# Annual Report of Research and Monitoring in the Greater Kejimkujik Ecosystem 2005

Parks Canada Parcs Canada

Canada

Mersey Tobeatic Research Institute

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**Cover photos:**
- Bottom left: Piping plover (photo by L.Newel, Parks Canadal)
- Bottom right: Hemlocks and Hardwoods trail, Kejimkujik (photo by D.Ure, Parks Canada)
- Middle: Kejimkujik Loon Watch mentor J.Kerekes (photo by P.Hope, Parks Canada)
- Top left: Syphid fly on Plymouth gentian (photo by J.Lusk)
- Top right: Southern flying squirrel (photo by A.Lavers, MTRI)

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*We wish to thank the Parks Canada Western Arctic Field Unit and specifically Jacquie Bastick for providing the design template and technical assistance for this report, which was modeled upon the "Annual Report of Research and Monitoring in National Parks of the Western Arctic". These exemplary annual reports capture the essence of research and monitoring and we think they are an effective tool for communicating the scope of research and monitoring projects to a range of audiences. We are excited to bring this tool to the Greater Kejimkujik Ecosystem.*

## ACKNOWLEDGEMENTS

A steering committee provided guidance and support for the report and included Amanda Lavers (MTRI) and Sally O'Grady, Darien Ure and Chris McCarthy (Parks Canada). Jonathan Sheppard (Parks Canada) provided additional logistical support.

Many thanks to all the researchers who took the time to submit their research and monitoring project summaries that are included in this annual report.

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Pierre Martel, Editor
Mersey Tobeatic Research Institute

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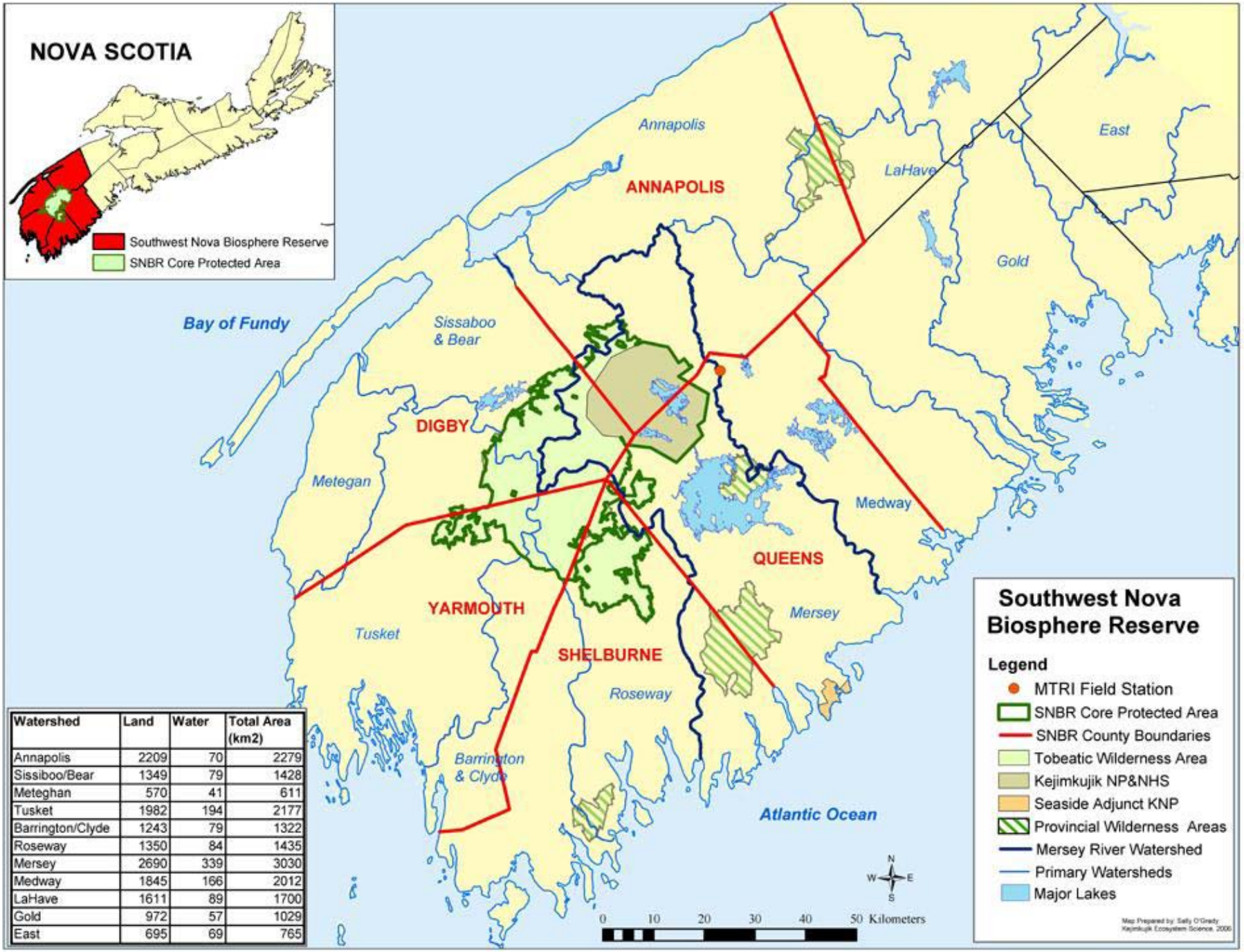



| Watershed | Land | Water | Total Area (km2) |
|---|---|---|---|
| Annapolis | 2209 | 70 | 2279 |
| Sissiboo/Bear | 1349 | 79 | 1428 |
| Meteghan | 570 | 41 | 611 |
| Tusket | 1982 | 194 | 2177 |
| Barrington/Clyde | 1243 | 79 | 1322 |
| Roseway | 1350 | 84 | 1435 |
| Mersey | 2690 | 339 | 3030 |
| Medway | 1845 | 166 | 2012 |
| LaHave | 1611 | 89 | 1700 |
| Gold | 972 | 57 | 1029 |
| East | 695 | 69 | 765 |

Map prepared by S.O'Grady, Kejimkujik Ecosystem Science, 2006.

# INTRODUCTION

This "Annual Report of Research and Monitoring in the Greater Kejimkujik Ecosystem" focuses on Kejimkujik National Park and National Historic Site of Canada (Kejimkujik), the Tobeatic Wilderness Area (Tobeatic) and the Mersey and Medway River watersheds. This report was produced in spring 2006 and is a compilation of the research and monitoring projects that were conducted in 2005. While not all projects are detailed in the main body of this report, Appendix 1 includes a comprehensive list. It is hoped that this will be the first in a series of annual reports that will make information about the research and monitoring projects in the Greater Kejimkujik Ecosystem easily available to the public, government agencies, researchers and other stakeholders.

The research and monitoring projects depicted in this report are essential tools for attaining sustainable management of our natural resources and maintaining ecological integrity of our protected areas. The monitoring projects are conducted to keep track of how the ecological systems around us are changing over time and the effectiveness of management actions. The research projects provide a better understand of the ecology of the area and how it is affected by natural and human-related disturbances.

This report is a co-production between the Mersey Tobeatic Research Institute (MTRI) and Kejimkujik. The projects are organized by four main ecosystem types (Coastal, Forest, Wetland or Freshwater) and are further sorted by the category of either research or monitoring. The summaries included in this annual report are overviews of the projects written by the researchers; more details can be obtained from the individuals listed as contacts.

Kejimkujik represents the Atlantic Upland region in Parks Canada's network of protected areas. Kejimkujik consists of 382 $km^2$ inland and a 22 $km^2$ adjunct on the coast and, in combination with the Tobeatic, provides the core of the Southwest Nova Biosphere Reserve. Since its establishment, Kejimkujik has been an important centre of science for southwest Nova Scotia. In collaboration with partners, research and monitoring in the park and surrounding landscape has informed decision-makers on a number of management issues at local, regional and national scales. Kejimkujik was declared the first Ecological Monitoring and Assessment Network site in Canada (1993) and was the first to install a Smithsonian Institution Monitoring and Assessment of Biodiversity plot in Canada (1994). Kejimkujik also serves as one of five primary Canadian Acid Precipitation Monitoring Network sites that monitor long-range transport of air pollutants and is a long-term climate monitoring station for Environment Canada. In 1995, Kejimkujik was designated a national historic site (the only national park in Canada with this dual designation) highlighting the cultural significance of the area and the importance of aboriginal peoples to understanding and presenting commemorative integrity. Kejimkujik is identified by the Parks Canada Agency as a species at risk priority site where stewardship and recovery of species at risk are paramount. More information about Kejimkujik can be found at www.pc.gc.ca/pn-np/ns/kejimkujik or at the Friends of Keji site www.friendsofkeji.ns.ca.

The MTRI represents an innovative approach to advancing knowledge and effective sustainable resource management across southwestern Nova Scotia. In partnership with the Southwest Nova Biosphere Reserve, MTRI reflects a spirit of cooperation typical of southwestern Nova Scotia, and features partnerships with the public, communities, educators, governments, businesses, and international institutions. MTRI is a non-profit organization based in Kempt, Queens County, Nova Scotia whose mission is to advance collaborative research, monitoring, and management that promote sustainable use of resources and biodiversity conservation in the Southwest Nova Biosphere Reserve. The MTRI maintains a field station facility that provides office workspace, basic accommodation for researchers, space for public presentations and a site for training. MTRI provides scientific and research expertise, project coordination services, studies of physical and social research to address the goal of sustainable resource management, and communication of information about local research to the public. More information about the co-operative can be found at www.merseytobeatic.ca.

The Southwest Nova Biosphere Reserve (SNBR) comprises a large portion of terrestrial and coastal southwestern Nova Scotia. The United Nations Educational, Scientific, and Cultural Organization (UNESCO) internationally recognizes a biosphere reserve as an area in the world that is deemed to demonstrate a "balanced relationship between humans and the biosphere." Biosphere Reserves around the world fulfill the following three functions: conservation, sustainable development, and capacity building. Collaborative efforts among people in the designated area promote the sustainability of local economies and communities, as well as the conservation of the ecosystems. A biosphere reserve is also a mechanism used for regional planning and multi-sector collaboration. It offers an opportunity for the community to envision sustainability for the region and to work towards achieving it. In 1999, a committee from Queens and Annapolis Counties in Nova Scotia developed a proposal for the establishment of a UNESCO Biosphere Reserve incorporating Kejimkujik and the Tobeatic as the core protected area. This committee later became incorporated as the Southwest Nova Biosphere Reserve Association (SNBRA). In September 2001, the nomination document received approval and the region of southwest Nova Scotia was designated a biosphere reserve by UNESCO.

**Photos by:**
- Bottom left: P.Hope, Parks Canada
- Bottom right: P.Hope, Parks Canada
- Middle: M.Burzynski, Parks Canada
- Top left: P.Hope, Parks Canada
- Top right: P.Hope, Parks Canada

## COASTAL

## Rationale

The Piping plover is a small shorebird that has been listed as Endangered by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) since 1985. Presently, the Piping plover nests on St. Catherine's River Beach at the Kejimkujik Seaside Adjunct. Piping plover is negatively impacted by a variety of stressors including the following: habitat disturbance, loss and fragmentation; predation; severe climate and storm events; and problems encountered during migration and over-wintering. The Piping plover is now referred to as a "management dependent species" because sustained management actions are needed to maintain and increase population levels. To assess Piping plover population levels at the Kejimkujik Seaside Adjunct and to implement a suite of management strategies focused on protecting and sustaining plover numbers, park staff have monitored plover adults and chicks within the park since 1985.

Piping plover on nest (photo by L.Newell, Parks Canada).

# Monitoring

## PIPING PLOVER MONITORING PROGRAM

### OBJECTIVES

- To observe and evaluate the general status of Piping plover populations, breeding pairs, chick fledgling success, movement patterns and other factors.
- To implement protective measures such as nest exclosures for nesting plovers.
- To educate people about the Piping plover's Endangered status and recovery efforts.

### METHODS

- Park wardens conduct frequent patrols of St. Catherine's River Beach during Piping plover nesting season.
- Piping plover monitoring is accomplished at distance with binoculars and spotting scopes. Other birds and animals, including predators, are also noted.
- Observations are recorded about plover nests, chicks and habitat and are entered into a digital database. Nests are located by observing territorial and other nesting behaviours.
- After two eggs are laid (of four in a full clutch) protective wire predator exclosures are installed to protect the eggs and nesting adults from most predators. All nests are coded and georeferenced using a Global Positioning System and all this information is recorded in a digital database.

Piping plover nest exclosure (photo by J.Steeves, Parks Canada).

## RESULTS

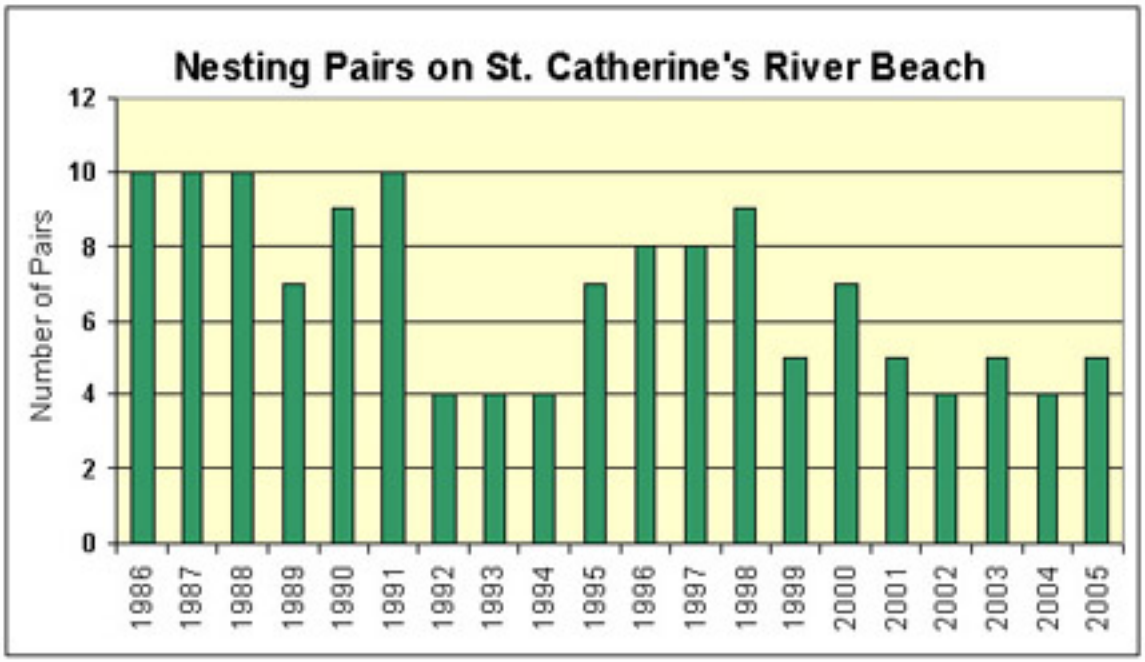
- Five pairs of Piping plover (10 adult birds) established five nests and nested successfully during 2005.
- Eighteen eggs were laid, 16 hatched and 12 chicks "fledged" (survived past twenty-one days of age).
- One chick was predated by a Greater black-backed gull, one chick died in the nest and two others lost to unknown causes.

## YEARS OF DATA

- 1985 until present
- On-going

## PARTNERS

- Parks Canada
- Piping Plover Recovery Team (Eastern Canada)
- Canadian Wildlife Service
- Nova Scotia Department of Natural Resources
- Nova Scotia Plover Guardian Program

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## Rationale

Piping plover nest on sparsely vegetated sandy beaches, a dynamic habitat influenced by extreme weather events essential for sand dune formation and destruction. Marram grass stabilizes sand dunes but makes substrate unsuitable for plover nests. Periodic hurricanes and resulting storm surges cause localized destruction of marram grass by means of 'blowouts,' high water surges and shifting sand masses. A lack of such events at St. Catherine's River Beach of Kejimkujik Seaside Adjunct has allowed the Marram grass and Beach pea to dominate previously suitable Piping plover nesting habitat. Habitat management is being implemented at the Seaside Adjunct as an experimental treatment to recreate and/or restore former Piping plover nesting habitat. This is being undertaken in suitable areas of St. Catherine's River Beach through mechanical removal of root systems. This is the first time this management technique has been utilized in eastern Canada and its success is being monitored by the National Piping Plover Recovery Team (Eastern Canada).

Piping plovers (photo by R.Brunt, Parks Canada).

# Research

## PIPING PLOVER HABITAT MANAGEMENT

### OBJECTIVES

- To increase the amount of nesting (and foraging) habitat for plovers and other shorebirds with similar habitat requirements in areas that are presently protected.
- To reduce chick mortality due to predation by decreasing predator efficiency by providing separated areas for nesting (predators may have a greater success with a linear search pattern along the dune edge of the ocean beach).
- To explore feasibility of habitat enhancement through mechanical means.

### METHODS

- The habitat management zone is located in the eastern section of the St.Catherine's River Beach dune/lagoon complex.
- Habitat management and site modification was achieved by mechanical harrowing and using hand tools.
- All growth of Marram grass, Beach pea and other woody shrubs was plowed and raked off the management site.
- Vegetation cover was surveyed to measure previous cover, vigour and extent of regrowth. Random quadrats within the habitat management zone were assessed for species association and composition as well as the biomass (number of plants per unit area). Photographs were taken to record site conditions.
- The habitat management zone was surveyed before and after modification with a surveyor's level to establish landscape profile.

Modified site (photo by R.Brunt, Parks Canada).

## METHODS (continued)

- Piping plover presence and nesting success within the habitat management zone was assessed.
- Beach dynamics, substrate alterations and vegetation regrowth will continue to be monitored.

## RESULTS

Piping plover nest with four eggs (photo by J.Steeves, Parks Canada).

- In 2003, Piping plovers were observed in the habitat management zone but no nesting occurred.
- In 2004, a pair of adult Piping plovers nested successfully in the habitat management zone. Four eggs hatched successfully and all of the chicks fledged. The chicks were observed as late as August 5th, 2004.
- In 2005, two pairs of Piping plovers nested inside the habitat management zone. The two nests produced seven eggs. Of the seven chicks that hatched, five fledged.
- The use of this habitat management zone by Piping plover for nesting and the subsequent fledging of chicks can be considered a success story for both Parks Canada and the endangered shorebirds. The birds' utilization of this managed habitat is of paramount importance to the region's efforts to sustain and increase Piping plover populations.

## YEARS OF DATA

- Since 2000
- On-going

## PARTNERS

- Parks Canada
- Piping Plover Recovery Team (Eastern Canada)

Researchers conducting vegetation surveys within quadrats to assess plant abundance (photo by C.McCarthy, Parks Canada).

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## Rationale

The Canadian Wildlife Service (CWS) has recently completed a recovery strategy for the Piping plover which identifies the need to describe and define critical habitat. Kejimkujik is interested in delineating critical habitat at the Seaside Adjunct and comparing habitats between the two main beaches. St. Catherine's River Beach and Little Port Joli Beach are both historical breeding areas for Piping plover; however, only St. Catherine's River Beach has supported nesting pairs in recent years. The purpose of this project was to develop a methodology for delineating critical habitat for Piping plover based on guidelines set by the CWS. Detailed maps showing critical habitat boundaries were produced using GPS and Light Detection And Ranging (LiDAR) data to compare active and inactive nesting habitat.

Piping plover (photo by Parks Canada).

# Research

## PIPING PLOVER CRITICAL HABITAT

### OBJECTIVES

- To develop a method for delineating critical habitat using GPS.
- To examine and compare critical habitat components such as beach width, substrate, slope and vegetation on two active and inactive nesting sites on the South Shore of Nova Scotia.
- To examine the use of LiDAR for mapping beach habitat for Piping plover.

### METHODS

- High precision GPS data were collected on beaches along the low tide line and beach transects extending from the high tide line to the start of the vegetated dune line. Training sites and validation points were collected for the classification of the LiDAR data.
- Beach characteristics such as slope, beach width, percent cover of substrate and vegetation were recorded along each transect.
- The GPS and beach data were compiled in a geographic information system and critical habitat boundaries were delineated based on criteria outlined by the CWS.
- An airborne LiDAR survey was completed over the South Shore study area during October 2005.
- Beach habitats were classified using LiDAR elevation and intensity data.

R.Goodale taking GPS points on St. Catherine's River Beach (photo by R.Brunt, Parks Canada).

## RESULTS

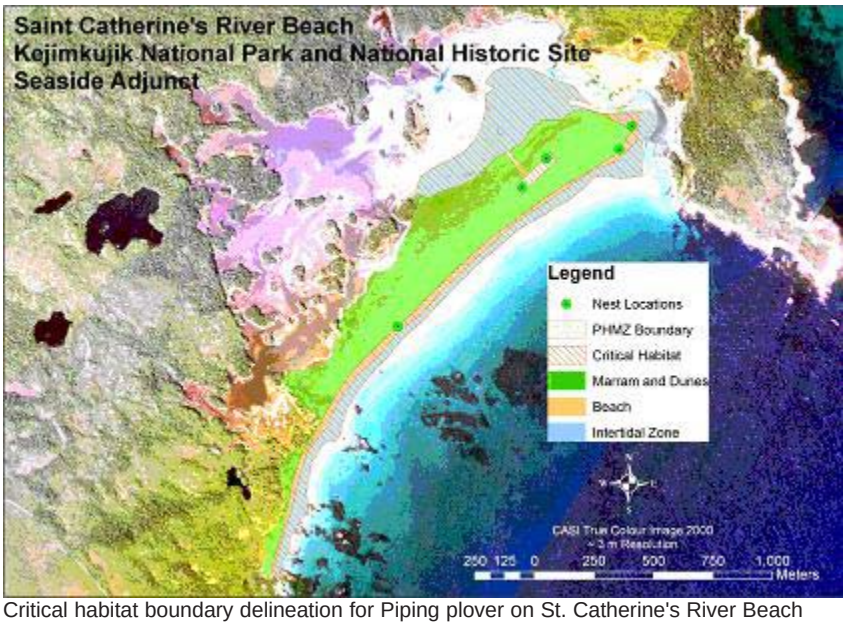
Piping plover nesting and feeding habitat on Johnston's Pond Beach (photo by R.Goodale, Parks Canada).

- Critical habitat was effectively delineated by using GPS data combined with the CWS criteria.
- Beach width, slope and substrate were optimal on St. Catherine's River Beach compared to Little Port Joli Beach. These physical factors could explain why Little Port Joli Beach has not supported Piping plover nesting pairs in recent years.
- LiDAR classification of beach habitat was most effective using a logical filter approach. The use of slope, range, intensity and elevation were effective at categorizing general beach habitats; however, detailed classifications were difficult to achieve.
- Using a logic-based approach, important nesting and feeding habitat for Piping plover could be accurately mapped using classified beach habitat and slope.

## PARTNERS

- Applied Geomatics Research Group
- Canadian Wildlife Service
- Parks Canada
- Science Horizons Youth Internship Program

Little Port Joli Beach (photo by R.Brunt, Parks Canada).




Critical habitat boundary delineation for Piping plover on St. Catherine's River Beach (produced by R.Goodale).

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- Middle left: J.Brownlie, Parks Canada
- Top left: A.Lavers, MTRI
- Top right: Parks Canada

## FOREST

## Rationale

Forest inventory plots are one means of documenting and monitoring plant diversity and obtaining long term data on forest dynamics. Smithsonian Institution Monitoring and Assessment of Biodiversity (SI/MAB) plots were installed in Kejimkujik as both a training exercise and an experiment to evaluate the SI/MAB plot protocol for monitoring the impact of long range transport of air pollutants on Nova Scotia Acadian forests. The one hectare plots are large enough to explore opportunities for analysis of different biodiversity measures. These plots allow data comparison with other types of forestry plots in Nova Scotia and around the world. The first two SI/MAB plot installations in Canada were at Kejimkujik in 1994. Since then five more SI/MAB plots have been paired with forest sites in the working landscape to investigate different forestry treatments.

Tagged tree with marked DBH measuring lines in blue (photo by C.McCarthy, Parks Canada).

# Monitoring

## SI/MAB TREE MONITORING

### OBJECTIVES

- To inventory initial components of biodiversity.
- To repeatedly measure trees greater than 4 cm in diameter at breast height (DBH) to understand species shift, growth, mortality and recruitment processes.
- To compare trees at different plots and describe change through time based on different management regimes.
- To refine plot size to optimize tree species and ecological process detection.

### METHODS

- One-hectare plots were surveyed and divided into twenty-five 20x20m quadrats.
- Every tree larger than 4 cm DBH was mapped and labeled.
- SI/MAB standard protocols were followed to determine tree species, tree condition, and measure height, diameter, and relative location in the plot for existing and new recruits every five years.
- Trends were assessed over time and compared with other plots.

YCW Crew conducting forest plot measurements (photo by C.McCarthy, Parks Canada).

### RESULTS

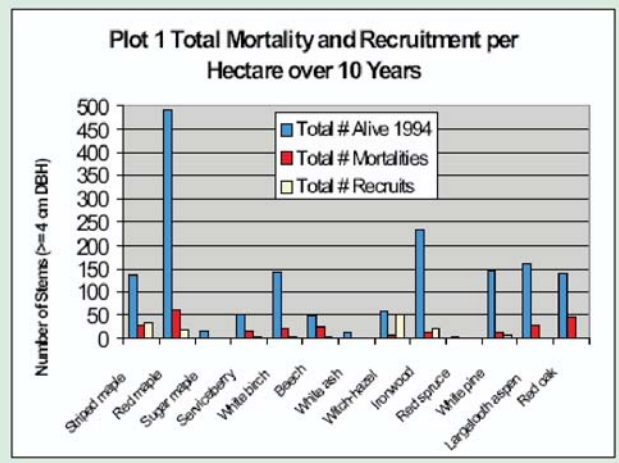
- SI/MAB plots can play a role in understanding forest processes such as growth, mortality, recruitment and composition.
- As an example, some species shifts are occurring. In the mixed hardwood plot (Plot 1) aspen and Red oak are declining. The mixed softwood plot (Plot 2) is shifting towards a predominantly hemlock stand.
- Statistical analysis of growth, mortality and recruitment has found that plot size can be substantially reduced in size to 9 quadrats in the two forest types analyzed.

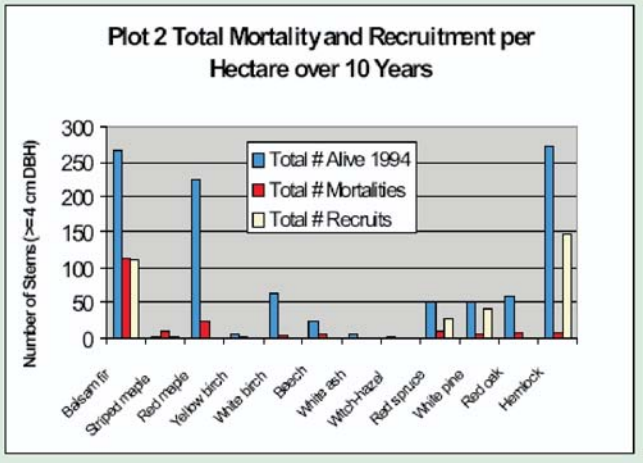
## YEARS OF DATA

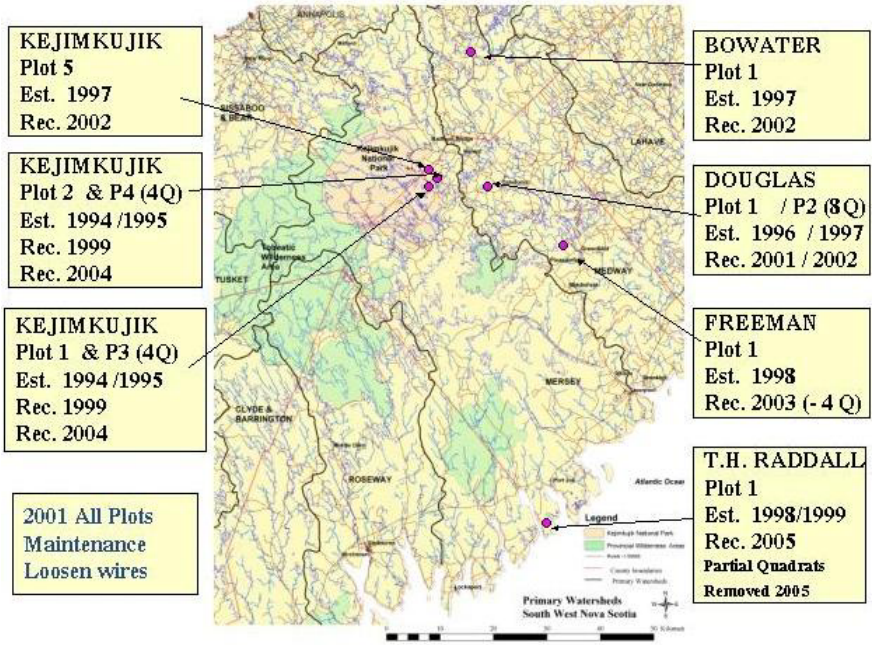
- 1995-2005
- Data have been collected for seven plots with staggered start years
- The plots are re-surveyed every five-years, with maintenance every three years.

## PARTNERS

- Ecological Monitoring and Assessment Network
- Bowater Mersey Paper Company
- N.F. Douglas Lumber Company
- Harry Freeman and Son Lumber Company Limited
- Nova Scotia Department of Natural Resources
- College of Geographic Sciences
- Parks Canada
- Young Canada Works Program




Map of Southwest Nova Scotia showing SI/MAB forest plot locations (produced by S.O'Grady Parks Canada) .

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## Rationale

Kejimkujik's Hemlocks and Hardwoods Trail winds through one of the few remaining old-growth Eastern hemlock stands in Nova Scotia. The area was designated as a Zone 1 - Special Preservation Area in the 1995 Park Management Plan. In 2004, a boardwalk was installed on the trail in response to increasing concerns about the impact of human use on the surrounding forest (*i.e.* soil compaction, braided trails, trampling). The boardwalk attempts to limit visitors to the trail surface, reduce the amount of impact on the forest floor, and foster regeneration of the sensitive ecosystem. This monitoring project was initiated in 2004 to assess the effectiveness of human use management on Hemlocks and Hardwoods Trail. The results of this 5-year project will provide information on current use of the trail and status of the surrounding forest and will assist in managing the trail to ensure its long-term sustainability.

Trail braiding and soil erosion adjacent to the trail (photo by D.Ure, Parks Canada).

# Monitoring

## HEMLOCKS AND HARDWOODS TRAIL USE

### OBJECTIVES

- To characterize human use of the Hemlocks and Hardwoods Trail.
- To determine if users are complying with off-trail travel restrictions.
- To determine if installation of the boardwalk was effective in protecting and restoring the forest floor in the vicinity of the trail.

### METHODS

- A TRAFx infrared trail counter was installed at the beginning of the boardwalk that records the number of visitors and the time at which they come through.
- Two infrared trail counters were installed at locations of known high impact areas. These counters record the number of visitors going off trail in these locations.
- Forest floor assessments were conducted in 34 1-$m^2$ quadrats along the length of the trail, including six control sites and four high impact test sites. Percent ground cover and species presence were assessed within each quadrat. Qualitative assessments of disturbance were provided for each plot based on levels of soil exposure, footprints, trail formation, rutting, trampling, root damage, and plant breakage.

Human use impact on Hemlocks and Hardwoods trail (photo by D.Ure, Parks Canada).

## RESULTS

Assessing ground cover regeneration following boardwalk installation (photo by D.Ure, Parks Canada).

- In 2004, the counter was in operation from August to November and the total count was 1934. In 2005, the counter was in operation from May to November and the total count was 4205.
- Both years show comparable results that suggest an average of 21 people/day on the trail. However, this number increases to 40 during the busy season (July and August). Shoulder seasons (spring and fall) seem less busy with 9 counts/day.
- Use of the trail on a typical summer week was similar over the two years; it averages 35 counts/day on weekdays and 51 counts/day on weekends.
- The busiest time of day in summer is 12-4:00pm when there were an average of 6 counts/hour and up to 9 counts/hour on weekends. In summer there could be a person on the trail every 10 minutes or less, but during the shoulder season, only once every 40 minutes.
- Results from the off-trail counters indicate that about 10% of all traffic goes off trail to high impact areas (13% at one location and 6% at the other).
- Disturbance occurred in trailside and high impact plots including root damage, soil exposure, soil compaction, trampling, trail formation and litter.
- Percent ground cover is highest in control sites (more than 70%), moderate in trailside plots (about 40%) and lowest in high impact areas (less than 10%).

## YEARS OF DATA

- 2004-2009
- This is the 2nd year of a 5-year monitoring project.

## PARTNERS

- Parks Canada

Eastern hemlock forest (photo by D.Ure, Parks Canada).

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## Rationale

Between 1987 and 1994, Kejimkujik reintroduced 116 American marten in the park. Organized monitoring for marten ceased in Kejimkujik in 1995. Very little research has been conducted within the park to assess Fisher and Bobcat populations. Recent sightings and local knowledge suggest that these three species currently live within Kejimkujik, however their status within the park and in the surrounding area is unknown. To address this knowledge gap, a project was designed and implemented in winter 2004 and 2005. Assessing and monitoring these species is important because: (i) their status provides information on the trophic structure of forest ecosystems at Kejimkujik; and (ii) there is a need to assess the effectiveness and success of American marten reintroduction programs that occurred in the 1980s and 1990s.

American marten detected at Eel Weir bait station, February 2006 (photo by Parks Canada).

# Monitoring

## MAMMAL PREDATOR DETECTION PROGRAM

### OBJECTIVES

- To refine a methodology for monitoring mammal predators.
- To assess and monitor presence and distribution of American marten, Fisher and Bobcat within Kejimkujik.
- To assess the effectiveness of past American marten reintroduction programs.
- To provide reliable baseline data on mammal predators for future research initiatives.
- To work with a variety of local and regional stakeholders to ensure that these species are adequately protected.

### METHODS

American marten detected at Eel Weir bait station, January 2006 (photo by Parks Canada).

- The use of photographic bait stations to detect mammal predators was developed by the US Department of Agriculture Forest Service and has been a widely used technique for the past 20 years.
- The experimental design for this project involved dividing the park into thirty 16 $km^2$ sampling units based on home range of the target species. Each year, 2-5 sampling units were selected for monitoring. A minimum of two photographic bait stations (PBSs) was established within each sampling unit.
- Each bait station included a piece of bait (*i.e.* venison or beaver) placed approximately 2 m up a tree. A Trailmaster infrared sensor attached to a 35 mm camera was positioned so that movement at the bait triggered the infrared sensor and resulted in a photograph of animals that visited the bait station.

## METHODS (continued)

- The bait stations were placed in areas of most appropriate habitat or where unconfirmed sightings have occurred within the sample unit.
- Bait stations were visited once every 7-10 days during December - March to provide maintenance, check sensor and camera batteries, replace film, check for species detection or other evidence of presence, and replace bait if necessary.

Photographic bait station (photo by D.Ure, Parks Canada).

## RESULTS

- In 2004-5, two bait stations were established in two different sampling units. A total of 220 pictures were captured at the four stations, 83 of which were positively identified as triggered by an animal (38% photo success); however only one of these pictures captured a focal species (Fisher - Fire Tower Road, February 9-21, 2005).
- In 2005-6, the same bait stations were re-established to refine sampling methodology. A total of 360 pictures were captured at the four stations, 100 of which were positively identified as triggered by an animal (28% photo success). One bait station confirmed presence of American marten (Eel Weir). Fisher and marten tracks were also identified between the 12-24 km markers along Peskowesk Road.

## YEARS OF DATA

- 2004-2010.
- 2005-6 was the 2nd year of a 6-year research and monitoring project.

## PARTNERS

- Parks Canada
- Nova Scotia Department of Natural Resources

Northern flying squirrel detected at Eel Weir station, February 2005 (photo by Parks Canada).

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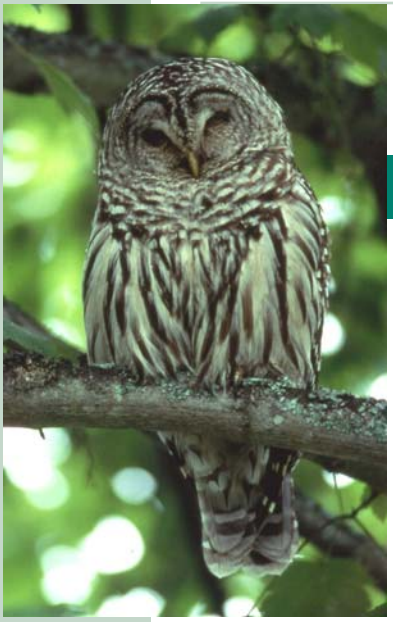
## Rationale

Owls are known to be excellent indicators of forest ecosystem health. As top predators in the food chain, they are vulnerable to toxic substances and habitat disturbance. Barred owls have specialized habitat requirements that link them to large hardwood trees for cavity nesting. Additionally, they are sensitive to forest cover and composition changes association with forest management activities. Owls are not easy to monitor due to their secretive, nocturnal activities. They roost for much of the day and attempts to conduct visual surveys are challenging. Bird Studies Canada has devised a methodology for conducting nighttime surveys and has partnered with a variety of organizations and volunteers to conduct surveys on more than 140 routes (transects) in Atlantic Canada. The methodology uses a standardized playback of taped owl calls to elicit responses from owls along these random survey routes.



Barred owl (photo by Parks Canada).

# Monitoring

## NOVA SCOTIA NOCTURNAL OWL SURVEY

### OBJECTIVES

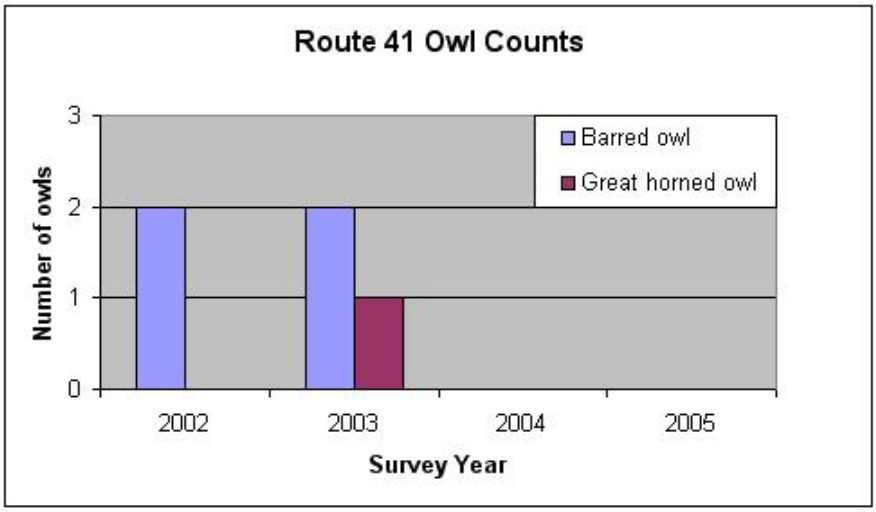
- To estimate trends in the abundance of owls over at least a 10-year period.
- To gather location information on rare or little-known owl species (especially Boreal, Long-eared, and possibly Northern hawk owls) in Atlantic Canada.
- To involve volunteer birders from across the region in wildlife monitoring.

### METHODS

- The surveys began one half hour after sunset and took approximately 2.5 hours to complete. The route was surveyed at least once per year between April 1 and May 15.
- A team of two (or more) individuals drove a pre-determined route and stopped at 10 fixed intervals every 1.6 km along the route.
- At each stop, a CD was played with calls of Boreal and Barred owls alternating with timed listening periods.
- Surveyors identified and recorded all owls heard or seen during each listening period.
- Standardized forms were used to record site descriptions, weather conditions, owl responses, estimated distances to owl, whether responses are from the same owl at different stations, and audible disturbances and background noise.
- Trends in owl abundance over time were examined.

Surveyor conducting trials (photo by C.McCarthy, Parks Canada).

## RESULTS



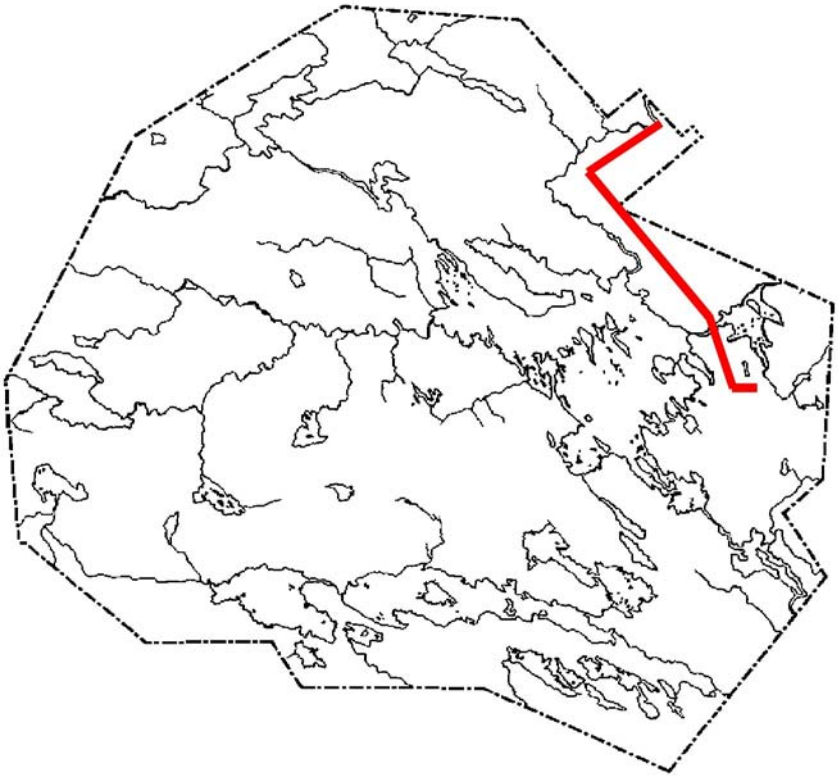

## YEARS OF DATA

- The survey has been conducted annually since 2002
- Monitoring will continue on an annual basis

## PARTNERS

- Parks Canada
- Bird Studies Canada

Great-horned owl (photo by Parks Canada Terra Nova).



Route 41 Kejimkujik Nocturnal Owl Survey Route.

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## Rationale

Air pollution and acid rain are threats to maintaining ecological health of protected areas. Protected areas managers require a meaningful way to measure impacts of these threats. Lichens are one of the most sensitive groups of organisms to acid rain and air pollution and can provide an early warning indication of impacts to ecosystems. Hundreds of studies have linked lichen communities to air quality. Lichens have been used in long-term monitoring of air quality in Europe and in mapping air quality zones in cities throughout the globe.

Few lichens on a maple tree in downtown Halifax (top) and healthy, abundant lichens on a maple tree in central Nova Scotia (bottom) (photos by J.Towers).

# Monitoring

## AIR QUALITY MONITORING WITH LICHENS

### OBJECTIVES

- To determine current impacts of acid rain and air pollution on ecosystems in Nova Scotia.
- To determine how air quality varies within Nova Scotia and use these data to map air quality zones.
- To establish permanent lichen monitoring plots that will enable long-term monitoring of air pollution and acid rain.

### METHODS

- Forty-four plots were randomly located across the province in protected areas.
- Each plot was visited in 2005 and presence and frequency of sixteen indicator lichen species were measured.
- An index of air purity was calculated for each plot based on the lichen species presence and frequency.

### RESULTS

- Urban and industrial centers (Sydney, Port Hawkesbury, Pictou, Halifax) had the lowest air quality.
- Much of the province had very high air quality, including most of Cape Breton, central Nova Scotia and the eastern shore.
- Southwestern Nova Scotia shows some areas where air quality may be slightly lower than central Nova Scotia and Cape Breton.
- The permanent plots provide the foundation for long-term monitoring of air pollution effects on ecosystems in Nova Scotia.

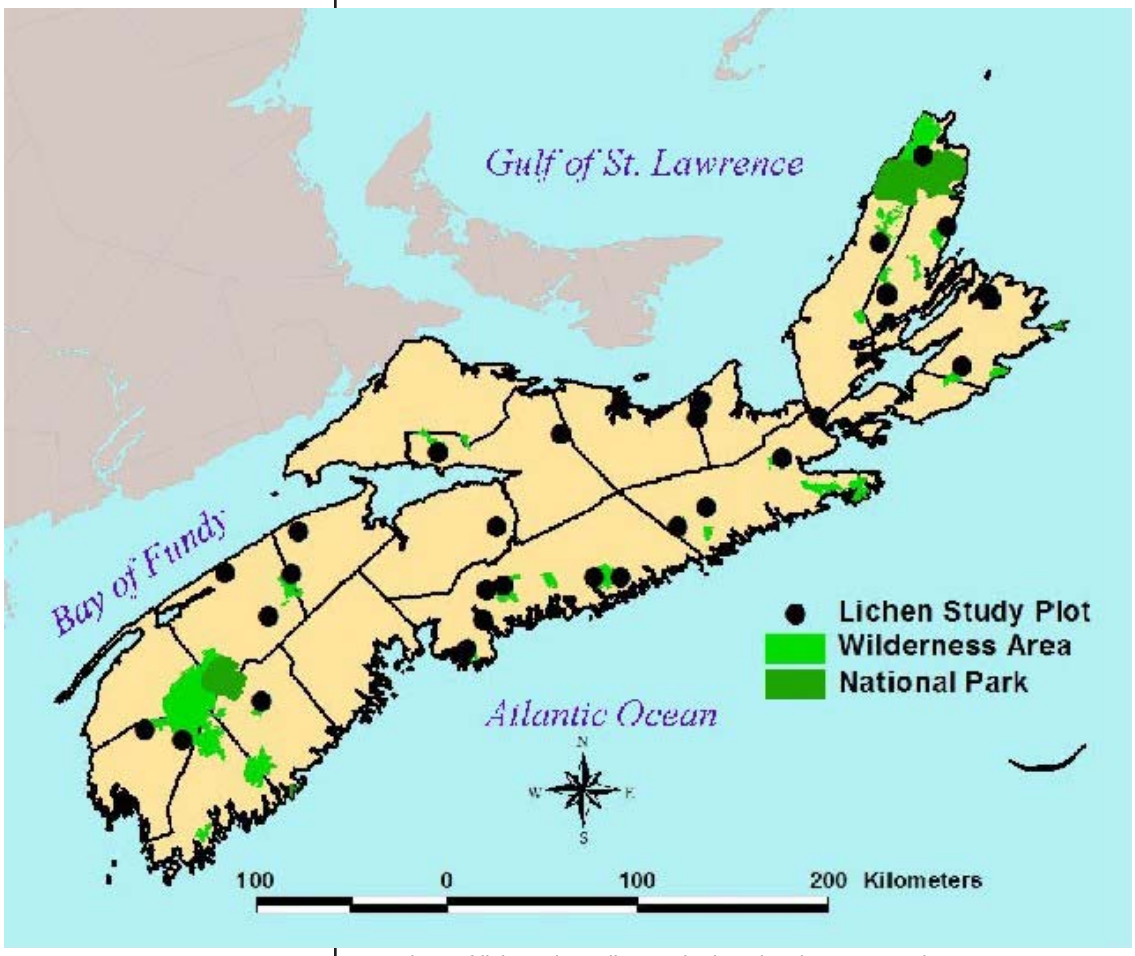
Lichen researcher C.Taylor shows Saint Francis Xavier University student how to sample lichens. (photo by A.Norman).

## YEARS OF DATA

- 2005
- Re-measurement in 2 to 5 years.

## PARTNERS

- Nova Scotia Environment and Labour, Protected Areas Branch and Air Quality Branch
- Saint Mary's University
- Nova Scotia Youth Conservation Corps




Locations of lichen air quality monitoring plots in Nova Scotia.

## CONTACTS

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## Rationale

Remote sensing and Geographic Information Systems (GIS) are extremely valuable tools for conducting landscape analysis. Remote sensing can provide timely views of the landscape while GIS can be used to manage these views and convert them into valuable information. The conversion of image pixels to landscape patches allows the recognition of objects that can then be analyzed. Humans have the tendency to modify the shape, size and number of landscape patches with forestry practices, agriculture, road construction, mining and urban development. These activities have the potential for fragmentation and alteration of natural habitats. Monitoring can provide an understanding of the rate of change that is occurring and can highlight the need to develop strategies to minimize impacts associated with land use and development.

Landsat TM scene of southwestern Nova Scotia acquired on 28 September 2005. Primary watershed and Kejimkujik boundaries are outlined.

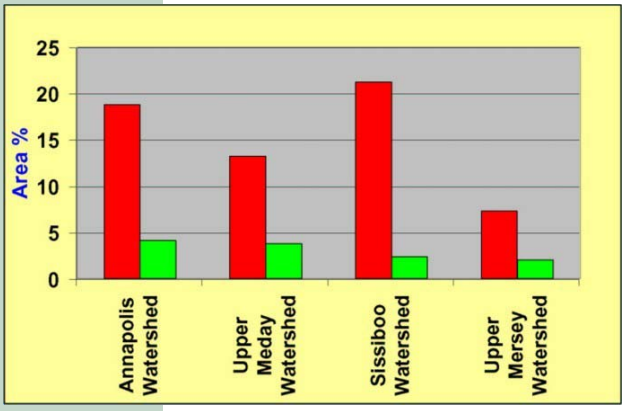
# Monitoring

## LANDCOVER CHANGE

### OBJECTIVES

- To use satellite images collected over a 15 year period (1991 to 2005) to determine how forest cover in southwestern Nova Scotia has changed and to understand the relationship between forest loss and forest gain.
- To distinguish between types of forest change (*i.e.* clear-cut verses thinning) and to assess the accuracy of the results using aerial photography, fieldwork, and other available information.
- To analyze the areas of forest loss to determine the forest conditions that have been impacted and to assess the conditions that remain.
- To analyze forest fragmentation and relate the results to landscape connectivity issues and potential down stream impacts (*i.e.* proximity of clear-cuts to streams and lakes).

### METHODS




Forest Change in southwestern Nova Scotia from 1991 to 2005 (Red = Forest Loss; Green = Forest Gain).

- Image analysis software was used to line up satellite images and ensure that they all share the same georeferencing.
- Images were corrected for clouds and seasonal effects to focus the change delineation on actual changes in forest conditions.
- Spectral differences occurring in Band 5 were computed between consecutive images. A user-specified threshold value was used to identify area of landscape change.
- GIS software was used to compare the resulting areas of change to the Department of Natural Resources forest inventory (a GIS data layer based on 1:10,000 scale aerial photography flown in 1992) to characterize the forest conditions that have been lost and to assess how much of the remaining landscape contains similar conditions.

## RESULTS

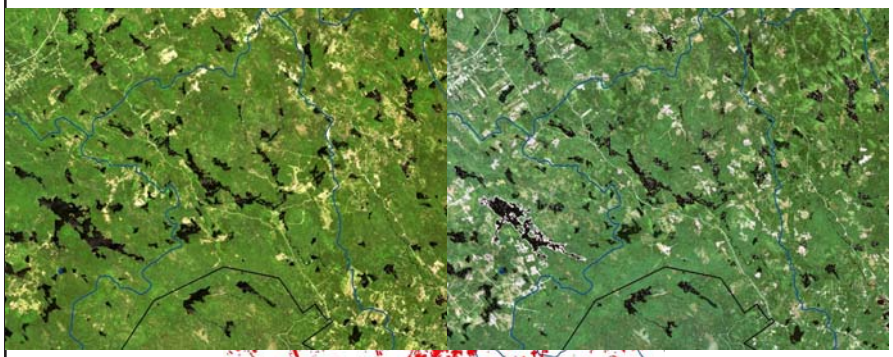
- The rate of forest loss has increased between 1997-2005 compared to the 1991-1997 period.
- Up to 20% of the forest cover in some of the primary watersheds in southwestern Nova Scotia has been lost between 1991 and 2005.
- Analyzing forest change over shorter time intervals (*i.e.* 2 or 3 years) allows for the detection of more change (due to the forest regeneration process). Longer time intervals (*i.e.* 5 years) are more effective for detecting forest gain.
- Forest loss, road development and anthropogenic activity have had significant impacts on landscape connectivity in southwestern Nova Scotia in recent years.

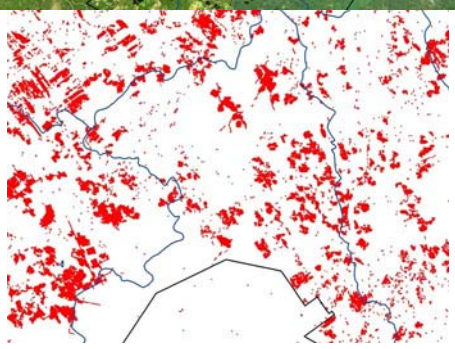
## YEARS OF DATA

- Satellite imagery acquired between 1991 and 2005 has been the main focus of this project. Images acquired before 1991 (*i.e.* 1974 and 1986) were also used to provide a more historic view of the southwestern Nova Scotia landscape.
- Image intervals of 2, 3, 5, 10, and 15 years were assessed to determine the optimal time interval for tracking landcover change.

## PARTNERS

- Applied Geomatics Research Group
- Mersey Tobeatic Research Institute
- Parks Canada





Landsat TM imagery of the upper Mersey Watershed:
Left - 18 June, 1991
Right - 28 September, 2005
Bottom - Areas of forest loss.

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## Rationale

The interest in arthropods as indicators of ecological integrity has been growing over the last several years. Arthropods are abundant in forest ecosystems and play a significant role in many important forest processes. Specifically, beetles and spiders demonstrate several qualities that contribute to their utility as indicators of forest ecosystem health. Spiders are predators and habitat specialists and as a result, populations respond quickly to disturbance. Beetles are present in a wide array of trophic levels and play a significant role in many forest processes. This project focuses on these two taxa to develop and implement long-term monitoring protocols to track changes in ecological integrity in forest ecosystems at Kejimkujik.

Pardosa species (photo byT.Rossolimo).

# Monitoring

## FOREST FLOOR ARTHROPOD MONITORING

### OBJECTIVES

- To test the effectiveness of various arthropod traps for long-term monitoring.
- To determine the most effective level of identification for long-term monitoring.
- To determine the most appropriate sample size for long-term monitoring to detect trends in arthropod communities.
- To develop protocols for data analysis and interpretation for long-term arthropod monitoring.

### METHODS

- Arthropod sampling was conducted in Kejimkujik at six sites in 2004 and four sites in 2005. Sites were chosen randomly to represent two major forest types: hemlock and mixed hardwood.
- Sampling was conducted at established long-term forest ecosystem monitoring plots in Kejimkujik in order to integrate with other forest measures (*i.e.* forest birds, salamanders, decomposition, vegetation).
- Pit-fall traps and ramp traps were established at each site to compare the effectiveness of different trapping methods.
- Sampling occurred over two ten-day periods in July and August of 2005.
- Following the sampling periods, arthropods were collected from traps and identified to species level.

Researcher using a ramp trap (photo by T.Rossolimo).

## RESULTS

Researcher using a pit trap (photo by T.Rossolimo).

- Beetle and spider populations at Kejimkujik were inventoried. Seventy-four species of beetles were identified within 19 families.
- Fourty-four species of spiders were identified within 14 families.
- There was no significant difference between the species composition of arthropods in pitfall traps and ramp traps; however, the ramp traps were more effective at avoiding by-catch of non-target species.
- There was a significant difference in the species composition of beetles in July and August. Additionally, there was a difference in the species composition of spiders within the two forest types.
- Species richness of arthropods was greatest in July.
- The majority of beetles collected were representative of a predaceous trophic class.
- These data provide a baseline for long-term monitoring of forest ecosystems in Kejimkujik.

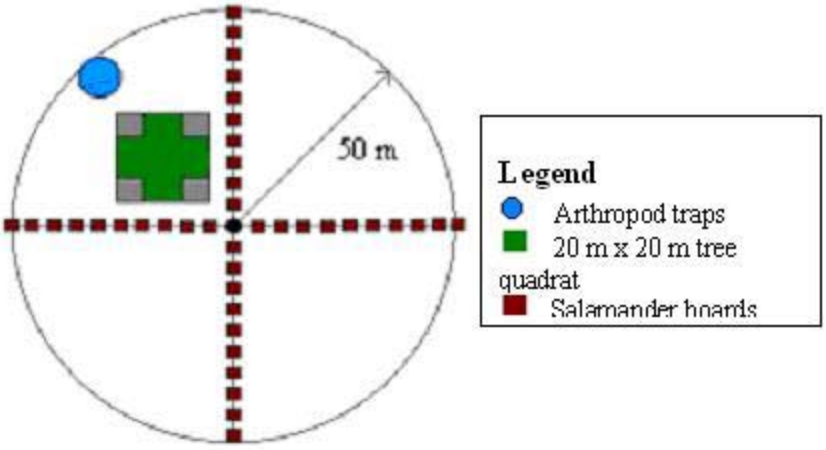
## YEARS OF DATA

- 2004-2005
- Re-assessment frequency of 5 years

## PARTNERS

- Dalhousie University
- Parks Canada

Tiger beetle (photo by Parks Canada).




Schematic of sites chosen for Kejimkujik long-term forest ecosystem monitoring plots.

## CONTACTS

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## Rationale

Fire behaviour analysis assists firefighters in making appropriate decisions in critical wildfire situations. The way fire behaves on the landscape is dependent on three specific parameters: weather, topography and fuel characteristics. In Canada, a mathematical model called the Canadian Forest Fire Behaviour Prediction (FBP) System integrates these three factors and provides predictions for wildfire behaviour in a particular landscape. Within the FBP System, 16 fuel types were devised to characterize 16 typical Canadian forest compositions according to how they influence fire behaviour. In order to use the FBP System effectively, fire officials need to characterize the land they are responsible for in terms of these 16 fuel types.

Typical stand of "Nova Scotia Special" fuel type: Heath land of ericaceous shrubs species (photo by R.Brisson, Parks Canada).

# Research

## FUEL TYPING KEJIMKUJIK'S FOREST

### OBJECTIVES

- To develop a process to classify the forest of Kejimkujik according to the 16 fuel types of the FBP system.
- To produce a fuel type map that illustrates the fuel types of Kejimkujik to provide an effective management tool.

### METHODS

- The 1992 NSDNR Forest Cover Database was reviewed to determine the fuel types present in the park.
- Fuel types were structured in a chart to assign the forest stands into appropriate classifications.
- GIS software was used to assign fuel types to the forest stands according to the classification chart.
- The accuracy of the chart was evaluated by field verifying the fuel types of 175 sample forest stands.
- Corrections identified through field observations and accuracy results were applied to the chart to enhance precision.
- A geo-referenced colour map was produced that illustrates the fuel types found in Kejimkujik.
- A similar exercise was performed at the Kejimkujik Seaside Adjunct.

Kejimkujik's fuel type classification chart.

| Fuel type | *Area (ha)* | *Percentage of park land base (%)* |
|---|---|---|
| Boreal spruce | 4649 | 14 |
| Mature jack/Lodgepole pine | 10727 | 33 |
| Immature jack/Lodgepole pine | 907 | 3 |
| Red/White pine | 1540 | 5 |
| Leafless aspen | 2783 | 9 |
| Boreal mixedwood | 9835 | 31 |
| Dead Balsam fir mixedwood | 6 | >1 |
| Open grass | 224 | 1 |
| White spruce/Balsam fir slash | 1 | >1 |
| Nova Scotia Special | 1450 | 4 |
| No fuel | 118 | >1 |
| Land Base | 32240 | 100 |
| Water bodies | 5874 | n/a |
| Whole park | 38114 | n/a |

## RESULTS

Maple-spruce forest on poorly drained soil (photo by R.Brisson, Parks Canada).

- Although the results of the first version of the classification chart were very positive, a number of observations contributed to revisions in the methodology. Key observations are listed below.
    - The chart did not assign a C-5 fuel type to most mature hemlock stands.
    - Field observations revealed that the lack of understory in mature mixedwood stands prevented them to be assigned one of the "Mixedwood" fuel types (one characteristic of which is the presence of a coniferous understory).
    - Several of the mature mixedwood stands without an understory were assessed in the field as one of the "Mixedwood" fuel types regardless of the lack of understory.
- A new fuel type was defined as "Nova Scotia Special" (as agreed with provincial officials). This type of vegetation composition is not described in the FBP System and is so different from any other fuel types that it must be characterized separately.
- Out of the 16 FBP fuel types, three largely dominate Kejimkujik's landscape and cover 78% of the land base. They are “mature jack/ lodgepole pine” (33%), “boreal mixedwood” (31%), and “boreal spruce” (14%). Note that the new "Nova Scotia Special" fuel type covers only 4% of the land base.

## YEARS OF DATA

- This project started in summer 1994 and ended in spring 2006.
- The fuel type map should be revised every 10 years or when a new Forest Cover Database is produced.

## PARTNERS

- Parks Canada

Travelling cross-country to assess the fuel type of sample stands (photo by E.Gillis, Parks Canada).

## CONTACTS

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## Rationale

American moose populations throughout most of northeast North America have recovered from population declines over the past 50 years and now appear to be stable or increasing in density. In Nova Scotia, moose densities in the highlands of Cape Breton are increasing; however, moose populations in the mainland remain low with only scattered pockets of animals. Under the Nova Scotia Endangered Species Act (2003), mainland moose were designated as an endangered species. The Tobeatic region of western Nova Scotia is of special interest because it represents one of the last remaining indigenous moose populations in mainland Nova Scotia. Moose have persisted in this region while extirpations have occurred elsewhere. This may be due to topography, habitat type, lack of exposure to White-tailed deer or being insularized from human activity (including poaching). With only scattered populations of animals distributed across mainland Nova Scotia, the ability of the species to persist in the mainland is of concern. In the absence of biological information on mainland moose, this study was designed to explore the population biology and ecology of moose in mainland Nova Scotia.

Moose cow and calf from 1936 (photo by NSDNR).

# Research

## MOOSE OF MAINLAND NOVA SCOTIA

### OBJECTIVES

- To investigate the changes in moose abundance and distribution through time across mainland Nova Scotia using provincial pellet group data.
- To estimate population abundance and sex/age composition of moose within the Tobeatic and the Cobequids.
- To investigate calf survival within the Tobeatic.
- To investigate moose habitat use/availability in mainland Nova Scotia through building habitat models.

### METHODS

- Provincial pellet group data were analyzed to detect changes in distribution and abundance of moose over time.
- Fifteen moose were collared within the Tobeatic. Using radio-telemetry, moose movements and estimates of adult and calf survival were determined.
- An aerial survey was conducted during the winter of 2001. Survey data enabled researchers to determine sex/age composition and abundance of the Tobeatic population.
- A combined GIS and statistical approach was used to model winter habitat use within mainland Nova Scotia at three spatial scales. Using a generalized linear modeling framework, logistic regression models were developed relating habitat variables to a presence/absence variable (pellet group data).

Aerial habitat photo in the Tobeatic with Moosehead Lake in the middle (photo by D.Brannen).

## RESULTS


Bull Moose (photo by Parks Canada).

- From 1983 to 2002, pellet group data showed continual declines in moose relative abundance across mainland Nova Scotia.
- Mean home range size was 45.1 $km^2$.
- Mean newborn calf/cow ratio was 1.3:1.
- Mean adult survival was 0.88. Mean first nine week calf survival was 0.38.
- Six hundred and thirty-two $km^2$ of the core Tobeatic were surveyed. Results showed a mean density of 0.18 moose/$km^2$. The bull/cow ratio was 0.61:1, while the calf/cow ratio was 0.18:1. General comparison to a survey conducted in 1993 suggests a possible 35% decrease in the Tobeatic population.
- Given weather, helicopter availability and the short window of opportunity in western Nova Scotia, conducting aerial surveys was a challenging approach.
- Habitat models were developed at three spatial scales (1 $km^2$, 6 $km^2$ and 30 $km^2$). Various aspects of softwood stand height, canopy closure, mixed forest stands, presence of roads, number of wetlands, elevation, and clearcuts were factors in predicting moose presence.

## PARTNERS

- Acadia University
- Nova Scotia Department of Natural Resources
- J.D. Irving Limited
- Bowater Mersey Paper Company
- Wildlife Associations of Nova Scotia


Collaring a moose in the Tobeatic (photo by NSDNR).

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## Rationale

Periodic outbreaks of insect defoliators can result in removal of foliage and potential mortality of host trees. The Pale-winged gray is a native geometrid moth that feeds on a wide range of hardwood and softwood trees and shrubs. Moths use chemical communication to locate mates (*i.e.* the female produces a chemical, called a sex pheromone, which attracts only males of that species). Identification of this sex pheromone can lead to the development of tools to: (i) monitor and determine the extent of insect populations; and/or (ii) manipulate population levels by interrupting mating through mass trapping of male moths or confusing male moths by saturating the environment with synthetic lures containing the sex pheromone.

Pale-winged gray larvae on a defoliated hemlock branch (photo by CFS).

# Research

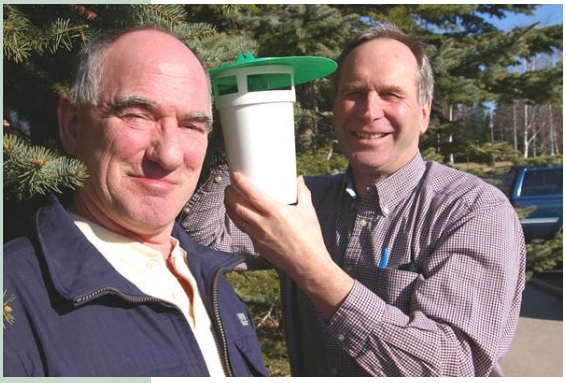
## PALE-WINGED GRAY MOTH PHEROMONE

### OBJECTIVES

- To isolate, identify and synthesize the sex pheromone of the Pale-winged gray.
- To assess the effectiveness of the pheromone in trapping male moths.
- To develop a tool for monitoring Pale-winged gray populations to provide an early warning of impending outbreaks.

### METHODS

- The research was conducted in mature Eastern hemlock stands located in Kejimkujik (at the junction of the Canning Field Road and park boundary) and in a private woodlot near Caledonia, Nova Scotia.
- Pale-winged gray larvae were collected and reared in a laboratory to the adult stage.
- The terminal segments of the adult female body, which contain the glands producing the sex pheromone, were removed.
- Chemicals from the gland were removed by washing in appropriate solvents or collecting directly from live females.
- The response of male moths to the chemicals was evaluated by passing the chemicals over the antenna on which the sensory organs are located.
- The chemicals that elicited a response were identified using gas chromatography/mass spectrometry analysis.
- The identified chemicals were then synthesized in the lab.
- Field trapping was conducted using synthetic chemicals to determine their ability to attract and capture male moths.



P.Silk (Left) and D.Ostaff (Right) checking a pheromone trap (photo by CFS).

## RESULTS

- Sex pheromone gland extracts and volatiles were analyzed, synthesized and formulated in lures.
- In field trapping studies, a significant number of male moths were captured in traps baited with some, but not all, lures when compared to traps baited with virgin females.
- Two chemicals have been identified as the most likely components of the sex pheromone of the Pale-winged gray.
- Additional tests are needed to determine the appropriate concentration of the chemicals to capture the greatest number of moths.
- Capturing large numbers of moths would require the use of suitable traps.

## PARTNERS

- Nova Scotia Department of Natural Resources
- University of New Brunswick
- Parks Canada
- Canadian Forest Service

Moth adults on bole (photo by CFS).

Electroantennographic detection equipment (photo by CFS).

## CONTACTS

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## Rationale

The Pale-winged gray moth is a native moth distributed widely across eastern North America. Caterpillars of this species feed on leaves from a variety of trees and smaller plants with woody stems. An outbreak of this insect has been occurring in Kejimkujik and in the surrounding area since 2002, causing widespread defoliation of Eastern hemlock trees and the death of understory hemlock in some mature hemlock stands. As there are no peer-reviewed scientific articles on this insect, park managers and neighbouring woodlot owners did not possess monitoring tools to sample it or ecological information to predict the impact of the outbreak on tree mortality and other ecosystem processes.

# Research

## PALE-WINGED GRAY MOTH ECOLOGY AND MANAGEMENT

Last instar Pale-winged gray larvae feeding on Eastern Hemlock (photo by L.Pinault).

### OBJECTIVES

- To develop sampling methods to monitor the different life stages of the Pale-winged gray moth.
- To describe the different life stages of the Pale-winged gray moth.
- To determine the major factors influencing survival and reproduction.
- To produce reliable predictions of the amount of hemlock defoliation that will occur by the end of summer based on the number of eggs laid the previous fall, or on the number of hatched eggs at the beginning of the same summer.

Summer student L.Carrat counts first-instar Pale-winged gray larvae on sticky tape (photo by L.Pinault).

### METHODS

- Field surveys and subsequent rearing of insects on cut stems were conducted to describe all life stages.
- Field surveys, rearing of juveniles and adults, dissections of dead individuals and behavioural studies were used to examine factors influencing survival and reproduction.
- Eggs laid in crevasses in tree bark were extracted using a modified washing method developed previously for hemlock looper eggs. Female moths prefer to lay eggs in foam rather than in bark and so egg densities were also estimated by placing small pieces of upholstery foam on tree trunks. During the June hatch, the density of newly emerged larvae was estimated by placing a sticky tape around the lower trunk of trees, and the density of older larvae was estimated using a "beating-sheet" method.
- Density estimates from the sampling procedures described above were correlated with subsequent levels of defoliation to produce predictive relationships between egg or larval densities and subsequent defoliation.

## RESULTS

Adult Pale-wing gray moth (photo by C.McCarthy, Parks Canada).

- Eggs of the Pale-winged gray are laid in the bark of host trees in late summer and hatch the next spring, coinciding with the flush of new hemlock growth. There are five developmental stages (instars) of caterpillars. Newly-emerged larvae feed exclusively on new foliage but older larvae also feed on old foliage of hemlock. In mid-July to early August, larvae fall to the ground, bury themselves into the duff or loose soil, and pupate. Adults emerge approximately three weeks later, mate during the night (midnight until 6:00am) and during the next couple of days females lay eggs at dusk (10:00pm to midnight).
- Both food quality and a fungus influenced larval survival during the past two summers. Pupal mortality was high, presumably due to predation. Females usually laid 20-50 eggs, depending on their size and access to nectar.
- All four sampling methods appear to provide reliable estimates of Pale-winged gray densities.
- Egg and larval densities from all four sampling methods were correlated to subsequent defoliation, suggesting that they can be used as predictive tools for managers and woodlot owners.

## YEARS OF DATA

- After a preliminary assessment in 2003, this study was initiated in 2004.
- A full field season of research is planned for summer 2006.

## PARTNERS

- Parks Canada
- Nova Scotia Department of Natural Resources
- Canadian Forest Service
- Forest Protection Limited
- Natural Sciences and Engineering Research Council of Canada

Graduate student L.Pinault samples Pale-winged gray larvae from hemlock using a beating sheet (photo by L.Carrat).

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## Rationale

Habitat fragmentation is one of the most common threats to species extinction and biodiversity loss. The negative effects of fragmentation include loss of species, changing species assemblages and altered ecological processes. These effects can be countered by maintaining landscape connectivity. Protected areas are often too small to maintain species populations over the long term. The purpose of this project is to identify key areas for landscape connectivity among a suite of protected areas in southwestern Nova Scotia. Because there is no common recipe for including landscape connectivity in conservation planning, local expert knowledge is being used to identify key areas of landscape connectivity. Results of this project will pinpoint existing knowledge gaps and opportunities for future research, and may be used to guide decision-makers in the establishment of conservation-minded management practices that maintain connectivity throughout the landscape over time.

Research

# IDENTIFYING KEY AREAS OF LANDSCAPE CONNECTIVITY

Aerial photo showing landscape fragmentation in West Caledonia, Queens County (photo by Google Earth).

## OBJECTIVES

- To select a suite of focal species for connectivity in southwestern Nova Scotia.
- To consider local expert knowledge in developing a process to include landscape connectivity in conservation planning.
- To apply the process in southwestern Nova Scotia by using existing information to create connectivity maps for the chosen focal species.
- To identify key areas of landscape connectivity in southwestern Nova Scotia among a suite of protected areas.

## METHODS

- The first phase of this project followed a procedure called the Delphi method, which consisted of interviews and a follow-up workshop. The Delphi method is an iterative, structured group communication process used to ease the task of solving complex problems.
- Eleven interviews were conducted with local experts during summer 2005.
- A workshop was held where emerging themes from the interviews were presented and discussed to determine an approach for identifying key areas of landscape connectivity.
- Workshop participants also completed an activity to rank focal species and elements for connectivity.
- Based on the workshop results, a list of focal species was refined to a suite of eight focal species and elements to be used to address connectivity at multiple scales in different ecosystems in southwestern Nova Scotia.

Candidate focal species and elements for connectivity in southwestern Nova Scotia and the refined suite to identify key areas of connectivity in this project.

| Focal Species/Elements | Refined Suite |
|---|---|
| American moose | X |
| American marten/Fisher | X |
| Flying squirrels | X |
| Northern goshawk | |
| Blanding's turtle | |
| Red-backed salamander | |
| River otter | |
| Brook trout | X |
| American eel | |
| Eastern hemlock | X |
| Red maple | |
| Lichen species | |
| Atlantic coastal plain flora | X |
| Dragonflies | |
| Old-growth forest beetles | |
| Passerine birds | |
| Riparian areas | X |
| Old-growth forest | X |

## METHODS (continued)

- Data were acquired on the habitat preferences, occurrence, dispersal ability and movement patterns of the chosen focal species, and used to create connectivity maps identifying key areas for connectivity in southwestern Nova Scotia.

## RESULTS

- Interview and workshop participants supported the use of focal species as one component of a mixed approach for biodiversity conservation and maintenance of functional landscape connectivity.
- For greatest utility, this approach should be combined with analysis of structural connectivity elements.
- A list of 18 candidate focal species and focal elements for connectivity in southwestern Nova Scotia was selected that can be used to guide future connectivity studies.
- Focal species have their own connectivity requirements within the study area. Focal elements, such as old-growth forest and riparian corridors, act as umbrellas for species that require connectivity.
- The overall list of focal species and elements was refined because of time limitations and the availability of existing data. The remaining focal species and elements could be considered in future applications of the process developed here to identify key areas of landscape connectivity.
- Connectivity mapping for the chosen focal species and elements is underway.

American moose, a selected candidate focal species for connectivity (photo by Multi Image Inc, Parks Canada).

## YEARS OF DATA

- Interviews and workshop took place summer 2005.
- Landscape connectivity mapping process is ongoing.
- Project to be completed by September 2006.

## PARTNERS

- Dalhousie University
- Centre of Geographic Sciences, Nova Scotia Community College
- Nova Scotia Department of Environment and Labour
- Mersey Tobeatic Research Institute
- Parks Canada

Old-growth forest, a selected candidate focal element for connectivity (photo by A.Lavers, MTRI).

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## Rationale

Ecologists consider that landscape connectivity is what allows organisms to move through resource patches in both time and space. A landscape that does not have connectivity can be described as fragmented. Flying squirrels may be sensitive to fragmentation and good indicators of landscape connectivity because they need mature trees to climb for gliding and to sleep in during the day. To understand the connectivity requirements of flying squirrels in Nova Scotia, local life history data are required about how long they live, how many young they have and how they disperse. The aim of this project is to determine whether passive integrated transponder (PIT) tags can be used to collect some life history data for flying squirrels. PIT tags are small glass microchips that are inserted under an animal's skin and which provide the time, date and unique code for the animal when they pass through a circular antenna.

Southern flying squirrel (photo by A.Lavers, MTRI).

# Research

## TESTING FLYING SQUIRREL PIT-TAGS

### OBJECTIVES

- To determine how PIT tags and live-trapping compare for tracking survivorship of flying squirrels.
- To determine the optimal bait, spacing and configuration for deploying PIT-tag recorders in study grids.

### METHODS

- A 15 ha study site has been established on private land in West Caledonia with wooden brackets placed on the south side of trees at chest height.
- Live traps were placed on the brackets and baited with peanut butter.
- Captured flying squirrels were implanted with PIT-tags and released where they were caught.
- Six receiving stations were placed at random locations within the grid and moved to other random locations every six days between December 22, 2005 and March 27, 2006.
- Live traps were used again in April to capture flying squirrels.

A.Lavers downloading data from a PIT-tag recorder (photo by P.Hope).

### RESULTS

- Preliminary results suggest that PIT tags will be effective for measuring survivorship, analyses are ongoing to optimize study designs.
- Seventeen flying squirrels (9 Southern and 8 Northern) were live-trapped on the study grid in December. Five of the 15 tagged animals visited recording stations between January and March.
- Four of the five animals who regularly visited recording stations were live-trapped in April.

## RESULTS (continued)

- Squirrels visited recording stations throughout the night but commonly visited just after dusk. Most animals appeared to be tied to a particular area.
- Seven new Northern flying squirrels were live-trapped on the study grid in April.

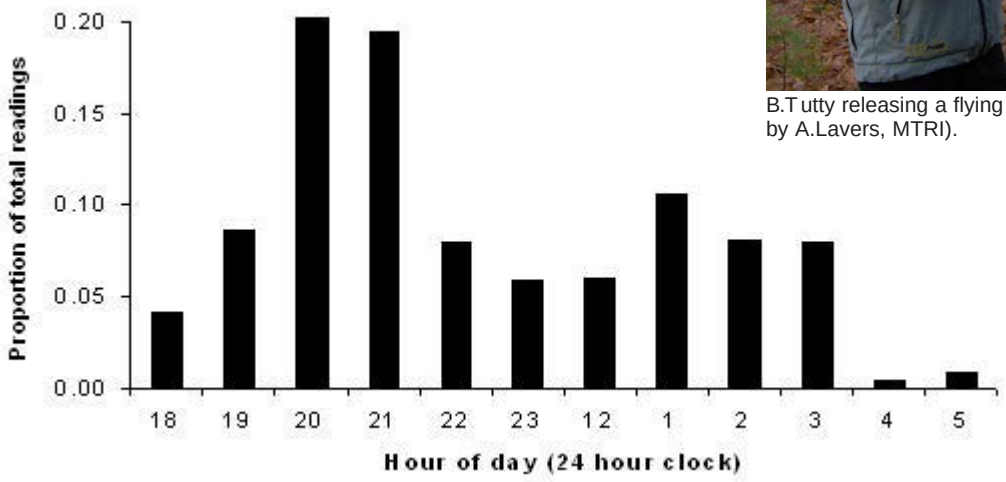
## YEARS OF DATA

- 2006

## PARTNERS

- Parks Canada
- Mersey Tobeatic Research Institute
- Saint Mary's University
- Greater Fundy Ecosystem Research Group

B.Tutty releasing a flying squirrel (photo by A.Lavers, MTRI).




Flying squirrel daily activity time (produced by A.Lavers).

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PIT-tagging a flying squirrel (photo by A.Lavers, MTRI).

## Rationale

Old-growth forests are considered to be of high biodiversity conservation value, due in part to their relative rarity in many forest regions and also because they are more structurally complex than younger stages of forest development. This structural complexity creates a variety of habitat niches and keystone structures that enhance the forest's capacity to support biodiversity. In managed forests, preserving these characteristics in existing old-growth and promoting them in younger forests enhances the capacity of forests to support biodiversity, and particularly species that rely upon old-growth features. Research on existing old-growth forests, and the processes that characterize the transition from young or mature forests to old-growth, can inform the development of management strategies and practices that preserve and promote key structural elements and patterns. This project examined the trends of old-growth development in conifer-dominated forests in southwestern Nova Scotia.

Research

# STRUCTURAL COMPLEXITY IN OLD-GROWTH FORESTS

Looking skyward into the canopy of a 380-year-old forest along the Mersey River (photo by P.Duinker).

## OBJECTIVES

- To examine trends in the development of forest structure and structural complexity as forests progress from young to old-growth stages.
- To identify key elements of forest structure that distinguish old-growth forests from those at earlier stages of development.
- To develop recommendations for forest management to promote the development and conservation of old-growth and old-growth features across the managed forest landscape.

Eastern hemlock on Bowater Mersey Paper Company land (photo by A.Lavers, MTRI).

## METHODS

- Sites dominated by late-successional coniferous species (*i.e.* Eastern hemlock, Red spruce, and White pine) were sampled.
- Date were collected from forest plots on variables such as species composition of the overstory and understory, canopy tree size, density of the canopy and understory, amount and type of standing and downed deadwood, vertical distribution of foliage in the canopy, and the horizontal pattern of tree distributions across forest sites.
- Trends of development of key structural features such as canopy gaps, large snags (dead trees), and multi-layered understories were identified.
- Profiles of stages of forest development as sites progress from young- to old-growth were developed. Key features and processes characteristic of different stages were identified.

## RESULTS

Researcher V.Woolfrey amid Eastern hemlocks over 300 years old and more than nine stories tall (photo by T.Pesklevits).

- Sampled sites ranged from 50 to 400 years old. The proportion of Eastern hemlock increased and the proportion of White pine decreased with site age. This suggest that there is a clear successional gradient in the sampled forests and also that historic targeted harvesting of white pine has reduced its significance in Nova Scotia's old-growth forests.
- The prevalence of key structural variables, such as large-diameter trees and snags and the volume of dead wood, increased with site age, but this trend showed high variability even among sites with similar ages. This suggests that site context is a key factor in the development of structural complexity in old-growth forests.
- No single model captures the full range of diversity of structural development of old-growth forests. As forests age, they become increasingly dominated by localized processes that create high spatial variability in structural attributes. These localized processes create a variety of microhabitats for forest organisms, such as cavity trees and dense patches of understory growth, but this happens at different rates depending on site factors such as the species that dominate the overstory and the average size of trees in the overstory.
- As a result, forest management activities may be able to direct the development of these structural features in younger forests through small-scale, low-intensity intervention using specific development objectives.

## YEARS OF DATA

- This project is part of a three-year multidisciplinary project examining ecological, social, and economic aspects of old-growth management and conservation in eastern Canada.
- Data collection for this component of the project occurred in 2005. Project deliverables are due for completion in 2007.

## PARTNERS

- Dalhousie University
- Sustainable Forest Management Network
- Bowater Mersey Paper Company
- The larger project involves researchers at Lakehead University, University of British Columbia, and University of Toronto

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## Rationale

As a forest develops the types of epiphytic (growing on trees) lichen species within it change. To be present, each species requires specific moisture levels, light exposure, substrate and nutrients. The quantity of each of these conditions changes as a forest ages and develops making epiphytic lichens good indicators of forest age and structure. The conditions that each lichen species requires at the micro-level have been examined widely. However, little is known about the stand level structural complexities necessary to create the particular microhabitats required for each species to be present, which provided the rationale for this project. The results from this project will assist with stand level coniferous old-growth forest conservation strategies.

*Usnea* spp. (Old man's beard) (photo by T.McMullin).

# Research

## LICHENS IN OLD-GROWTH FORESTS

### OBJECTIVES

- To explore stand level structural complexities of various coniferous old-growth forests in southwestern Nova Scotia that may influence the presence of particular epiphytic lichens within them.

### METHODS

- Fifty-one unmanaged coniferous forest stands, between 60 and 350 years old were examined in southwestern Nova Scotia.
- A temporally and spatially constant plot was established in each stand.
- The presence of all epiphytic lichens located within each plot was recorded.
- Each stand's structural complexity was established by assessing canopy cover, basal area, stand height, tree species and tree age.
- Epiphytic lichen presence and structural complexity were examined for correlations.

Collecting lichens in the old forests around Lake Rossignol (photo by T.McMullin).

### RESULTS

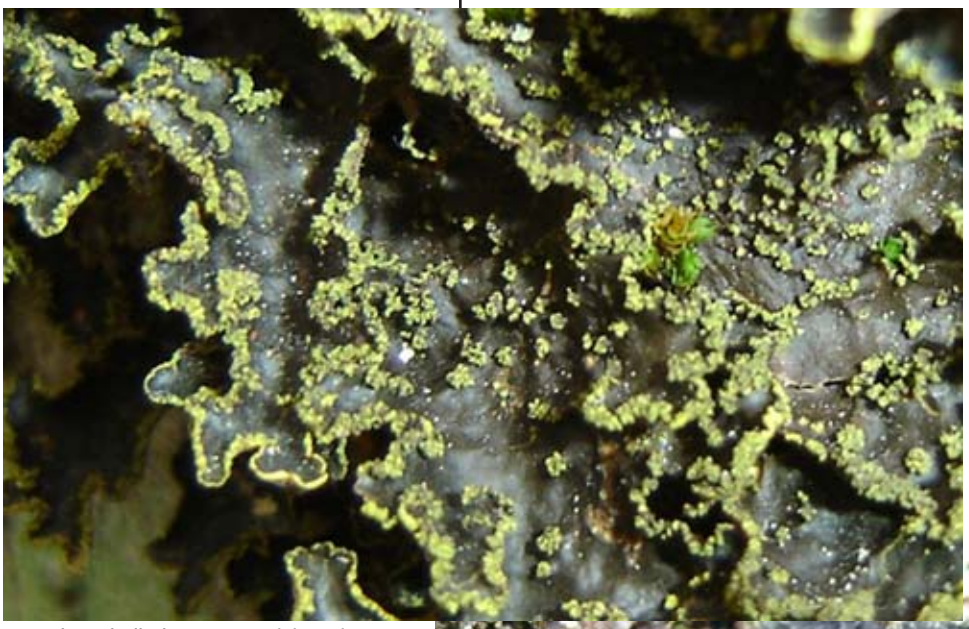
- One hundred and forty lichen species were located throughout all 51 stands.
- Preliminary results suggest that epiphytic lichen richness does not increase with forest age.
- Particular epiphytic lichens have been found to be present only in older stands.
- Several rare lichens have been discovered, as well as new species to Nova Scotia, new species to North America and new world wide species.
- Further data analysis will be used to examine other correlations between old-growth forest structural complexity and epiphytic lichen presence.

**YEARS OF DATA**

- 2005

**PARTNERS**

- Dalhousie University
- Sustainable Forest Management Network
- Bowater Mersey Paper Company



*Pseudocyphellaria perpetua* (photo by T.McMullin).

*Pannaria rubiginosa* (photo by T.McMullin).

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## Rationale

The management of old-growth forests is complex. In the last centuries and decades, old-growth forests have declined significantly. Scientific and management organizations are concerned that data gaps, policy pressures and value conflicts will hamper sustainable forest management of old-growth forests. The purpose of this study is to describe and prioritize old-growth values of citizens and groups in Nova Scotia for integration in future sustainable forestry decision-making. This study is based on eight one-day field trips to forest stands in Queens County, Nova Scotia. Participants were selected to represent five citizen groups identified in the literature as groups whose values should be taken into consideration in forestry decision-making. These include Aboriginal groups, environmental non-government organizations (ENGOs), forestry professionals, and the general public (urban and rural). To date 70 participants attended the one-day sessions during September/October 2005. Another session is scheduled for May 2006.

Old-growth hemlock stand (photo by A.Lavers, MTRI).

# Research

## OLD-GROWTH FORESTS' SOCIAL VALUES

### OBJECTIVES

To understand and describe:

- What makes a forest old-growth?
- What elements of forests are valued?
- What elements of old-growth forests are valued? Are some elements more valuable than others? Why?
- What is the extra or added value of old-growth as compared to non old-growth?
- Are old-growth values compromised by silvicultural interventions? If yes, which values are compromised? Why?
- Do values differ by citizen constituency?
- What types of old-growth values are described?

### METHODS

- Each participant was given a diary to record personal thoughts during visits to young and old-growth forests stands in the morning.
- In the afternoon a group discussion and rating sheet was used to elicit additional information.
- These three sets of data were being used for triangulation and theme building purposes.
- The qualitative data were being analyzed using N6, qualitative research software.
- Through the support of a Dalhousie PhD statistics candidate, the quantitative data were analysed using the statistical software, R.

Study participants entering a stand (photo by R.Owen).

## RESULTS

Mossy log in an old-growth site (photo by R.Owen).

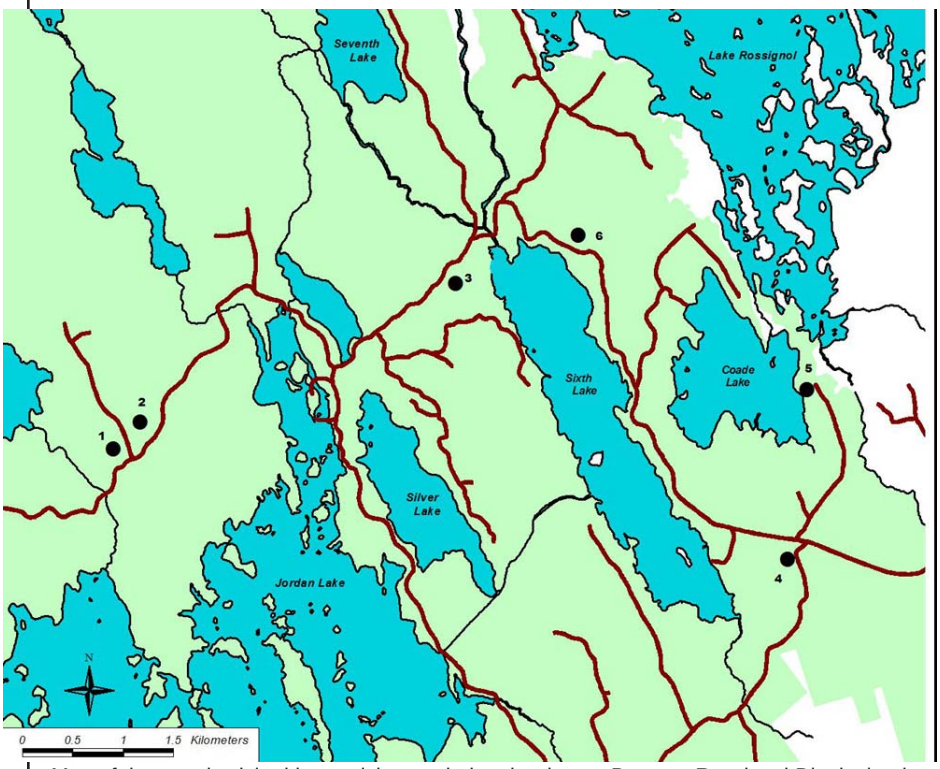
- Preliminary results suggest a variety of environmental, economic, moral/spiritual, and aesthetic values were assigned to old-growth forests by all constituency groups.
- There is a trend emerging that reveals stronger preference by most constituency groups towards environmental and moral/spiritual values for old-growth forests.
- The attributions of some values such as habitat are ascribed by participants to both young and old-growth forests. The value difference often lies in the interpretation of the value definition and the strength of the value conviction.
- The strength of certain value convictions appears to be influenced by some socio-demographic characteristics; however, some moral/spiritual values have remained consistently important across all groups.

## YEARS OF DATA

- Fall 2005: Eight one-day field trips
- Spring 2006: One or two one-day field trips

## PARTNERS

- Dalhousie University
- Bowater Mersey Paper Company
- Sustainable Forest Management Network




Map of the stands visited by participants during the day on Bowater Rossignol District land (produced by R.Owen).

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## Rationale

The use of trees and tree rings to understand past climates, biological processes, adaptations to change and forest evolution through time, is one of the few techniques that can illuminate all of these research areas on an annual basis. Because of the fine scale resolution in past records that tree-ring analysis (dendrochronology) provides, it is seen as a very strong technique to further understand the past environment in southwestern Nova Scotia. Understanding the past growth dynamics enables modelling and assessment of the future dynamics of forests and their inhabitants, specifically which species might be able to adapt to the changing ecosystems easier, and which cannot.

Students coring trees in a pine forest near Atkin's Brook, Kejimkujik (photo by C.Laroque).

# Research

## TREE-RING ANALYSIS

### OBJECTIVES

- To obtain core samples from all species of coniferous trees in the region to establish climate/growth relationships between radial-tree growth and the instrumental record.
- To establish long-term proxy climate records for targeted species whose radial growth/climate relationships are key to the Blanding's Turtle Recovery Team program.
- To combine climate/growth relationships with future climate change scenarios to forecast tree species ability to adapt to future changes in climate.

### METHODS

- Selected tree species and sites were identified and increment cores were collected from the region.
- Samples were analyzed in the Mount Allison Dendrochronology Laboratory (MAD Lab) and rings were measured to a thousandth of a mm.
- All conifer tree species were pattern matched to establish each species overall growth characteristics.
- Climate/tree-ring relationships were developed for each species.

Forest edge along a Blanding's Turtle nesting beach near Atkin's Brook, Kejimkujik (photo by C.Laroque).

### RESULTS

- Balsam fir is the best climate predictor species, but this species has the youngest trees in the region.
- Eastern hemlock is the oldest tree species in the region, but is a poor climate predictor.
- White pine and Larch are temperature sensitive species.
- Eastern hemlock and Balsam fir are precipitation sensitive species.
- Red spruce is a generalist species that shares commonalities with both temperature and precipitation groups.

**YEARS OF DATA**

- 2004-2009

**PARTNERS**

- Mount Allison Dendrochronology Lab
- Acadia University
- Atlantic Centre for Global and Ecosystem Research
- Natural Sciences and Engineering Research Council of Canada

M.Richard coring a hemlock near McGowan Lake, Nova Scotia (photo by C.Laroque).

Forest edges near the Pleasant River Meadows which are known Blanding's turtle habitat (photo by C.Laroque).

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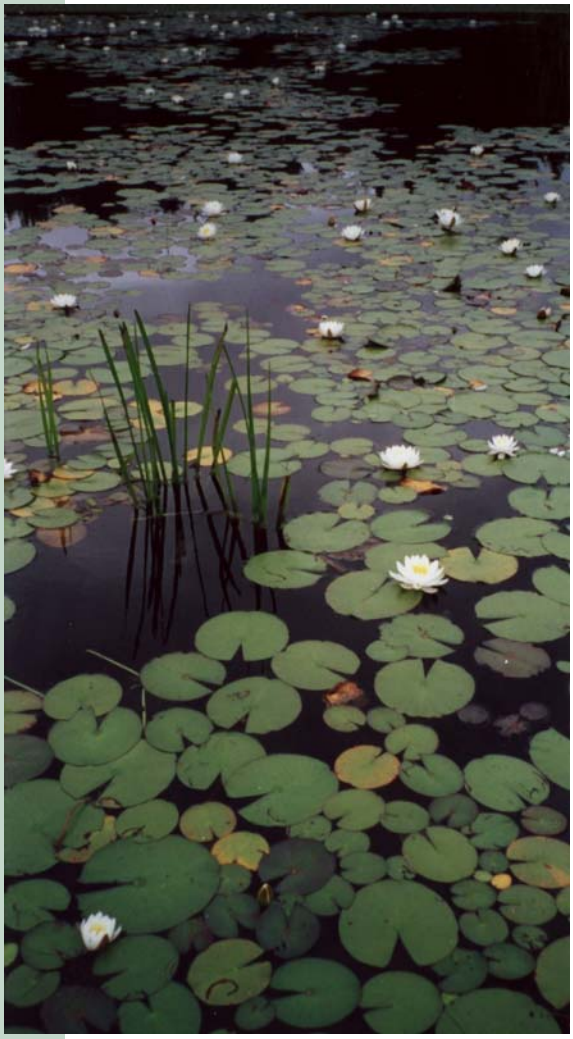
**Photos by:**
- Bottom left: A.Lavers, MTRI
- Bottom right: A.Lavers, MTRI
- Middle right: P.Hope, Parks Canada
- Top left: A.Lavers, MTRI
- Top right: A.Lavers, MTRI

## FRESHWATER



## Rationale

Acid rain is a significant threat to Kejimkujik ecosystems. The atmospheric systems affecting this region pass over central Canada and central United States, collect nitric and sulphuric acids from emissions, and deposit them via precipitation over eastern Canada. Additionally, southwest Nova Scotia is sensitive to acid precipitation because its soils and bedrock have poor acid-buffering capacities. Freshwater ecosystems are particularly sensitive to acidification. As a result, Environment Canada has been monitoring changes in water chemistry in Kejimkujik and throughout the Atlantic region since 1980 in order to assess the impacts of acid precipitation. During this time, acid precipitation in the region has decreased, as a result of international sulphur dioxide emission controls. However, recent studies are necessary to understand why surface water chemistry is recovering from acidification at such a slow rate in this region.

# Monitoring

## ACID RAIN AND WATER CHEMISTRY MONITORING

Mill Falls on the Mersey River in Kejimkujik (photo by EC).

### OBJECTIVES

- To monitor the water chemistry of 30 lakes at Kejimkujik twice-yearly (May and October) to track changes in acidification.
- To monitor the water chemistry of 4 streams at Kejimkujik and in the surrounding region on a weekly basis in order to assess rates of chemical change.
- To develop chemical models to understand the low rates of improvements in freshwater acidification in this region.

### METHODS

- Helicopter and land-based sampling were conducted of surface waters.
- Laboratory analyses were conducted of over 300 water samples each year.
- Computer modeling was conducted to understand and predict the changes occurring in water chemistry.

### RESULTS

- Acid deposition has been reduced by over 50% over the last 20 years, but acidity of lakes and rivers in this region has only changed slightly.
- Poor buffering capacity of soils and wetlands seem to be impeding a return to pre-acidification conditions.
- Long-term monitoring data and reports associated with this project are distributed on a compact disc compiled by Environment Canada entitled: Acid precipitation monitoring networks in Atlantic Canada - Update 1982-2003. 2005. Environment Canada - Atlantic Region, Occasional Report #24.

Mercury study (photo by P.Hope, Parks Canada).

## YEARS OF DATA

- 1980- present
- This is an on-going long-term monitoring project

## PARTNERS

- Parks Canada
- Canadian Coast Guard
- Environment Canada Acid Rain Program

T.Clair collecting a water sample (photo by P.Hope, Parks Canada).

Kejimkujik Lake (photo by P.Hope, Parks Canada).

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## Rationale

Water quality has a key influence on the ecological integrity of aquatic ecosystems, and on their sustainable use. Routine monitoring of physical and chemical attributes of waterbodies determines whether they are changing and allows a degree of prediction of the potential biological and ecological threats. This project examines variations and trends of the following: (a) the hydrology and water chemistry of the Mersey River over the 25-year period 1980 to 2004, and (b) a 21-year dataset (1983 to 2003) for water chemistry of a suite of 27 lakes in Kejimkujik. The data were anlyzed to determine variations and trends of water chemistry among the lakes, as well as any exceedances of regulated threshold values for the protection of aquatic life.

# Monitoring

## CHEMISTRY OF SURFACE WATERS IN KEJIMKUJIK

Mersey River (photo by A.Lavers, MTRI).

### OBJECTIVES

- To examine variations and trends of hydrology and water chemistry of the Mersey River over the period 1980 to 2004.
- To determine spatial and temporal trends of water chemistry of 27 lakes in Kejimkujik.
- To identify chemical variables for long-term monitoring of ecological integrity.
- To interpret data with respect to threshold values for the protection of aquatic quality.

### METHODS

- Physical-chemical and hydrological data were provided by Environment Canada for the Mill Falls station on the Mersey River and various lakes in Kejimkujik.
- For the Mersey River, descriptive statistics were used to characterize water quality. Changes were examined using plots versus time, followed by regression analysis and isopleth contour diagrams. The non-parametric Kendall Test was used to test the significance of temporal changes of variables.
- For a suite of 27 lakes in Kejimkujik, a principal component analyses was used to identify groups and variables important in their differences. The key variables discriminating the groups were confirmed by cluster analysis. Variations of variables among clusters were examined by Kruskal-Wallis tests. Variables showing significant differences were examined with a time-series analysis.

Mersey River (photo by P.Hope, Parks Canada).

## RESULTS

Mersey River (photo by A.Lavers, MTRI).

- The Mersey River has lower concentrations of colour, dissolved organic carbon (DOC), and H+ and slightly higher alkalinity during the summer low-flow. The highest colour occurs during the high-flow winter, and the most negative alkalinity in the highest-flow springtime. Values of pH, acid neutralizing capacity (ANC), Al, Fe, and Cd exceed criteria for the protection of aquatic life. The river is chronically acidic, with severe episodes during high-flow periods, accompanied by high aluminum and iron. The dissolved metals occur in organic complexes, which helps to detoxify them.
- The acidity is largely due to fulvic acids (DOC) and low calcium and magnesium (causing low alkalinity). The low calcium and magnesium reflect base-poor parent materials in the watershed, plus decades of leaching under acid-loading atmospheric conditions.
- Kejimkujik lakes are aggregated into three groups. Group-1 includes brownwater acidic lakes at higher altitude in their hydrological system. Group-2 includes the darkest-coloured acidic lakes. Group-3 lakes are relatively clear and less acidic, and include the exceptional waterbodies such as Grafton and McGinty.
- All Kejimkujik lakes are acidic and have low alkalinity (only a few Group-3 lakes have positive alkalinity). Vulnerability to acidification of clearwater lakes is due to low alkalinity, related to the low capacity of watersheds to supply calcium and magnesium. In watersheds with bog and poor-fen, the acidification is largely due to a drainage high in fulvic acids. Acidity of organic-influenced lakes will not be much influenced by decreased loading of atmospheric sulphate.
- Most Kejimkujik lakes have high concentrations of aluminum and iron, but these are bound to DOC rather than occurring in free ionic forms, and so do not represent a high toxic risk.
- Although the Kejimkujik study lakes have been monitored since 1983, their record does not reveal long-term changes in chemical conditions.

## YEARS OF DATA

- Mersey River over the 25-year period 1980 to 2004
- Suite of 27 lakes in Kejimkujik over 1983 to 2003
- Water chemistry data is being collected by Environment Canada as part of a long-term monitoring program (see p.56)

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## PARTNERS

- Parks Canada
- Environment Canada
- Dalhousie University
- Natural Sciences and Engineering Research Council of Canada

## Rationale

The Common loon is a highly visible water bird inhabiting most of the lakes within Kejimkujik. It is an icon of wilderness that captivates people by its beauty and haunting call. Concerns have been raised about the health of loons at the park after a study by the Canadian Wildlife Service found very high blood mercury concentrations in Kejimkujik loons. These levels have been associated with impaired reproduction and altered breeding behaviour of loons in some areas. 2005 marked the 10th consecutive year of loon monitoring at Kejimkujik thanks to a dedicated group of volunteers who make annual outings to observe loon abundance and breeding success.

Common loon (photo by G.Corbett, Parks Canada).

# Monitoring

## KEJIMKUJIK LOONWATCH

### OBJECTIVES

- To observe Common loon abundance and breeding success on 16 study lakes within Kejimkujik.
- To determine status and trends in loon abundance, lake use and reproductive potential of resident birds.

### METHODS

- Trained volunteers simultaneously surveyed study lakes within a three-hour observation period, beginning at noon.
- Participants were screened for their ability to canoe and cover assigned lakes, to identify loons and classify the young, and to accurately report the findings.
- The first Loon Watch day was held in early June to document resident pairs of loons at the beginning of nesting season.
- The second Loon Watch occurred during the third week of August to record loon broods and determine the post nesting number and distribution of adult loons can be determined.
- Loon counts, relative location on the lake, environmental variables and amount of effort were also recorded.
- Public observations and repeated surveys by park staff were used to supplement to LoonWatch data.

Kejimkujik Loon Watch mentor J.Kerekes searching for loons on Grafton Lake (photo by P.Hope, Parks Canada).

## RESULTS

Loon and chick (photo by G.Corbett, Parks Canada).

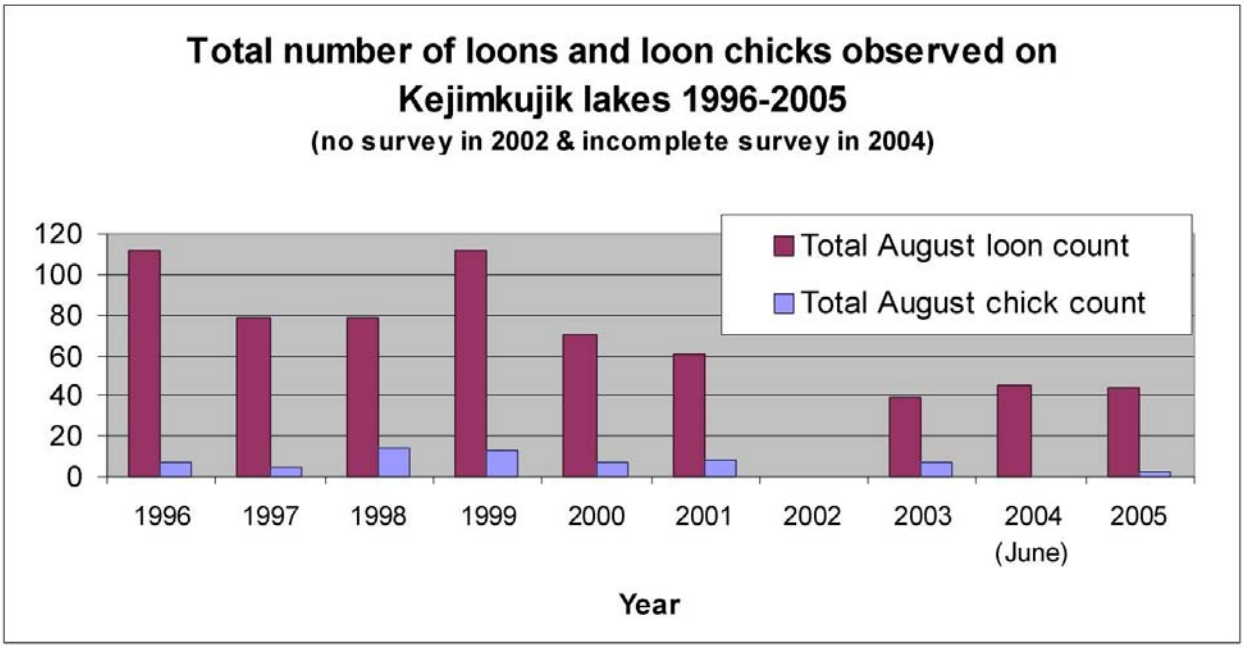
- 2006 was a poor year for Common loon nesting success due to extreme flood conditions at nesting time. Only two chicks were noted by surveyors, both on Mountain Lake, the only headwater lake of significant size in the park. This is the lowest number of loon chicks noted since the survey began. A large raft of adults was noted on Kejimkujik Lake during the August survey, a time when loon broods are usually inhabiting smaller survey lakes.
- Thirty-two volunteers participated in the study this year dedicating more than 400 hours of total time over both LoonWatch days. Many of the same individuals have taken part in these surveys over the years providing a relatively consistent coverage of sample lakes.

## YEARS OF DATA

- Data have been collected through LoonWatch since 1996
- Monitoring will continue on an annual basis

## PARTNERS

- Parks Canada
- Pool of 40+ dedicated volunteers and park staff
- Canadian Wildlife Services, Environment Canada

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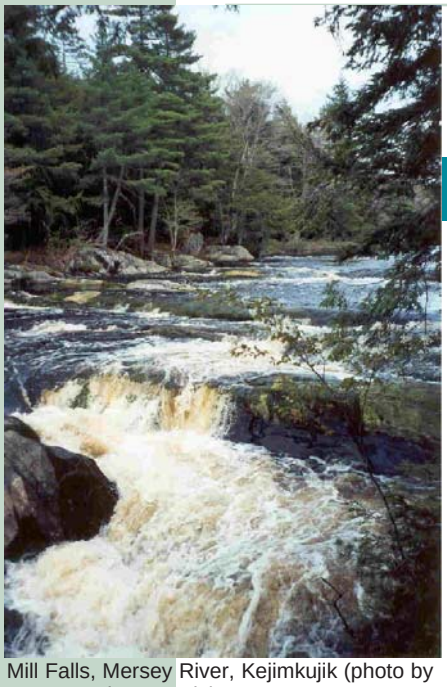
## Rationale

Hydrological processes greatly influence aquatic community structure, water quality, stream morphology and aquatic habitats. These processes are influenced by stressors such as deforestation, land use change and climate change. Knowledge of long-term fluctuations in stream flow are important to understand the response of an aquatic system to natural (*e.g.* drought, floods) and human-caused (*e.g.* land use, ground water withdrawal, climate change) factors. Environment Canada maintains hydrometric stations and automated gauges throughout the country as part of the Water Survey of Canada program. The intent of this project is to examine trends in existing stream flow data from a hydrometric station on the Mersey River at Kejimkujik and to identify the most sensitive hydrological measures for monitoring and reporting on the health of aquatic ecosystems in national parks.



Mill Falls, Mersey River, Kejimkujik (photo by D.Ure, Parks Canada).

# Monitoring

## STREAM FLOW MONITORING

### OBJECTIVES

- To identify the most sensitive measures for long-term monitoring.
- To detect long-term trends in hydrology of the Mersey River (*i.e.* stream flow, flashiness, droughts, floods).
- To understand how stream flow responds to natural and anthropogenic change.
- To provide recommendations for long-term monitoring and data analysis to detect trends in stream flow.

### METHODS

- Existing stream flow data from the hydrometric station at Mill Falls on Mersey River in Kejimkujik were acquired for analysis.
- Several measures were identified and used to examine data for trends including: (i) frequency and magnitude of floods; (ii) frequency and duration of low water events; (iii) variation in stream flow and flashiness (unit hydrograph analysis); (iv) ratio of total annual precipitation to total flow; and (v) rate of decline of flow after an event (base flow recession).
- Trends in stream flow in the Mersey River over the past 35 years will be presented (*i.e.* changes in flooding and drought regime, variation in stream flow, flashiness, water retention).
- The most sensitive and meaningful measures for monitoring stream flow will be identified.
- The relationship between stream flow, water chemistry and land use change in the Upper Mersey watershed will be examined.
- Recommendations will be provided for long-term monitoring and data analysis to detect trends in stream flow.

## RESULTS

- Analysis of average flow per month in the Mersey River from 1968-2005 shows a slight trend towards lower average daily flows in recent years for most months.
- Minimum average flow for low flow periods (1, 3, 7, 30, 90 days intervals) has decreased in recent years.
- Maximum average flow for high flow periods (same intervals as above) does not show trends over time.
- Analysis of the remaining hydrological measures is currently in progress and is expected to be complete by March 2007.

## YEARS OF DATA

- Daily stream flow data is collected since 1968

## PARTNERS

- Parks Canada
- Environment Canada
- Dalhousie University

Hydrometric sampling site, Mersey River, Kejimkujik (photo by D.Ure, Parks Canada).

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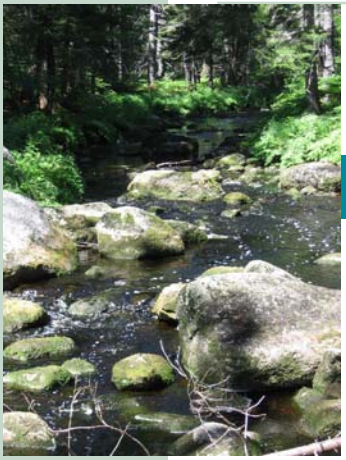
## Rationale

The protection of ecological integrity is the primary mandate of Canada's national parks system. Transboundary impacts from land use and long-range transport of air pollutants have been identified as significant stressors to the ecological integrity of aquatic ecosystems at Kejimkujik. As a result, there is a need to assess and monitor the state of freshwater ecosystems at Kejimkujik to inform and direct park management. Benthic macroinvertebrates which are bottom-dwelling aquatic organisms are useful indicators of aquatic health because (i) they are sensitive to stressors, (ii) sedentary, and (iii) diverse. The Canadian Aquatic Biomonitoring Network (CABIN) provides a nationally standardized program for assessing aquatic health using benthic macroinvertebrate communities. The intent of this long-term monitoring program is to use CABIN protocols to assess and report on the status and trends of aquatic health in freshwater ecosystems at Kejimkujik.



Riffle habitat, Southwest branch, West River, Kejimkujik (photo by D.Ure, Parks Canada).

# Monitoring

## BENTHIC MACROINVERTEBRATE MONITORING

### OBJECTIVES

- To assess aquatic health in representative streams at Kejimkujik.
- To determine how aquatic health of stream ecosystems is changing over time, as represented by benthic macroinvertebrate communities.
- To contribute to Environment Canada's National Aquatic Biodiversity Monitoring Program.

### METHODS

- Standard CABIN protocols were used for data collection and processing. Field procedures included benthic invertebrate kick-net sampling, stream habitat assessment, and water chemistry sampling.
- Water chemistry and taxonomic identification of the benthic invertebrates to species level were analyzed by Environment Canada.
- Data were entered on the national CABIN database (Benthic Information System for Reference Conditions (BIRC)).
- Data were analyzed to develop various community metrics and pollution tolerance indices for each stream.
- The results from ongoing monitoring will be analyzed to determine status and trends in stream ecosystems at Kejimkujik.

Kick net sampling, Mersey River, Kejimkujik (photo by D.Ure, Parks Canada).

## RESULTS

Back swimmer (photo by A.McFetridge, Parks Canada).

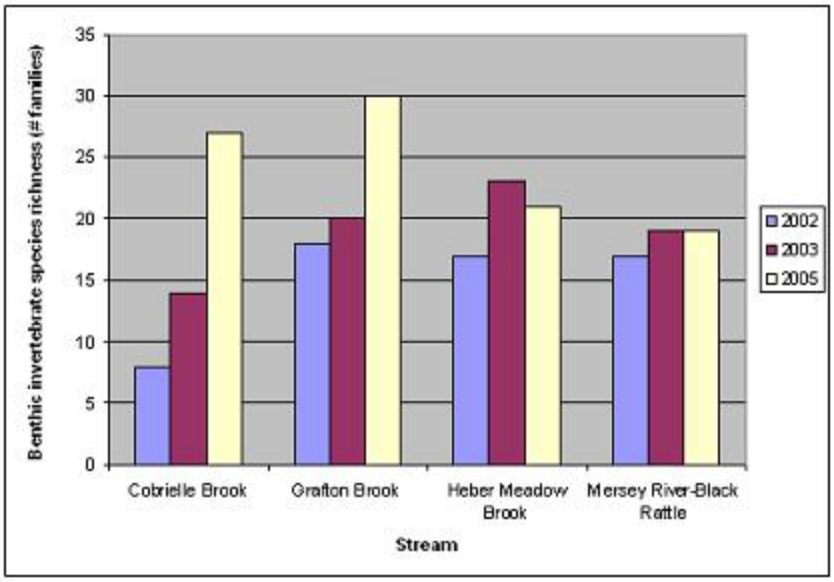
- Benthic macroinvertebrates were sampled in 22 streams at Kejimkujik in 2005. Five of these sites had also been sampled in previous years.
- Benthic macroinvertebrate communities at Little River had the highest taxonomic richness (33 families) and the highest diversity (Simpson's diversity = 0.9). Benthic macroinvertebrate communities at Innes Brook had the lowest taxonomic richness (17 families) and were the least diverse (Simpson's diversity = 0.55).
- Mayflies, stoneflies and caddisflies are sensitive to disturbance. As a result, samples with a high proportion of these taxa may represent streams with higher levels of aquatic health. Benthic macroinvertebrate communities at Still Brook had the highest proportion of mayflies, stoneflies and caddisflies (%EPT = 68.37). Benthic macroinvertebrate communities at Cobrielle Brook had the lowest proportion of these taxa (%EPT = 7.49%).
- Finally, the graph below shows changes in taxonomic richness (total number of families) between 2002-2005 in four streams at Kejimkujik.

## YEARS OF DATA

- Long-term monitoring was initiated in 2005, however previous sampling of some sites occurred in 2002 and 2003.
- The sampling frequency for monitoring will be every 5 years.

## PARTNERS

- Parks Canada
- National Water Research Institute, Environment Canada
- Mersey Tobeatic Research Institute




Taxonomic richness (total number of benthic macroinvertebrate families) in four streams at Kejimkujik (2002-2005).

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## Rationale

Human activities such as forestry and land development are affecting the health of aquatic ecosystems in the Upper Mersey watershed. To understand, communicate and mitigate the impact of these stressors, there is a need to assess aquatic health throughout the region and monitor how it is changing over time. Benthic macroinvertebrates are useful indicators of aquatic health because they are sensitive to a variety of stressors; they stay in the same area, and are long-lived and diverse. Environment Canada, through their Canadian Aquatic Bio-monitoring Network (CABIN), provides a nationally standardized and robust program for assessing aquatic health using benthic macroinvertebrates. This project provides reference and test sites to monitor aquatic health and assess the effect of silviculture treatments on benthic macroinvertebrate communities in the upper Mersey and Medway watersheds.

Forest headwater stream, inflow into Cannon lake, Mersey watershed (photo by P.Martel, MTRI).

# Research

## ASSESSING AQUATIC HEALTH

### OBJECTIVES

- To assess aquatic health in the upper Mersey and Medway watersheds.
- To determine the effect of silviculture treatments on aquatic health in the upper Mersey and Medway watersheds.
- To establish reference condition sites for long-term monitoring in Kejimkujik and the Tobeatic Wilderness Area.
- To contribute to the Environment Canada (EC) national reference database on benthic invertebrates for Canada.

### METHODS

Mayfly larvae (photo by C.Logan, EC).

- The standardized CABIN protocol was used for data collection and processing to assess benthic macroinvertebrate communities.
- Sites were chosen along a gradient of silviculture intensities. Sixteen headwater forest streams were sampled outside protected areas and 13 control sites were sampled inside protected areas.
- Site procedures included habitat assessment, benthic macroinvertebrate sampling and water chemistry sampling. Invertebrate samples were processed in the lab and identified to the lowest possible level (*i.e.* family, genus or species).
- GIS was used to calculate catchment basins of each site and to assess the human activities (roads, silviculture, etc.) occurring inside these catchments over the last 15 years.
- Multivariate statistical analyses were conducted on the data from all sites.

## RESULTS

(Top) P.Martel using a kick-net to sample invertebrates and (Bottom) identifying them under the microscope (photos by A.Lavers).

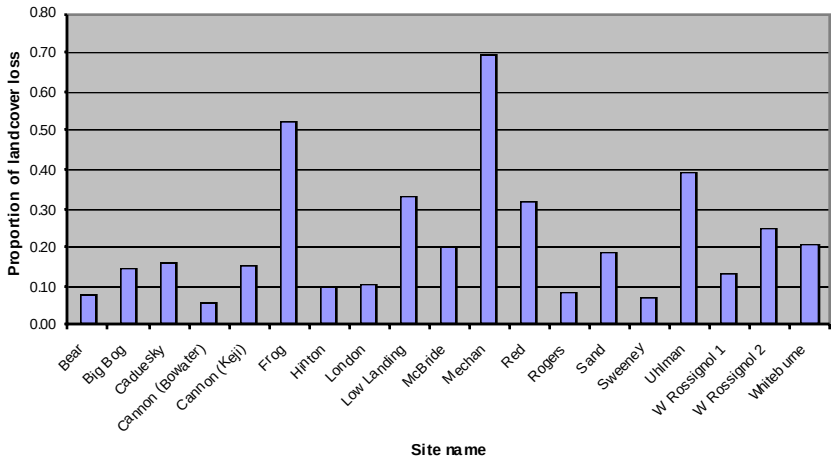
- Eighteen sites were sampled for benthic invertebrates, water chemistry, and habitat characteristics, and GIS data were acquired for all of them.
- Five sites had more than 30% of their catchment area cut since 1992: stream south-west of Menchan Lake (70%), Frog Lake Stream (52%), Uhlman Meadow Brook (42%), Low Landing Stream (33%) and Red Brook (32%).
- According to the mayflies, stoneflies and caddisflies (EPT index), which are in general the most sensitive groups, the sites that seem to be the most impaired are Hinton Meadow Brook, Sand Lake Stream, McBride Brook, London Brook, stream south-west of Menchan Lake and Low Landing Stream.
- Interestingly, McBride Brook, which is located mostly within Kejimkujik, has over 20% of its catchment that has been cut since 1992 due to forestry operations just outside the park and is also one of the most impaired sites according to the EPT index.
- Eighty-three families of aquatic invertebrates were identified through this project. The lowest diversity for a site was 14 families at London Brook and the highest was 30 families at Mount Tom Brook at Kejimkujik.
- Additional statistical analysis on the data will help us understand the relationship between forestry operations and aquatic health.

## YEARS OF DATA

- 2005

## PARTNERS

- Mersey Tobeatic Research Institute
- Parks Canada
- Applied Geomatics Research Group
- Bowater Mersey Paper Company
- Ecological Monitoring and Assessment Network (EC)
- Canadian Aquatic Bio-monitoring Network (EC)




Proportion of landcover loss in the catchments from 1992 to 2005.

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## Rationale

A major objective of the Mersey Tobeatic Research Institute is to assess the health of aquatic ecosystems in the upper Mersey River watershed. With respect to cold-water fish species, such as Brook trout, a major limiting factor is the presence of summer refugia having cold water and adequate dissolved oxygen. The extent of well-oxygenated, cold-water refugia present in the deeper, stratified lakes of Nova Scotia is not well known. Although considerable data have been collected over the last several decades as part of the Lake Survey Program carried out by the Nova Scotia Department of Agriculture and Fisheries, it has never been adequately analyzed to determine how many and which of the approximately 1600 lakes surveyed to date contain cold-water habitat suitable for Brook trout. Recent studies of some stratified Nova Scotia lakes revealed that, over the past 20 years, many lakes have experienced a decrease in suitable cold-water habitat.

Mountain Lake, Kejimkujik (photo by P.Hope, Parks Canada).

# Research

## COLD WATER LAKE HABITAT

### OBJECTIVES

- To initiate a survey of lakes within the upper Mersey watershed to determine the current level of existing cold-water lake habitat present.
- To determine if there has been any change over time in the extent of cold-water habitat present in these lakes.

### METHODS

- The general approach adopted to meet these objectives was to initially identify lakes within the upper Mersey watershed likely to contain cold-water habitat based on information contained in existing databases.
- The primary condition for selection was that the maximum depth of the lake had to be greater than 6 m to ensure sufficient hypolimnetic volume to serve as cold-water habitat.
- A secondary selection condition, necessary to assess the degree of change in cold water habitat, was the availability of historical survey data collected during either July or August, the time when water column stratification is strongest and hypolimnion dissolved oxygen concentrations are the lowest.
- A total of 45 lakes met these conditions and, of these, five were selected for survey during August 2005.

M.Brylinsky and R.Baird surveying Kejimkujik Lake (photo by A.Lavers, MTRI).

## RESULTS

M.Brylinsky sampling lake water (photo by A.Lavers, MTRI).

- Of the five lakes surveyed in this study, four lacked suitable cold-water habitat during August, and the remaining lake only contained suitable cold-water habitat within the lower portion of the metalimnion.
- When compared to surveys carried out 20-30 years earlier, all of the lakes except Mountain Lake exhibited a significant decrease in cold-water habitat. This decrease was due to reduced levels of dissolved oxygen rather than elevated water temperatures.
- These results are similar to that obtained in a similar survey of 20 lakes located throughout Nova Scotia which suggested that the differences observed over time could be a result of either a change in the trophic status of the lakes or to a difference in the length of the growing seasons between survey years.
- With respect to differences in trophic status, the required data for evaluation is only available for Kejimkujik and Mountain lakes. Mountain Lake does not appear to have changed significantly in either trophic status or available cold-water habitat. In contrast, Kejimkujik Lake had less available cold-water habitat and the trophic status has increased from oligotrophic to oligo-mesotrophic.

## YEARS OF DATA

- Harmony Lake: August 1972 and August 2005
- Sand Lake: April 1985 and August 2005
- Sandy Bottom Lake: July 1985 and August 2005
- Kejimkujik Lake and Mountain Lake: August 1971 and August 2005
- 5 more lakes will be resampled in summer 2006

## PARTNERS

- Acadia Centre for Estuarine Research, Acadia University
- Mersey Tobeatic Research Institute
- Nova Scotia Department of Agriculture and Fisheries
- Parks Canada


Maps of the sampled lakes.

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## Rationale

Brook trout are important indicators of aquatic health because they require cool, clean and well-oxygenated water. They may, however, need to travel across political boundaries to meet these needs. Mark and recapture studies in Kejimkujik over the past two decades have shown that trout move in and out of the park and appear to make seasonal migrations. This radio telemetry study can help us identify summer thermal refuges and fall spawning areas both inside and outside Kejimkujik for the long term management of Brook trout in the watershed and help to develop a monitoring program for the watershed's aquatic health.

Brook trout (photo by J.Steeves, Parks Canada).

# Research

## BROOK TROUT MIGRATION STUDY

A trap net in the Mersey River, Kejimkujik (photo by G.Corbett, Parks Canada).

### OBJECTIVES

- To identify Brook trout feeding areas, summer refugia, spawning areas, and overwintering sites in the Upper Mersey watershed.
- To assess Brook trout movement and migration patterns using marked trout and radio-tagged trout.
- To measure depth profile, substrate, flow, temperature, pH, nitrogen, dissolved oxygen, calcium, phosphorous, conductivity of feeding areas, summer refugia, spawning areas, and overwintering sites, using standardized provincial classification for fish habitat.
- To identify the presence of site-specific stressors on identified Brook trout feeding areas, summer refugia, spawning areas and overwintering sites (*e.g.* roads, dams, acidity, pollutants, sedimentation, riparian coverage, water temperature, land use).
- To provide recommendations for the conservation of important Brook trout habitat throughout the Upper Mersey watershed.

### METHODS

- Brook trout were captured in nets and by angling when water conditions were acceptable. Each were measured, weighed and examined externally for general health, condition, presence of external parasites, injuries, etc.
- Scales were also collected for aging and each fish were marked with a serial numbered tag. A minimum of 10 selected Brook trout will have a radio transmitter surgically implanted in them to allow researchers to follow their movements.

## METHODS (continued)

Fishing (photo by G.Corbett, Parks Canada).

- Radio-tagged trout were age 4 or 5 and weighed over 275 grams in weight. Transmitters weighing 7.7 grams representing, at a minimum, less than 3% of body weight were used.
- Radio-tagged trout were actively tracked by truck, foot, canoe and aircraft.
- Monitoring of all tags was done as often as possible and often daily during the ice-free season and once per month during the ice cover season.
- Once located, attempts were made to get an accurate GPS position to within 10 metres and to record habitat type (pool, riffle, run, etc). All pertinent data on date, time, location, coordinates, habitat, etc. of each fish were entered into a field data sheet.

## RESULTS

R.Baird weighting (photo by G.Corbett, Parks Canada).

- During the spring, summer and fall of 2005, 269 Brook trout were captured marked and released. Of those 44 were recaptured by anglers.
- Seven Brook trout in the Mersey River watershed were radio tagged in June 2005 and two in November.
- Tracking of these fish indicates that Brook trout feed actively in the rivers and larger brooks of the watershed in May and June.
- In the summer months some move to Kejimkujik Lake to deeper, cooler water where there is sufficient oxygen. Some trout spend the summer in small thermal refuges in the river. These are sites where cold groundwater provides suitable conditions throughout the summer.
- In the fall when river water cools, some trout re-enter the river to spawn and some spawn in the lake. After spawning some trout move back into the lake to overwinter while some winter in the river.
- Brook trout depend on the availability of thermal refuges to survive the summer months when river water temperatures soar and oxygen levels are depleted.

## YEARS OF DATA

- 2005 - 2007

## CONTACTS

## PARTNERS

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- Parks Canada
- Mersey Tobeatic Research Institute
- Trout Nova Scotia
- Inland Fisheries Division of Nova Scotia Fisheries and Aquaculture

## Rationale

Water quality depends strongly on the condition of the shorelines of lakes and rivers. Therefore, the protection of riparian areas and the transition zone between land and water is particularly important. As riparian areas are home to a variety of plants and animals, their protection is significant for the Greater Kejimkujik Ecosystem. The Upper Mersey River is the largest watercourse flowing through Kejimkujik and is thus a major pathway for water, nutrients, pollutants, fish and wildlife in and out of the park. The objective of this study is to identify sustainable land use practices aimed at preserving riparian areas. This supports the mandate of the Southwest Nova Biosphere Reserve, which includes the Mersey River watershed, of testing and implementing strategies that reconcile conservation with natural resources use.

The riparian area: shoreline and water's edge (photo by P. Stoffyn).

# Research

## MERSEY RIPARIAN AREA CONSERVATION

### OBJECTIVES

- To define the riparian area along the Upper Mersey River on the basis of geomorphology.
- To determine whether riparian areas provide adequate habitat for species that can only live near water such as beavers, muskrats, otters, turtles and frogs (riparian obligates).
- To establish land use practices that will protect the riparian area, such as riparian buffers, best forestry practices and sustainable resource development.
- To design a simple method to delineate the riparian area for land managers in the field.

### METHODS

Eastern painted turtle, a riparian obligate (photo by P. Stoffyn).

- This study relied mostly on mapping using Geographic Information Systems (GIS).
- The digital hydrography and topography GIS layers were used to delineate the riparian area at a scale of 1:10 000. The watercourse was defined as all lakes, rivers and connected wetlands at the high water mark. The terrestrial portion of the riparian area included steep slopes near the watercourse and the zone significantly affecting the provision of leaves, woody debris and shade to the watercourse.
- Published data on the habitat range of riparian obligate species (*e.g.* beaver) was used to rate the capability of the delineated riparian area to adequately support these species.
- The delineated riparian area was overlain on forestry inventories and other land use digital data layers (roads, buildings, agriculture use) to evaluate resources and human activities in and near the riparian area.
- The GIS results were verified by field observations.

## RESULTS

- The flow regime of the Upper Mersey River is unaltered by dams or other man-made structures.
- Most shorelines of the watercourse are forested with native species, although not old-growth.
- The most common land uses in the riparian area are forestry and residential development.
- Preliminary results suggest that a minimum buffer width of 30 m along water bodies and wetlands should be left untouched to preserve water quality and aquatic habitat.
- A well-preserved riparian area has the potential to enhance landscape connectivity in the Greater Kejimkujik Ecosystem.

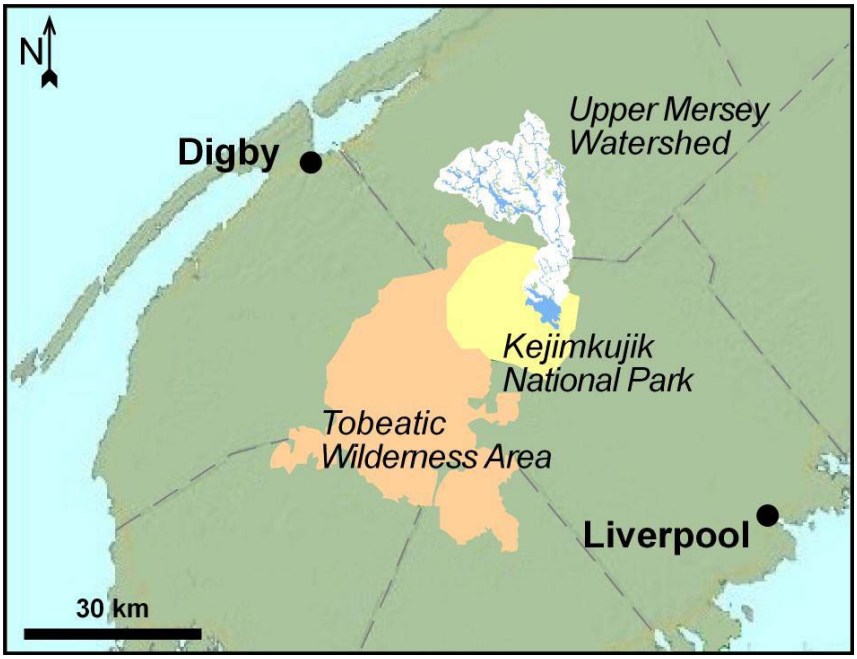
## YEARS OF DATA

- Field work - Phase I: July 2005
- Field work - Phase II: Spring 2007

## PARTNERS

- School for Resource and Environmental Studies, Dalhousie University
- Bowater Mersey Paper Company
- Mersey Tobeatic Research Institute

Rose pogonia, an orchid growing in wetlands (photo by P.Stoffyn).




Map showing the Upper Mersey watershed (produced by P.Stoffyn).

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## Rationale

Acidification of surface waters is a major environmental concern and has been cited by Parks Canada as a threat to ecological integrity in Nova Scotia's national parks. Environment Canada has monitored water chemistry in sensitive lakes for over 20 years but has not observed any changes in response to decreased levels of sulphate deposition. What is critically needed is a method to determine the natural background environmental conditions of these lakes before acid rain was a problem (*e.g.* 1850). Using biological indicators (*e.g.* fossilized algae) archived in the sediments of lakes, it is possible to infer past environmental conditions in these lakes and thus assess the pre-impact environment, how much change has occurred, when did these changes occur, and what are realistic mitigation targets for recovery of these lakes.

Kejimkujik Lake (Photo by P.Hope, Parks Canada).

# Research

## TRACKING SURFACE-WATER ACIDIFICATION

### OBJECTIVES

- To obtain sediment cores from 51 lakes in Nova Scotia, including 15 in Kejimkujik and 16 in Cape Breton Highlands.
- To determine present-day diatom assemblages in these lakes and relate these communities to present-day environmental conditions.
- To find out which of these 51 lakes have acidified by comparing present-day diatom assemblages and environmental conditions to those of 150 years ago.
- To study 14 lakes in detail (eight in Kejimkujik, six in Cape Breton Highlands) to determine the timing of any environmental changes and determine a probable cause.

Collecting a sediment core from Kejimkujik Lake (Photo by B.Ginn).

### METHODS

- Vertical cores of sediment were collected from 51 Nova Scotia lakes between May 2002 and July 2005 and sectioned into 0.25 cm thick slices (representing 2-3 years of sediment accumulation).
- Diatom fossils were isolated, identified, and enumerated, and used to construct a calibration between species and observed environmental conditions.
- Past (downcore) diatom assemblages were used to infer environmental conditions and thus study what changes have taken place over the past 150 - 300 years.
- Detailed sediment cores were dated using radiometric techniques (210Pb and 137Cs isotopes).

## RESULTS

- Lakes in Kejimkujik have been more greatly impacted by acidic deposition than lakes in other areas of Nova Scotia.
- Most of these lakes (ones which are currently dark-coloured waters due to dissolved organic carbon or DOC) have a naturally acid pH but still acidified further.
- Lakes in Kejimkujik have seen an average pH change of -0.4 pH unit since 1850 (average natural change (1700-1850) is -0.2 pH unit which was used as a critical value) and have seen complete changes in species dominance of diatom assemblages.
- Pre-industrial diatom-inferred pH values (current measured pH in parenthesis) for study lakes are: Kejimkujik (4.9) = 5.8; Big Dam (East) (6.1) = 6.2; Big Dam (West) (5.1) = 5.8; Frozen Ocean (4.9) = 5.6; Channel (4.8) = 5.5; Grafton (6.0) = 5.9; Loon (5.1) = 5.7; Mountain (5.3) = 5.4; Cobrielle (5.4) = 6.1; Back (5.6) = 6.0; Upper Silver (6.1) = 6.2; Pebbloggitch (4.5) = 5.6; Peskawa (4.7) = 5.5; Peskowesk (4.9) = 5.7; Beaverskin (5.5) = 6.4.
- Analysis at decadal scale resolution shows acidification occurred in clear (non-coloured) lakes circa 1925-1930, whereas coloured (high DOC) lakes acidified circa 1940-1950.

## YEARS OF DATA

- May 2002
- June 2003
- July 2005

## PARTNERS

- Parks Canada
- Environment Canada - Atlantic Region
- Nova Scotia Department of Environment
- Nova Scotia Inland Fisheries
- Natural Sciences and Engineering Research Council of Canada

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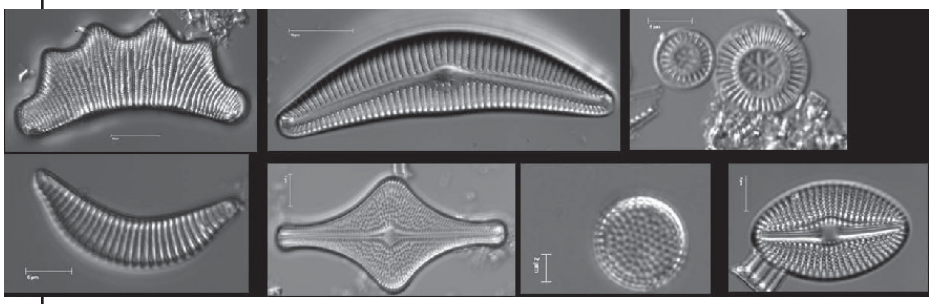

Diatoms fossils found in lakes from Kejimkujik National Park (Photo by B.Ginn).

**Photos by:**

- Bottom left: A.Lavers, MTRI
- Bottom right: A.Lavers, MTRI
- Middle left: A.Lavers, MTRI
- Middle right: A.Lavers, MTRI
- Top left: A.Lavers, MTRI
- Top right: M.Elderkin, NSDNR

## WETLAND

## Rationale

Water-pennywort is a small, clonal macrophyte that grows along freshwater lakeshores in southern North America and South America. Its distribution in Canada is limited to two regions in Nova Scotia: Wilson's Lake and Kejimkujik. The species was designated as 'Endangered' by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) in 1985 due to its limited range and threats to its habitat. Water-pennywort is currently listed as 'Threatened' by COSEWIC and a recovery plan was developed in 2003. As a federal agency, it is the responsibility of Parks Canada to protect species at risk. Water-pennywort populations are monitored at Kejimkujik to detect changes in species distribution and abundance and to better understand the influence of environmental variables and human impacts on the species to inform management and ensure protection.

Water-pennywort (photo by R. Swain, Parks Canada).

# Monitoring

## WATER-PENNYWORT MONITORING

### OBJECTIVES

- To monitor Water-pennywort population abundance and density.
- To monitor spatial distribution of Water-pennywort at Kejimkujik (*i.e.* stand surface area and locations).
- To survey potential habitat at Kejimkujik for the establishment of new stands of Water-pennywort.
- To assess water levels at Water-pennywort stands.
- To assess stem height and percent damage within Water-pennywort stands.

### METHODS

Sampling Water-pennywort (photo by C.Brittain, Parks Canada).

- Water-pennywort surveys are conducted annually at known stands on Kejimkujik and George Lakes within Kejimkujik; both shoreline and aquatic habitats.
- Extensive surveys are also conducted every three years to search for new stands.
- Population abundance, density, stem height and percent damage of individual Water-pennywort stands are assessed by systematic transect surveys in early August. Water height is also measured within the survey. Survey results are compared to historic data in order to determine population size fluctuations.
- In the past, stand surface area was approximated manually with a measuring tape. In addition to manual measurement, an initial attempt was made to GPS stand perimeter in 2005. This will provide a more accurate estimate of stand area while enabling changes in stand movement and shape to be observed over time.

## RESULTS

- Historic surveys indicate stable to increasing populations of Water-pennywort within Kejimkujik. In 2002, population estimates were extremely large suggesting error in sampling methodology or population estimate calculations.
- In 2005, data suggest a dramatic increase in population size, which is directly related to an expansion of stand area. Average water heights were significantly lower at all stands. It appears that water level affects population size. What is unclear is how it affects the population, as changes in water depth results in inconsistent fluctuations in both ramet density and stand size.
- Spatial distribution analysis demonstrates the ability of stands to fluctuate. In 2000 a new stand established within the George Lake population (Mersey). This population existed until the 2005 survey, when no ramets were observed. One of the Meadow Beach populations was lost in 2004 but re-established in 2005.
- Both the Merrymakedge and Indian Point populations have expanded significantly in size.
- No inflorescences were observed during the survey.

Water-pennywort (photo by J.Steeves, Parks Canada).

## YEARS OF DATA

- Initial population estimates were conducted in 1983
- Consistent sampling was initiated in 1999, continued in 2000, 2001, 2002, and has been conducted annually since 2004
- Monitored on an annual basis

## PARTNERS

- Parks Canada
- Water-Pennywort Recovery Team

**Estimated aerial extent ($m^2$) of Water-pennywort stands at Kejimkujik.**

| Stand Name | 1999/2000 | 2001 | 2002 | 2004 | 2005 |
|---|---|---|---|---|---|
| Merrymakedge | 128 | 138 | 2,791 | 106 | 1,920 |
| Meadow | Unknown | 175 | 1,260 | 140/48 | 222 |
| Jim Charles Point | 212 | 172 | 858 | 42 | 401 |
| Jeremy's Bay (Indian Point) | 30 | -* | 2,300 | 158 | 4,854 |
| George Lake | 104 | -* | 210 | 45 | 178 |
| Mersey River | 0 | 2 | 4 | 1 | 0 |
| Petroglyphs | 125 | -* | -* | 122 | 276 |

(*Populations not reached in a specific year.)

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## Rationale

The Rare Plant Monitoring program is part of the Nature Trust's Plants on the Edge project - an initiative to protect critical habitat for unique coastal plain plants found along lakeshores and bogs in southwest Nova Scotia. Monitoring helps to determine how these rare plant populations behave over time. Are they migrating over the shoreline? Are they staying in one established location? Are the numbers of plants increasing or decreasing? This information improves our ability to understand population changes and to protect these exceptional plants and their habitat. The coastal plain flora is one of the most endangered plant groups in Canada. Of the 64 species, 11 are extremely rare and listed nationally by the Committee on the Status of Endangered Wildlife in Canada, occurring in Canada only in Nova Scotia. Five species are considered to be globally at risk of extinction and 25 are listed as 'at risk' or 'sensitive' by the Nova Scotia government.

Syphid fly on Plymouth gentian (photo by J.Lusk)

# Monitoring

## RARE PLANT MONITORING PROGRAM

### OBJECTIVES

- To involve local landowners, recreational land-users, and other interested individuals in the conservation and recovery of coastal plain plants in southwest Nova Scotia.
- To collect information on the geographic distribution of coastal plain plants on private lands in southwest Nova Scotia.
- To track changes and assess threats to coastal plain plant populations and habitat in southwest Nova Scotia.

### METHODS

- Outreach and education is conducted with landowners in Lunenburg, Queens, Shelburne, Yarmouth, Digby and Annapolis counties about the importance of protecting coastal plain plants and habitat on their property.
- Volunteer Rare Plant Monitors are trained to identify coastal plain plant species, observe changes and threats to habitat, and record information using Nature Trust data sheets.
- Monitors visit selected coastal plain sites on private lands a couple of times each year to count plant populations, photograph the sites, and record observations of habitat.
- Monitoring data collected by the Nature Trust are submitted to the Atlantic Coastal Plain Flora Recovery Team, who uses the data to plan the conservation and recovery of coastal plain plants.

Typical coastal plain shoreline (photo by NS Nature Trust).

### RESULTS

- A National Recovery and Conservation Plan for Atlantic Coastal Plain Flora was finalized in 2005, with input from the Nature Trust's monitoring program.

## YEARS OF DATA

- 1999 - ongoing

## PARTNERS

- Nova Scotia Nature Trust
- Atlantic Coastal Plain Flora Recovery Team
- Habitat Stewardship Program for Species at Risk
- Nova Scotia Habitat Conservation Fund
- Endangered Species Recovery Fund
- Aveda
- O Beautiful Gaia Project
- F.K. Morrow Foundation

Pink coreopsis (photo by NS Nature Trust).

(Top) Photographing goldencrest during monitoring training and (Bottom) a guided walk (photos by NS Nature Trust).

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## Rationale

Initial Atlantic Coastal Plain Flora (ACPF) assessment for Kejimkujik, carried out in mid-1970's by Dr. A.E. Roland, noted 34 species of ACPF. Subsequent additional locations and species have been added to this list. Currently the ACPF recovery plan has listed 64 species for the province. Twenty-seven of the original species listed by Dr. Roland are on that list including one COSEWIC species (Water-pennywort). This project updates the distribution of coastal plain flora within Kejimkujik by providing accurate coordinate data collected by GPS, detailed site data compiled to current standards and information about population, distribution, development, reproduction and habitat. This will provide baseline data to measure change over time and to manage this suite of species. This report is for the first year of a two-year survey of the shoreline around Kejimkujik Lake.

Zigzag bladderwort (photo by AGRG).

# Monitoring

## ASSESSMENT OF COASTAL PLAIN FLORA

### OBJECTIVES

- To revisit documented sites to determine the present distribution of ACPF within Kejimkujik.
- To collect site and field data at these sites with protocols designed by Parks Canada for species at risk inventories.
- To develop a database for all Atlantic Coastal Plain Flora found in Kejimkujik for future population monitoring.
- To provide data to assist park resource management decisions concerning ACPF.

### METHODS

- Site selection criteria were based on information from historic maps.
- Along the shoreline of Kejimkujik Lake, sites were set up and searched for ACPF. Site characteristics such as GPS coordinates, zone of occurrence width (from shrubline), dominant plant species in zone, slope and aspect were measured. Physical characteristics of the beach substrate were recorded for each zone.
- Within the site, occurrences of each ACPF species were measured where patch size, distribution, zone, phenology, rough counts, and element occurrence observations were documented.
- All data were entered into an Microsoft Access database for query by species, zone, substrate etc.
- Spatial data collected for sites, zones and species was downloaded into geodatabase for comparison with other physical datasets.

Typical shoreline habitat for ACPF on west side of Kejimkujik Lake (photo by AGRG).

## RESULTS

Population of Meadow beauty on west side of Kejimkujik Lake (photo by AGRG).

- One hundred twenty-eight sites were described around Kejimkujik Lake where 1354 patches of ACPF were described. The mean number of patches per site for the 34 species was two.
- ACPF sites had between 0 and 4 zones that could be discerned by vegetation and substrate. Sites with no zones were in wetlands or streams, there were three terrestrial zones (upper, middle and lower beach) and one aquatic zone.
- Determining zonation and number of ACPF per zone was an important component of the survey. The upper and middle zones are constant throughout the summer but the lower beach zone is dynamic, increasing in width throughout the summer. This fluctuation is a major contributing factor to coastal plain habitat. Mean zone widths were upper 4.5 m, middle 4.3 m, and lower 7.56 m.
- The lower beach zone contained 20 ACPF species, the middle zone contained 23 ACPF species and the upper zone 17 ACPF species. Some of these species overlapped two zones but never three as there is species fidelity for zones and substrates. The upper zone had highest coverage of cobble, middle had coverage of cobble and organic and the lower zone had highest coverage of gravel.
- Golden pert was the most commonly encountered ACPF species followed by Yellow-eyed grass, Spoon-leaved sundew and Narrow-leaf fragrant goldenrod.

## YEARS OF DATA

- 2005 - Data collection around Kejimkujik Lake
- 2006 - Data collection around shorelines of other lakes with documented ACPF species and backcountry trails

## PARTNERS

- Parks Canada
- Applied Geomatics Research Group
- Natural Sciences and Engineering Research Council of Canada

Water-pennywort, an ACPF found in Kejimkujik (photo by AGRG).

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## Rationale

Blanding's turtles in Nova Scotia exist in three small populations on the Mersey and Medway watersheds and have been listed as Endangered under both the federal Species at Risk Act and the Nova Scotia Endangered Species Act. One of the concerns for this long lived (70+ years), slow maturing (20+ years) species is the lack of young adults in the population. This is of particular concern in the population at Kejimkujik where only 5 young females have been recorded during the last decade. Rates of predation of unprotected nests vary but can reach 100%. Raccoons are the primary nest predators and their populations may be unusually high in human inhabited areas (*e.g.* campgrounds, communities). An annual volunteer-based nest protection program was established in Kejimkujik and then expanded to populations outside the park, where local community members could become engaged in nest stewardship.

Newly emerged Blanding's turtle hatchling (photo by J.McNeil).

# Monitoring

## BLANDING'S TURTLE NEST MONITORING

### OBJECTIVES

- To protect Blanding's turtle nests from predation to bolster recruitment into the populations.
- To provide an opportunity for volunteers to engage in species at risk recovery.
- To collect long-term data on female survivorship, clutch size, hatching success and site fidelity.
- To reduce threats to females and their hatchlings by enhancing or creating nest sites where appropriate to try to keep them from nesting in or near roads.

### METHODS

Protected Blanding's turtle nest (photo by T.Herman).

- Known nesting sites were monitored on a nightly basis during nesting season (typically mid June - early July).
- Individual turtles were radio tracked to locate new nesting sites.
- Trained volunteers and researchers surveyed each site starting at ~8pm, taking care to minimize disturbance to the turtles.
- Observers watched each turtle as she went through the nesting process and recorded a variety of data including behaviour and movements, weather, timing of activities and clutch size.
- Once a nest was complete and the female had left the site, volunteers covered the nest with a wire mesh cage and secured it with large rocks to protect the nest from predation.
- Nests were monitored periodically until first emergence and then monitored daily. Hatchlings were marked, measured, weighed and released at the nest site.

## RESULTS

Volunteer checking nests for hatchlings (photo by J.McNeil).

- In 2005, 62 volunteers and researchers logged 834 hours in Kejimkujik and located 19 Blanding's turtle nests.
- An additional 21 nests were protected in the two populations outside the park. Nine families became nest stewards and looked after nests on or near their properties.
- Nesting season started unusually late in 2005. The first nest was recorded on June 23 and the last on July 8.
- A Scout troop from Truro constructed nest cages for the program and helped to remove encroaching vegetation from a nesting site that females may have abandoned in favor of more open substrate in an adjacent road. One of the four females at this site did nest in the road, but her nest was successfully relocated.
- Nesting substrate was laid in several locations to provide alternative nesting sites and to attempt to lure females away from the edge of the road. No nests were laid in the new substrate in 2005.
- Because Blanding's turtles take 20+ years to mature, it will be another 5-10 years before it can be determined if the program will increase the number of new adults recruiting into the population.

## YEARS OF DATA

- In Kejimkujik, nests were first protected in 1989 and have been protected and monitored annually since 1992
- Outside the park, nest protection began in 2000 and the program has been expanding each year

## PARTNERS

- Blanding's Turtle Recovery Team
- Parks Canada
- Acadia University
- Friends of Keji
- Mersey Tobeatic Research Institute
- Habitat Stewardship Program for Species at Risk
- Second Truro Scout Troop


Turtle road sign in Kejimkujik (photo by D.Smith, Parks Canada).

Blanding's turtle laying egg (photo by J.McNeil).

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## Rationale

The Nova Scotia Blanding's turtle is Endangered and is found in three distinct populations in southwest Nova Scotia, which are genetically and morphologically distinguishable. Juvenile dynamics are not well understood in this population complex. Recruitment of juveniles into the adult populations is generally poor but very little is known about what mechanisms influence this recruitment. Analysis of growth rings is a useful technique for estimating particular aspects of population ecology since a record of individual growth is laid down in the plastron of each turtle. The use of this long-term information is ideal for species at risk since its collection is not invasive and does not harm the individual. This study will contribute valuable information on how growth and maturation of this species at risk might respond to climate change.

Wild immature Blanding's turtle in Kejimkujik (photo by M.Richard).

# Research

## CLIMATE AND BLANDING'S TURTLE GROWTH

### OBJECTIVES

- To use growth ring analysis to gain a better understanding of growth dynamics in Blanding's turtles.
- To understand the relationship between turtle growth rings and climate variability by relating them to existing climate records and dendroclimatology.
- To address the following questions:
    - What are the contributions of individual, subpopulation and climatic variability to overall variability in growth in this population complex?
    - Are turtle growth rings a sensitive signal of climatic variation?
    - How do turtles and trees differ in their growth sensitivities to climate variability?
- To predict the growth response of turtles to both past and future climatic variation.

Researchers T.Herman and M.Richard in Blanding's turtle habitat (photo by M.Lawton).

### METHODS

- Plastrons of immature turtles were scanned with a flatbed scanner.
- Rings in plastrons were measured with ImageTool (shareware) and WinDENDRO (dendrochronology software) and their accuracies were compared.
- Turtle growth was modeled.
- All twelve plastral scutes were examined for homogeneous growth patterns.
- Correlations between growth rings and the following variables were analyzed: population, area, individual, annual mean temperature and annual mean precipitation (latter two employing temperature and precipitation data from Environment Canada's Greenwood station).

## METHODS (continued)

- Tree species with similar correlations to climate were chosen, correlation between tree rings and turtle rings was analyzed, and turtle rings were cross dated with tree rings.
- Climate change was projected for Nova Scotia using Canadian Centre for Climate Modeling and Analysis data.
- Predictions were made for how Blanding's turtles would respond to climate change using growth rings and known ecological traits such as growth, clutch size and temperature sex determination.

## RESULTS

Plastron scan of immature Blanding's turtle with growth rings (Scan by Blanding's turtle research team).

- ImageTool and WinDENDRO were equivalent for this research (Pearson correlation = 0.99).
- Turtle rings ranged from 1972 to 2005.
- Scutes 1 and 6 were unsuitable for this research.
- Scutes 3-5 were symmetrical from left to right sides (3-parameter Weibull Distribution and ANOVA) and once standardized by growth index were homogeneous (3-parameter Weibull Distribution and ANOVA).
- Within individuals, annual scute growth decreases with age.
- Preliminary data have shown that climate, population and birth size are significant to turtle growth.
- Turtle growth varied among populations; it was fastest in Kejimkujik and slowest at McGowan.
- More results are expected soon.

## YEARS OF DATA

- The turtle rings were collected between 1998 and 2005
- Data on tree rings were collected in summers of 2004 and 2005
- Temperature data were obtained using historical climate records from Environment Canada
- This project will be completed in late 2006

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## PARTNERS

- Acadia University
- Mount Allison Dendrochronology Lab (MAD Lab)
- Parks Canada
- Bowater Mersey Paper Company
- Nova Scotia Department of Environment and Labour
- Atlantic Centre for Global Change and Ecosystem Research
- Acadia University Graduate Association

## Rationale

Southwest Nova Scotia's Blanding's turtles are designated both nationally and provincially as Endangered. This small peripheral population complex is disjunct from the main species range, centered around the Great Lakes. The distribution of Blanding's turtle is primarily limited to wetlands. The aim of this work is to develop a habitat model based on the physical and biological characteristics of wetlands that will predict the species' presence or absence. Data used include on-site measurements, remote sensing data (provided by Nova Scotia Department of Natural Resources) and previous Blanding's turtle trapping data. This model will contribute to concrete recovery actions by identifying: (i) key features of critical habitat; (ii) wetlands containing sub-populations at high risk, for which conservation actions can be targeted; and (iii) suitable wetlands where turtles are not known to occur at present, but may support populations in future.

Typical Blanding's turtle habitat: stream fen in North Brookfield (G.Bourque).

# Research

## BLANDING'S TURTLE HABITAT MODELING

### OBJECTIVES

- To describe wetlands used by Blanding's turtles in Nova Scotia.
- To identify key habitat features critical to Blanding's turtle in Nova Scotia.
- To develop a user-friendly predictive model of Blanding's turtle presence to inform future distribution studies and management actions.
- To identify wetlands containing sub-populations at high risk for which conservation actions can be targeted.
- To identify suitable wetlands where turtles are not known to occur at present, but may support populations in future.

### METHODS

J.P. Hastey (Left), field assistant, and G.Bourque (Right), principal investigator (G.Bourque).

- Two independent observers took on-site measurements simultaneously during July and August 2005.
- The wetland characteristics recorded included: species and relative abundance of terrestrial and aquatic vegetation, bank type, shoreline configuration, water flow, substrate, habitat type according to the Canadian Wetland Classification system, morphometrics (minimum, maximum and mean depth, stream width, bank height, distance from water to forest), georeferenced location, geo-hydrologic descriptors, and percentage of flooded habitat.
- Occurrence of features potentially important to turtles such as basking areas, beaver activity and side channels were also recorded.
- Water samples were taken from each wetland, and were analyzed in the lab for pH, conductivity and water colour.

## METHODS (continued)

- Landscape features were measured from remote sensing data in a Geographic Information System (GIS) environment. These included: wetland type, area, perimeter, distance to nearest neighbour, catchment area, number and surface area of wetlands within specific radii, and distance to other wetland types.
- Blanding's turtle presence/absence in each studied wetland was assessed from the Blanding's Turtle Recovery Team database trapping records, using data from 2001-2005.

## RESULTS

Blanding's turtle (G.Bourque).

- One-hundred-and-sixty wetlands were characterized, including all three known Blanding's turtle populations in Nova Scotia as well as areas outside these populations. Approximately two thirds of the wetlands with trapping records in each population or area were surveyed to adequately represent the diversity and variability of wetlands with and without Blanding's turtles. This included wetlands within the range of each known population that were not known to contain Blanding's turtles.
- A database has been created in Access 2000 to compile all the recorded measurements by both observers.
- The occurrence of Blanding's turtle has been assessed in 147 of the 160 characterized wetlands using available trapping records. There are no trapping records in the database for the other characterized wetlands (including some known to contain Blanding's turtles). Blanding's turtle occurrence has also been assessed in 64 other wetlands that were not characterized. These data will be included in the final model to take into account the spatial patterns in Blanding's turtle presences.
- GIS measurements and model development are presently underway.

## YEARS OF DATA

- 2002-2005

## PARTNERS

- Blanding's Turtle Recovery Team
- Acadia University
- Nova Scotia Department of Natural Resources
- Parks Canada
- Natural Sciences and Engineering Research Council of Canada
- Endangered Species Recovery Fund

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## Rationale

Nova Scotia is home to a small, endangered population of Blanding's turtle. The Blanding's turtle population complex in southwest Nova Scotia is separated into three, small genetically distinct subpopulations: Kejimkujik, McGowan Lake and Pleasant River. In 2004, researchers determined that without further intervention this population would continue to decline and eventually go extinct. Literature on the incubation of turtle eggs suggests that hatchling success is much higher in the laboratory then in natural conditions. Raising hatchling turtles in captivity allows researchers to control environmental conditions promoting rapid growth giving the hatchlings a 'head-start' once released into their natural environment. Over the past decade researchers have attempted this head-starting method in a short (1 year) and somewhat successful manner. Some concerns regarding overly rapid growth in the conservative program led to the proposal for an extended head-start program that lasted 2 years.

# Research

## GROWTH DYNAMICS OF BLANDING'S TURTLES

Blandin's turtle hatchlings (photo by P.Hope, Parks Canada).

### OBJECTIVES

- To explore captive measures (*i.e.* head-starting and incubation) and their usefulness as a conservation tool.
- To address the following questions:
    - Can these invasive measures help increase the survivorship of the young age-classes?
    - Will these head-started young age classes have a positive effect on population rehabilitation?
- To create protocols for captive rearing of hatchling Blanding's turtles.
- To examine and compare the growth dynamics of hatchlings from McGowan and Kejimkujik subpopulations.
- To gain a better understanding of peripheral populations.

### METHODS

- Eggs from each subpopulation (*i.e.* Kejimkujik, McGowan Lake and Pleasant River) were incubated together in identically controlled environments.
- Hatchlings from each subpopulation were head-started together within a controlled environment.
- The growth from each subpopulation was monitored.
- Differences in growth patterns within controlled environments were measured to understand whether growth dynamic differences are genetically or environmentally driven.

Blandin's turtle (photo by J.Steeves, Parks Canada).

## RESULTS

- Past data has exhibited increased survivorship in conservative head-starts (1 year captive rearing) over wild juveniles.
- The initial attempts at incubating eggs in 2005 failed to hatch a significant number of animals needed to attempt the experiment and is being implemented again in 2006.
- Research is on-going.

## YEARS OF DATA

- 2005-2007

## PARTNERS

- Blanding's Turtle Recovery Team
- Acadia University
- Parks Canada
- Oaklawn Farm Zoo

Blanding's turtle hatchlings in aquarium (Bottom right) and swimming (Top right) and eggs ready to be incubated (Left) at Oaklawn Farm Zoo (photos by J.McNeil).

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## Rationale

Blanding's turtle, a nationally and provincially Endangered species, aggregates in the fall, winter, and early spring in common overwintering locations. These aggregations are potentially vulnerable to local disturbance. Very little is known about the site characteristics or the requirements of the wintering turtles. Understanding the conditions these turtles need to survive, and how they move during the winter within these sites, will give the Blanding's Turtle Recovery Team a better framework for conserving critical habitat for this species in Nova Scotia.

A Blanding's turtle in McGowan Lake lived in 7ºC water all winter in 2004-2005 (photo by E.Newton).

# Research

## OVERWINTERING OF BLANDING'S TURTLES

### OBJECTIVES

- To characterize the range of physical and chemical attributes experienced by overwintering turtles in seven sites in three populations. These data will shed light on the physiological strategies of this species.
- To document the winter movements of Blanding's turtles in order to more effectively manage winter critical habitat.

### METHODS

- Sites were characterized in the fall to gain an understanding of the plant community and physical characteristics of Blanding's turtle overwintering sites.
- All sites are visited biweekly during the winter to assess water chemistry (dissolved oxygen and pH) and movement of 25 individual turtles by radio telemetry and additional turtles by visual survey.
- At each site, four turtles and three locations have been equipped with digital loggers that record temperature at 4-hour intervals.

Blanding's turtle (photo by J.Steeves, Parks Canada).

### RESULTS

- Blanding's turtles overwinter in a variety of wetland types, from discrete bog and fen holes to anthropogenic trenches and flooded woodlands.
- Preliminary results from 2004-2006 suggest that Blanding's turtles can successfully overwinter in a wide range of temperatures (0-7ºC) and dissolved oxygen (10-100%).
- During periods of extreme cold (less than 2ºC) and when ice covers the site, Blanding's turtles may only move 1-2 m under the ice, or stop movement altogether.
- Blanding's turtles have been observed overwintering under a layer of organic substrate, resting on the bottom of the site, and positioned directly beneath the ice among woody vegetation.

## YEARS OF DATA

- This is a two-year research project, beginning in 2004-2005 and continuing in 2005-2006.

## PARTNERS

- Blanding's Turtle Recovery Team
- Acadia University
- Parks Canada
- Natural Sciences and Engineering Research Council of Canada
- Species at Risk Recovery and Education Fund

Researcher E.Newton records oxygen in Kejimkujik in 2005-2006, a very warm winter (photo by P.Newton).


E.Newton at a public display outside a strawberry supper in Pleasant River (photo by B.Caverhill).

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## Rationale

The Blanding's turtle in Nova Scotia, which occurs in a complex of three distinguishable populations, is nationally and provincially Endangered. One of the three populations occurs in a working landscape in and around Pleasant River (PR), and formed the focus of this study. We operate on the premise that people are a part of nature, not apart from it. This promotes the view that *[science → public education → stewardship]* is an effective strategy to generate diverse conservation opportunities, in this case to save the Blanding's turtles and their habitat.

A radio-tagged Blanding's turtle in Barren Meadow Brook (photo by B.Caverhill).

# Research

## BLANDING'S TURTLE CONSERVATION

### OBJECTIVES

- To help ensure the survival of the Blanding's turtle in perpetuity.
- To help conserve the Pleasant River Blanding's turtles through science, public education and stewardship.
- To better understand the occurrence, abundance and distribution of Blanding's turtles in the working landscape that surrounds the Pleasant River region.
- To better understand and work to mitigate the threats that face the Blanding's turtles in Pleasant River, specifically those that relate to their nesting and winter ecology.

### METHODS

Researcher B.Caverhill talking to a local youth in Pleasant River (photo by E.Newton).

- Sampled wetlands throughout southwest Nova Scotia for Blanding's turtles through trapping, radio-telemetry, and visual surveys between May 2002 and December 2005; efforts were concentrated in the Pleasant River region, but included areas throughout Queens, Lunenburg, Annapolis and Shelburne counties.
- Conducted 334 trap sessions for a total of 6562 trap nights and 3201 person-hours of effort (this included 2200 hours of trap effort, 700 hours of radio-telemetry, and 300 hours of visual surveys).
- To help conserve the Pleasant River Blanding's turtles a link was established between science and stewardship through public education; first had to learn about the turtles, which allowed the sharing of acquired knowledge with people, so they could effectively respond and aid the conservation efforts.
- Facilitated public education by moving into the Pleasant River community and living there for three years; this allowed closer contact with both the turtles and the people.
- Public education was both planned and spontaneous.

## RESULTS

Researcher E.Newton giving a school presentation in Newcombville (photo by B.Caverhill).

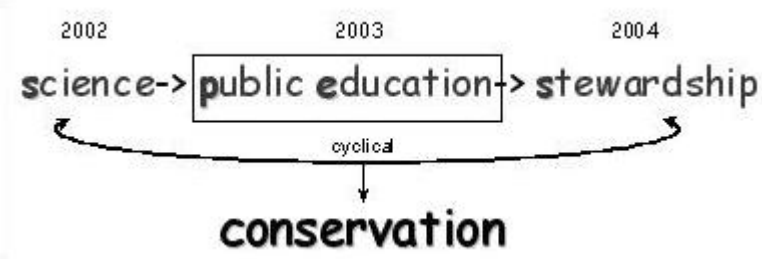
- From May 2002 to December 2005 trapping, radio-telemetry and visual surveys yielded 124 Blanding's turtles (39 males, 35 females and 50 juveniles) in seven primary areas around the Pleasant River region.
- Females nested in a widely distributed variety of mostly artificial habitats and substrates, including abandoned railroads, gravel roads, residential driveways, vegetable gardens, abandoned mine tailings, mine roads and shafts and greywacke outcrops.
- Nesting appeared to be synchronized within areas, but timing was variable among areas and years; hatching success was low (34%) but variable among nests and years.
- Turtles showed fidelity to a variety of winter aggregation sites that had unique oxygen, temperature and habitat profiles.
- Planned and spontaneous public education was used to spread awareness locally, which in turn generated stewardship actions from the public (sighting reports and volunteer nest stewards).
- Overall, intensive research over the past four years in Pleasant River resulted in the convergence of science and stewardship, which was facilitated by effective public education and outreach.

## YEARS OF DATA

- May 2002 - December 2005

## PARTNERS

- Blanding's Turtle Recovery Team
- Acadia University
- Parks Canada
- Natural Sciences and Engineering Research Council of Canada
- Species at Risk Recovery and Education Fund
- Mersey Tobeatic Research Institute
- Nova Scotia Department of Natural Resources
- Nova Scotia Department of Environment and Labour
- Habitat Stewardship Program
- Endangered Species Recovery Fund




The science, public education, and stewardship cycle.

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## Rationale

Blanding's turtles in Nova Scotia, which occur in three small, isolated populations, are listed as Endangered, based partly on a recent Population Viability Analysis (PVA) on one of these populations. This first simple model, which predicted future population trends based on current survivorship values for different life stages, indicated that the population was declining. To follow up, a more complex PVA model was developed to incorporate additional parameters including between-year variability in survivorship and uncertainty in the calculations' accuracy. This second model indicated an even more precipitous decline in the population. These alarming results led to the organisation of a two-day workshop in spring 2006 to investigate the impacts of various management regimes on the projected population trend and to discuss recovery options. In preparation for this workshop, survivorship estimates were re-calculated using additional data and more robust statistical techniques.

# Research

## BLANDING'S TURTLE POPULATION VIABILITY ANALYSIS

One of the first Blanding's turtles marked in the Park, this female is at least 55 years old (photo by J.McNeil)

### OBJECTIVES

- To conduct live trapping and visual surveys in Kejimkujik to obtain new data to refine estimates of adult and juvenile survivorship.
- To update the PVA with re-calculated survivorship estimates obtained using additional data and more robust statistical techniques.
- To run simulations to explore the relative impact of various management regimes on population trends.
- To hold a workshop for Recovery Team members, Parks Canada personnel and other experts to discuss the reliability of the model and potential recovery actions for Blanding's turtle.

### METHODS

Researcher G.Bourque working on PVA simulations (photo by G.Bourque).

- Live trapping (590 trap nights) and visual surveys (50.8 hrs) were conducted in areas known to contain Blanding's turtles, concentrating on areas that had not been trapped for long intervals.
- Adult and juvenile abundance and survivorship were re-calculated by adding recapture data from 2004-5 as well as archival data from 1969-86 and using more robust statistical techniques that incorporated variable search effort between years into the calculations.
- The PVA was re-run using the updated model parameters. Simulations investigated included "no management" (no direct intervention) and various combinations of nest protection, head-starting (captive rearing for the first one or two years of life) and laboratory incubation of eggs, all three at varying intensity levels and implementation intervals.

## METHODS (continued)

- Each scenario was examined with two possible adult survivorship estimates: 97.1% (based on current data) and 98.5%. The higher estimate both reflected our uncertainty of the true adult survivorship and allowed us to examine simultaneous impact of increasing adult survivorship along with management of early life stages.
- An initial PVA was conducted on a second population, McGowan Lake, using data collected over the last decade.

## RESULTS

- Fourty turtles were captured, including 10 new individuals and several recaptures of individuals not sighted for long periods (up to 17 years). These captures suggest that additional effort is warranted in particular areas to continue to refine estimates of survivorship and abundance.
- Newly re-calculated survivorship estimates were higher than those previously obtained.
- The new models suggested that the population decline is real but appears to be less precipitous than previously thought, and more likely reversible with appropriate management, including nest caging, hatchling head-starting and captive incubation.
- The population at McGowan Lake also appears to be declining but this may be partly due to gaps in knowledge of juvenile survivorship.
- Workshop participants agreed to proceed with an experiment to test the efficacy of headstarting and incubation.

Live-trap to recapture Blanding's turtles (photo by J.McNeil).

## YEARS OF DATA

- Monitoring adult and juvenile Blanding's turtles is ongoing
- The PVA will be updated as necessary

## PARTNERS

- Blanding's Turtle Recovery Team
- Parks Canada
- Acadia University
- Friends of Keji
- Mersey Tobeatic Research Institute
- Natural Sciences and Engineering Research Council of Canada

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Male recaptured for the first time in 17 years (photo by J.McNeil).

## Rationale

The Eastern ribbonsnake is one of several species at risk with disjunct ranges in Nova Scotia. Many of these species exist in small populations scattered across protected and working landscapes in the southwest interior of the province. Very little is known about this Threatened snake, which reaches the northeastern limit of its range in Nova Scotia. It appears to be patchily distributed and, with some exceptions, occurs at low densities. The majority of known sites occur in working landscapes where snakes are potentially vulnerable to threats from wetland modification and degradation. At present, there is a lack of information on abundance, population trends, geographic limits of the population and scale of the threats facing the species. The intention of this project is to try to locate additional populations of this small, cryptic species through systematic visual surveys.

Ribbonsnake emerging from sedge (photo by T.Herman).

# Research

## EASTERN RIBBONSNAKE DISTRIBUTION

### OBJECTIVES

- To extensively survey sites in and around the known range of ribbonsnakes in Nova Scotia to try to ascertain the structure and geographic limits of the population.
- To identify additional concentrations of ribbonsnakes to target further research and future stewardship and conservation efforts.
- To develop a standardized sampling protocol to maximize the likelihood of finding this small, cryptic species.
- To distribute ribbonsnake pamphlets to inform the public about this rare, harmless snake and to solicit sighting reports.

### METHODS

- Areas selected for dedicated surveys were visually searched on foot or by canoe. Additionally, all researchers working on Blanding's turtle projects looked for snakes during turtle sampling. The majority of sampling was confined to a 10 m zone bounded on one side by the water's edge.
- Data recorded included sampling effort, search conditions and location and behaviour of each snake observed.
- An attempt was made to capture all snakes sighted. Snakes were measured, photographed and sampled for DNA following established protocols. At sites that received repeated visits, snakes were marked individually by ventral scale clipping.
- Fine-scale habitat data were collected within a 2.5 m radius of each capture site.

Researchers surveying (photo by N.Seguin).

## METHODS (continued)

- An educational pamphlet was developed and distributed to park visitors, outdoor groups, and naturalist organizations. Additionally, ribbonsnakes were incorporated into educational programs for school groups and community events and a website was developed.
- A toll free number (1-866-727-3447) was maintained for people to report sightings of ribbonsnakes or other species at risk.

## RESULTS

- Twenty-one areas were searched by dedicated snake surveys, yielding 16 ribbonsnake sightings. Researchers conducting work on Blanding's turtle also looked for ribbonsnakes during all aspects of turtle work, yielding an additional 31 sightings.
- Areas searched by both methods included sites on six watersheds: Mersey, Medway, LaHave, Bear, Clyde and Roseway.
- In 2005, the first confirmed sightings on the LaHave watershed were recorded, extending the known range to the east.
- Ribbonsnakes were also confirmed in four additional areas within their known range on the Mersey and Medway watersheds.
- Locating this small, cryptic species presents a challenge and even in areas known to contain ribbonsnakes, the capture per unit effort is low. Visibility of snakes is influenced by the height and density of vegetation; this becomes particularly problematic in mid summer. The intention was to concentrate sampling in spring. However, intensive rainfalls (423 mm rain during April and May - data from Environment Canada) and associated high water levels resulted in cancellation of surveys during most of this time period.
- Approximately five ribbonsnake sightings were reported from the public.

Ribbonsnake habitat (photo by G.Bourque).

## YEARS OF DATA

- This is a multi-year project that was initiated in 2004.

## PARTNERS

- Eastern Ribbonsnake Recovery Team
- Parks Canada
- Acadia University
- Dalhousie University
- Mersey Tobeatic Research Institute
- Habitat Stewardship Program for Species at Risk

Researchers J.Todd and J.Caron recording data (photo by N.Segiun).

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## Rationale

The Eastern ribbonsnake (Atlantic Population) is the rarest snake in Atlantic Canada, found only in limited areas of Nova Scotia. Its autecology, including where it hibernates, how it knows when to emerge from hibernation (cues) and when and where it breeds remains largely unknown. Our goal is to collect that information and apply it to the development and implementation of a Recovery Plan for the ribbonsnake in Nova Scotia. Previous research has provided basic information on the population size, sex ratio and seasonal movement of the snakes in a well-defined area on the shores of Grafton Lake (Kejimkujik). However, the behavioural ecology of the snake during its active season needs to be better established in order to know its environmental requirements for successful growth and reproduction. Similarly, the characteristics of successful hibernation sites also need to be established to know what habitats to protected to assure the animal safe places to overwinter.

Ribbonsnake on sphagnum (photo by J.McNeil).

# Research

## EASTERN RIBBONSNAKE ECOLOGY

### OBJECTIVES

- To identify habitat preference and spatial distribution of the Eastern ribbonsnake at Grafton Lake in Kejimkujik.
- To identify and characterize hibernacula used by the Eastern ribbonsnake.
- To learn more about this rare species' autecology including seasonal movement patterns, feeding, mating and basking behaviours.
- To record body temperatures relative to environment to investigate the possibility that a ribbonsnake can alter blood flow to its tail, thus conserving heat at low temperatures.

### METHODS

- Visually survey habitat and hand capture observed snakes.
- Collect data on physical condition (*i.e.* length, weight, age class and injuries), behaviour when first seen, environmental conditions and GPS location.
- Photograph animals for ribbonsnake database and give them a ventral scale clip code to help interpret seasonal movements.
- Observe movement patterns using fluorescent powder.

Spring at Grafton Lake (photo by J.Phillips).

### RESULTS

- Public awareness of the Eastern ribbonsnake was expanded via pamphlet distribution both inside and outside Kejimkujik and with presentations at the Mersey Tobeatic Research Institute and to the Nova Scotia Herpetoculture Society.

## RESULTS (continued)

R.Wassersug measuring a ribbonsnake (photo by J.Phillips).

- Daily activity patterns of the ribbonsnakes at Grafton Lake were observed throughout their active season and confirmed to include basking swimming and eating.
- The confirmed active season was extended into November; previously the latest recorded sighting of a ribbonsnake was October 27th.
- A large seasonal range was documented for individual animals, both in and out of the study area.
- A shift in movements of the animals, correlating with spring and autumn flooding regimes, was documented.
- Behaviours consistent with mating (extreme tongue flicking) were observed.
- Regrowth of clipped scales was confirmed; suggesting a need to use passive integrated transponder (PIT) tags to mark individuals in the future.

## YEARS OF DATA

- Past data exists for 2001, 2003, 2004 and 2005
- This research is continuing in 2006 and 2007

## PARTNERS

- Dalhousie University
- Acadia University
- Parks Canada
- Mersey Tobeatic Research Institute

Ribbonsnake basking at the edge of the water (photo by J.McNeil).


A young ribbonsnake being very docile and flagging tape to mark where it was caught (photo by J.Todd).

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## Rationale

Most wetlands are protected from adjacent habitat disturbance through the preservation of 20+ m buffer zones; however wetlands without watercourses, such as treed bogs, have been excluded from these regulations and timber and/or peat harvesting are permitted within them. In Nova Scotia, the ramifications of these activities could be high because treed bogs are the most common wetland type in the province and the most likely to be encountered by foresters. Further, some organisms show high diversity within these systems and many designated Species at Risk and other rare and highly specialized species use these habitats. This project uses the total number of dragonfly species and the presence of particularly sensitive species as indicators of habitat disturbance and as a means to determine appropriate buffer zones to maintain dragonfly diversity within treed bogs.

Calico pennant, a species at the northern edge of range that is relatively common in southwest Nova Scotia (photo by D.Hurlburt).

# Research

## DRAGONFLY DIVERSITY OF TREED BOGS

### OBJECTIVES

- To describe dragonfly diversity in treed bogs.
- To evaluate dragonflies as indicators of wetland health for long-term monitoring.
- To evaluate the effectiveness of Nova Scotia Wildlife Habitat and Watercourses Protection Regulations to protect treed bog biodiversity and make recommendations for improved regulations.

### METHODS

- The diversity of 18 treed bogs on Bowater Mersey Paper Company land and crown land around Kejimkujik and Tobeatic was described.
- Dragonflies were captured by aerial net (adults) and aquatic D-nets (larvae) using standardized protocols that can be compared across sites.
- The type and intensity of forestry around bogs occurring within 20, 50, 100, 250 and 500 m of each site was described.
- Species richness and evenness was calculated for dragonflies and related to forestry activity.

Elfin skimmer, a yellow-listed species in Nova Scotia previously known from very few sites. North America's smallest dragonfly (photo by D.Hurlburt).

### RESULTS

- Forty-six species of adult dragonflies were found in treed bogs, representing 36% of all Nova Scotia dragonfly species.
- Fourteen species of conservation concern (Atlantic Dragonfly Inventory), including four "Yellow-listed" species (Status of NS Wildlife) were documented.
- Doubled Nova Scotia's records of the Elfin skimmer.
- Analysis of forestry activity is ongoing.

## YEARS OF DATA

- This project was initiated in 2005 and will continue until 2007

## PARTNERS

- Bowater Mersey Paper Company
- Nova Scotia Department Natural Resources
- Acadia University
- Mersey Tobeatic Research Institute
- Parks Canada
- Natural Sciences and Engineering Research Council
- Atlantic Dragonfly Inventory

K.Nickerson (Top) waiting for dragonflies and S.Hubley (Bottom) sorting through sample (photos by D.Hurlburt).

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## Rationale

The Mersey watershed (approximately 299,000 ha) consists of 15,000 ha of peatlands, equivalent in area to Rossignol Lake, the largest lake in the watershed. Very little study has been done on how silvicultural practices and associated road building effect peatlands when they are adjacent to these cuts. Are there water chemistry changes and if so what is the duration of this change? We know that peatland chemistry influences mosses. Are there changes in the vegetation? Following clear-cutting, the effect of "watering-up" in the cut, as well as adjacent wetlands has been documented by other scientists. Little study has been done on peatland water chemistry in the region and on land-use effects on water quality and quantity in peatlands.

Heber Meadow, Kejimkujik, monitoring well in fen along riparian habitat (photo by AGRG).

# Research

## SILVICULTURE IMPACTS ON PEATLANDS

### OBJECTIVES

- To determine effects of silvicultural practices on adjacent peatlands (fen and bog type) by setting up a series of plots along a transect with increasing distance from proposed forestry cuts and measuring water quantity and vegetation cover.
- To set up similar plots measuring the same variables within similar habitats at Kejimkujik to serve as reference plots.

Water measurement at Heber Meadow, Kejimkujik (photo by A.Lavers, MTRI).

### METHODS

- Fens or bogs with less than 40 cm of peat adjacent to proposed silvicultural treatments were selected and matched with reference sites inside Kejimkujik.
- Piezometers were installed in each plot for water quality and quantity measure. Measurement was completed using a probe and water was pumped into 250 ml bottles for lab analysis. Well depth and water depth at each visit were recorded.
- Two visits occurred in the first year, one for installation and vegetation assessment and one during high water season.
- Plots were set up to assess vegetation cover. All plant species were assessed and recorded.
- Trees above 5 m were assessed. Site characteristics such as microhabitat were noted for mosses.

### RESULTS

- Four control/reference sites were selected in Kejimkujik (three plots at each site) and two treatment sites were selected in the upper Mersey Watershed on Bowater Mersey Paper Company land. Seventeen plots were sampled in total.

## RESULTS (continued)

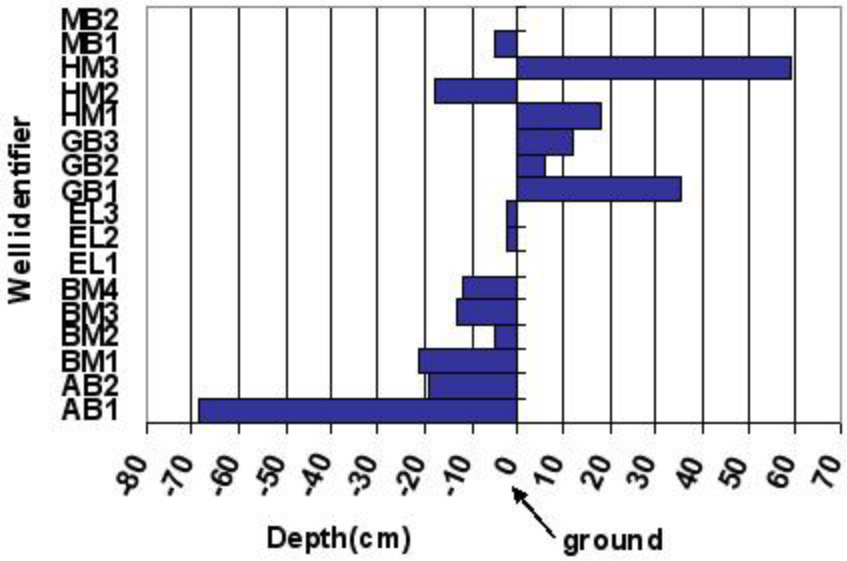
- No silviculture treatments occurred during the first season.
- Average well depth was 1.5 m with maximum well installation at 2.5 m.
- No water quality variables were collected in August, because water levels were too low.
- Average fall pH was 4.89, which is consistent with bog and poor fen values. Principal component analysis of chemistry yielded 47% variation in axis 1 and 22% in axis 2 with calcium, chlorine and magnesium being positively correlated with axis 1.
- Sixty-one species of plants were found in total and 44 species had cover greater than 5%. Dominant vegetation type was shrub (17 species) and the dominant species was Rhodora with a frequency of 94%. Fifteen species of Sphagnum were found with *Sphagnum recurvum* ranking as third species (70%). Lichens were the least frequent vegetation type (four species) but ground lichens were not included in the assessment. Diversity summary indicates that mean richness was 11.6 with an evenness of 0.71. Shannon diversity calculated between plots was 1.72 and the Simpsons index was 0.76.

## YEARS OF DATA

- 2005 - Baseline reference wells set up and vegetation was assessed.
- 2006 - Monitor existing wells and setting up additional treatment sites.
- 2007 - Monitor all sites.
- Sampling frequency will be every three years after that.

## PARTNERS

- Applied Geomatics Research Group
- Mersey Tobeatic Research Institute
- Bowater Mersey Paper Company
- Parks Canada



Well fall water level. All measures from ground level.

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# APPENDIX

| | Kejimkujik | Greater Kejikmkujik Ecosystem | Monitoring | Research |
|---|---|---|---|---|
| **COASTAL** | | | | |
| Piping plover monitoring program | X | | X | |
| Piping plover habitat management | X | | | X |
| Piping plover critical habitat | X | X | | X |
| **FOREST** | | | | |
| SI/MAB tree monitoring | X | X | X | |
| Hemlocks and Hardwoods trail use | X | | X | |
| Mammal predator detection program | X | | X | |
| Nova Scotia nocturnal owl survey | X | | X | |
| Air quality monitoring with lichens | | X | X | |
| Landcover change | X | X | X | |
| Forest floor arthropod monitoring | X | | X | |
| Fuel typing Kejimkujik's forest | X | | | X |
| Moose of mainland Nova Scotia | | X | | X |
| Pale-winged gray moth pheromone | X | | | X |
| Pale-winged gray moth ecology and management | X | | | X |
| Old-growth forests' social values | | X | | X |
| Identifying key areas of landscape connectivity | X | X | | X |
| Testing flying squirrel PIT-tags | | X | | X |
| Lichens in old-growth forests | | X | | X |
| Structural complexity in old-growth forests | | X | | X |
| Tree-ring analysis | X | X | | X |

| | Kejimkujik | Greater Kejikmkujik Ecosystem | Monitoring | Research |
|---|---|---|---|---|
| **FOREST** | | | | |
| ***Projects not included in this report:*** | | | | |
| Forest bird monitoring | X | | X | |
| Riparian buffers and birds | X | X | | X |
| Breeding bird survey | X | X | X | |
| Forest salamander monitoring | X | | X | |
| Forest decompostion monitoring | X | | X | |
| Provincial forest plot monitoring | X | X | X | |
| Invasive plant monitoring | X | | X | |
| White-tailed deer roadside survey | X | | X | |
| Riparian stream invertebrates | X | X | | X |
| Dioecious herbivory in plants | X | | | X |
| Eastern pipistrelle bats and connectivity | X | X | | X |
| **FRESHWATER** | | | | |
| Acid rain and water chemistry monitoring | X | | X | |
| Kejimkujik LoonWatch | X | | X | |
| Benthic macroinvertebrate monitoring | X | | X | |
| Stream flow monitoring | X | | X | |
| Chemistry of surface waters in Kejimkujik | X | | X | |
| Cold water lake habitat | X | X | | X |
| Brook trout migration study | X | X | | X |
| Assessing aquatic health | X | X | | X |
| Mersey riparian area conservation | X | X | | X |
| Tracking surface-water acidification | X | | | X |
| ***Projects not included in this report:*** | | | | |
| Acid precipitation monitoring | X | | X | |
| Climate monitoring | X | X | X | |
| Cobrielle ecosystem restoration monitoring | X | | X | |
| Lake thermal sensitivity | X | X | X | |
| Diatom monitoring | X | | | X |
| **WETLAND** | | | | |
| Water pennywort monitoring | X | | X | |
| Rare plant monitoring program | | X | X | |
| Assessment of coastal plain flora | X | | X | |
| Blanding's turtle nest monitoring | X | X | X | |
| Climate and Blanding's turtle growth | X | X | | X |
| Blanding's turtle habitat modeling | X | X | | X |
| Growth dynamics of Blanding's turtles | X | | | X |
| Overwintering of Blanding's turtles | X | X | | X |
| Blanding's turtle conservation | | X | | X |
| Blanding's turtle population viability analysis | X | X | | X |
| Eastern ribbonsnake distribution | X | X | | X |
| Eastern ribbonsnake ecology | X | | | X |
| Dragonfly diversity of treed bogs | | X | | X |
| Silviculture impacts on peatlands | X | X | | X |

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