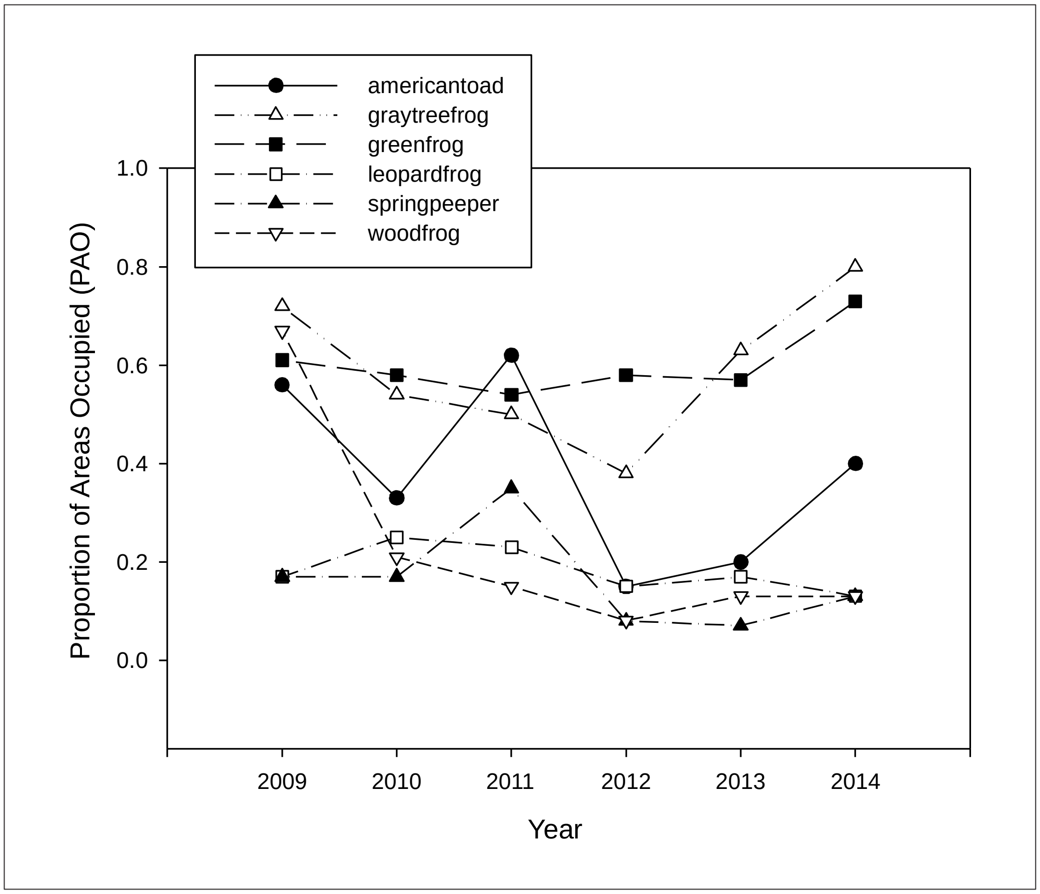


Figure 3: Trends in proportion of areas occupied in 6 amphibian species in RNUP between 2009 to 2014.

Table 15: Trend analysis, controlling for varying detectability, in PAO for 6 species between 2009 to 2014.

```
> z1<-by(data, data$species, function(x) summary(glm(formula=pao ~ year +detectability,
family=binomial(logit), data=x)))
> sapply(z1,coef)

$americantoad
                 Estimate      Std. Error      z value      Pr(>|z|)
(Intercept)    28.2366720   1101.69783     0.0256301   0.9795523
year           -0.0151989    0.5472098    -0.0277753   0.9778414
detectability  11.7459630   16.1568384     0.7269964   0.4672282

$graytreefrog
                 Estimate      Std. Error      z value      Pr(>|z|)
(Intercept)    -56.920241    1083.6279     -0.0525275   0.9581084
year            0.02770809   0.5388569     0.0514201   0.9589908
detectability   5.53959055   8.9370594     0.6198449   0.5353599

$greenfrog
                 Estimate      Std. Error      z value      Pr(>|z|)
(Intercept)    -43.231337    1130.10605    -0.038254   0.9694850
year            0.0212844    0.5627986     0.037819   0.9698321
detectability   3.0913901    15.5652572    0.198608   0.8425691

$leopardfrog
                 Estimate      Std. Error      z value      Pr(>|z|)
(Intercept)    46.354626     1548.13340    0.029942   0.9761131
year           -0.0242864    0.7683317    -0.031609   0.9747836
detectability  15.090344     78.075215     0.1932796  0.8467400

$springpeeper
                 Estimate      Std. Error      z value      Pr(>|z|)
(Intercept)    162.419638    1451.14803    0.111925   0.9108829
year           -0.08220916   0.7212944    -0.113975   0.9092580
detectability  17.3792966    32.610468     0.532936   0.5940778

$woodfrog
                 Estimate      Std. Error      z value      Pr(>|z|)
(Intercept)    56.0199046    2052.08123    0.0272991  0.9782212
year           -0.02908529   1.019543     -0.028528   0.9772412
detectability  14.288636     23.23755      0.6148943  0.5386245
```

Monitoring Metric

Proposed Monitoring Metric: Two-year moving average in proportion of areas occupied (PAO) in 6 amphibian species.

This proposed monitoring metric has 3 important components: two-year moving average, proportion of areas occupied, and 6 amphibian species. A two-year moving average is recommended in order to reduce the number of "false alarms" reported. Data outliers are common in monitoring due to extraneous factors such as recent weather, wind noise, varying observers, etc. The FrogWatch protocol is known to be sensitive to these factors. By focusing the monitoring metric to a two-year average the potential impact on these extraneous factors is substantially reduced.

The frog chorus call intensity/visual inspection code (1 to 5 code) used in the FrogWatch protocol is recommended to be dropped in favour of proportion of areas occupied (PAO). Weaknesses in the FrogWatch code have been identified by a range of agencies in that changes in the code do not necessarily reflect a change in relative abundance but rather a change in detectability. By aggregating this code into "presence/not detected" a PAO metric can be used which has a much greater support in the literature in terms of being a useful surrogate for population abundance (MacKenize et al, 2006). Through the use of a PAO approach the 3 repeat visits per year as identified in the FrogWatch protocol can be directly used to estimate detection probability for each species across years. Variation in detectability can then be explicitly incorporated in trend analyses and improve the interpretation of monitoring results.

It is recommended that this measure focus on only 6 species: American toad, gray treefrog, green frog, leopard frog, spring peeper, and wood frog. Other frogs found within the RNUP database (bullfrog, chorus frog, mink frog, pickerel frog) occur too rarely to have sufficient counts to accurately track trends over time.

Monitoring Question

Proposed Monitoring Question: Has the two year moving average in proportion of areas occupied (PAO) changed by more than two standard deviations for 3 (or more) of 6 amphibian species in RNUP over a 10 year period?

This updated monitoring question incorporates the recommended new metric of a two-year average in PAO for the 6 most prevalent amphibian species found within the RNUP FrogWatch database. It also makes reference to "two standard deviations" which is discussed under Thresholds. The recommended monitoring question also makes reference to changes in a minimum of 3 out of 6 species. This refers to a simple "logic rule" in that the majority of the 6 species must be consistent with respect to its status or trend before the status or trend of the overall measure is changed.

Threshold

Poor	Fair	Good	Fair	Poor
- (≥3 SD)	- (2-3 SD)	<2 SD of Baseline	+ (2-3 SD)	+ (≥3 SD)

The recommended threshold for this measure is bi-directional (2-tailed). It is based on a standard change detection method that is common for many monitoring measures in national parks across Canada. Whether this approach is applied to a national park with an emphasis on ecological integrity, a NMCA with a focus on ecosystem sustainability, or a national urban park with a focus on ecosystem health, the logic is appropriate. The difference in these cases is the conditions that represent an appropriate "reference condition". A reference condition should be representative, stable, and represent a status that is desirable and consistent with management plan goals. For RNUP the reference condition is derived from FrogWatch monitoring sites that are distributed throughout the park and represent a range of rural and urban landscapes (not natural, wilderness conditions as per an appropriate reference condition in a national park). The reference period is from 2009 to 2014 which consists of the entire baseline time series of available data. During this time PAO for all species has been stable and not shown to be deviating from the baseline mean condition. Following this approach the recommended initial thresholds for this measure are presented in table 16.

Current amphibian community condition is assumed to be an appropriate baseline because the measure is stable and represents wetlands at the time when Rouge National Urban Park is designated. The current status of this measure, therefore, is Good (Green).

Table 16: Threshold values for the of the Amphibian community measure.

	Poor	Fair	Good	Fair	Poor
Species	T1	T2	T3	T4	
American toad	0.00	0.00	0.75	0.94	
Gray treefrog	0.14	0.29	0.90	1.00	
Green frog	0.40	0.47	0.74	0.80	
Leopard frog	0.04	0.09	0.28	0.32	
Spring peeper	0.00	0.00	0.37	0.47	
Wood frog	0.00	0.00	0.67	0.89	

An issue with this approach is that the baseline standard deviation is large enough in some cases to cause some thresholds to cross the bounds of the measure (ie, less than 0% or greater than 100%). As a consequence T1 and T2 are the same value for some species. The issue of coefficient of variation (magnitude of standard deviation relative to the mean) is discussed in the Power Analysis and Sampling Design sections. Suggestions to amending the sampling design of this measure are provided that will hopefully reduce the coefficient of variation and solve this problem of overlapping thresholds.

<u>Assessment Method</u>

Status: Direct comparison of species-specific two-year moving average in PAO to thresholds. A change in status occurs when a minimum of 3 in 6 species tracked by this measure cross a threshold.

Trend: Species-specific trend analysis using generalized linear mixed model (GLMM) with PAO as the response variable, Year as the fixed effect and Detection Probability as the random effect. A *change in trend occurs when a minimum of 3 in 6 species show a significant trend (P=0.2) in the same direction.*

The assessment method for Status is straightforward once thresholds are established. The two-year average in PAO for each species is directly compared to threshold values and the corresponding status is assigned.

The recommended assessment method for Trend is slightly more complicated and involves statistical analysis (although the statistical analysis method is common and implemented using R3.2.0). Separate trend analyses are conducted for each species (however, since the analysis method is the same for each species all trend analyses can be implemented simultaneously using the *by()* and *sapply()* commands in R). The trend model involves a generalized linear mixed model where PAO is the response variable, Year is the fixed effect variable, and Detection Probability is a random effect variable. Examples of this output are in Table 17. Slopes from the trend models from each species are categorized as follows: significantly increasing, significantly decreasing, not significantly different from zero. The number of species in each of these three categories is tabulated. If 3 or more of the 6 species are significant increasing or decreasing then this trend category is assigned to the measure. Others results are given a trend assessment of "Stable". Through this approach variation in detection probability can be explicitly incorporated into the assessment of the measure which will substantially improve the quality of information.

Variable detection probability is a major concern in any wildlife monitoring program. Probability of detection can vary over time in ways not related to population abundance. Therefore it is difficult to determine if a trend is due to wildlife decline or simply to a change in detectability. This monitoring measure explicitly quantifies detection probability and uses this information in its trend assessment method. This is a significant strength of this monitoring measure.

Power Analysis

Baseline FrogWatch data collected in RNUP was used to guide a power analysis based on a simple linear regression. A mixed model was not used in this case because insufficient data was available (ie, inconsistent Site data). As a consequence this power analysis is conservative and listed required sample sizes will be an overestimate (ie, smaller percent changes should be detectable for a given sample size). These power analyses were all conducted using PASS12.0.5 with a 80% confidence level and 80% power. A summary of results from the power analysis is shown in table 17. Specific effect sizes are highlighted in green in table 17 for an annual sample size of around 20 sites. This value is highlighted because, based on previous effort, it represents a level of investment that should be sustainable for RNUP. With a monitoring effort of around 20 sites per year for this measure the detectable effect sizes with 80% confidence/power are:

- 50% for American Toad
- 20% for Gray Tree Frog
- 5% for Green Frog
- 25% for Leopard Frog
- 35% for Spring Peeper
- 25% for Wood Frog

Table 17: Estimated annual sample size needed to detect various percent change in PAO for 6 species of amphibian in RNUP. Cells highlighted in Green estimate the detectable annual percent change for a sample size of approximately 20 sites per year.

	Percent Change												
Species	5%	10%	15%	20%	25%	30%	35%	40%	45%	50%	Mean	sd(Y)	CV
American Toad	2806	701	312	180	114	79	58	44	35	28	0.38	0.15	0.39
Gray Tree Frog	500	125	57	32	20	14	10	8	6	5	0.60	0.10	0.17
Green Frog	20	5	2	1	1	1	1	1	1	1	0.60	0.02	0.03
Leopard Frog	500	125	51	29	19	13	10	7	6	5	0.18	0.03	0.17
Spring Peeper	1125	281	125	70	45	30	22	17	13	11	0.16	0.04	0.25
Wood Frog	595	136	62	34	22	15	11	8	7	5	0.23	0.04	0.17

The coefficient of variation (CV) is the largest determining factor on how precise the detectable magnitude of change for each species can be. When CV is low (ie, 0.03 for green frog) the effect size is small (ie, 5% for green frog) and the monitoring program is very precise. When CV is high (ie, 0.39 for American toad) the effect size is large (ie, 50% for American toad for an annual sample size of 28) and the monitoring program is very imprecise. To maximize the cost effectiveness of RNUP's monitoring program, therefore, thought should be given to strategies to reducing the CV for each species considered part of the park's long term condition monitoring program. (Note: It is normal that information quality in a monitoring program is variable across species. No one design can be equally efficient for all species). Reducing CV is typically achieved through adjustments to the monitoring protocol and/or sampling design. Since the FrogWatch protocol is a standardized method used by many agencies throughout Canada we do not adjusting the protocol, therefore, we suggest adjustments to the sampling design (see Sampling Design). With refinements to the sampling design an annual investment of monitoring 20 sites per year should provide sufficient power to detect meaningful changes in amphibian PAO throughout RNUP. An exception may be American toad. If changes to the sampling design is not successful in reducing the effect size for American toad from 50% to 25% then the park should consider removing this species from this monitoring measure.

Sampling Design

Figure 4 displays the location of 29 FrogWatch monitoring sites found within RNUP. While these sites are generally well distributed across the entire park the majority are clustered around the central-lower portion of the park. Also several sites do not reside within wetland complexes as identified by the park's ELC (Ecological Land Classification) database but rather along roadsides and drainages. As a consequence the existing FrogWatch sampling design may not adequately represent large, important wetlands across all regions of the park. In addition, the variety of sites that represent roadsides, drainages, small isolated wetland patches, and larger well-connected wetland complexes may contribute to the variability found within the existing FrogWatch database. This increased variability will reduce statistical power for trend analyses (see Power Analysis) and may bias monitoring thresholds.

Figure 5 shows a hypothetical sampling design that may be preferred for this measure. This sampling design has the following attributes:

- Target wetlands represent large wetland complexes (ie, treed swamps, typha marsh, open aquatic marsh) over 2ha within RNUP (57 occur within the park). This eliminates small roadside and drainage areas from the design.
- Road density, representing Matrix Quality, and amount of adjacent natural land cover, representing potential Connectivity habitat, were quantified (not shown but available from Paul Zorn, MEI).
- A two-stage stratified random sampling design was implemented whereby 20 wetland complexes were selected and 1 random location per wetland was generated.
- The resulting 20 locations represent the full gradient of neighbouring road density and adjacent natural connectivity habitat at the scale of the park. This allows the park to detect any potential response in the amphibian community to issues pertaining to Matrix Quality and Connectivity.
- The 20 locations are also spatially dispersed across the whole park providing full representivity of conditions found throughout the landscape.

MEI does not recommend adopting the sampling design in figure 5 as is because it is important to retain existing FrogWatch monitoring sites (particularly those existing sites that are located in relatively large wetland complexes) where appropriate. Rather we recommend comparing the existing FrogWatch sites to those identified in figure 5. FrogWatch sites that overlap with target wetlands should be retained. Those that do not represent target wetlands could be candidates for removal (particularly if PAO in these sites has been low since 2009) and replaced by selected sites from figure 5.

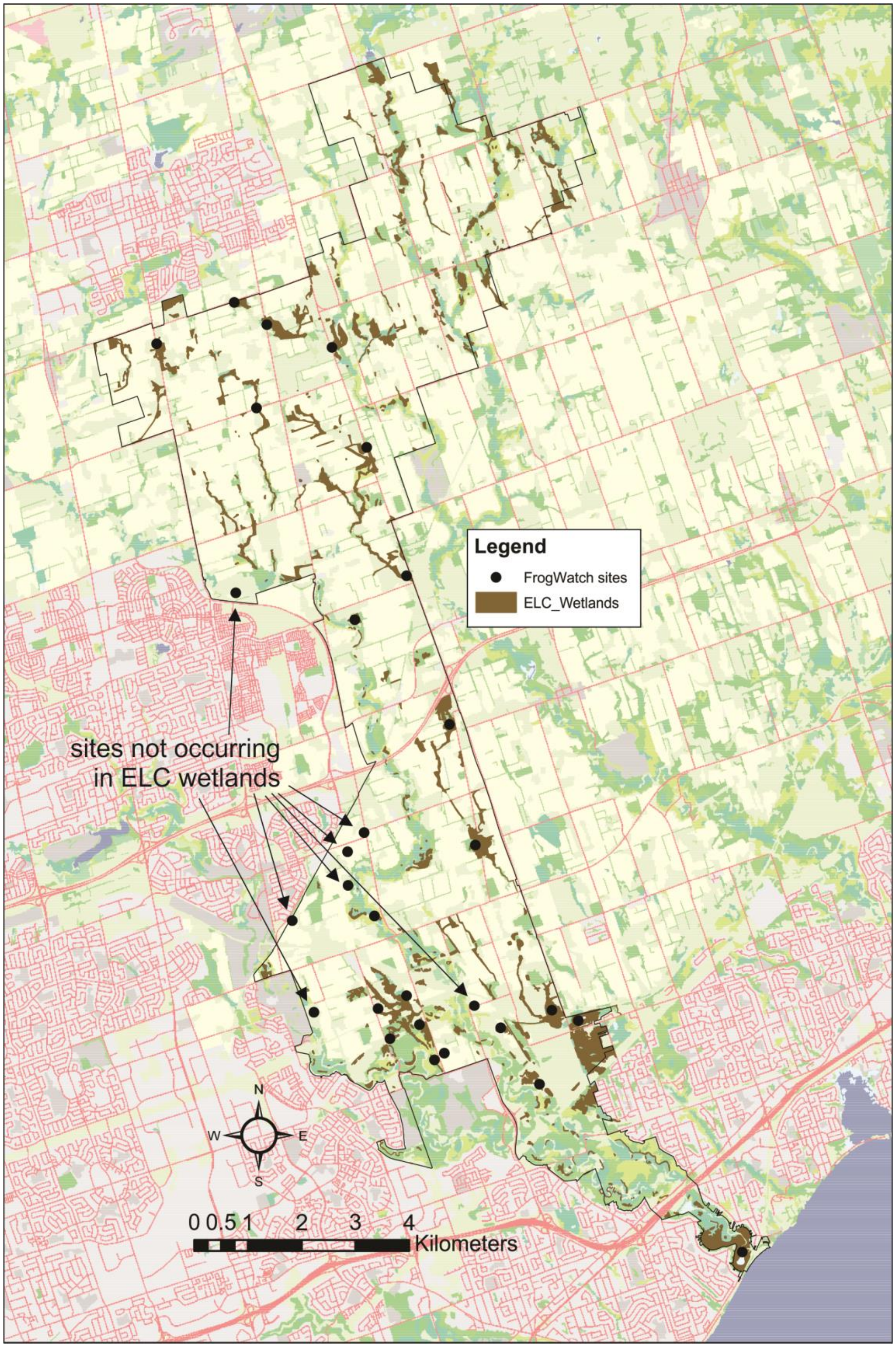


Figure 4 Location of existing FrogWatch monitoring sites in RNUP.

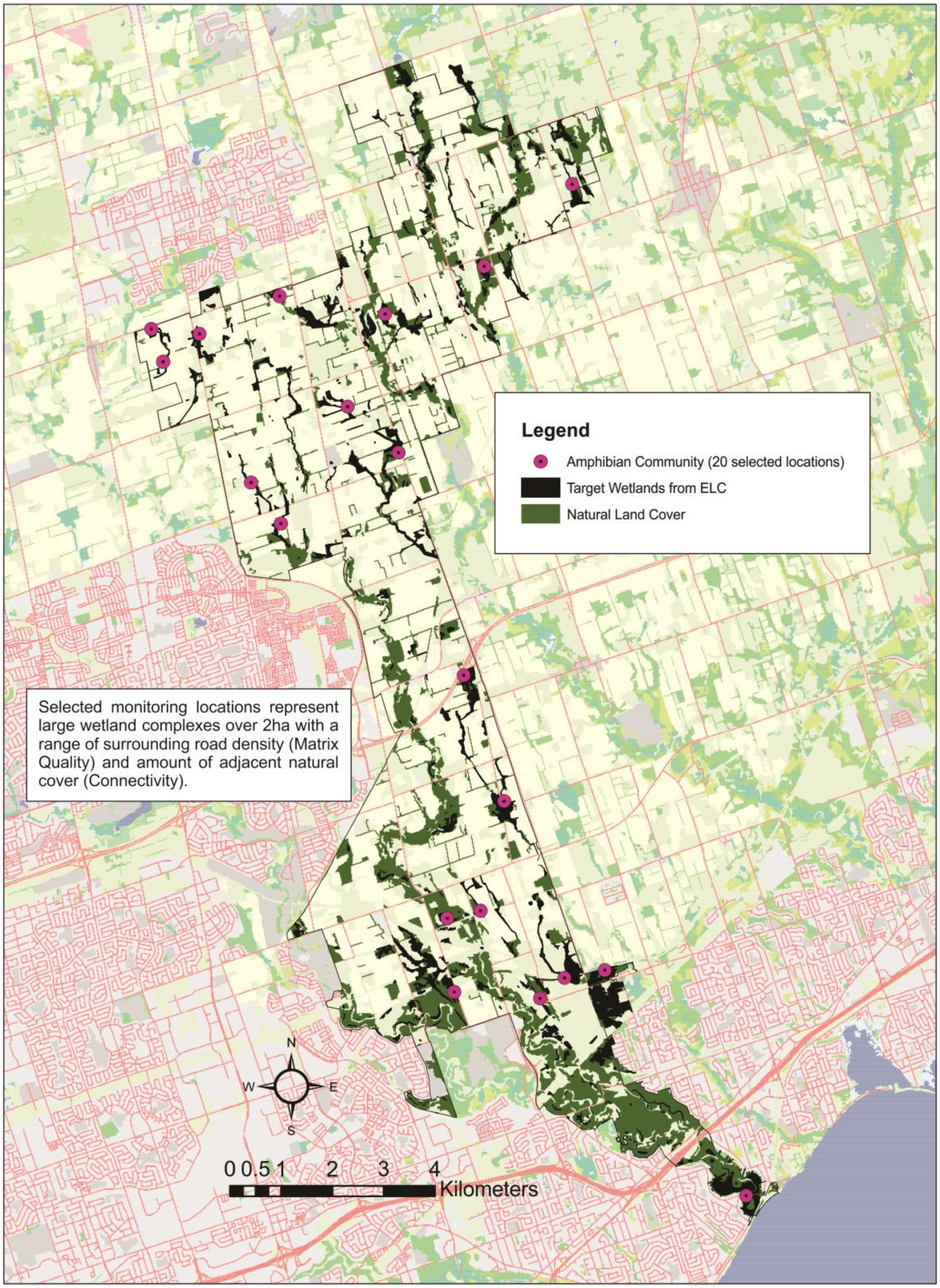
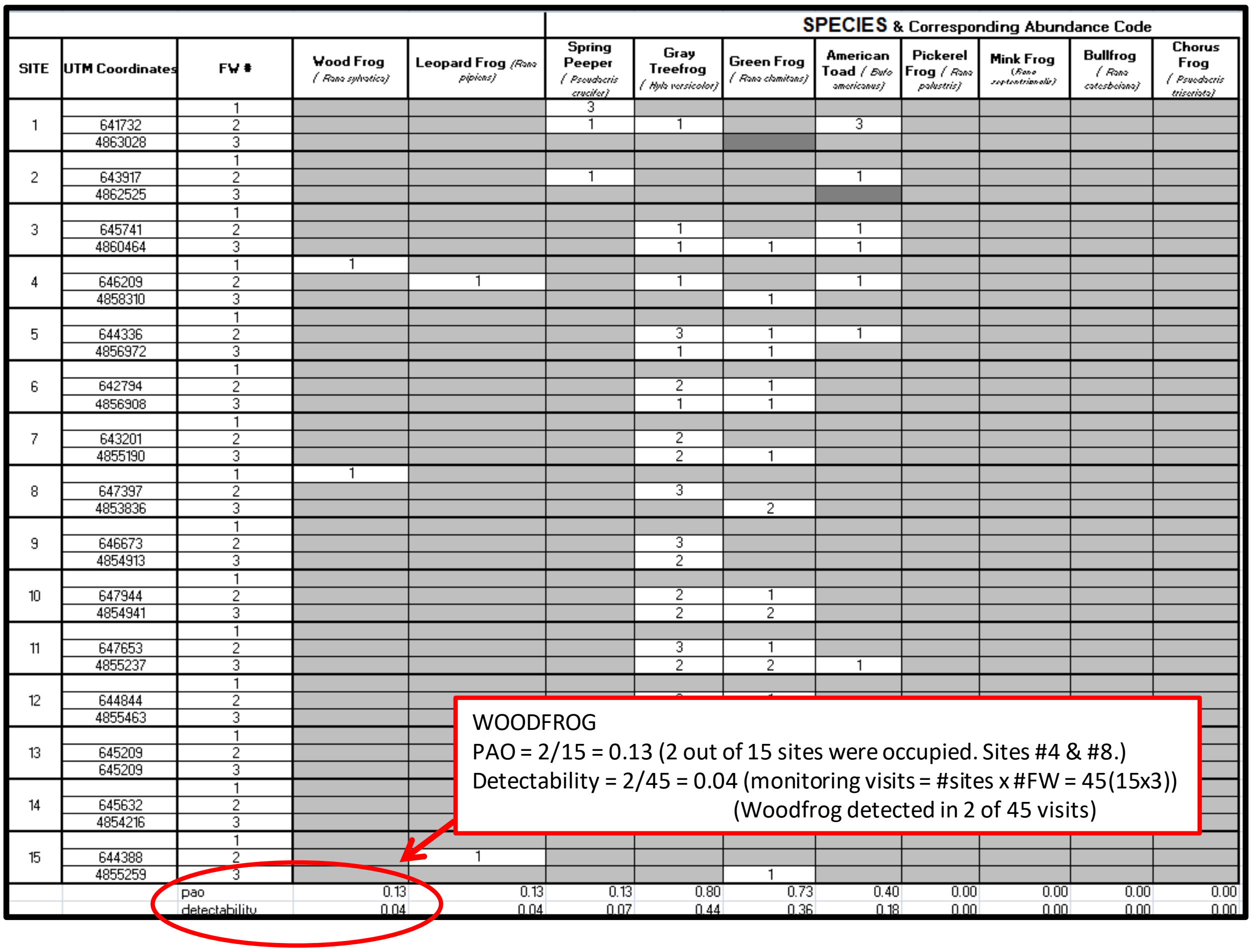


Figure 5: Hypothetical sampling design for Amphibian Community measure where sites represent wetland complexes greater than 2ha in a range of fragmention and matrix quality conditions.

Data Management

RNUP's current approach to FrogWatch data management does not facilitate analysis or efficient assessment of status and trend. The main issue is that FrogWatch data for each year are kept in separate files (ie, the baseline data from 2009 to 2014 are kept in 6 different files). In order to conduct an analysis of change over time all the data across all years must exist within the same file. This is not currently the case.

Another issue is that PAO and Detection Probability per species per year must be calculated from the raw data prior to analysis (figure 6). This is currently not done and the FrogWatch data is left in its raw form. MEI recommends that the data management for this measure be changed such that all data occur in one file, PAO and Detectability are automatically calculated from the raw data, and that the resulting database is saved in a "flat file" for efficient import into a statistical software package such as R3.2.0. RNUP can follow up with MEI after this operation review to learn the specifics about how to set up these data files.



					SPECIES & Corresponding Abundance Code							
SITE	UTM Coordinates	FW #	Wood Frog (Rana sylvatica)	Leopard Frog (Rana pipiens)	Spring Peeper (Pseudacris crucifer)	Gray Treefrog (Hyla versicolor)	Green Frog (Rana clamitans)	American Toad (Bufo americanus)	Pickerel Frog (Rana palustris)	Mink Frog (Rana septentrionalis)	Bullfrog (Rana catesbeiana)	Chorus Frog (Pseudacris triseriata)
		1			3							
1	641732	2			1	1		3				
	4863028	3										
		1										
2	643917	2			1			1				
	4862525	3										
		1										
3	645741	2				1		1				
	4860464	3				1	1	1				
		1	1									
4	646209	2		1		1		1				
	4858310	3					1					
		1										
5	644336	2				3	1	1				
	4856972	3				1	1					
		1										
6	642794	2				2	1					
	4856908	3				1	1					
		1										
7	643201	2				2						
	4855190	3				2	1					
		1	1									
8	647397	2				3						
	4853836	3					2					
		1										
9	646673	2				3						
	4854913	3				2						
		1										
10	647944	2				2	1					
	4854941	3				2	2					
		1										
11	647653	2				3	1					
	4855237	3				2	2	1				
		1										
12	644844	2										
	4855463	3										
		1										
13	645209	2										
	645209	3										
		1										
14	645632	2										
	4854216	3										
		1										
15	644388	2		1								
	4855259	3					1					
		pao	0.13	0.13	0.13	0.80	0.73	0.40	0.00	0.00	0.00	0.00
		detectability	0.04	0.04	0.07	0.44	0.36	0.18	0.00	0.00	0.00	0.00

Figure 6: Example of PAO and detectability calculation.

Freshwater ecosystem measures

Water quality

Proposed Monitoring Question:

"Is the last year's water quality index (WQI) for streams in Rouge National Urban Park above 80?"

Proposed Thresholds

These interim annual WQI thresholds are suggested based on CCME's WQI values categories (CCME, 2001) as:

Poor	Fair	Good
WQI < 65	WQI: 65 - 80	WQI > 80

Sampling frequency

-- Water quality samples were collected in the fixed WQ sites monthly, independent of precipitation.

Assessment Method

1) Reviewed the WQ sampling methods described in the Ontario Ministry of the Environment (OMOE)'s Provincial Water Quality Monitoring Network (PWQMN) protocol (OMOE 2003) and the Toronto and Region Conservation Authority (TRCA)'s 2012 Surface Water Quality Summary – Regional Watershed Monitoring Program (TRCA, 2013).
2) Reviewed available WQ guidelines and the data files of TRCA, provided by the RNUP.
3) Accessed statistical analysis results of the available WQ data by TRCA's staff, provided by the park.
4) Selected 7 parameters from the monitoring database as recommended variables for the WQI calculations.
5) Conducted an overall WQI analysis for the entire Rouge River Watershed and Petticoat Creek, based on 12 years of data from a total of 9 WQ sampling stations located in this region.
6) Conducted annual WQI calculations for RNUP only, based on the data of the 4 WQ sampling sites inside the park's boundary from 2002 to 2013.
7) Conducted annual WQI calculations at the site level, separately for the 4 WQ sampling sites inside the park, and for a suit of 6 sites (i.e. 2 sites just outside the park's boundary, plus the 4 sites inside the park's boundary), from 2002 to 2013.
8) Power analyses were conducted to test ability and efficiency of the water quality monitoring using only the 4 sampling sites inside the park, as well as using a suit of the 6 sampling sites.

<u>Status</u>:

1) The WQ sampling was conducted since 2002 by staff of Watershed Monitoring and Reporting Section, TRCA, as part of TRCA's Regional Watershed Monitoring Program (RWMP) in partnership with the OMOE. Among the parameters sampled, E. Coli was sampled since 2011.
2) The OMOE PWQMN protocol (OMOE 2003) was applied in the sampling, including in-situ measurements (e.g. water temperature, pH, and specific conductivity) collected using a hand-held YSI meter (Model 600QS). Grab bottle water quality samples were collected monthly throughout the year, typically in the third week of each month, irrespective of precipitation (TRCA, 2013).
3) The WQ samples were sent to MOE, York-Durham, and other labs for analysis.
4) The WQ database has been managed by TRCA, and shared with RNUP.
5) The available data files have surface water quality data of 8 sites in Rouge Watershed and 1 site in Petticoat Creek. Four of the sampling sites are located within the park's boundaries. The WQ data include the mean, minimum, max, and 5% quantiles values calculated for all parameters using non-negative data only.
6) Our analysis results suggest that the water quality of streams inside the RNUP has been improved since 2010. The status of the water quality by 2013 has changed from the poor (i.e. Red) to the fair (i.e. Yellow).

<u>Trend</u>:

1) No trend analysis was done for the Rouge Watershed so far. A simple linear trend of the annual WQI change in streams of RNUP was plotted, based on the WQ data of the 4 WQ sampling sites (i.e. the site ID: 104037, 97007, 97011, and 97013) inside the park's boundary. This result suggests that the water quality of the sampled streams inside the park has been slightly improved since 2010.

Review Summary

1) The field measurements of TRCA's Regional Watershed Monitoring Program are proper for describing health of the freshwater ecosystems of RNUP and addressing the issues of concerns on ecological health of the Rouge Watershed and Petticoat Creek. The sampling design catches up the conditions of all main reaches and tributaries of the Rouge River and Petticoat Creek. The sampling metrics and the sampling frequency are well designed as part of the regional watershed monitoring program. The WQ database is properly managed.

2) TRCA has a set of long-term WQ objectives set-up for the watershed based on CCME and Environment Canada (EC)'s WQ guidelines (TRCA 2013).The main issues of the WQ in the watershed are related to continuous higher concentrations of Chloride and Total phosphorus (TP) concentrations in the past 12 years. Metal Lead was also higher than the objectives in some years of last decade.
Recommendations: 1) We recommend the park's ecological health (EH) monitoring program continues the same WQ field measurements of TRCA's Regional Watershed Monitoring Program as that for the WQ measure of the Freshwater Indicator in RNUP. 2) We suggest that the sampling design, metrics, as well as the sampling frequency will be maintained for the 4 WQ sampling sites within the park as the minimum sites. If the FU's capacity and budget may be feasible for doing more sites, we suggest considering more than the 6 sites (the 4 sites inside the park, plus the 2 sites just outside the park's boundary), as long as the FU may maintain its sustainable operation of the monitoring program. 3) We recommend the WQI to be assessed annually, and calculated based on the 7 "indicator parameters" as recommended by PWQMN (TRCA, 2013). In this report, we calculated the WQI values from 2002 to 2013, based on the available WQ data (See below for detail.) 4) We suggest to consider including the E. Coli data for calculating the annual WQI. 5) We recommend a statistical trend analysis of WQI changes to be assessed after 2015 year of WQ sampling, or 3 years of establishing of this Park's monitoring program.

Detailed review

The RNUP is partnership with the Toronto and Region Conservation Authority (TRCA) on monitoring stream water quality in the 4 sites of Rouge River Watershed (Figure 7). TRCA has been doing the WQ sampling since 2002, at selected locations within the watersheds of the greater Toronto region on a monthly basis. "These activities have been undertaken as part of TRCA's Regional Watershed Monitoring Program (RWMP) in partnership with the Ontario Ministry of the Environment (OMOE)." (TRCA, 2012)

Water quality is a widely accepted and implemented measure for monitoring and assessing ecological health of freshwater ecosystems. Changes in water quality may provide an early warning of environmental stress to aquatic ecosystems. The Canadian Council of Ministers of the Environment (CCME) quality index (WQI) summarizes complex water chemistry data to a single index in order to simplify and standardize water quality assessment and reporting. It provides a mathematical framework for assessing ambient water quality conditions relative to water quality objectives. Thus, we recommend using WQI as one of the ecological health measures of the freshwater ecosystem of RNUP.

"The CCME WQI is flexible with respect to the type and number of water quality variables to be tested, the period of application, and the type of water body (stream, river reach, lake, etc.) tested. These decisions are left to the user. Therefore, before the index is calculated, the water body, time period, variables, and appropriate objectives need to be defined." (CCME 2001) We here list 7 water quality parameters as a suite of recommended key variables for development of a water quality index. They are: Chloride, Total Suspended Solids (TSS), Nitrate, Total Phosphorous (TP), Copper, Lead, and Zinc. Additional WQ variables may be considered depending upon the park's management needs, budgets, and priority. We also suggest to consider including the E. Coli data for calculating the annual WQI based on the monthly sampled data started from 2011, as elevated levels of microorganisms such as bacteria can impact directly human health and limit the recreational uses of the freshwater ecosystem in the park.

Figure 7: Locations of the 4 water quality sampling sites (TRCA 2013) within RNUP's boundaries, in the Rouge River Watershed (Mapped by Paul Zorn)

The WQ results are compared to the Provincial Water Quality Objectives (PWQO) guidelines as implemented by TRCA (TRCA, 2013). Table 18 provides a list of the PWQO and Canadian Water Quality Guidelines (CWQG). "The PWQOs are a set of numerical and narrative ambient surface water quality criteria that represent a desirable level of water quality that will protect all forms of aquatic life and all aspects of their aquatic life cycles during indefinite exposure to the water as well as protecting recreational water usage based on public health considerations and aesthetics" (OMOEE 1994). "When PWQO guidelines were not available, other objectives such as Canadian Water Quality Guidelines (CWQG) (CCME 2007) and Recommended Water Quality Guidelines for the Protection of Aquatic Life under the Canadian Environmental Sustainability Indicators (CESI) Initiative (EC 2012) were used." (TRCA 2013)

In this review, we conducted four steps of WQI calculations and the statistical analyses at watershed, park, and site levels, in order to examine effects of sampling sizes on detecting WQ changes.

We first used the monitoring results of these 7 variables from all of the 9 sampling sites in the Rouge River Watershed and Petticoat Creek from 2002 to 2013 have been analysed together in order to have a general long-term overall assessment of the water quality for the entire Rouge River Watershed. Table 19 summaries the calculations of the overall long-term WQI at the watershed level. The 7 parameters we recommended for WQI calculation are those that were selected for reporting as the PWQMN recommended indicator parameters with the objectives. They provide a meaningful and comprehensive indication of the water quality at the watershed. "Elevated concentrations of these parameters may point to natural and/or anthropogenic sources within the watershed." (page 4, TRCA, 2013)

Table 18: Provincial Water Quality Objectives (PWQO) and Canadian Water Quality Guidelines (CWQG)

Parameter	Chloride	Copper	Lead	Nitrate	T-P	TSS	Zinc	E. Coli
Guideline	CWQG: long term 120 mg/L (chronic) and short-term 640 mg/L (acute)	PWQO: 5 µg/L	PWQO: 5 µg/L	EC: 2.93 mg/L)	PWQO: 0.03 mg/L	CWQG: 30 mg/L	PWQO: 20 µg/L	PWQO: 100 CFU/100 mL
Source of the information	CCME 2007, & 2011; TRCA 2013.	TRCA 2013.	TRCA 2013.	EC 2012; TRCA 2013.	TRCA 2013.	TRCA 2013.	TRCA 2013.	TRCA 2013.

To understand better how the index is calculated, we list the step-by-step results as a demonstration in Table 19 with the available data. Detail of the formulas for calculation of WQI may be read in the reference provided (CCME 2001).

Then, we calculated the annual WQIs for RNUP at the park level, based on the WQ data from the 4 WQ sampling sites (i.e. 104037, 97007, 97011, and 97013) inside the park's boundary. The calculated annual WQI values are listed in Table 20. The results suggest that the water quality of streams inside the RNUP has been improved since 2010. The status of the water quality has changed from the poor (i.e. red colour) to the fair (i.e. in yellow colour). A simple linear trend of the annual WQI change in the sampled streams of RNUP was plotted in Figure 8 below, based on the WQ data of the 4 WQ sampling sites inside the park's boundary.

The third step is to conduct the annual WQI calculations at the site level for a suit of 6 WQ sampling sites, i.e. 2 sampling sites (just outside the park's boundary, plus the 4 sampling sites inside the park's boundary, from 2002 to 2013 (Table 21).

As the fourth step, statistical power analyses were conducted to test ability and efficiency of the water quality monitoring design, using only the 4 sampling sites inside the park, as well as using a suit of data from the 6 sampling sites as showing in Table 21.

Table 19: Calculation of the CCME’s WQI for the Rouge Watershed and 1 site in Petticoat Creek

		Annual Averages of the Monthly WQ Data								*excursion*		
Year	Chl	Copper	Lead	Nitrate	T_P	TSS	Zinc	*e_Chl*	*e_Lead*	*e_T_P*	*e_TSS*	*e_Zinc*
2002	**200.5**	1.01	1.42	1.80	**0.05**	21.57	1.86	0.67		0.52		
2003	**213.1**	1.18	1.28	0.98	**0.04**	22.84	1.61	0.78		0.46		
2004	**216.7**	1.59	**5.29**	1.29	**0.05**	11.36	1.65	0.81	0.06	0.68		
2005	**145.8**	1.02	0.85	0.67	**0.04**	9.56	1.14	0.21		0.41		
2006	**170.1**	2.80	**11.14**	1.27	**0.05**	16.74	15.86	0.42	1.23	0.54		
2007	**296.9**	2.80	**6.82**	0.99	**0.07**	15.33	11.81	1.47	0.36	1.21		
2008	**215.7**	3.22	**16.78**	1.26	**0.09**	**37.48**	**20.68**	0.80	2.36	2.00	0.25	0.03
2009	**194.2**	2.04	4.33	0.86	**0.04**	17.04	6.62	0.62		0.19		
2010	**198.4**	1.94	1.05	0.90	**0.04**	15.37	4.18	0.65		0.42		
2011	**200.1**	1.56	0.46	1.01	**0.05**	19.73	3.48	0.67		0.63		
2012	**201.9**	1.35	0.45	0.75	0.03	12.00	3.15	0.68				
2013	**220.4**	1.72	0.45	0.97	**0.06**	27.46	6.11	0.84		0.90		
Objective	120.0	5.00	5.00	2.93	0.03	30.00	20.00				***nse=***	0.25
F1(Scope)	1		1		1	1	1	71.43			***F3 (Amplitude)=***	19.90
F2(Frequncy)	12		4		11	1	1	34.52				
Sum of Square	6690.11											
Square Root	81.79											
CCME WQI =	53											

Note: Bolded values in the table indicate that do not meet the objective

Table 20: Annual WQIs for the entire RNUP, based on WQ data of the 4 WQ sampling sites (i.e. 104037, 97007, 97011, and 97013) inside the park’s boundary.

Year	***2002***	***2003***	***2004***	***2005***	***2006***	***2007***	***2008***	***2009***	***2010***	***2011***	***2012***	***2013***
WQI	58	62	38	70	46	58	40	56	73	72	73	69

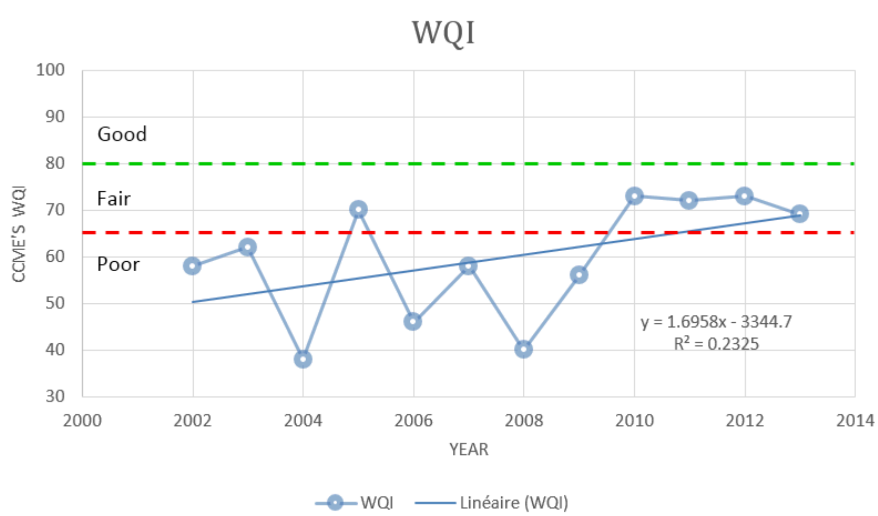


Figure 8: Trend of the annual WQI change in streams of RNUP, based on WQ data of the 4 WQ sampling sites (i.e. 104037, 97007, 97011, and 97013) inside the park’s boundary.

Table 21: Annual WQI calculations by site and year, based on 6 WQ sampling sites (i.e. the 104037, 97007, 97011, and 97013 inside the park's boundary plus other 2 sites just outside the park's boundary).

Site	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
97007					47	54	53	75	83	75	74	68	
97011	65	67	58	77	52	41	38	40	43	57	53	47	
97013	54	65	68	79	63	65	48	74	74	73	73	70	
104037	55	52	54	58	61	36	51	56	74	80	83	73	52
97003					50	41	49	58	75	75	75	75	
97999	55	52	57	71	42	59	50	67	83	75	75	75	

Our analysis results (Table 22) suggest that statistical powers are relatively low if the water quality monitoring program is only carried on by sampling the 4 sites inside the park; or, even if the sampling includes other 2 sites just outside the park's boundary. As we suspected, the two additional sites do not change much the results (see Figure 9).

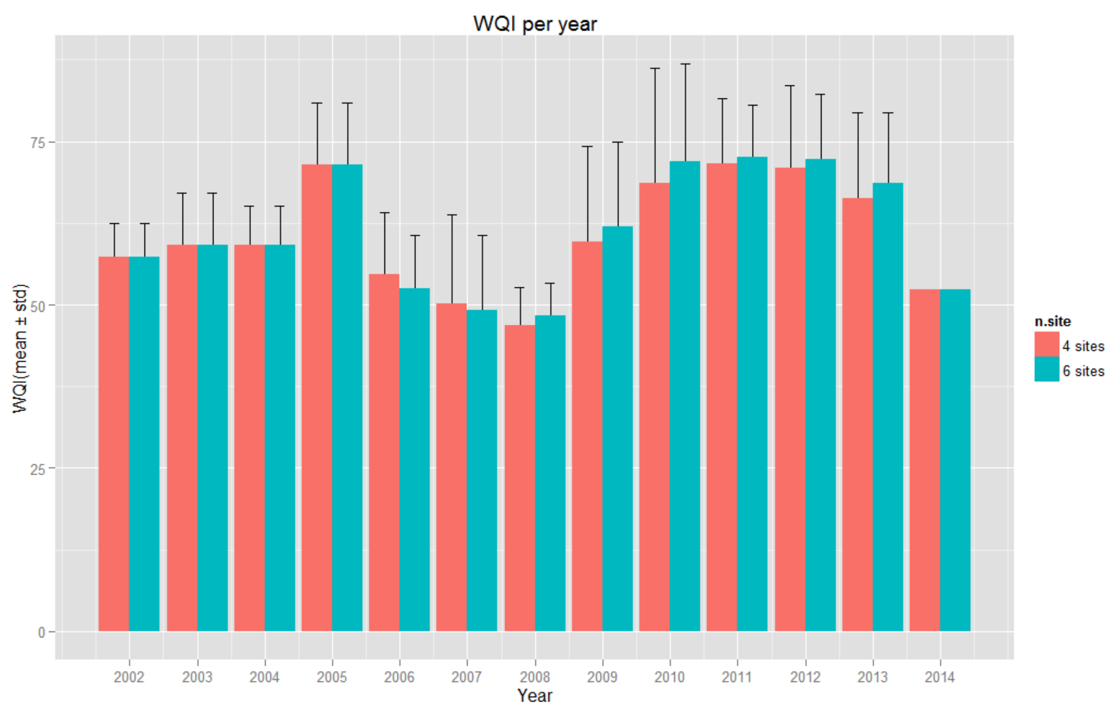


Figure 9: Average annual WQI in streams of RNUP, based on WQ data of the 4 WQ sampling sites inside the park's boundary, as well as using additional data from other 2 sites just outside the park's boundary.

The estimated Grand Mean and the STD of residuals from a linear mixed model with the site as a random factor were respectively 62.1 and 11.2 (2014 data were excluded as only one site was sampled). The annual sample size to detect a 5%-50% effect size over a 5 or 10 year period are presented in the table 22 below.

This power analyses results suggest that, if it is affordable in budget and staff-time, with repeated sampling of 20 sites, this monitoring design would be able to detect a 20% change over a 5 year period, or a 25-30% change over a 10 year period, assuming the same monthly sampling throughout the year.

Table 22: The annual sample size to detect a 5%-50% effect size over a 5 or 10 year period, based on the Power Analyses with the 6 sampling sites.

Effect size	5 year sampling period		10 year sampling period	
	Slope	Sample size	Slope	Sample size
5%	0.62	293	0.31	585
10%	1.24	73	0.62	146
15%	1.86	33	0.93	65
20%	2.48	19	1.24	37
25%	3.10	12	1.55	24
30%	3.72	8	1.86	16
35%	4.34	6	2.17	12
40%	4.96	5	2.48	9
45%	5.59	4	2.79	7
50%	6.21	3	3.10	6

An option for increasing the detecting ability may be, with similar amounts of investments, the sampling sites could be increased up to 20 sites, if the WQ sampling is only focused on the growing season from April to October. This monitoring design needs to recalculate the mean and STD of residuals to determine if the required sample size would be different.

Additional statistical trend analysis, by fitting a linear mixed model with a random factor with the 6 sites on the data, shows a significant trend over time, from 2002-2013 (see the results in the Appendix and Figure 10). In this analysis, data from 2014 were exclude as only one site has the data available so far.

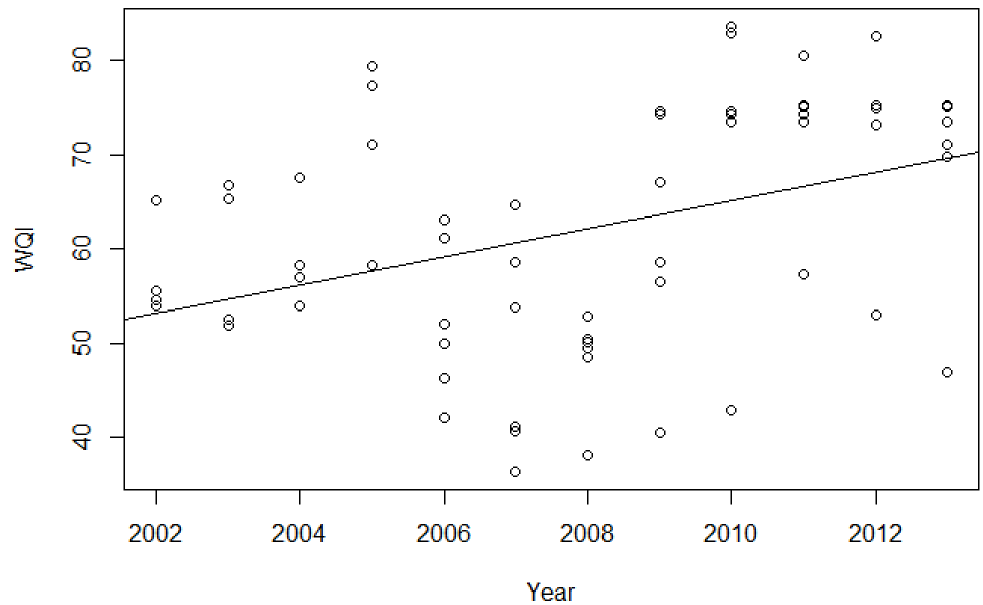


Figure 10: Trends in WQI in sites sampled within (n=4) and near (n=2) RNUP between 2002-2013.

In summary, we recommend the WQI to be examined annually by using at least the 6 sites within and adjacent to the park's boundaries, as the minimum WQ sampling sites. These 6 sampling sites cover different tributaries and the main stem sections of Rouge River, representing spatial distributions of the stream water quality. The sampling frequency at these sites should be remaining as monthly for all of the variables.

Keep in mind that the current monitoring design with the 6 sampling sites at monthly sampling frequency may only detect 35 % of possible WQ changes in a 5 year sampling period, and 50% of the changes in a 10 year sampling period, according to the statistical power analyses as stated above. To be able to detect 20 % of WQ changes in a 5 year period, it is suggested that 20 sampling sites are need.

A slightly increasing trend of the annual WQI change was suggested based available data up to 2013. We recommend that the trend to be assessed when the 2015 year of WQ data are available, or 3 years of establishing of this Park's monitoring program.

Recommendations on site selection

Recommendations on sampling design

Sampling design should be focused on ecological functions and processes in general. Given the park's total size, boundary shapes, patchiness, its position within the drainage system of the Rouge River watershed, etc., some criteria to be considered for selection of the 20 sites might be:

a) Including as many existing WQ sampling sites as possible (i.e. the 4 sites inside the park + the 2 sites just outside the park's boundary);
b) Consider a watershed-based approach, instead of a "park's boundary"-based approach. This approach implies that the FU needs to share and obtain the WQ data from their monitoring partners within the Rouge River watershed, and includes these data in the WQI calculation and WQ assessment. Up to 9 WQI sites, including one site in Petticoat Creek and the sites within the RNUP are available within the Rouge River watershed.

Additional WQ sites within the park's boundary should be selected based on:

1) Types and ecological functions of sub-freshwater ecosystems (for examples: stream, wetland, pond, etc.)
2) Sources of observed and potential pollutants and other impacts on the health and functions of the freshwater resources;
3) Ecological structures of the park's freshwater ecosystems and spatial patterns of the landscapes (such as drainage networks, patches of farming lands, roads, recreation areas, etc.);
4) Specific needs / requirements for the park's services related to the WQ.

List of Reviewed References

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Toronto and Region Conservation Authority (TRCA). 2013. 2012 Surface Water Quality Summary – Regional Watershed Monitoring Program. 28 pp + appendices.

Appendix

Outputs from a statistical trend analysis, by fitting a linear mixed model with a random factor with the 6 sites.

```
> m3.WQI<-lme(WQI~Year, random=~1|Site, data=WQIdat3)
> summary(m3.WQI)
Linear mixed-effects model fit by REML
 Data: WQIdat3
       AIC      BIC    logLik
  501.0366 509.5451 -246.5183

Random effects:
 Formula: ~1 | Site
        (Intercept) Residual
StdDev:    3.547216 11.50812

Fixed effects: WQI ~ Year
                 Value Std.Error DF   t-value p-value
(Intercept) -2928.8763  884.9804 57 -3.309538  0.0016
Year           1.4895    0.4407 57  3.379801  0.0013
 Correlation:
     (Intr)
Year -1

Standardized Within-Group Residuals:
       Min         Q1        Med         Q3        Max
-2.0937644 -0.6770259  0.0948017  0.6580733  2.0859738

Number of Observations: 64
Number of Groups: 6
```

Fish community

Proposed Monitoring Question:

"Has the fish community significantly changed (i.e. > 90^{th} percentile confidence limits) at a disproportionate number of monitoring sites during the last 3 years?"

Recommended Thresholds

Thresholds may be based on the number of sample sites (a total of 32 sites so far) that exceed the 90th percentile confidence limits (CL) determined by using the Control Chart analysis (Anderson 2008; Anderson, M.J. and Thompson, A.A., 2004).

Thresholds	Good	Fair	Poor
# of sites that exceeded the 90^{th} percentile CL in a sample year	< 6 sites	6 to 16 sites	> 16 sites

These thresholds are interim, and may be evaluated and modified after 3 years.

Sampling frequency

In the past, fish and habitat were sampled once every 3 years. We recommend to maintain the same frequency.

Assessment Method

1) Reviewed the electrofishing methods in the Section 3, Module 1, Ontario Stream Assessment Protocol (OSAP), v. 9 (Stanfield, L., editor, 2013) used to collect information on stream fish communities.
2) Reviewed the available fish database provided by the Toronto and Region Conservation Areas (TRCA).
3) Performed statistical analysis of the available fish data collected from 2003 to 2012. See below for detail.

<u>Status</u>:

1) The fish community sampling was conducted by staff of TRCA, following the OSAP protocol.
2) The most recent fish data collected in 2012 has been compiled in the database of TRCA.
3) Fish monitoring has 32 sampling sites in the Rouge and Petticoat watersheds. There were 38 taxa observed between 2001 and 2012.
4) No statistical analysis result has been provided for the surveyed fish populations in the watersheds.

<u>Trend</u>:

1) No trend analysis was done so far. Recommend that a difference greater than 3 sites (1/3 of the critical range) between two consecutive assessments be considered as an increase or decrease in ecosystem health.

Review Summary

1) This measure is directly linked to health of ecological processes and biodiversity component of the freshwater ecosystem. The fish surveys / monitoring are part of the regional watershed fish management plan by TRCA.
2) The sampling is based on a random design, guided by the OSAP fish sampling protocol for the fish monitoring with 3-year sampling interval.
3) The protocol is well-documented and comprehensive. The 3-year sampling frequency for fish and 1-year sampling for benthos provide a representative portrait of the expected range of variability through time.
4) The fish community data collected are properly stored and managed by TRCA. OSAP's latest version provides updated standardized field sampling and data forms.

Recommendations:

1) Based on scientific literature reviews, similar measure monitoring in other national parks of Canada, and analysis of the past fish data collected by TRCA, we recommend that the thresholds are determined using the number of sample sites in which the fish community changes exceeded the 90th percentile confidence limits (CL) determined by Control Chart analysis (Anderson 2008; Anderson, M.J. and Thompson, A.A., 2004; Scott Parker and Cavan Harpur, 2015).
2) Specifically, the initial lower and higher thresholds are suggested here at 20% (i.e. 6 sites) and 50% (i.e. 16 sites) of the sampled sites as the T3 and T4 thresholds for the fish communities changing as moderately and rapidly.
3) We recommend to maintaining the same frequency for the fish sampling.
4) Should costs prove restrictive, we recommend that the Park consider the option of using benthic macroinvertebrates as an alternative health measure for the freshwater ecosystem. This measure is relative mature, and has been used for EI monitoring in numbers of Canadian national parks. The OBBN protocol for sampling of benthic macroinvertebrates has been widely adapted in watershed ecological and environment monitoring in Ontario and other regions.

Detailed review

The Ontario Stream Assessment Protocol (OSAP) has been used for identifying sites, evaluating benthic macroinvertebrates, fish communities, physical habitat; geomorphology; hydrology; and water temperature in the watersheds with a series of standardized methodologies. This review focuses on the modules for monitoring fish communities (Section 3) and benthic macroinvertebrates (Section 2). The first module in the Section 3, Fish Community Sampling using Screening, Standard and Multiple Pass Electrofishing Techniques (S3.M1), describes three electrofishing approaches, with standard methods for sampling fish communities in streams.

The past conducted fish monitoring program has 32 sampling sites in the Rouge and Petticoat watersheds. There are 73 taxa have been tracked, although only 38 of them were observed in Rouge Watershed and Petticoat Watershed, from 2001 to 2012. Figure 11 shows the average numbers of fish captured per site for 9 fish species from 2003 to 2012. The y axis is the average number of fish captured per site. Some years there were few sites sampled. Notice that the three black-nose dace points for 2005, 2007 and 2008 are misleading as they just happened to be in the right habitat for these fish.

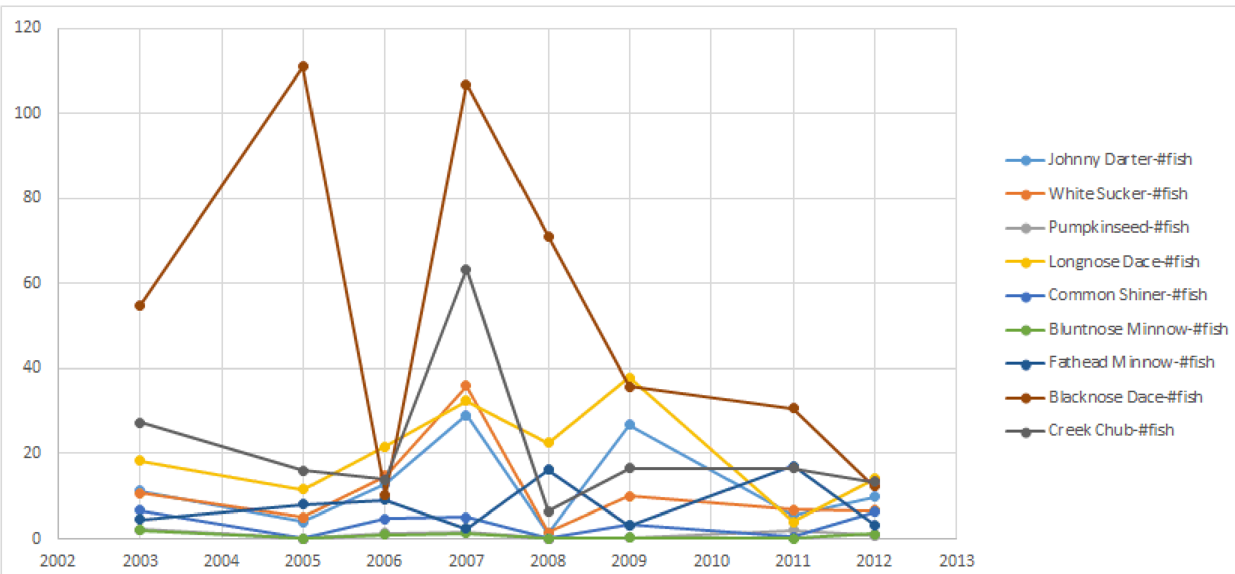


Figure 11: The average number of fish captured per site for 9 fish species from 2003 to 2012.

We recommend applying the fish community field measurement as the ecological health measure for the park's freshwater ecosystem, using a similar approach applied in Bruce Peninsula National Park. Essentially, this monitoring design looks at the number of sites that have changed drastically in composition (90% confidence interval) compared to the last time interval (Scott Parker and Cavan Harpur, 2015). Parker and Harpur developed this index comparing fish communities at two points in time. It was based on a "distance-based multivariate control charts" method described by Anderson, M.J. and Thompson, A.A. (2004) in monitoring coral reef fish assemblages of the Great Barrier Reef, Australia. "The method is flexible, as it can be based on any dissimilarity measure of choice, and useful, as it does not require any specific assumptions regarding distributions of variables." (Anderson, M.J. and

Thompson, A.A. 2004) More technical detail on this method may be found from a comprehensive review paper by Arthur B. Yeh, Dennis K. J. Lin and Richard N. McGrath (2006).

We recommend the thresholds at 20% (i.e. 6 sites) and 50% (i.e. 16 sites) of the sampled sites as the T3 and T4 thresholds for the fish communities changing as moderately and rapidly.

After consulting Cavan Harpur during this review, it is emphasized that when applying this method in the fish monitoring, there are a number of things that could be changed about the index. For example the fishing effort should be considered. It is critical to make the effort equal across samples, and the time at a site (e.g., area, time, etc.). Not so crucial to do this across sites. As well, correction of body size of fish may not be needed with a fish community metric, as suggested by Cavan Harpur (email communication, 2015-08-05).

List of Reviewed References

Anderson, M.J. (2008). Control Chart: a FORTRAN computer program for calculating control charts for multivariate response data through time, based on a chosen resemblance measure. Department of Statistics, University of Auckland, New Zealand. https://www.stat.auckland.ac.nz/~mja/Programs.htm.

Anderson, M.J. and Thompson, A.A., 2004. Multivariate control charts for ecological and environmental monitoring. Ecological Applications, 14(6), 1921-1935. (Read More on: http://www.esajournals.org/doi/abs/10.1890/03-5379)

Arthur B. Yeh, Dennis K. J. Lin and Richard N. McGrath, 2006. Multivariate Control Charts for Monitoring Covariance Matrix: A Review. Quality Technology & Quantitative Management. Vol. 3, No. 4, pp. 415-436. (A pdf version of this paper may be downloaded from: http://web.it.nctu.edu.tw/qtqm/qtqmpapers/2006V3N4/2006V3N4_F3.pdf)

Scott Parker and Cavan Harpur, 2015. Inland Lake Fish Monitoring Protocol, Ecological Integrity Monitoring Program, Bruce Peninsula National Park of Canada. 21 Pages.

Stanfield, L. (editor). 2013. Ontario Stream Assessment Protocol. Version 9.0. Fisheries Policy Section. Ontario Ministry of Natural Resources. Peterborough, Ontario. 505 Pages.

Measures Overview Tables

Overview of the measures are presented in tables 23-25 built from a template requested by the Chief Executive Office. This overview includes:

1. Justification or rationale of the measure
2. Field measurements or parameters used to evaluate the measure
3. Thresholds value or approach used to establish the status of the measure
4. Current status of the development of the measure
5. Current cost for measures already implemented in the park
6. Projected start date
7. Projected cost of the reviewed measure
8. A suggestion on possible management actions if the condition of the measure is poor.

The MEI division presented an overview for most of the elements included in the template and for most of the measures in each natural ecosystem. Presenting the missing elements or measures would have required further discussion with the Resource Conservation Service of the park, and could not be completed within the time frame available for this review.

Table 23: Overview of the measures related to the Forest ecosystem.

Measure	Rationale/Justification	Field Measurements	Metric, Logic model and/or thresholds	Current development status	Current cost	Projected start date	Projected cost	What would/could/should PCA do if the measure is in poor condition?
Forest Landscape	Habitat fragmentation is a major issue in the park, and connectivity within the park will likely need be improved in the future. Prioritization assessment: ➢ High information/cost ratio ➢ Managers have a significant control on the status of the measure ➢ Low potential for citizen science ➢ Some of metrics are related to stressors that are currently having an impact on the ecosystem ➢ Some partners could be involved in data collection	Total surface area Core surface area Distance between patches	Logic model based on the status and trends of the majority of field measurements	4/10 Thresholds, methodology and sampling design have been established. No protocol have been produced yet. No database have been built yet.	N/A (New measure)	2016?	$30K + 7 PD over 5-10 years Cost shared between measures related to the other ecosystems	Forest cover and connectivity restoration program within the park
Key tree species status	Dynamics of the plant community is a major ecological aspect of the health of the forest ecosystem in the RNUP, and can be described with characteristics related to key tree species. Tree species define the stand types according to the ecological land classification (ELC). Prioritization assessment: ➢ Fair information/cost ratio ➢ Managers have a significant control on the status of the measure ➢ Fair potential for citizen science ➢ Some of metrics are related to stressors that are currently having an impact on the ecosystem ➢ Some partners could be involved in data collection	Mortality rate Growth rate	Logic model based on the status and trends of the majority of field measurements	5.5/10 Thresholds, methodology and sampling design have been established. Preliminary protocol and database are available.	1 plot/5 year 10 PD + $1K over 5 years	2016?	20 plots/5 year 55 PD + $5K over 5 years	Forest composition restoration program, based on natural process mimicry

Measure	Rationale/Justification	Field Measurements	Metric, Logic model and/or thresholds	Current development status	Current cost	Projected start date	Projected cost	What would/could/should PCA do if the measure is in poor condition?
Forest birds	Birds are conspicuous species, known to be affected by various ecological factors and conservation issues, and could be easily monitored with field-tested protocols. Birds also generated large public interests and therefore have a high potential for citizen science integration in the monitoring program of the RNUP. Prioritization assessment: ➢ Fair information/cost ratio ➢ Managers have a significant control on the status of some species (interior birds) ➢ High potential for citizen science ➢ Some of metrics are related to stressors that are currently having an impact on the ecosystem ➢ Some partners could be involved in data collection	Abundance and occurrence of common bird species in various guilds	Logic model based on the status and trends of the majority of field measurements	6/10 Thresholds, methodology and sampling design have been established. Preliminary protocol and partial data are available.	1 site/year 20 PD + $2K over 5 years	2016?	15 sites/year 85 PD + $2.5K over 5 years	Forest cover and connectivity restoration program within the park
Deer browse rate	Deer population density can reach very high level in southern Ontario and cause major change in the composition and structure of vegetation communities. The white-tailed deer is a common species in the RNUP and play a significant role as a major browser in the forest and farmland ecosystem. Deer management is a major issue the RNUP. Prioritization assessment: ➢ Fair information/cost ratio ➢ Managers have a significant control on the status of the measure ➢ High potential for citizen science ➢ Some of metrics are related to stressors that are currently having an impact on the ecosystem ➢ Partners could be involved in protocol development	Two possible metrics: Annual Growth Browse Rate (AGBR) or White Trillium maximum leaf height (WTMLH)	Comparison of observed value to thresholds AGBR: Good: ≤60% Fair: 61%-80% Poor: >80% WTMHL: Good: ≥190 mm Fair: 150-190 mm Poor: ≤150 mm	6.5/10 Thresholds, methodology and sampling design have been established. Preliminary protocol is available. Some data on CAG browse rate are available.	AGBR: 32 plots 145 PD + $8K over 5 years WTMLH: New measure	2016?	AGBR: 16 plots 80 PD + $5K over 5 years WTMLH: 10 plots 35 PD + $5K over 5 years	Deer culling program Rare plants fencing

Measure	Rationale/Justification	Field Measurements	Metric, Logic model and/or thresholds	Current development status	Current cost	Projected start date	Projected cost	What would/could/should PCA do if the measure is in poor condition?
Invasive spp	Representativity of the plant community of the forest ecosystem is currently impaired by the presence of invasive plant species. Prioritization assessment: ➢ Relatively low information/cost ratio ➢ Managers have a significant control on the status of some species in localized sites ➢ High potential for citizen science ➢ Measure related to stressors that are having an impact on the ecosystem over the long term ➢ Partners could be involved in data collection	Abundance of localized invasive plant species	To be determined	2.5/10 Thresholds and sampling design have not been established yet. Preliminary protocol and partial data are available.	N/A (New measure)	2016?	To be determined	Control of invasive plants in local sites

Table 24: Overview of the measures related to the Wetland ecosystem.

Measure	Rationale/Justification	Field Measurements	Metric, Logic model and/or thresholds	Current status	Current cost	Projected start date	Projected cost	What would/could/should PCA do if the measure is in poor condition?
Wetland landscape change	Landscape context (ie, adjacent land use, wetland size) can impact wetland health and abundance of area-sensitive species such as least bittern and blanding's turtle. Prioritization assessment: ➢ Fair information/cost ratio ➢ Managers have a significant control on the status of the measure ➢ Low potential for citizen science ➢ Measure related to stressors that are having an impact on the ecosystem over the long term ➢ Partners could be involved in protocol development	Wetland area Wetland interior core area Amount of surrounding natural land cover	Logic model based on the status and trends of the majority of field measurements	4/10 Thresholds, methodology and sampling design have been established. No protocol have been produced yet. No database have been built yet.	N/A (new measure)	2015	$30K + 7 PD every 10 years.	Wetland restoration (reduce marsh infilling, decrease prevalence in invasive plants). Naturalization of buffer zones surrounding large wetlands.
Amphibian community	Amphibians are sensitive to a range of stressors (ie, water quality, habitat amount, climate change) and are in decline around the world. Opportunity for citizen science. Prioritization assessment: ➢ Fair information/cost ratio ➢ Managers have a limited control on the status of the measure ➢ Fair potential for citizen science ➢ Measure related to stressors that are having an impact on the ecosystem over the long term ➢ Partners could be involved in data collection	Proportion of areas occupied for 6 species (American toad, gray treefrog, green frog, leopard frog, spring peeper, wood frog)	Logic model based on the status and trends of the majority of field measurements	6/10 Thresholds, methodology and sampling design have been established. Preliminary protocol and database are available.	Approx. 20PD per year	2009	100 PD + $5K every 5 years	Hemi-marsh restoration / creation (mechanical removal of thick typha beds).

Measure	Rationale/Justification	Field Measurements	Metric, Logic model and/or thresholds	Current status	Current cost	Projected start date	Projected cost	What would/could/should PCA do if the measure is in poor condition?
Bird community	Diverse set of species that represent a range of wetland types and conditions. Prioritization assessment: ➢ Fair information/cost ratio ➢ Managers have a limited control on the status of the measure ➢ Fair potential for citizen science ➢ Measure related to stressors that are having an impact on the ecosystem over the long term ➢ Partners could be involved in data collection	Abundance and occurrence of common bird species in various guilds	Logic model based on the status and trends of the majority of field measurements	6/10 Thresholds, methodology and sampling design have been established. Preliminary protocol and partial data are available.	$5k (including salary) per year	2010	85 PD + $2.5K every 5 years	Wetland habitat restoration (see Wetland landscape change)
Turtle community	Not reviewed							
Invasive spp	Not reviewed							

Table 25: Overview of the measures related to the Freshwater ecosystem

Measure	Rationale/Justification	Field Measurements	Metric, Logic model and/or thresholds	Current status	Current cost	Projected start date	Projected cost	What would/could/should PCA do if the measure is in poor condition?
Aquatic connectivity	Aquatic connectivity is a critical measurement for the key consideration on fish movement, distribution of aquatic species and communities, as well as water quality of the freshwater ecosystems. It is fundamental for building and maintaining a healthy aquatic ecosystem. Such detail spatial information is needed at the park's level for best management practice. Prioritization assessment: ➢ Fair information/cost ratio ➢ Managers have a significant control on the status of the measure ➢ Fair potential for citizen science (TEK from farmers) ➢ Measure related to stressors that are currently having an impact on the ecosystem ➢ Partners could be involved in data collection	Remote sensing (RS)-based measurements which may be easily done by combining the image processes with other RS-based measurements for the forest and wetland ecosystems.	Remote sensing (RS)-based measurements. Logic model based on the status and trends of the majority of the field measurements.	In planning phase.	None	2016	TBD	-- Continuing collaborations with the Toronto and Region Conservation Authority (TRCA)'s Regional Watershed Monitoring Program (TRCA, 2013). -- Actively working with stakeholders on best management practises of sustainable regional development.

Measure	Rationale/Justification	Field Measurements	Metric, Logic model and/or thresholds	Current status	Current cost	Projected start date	Projected cost	What would/could/should PCA do if the measure is in poor condition?
Riparian cover type	This measure describes the conditions of a stream's temperature, sources of nutrients, and other factors influencing fish community, aquatic habitats, and adjacent ecosystems. Rapidly landscape alternations in this region lead to changes of the riparian cover types along the stream corridors in the park. A RS-based field measurement of these changes at landscape scale may provide detailed and quantitative spatial information for the park's ecological health management. Prioritization assessment: ➢ Fair information/cost ratio ➢ Managers have a significant control on the status of the measure ➢ Low potential for citizen science ➢ Measure related to stressors that are currently having an impact on the ecosystem ➢ Partners could be involved in data collection	The Cover Type is a Remote sensing (RS)-based measurement, which may be easily done by combining the image processes with other RS-based measurements for the forest and wetland ecosystems.	Remote sensing (RS)-based measurements. Logic model based on the status and trends of the majority of the field measurements.	In planning phase.	None	2016	TBD	-- Continuing collaborations with the Toronto and Region Conservation Authority (TRCA)'s Regional Watershed Monitoring Program (TRCA, 2013). -- Actively working with stakeholders on best management practises of sustainable regional development.

Measure	Rationale/Justification	Field Measurements	Metric, Logic model and/or thresholds	Current status	Current cost	Projected start date	Projected cost	What would/could/should PCA do if the measure is in poor condition?
Invasive spp	Systematic monitoring of all exotic invasive species may provide reliable information about the invasive plant species within RNUP which may be used for determining of direction regarding their removal. The current status of the invasive plants and trend of the changes may not be assessed with absence of such data. Prioritization assessment: ➢ Low information/cost ratio ➢ Managers have a significant control on the status of the measure ➢ Low potential for citizen science ➢ Measure related to stressors that are currently having an impact on the ecosystem ➢ Partners could contribute to protocol development	Species survey	TBD.	In planning phase.	None	2016 (?)	TBD	-- Continuing collaborations with the Toronto and Region Conservation Authority (TRCA)'s Regional Watershed Monitoring Program (TRCA, 2013). -- Actively working with stakeholders on best management practises of sustainable regional development.

Measure	Rationale/Justification	Field Measurements	Metric, Logic model and/or thresholds	Current status	Current cost	Projected start date	Projected cost	What would/could/should PCA do if the measure is in poor condition?
Fish community	This measure is directly linked to health of ecological processes and biodiversity component of the freshwater ecosystem. The fish surveys / monitoring are part of the regional watershed fish management plan by TRCA. There are 55 fish species found so far. The current status of the fish community and trend of the change need to be understood, so that such information may be integrated into design making on best management practice in the park. Prioritization assessment: ➢ Low information/cost ratio ➢ Managers have a limited control on the status of the measure ➢ High potential for citizen science ➢ Measure related to stressors that are having an impact on the ecosystem over the long term ➢ Partners could be involved in data collection	Fish community sampling and changes of physical fish habitats in fixed sampling sites. The sampling is based on a random design, guided by the OSAP fish sampling protocol for the fish monitoring with 3-year sampling interval.	The Ontario Stream Assessment Protocol (OSAP) has been used for identifying sites, evaluating fish communities, physical habitat, etc. with a series of standardized methodologies. We recommend that the thresholds are determined using the number of sample sites in which the fish community changes exceeded the 90th percentile confidence limits (CL) determined by Control Chart analysis.	In planning phase.	None	2016	TBD	-- Consider the option of using benthic macroinvertebrates as an alternative health measure. -- Continuing collaborations with the Toronto and Region Conservation Authority (TRCA)'s Regional Watershed Monitoring Program (TRCA, 2013). -- Actively working with stakeholders on best management practises of sustainable regional development.

Measure	Rationale/Justification	Field Measurements	Metric, Logic model and/or thresholds	Current status	Current cost	Projected start date	Projected cost	What would/could/should PCA do if the measure is in poor condition?
Water quality	Physical and chemical properties and processes of a water body have direct influence on aquatic biota and freshwater ecosystem processes. Many of the primary stressors to freshwater processes are reflected in water quality changes, such as acidification and eutrophication. Water quality is a widely accepted and implemented measure for monitoring and assessing conditions of freshwater ecosystems. It is critical for design making on improvement of the state of ecosystem health in the park. Prioritization assessment: ➢ Low information/cost ratio ➢ Managers have a limited control on the status of the measure ➢ Fair potential for citizen science ➢ Measure related to stressors that are currently having an impact on the ecosystem ➢ Partners could be involved in data collection	We recommend the park's ecological health (EH) monitoring program includes minimum of 7 Field Measurements. They are: Chloride, Total Suspended Solids (TSS), Nitrate, Total Phosphorous (TP), Copper, Lead, and Zinc.	The Water Quality Index (WQI) metrics are recommended following the OMOE PWQMN protocol (OMOE 2003). Interim annual WQI thresholds are suggested based on CCME's WQI values categories (CCME, 2001).	In planning phase.	None	2016	TBD	-- Using an alternative single parameter as the EH measure, such as the E. Coli. -- Continuing collaborations with the Ontario Ministry of the Environment (OMOE)'s Provincial Water Quality Monitoring Network (PWQMN) protocol (OMOE 2003) and the Toronto and Region Conservation Authority (TRCA)'s Regional Watershed Monitoring Program (TRCA, 2013). -- Actively working with stakeholders on best management practises of sustainable regional development.

Long term sustainability of a wide ranging monitoring program

Experience from the implementation of the ecological integrity monitoring program suggest that programs with 20 measures, i.e. 4 indicators with 5 measures each, are difficult to maintain over the long term. Indeed, the program of the large majority of southern national parks includes 15 measures, i.e. 3 indicators (see table 26 and appendix IV), even though the program guidelines recommend 3 or 4 indicators. The situation is similar in northern parks, where most programs includes 10 measures or 2 indicators, while the guidelines recommend 2 or 3 indicators.

Table 26: Proportion of national parks with an ecological integrity monitoring program which include 2, 3 or 4 indicators.

Number of indicators	Proportion of southern parks (n=31)	Proportion of northern parks (n=12)	Total (n=43)
2	3%	83%	26%
3	87%	17%	67%
4	10%	-	7%

Measures related to farming activities and to the condition of the managed land in the park still need to be identified, and the selection of more measures could lead to the development of a wide-ranging monitoring program. Another priority in the short term is developing a robust active management monitoring system to report on the results of ecological restoration efforts in the park. Experience in developing monitoring programs in National Parks suggests that the park could face significant challenges in implementing a program with >15 measures in a relatively short period of time.

It is expected that further policy and, possibly, legislative revisions will take place as federal, provincial and municipal levels of government come to a common vision of this national urban park. This should not detract from the work to date in setting out an overall framework of indicators and a rigorous means of measuring park condition and management effectiveness. The multiple land use concept and the proximity of the park to an urban centre will remain key concepts in any revision of park management direction. The Monitoring and Ecological Information division is prepared to revisit the thresholds and other concepts advanced in this document, as necessary, once this policy discussion has taken place.

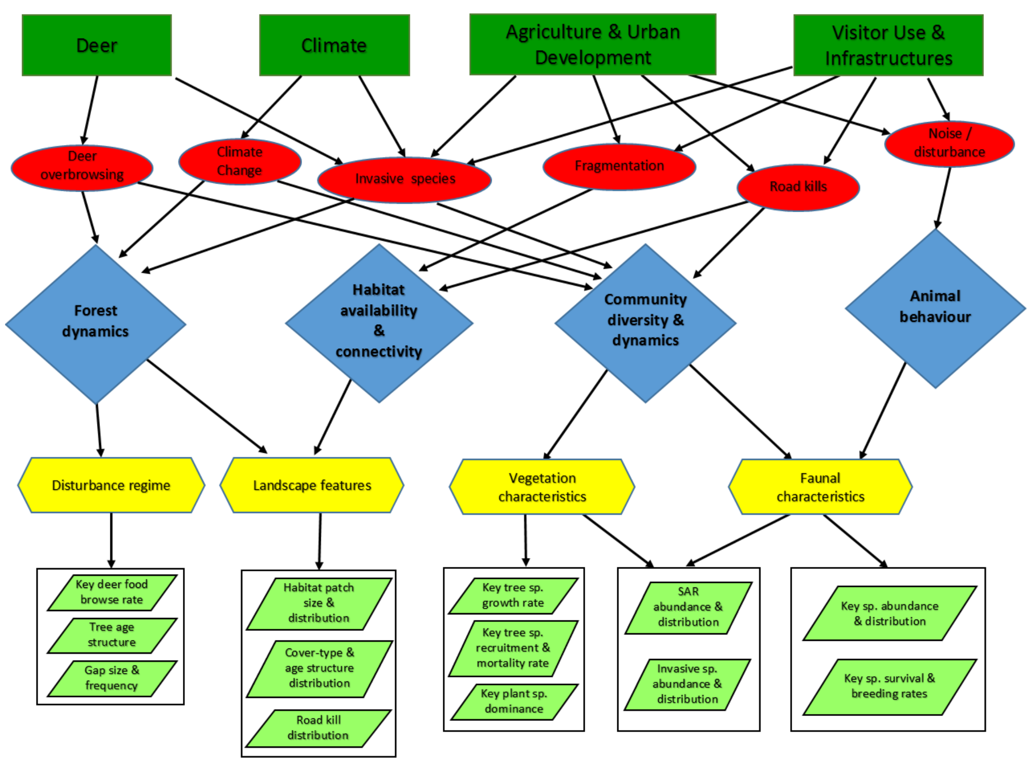
Appendices

Appendix I – Ecosystem conceptual models

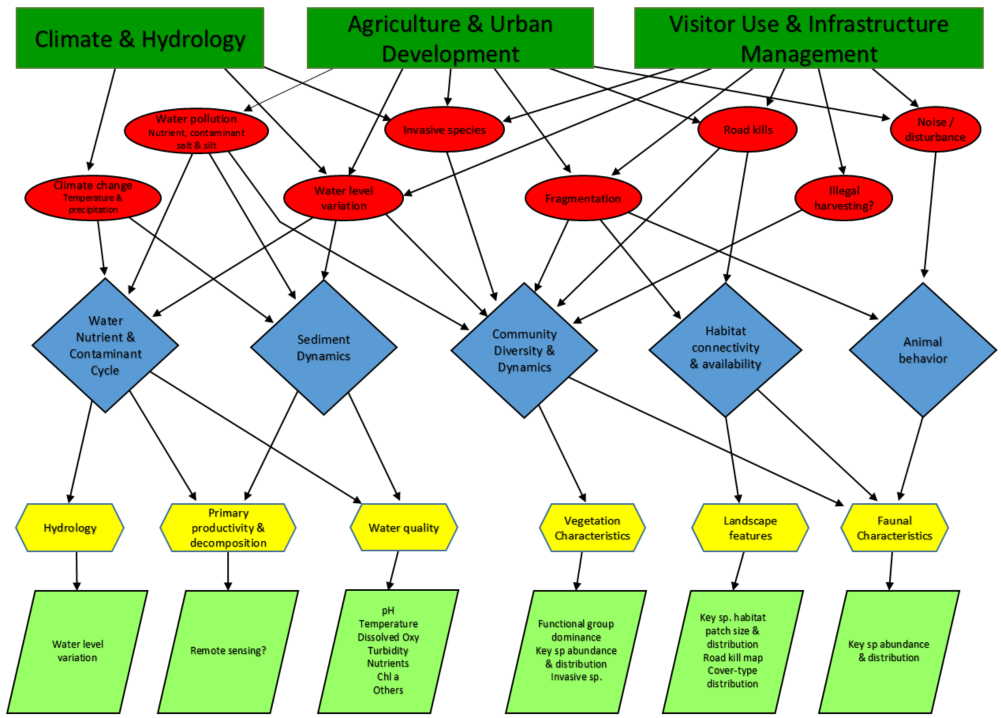
Legend of the models:

Symbol	Description
Drivers	Natural or anthropogenic forces of change
Stressors	Disturbance caused by drivers occurring at an *excessive* or *deficient* level, i.e. outside of the *acceptable range of variability*
Ecological effects	Physical, chemical, biological and/or functional responses of the ecosystem to drivers and stressors
Attributes	Categories of biotic or abiotic environmental features that can be measured to provide information on the condition of the ecosystem
Measures	Specific variables or parameters used to quantify the state of an attribute

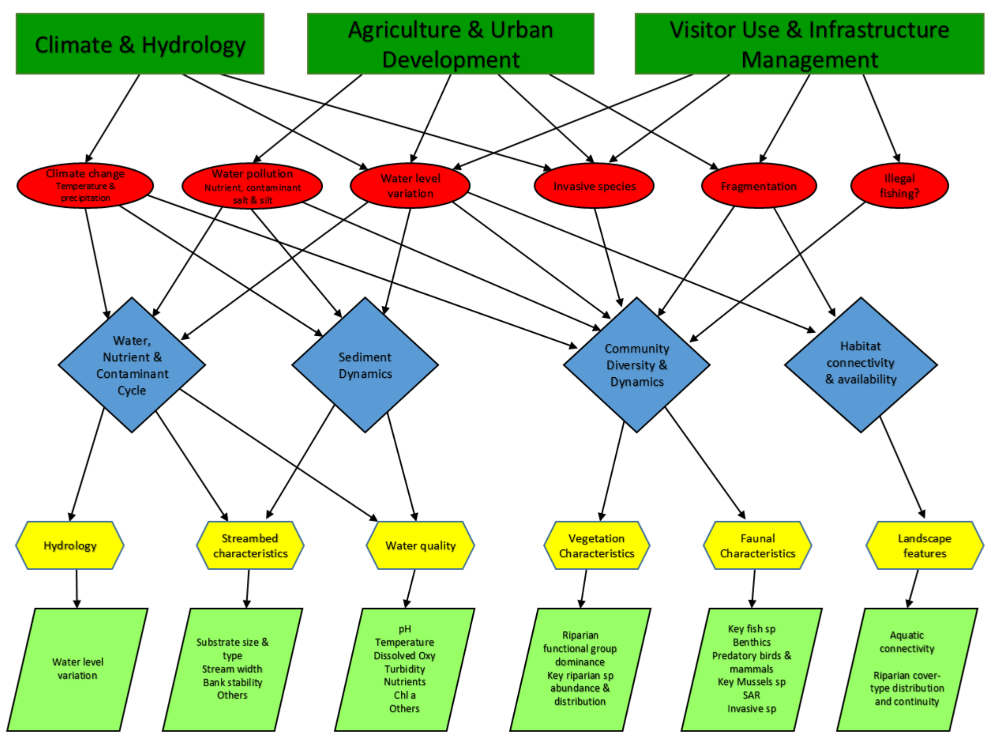
Forest Ecosystem



Wetland Ecosystem



Freshwater Ecosystem



Appendix II – Criteria and scoring system used to prioritize potential measures.

Criteria	Subcriteria	Statement	Score
Significance of current issue	Link to current stressors	Measure is directly related to a stressor that is currently having significant impact on ecosystem	1
		Measure is indirectly related to a stressor that is currently having significant impact on ecosystem or over long term	0.5
		Measure is not related to a stressor that is currently having significant impact on ecosystem or we lack information	0
Information quality	Potential to set thresholds	Historical data are available in the park or in the Greater Ecosystem	1
		Thresholds could be set through a literature review	0.6
		Baseline could be established within 5-10 years	0.3
		Baseline could not be established within 5-10 years	0
	Link with EH framework	Direct link with at least one significant biodiversity component, process or stressor	1
		No direct link with framework	0
	Spatial representativity	No access constraint to the population	1
		Limited access to the population	0
	Temporal representativity	Low variability over a 5-10 year period	1
		High variability over a 5-10 year period	0
Cost	Required sample size	Small number of strata and low frequency	0
		High number of strata and low frequency	0.5
		Small number of strata and high frequency	0.5
		High number of strata and high frequency	1
	Methodology	Free Public database can be used or existing protocol	0
		Protocol available from partners and feasible with current capacity	0.3
		New protocol TBD and feasible with current internal capacity	0.6
		Significant investment required (aerial survey, lab analysis, RS, external expert)	1
	Colocation of measures	The same protocol or same sampling design could be used for >1 measure	0
		The measure require a specific protocol or sampling design	1
Level of management control		Managers of the park have a significant control on the status of the measure	1
		Managers of the park don't have a significant control on the status of the measure	0
Potential for citizen science	Volunteer/Visitor experience	Volunteers or visitors could have a significant contribution to the project	1
		Project could be conducted only by trained employees	0
	Traditional knowledge	TEK from first nations or farming communities could be used to obtain data	1
		TEK from first nations or farming communities could be used to assist in project development (thresholds, sampling design, etc.)	0.5
		TEK cannot contribute significantly to this project	0
Potential for use of innovative technology		The data can be collected more efficiently and accurately with innovative technology	1
		No innovative technology can be involved	0
Potential for partner collaboration		A major partner could contribute to data collection	1
		A major partner could contribute to protocol development	0.5
		No major partner could be involved in the project	0

Formula to calculate the Information/Cost ratio:

$$\frac{Information}{Cost} = \left(\frac{\sum Information\ quality\ scores}{\sum Cost\ scores + 1}\right) \times 0.25$$

The “perfect” measure would have a score of 1 for all information subcriteria, and a score of 0 for all cost subcriteria, which will provide the highest Information/Cost ratio:

$$\frac{Information}{Cost} = \left(\frac{1+1+1+1}{0+0+0+1}\right) \times 0.25 = 1.00$$

The table below provides the weighting factor of each criteria and example of priority score calculation (see appendix IV for detailed scores of Deer browse rate measure):

Criteria	Weighting factor	Example: Deer browse rate	
		Score	Relative value
Information/cost ratio	40%	0.5	0.20
Level of management control	20%	1.0	0.20
Potential for citizen science*	15%	0.5	0.08
Significance of current issue	10%	1.0	0.10
Potential for partner collaboration	10%	0.5	0.05
Potential for use of innovative technology	5%	0.0	0.00
Total	100%	-	0.63

*Average of the subcriteria scores was used for this criteria

Appendix III – Prioritization scores of potential measures in each ecosystem.

Ecosystems	Attributes	Potential measures	Information quality				Cost			Level of management control	Potential for citizen science		Potential for use of innovative technology	Potential for partner collaboration	Ecological importance of the issues	Total score	Rank
			Potential to set thresholds	Link with EH framework	Spatial representativity	Temporal representativity	Required sample size	Methodology	Colocation of measures		Volunteer/Visitor experience	Traditional knowledge					
Forest	Vegetation characteristics	Key tree species growth rate	1	1	1	1	0.5	0.3	0	1	1	0.5	0	1	0	0.63	7
		Key tree species recruitment & survival	1	1	1	0	0.5	0.3	0	1	1	0.5	0	1	1	0.68	4
		Key tree species dominance	1	1	1	1	0.5	0.3	0	1	1	0.5	0	1	0.5	0.68	3
		Wide spread invasive plant sp	1	1	1	0	1	0.6	0	0	1	0.5	0	1	1	0.43	17
		Localised invasive sp	0.6	1	1	0	0.5	0.6	1	1	1	0.5	0	1	0.5	0.55	11
		SAR	1	0	1	0	0	0	1	1	0	0	0	0	0.5	0.35	19
	Disturbance regime	Stand level tree age structure	1	0	1	1	0.5	0.3	0	1	1	0.5	0	0.5	0	0.53	15
		Deer browse rate	1	1	1	0	0.5	0	0	1	1	0	0	0.5	1	0.63	8
		Deer browsing indicator plant species	1	1	1	0	0	0.3	1	1	1	0	0	0.5	1	0.56	10
		Gap size & frequency (Remote sensing)	1	1	1	1	0.5	1	0	0	0	0	1	1	0	0.31	21
	Landscape features	Cover type distribution (ELC & RS)	0.6	1	1	1	0	0	0	1	0	1	0	1	0.5	0.79	1
		Stand Age Structure (ELC & RS)	0.6	1	1	1	0	0	0	1	0	1	0	1	0	0.74	2
		Key animal species habitat	0.6	1	1	1	0	0.3	0	1	0	0	0	0	1	0.58	9
	Faunal characteristics	Deer pop. density (aerial census)	0.6	1	1	0	0	1	1	1	0	0.5	1	0	1	0.47	16
		Deer pop. density (road side survey)	0.3	1	1	0	0.5	0.6	1	1	1	0.5	1	0	1	0.54	12
		Deer road kill	0.3	1	1	1	0.5	0.6	1	1	0	1	0	0.5	1	0.53	14
		SAR Birds species	1	1	1	0	1	0	1	0	1	0	1	1	0	0.33	20
		Coyote pop. index & distribution	0.3	0	1	0	0	1	1	0	0	0	1	0	0	0.09	22
		Interior bird species: oven bird & others	1	1	1	0	0.5	0	1	1	1	0	1	1	1	0.65	5

Ecosystems	Attributes	Potential measures	Information quality				Cost			Level of management control	Potential for citizen science		Potential for use of innovative technology	Potential for partner collaboration	Ecological importance of the issues	Total score	Rank
			Potential to set thresholds	Link with EH framework	Spatial representativity	Temporal representativity	Required sample size	Methodology	Colocation of measures		Volunteer/Visitor experience	Traditional knowledge					
		Noice sensitive breeding birds	1	1	1	0	0.5	0	1	1	1	0	1	1	1	0.65	5
		Red-back salamander abundance & distribution	1	1	1	0	0.5	0	0	0	1	0	0	1	0.5	0.43	18
		Road kill map	0.3	1	1	0	0.5	0.6	0	1	1	0	0	0.5	1	0.53	13
Wetlands	Hydrology	Water level variation	0.6	1	1	0	0.5	0.6	0	0	1	0	0	1	0.5	0.35	11
	Primary productivity & decomposition	Plant growth rate	0	0	1	1	0	0.6	1	0	0	0	1	0	0	0.13	14
		Plant decomposition rate	0	0	1	1	0	0.6	1	0	0	0	1	0.5	0	0.18	13
	Water quality	Water Quality Index	0.6	1	1	0	0.5	0	1	0	1	0	1	0.5	1	0.38	9
	Vegetation Characteristics	Functional group dominance	0.3	1	1	1	0.5	0.3	0	1	0	0	1	0.5	0.5	0.53	3
		Key sp relative abundance (dominance) & distribution	0.6	1	1	1	0.5	0.6	0	1	0	0	1	0	0.5	0.47	5
		Invasive sp: % of wetland dominated by invasive sp	0.6	1	1	0	0.5	0.6	0	1	0	0	1	1	1	0.57	1
	Landscape Features	Key species habitat patch size & distribution	0.3	1	1	1	0	0.6	0	1	0	0	1	0.5	0.5	0.56	2
		Road kill map & rate (density)	0.3	1	1	0	0.5	0.3	0	0.5	1	0	0	1	0.5	0.45	6
		Wetland type amount & distribution	0.3	1	1	1	0.5	1	0	1	0	0	1	0.5	0.5	0.48	4
	Faunal Characteristics	Amphibian abundance	0.6	1	1	0	0.5	0.3	0	0	1	0	1	1	0.5	0.42	7
		Marsh breeding bird abundance	0.6	1	1	0	0.5	0.3	0	0	1	0	1	1	0.5	0.42	7
		Blanding Turtle abundance	0.6	1	1	0	1	0.6	1	1	0	0	0	0.5	0.5	0.37	10
		Odonates	0.6	1	1	0	0.5	0.6	1	0	1	0	0	1	0.5	0.31	12
Freshwater	Hydrology	Water Level Variation	0.6	1	1	0	1	0.3	1	0	0	0	0	1	0.5	0.23	14
	Streambed Characteristics	Benthic Habitat Quality	1	1	1	1	0.5	0.3	1	0	0	0	0	1	0.5	0.29	12
	Water Quality	Water Quality Index	1	1	1	0	0.5	0.3	1	0	1	0	1	1	1	0.43	7

Ecosystems	Attributes	Potential measures	Information quality				Cost			Level of management control	Potential for citizen science		Potential for use of innovative technology	Potential for partner collaboration	Ecological importance of the issues	Total score	Rank
			Potential to set thresholds	Link with EH framework	Spatial representativity	Temporal representativity	Required sample size	Methodology	Colocation of measures		Volunteer/Visitor experience	Traditional knowledge					
	Vegetation Characteristics	invasive species abundance and distribution	0.6	0	1	0	0.5	0.3	0	1	1	0.5	1	0	1	0.55	3
		functional group dominance	0.6	1	1	1	0.5	0.3	0	0	1	0	1	1	0.5	0.48	5
		Key species dominance and distribution	0.6	1	1	1	0.5	0.3	0	0	1	0	1	1	0.5	0.48	5
	Landscape Features	Riparian cover-type amount and distribution	1	1	1	0	0.5	0.3	1	1	0	0.5	1	1	1	0.59	2
		Aquatic connectivity	1	1	1	0	0.5	0.3	1	1	0	1	1	1	1	0.63	1
	Faunal Characteristics	Benthic community	0.6	1	1	0	0.5	1	0	0	1	0	0	1	0.5	0.33	11
		Fish community	1	1	1	0	0.5	1	1	0	1	0.5	0	1	0.5	0.35	9
		Mussels community	0.6	1	1	1	0.5	0.6	1	0	1	0	0	1	0.5	0.34	10
		Predatory birds & mammals	1	1	1	0	0.5	0.6	0.5	0	1	1	1	0.5	0.5	0.42	8
		SAR (1 fish & 1 mussel)	1	1	1	0	0.5	0.3	0	1	0	0	0	1	0.5	0.52	4
		Invasive sp abundance and distribution	0.6	0	1	0	0.5	0.6	0	0	0	0.5	0	1	0.5	0.26	13

Appendix IV - Habitat conservation guidelines from Environment Canada (2013)

Table 1. Summary of Wetland, Riparian, Forest and Grassland Habitat Guidelines

Parameter	Guideline
Wetland Habitat	
Percent wetlands in the watershed and subwatersheds	Ensure no net loss of wetland area, and focus on maintaining and restoring wetland functions at a watershed and subwatershed scale based on historic reference conditions. At a minimum, the greater of (a) 10% of each major watershed and 6% of each subwatershed, or (b) 40% of the historic watershed wetland coverage, should be protected and restored.
Wetland location in the watershed	Wetlands can provide benefits anywhere in a watershed, but particular wetland functions can be achieved by rehabilitating wetlands in key locations, such as headwater areas (for groundwater discharge and recharge), floodplains and coastal wetlands. Consideration should also be given to protecting networks of isolated wetlands in both urban and rural settings.
Amount of natural vegetation adjacent to the wetland	Critical Function Zones should be established around wetlands based on knowledge of species present and their use of habitat types. Protection Zones should protect the wetland attributes from stressors. Recommended widths should consider sensitivities of the wetland and the species that depend upon it, as well as local environmental conditions (e.g., slopes, soils and drainage), vegetative structure of the Protection Zone, and nature of the changes in adjacent land uses. Stressors need to be identified and mitigated through Protection Zone design.
Wetland proximity	Wetlands that are in close proximity to each other, based on their functions, or that are in close proximity to other natural features, should be given a high priority in terms of landscape planning.
Wetland area, shape and diversity	Capture the full range of wetland types, areas and hydroperiods that occurred historically within the watershed. Swamps and marshes of sufficient size to support habitat heterogeneity are particularly important, as are extensive swamps with minimum edge and maximum interior habitat to support area-sensitive species.
Wetland restoration	Focus on restoring marshes and swamps. Restore fens under certain conditions. For effective restoration, consider local site conditions, have local sources to propagate new vegetation, and wherever possible refer to historic wetland locations or conditions. Prioritize headwater areas, floodplains and coastal wetlands as restoration locations.
Riparian Habitat	
Width of natural vegetation adjacent to stream	Both sides of streams should have a minimum 30-metre-wide naturally vegetated riparian area to provide and protect aquatic habitat. The provision of highly functional wildlife habitat may require total vegetated riparian widths greater than 30 metres.
Percent of stream length naturally vegetated	75% of stream length should be naturally vegetated.

How Much Habitat is Enough? 13

Parameter	Guideline
Percent of an urbanizing watershed that is impervious	Urbanizing watersheds should maintain less than 10% impervious land cover in order to preserve the abundance and biodiversity of aquatic species. Significant impairment in stream water quality and quantity is highly likely above 10% impervious land cover and can often begin before this threshold is reached. In urban systems that are already degraded, a second threshold is likely reached at the 25 to 30% level.
Forest Habitat	
Percent forest cover	30% forest cover at the watershed scale is the minimum forest cover threshold. This equates to a high-risk approach that may only support less than one half of the potential species richness, and marginally healthy aquatic systems; 40% forest cover at the watershed scale equates to a medium-risk approach that is is likely to support more than one half of the potential species richness, and moderately healthy aquatic systems; 50% forest cover or more at the watershed scale equates to a low-risk approach that is likely to support most of the potential species, and healthy aquatic systems.
Area of largest forest patch	A watershed or other land unit should have at least one, and preferably several, 200-hectare forest patches (measured as forest area that is more than 100 metres from an edge).
Forest shape	To be of maximum use to species such as forest breeding birds that are intolerant of edge habitat, forest patches should be circular or square in shape.
Percent of watershed that is forest cover 100 m from forest edge	The proportion of the watershed that is forest cover and 100 metres or further from the forest edge should be greater than 10%.
Proximity to other forested patches	To be of maximum use to species such as forest birds and other wildlife that require large areas of forest habitat, forest patches should be within two kilometres of one another or other supporting habitat features. "Big Woods" areas, representing concentrations of smaller forest patches as well as larger forest patches, should be a cornerstone of protection and enhancement within each watershed or land unit.
Fragmented landscapes and the role of corridors	Connectivity width will vary depending on the objectives of the project and the attributes of the forest nodes that will be connected. Corridors designed to facilitate species movement should be a minimum of 50 to 100 metres in width. Corridors designed to accommodate breeding habitat for specialist species need to meet the habitat requirements of those target species and account for the effects of the intervening lands (the matrix).
Forest quality – species composition and age structure	Watershed forest cover should be representative of the full diversity of naturally occurring forest communities found within the ecoregion. This should include components of mature and old growth forest.

Appendix V - Maps showing the current spatial pattern of the different parameters of the Landscape change measure in each natural ecosystem of the Rouge National Urban Park, based on the 2013/15 ELC database.

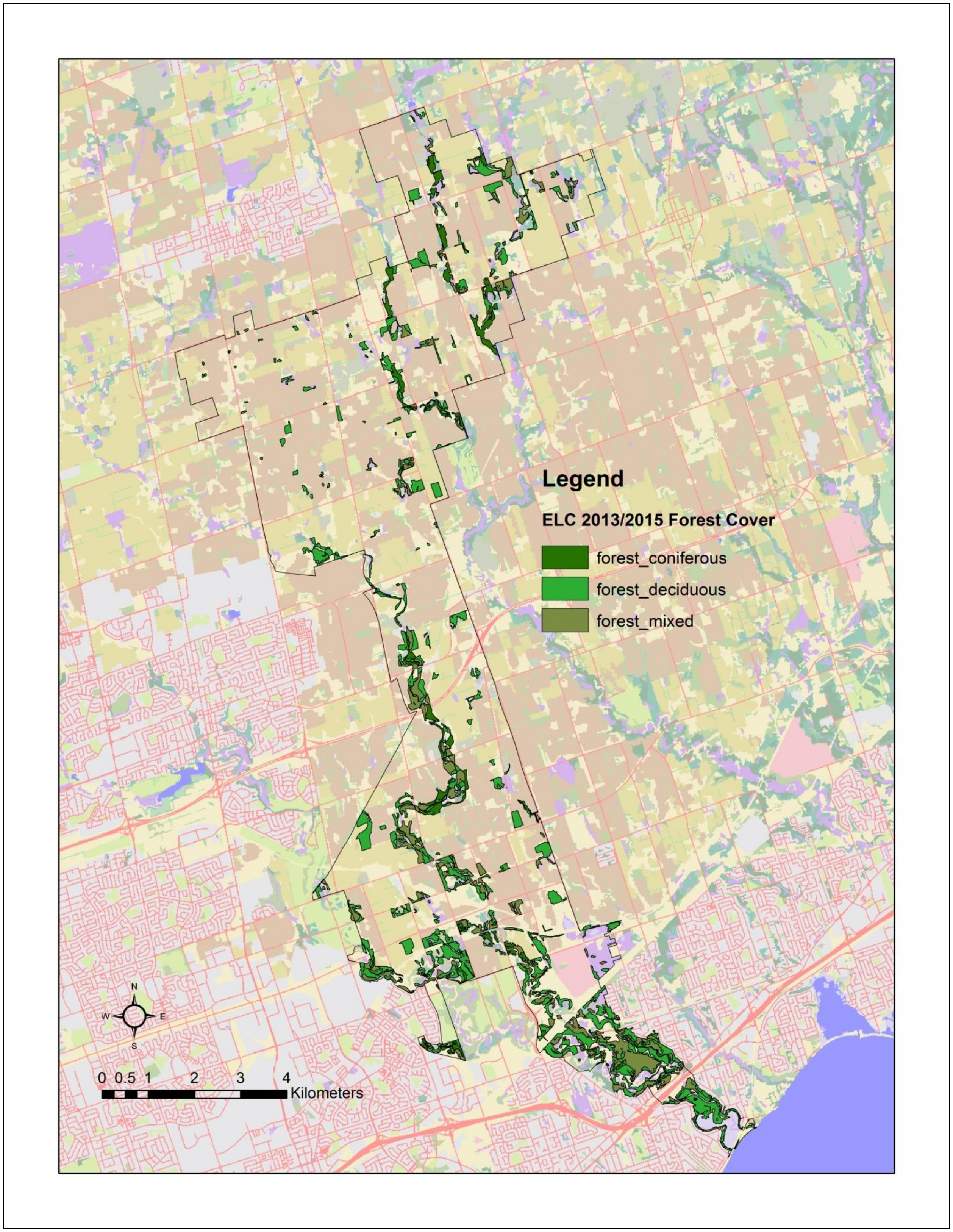


Figure A.1: Pattern in total forest amount.

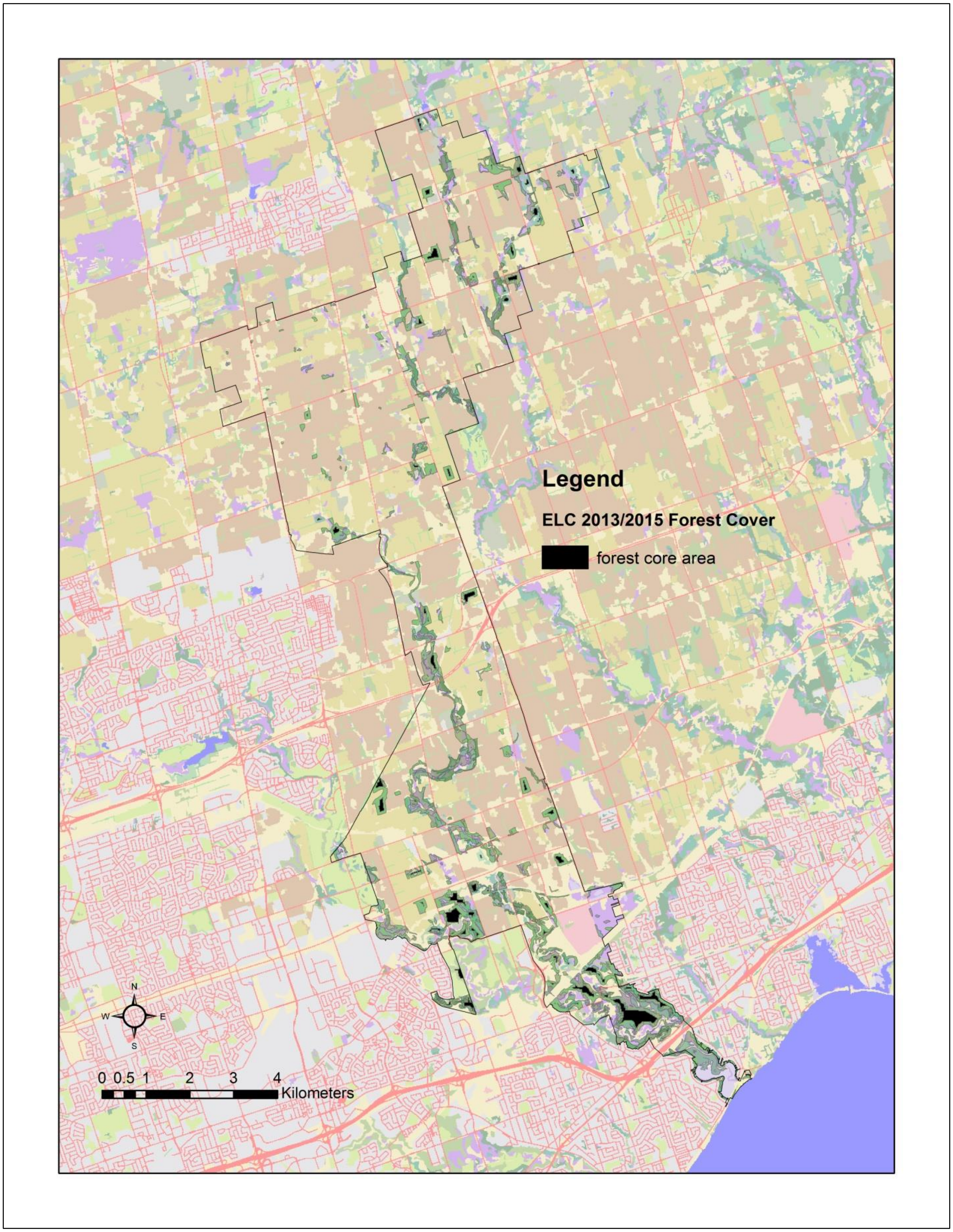


Figure A.2: Pattern in total forest core area.

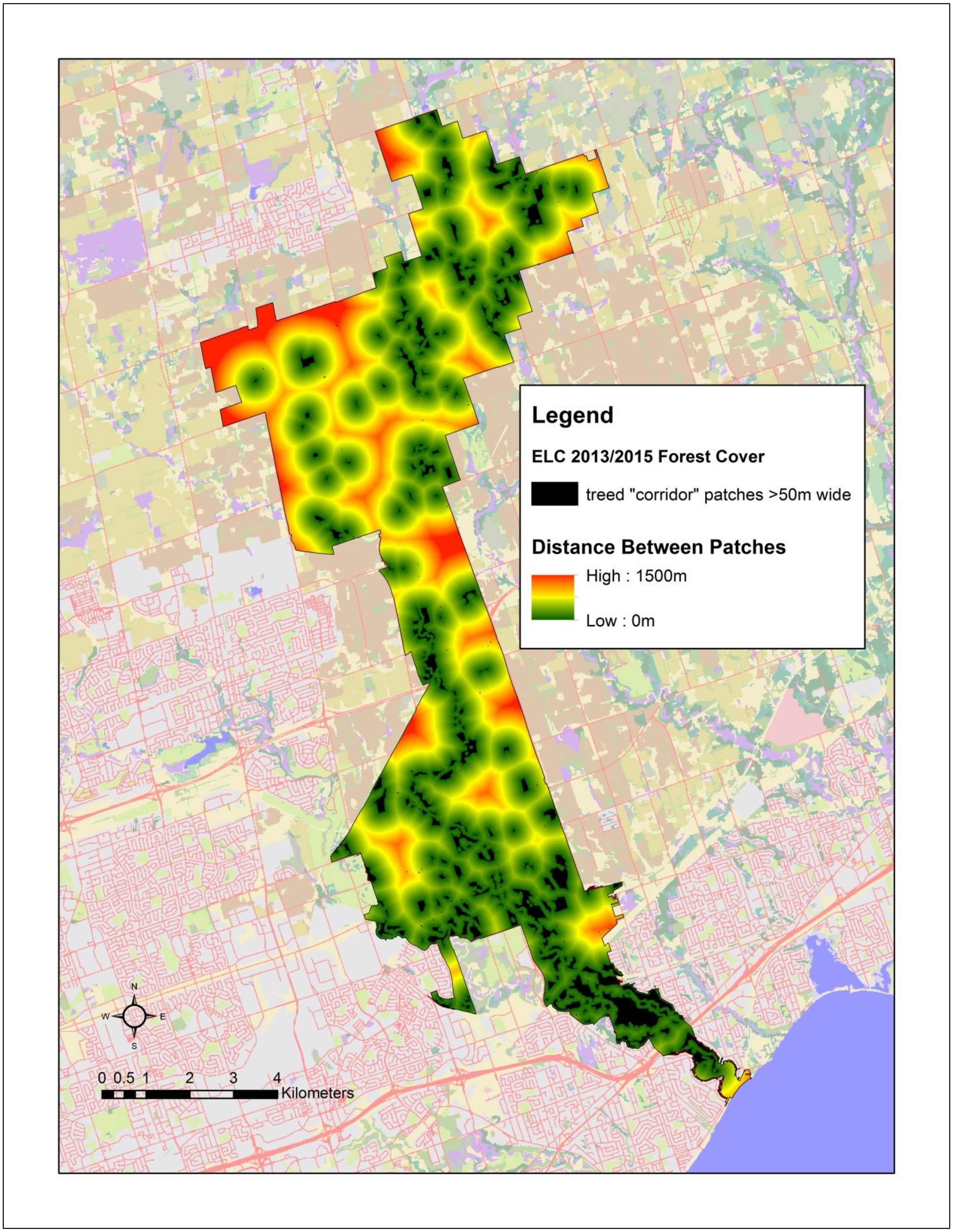


Figure A.3: Pattern in distance between forest patches, linked with ≥50 m wide corridors.

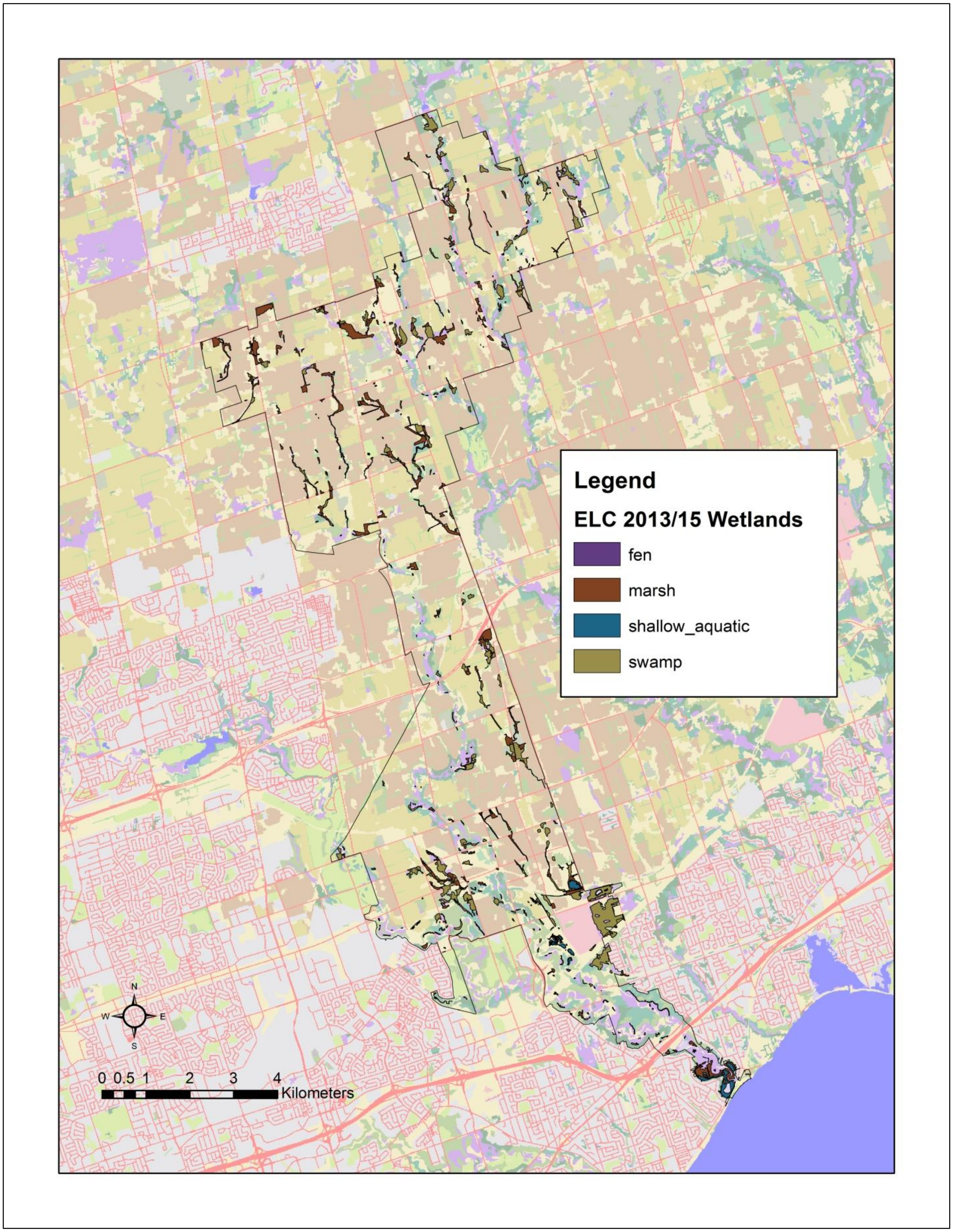


Figure A.4: Pattern in total wetland amount.

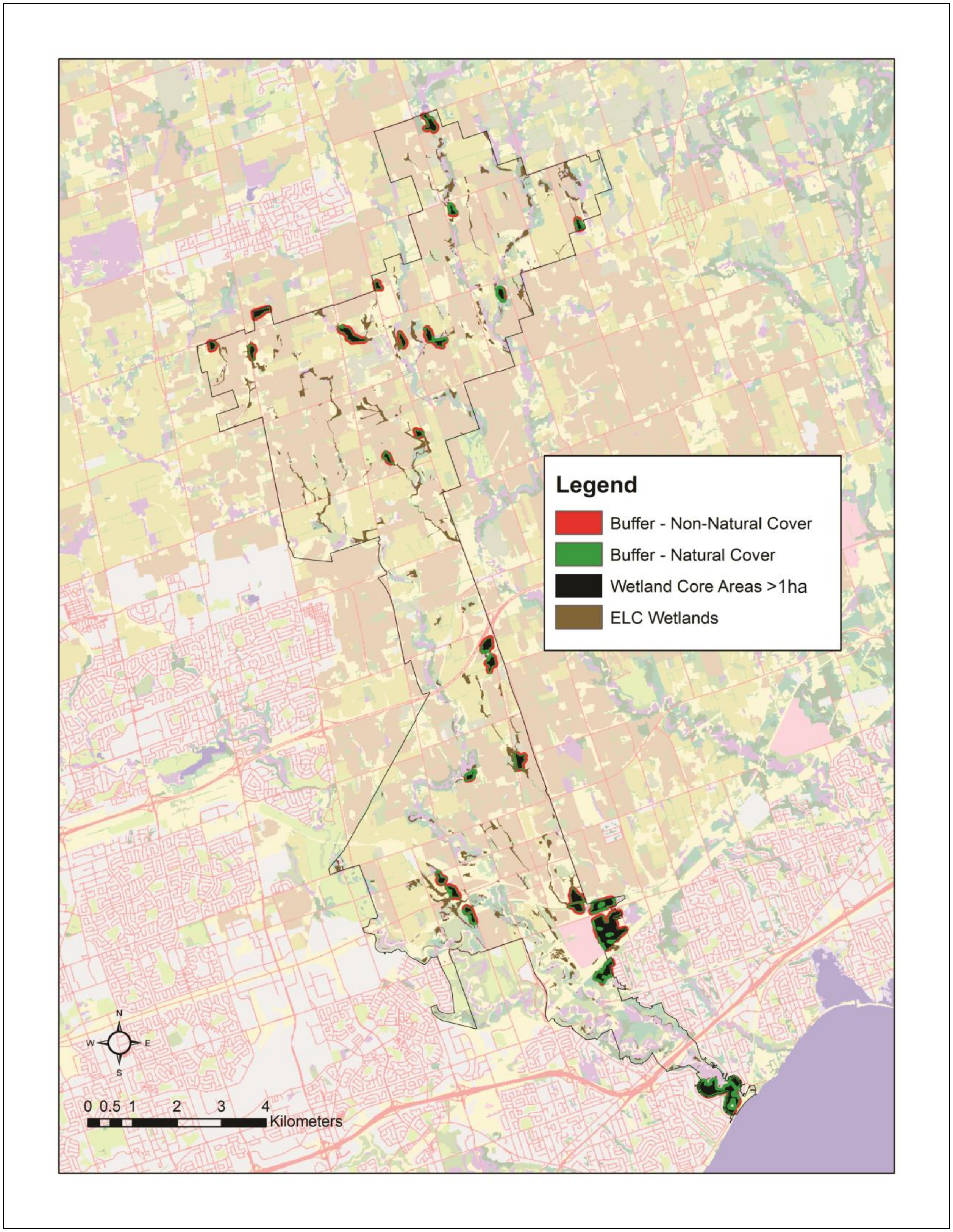


Figure A.5: Pattern in natural cover intersecting wetland core areas within a 50m buffer

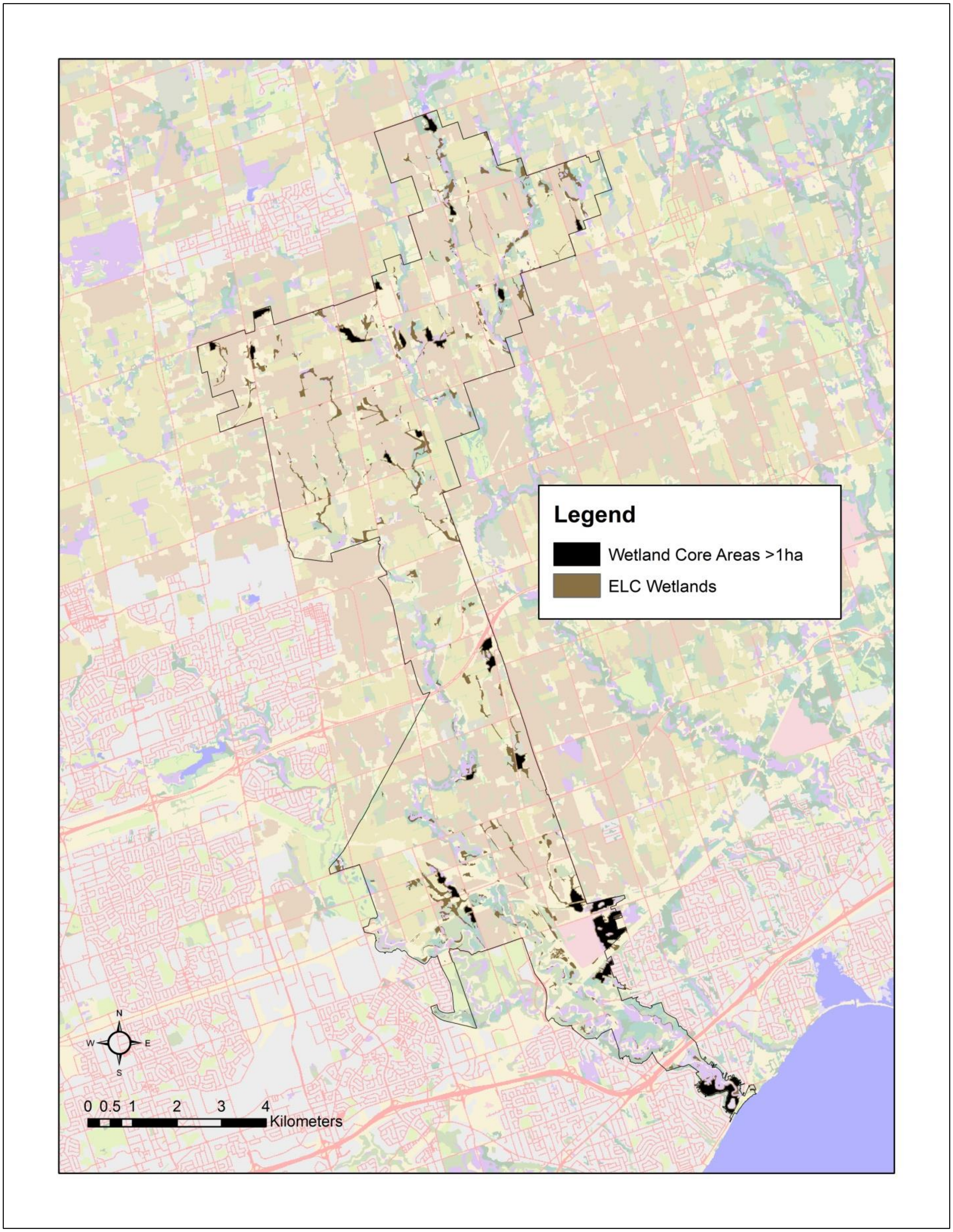


Figure A.6: Pattern in total amount of wetland core area.

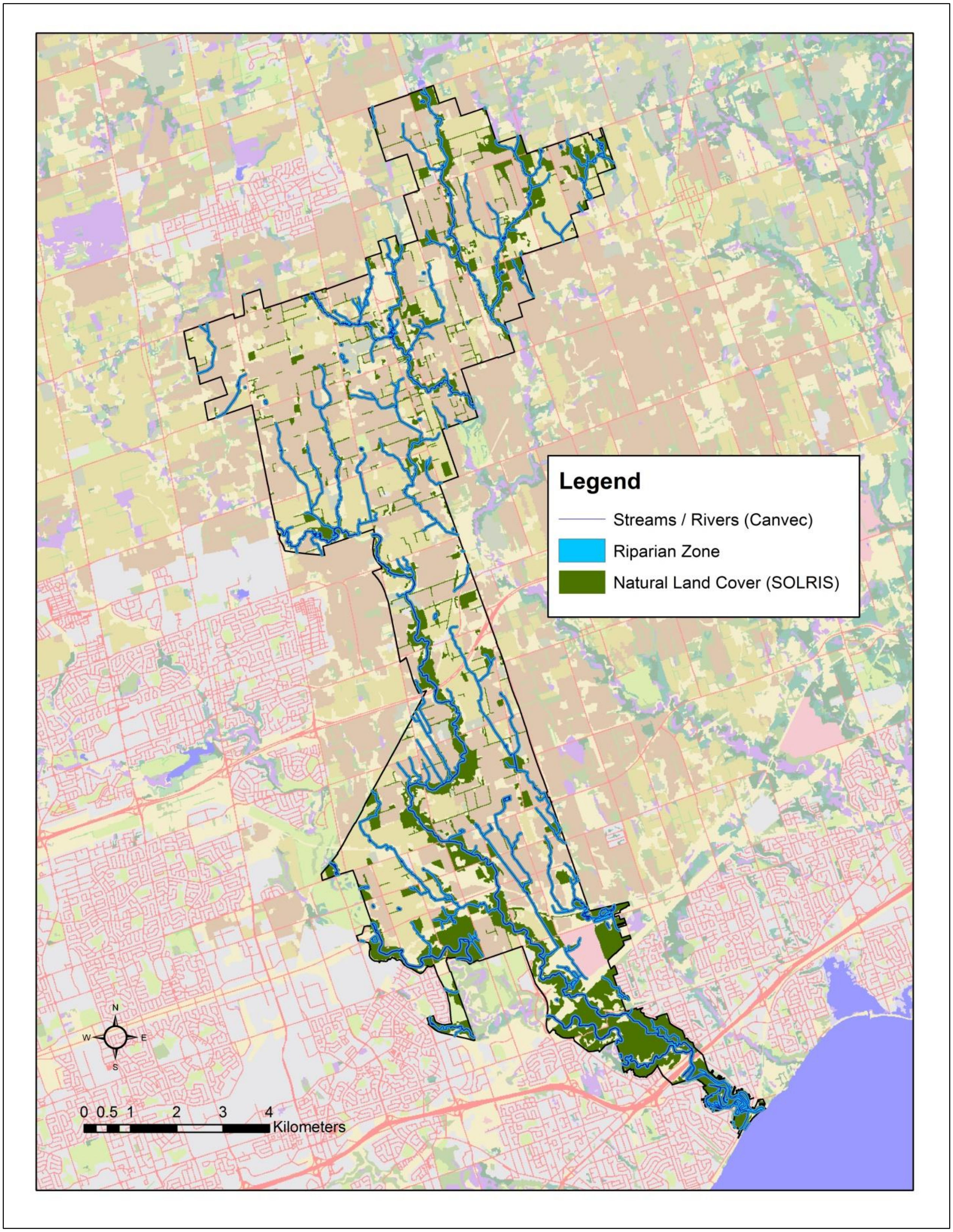


Figure A.7: Pattern in natural riparian vegetation and stream length naturally vegetated.

Appendix VI - Proportion of surface area of detailed stand types within each general stand type category found in the forest ecosystem of the park.

General stand types*	Detailed stand types	% of surface area
Dry-Fresh Deciduous	Dry-Fresh Hawthorn - Apple Deciduous	23.3%
	Dry-Fresh White Ash Deciduous	23.0%
	Dry-Fresh Poplar Deciduous	21.5%
	Dry-Fresh Beech Deciduous	14.1%
	Dry-Fresh Oak - Hardwood Deciduous	12.1%
	Dry-Fresh Manitoba Maple Deciduous	2.8%
	Dry-Fresh Basswood Deciduous	1.7%
	Dry-Fresh White Oak Deciduous	0.9%
	Dry-Fresh Norway Maple Deciduous	0.5%
Dry-Fresh Sugar-Maple**	Dry-Fresh Sugar Maple - Oak Deciduous**	34.4%
	Dry-Fresh Sugar Maple Deciduous**	29.9%
	Dry-Fresh Sugar Maple - Beech Deciduous**	19.7%
	Dry-Fresh Sugar Maple - White Ash Deciduous	5.9%
	Dry-Fresh Sugar Maple - Black Cherry Deciduous	2.7%
	Dry-Fresh Sugar Maple - Basswood Deciduous	1.8%
	Dry-Fresh Sugar Maple - Hickory Deciduous	1.4%
	Dry-Fresh Sugar Maple - Red Maple Deciduous	1.3%
	Dry-Fresh Sugar Maple - Ironwood Deciduous	1.2%
	Dry-Fresh Sugar Maple - Paper Birch - Poplar Deciduous	0.9%
	Dry-Fresh Sugar Maple - Norway Maple Deciduous	0.4%
	Dry-Fresh Sugar Maple - Hawthorn Deciduous	0.4%
Fresh-Moist Deciduous	Fresh-Moist Poplar Deciduous	66.0%
	Fresh-Moist Oak - Sugar Maple Deciduous	21.6%
	Fresh-Moist Oak - Lowland Maple Deciduous	3.0%
	Fresh-Moist Bur Oak Deciduous	2.6%
	Fresh-Moist Bitternut Hickory Deciduous	2.4%
	Fresh-Moist Oak - Beech Deciduous	2.4%
	Fresh-Moist Red Oak - Ash Deciduous	1.1%
	Fresh-Moist Paper Birch Deciduous	0.9%
Fresh-Moist Lowland Deciduous	Fresh-Moist Willow Lowland Deciduous	40.3%
	Fresh-Moist Manitoba Maple Lowland Deciduous	32.8%
	Fresh-Moist Ash Deciduous	15.3%
	Fresh-Moist White Elm Lowland Deciduous	2.8%
	Fresh-Moist Hawthorn - Apple Deciduous	2.8%
	Fresh-Moist Exotic Lowland Deciduous	2.4%
	Fresh-Moist Basswood Lowland Deciduous	2.1%
	Fresh-Moist Black Walnut Lowland Deciduous	1.3%
	Fresh-Moist Black Maple Lowland Deciduous	0.2%

General stand types*	Detailed stand types	% of surface area
Fresh-Moist Mixed**	Fresh-Moist Sugar Maple - Hemlock Mixed**	31.7%
	Fresh-Moist White Cedar - Hardwood Mixed**	24.8%
	Fresh-Moist White Cedar - Sugar Maple Mixed**	19.4%
	Dry-Fresh Hardwood - Hemlock Mixed	6.0%
	Dry-Fresh White Pine - Sugar Maple Mixed	4.1%
	Dry-Fresh White Pine - Oak Mixed	2.5%
	Dry-Fresh Hemlock - Sugar Maple Mixed	2.1%
	Dry-Fresh White Cedar - Hardwood Mixed	1.8%
	Fresh-Moist Hemlock - Hardwood Mixed	1.7%
	Fresh-Moist White Pine - Sugar Maple Mixed	1.7%
	Dry-Fresh Poplar Mixed	1.0%
	Dry-Fresh White Pine - Hardwood Mixed	1.0%
	Fresh-Moist Ash Mixed	0.7%
	Dry-Fresh White Cedar - Paper Birch Mixed	0.7%
	Fresh-Moist Poplar Mixed	0.6%
	Dry-Fresh White Cedar - Poplar Mixed	0.2%
	Fresh-Moist Paper Birch Mixed	0.2%
Fresh-Moist Sugar-Maple	Fresh-Moist Sugar Maple - Hardwood Deciduous	58.4%
	Fresh-Moist Sugar Maple - Black Maple Deciduous	20.8%
	Fresh-Moist Sugar Maple - Ash Deciduous	19.1%
	Fresh-Moist Sugar Maple - Yellow Birch Deciduous	1.1%
	Fresh-Moist Sugar Maple - White Elm Deciduous	0.6%
White Cedar, Pine & Hemlock	Fresh-Moist White Cedar Coniferous	54.9%
	Dry-Fresh White Cedar Coniferous	19.0%
	Fresh-Moist White Cedar - White Pine Coniferous	9.4%
	Fresh-Moist White Cedar - Hemlock Coniferous	7.8%
	Fresh-Moist Hemlock - White Pine Coniferous	4.3%
	Fresh-Moist Hemlock Coniferous	2.4%
	Dry-Fresh White & Red Pine Coniferous	2.2%

* Plantations, hedgerows, thickets and exotic woodlands were excluded from this classification.

**Stand types recommended to be included in the sampling design

Appendix VII - List and number of ecological integrity indicators in monitoring program of national parks as indicated in the ICE registry on September 11th 2015.

Region	Park	Indicators										
		Freshwater	Forest	Tundra/Barrens	Wetlands	Coastal	Grasslands	Coastal/marine	Shrublands	Glaciers	Marine	Total
Québec/Atlantique	Cape Breton Highlands	X	X		X							3
	Forillon	X	X					X				3
	La Mauricie	X	X		X							3
	Kejimkujik	X	X		X	X						4
	Sable Island	X				X						2
	Mingan-Archipelago		X	X		X						3
	Terra Nova	X	X		X			X				4
	Gros Morne	X	X	X								3
	Kouchibougouac	X	X			X						3
	Prince Edward Island	X	X		X	X						4
	Fundy	X	X		X							3
Great Lakes	Bruce Peninsula	X	X						X			3
	Georgian Bay Islands		X		X	X						3
	Thousand Islands	X	X		X							3
	Pukaskwa	X	X			X						3
	Point Pelee		X		X	X						3
Interior Plains	Elk Island	X	X				X					3
	Prince Albert	X	X				X					3
	Riding Mountain	X	X				X					3
	Grasslands	X					X		X			3
	Wood Buffalo	X	X		X							3
Montane	Banff	X	X	X								3
	Jasper	X	X	X								3
	Kootenay	X	X	X								3

Region	Park	Indicators										
		Freshwater	Forest	Tundra/Barrens	Wetlands	Coastal	Grasslands	Coastal/marine	Shrublands	Glaciers	Marine	Total
Pacific Coast	Yoho	X	X	X								3
	Glacier	X	X	X								3
	Mount Revelstoke	X	X	X								3
	Waterton	X	X				X					3
	Gulf Islands	X	X					X				3
	Pacific Rim	X	X					X				3
	Gwaii Haanas	X	X			X						3
North	Wapusk				X	X						2
	Torngats Mountains	X		X								2
	Auyuittuq			X						X		2
	Quttinirpaaq	X		X								2
	Sirmilik			X						X		2
	Ukkusiksalik			X							X	2
	Nahanni	X	X	X								3
	Aulavik	X		X								2
	Ivvavik	X		X								2
	Tuktut Nogait	X		X								2
	Kluane	X	X	X								3
	Vuntut			X	X							2