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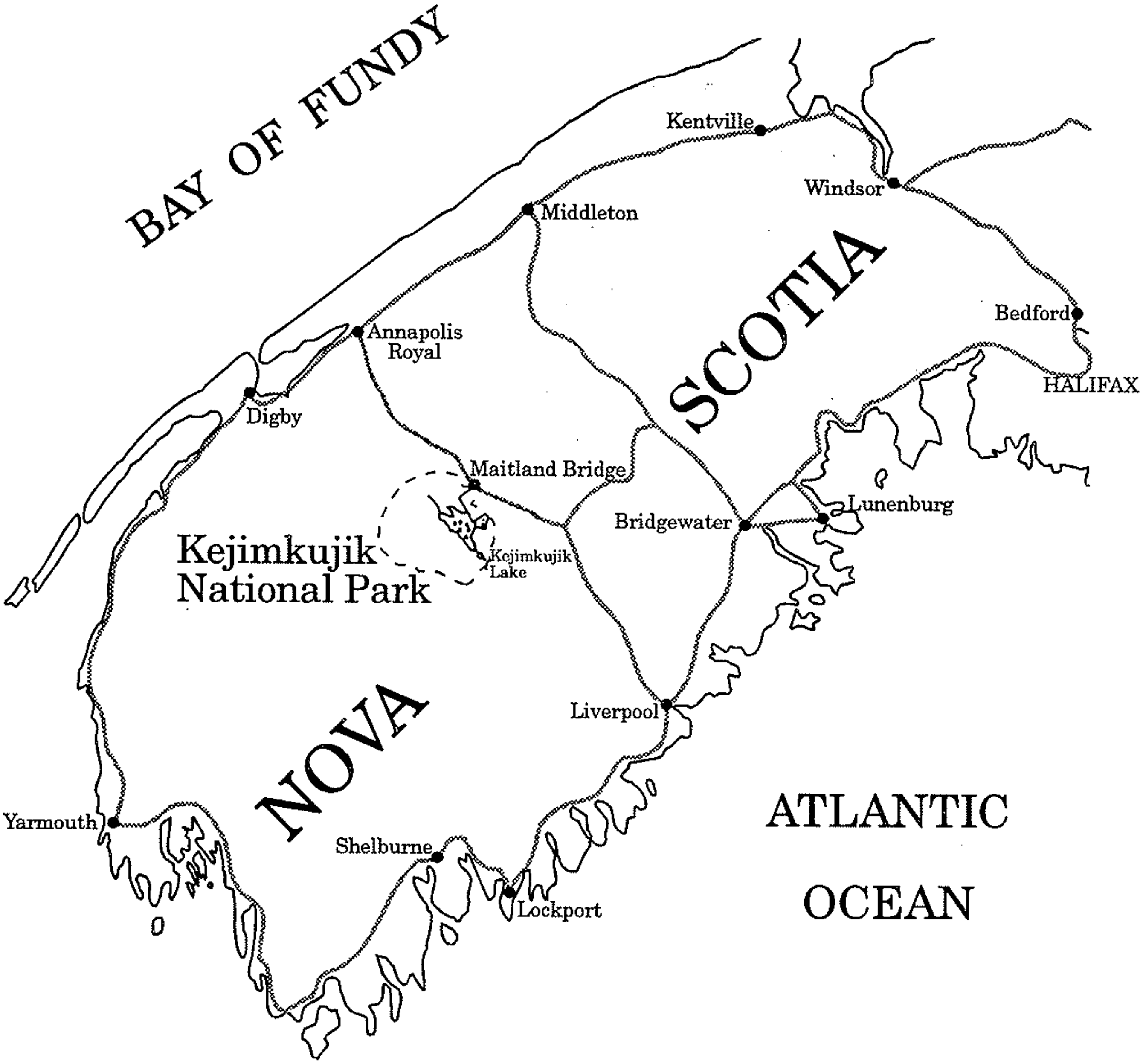
Ecological Monitoring and Research at Kejimkujik National Park 1978-1992

Occasional Report No. 2

onal Environmental Monitoring And Research Coordinating Committee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ECOLOGICAL MONITORING AND RESEARCH AT KEJIMKUJIK NATIONAL PARK 1978-1992

by

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TABLE OF CONTENTS

EXECUTIVE SUMMARY

Canadian ecosystems are subject to an increasing number and complexity of environmental stresses stemming from human activity. The determination of the ecological consequences of these stresses is not possible using information provided solely by conventional sectoral monitoring and assessment activities. Comprehensive ecosystem monitoring and assessment is required to establish ecological, spatial, process and temporal relationships which exist among individual ecosystem components (i.e. air, water, land, and biota). Through this ecosystem approach, relationships between stresses, exposure and ecological responses can be established. Indicators, in turn, can be developed that serve both to monitor trends in the health of ecosystems and the environmental response of these ecosystems to control actions.

A national network for ecosystem monitoring and assessment has been proposed to provide such integrated ecological information. Together with existing monitoring, this network would provide background data for the development and monitoring of regional and national indicators of the status and trends of the health of our major ecosystems.

Kejimkujik National Park is ideally suited as a candidate site for this national network. Being a National Park, it is protected from development which may endanger long term monitoring and assessment. As well, the park is generally representative of the Atlantic Maritime Ecozone and has a key role in the acid precipitation monitoring network. The historical data available from the calibrated watersheds and complementary environmental surveys provides an existing data base from which to build and establish at least minimal trend information to date. The infrastructure, including monitoring instrumentation, established to serve the Canadian Acid Rain Program, is in place and can serve as the nucleus for an expanded comprehensive ecosystem monitoring and assessment site.

RESUME

Les écosystèmes canadiens sont assujettis à des stress de plus en plus nombreux et de complexité croissante qui découlent de l'activité humaine. Il n'est pas possible de déterminer les conséquences de ces stress sur l'environnement en utilisant uniquement les renseignements que fournissent les activités traditionnelles de surveillance et d'évaluation sectorielles. Il faut procéder a une surveillance et a une évaluation en profondeur des écosystème pour établir les liens d'ordre écologique, spatial, temporel - ainsi que les liens touchant aux processurs - qui existent entre les éléments individuels des écosystèmes (c'est-à-dire l'eau, l'air, la terre et la biote). Grâce a une méthode ainsi fondée sur les écosystèmes, it est possible de cerner les relations entre les stress, l'exposition et les réponses écologiques. Des indicateurs peuvent en retour etre mis au point pour suivre les tendances de la santé des écosystèmes et de la response écologique de ces écosystèmes aux mesures de contrôle.

Un réseau national visant la surveillance et l'évaluation des écosystèmes a été proposé pour fournir des renseignement integres sur le plan ecologiques. Avec les outils de contrôle existants, le réseau fournirait des données de base pour l'élaboration et la surveillance des indicateurs, sur le plan régional et national, attestant de l'état de santé de nos principaux écosystème et des tendances.

Le parc national Kejimkujik est un candidat idéal pour le réseau national. Comme il s'agit d'un parc national, it est protégé de tout aménagement susceptible de compromettre la surveillance et l'évaluation à long terme. De plus, le parc est généralement représentatif de l'écozone maritime de L'Atlantique et il houe un rôle clé au sein du réseau de surveillance des précipitations acides. Les données historiques recueillies à partir des bassins hydrographiques jaugés et des relevés environnement auz complémentires sur les tendances décelées jusqu'a maintenant. L'infrastruture, y compris l'appareillage de surveillance, établie aux fins du Programme canadien sur les pluies acides est en place et elle peut servir de base à la création d'un site d'évaluation et de surveillance élargie et approfondie des écosystèmes.

INTRODUCTION

Canadian ecosystems, and the human and environmental resources contained therein, are subject to an increasing number and complexity of stresses. Climatic change, ozone depletion, acid rain, and toxic chemicals represent some of the more high profile stressors. Concerns, however, over polluted water and air, an increasing list of endangered species, habitat loss, forest dieback, and general land degradation are prevalent. Causal stressors, more often than not, are multiple and cumulative in their impact.

The determination of the ecological consequences of theses stresses is not possible from information provided by conventional sectoral inventory and assessment activities. Sectoral approaches rarely are able to establish the spatial, process and temporal relationships which exist among individual ecosystem components (air, water, land, biota) or with human activities. It is essential that monitoring and assessment be able to determine these ecological relationships and responses to control actions. As the Green Plan emphasizes: "we must think, act, and plan in terms of ecosystems." To do this, we must understand how ecosystems function, their interrelationships among various levels of hierarchy, and their response to external stresses. The difference between the natural dynamics of particular ecosystems and those changes induced by anthropogenic agents must be determined. With an understanding of linkages between anthropogenic stressors, exposure pathways and ecosystem response, appropriate indicators of ecosystem change can be developed and monitored.

Comprehensive data, sufficient in terms of key biological and physical/chemical variables must be collected for "typical" ecosystem sites over the long term. Research is needed to complement data collection to determine linkages among these variables. Such requirements are the "raison d'etre" for establishment and maintenance of a ecological monitoring and research network centres.

These centres may be considered as research parks through which crucial links between research and monitoring are developed and enhanced. The primary objective is to develop and monitor indicators of ecosystem change that will allow evaluation of control actions for specific stressors or groups of stressors. Through ecosystem frameworks, extrapolation of results would extend to regional analyses. A national network of monitoring centres would serve as the backbone to the monitoring and assessment of the "health" of the country's major ecosystems.

In general, these centres should have a common framework for establishment and implementation.

1. **Representativity:** Each site must be "typical" of regional ecosystems to allow for extrapolation of results.

2. **Ecosystem Approach:** All research leading to indicator development and related monitoring must consider results in terms of ecosystem function and process. Linkages among ecosystem components are paramount.

3. **Partnerships:** Sites must be amenable to research and monitoring for the major ecosystem components of air, water, land and biota. Active participation by universities and the private sector as well as all levels of government is encouraged. Site management and related infrastructure should promote such involvement.

4. **Regional Stressors:** Sites must be under the influence of many regional stressors (but not localized stressors) in order to serve as "baseline" for regional ecosystems, which may be impacted by various localized stressors.

5. **Long Term Protection:** Sites must be guaranteed protection from major local impacts (e.g. land use practices such as logging) to allow the accumulation of long term research and monitoring records for analytical purposes.

KEJIMKUJIK NATIONAL PARK AND ENVIRONS AS A STUDY SITE

Research and Monitoring History

Long term monitoring and assessment of ecosystem components at representative sites form the basis of a national environmental monitoring network. This network should build on existing sites that meet the general selection criteria. Kejimkujik National Park (KNP), located in southwestern Nova Scotia (Figure 1) is one such site. This paper discusses past, current and future research and monitoring activity at KNP. The site is described in terms of its spatial representivity, science partnerships and other aspects which suit its inclusion as part of a national network.

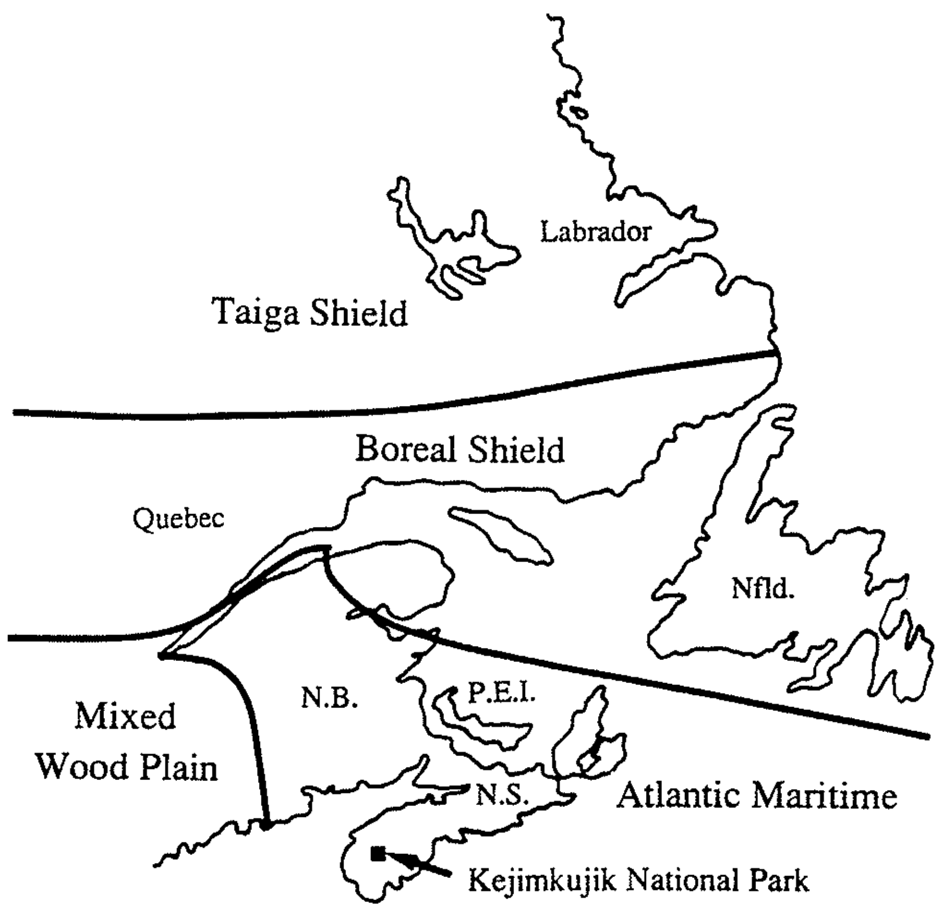


Figure 1. Location of Kejimkujik National Park on a regional ecozone map.

Research and monitoring activities related to acid rain and participation in the eastern Canadian Long Range Transport of Airborne Pollutants (LRTAP) network are probably the first arguments for considering KNP as a centre for the Atlantic Maritime Ecozone.

The Canadian LRTAP program has adopted the ecosystem approach for its research and assessments. "Integrated monitoring sites," such as KNP, were instrumental in developing an understanding of basic ecological relationships. Various ecological frameworks were used to extrapolate relationships and provide risk assessments. This work has been widely supported and recognized by numerous federal and provincial agencies as well as non-government research bodies and environmental organizations.

Since the early days of KNP there has been strong and continuing interest in research of park resources and long-term changes in the environment in response to stress. In 1964, one year prior to the onset of park development, a reconnaissance survey of limnological resources in the park area was done on representative lakes. This survey was to form the initial platform for the first eutrophication studies and also the Natural Resources Inventory Program, both initiated in 1970. Data from this work, together with data obtained from the climate station and hydrological monitoring, provided support for further studies. In 1978, KNP was selected as the Atlantic region Long Range Transport of Air Pollutants (LRTAP) Study site. The abundance of preexisting background data, protection from future disturbance, and high sensitivity to acidic deposition all contributed significantly to its selection.

The LRTAP program at KNP has included participants from branches of federal and provincial government, as well as universities. Associated projects covered a broad range of topics from many diverse disciplines (see Appendix A, B). As this multidisciplinary program grew, a Coordinating Committee was formed to ease communication and decision-making among the different research, monitoring and assessment aspects of the project. The Committee organized workshops (see Appendix B) with published proceedings to facilitate information exchange. In 1984, the KNP LRTAP Study obtained an excellent recommendation from peer review by the Royal Society of Canada. A major symposium on the acidification of organic waters focused on results from the KNP LRTAP Stud. This symposium, held in Wolfville, NS, in 1988, attracted much international interest.

The many lakes, rivers and streams of KNP range in morphology, chemistry and degree of isolation from other water bodies. Beaverskin and Pebblelogitch Lakes are two of the Benchmark Lakes (see Appendix A, Figure 2) which have provided a wealth of information for the LRTAP Study. The lakes are very close together and yet have radically different chemistry making them different in sensitivity to acid precipitation. Comparisons of these two lakes have helped to advance the understanding of the effects of acid deposition on naturally organic waters.

Overall, basic findings from the KNP LRTAP study demonstrated that, even low acid deposition rates are acutely perceived in the acid sensitive waters of the Atlantic region. The work has also shown that anthropogenic sources of sulfate cause additional acidity in humic organic waters, which are naturally acidic. Water and atmospheric chemistry, climate, hydrology, and wildlife monitoring continue to provide invaluable information to assess environmental quality parameters and to detect changes in stress level due to acid deposition. This continuing work also provides solid baseline information for monitoring of other ecosystem parameters, such as carbon and air and water temperature, for climate change work, much in the same way the early studies at KNP provided a springboard for the LRTAP program.

Specific parameters and indicators that have and are being measured are many (Appendix A). The pH of precipitation and water is the key indicator of the degree of stress exerted by acid rain, and has been monitored extensively by the LRTAP project. The distribution of certain aquatic invertebrates is a biological indicator of the degree of acid stress in aquatic systems. The distribution and success of loons in some of the benchmark lakes has proven to be a valuable biological indicator of the degree of acid stress to the ecosystem. The status of rare species in the park (Blanding's Turtle, Northern Ribbon Snake and Water Pennywort) are also monitored. Fluctuation in their distribution and success both temporally and spatially can provide indication of changes in ecosystem stress level. Other monitored biological indicators such as fish population dynamics, primary productivity of forest and lakes, wetland characteristics, and forest insect populations may serve as invaluable indicators of ecosystem health.

In 1986, detailed resource inventories and other studies were complied and analyzed in a volume published by Parks Canada (Drysdale 1986). Topics from this compendium specify not only physical, chemical, and biological resources, but also evaluate the results in terms of necessary research and implications for park management. This document made comprehensive survey information easily available to the public and other interested parties at low cost (Appendix C).

Recently, there has been a growing interest in the potential impacts of global warming due to rapid changes in carbon dioxide concentrations. Researchers at Environment Canada are currently taking advantage of the long-term continuous data set, established from the climate station and hydrological monitoring at KNP, to analyze potential climatic trends. Detailed monitoring has also been set up at Pine Marten Bog to begin evaluation of carbon cycling. Current projects, monitoring stations, and occasional surveys (Appendix A) continue to add to the substantial reference material available for environmental monitoring.

Partnerships

The LRTAP Study at KNP established an interagency coordinating committee to communicate findings and coordinate objectives within the project. LRTAP findings also had both public policy and public information consequences. Researchers representing many agencies and institutions have chosen to work at KNP because of the excellent existing infrastructure and background data. Good working relationships are therefore established with federal and provincial departments, universities, and local groups. Table 1 provides a listing of the extent and variety of agencies and organizations that have carried out research, monitoring and assessment within KNP.

Cooperation from local landowners has made it possible for many successful research activities to be focused on the border or outside the park. Researchers are kept informed of any changes which might affect their project (e.g. spraying, logging), in return they are careful to respect the rights of the property owner.

The park has established valuable relationships with native groups, local environmental groups and ecotourism advocates. Native groups have a particular cultural interest in maintaining park integrity because of the archaeological and petroglyph sites located on the northwestern shores of Kejimkujik Lake.

Table 1: Groups involved in environmental research and monitoring activities at Kejimkujik National Park over the last ten years.

1. Federal Government

    Environment Canada:
    - -Canadian Parks Service (CPS)
    - -Atmospheric Environment Service (AES)
    - -Conservation and Protection (CP)
        - -Inland Waters Directorate (IWD)
        - -Environmental Protection (EP)
        - -Canadian Wildlife Service (CWS)

    Forestry Canada-Maritimes Region (FC)

    Department of Fisheries and Oceans (DFO):
    - -Halifax
    - -St. Andrews

2. Universities, Colleges, Museums, and Institutes:
    - -Acadia University (Wolfville, NS)
    - -College of Geographic Sciences (Lawrencetown, NS)
    - -Dalhousie University (Halifax, NS)
    - -McMaster University (Hamilton, ONT)
    - -Mount Allison University (Sackville, NB)
    - -Mount Saint Vincent (Halifax, NS)
    - -Nova Scotia Museum (Halifax, NS)
    - -Saint Mary's University (Halifax, NS)
    - -University of New Brunswick (Fredericton, NB)
    - -University of Waterloo (Waterloo, ONT)
    - -Wood's Hole Institute for Oceanographic Studies (Wood's Hole, MA, USA)

3. Provincial Government: Nova Scotia
    - -Department of Environment
    - -Department of Fisheries
    - -Department of Natural Resources
    - -Department of Agriculture

4. Local Landowners: Bowaters Mersey

Representativity

For State of the Environment reporting purposes, Canada is divided into 15 ecologically distinctive terrestrial ecozones. These ecozones represent the broadest level of generalization of a hierarchial ecological land classification of the country. The most detailed national level of hierarchy - the ecodistrict - consists of over 5500 ecological units. The objective of a national network of ecosystem monitoring and assessment sites, at a minimum, is to secure and implement one site representative of each ecozone.

Within the ecozone framework, Kejimkujik National Park is representative of the Atlantic Maritime ecozone (Figure 1). The National Park itself approximates an area of 381 square kilometres with other studies being carried out in adjacent lands. The Park is located in a sparsely populated area of south central Nova Scotia, typified by interconnected lakes, streams, wetlands and low-lying topography.

Canadian Parks Service (CPS), for its National Parks System Planning purposes, has divided the country into 39 Natural Regions. CPS is committed to protecting representative areas within all these Regions. Kejimkujik, in this regard, is representative of the Atlantic Coast Upland Natural Region. This designation adds weight to the use of the Park to establish research and monitoring linkages which can be extrapolated spatially to provide a regional perspective for ecological stress/response trend analyses. Detailed ecological survey, characterized primarily by patterns of landforms, soils and vegetation, has been carried out within the park (Gimbarzevsky 1975). This survey provides a basis for separating natural resources into ecologically significant regions, and allows an integrated approach to resource evaluation.

The primarily mixed coniferous and deciduous forest grows on thin, stony soils which range from being excessively drained to very wet. The main tree species within the park are: red maple, red oak, white birch, red spruce, black spruce, eastern hemlock, balsam fir, and white pine. Encompassing some fourteen forest cover type groups (Gimbarzevsky 1975). Most of the Park was logged at various times before Park inception. Thus the current forest cover represents a range of old and new growth stages. Many forests around the park (the Greater Kejimkujik Park Area) are still logged and generally represent young growth stages. This condition offers an excellent opportunity for comparative studies.

Regional Stressors

A workshop on environmental monitoring and regional indicators, with participation from federal and provincial agencies as well as academia, was held in Halifax in 1991. Participants identified several regional stressors that impact on the Atlantic Maritime ecozone. The anthropogenic stressors included acidic deposition, climatic change, ground oxidants, trace toxic chemicals and stratospheric ozone. Extensive land use was a generic stressor covering activities such as residential development, agriculture, forestry, transportation corridors, mining, etc. One or a combination of these activities can greatly impact regional ecosystems. The workshop also emphasized that major natural stressors must not be overlooked. Natural disturbances such as fires, windstorms and insect infestations need to be assessed in order to provide a proper context for impact assessment of anthropogenic stressors on regional ecosystems.

Although relatively pristine in nature, KNP is subject to a variety of these regional ecosystem stressors. Acid precipitation, ground level ozone and land use all impact KNP ecosystems to a different extent. KNP can serve as background to other identified stressors that have a future potential to impact regional ecosystems. Stressors in this category include climatic change, long-range transport of toxic chemicals, and stratospheric ozone.

KNP's ecological make-up also allows for regional assessments of specific environmental concerns. Waters across much of Canada are highly sensitive to acid deposition. Results from acid precipitation studies done at KNP have proven invaluable in determining both the impacts of atmospheric acid deposition, and tolerable loading levels for ecosystems where pH is naturally depressed. Additional, anthropogenic sources of acid stress will have a profound effect on the chemical balance of these ecosystems.

Similarly, wetlands have been identified as ecosystems which are highly sensitive to changes in climate. The abundant wetlands of KNP are, therefore, an important resource in predicting the rate and scope of potential impacts of global climatic change.

In the past, KNP has been subject to logging and some farming. Areas around the park continue to be subject to this stress. The Greater KNP area represents an ideal site to:

1) make direct comparisons of the characteristics of wilderness areas vs. land use areas;

2) compare the impacts of a stressor on both wilderness and land use areas.

3) allow integration with other initiatives striving to improve ecosystem management such as the Model Forest program of Forestry Canada.

National Park Status

The national network sites are intended for long-term ecological monitoring and assessment. As such, guarantees of long term protection from local disturbances such as logging and point source pollution are required. The need is for "typical" undisturbed regional ecosystem conditions (save for regional stressors) that can be monitored in perpetuity. National Parks, as a group, afford such protection. Kejimkujik, specifically, also has the infrastructure in place to facilitate both monitoring and research.

The LRTAP Program has laid the groundwork for links between research, data collection, public policy and the public. These linkages ensure that data are collected and used effectively to benefit science and the public. The Kejimkujik LRTAP Coordinating Committee is an interagency body that was formed to provide a forum for evaluating monitoring and its results, exchanging ideas, and coordinating project initiatives.

Results from LRTAP research have had a direct impact on public policy of acid rain. Research demonstrated that a single threshold level for acidic deposition was not satisfactory. Waters that are naturally low in buffering capacity such as those at KNP cannot tolerate the same loading levels as well-buffered systems. Further, the Kejimkujik Park Interpretation Program provides a wealth of environmental information directly to the public. This program used information based on LRTAP research to explain the acid rain problem to the public, and continues to use research at the park to educate the public about the functioning of natural ecosystems. Again, this experience with the LRTAP program can serve well to translate to the public other issues and concerns related to ecosystem health.

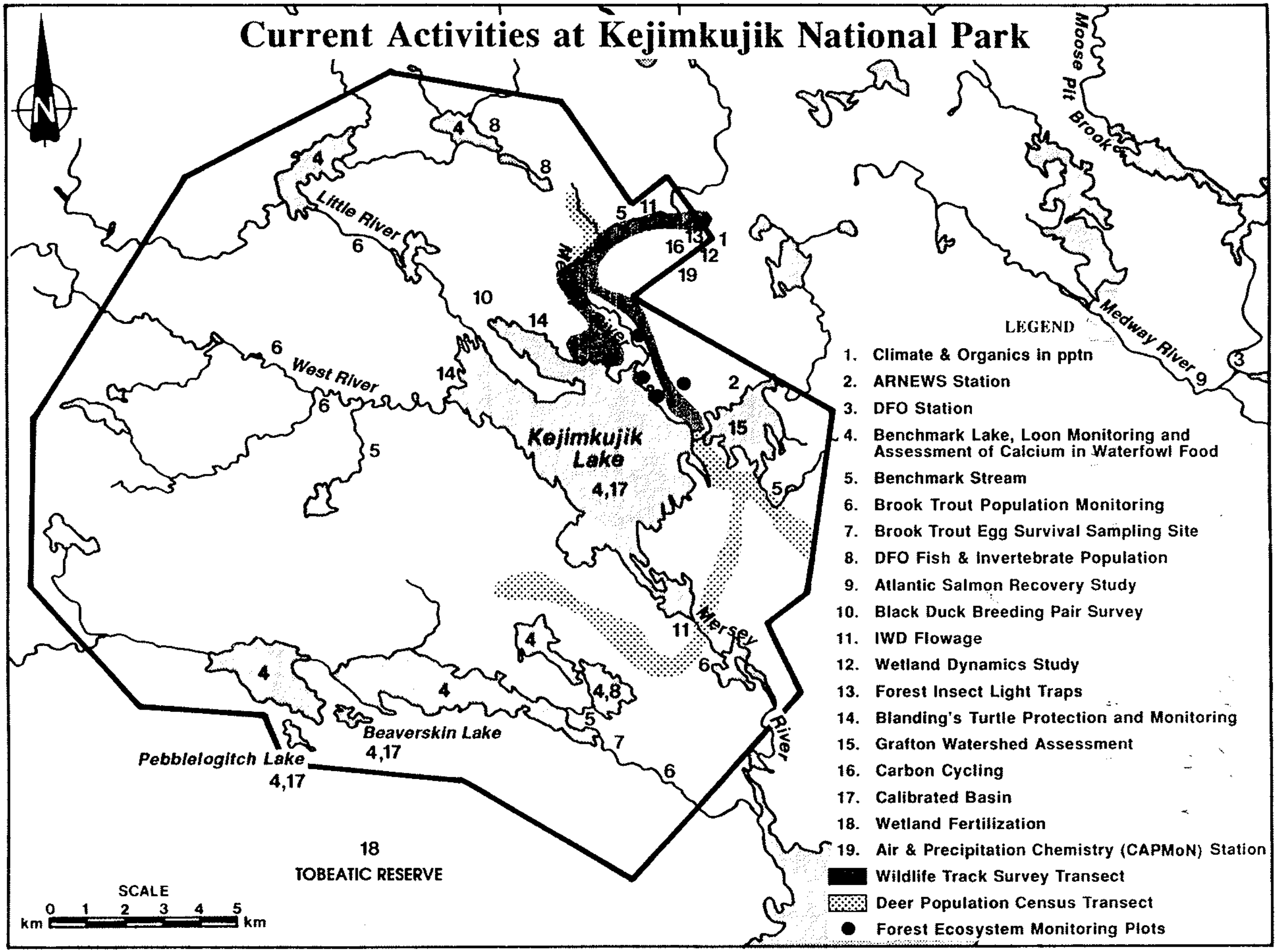
Interest has also been recently expressed on the part of Parks, local landowners and academics for establishing an International Biosphere Reserve at KNP and the surrounding area.

DATA GAPS IN MONITORING AT KEJIMKUJIK

Currently, much of the monitoring activities at KNP relate to acid precipitation, climatic change, and wildlife populations (Figure 2). The calibrated basins, and climate station, provide accurate, continuous data which are readily useable for analysis and interpretation. Initiatives in climatic change processes will hopefully establish a meaningful analysis of monitoring necessary to detect trends over time.

Figure 2. (see opposite page) Summary of monitoring and research activities at Kejimkujik National Park.

Current Activities at Kejimkujik National Park



A number of other areas need more attention to provide a better understanding of regional ecosystem dynamics. Firstly, a better understanding of hydrological relationships is required. Understanding water flow between air, land, lakes, streams, wetlands and groundwater is crucial to evaluation of ecosystem function and process and the impact of various stressors on these. Secondly, biomonitoring of forests and aquatic life needs to be enhanced and incorporated into regular monitoring and reporting activities.

Data collection procedures should be automated where possible to streamline logistics. A data and communication network should be established within and among national monitoring centres to facilitate transfer of monitoring data and information exchange. Eventually, transfer of information would extend to the greater scientific community and to the public through State of the Environment (SOE) reporting and other activities.

It is important that information and results from monitoring efforts be communicated to the public. Canadian Parks Service Interpretation Programs could be better integrated with the monitoring centres to educate the public about ecosystem functions and processes and how they may be affected by anthropogenic activity. An extensive educational program at the monitoring centres would be especially valuable because visitors would see meaningful scientific assessment of the natural world around them. The Parks Interpretation Program has already proven successful in making science readily available to the public.

CONCLUSIONS

The foundations of a successful environmental monitoring centre are well established in the Greater Kejimkujik National Park Area. A wealth of background data and organizational structures already exist. A Coordinating Committee maintains communication between researchers and Park Management and can serve as the basis for an expanded science coordinating group. The Park currently houses sophisticated atmospheric sampling, including a Canadian Air and Precipitation Monitoring Network (CAPMoN) site and long-term water monitoring is in place. Infrastructure is in place to allow year-round monitoring, assistance from Park wardens when appropriate, and some accommodation for researchers.

The Park is recognized as representative of both the Atlantic Maritime Ecozone of Canada's national SOE reporting ecological framework and of the Atlantic Coast Uplands Natural Region of the National Parks System Plan. Data from monitoring and resultant assessments can be readily extrapolated for regional syntheses.

Local stressors that would negate regional assessments do not affect the Park ecosystems. Yet this area is impacted by several regional anthropogenic stressors. These conditions allow for research and monitoring of both stress/response relationships for regional stressors and for baseline conditions that can be compared with ecosystems impacted by local stressors.

Because the area is a National Park, the Parks Interpretation program can facilitate public education about ecosystem dynamics in general. Partnerships and good working relationships are already established with federal and provincial government, universities, industry, private citizens, and local groups. These sites are also intended to attract researchers from universities to augment governmental activities. Because of past LRTAP activity and Parks Service initiatives to encourage research within National Parks, the foundation of cooperative programs with academia is in place at Kejimkujik.

ACKNOWLEDGEMENTS

None of the work described in this report could have been done without the continuing help and support of a number of people located at Kejimkujik National Park. In particular, we must thank the Superintendent, Bill Wambold, the Chief Warden Jordan Wentzell and the rest of the staff at the Park who have helped us out in numerous ways. We also thank Floyd Luxton, whose careful and diligent work has allowed us to maintain high quality air and water sampling programs over the years.

APPENDIX A

Current Projects and Activities in the Greater KNP Area

Benchmark Lakes and Streams* Monitoring (CPS):	Hydrology Weekly Chemical Profiles Benthic Invertebrates Loon Monitoring Fish Populations: Angling permitted and prohibited lakes Species, density and growth characteristics (lakes) Species and trout fry production (streams)
Climate (AES, CPS):	Climate Station
Air and Precipitation Chemistry (AES)	CAPMoN Station
Water (IWD):	Flow Gauges on the Mersey River Water Level Monitoring on Kejimkujik Lake Water Quality Monitoring of Streams, Rivers and Lakes Sulfate Input/Output Budgets Wetland Studies of Pine Marten Bog
Soils (CPS, IWD):	Monitoring in Forest Study Plots Chemistry of Wetland Soils

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* Benchmark Lakes and Streams are: Big Dam Lake, Frozen Ocean Lake, Kejimkujik Lake, Peskowesk Lake, Peskawa Lake, Pebbleogitch Lake, Beaverskin Lake, Cobrielle Lake, Mountain Lake, Peskowesk Brook, Sweeney Brook, Pine Marten Brook, and Luxton Brook

Vegetation (CFS, FC):	Forest Insects and Disease Survey Verification of Rare Plant Status in Zone 1 Areas Forest Study Plots Surveyed Forest Cover Based on Air Photos and Satellite Imagery ARNEWS stations (210 and 211) Nitrogen Cycling Soils and Vegetation White Pine Monitoring
Invertebrates (FC, CPS, DFO):	Daily Monitoring of Light Trap (Spring, Summer and Fall) Gypsy Moth Pheromone Trap Survey Biomonitoring of Invertebrates in Three Lakes Forest Insect and Disease Condition Monitoring
Fish (CPS, DFO, CWS):	Brook Trout Movement (Tagging), Brook Trout Population Status (Creel, Various) Monitoring of Fish Populations at the Medway River Site (to Determine Changes in Salmon Populations Due to Changes in Water Chemistry) Assessment of Fish Populations in Three benchmark Lakes (Cobrielle, Big Dam East and West Lakes) Fish Sampling in Ten Lakes (Food for higher Estuary Birds)
Reptiles (CPS):	Blandings Turtles: Sightings Recorded Marking and Monitoring Nest Protected and Hatchlings Marked Genetic Analysis Ribbon Snake: Sightings Recorded
Birds (CPS, CWS):	Loons and Other Waterbirds: Broods and Nests Common Tern Nest Recorded Christmas Bird Count (Volunteers) Breeding Bird Survey Baseline Characterization of Piscivorous Waterfowl and their Food (Biomonitoring) Assessment of Calcium Levels in Aquatic Invertebrates as Waterfowl Food Black Duck Breeding Pair Survey Study Block Wetland Fertilization Study (in the Tobiatic Wildlife Management area)

Mammals (CPS):	Am. Marten Reintroduction and Annual Track Surveys White-tailed Deer Road Count and Dead Deer Surveys
Archaeology (CPS):	Petroglyph Sites Monitored for Weekly Damage Archaeological Sites Checked Annually
Visitor Use (CPS):	Park Use Statistics Main Campground and Wilderness Campsites Monitored for Impact
General (IWD, CWS, CPS):	Nitrogen Cycling, Soils, Vegetation Effects of Acidity on Productivity; Nutrient and Invertebrates Kejimkujik Basins Study; Modeling and Long-term Monitoring Hydrological, $SO_{4^{-2}}$, and NO_x Modeling
Contaminants (IWD, UW):	Organics in Precipitation Nutrient and Metal Effects on: Algae in Acidified Lakes and Lake Sediments
Climate Change (IWD, AES):	Carbon cycling at Pine Marten Bog Analysis of Long-Term Hydrological and Meteorological Data
Education (CPS):	Interpretation of Acid Rain to Park Visitors Educational Programs at the Park for High School Students

APPENDIX B

Brief History of Events at Kejimkujik National Park

1964	Limnological Reconnaissance Survey
1965	Park Development Begins Climate Station Begins Operation
1966	Stream Flow Monitoring Begins at the Mersey River Water Level Monitoring Begins at Kejimkujik Lake
1967	Kejimkujik National Park Opened
1970-71	Aquatic Resources Inventory (Eutrophication Study)
1971	Biophysical Inventory
1970-75	Resources Inventory
1977	CWS Research Proposal to Study Acid Precipitation
1978	CANSAP (Precipitation Monitoring Station Established) Sampling of Three Lakes and Tributaries Initiated (Beaverskin, Pebblelogitch, and Kejimkujik Lakes) LRTAP Program Initiated
1979	APN (Canadian Air and Precipitation Monitoring Initiated)
1980	Launching of the cooperative LRTAP Program Workshop, Kejimkujik N. P. Baseline Characterization of Beaverskin and Pebblelogitch Catchments Initiated: Forestry Planktonic Primary Production Macrophytes Microbiology Microfossils in the Sediments Macroinvertebrates Fish Amphibians Heavy Metals in the Biota

1981	Formation of the Coordinating Committee Workshop Held
1982	LRTAP Studies Workshop, Halifax
1983	LRTAP Studies Workshop, Halifax APN converted to CAPMoN station
1984	Royal Society of Canada Peer Review ARNEWS Plots Established (outside park boundaries)
1986	LRTAP Studies Workshop, Kejimkujik National Park
1988	Acidification of Organic Waters Symposium, Wolfville, NS
1991	Workshop on Environmental Monitoring and Regional Indicators, Halifax

APPENDIX C

Brief Overview of Information Available in

"Kejimkujik National Park Resource Description and Analysis"

The volume entitled above (Drysdale 1986) synthesizes the resource inventory and numerous other surveys done at the park. It is primarily a management tool used to develop plans for further park development and future research. However, it also make available an abundance of baseline data about the park at low cost, in an accessible, easy-to-use form. The following briefly describes the information available in this volume.

Climate:	Description, Temperatures, Precipitation, Precipitation Chemistry, Visibility, Wind
Water:	Description, Drainage Basins, Thermal relations, Hydrogen Ion, Chemical Characteristics, Productivity, Acid Rain
Bedrock Geology:	Description, Bedrock characteristics, Mineral occurrences, Fossils
Geomorphology:	Description, Glacial history, Glacial land forms
Soils:	Description, Soil Formation, Soil Types, Soil-Vegetation Relationships, Soil-Hydrology Relationships
Vegetation:	Description, Origin of Vegetation Complex, Composition of Flora, Non-vascular Flora, Vegetation Associations, Non-forest Vegetation Associations, Forest Ground Vegetation Associations, Processes of Change, Forestry, Fire History, Storms, Farming, Diseases and Insect Infestations, Pollution Impact, Succession, Significant and Rare Plant Species
Invertebrates:	Description, Evaluation, Species Status, Species of Significance, Terrestrial Species, Aquatic Species

Fish:	Description (including presence/absence in thirty lakes, and historical references), Evaluation
Amphibians:	Description, Evaluation, Species Status, Species of Major Significance
Reptiles:	Description, Evaluation, Species Status, Species of Significance
Avifauna:	Description, Evaluation, Species Status, Species of Significance
Mammals:	Description, Evaluation, Species Status, Species of Significance
Archaeology:	Description, Cultural History Summary, Site Surveys, Petroglyph Research, Evaluation, Site Analysis, Archaeological Site Significance
Past Land Uses:	Description, Agriculture, Meadow Hay, Lumbering, Gold Mining
Present Land Uses:	Description, Recreational Activities, Visitor Use, Visitor Facilities, Recreation Facilities, Regional Setting, Markets, Trends, Types of Use

Appendix D

Acid Precipitation Bibliography:

Kejimkujik Calibrated Catchments Program (Nova Scotia)

on

The Aquatic and Terrestrial Effects of the Long-Range

Transport of Air Pollutants

as of January, 1993

compiled by J. Kerekes

Environment Canada
Canadian Wildlife Service
Bedford Institute of Oceanography
Post Office Box 1006
Dartmouth, Nova Scotia
B2Y 4A2

Entries identified with an asterisk (*) indicate background material prepared before the start of the acid rain program in 1978.

Introduction

This bibliography was compiled based primarily on the holdings of the library of Kejimkujik National Park. Contributors to the Kejimkujik Calibrated Catchments Program on the Aquatic and Terrestrial Effects of Long-Range Transport of Air Pollutants, initiated in 1978, were encouraged continuously to submit three copies of their completed reports or publications to the Superintendent of Kejimkujik National Park. One of these copies is retained in the library of Kejimkujik National Park, the second copy is placed in the library of Parks Canada, Atlantic Region, Halifax and the third copy is held in the library at Parks Canada Headquarters, Ottawa.

In addition to the holdings of the Kejimkujik National Park library, reports and publications known to the author which are related to the Kejimkujik LRTAP studies are included in this bibliography.

Individual abstracts included in the proceedings of the three workshops on the Kejimkujik Calibrated Catchments Program, held in November, 1981, April, 1983 and October, 1986 are also included. Entries for background material prepared before the commencement of the acid rain study in 1978 are identified with asterisks (*).

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APPENDIX E

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as of January, 1993

compiled by C. Drysdale

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