PART 3: Monitoring at the Landscape Level

Evaluating Regional Environmental Monitoring Programs: An Ecosystem Approach Applied to South-central Ontario, Canada

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Abstract

Environmental monitoring programs need to be coordinated over regional spatial scales to produce long term records that can be effectively used in landscape management. In south-central Ontario there are a number of agencies that are developing these types of programs with a goal of using the monitoring to assess the effectiveness of their conservation management strategies. Land managers such as the Niagara Escarpment Commission (ONE monitoring program) and Credit Valley Conservation (Integrated Watershed Monitoring Program) are challenged by the escalating pressure on species of concern and biodiversity loss within the urbanizing landscape. An assessment of environmental biodiversity-based monitoring programs was initiated that encompassed the boundaries of regional government, biosphere reserves and watersheds administered by conservation authorities. These programs ranged from local naturalist clubs monitoring bird species to those with an international focus such as the SIMAB forest biodiversity program. Three criteria were considered important when assessing the success and gaps of the regional monitoring programs from an ecological perspective: a) the degree of representation of ecological components, structure and processes, b) the spatio-temporal pattern of monitoring plots and sampling periods, and c) the characteristics of management and issues-related programs. The results suggest that there is limited monitoring of indicator species, a limited range of species and habitats monitored, few programs monitoring ecosystem processes, a concentration of monitoring along the Niagara Escarpment and limited coordination among agencies,

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Citation: Milne, R.J. and L.P. Bennett. 2007. Evaluating Regional Environmental Monitoring Programs: An Ecosystem Approach Applied to South-central Ontario, Canada Paper presented at the "Monitoring the Effectiveness of Biological Conservation" conference, 2-4 November 2004, Richmond, BC. Available at: http://www.forrex.org/events/mebc/papers.html

Notes: This paper has been peer reviewed prior to posting.

even where interests overlap. It is recommended that: 1) all monitoring programs begin with a discerning research question to guide data collection, 2) that process level ecological data is collected where possible, 3) that the spatial and temporal scale of monitoring programs reflect the scale of the affected ecological system and 4) that co-ordination and cooperation among agencies and other monitoring groups be strengthened.

Effectiveness and Regional Monitoring

Environmental management of planning units at the regional scale requires embracing a strong ecological foundation. There has been a growth in holistic planning at the regional scale as is evident in North America by large watershed projects (Graham et al. 2000), regional vulnerability assessment programs (REVA) (Smith 2000), and Greenbelt strategies (e.g., OMAH 2004). These strategies tout the principles of biological conservation and have a base in landscape ecology engaging concepts such as corridors and fragmentation. We are now entering a phase where these monitoring programs are being reviewed and need to be assessed on their ability to effect change. To monitor the effectiveness of these regional eco-political management systems requires a regional monitoring program that provides a baseline to measure change in the ecosystem. Long-term data sets supply this information of change and allow for the assessment of specific programs and policy success. This has been especially evident in areas of climate change, ozone fluctuations, and land use and wildlife (Peterson 2000; Greenwood 2003).

The establishment and maintenance of a monitoring program becomes increasingly difficult as the regional scale is approached. At the site level, monitoring programs are usually focused on a single indicator or a few plots which can more easily be supported financially and voluntarily by a single agency or an environmental non-government organization (ENGO). In comparison, at the regional scale the framework expands exponentially as suites of indicators are employed to capture the holistic changes within the ecosystem. These scalar differences are also evident in effectiveness monitoring programs. For instance, effectiveness monitoring is an important component of the Environmental Impact Assessment (EIA) process to measure the success of project mitigation (e.g., site rehabilitation) (Wilson 1998). Impact auditing or follow-up can be applied at the local level to fulfill the obligations of a proponent following the guidelines of an environmental assessment (Ramjeawon and Beedassy 2004). However, at the regional scale, the effectiveness of transboundary, multi-jurisdictional programs are difficult to determine because of the logistics of organizing all parties (Graham et al. 2000) or in properly structuring and maintaining the program (Innes 1998; Ferretti and Chiaruzzi 2003; Bennett and Milne 2004). Regional plans can also have a monitoring component to assess the long-term success of environmental strategies and are often incorporated as part of the review process (OMEE 1994; CVC 2003)

Environmental monitoring programs can include combinations of target indicators, measuring some index of environmental ‘health’, ‘integrity’ or ‘quality’ (e.g. Barbour et al. 2000; Paul 2003). It is proposed that monitoring programs should be designed to capture the framework of ecosystems or, in other words, the ‘components’, ‘structure’ and ‘process’ of ecosystems (Slocombe 1998). A successful monitoring program requires the tracking of ecosystem change and the processes that initiate and direct these events.

Components (e.g. species) alone can not provide the information on impact response needed in determining the dynamics of change (Moss and Milne 1998). For instance, measures of the rate of wildlife reproduction or forest canopy cover dieback will provide a stronger assessment of ecosystem health than a measure of species densities. Similarly, exchanges through ecosystem structures, both spatially and temporally, such as predator-prey dependencies or nutrient flow should be measured to identify change in ecosystem linkages.

This paper investigates these concepts by presenting as a case study the framework and spatial pattern of overlapping regional monitoring programs for an area on the western edge of the Greater Toronto Area (GTA). In this region, there are several forms of regional management including the Niagara Escarpment Biosphere Reserve, a management zone that has at the core a biosphere reserve. This area is surrounded by the drainage basin of several watersheds, managed in Ontario as Conservation Authorities. These include Conservation Halton and Credit Valley Conservation. Bird Studies Canada is directing a Forest Bird Monitoring Program and Marsh Monitoring Program in the area. A number of local Naturalists Clubs and the Bruce Trail Association are also involved in monitoring programs. An inventory of all terrestrial monitoring programs has been undertaken. For this study, only those programs directly related to the biological component of the terrestrial systems, including wildlife and vegetation populations, were examined. The goals of the programs were assessed within an ecological framework from which gaps and recommendations were then derived.

Regional Monitoring in South-Central Ontario

Several agencies within the study region have developed strategies and structures for regional monitoring. To date, the Niagara Escarpment Commission and Credit Valley Conservation have formulated working frameworks, while other regional agencies are in various stages of developing monitoring programs.

The Ontario Niagara Escarpment (ONE) Monitoring Program was initiated in 1995 to bring together monitoring information and aid in assessing the cumulative effects of landscape change on the Niagara Escarpment (Milne et al. 2000b). This will assist future decisions on land use management and policy directives and provide the information for assessment of the Niagara Escarpment Commission plan during the 10 year review process. The ONE program centres on an ecosystem-based approach to planning, focusing on several concerns including terrestrial ecology, water, recreation, open landscape character, land use and public access. The nature of the information to be collected is dictated by planning questions. For example, the terrestrial ecology objective would include questions regarding ecosystem processes and wildlife habitat related to regeneration of abandoned fields, aggregate pits and so on.

Credit Valley Conservation established the Integrated Watershed Monitoring Program (IWMP) in 1999 to determine the progress of conserving the health and sustainability of the Credit River watershed and to assist managers in adaptive management. The main goals of this program are to protect water quality and quantity. However, it is realized that water quality and quantity are determined by terrestrial conditions and impacted by land use changes. The IWMP focuses on a diverse range of monitoring parameters that are indicators of ecosystem health and detect environmental changes, spatially and temporally.

One component of the IWMP is the Terrestrial Monitoring Program which identifies ecosystem indicators at three scales: landscape, community and species. Landscape level indicators measure the composition, structure and function of natural patches within the landscape mosaic, while at the community level specific habitats are monitored by recording the suite of species present. There are strong linkages between upland forest, wetland and riparian systems and the biological components of these habitats provide integrative indicators of the health of the watershed. The monitoring program recognizes the immediate linkages and couples wildlife with land unit. For example, birds are monitored with upland forests, frogs with wetlands and fish with riparian systems.

Assessing Monitoring Programs

A review of the effectiveness of monitoring programs to provide ecological and spatial coverage and measure ecological change was conducted for a region of southern Ontario that included the lands north of the west end of Lake Ontario. This included the watersheds of the Credit and Halton regions (Figure 1). The monitoring was primarily conducted by government or volunteers from ENGOs. Data were collected by interviewing all agencies and individuals involved in biological monitoring in the designated study area. These included the Niagara Escarpment Commission, Credit Valley Conservation, Conservation Halton, Bird Studies Canada (Forest Bird Monitoring Program and Marsh Monitoring Program) and several ENGOs including Naturalists Clubs and the Bruce Trail Association.

Three criteria were considered when assessing the success and gaps of these monitoring programs: a) the degree of representation of ecological components, structure and processes, b) the spatio-temporal pattern of monitoring plots and sampling periods, and c) the characteristics of management and issues-related programs.

The assessment was initiated by classification of the various programs on the basis of their level of ecological monitoring as follows:

- Species or Ecosystem Composition– some possible considerations are indicator species and species at risk
- Community or Ecosystem Structure – commonly measured as all species within one habitat
- Process or Ecosystem Function – measurements of exchanges, fluxes, etc. such as stem dieback

The location of all monitoring plots were ascertained and mapped. Examples are presented in the following section of this paper.

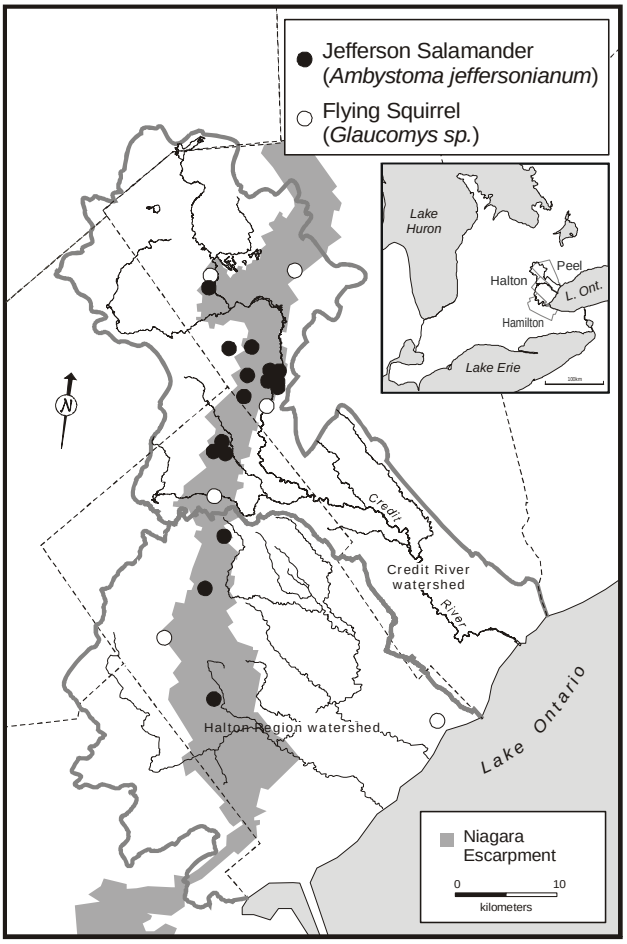

Figure 1: Species-level monitoring (ecosystem composition). These species-level studies are generally limited to unique habitats along the Niagara Escarpment.

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Results

Monitoring Species or Ecosystem Composition

Examples

One of the rudimentary forms of terrestrial ecology monitoring is to observe the changes in a particular species or suite of species such as indicator or keystone species or in general focal species (Simberloff 1998; Zacharias and Roff 2001). A change in a focal species population will provide the most direct response to environmental change. In this

study region, target species programs were limited. Example(s) of this type of monitoring includes Jefferson Salamander (*Ambystoma jeffersonianum*) which was first mapped in Ontario in the 1970s and was found to have a limited range along the central Escarpment (see Figure 1). Consequently, increased land use pressure has threatened this population leading to its recognition by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) as threatened in 2000. In response, this species was re-investigated in 2003-2004 to determine if its range has decreased.

Another recent species-specific project concerns Northern and Southern Flying Squirrel (*Glaucomys sabrinus* and *G. volans* respectively). A catch and release program was initiated for six sites within this study area in 2004-2005. This project is investigating the status of these species to determine if habitat loss and forest fragmentation is impacting on their ranges. From the map (Figure 1), it is apparent that these species-level studies are generally limited to unique habitats along the Niagara Escarpment.

Monitoring Gaps
There were few programs that have been developed to use indicator species for long-term monitoring. CVC recognizes a suite of species (Species of Conservation Concern) (Milne et al. 2000a) but they are only considered within larger programs of the habitat type as described below and are not target monitoring programs. Species-specific monitoring is usually initiated in response to a specific issue or conflict, especially land use development. Presently lacking are programs that target focal species. These types of programs can be facilitated by volunteer groups since the identification skill levels can be quickly mastered and are not usually time-demanding.

Monitoring Community or Ecosystem Structure

Examples
Many terrestrial monitoring programs are based on the collection of data for a community or suite of species, usually building on the relationship exhibited between guilds and habitat type (e.g. Canterbury et al. 2000). In this area, these programs were dominated by several habitat-specific studies in which species presence, and in some cases abundance are measured. These included larger regional programs such as the Forest Bird Monitoring Program and the Marsh Monitoring Program of Bird Studies Canada (Bradshaw and Dunn 1997; Schalk et al. 2002).

The Forest Bird Monitoring Program addresses the concern for the continental decline of birds in forested uplands from impacts such as forest fragmentation and parasitism. There are over 30 volunteer plots within the study area and the Niagara Escarpment Plan. There are another 26 plots administered by CVC that are distributed between each of their subwatersheds, providing representative coverage of this section of the region (see Figure 2). In comparison, there are only a handful of sites for the Marsh Monitoring Programs where birds are included in the observations. These sites are found in the north and near the shores of Lake Ontario.

In the IWMP, wildlife monitoring is coupled with monitoring of forest communities at the same site. The forest bird plots overlay Smithsonian Institute, Man and the Biosphere Program (SIMAB) Forest Plots (Dallmeier 1992). Within these plots, a number of vegetation attributes are recorded every five years with the focus on forest tree species. There are several 1ha plots located on the Escarpment and six located within the Credit

River valley. Twenty smaller 20 x 20 m plots have also been established in the CVC region and each of these sites is paired with a forest bird plot.

Monitoring Gaps
Avian populations have been the primary focus of many monitoring programs. This reflects the strength of volunteer programs such as the Forest Bird Monitoring Program and the popularity of bird watching (or 'birding') and participation in similar programs such as the Ontario Breeding Bird Atlas (Cadman et al. 1987) and Christmas Bird Counts.

There has been an increase in interest in monitoring amphibians. Projects by the ONE program and CVC are increasing the knowledge of frogs and salamanders in this region. These projects, combined with volunteer programs such as Frogwatch, a program administered by EMAN (Ecological Monitoring and Assessment Network, Environment Canada), provide an increasing spatial coverage of this region.

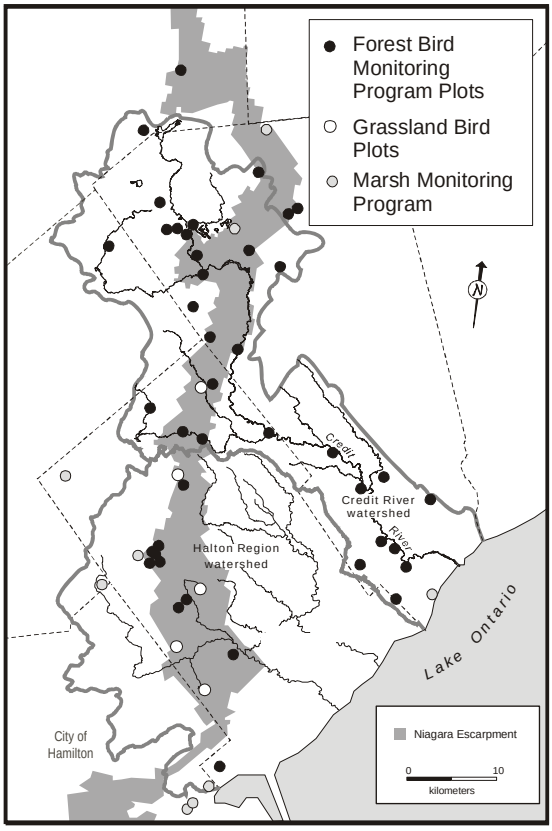

Figure 2: Community monitoring (ecosystem structure). These studies generally focus on habitat-specific programs in which species presence, and in some cases, abundance are measured.

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The gaps exist in the coverage of other terrestrial species. There has been little consideration of mammal populations in this region or with insect groups such as butterflies and dragonflies. There are also gaps in the variety of habitat monitored. Programs have generally been directed at upland forests, with a heavy concentration of avian plots in upland forest on the Niagara Escarpment and Credit River system. The Marsh Monitoring Program is poorly represented in this region (see Figure 3). There are few sites on the Escarpment and in the urban regions of the watersheds. An additional volunteer program designed to monitor avian populations in grassland areas however, was discontinued because of the loss of monitoring sites to development (B. McIlveen, pers. comm.).

Monitoring Process or Ecological Function

Examples
There are few projects monitoring terrestrial indicators of ecological processes, i.e., those that go beyond species composition and community structure. Examples include a pilot project focused on bird productivity on the Niagara Escarpment (see Figure 3). This measured the nesting success of several forest interior species, such as Wood Thrush and Rose-breasted Grosbeak, to provide a better knowledge of turnover rates and the importance of metapopulations as a source for regional bird populations (Friesen et. al., 1999).

Indicators of forest health are being measured at the sites where SIMAB forest plots have been established, including stem defects, canopy dieback and crown and stem status and mortality. These measurements focus on the rate of forest dynamics in response to atmospheric changes such as acid rain and ground-level ozone.

Monitoring Gaps
It is difficult to assess gaps since there are few programs centring on ecological processes. The bird productivity study which provided background into metapopulations on the Escarpment was discontinued. The recent establishment of forest plots through the IWMP has provided the opportunity to consider the response of wildlife populations to vegetation change. A similar opportunity exists to establish relationships for wetland species through the marsh vegetation and amphibian plots in CVC watershed. This type of monitoring needs to be extended beyond the boundaries of the Credit River watershed.

Discussion

The results reveal a number of gaps that limit the effectiveness of regional monitoring programs for this part of south-central Ontario (Table 1). This area has several of the stronger monitoring programs in Ontario and therefore these problems can be projected across the rest of the province. Firstly, there needs to be a stronger consideration of the questions that the monitoring program is endeavouring to answer. This is the first step in creating a program specifically tailored to address environmental concerns. It is the questions that should guide data collection rather than the other way around as monitoring for the sake of monitoring creates questions, not answers. It was not clear that all monitoring projects in the study area were guided by research questions.

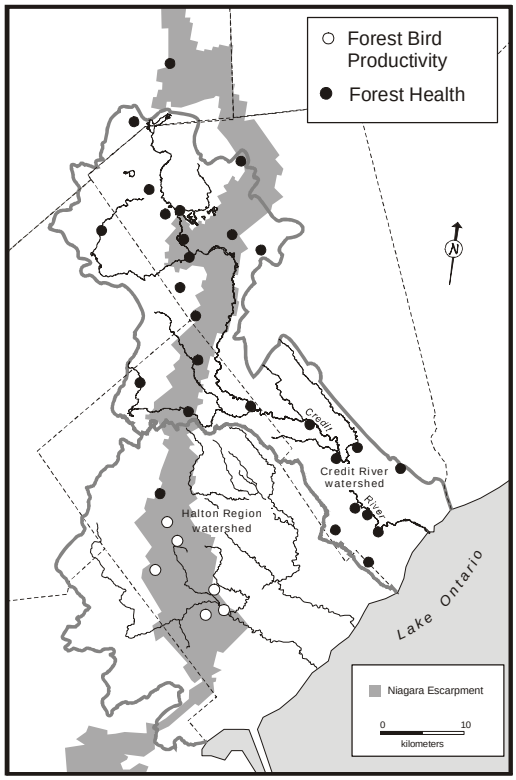

Figure 3: Productivity and health monitoring (ecosystem processes). These process-level studies focus on the measurement of avian nesting success and rate of forest dynamics (in response to atmospheric changes associated with acid rain and ground level ozone for example).

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Table 1: Summary table identifying gaps in environmental monitoring programs on the basis of monitoring focus (ecological level).

Monitoring Focus	Gaps
Ecosystem Composition	1. few programs developed to use indicator or target focal species
	2. projects generally limited to habitats along the Niagara Escarpment
Ecosystem Structure	1. limited range of species monitored (little consideration of mammals or insects for example)
	2. limited range of habitats (primary focus on upland forests distributed throughout study area; few marshes monitored and such monitoring poorly represented on Escarpment or in urban regions)
Ecosystem Function	1. few programs to monitor terrestrial indicators though recent projects have been developed with this potential
	2. projects limited to Credit River watershed

Monitoring should assist in the assessment of the success of planning strategies. To increase the understanding of environmental change (whatever the cause), there needs to be a stronger emphasis on process-level monitoring and a greater recognition of information at this level to feed into the planning process. In the research area, one process-level study was discontinued though two emerging projects have the potential to provide this level of data. Many of the studies described to us were restricted to simply monitoring composition or structure of the ecosystem; that is, collecting data regarding the biodiversity and abundances of species. Indicator species alone will not be informative enough to provide the baseline information to direct and assess the effectiveness of planning.

Both the NEP and CVC acknowledge their regional monitoring program is to assist in the assessment of management strategies and to be used for adaptive management. The Niagara Escarpment Plan is to be reviewed every ten years and then modified to improve the ability of this approach to manage the multi-uses of this region. There are several examples within this region of such monitoring including: 1) a study of impacts resulting from aggregate extraction on the Niagara Escarpment and 2) the use of frog monitoring plots by CVC as a baseline to measure possible impacts from spraying to control the spread of West Nile Virus in the region of Peel (Figure 4). However, most of the monitoring will only provide a measure of species change over time; this will limit the ability to ascertain the efficacy of management.

From the spatial perspective, there are obvious clusters of monitoring activity. Monitoring plots are concentrated along the Escarpment, especially in the southern portion of the region in the heavily forested and protected areas. There are fewer sites situated in the less-protected north and at sites that are situated along areas of the Escarpment where there are no large cliff faces (sites consequently provided less protection as natural areas). At the provincial scale, this area of southern Ontario has one of the densest concentrations of bird monitoring. This emphasizes the importance and attractiveness of this region for volunteer birding and the significance of local access. The other evident concentration of plots centres on the program established by CVC. This includes a number of sites within the NEC plan area as well as a number of sites throughout the watershed southeast to Lake Ontario. Thus, several large gaps in monitoring activity within the planning region may be identified, especially in southern Halton Region. The spatial distribution of monitoring sites reflects two facts. Firstly, the effectiveness of planning cannot be assessed where there are no studies to indicate ecosystem condition or change. Secondly, the success or failure of a species or a community is not simply a function of the woodlot or meadow in which they are found. It is a function of the surrounding landscape, of the natural and human disturbances that play an indirect role. Monitoring in spatially-limited areas will not answer questions regarding planning strategies if the system is affected by species or processes acting at a broader scale. It is necessary that the monitoring questions result in the collection of appropriately scaled data.

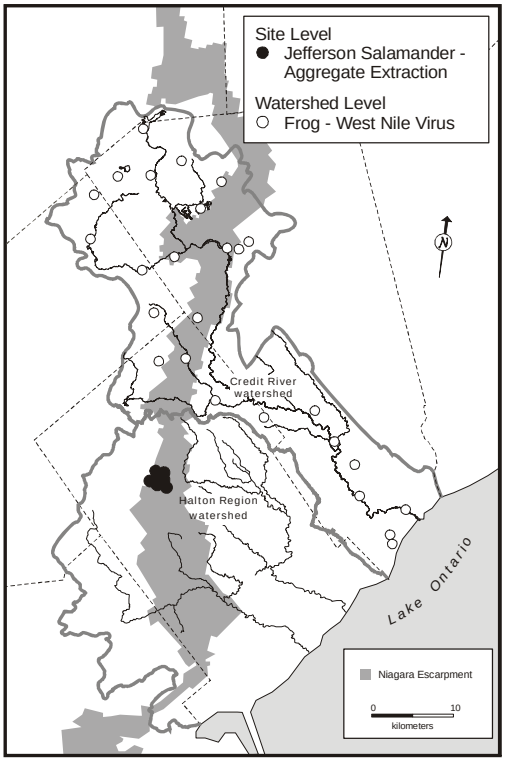

Figure 4: Monitoring for ecosystem response to impacts such as aggregate extraction and West Nile virus.

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There is the need for a stronger coordinated regional monitoring program that integrates the regional-level agencies. Currently, there has been some discussion between the prominent groups but the programs operate separately. There is also an evident ebb and flow of support for monitoring within specific agencies. Over time thus, the support for long-term monitoring varies which reduces the strength of the regional monitoring system (especially when several agencies provide limited support simultaneously). These circumstances do not provide the required information for an enhanced understanding of environmental change. Regional monitoring cannot just be a response to current projects or issues with a limited life expectancy. These only provide small windows of opportunity and only initiate understanding of ecosystem health or sustainability.

Finally, there has to be greater integration of volunteer programs within a regional framework. There are several successful volunteer programs that provide long-term data on suites of species but these need to be organized within the larger framework of the regional agencies. The regional agencies need to recognize the gaps and limitations of volunteer organizations and commit to filling these gaps through in-house or contract

programs to collect the data. In this area, there are several regional frameworks as well as a number of volunteer projects, but there has been limited coordination between the groups.

The following recommendations may improve the effectiveness of monitoring programs in this part of Ontario:

1. the study must begin with a clearly defined question(s) which will then guide in the collection of appropriate data (whether at species, composition or process level),
2. the monitor must recognize that the composition and structure of an ecosystem will change as a result of processes; monitoring indicator species or target focal species alone, while useful, will only allow one to speculate as to cause, while monitoring processes will provide a deeper understanding of the functioning system and better reflect the impact of planning decisions,
3. the spatial and temporal pattern of monitoring plots and sampling periods should reflect the spatial and temporal scale of processes affected by management decisions (regions in which there is presently no ecological monitoring or monitoring limited to very short time frames will not be able to assess the effectiveness of any planning decisions)
4. monitoring is an expensive and time consuming investment; coordinating regional programs and integrating within them volunteer programs will much improve the efficiency of data collection and potentially broaden the questions that may be asked and answered. This may increase the range of species and habitats monitored. In addition, this may allow a change in focus from ecosystem composition to ecosystem function if this level of information better answers the research question.

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