First Regional Workshop on Integrated Transboundary Monitoring, St. Andrews, New Brunswick, 31 May - 2 June, 1988

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INTERNATIONAL AIR QUALITY ADVISORY BOARD

FIRST REGIONAL WORKSHOP ON INTEGRATED TRANSBOUNDARY MONITORING

St. Andrews, New Brunswick
31 May - 2 June 1988

May 1989

International Joint Commission
Commission mixte internationale
The International Joint Commission was set up under the Boundary Waters Treaty of 1909. It provides for the adjustment and settlement of questions involving the rights, obligations, and interests of either country in relation to the other or to the inhabitants of the other along the common frontier. The International Air Quality Advisory Board advises the Commission on air quality issues in the Canada-United States transboundary area and was asked to explore the benefits of integrated monitoring to assess the environmental well-being along the international boundary. The present workshop is one of a series intended to explore the possibility of opportunities for integrated monitoring in the transboundary area from the Atlantic to the Pacific. This workshop examines the current transboundary monitoring activities in the Atlantic region.

The cover of this report represents the atmospheric regions of influence for this area and illustrates the widespread origin of potential influences of the environmental quality of the Atlantic Region.
The International Joint Commission was created under the Boundary Waters Treaty of 1909 to monitor the pollution and conditions of the Great Lakes and to provide a forum for resolving disputes related to the lakes. The Commission includes representatives from Canada and the United States, who work together to ensure the health and well-being of the Great Lakes ecosystem. The Commission monitors water levels, water quality, and other factors that affect the health of the Great Lakes. The Commission also works to resolve disputes that arise between the United States and Canada regarding the Great Lakes.
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Appendix A

(1) Membership of the IJC Expert Group on Monitoring

(2) Terms of Reference, IJC Expert Group on Monitoring

(3) Technical Guidance, IJC Expert Group on Monitoring

Appendix B

List of attendees, and working group associations
Every politician knows the powerful implications of an "idea whose time has come" — charisma and inevitability, as a groundswell of support evolves to cause the idea to be manifested in real systems, institutions, and programs.

For many of us at the International Joint Commission (IJC) dealing with man/environment relationships, the notion of an integrated transboundary monitoring program for the United States and Canada (in their shared border region) seems like such an idea. For the past six years or so, the Commission has been slowly nurturing the evolution of the idea and catalyzing the opportunities to generate the needed support of citizens, groups, institutions, and governments.

As part of its activities, the International Joint Commission sponsored two prior workshops on the subject of transboundary monitoring. The first workshop (Philadelphia, 1984) emphasized concepts and permitted discussion of a full range of appropriate concerns on this challenging topic. The workshop catalyzed consideration of an integrated transboundary monitoring network that Canada and the United States of America might share to mutual advantage.

An offshoot of the workshop in Philadelphia was described in the 37th Report of the International Air Pollution Advisory Board and in the First Progress Report of the renamed International Air Quality Advisory Board. There were descriptions of the elements of a program to gather information to analyze it and to advise the IJC on transboundary monitoring. A central component was an inventory of existing monitoring networks for air, water, land, and biota and characteristics of that inventory for a transboundary region defined as "sites located within 400 kilometres (250 miles) of the U.S.-Canadian border and operational after 1980." A first computer analysis of the inventory has been completed, and the results are easily accessible to interested parties.

Three other program elements then envisaged were: (1) developing methods to integrate monitoring data suitable for reporting to governments and jurisdictions on the state of the environment within the entire transboundary region; (2) recommending needs for new or modified networks which optimize components
of existing networks; and (3) defining — if a new or modified network is desirable — its purpose, structure, size, activities, costs of establishment and maintenance.

The second workshop (Scarborough, 1986), drew together three of the Commission’s boards to focus cooperatively on a specific real case: quantification of the atmospheric loadings of certain toxic chemicals to a watershed of regional scale — the Great Lakes basin. Each of these earlier activities has been an important learning experience and both directly and indirectly gives today’s workshop "a leg up."

Today, in St. Andrews, the International Air Quality Advisory Board holds its first of a planned series of regional workshops on the subject. As you set about you deliberations and discussions, I encourage you to pose questions. I believe that at this stage we should be questioning and formulating hypotheses for testing, especially with respect to the real ecosystems upon which humans depend.

I want to encourage you to undertake what the IJC and the parties to the Great Lakes Water Quality Agreement have pledged to pursue — a systematic and comprehensive ecosystem approach in meeting your subject head-on. From what I have seen and heard of deliberations about transboundary monitoring, we are not yet ready to eliminate any of the possible ecomanagement approaches that have been suggested.

Transboundary monitoring for the United States and Canada far exceeds your present region of focus. Knowing that, I urge you to look outward as you deliberate. Your two host nations will benefit the most from your advice if the record of this proceeding explicitly identifies the pathways to the larger system in which your regional system is embedded. The opportunities and constraints afforded by that larger system define to a considerable extent the practicability of what you will conclude.

A truly systematic approach will entail an accounting of important interrelationships not well "bounded" by the particular region you are now addressing. Partly because of your time constraints here, you might very likely view this geographic region through one "window" with a particular orientation. Such a window is not the only one; there are others. By considering the advantages and the disadvantages of choosing a particular window, you can take measures to compensate for the perceived disadvantages. If your window of observation happens to highlight structural relationships, then you ought to use other windows which might give a clearer view of process relationships.
A comprehensive approach employs a complementary strategy that accounts for timing as well as for location. The strategy cannot be restricted either only to temporal or spatial concerns. Rather the strategy should be dynamic: spatio-temporal.

By choosing a regional scale for problem-solving, you accept that slower process rates of the larger-scale ecosphere will constrain what is locally feasible. At the same time, by choosing a regional scale, you run a risk of overlooking important small scale phenomena that collectively might greatly influence a system and thus miss possible emerging problems affecting the region.

In its most recent report to the IJC, the IAQAB used the idea of "atmospheric region of influence" which combines the residence time of pollutants with the pattern of predominant airflow pathways to receptors of interest. The Commission enthusiastically supports this idea because the spatio-temporal perspective allows a more meaningful bounding of the transboundary region than one obtained by defining the transboundary region as a strip 500 miles wide along the political border of Canada and the U.S.A.

Because ecosystems operate via subsystems, mathematical modelers and theoreticians can examine ecosystem behavior in systematic ways. Only a careful selection of subsets assures that a reader will respect the findings and not consider them capricious (which is the death knell of many models, theories, and advice with respect to ecology). Please assure your readers that your selection of a "manageable" number and type of subsets and their analyses result not from whim, but from a creditable deliberative process.

To assess the "ecosystemic state" of a portion of the transboundary region, subsets selected must comprise an interlinkage of parts whose combination operates to define, restore, and maintain the health of the larger entity. I caution against selecting subsets based only on pet concerns. On a regional scale, the selected subsets should reflect the essence of our interdependent system and should collectively depict the likely role this region plays in the overall Canada/U.S.A. transboundary region.

As to integrated transboundary monitoring, I suggest that the reliable answers to the question, "Do regional approaches have utility?", will come as much from use of the method of science as they do form judgments made in other realms. If you formulate meaningful and testable hypotheses as an integral feature of your anticipated workshops, and pursue answers and analyses methodically (both strategically and tactically), those who implement your advice will have confidence in your work and your findings.
Further, I hope that each successive regional workshop serves to narrow the bank of uncertainty that preceded our testing of our hypotheses about integrated monitoring. That means that some hypotheses should relate to matters testable in the short-term. You have such opportunity in some matters of mass balance and in investigations of atmospheric regions of influence.

But — in looking at the short-term — the need for long-term experimentation, designation of reference (baseline) locales, inter-regional cooperation, sustained integrated transboundary monitoring, etc., cannot be ignored. It is the long-term evaluations that will allow us to measure such things as sustainable progress in restoring and maintaining the chemical, physical, and biological integrity of a Great Lakes basin ecosystem and the health of the transboundary region as an entity.

And now I come to the last of my points: the matter of learning. What justifies the time, trouble, and expense of this workshop is the opportunity it gives your firsthand give-and-take deliberations to produce more than what would be the sum of your individual efforts at sites dispersed around North America.

A workshop (of a series of workshops) is not needed if you individually can produce papers which can be assembled to become a "proceedings." If piecemeal approaches taken in isolation were sufficient, we would not need to assemble here to reason together.

We who need your best efforts in the transboundary region hope that you are excited about the thought that there are important things to learn.

Among the reasons underlying this workshop are: that we do not know the fitting systematic responses to what we and our neighbors have been planning and initiating; that we are not sufficiently in control of the transboundary situations that we are attempting to manage; and that our decisionmaking is not adequately-informed from the standpoint of our ecosystem's abilities to sustain our activities. Realizing these things, we should be here to learn rather than act as if we already know the answers.

In a Congressional Research Service report on strategic issues, any of which parallel our concerns here, Donald N. Michael put it this way: "Not only do we have to become learners, but we have to do this openly 'cause everyone has to become a learner, not just the decision maker, not just the expert, not just the politician or the corporate executive, but everybody. A societal reality... has to be created. If only a few members of the society act this way it won't work: they'll be smashed by those who think that the leadership and the experts ought to know the answers, ought to be able to control things or, alternatively that, even
if the experts and leaders don’t, they ought to. What is critical is to shift from a mode of believing and acting as if we know the answers to a mode where we acknowledge we don’t and that our task is to discover our way into the future, to learn our way."

This seems to me to be the approach we need to achieve the purpose of this workshop: "to focus on how the monitoring data collected in this area have been used and what lessons we have learned that can be applied to the overall evaluation of transboundary monitoring."

Let us be open to experience, take the learner’s role in a continually emerging situation, embrace and learn from error and acknowledge what we don’t know but should know. If we do, then we can justify this regional workshop on integrated transboundary monitoring as part of a necessary series of such workshops.

The resolve you’ve demonstrated to achieve a full set of regional perspectives needs to be well-matched by the yearn to learn.
BACKGROUND

The International Joint Commission (IJC) was created under the Boundary Waters Treaty of 1909 to advise the Governments of Canada and the United States on water issues in the transboundary region. The purview of the IJC has since been extended to air and land issues. The Commission consists of three Canadian and three American Commissioners who act as a single body seeking common solutions.

Under the auspices of the IJC a number of Boards, such as the Great Lakes Water Quality Board, Great Lakes Science Advisory Boards, and the International Air Quality Advisory Board (IAQAB) have been established as a result of specific agreements to assist the Commission in planning and implementing joint programs and recommending solutions to transboundary problems.

Several years ago, following inquiries from the Commissioners about the status of monitoring in the transboundary region, the IAQAB embarked upon a program to understand the strengths and weaknesses of existing multi-media monitoring. More specifically, the program plan included:

- describing the characteristics of existing monitoring networks for air, water, and biota in the transboundary region along the entire length of the U.S.-Canadian border;
- developing methods to integrate monitoring data which could be used to report to governments and jurisdictions on the state of the environment within the entire transboundary region;
- recommending the need for new or modified networks which optimize existing networks; and
- defining, if a new or modified network is desirable, its purpose, size, activities, costs of establishment and maintenance.

The general conceptual framework is depicted as a triangle (see Figure 1). At the bottom of the triangle are the various monitoring media and associated monitoring activities; at the top of the triangle are the data users and decision-makers. In this case, the IAQAB serves to define and promote the requirements of the data users, a top-down approach. The IAQAB, in turn, sponsored the establishment of the Expert Group on Monitoring to provide the alternative, bottom-up approach. More specifically, the Expert Group is charged with advising
the IAQAB on scientific and technical matters pertaining to transboundary monitoring and the programs of the Board and to provide analyses of existing monitoring networks and their databases. The membership of the Expert Group on Monitoring is summarized in Appendix A (1).

In order to evaluate existing networks and to provide recommendations for future monitoring needs, an inventory of existing monitoring projects was required as a starting point.

The 226 projects listed in the inventory have monitoring stations located within 400 km (250 miles) of the U.S.-Canadian border. The original database contained the 184 records compiled by Glantz et al. (1986). In 1987, 42 projects in the Great Lakes region were added to the database, based on information from the Concord Scientific Corporation (1985). The projects encompass environmental studies in the areas of deposition monitoring, air and water quality, forest, soils, and vegetation research, and ecosystem impacts. Each record contains the following information: name of the project, common acronym, program emphasis, monitoring site locations, time period, parameters measured, frequency of sample collection, data storage information, and the name, address, and phone number of the principal contact.

The database was created using a computer spreadsheet program, and is designed for use on IBM-compatible personal computers. Searches can be performed and reports generated which key in on the variables of interest to the investigator. Samples of the way in which this can be accomplished are given in the Inventory User’s Guide (Ballinger et al., 1987). Outputs of the database might include summary statistics on such considerations as the geographic distribution of projects, funding sources, investigators, and sampling protocols. Figures 2 and 3 give examples of the kind of product that can be extracted from the database, using standard desktop computer techniques.

A series of regional workshops is planned, at which local decision makers, program managers, and scientists will be invited to discuss regional pollution and monitoring issues. From information gleaned at these workshops, the Expert Group is to update the inventory and recommend changes to the monitoring programs pertinent to IJC issues. The first workshop was held May 31 - June 2, 1988 at St. Andrews, New Brunswick, for the Maritime Provinces - Maine region. In this region, the St. Croix River has been the focus of considerable environmental activity; its basin spreads across the Canada-U.S. border and constitutes a clear example of the transboundary issues of present interest. Figure 4 shows the geographical location of the basin. Figure 5 gives a more detailed view of the area, showing the lakes, waterways, and major towns. The present document constitutes the proceedings of the St. Andrews workshop.
Subsequent workshops are planned for other parts of the transboundary region. At the time of this writing, the second workshop in the series is planned to be held at Burlington, Vermont, early in 1989.

REFERENCES


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In this respect, the St. Croix River has been the focus of considerable environmental activity. Issues spread across the Canada–U.S. border and constitutes a significant

Figure 1. A schematic representation of the management approach to integrated monitoring, showing the needs at the apex of a triangle, being served by measurement programs aligned along the base. Integration amounts to the organization of the intermediate area.
Figure 2. The distribution of different kinds of monitoring activity in the transboundary region, as derived from the IJC inventory.
Figure 3. The duration of monitoring projects, by category (as shown in Figure 2), derived from the IJC inventory.
Figure 4. A map of the eastern portion of the transboundary region, showing the location of the St. Croix River basin.
Figure 5. The St. Croix River basin, showing lakes, rivers, and major towns. The sampling stations relate to water monitoring activities mentioned later in this report.
The International Joint Commission (IJC) was created to advise the Governments of Canada and the United States on issues pertaining to the air, land, and water environments in the boundary region. Several years ago, the Commissioners of the IJC initiated an effort to understand the strengths and weaknesses of environmental monitoring programs in this region, and to recommend how and where to improve environmental monitoring over the long-term. A very successful workshop was held in 1984 in Philadelphia, entitled, "Toward a Transboundary Monitoring Network"; this started the coherent IJC effort. The next step is to focus on one region of the border, to bring together various viewpoints related to the question of multimedia, integrated monitoring of the environment in this transboundary region.

The viewpoints of interest include those of the people running monitoring networks, those of the people using monitoring data, and those of the various groups in the IJC. The expectation is that there are benefits to be derived both from a better understanding of the strengths and weaknesses of current monitoring efforts and from specific actions such as collocation of research sites and adoption of standardized measurement protocols on both sides of the border.

Thus, the present workshop is being conducted in response to a request by the IJC to provide advice on the broad area of integrated monitoring. The IAQAB has approached this task in a hierarchical manner, visualized in the form of a triangle (previously presented as Figure 1).

At the top are the needs of users (politicians, decisionmakers)

At the bottom is all the monitoring information available from the various environmental compartments.

The middle is where all of the synthesis/analysis is concentrated.

The IAQAB is working from the top of the triangle toward the middle and our Expert Group on Monitoring (the hosts of this meeting) is working from the
bottom toward the middle. It is hoped that your input will help us meet in the middle so that we understand the environment and can use all the monitoring data collected.

To help set the stage and clarify our expectations for this workshop, it appears appropriate to consider the overall purpose of monitoring. In general, the goals of monitoring programs are:

1. to provide a sense of the present state of the ecosystem under consideration,

2. to document changes in that state, by measuring improvement and/or deterioration from the past, and

3. to help identify potential problem areas for the future.

The need to conduct routine monitoring programs is based on an increasing awareness of the complexity of today’s issues (such as climate change) and their technical subtlety (as in the case of toxic chemicals). For studies of such issues, we need a long period of data so that we can interpret and understand the effects we are seeing; problems and issues of concern can have greatly different time and space scales but are interconnected. The molecules of air that we breathe today can be anywhere in the northern hemisphere in two weeks time.

This workshop is "The First Regional Workshop on Integrated Monitoring" conducted under the auspices of the IJC. There is an increasing perception that integrated monitoring is required to understand the issues and problems that are presently confronting us, and that new issues that are likely to arise will amplify the importance of having integrated monitoring.

- For example, Swedish scientists noticed a few years ago that a certain migratory bird population was declining and their data showed that the decline paralleled the increasing levels of toxics in eggs. The evidence seemed clear, but further study showed that the decline was due to drought in the birds' wintering areas in northern Africa. The birds simply were not returning after the winter.

- As another example, there has been considerable concern about water clarity changes in the Great Lakes. We now know that clarity is a function of the phosphorus loading and fish populations. We needed measurements of both to understand the change in the ecosystem. No single set of observations was adequate to point to the offending factor; integrated monitoring was required.
But there is a logistical and financial constraint: we cannot measure everything all the time. In this context, the IJC has set up the Expert Group on Monitoring, with the following terms of reference:

The Expert Group on Monitoring will analyze existing monitoring networks and their databases to develop methods of integration to help jurisdictions describe the state of the environment in the transboundary region. This Group will further look at the need for new or modified networks in moving toward the concept of a Transboundary Integrated Monitoring Network.

The complete Terms of Reference are listed in Appendix A (2). Additional guidance has been given to the Group, as shown in Appendix A (3). This guidance provides specific instructions to the Expert Group on Monitoring to describe the extent of its work. These cover broad multimedia aspects, quality assurance, data archival, dissemination, and analysis.

In the context of the existing monitoring program in the St. Croix River basin, the focus is narrow and primarily on water quality. But the goals of this meeting encompass the entire environment, not just water quality. The desire to focus on "integrated monitoring" imposes a need for more than the narrow perspective of individual specialties or disciplines. As an initial step, this workshop is designed to bring together representatives of the various relevant specialties to address the broader picture of ecosystem measurement as a whole, so that we do not risk solving the problems detected in one medium by transferring them to another.

We must also be concerned with the economy and efficiency of environmental monitoring efforts. Are we spending too much time in one area, and would a different distribution of monitoring activities among the media give a better overall coverage?

Speakers have been selected to provide a broad coverage of the various issues that have arisen in the St. Croix River area. In considering the presentations, speakers were requested to keep four questions in mind:

1. What are the needs for environmental monitoring data and how should the data be used?
2. From the viewpoint of each individual specialty and the issues that are of concern, do the existing monitoring efforts provide adequate information to quantify the environmental quality in the region, to detect problems in environmental quality and/or show trends?

3. Do the networks measure the variables that are necessary to address environmental quality and/or to design remedial strategies? Are the networks sufficiently flexible that they might be used to address future environmental pollutants?

4. What steps (studies or actions, short-term or long-term) could be taken to improve the existing measurement programs?

In this first of a series of regional workshops, we want to address some specific questions with the aid of the expertise that has been assembled. Specific attention will be directed not only to examples of useful, high-quality monitoring in the transboundary region, but also to examples for which the products have not been adequate to answer the questions that have arisen. We want to initiate a dialogue about the whole environment; we want to learn from the lessons of the past.

The intent is for us all to share our experiences of monitoring activities in different media, in the expectation that this will help improve the capabilities for integrated monitoring in the future.
The title refers to the "St. Croix River Agreement." In fact, there is no such agreement, but instead an arrangement between the United States and Canada, concerning the St. Croix River. This arrangement is governed by the Boundary Waters Treaty, signed on January 11, 1909. The treaty was designed to create a framework of principles and institutional mechanisms to bring about the rational management of issues concerning the levels, flows, and quality of water across or along the international boundary. An important underlying concept was the acceptance by both Canada and the U.S. that the interests of the other country cannot be disregarded when deciding on actions concerning shared water resources. The Boundary Waters Treaty has withstood the test of time; it has been amended four times and remains a remarkable piece of legislation.

To help ensure that the important commitments and obligations of the treaty were respected, and that consultation would prevail, the International Joint Commission (IJC) was set up by the treaty. The IJC consists of three Canadian and three U.S. Commissioners. The six Commissioners make up a regional body, one or two steps removed from national interests, in order to seek common and impartial solutions to the problems confronting both countries along their common border. The Commission operates along lines that are not necessarily aligned with the countries' national interests.

The history of the activity concerning the St. Croix River starts with the signing of the Boundary Waters Treaty. Boundary waters are defined as water courses that cross the international boundary, anywhere along its length from east to west. This includes lakes, rivers, waterways, streams, bays, and inlets. The St. Croix is only one of more than 200 water courses that mark the border between Canada and the United States. The Pollution Advisory Board of the St. Croix was instructed by the Commission in 1984 to report on the quality of water in the tidal estuary of the St. Croix. It should be noted here that the focus is not limited to the freshwater parts of the boundary.
The Boundary Waters Treaty establishes that on each side of the boundary each country shall have equal rights to the use of the waters. The boundary waters must be open to both Canadian and U.S. commercial shipping. Any action that will influence the levels or flows requires the approval of the IJC. The treaty also stipulated that waters flowing across the boundary shall not be polluted on either side. The treaty specifies a hierarchy of water uses, with top priority given to domestic use of a watershed, second is sanitary use, followed by navigation, irrigation, and power production. Any differences arising between Canada and the United States are to be presented to the IJC for study and examination. In these cases, the IJC shall make reports that are advisory in nature; these reports do not in themselves carry any authority of law. The IJC is an advisory body.

THE ST. CROIX SITUATION

(a) Water Flow

In the early 1800s, dams were built along the river to help logdriving and to power small mills along the shores. Dams allowed enough natural flow to permit passage to fish, however in 1825 a new dam at Calais essentially blocked all fish passage and destroyed the river as a fish hatchery. At the time the dam was built, there were no regulatory controls that were aimed at dam structure height, water impoundments or any related concerns. However, when the hydroelectric dam at Grand Falls was constructed in the early 1900s, the Boundary Waters Treaty came into play. In 1915, the Board of Control was established, as a committee of the IJC, to oversee the construction and the operation of the dam. Later on, the terms of reference of the Board of Control were extended to include other dams including, on the east branch of the St. Croix, at Forest City, Vanceboro, and Milltown.

The Board of Control was established to advise the IJC on discharge or flow control mechanisms existing or planned for the basin, and on how they should be operated. It is this Board which has had to study the controversy over water levels in some of the storage lakes and to assess the overall management of the limited quantity of water in the basin. Although the Board of Control has the authority to regulate levels and flows, the Board has adopted the policy of letting the owners of dams regulate the reservoir levels. The Board has only provided the supervision necessary to ensure that the Commission's orders are complied with. Minimum and maximum levels are specified for Spednic and East Grand Lakes, minimum flows are specified for Vanceboro dam and Milltown dam. Usually, there is very little difficulty in meeting these requirements. However, dry summers cause low levels and low flows, and this is when problems arise.
The supervision is based upon extensive monitoring of levels of water at, for example, Grand Lakes, Spednic Lake, Grand Falls, and Milltown dams. The monitoring is a cooperative effort, conducted mainly by Georgia Pacific, Environment Canada, the U.S. Geological Survey and the New Brunswick Power Commission. The Board also conducts inspections of all the facilities within its jurisdiction, and reports its findings to the IJC. It also responds to requests from the commissioners to conduct specialized studies, such as the 1975 Spednic Lake regulation study. In 1979, a report was prepared on the discharge controls at Forest City. At the present time, a rule curve developed by Georgia Pacific is being used as a regulatory tool for the St. Croix.

(b) Water pollution

During its early history, and up to the early 1900s, the St. Croix river system was used as a dump for domestic and industrial waste. The building of the St. Croix Paper Company plant in the 1930s certainly accelerated pollution processes. On June 10, 1955, the U.S. Government directed the IJC to study the improved use of conservation and regulation of water in the St. Croix basin. This task was assigned to the International St. Croix Engineering Board in a reference to the IJC. The issues to be addressed at that time were fairly expansive:

1. the feasibility of more hydroelectric power generation,
2. the rehabilitation of the natural fish species,
3. water pollution and its sources, and
4. land management and recreation within the basin.

At that time, the river between Woodland and Calais was badly polluted. The source of the pollution was primarily the St. Croix Paper Company at Milltown, but also contributing was a textile mill at Woodland, now closed, and untreated municipal waste from Woodland, Baring, and Milltown. Wood driving also contributed bark and wood debris. The problems from these sources were those that were perceived in the receiving environment, slime and mold growth along the shores, wood waste disposal, coal wash dumping, chemicals such as dyes, pesticides, and detergents, bacterial contamination, etc. The report that was prepared to conclude the study, in 1955, recommended treatment of the bulk disposal, and regulation of streamflow to maintain a more regular level for the installation of fishways at all dams.

In 1961, the Governments adopted water quality objectives for the St. Croix River. At that time, the focus was limited to pH and dissolved oxygen; these were
the two principal factors then known to be related to a healthy habitat for fish. In 1962, a directive was issued by the IJC to establish a pollution advisory board for the St. Croix River. The responsibilities assigned to this board were to maintain surveillance of water pollution, to encourage the meeting of the water quality guidelines adopted in 1961 through the stimulation of programs and other actions (both government and nongovernment), to advise on the need for new or revised water quality objectives, to cut sources of pollution that threaten water quality in the river, to work with the appropriate agencies (federal, state, provincial, and local) to improve pollution controls, enhance water quality and utilization, and to enforce regulations. It is mostly through the efforts and influence of this board that significant advances have been made in water quality of the St. Croix River, and in providing habitat suitable for return of the fish population.

The Georgia Pacific Corporation, which took over the St. Croix paper Company in 1960, installed primary and secondary treatment systems in the 1970s. The plant has undergone considerable additional upgrading since that time, and now operates in a reasonably dependable fashion. Sewage treatment facilities were installed at Calais, St. Stephen, Woodland, and Milltown, during the 1970s; these have since been upgraded as well. Future upgrading must be expected as environmental controls become more demanding. Upstream fish passages have been installed on all dams of the main east branch; these are constantly being improved.

An important contribution has been made by fish managers on both sides of the border. Special mention should be made of the efforts of the Maine State Government for its annual contributions to the fish stocking program of the St. Croix River. Also, the St. Croix fisheries steering committee should be complimented on their recently published plan. Without the expectations and efforts of these fish managers, it is doubtful that the St. Croix River Pollution Advisory Board would be attaining its present level of success.

The IJC provided the Pollution Advisory Board with new directives in 1985. The Board was asked to undertake specific studies using salmon as an indicator of ecosystem change. The intent was to take a first step in integrated monitoring. The Board was also charged with advising the IJC on the use of other suitable indicators of ecosystem health. There are many benefits to be derived from improved water quality, and the Board is to explore and advise on yet unrealized methods.

The integrated studies conducted in the St. Croix basin have been nurtured by the IJC over many years, and the concept of monitoring integration has been shown to be successful. In the St. Croix basin, the intent of integrated monitoring
is to understand the behavior of this particular ecosystem so that it can be managed in an enlightened way for all users, particularly users from future generations. This requires a continuation of the traditional cooperation that has been experienced in the studies outlined above, and an understanding such as that which forms a background for international accord along the St. Croix River.

On 21 June 1955, the Governments of Canada and the United States of America requested the International Joint Commission (IJC or Commission) to undertake studies of the St. Croix River basin. The intent was to work towards the better use, conservation, and regulation of the St. Croix waters.

On 7 October 1959, the Commission reported to the two governments with recommendations concerning lake levels, pollution abatement, restoration of ecosystems, fish farms, and further study of flow regulation. About two years later, on 30 September 1961, recommendations regarding pollution abatement were approved by the two governments. These included the adoption of specific water quality objectives for the river and authorization for the Commission to maintain continuing surveillance over water quality.

In April 1962, the Commission established the all-member Advisory Board on Control of Water Pollution - St. Croix River. Three years later, the agency now known as the Water Quality Branch, Inland Waters Directorate, Environment Canada, began a monitoring program on the St. Croix River. The sites that were chosen were selected to study water quality; they were selected from among those used earlier to report to the IJC on the performance and feasibility of stations on either side of the river. These stations had previously had a chequered career. From them, those with the longest records on the St. Croix were selected for the DCrowning activity, together with other stations selected on a basis where new activity might be initiated by Environment Canada.

Figure 6 shows the array of sampling sites now operated by the Water Quality Branch in the St. Croix River basin. Figure 7 shows the long-term history of measurement for each of the sites. For some, measurements are available from the early 1950s. Table 1 is a sample of the record that is provided, showing the parameters that are measured at the Milltown location. The list of parameters is aimed at characterizing the physical and chemical properties of river waters in the basin. Eight to twelve samples are taken each year at every site.
The Council on Environmental Policy and St. Croix River Foundation is proud to present its annual report for 1995. This year, we have focused on several key initiatives aimed at improving the health and well-being of the St. Croix River and its surrounding communities.

One of our primary goals is to address the issue of water quality. The St. Croix River is a vital resource for local residents, and we are committed to working with all stakeholders to ensure that its waters remain clean and safe.

Another area of focus has been the development of new programs to promote conservation and sustainable practices. We believe that by working together, we can make a real difference in protecting the St. Croix River for future generations.

We are also proud to announce the launch of our new online resource center, which provides up-to-date information on a wide range of topics related to the St. Croix River. This resource center is available to the public at no cost and is designed to be a one-stop-shop for information on environmental issues.

As always, we would like to extend our deepest gratitude to all of our partners and supporters who have helped make our work possible. Without your support, we would not be able to continue our important work.

We look forward to continuing our efforts in 1996 and beyond, and we invite you to join us in our mission to protect and preserve the St. Croix River for future generations.
A TRANSBORDER MONITORING PROGRAM - RESULTS
Tom Pollock
Monitoring and Surveys Division
Inland Waters Directorate, Environment Canada
Moncton, New Brunswick E1C 8N6

INTRODUCTION

On 10 June 1955, the Governments of Canada and the United States of America requested the International Joint Commission (IJC or Commission) to undertake studies of the St. Croix River basin. The intent was to work towards the better use, conservation, and regulation of the St. Croix waters.

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Figure 6 shows the array of sampling sites now operated by the Water Quality Branch in the St. Croix River basin. Figure 7 shows the long-term history of measurement for each of the sites. For some, measurements are available from the early 1950s. Table 1 is a sample of the record that is provided, showing the parameters that are measured at the Milltown location. The list of parameters is aimed at characterizing the physical and chemical properties of river waters in the basin. Eight to twelve samples are taken each year, at every site.
A general awareness has developed concerning the physical and chemical properties of the river waters. The items measured (as identified in Table 1) include specific conductance, which can be considered in the context of regional data obtained in other programs. Figure 8 shows how the St. Croix River database relates to that for the Maritime Provinces. The specific conductances measured in the upper parts of the St. Croix River appear to be about the same as in many parts of Nova Scotia and some parts of New Brunswick.

The monitoring program involves measurements of many additional indicators of water quality, as listed in Table 1. Figures 9 and 10 illustrate some of the results that have been obtained at Milltown, for sulfate ion concentrations (Figure 9) and magnesium (Figure 10). The consequences of conversion from the sulfate to the kraft pulping process at the paper mill at Milltown are evident in these records.

In conjunction with federal, state, and provincial colleagues, we can now provide a "comprehensive" picture of the dissolved oxygen concentrations in the river at Milltown. Figures 11 and 12 show data for 1975 to 1985 (for the months of July and August, respectively), derived from operation of an automatic water quality monitoring system. These indicate some continuing problems with excursions.

Even though there are frequent excursions in dissolved oxygen that remain a concern, it is evident that since 1980 dissolved oxygen levels have been consistently above the "objective" of 5 ppm.

The Inland Waters Directorate has looked into two hydrologic models for modelling dissolved oxygen, and has concluded that the one-dimensional hydrodynamic (1-DIM) model is preferable to alternative simpler models (e.g. HEC-2 and WATQUAL), because the 1-DIM tends to err on the conservative side for worst case conditions. Figures 13 and 14 show examples, involving the 1-DIM and WATQUAL models and comparing the predictions of each against data obtained along the St. Croix River, between Milltown and Woodland. (The effluent causing the reduction in dissolved oxygen is at Milltown; dissolved oxygen levels decrease as water moves downstream from the injection point.)

Figure 15 emphasizes the conservative nature of the 1-DIM model. Here, predicted values of the dissolved oxygen saturation ratio are plotted against observations from both monitoring and grab-sampling programs. It is evident that the model tends to underestimate the level of dissolved oxygen. Inspection of these data reveals that there is a relationship between the specific conductance, the
water temperature, and the dissolved oxygen level as measured at Milltown. The data can be used to construct a nomogram (Figure 16) to estimate the requirements if specific water quality criteria (particularly concerning dissolved oxygen concentrations) are to be maintained. A note of caution is necessary, however; the relationship expressed by the nomogram assumes that the pulp and paper mill outflows are well under control. This may not always be the case.

CONCLUSIONS

The Boundary Waters Treaty appears to have worked very well in the St. Croix River basin. The list of parameters being measured has served us well so far. It has been possible to follow and quantify changes in the water quality in the lowest 14 km of the St. Croix River. Monitoring is now such that data can be generated on long-term changes in water quality, should this become necessary. To this degree, the network is quite flexible. The locations appear appropriate, even if it is needed to address questions of toxic organic compounds, as are presently becoming increasingly important.

The timeliness of data remains an area where some improvement might well be desired. Some data are now available on a day-by-day basis, as a result of the use of new automatic monitoring equipment. The two federal agencies that are involved have equipped the automatic water quality monitoring station at Milltown and the water level gauge at Baring with a data collection platform so that results can be obtained via satellite, with retransmission on a daily basis. This has resulted in a marked improvement in the timeliness of data. Figure 17 is an example of the data provided by this system.

As monitoring activities evolve, steps should be taken to address all of the causes and consequences of the natural variability that is observed. The monitoring program should define the quality of the river water, and follow its trends with time. It should be flexible enough to address immediate questions. The ability to address future questions will depend on the ability to predict or assess the consequences of changes in processes or flow changes. As well, the monitoring activities might be broadened in scope to address other environmental issues such as acid or toxic rain.

DISCUSSION

Q. Are any properties other than water chemistry monitored, and do you look in compartments other than water?
A. The Water Quality Branch has looked at bottom sediments and macrophytes in the river, but only during one survey. Studies of this kind have been carried out by other agencies, such as the Maine Department of Environmental Protection and Fisheries and Oceans, Canada. The focus at the moment is on the effects of chlorine bleaching on the effluents from pulp and paper mills. Environment Canada is looking at the sediment and biota, including forage fish, and other related indicators of environmental quality.

Q. Are there any problems with metals in the St. Croix River system?

A. The metals we have looked at are aluminum, copper, zinc, and lead. We have also looked at cadmium. In all cases, levels can be somewhat elevated, due to use in industrial processes, however the presence of complexing agents associated with the dissolved organic carbon ensures that biologically available concentrations are kept well within acceptably safe levels.

Q. What about pesticides in the river?

A. More resources would be needed to study pesticides in any detail. There are spray operations in the lower basin, but the past spray surveys have measured no parent compounds in the water column or stream bed sediments.

Q. Is there any estimate of how much of the pollution in the water is due to atmospheric deposition to the river basin? The case of sulfate is an interesting example.

A. It's not an insignificant contribution, approximately 20 kg/ha, which with the average 1 m of runoff would translate to 2 mg/L (ppm) in the stream water.

Q. Do you think that the recent study of nitrate inputs into the Chesapeake might have relevance in the St. Croix River basin?

A. In surface water in the Atlantic Region of Canada, nitrate deposition is at levels that certainly suggest some input from the atmosphere, roughly one half of the sulfate deposition, but water column concentrations of nitrate-nitrogen above Woodland are characteristic of oligotrophic waters.
Q. What uses are being impaired as a result of changes in water quality in the St. Croix River basin?

A. Firstly, we are not meeting the standards recommended by the Fisheries Steering Committee for salmon runs on the river itself, or for shellfish in the estuary. There are recreational expectations that are far beyond present capabilities; for example, there is foaming on the river that inhibits sports fishing. In general, there are several factors that have to be "tuned up" in order for aesthetic expectations to be met. But the problem is not only water pollution. Some of the expectations relate to canoeing, and cottages, for which water quantity is important.

Q. Does the river smell?

A. Not noticeably.

Q. Are any indicator species being measured?

A. Downstream of the pulp and paper mill, workers of the Environmental Protection Department of Maine have measured the benthic community diversity and health. Bacteria levels in the estuary are being monitored for protection of the shellfish industry.

Q. Is there a central organization which looks after such things as QA/QC?

A. Within Environment Canada, such a system exists. The procedures include blind sample testing. The Atlantic Region Laboratory participates in round robins which include laboratories from the northeastern U.S.A. who analyze samples from the Great Lakes.

Q. Are samples transferred across the border for comparison with the United States QA/QC systems?

A. We have never done any split sampling, but coincident sampling has taken place by U.S. and Canadian teams.
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Description</th>
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Figure 6. Sampling sites in the St. Croix River basin, operated by the Water Quality Branch of the Inland Waters Directorate.
Figure 7. Period of record of sampling stations operated by the Water Quality Branch in the St. Croix River basin.
Specific Conductance $\mu$mho/cm

Figure 8. Specific conductances ($\mu$mho/cm) for water quality monitoring sites in the Atlantic Region. The St. Croix area is contained in the box at the lower left of the diagram.
Figure 9. Sulfate concentrations (mg/l) in St. Croix river water, sampled at Milltown. Ranges indicate highest and lowest values recorded. The central line shows the median value, and the extremities of the boxes correspond to the 25 percent and 75 percent quartiles. Data are from Water Quality Branch grab samples.
Figure 10. Magnesium concentrations (mg/l) in St. Croix river water, sampled at Milltown. Data are from Water Quality Branch grab samples.
Figure 11. Minimum, maximum, and mean dissolved oxygen concentrations (mg/l) for the month of July, for the period from 1975 to 1984 (Source: U.S.G.S. published data obtained using an automatic water quality monitoring system at Milltown).
Figure 12. Minimum, maximum, and mean dissolved oxygen concentrations (mg/l) for the month of August, for the period from 1975 to 1984 (Source: U.S.G.S. published data obtained using an automatic water quality monitoring system at Milltown).
Figure 13. Comparisons of model predictions against field observations of dissolved oxygen between Woodland and Milltown on the St. Croix River, for 29 July 1981.
Figure 14. As for Figure 13, but for 22 July 1982.
Figure 15. Predicted values of the dissolved oxygen saturation ratio plotted against observations from both monitoring and grab-sampling programs.
Figure 16. A nomogram to predict dissolved oxygen saturation from specific conductance and water temperature information (based on automatic water quality monitoring data provided by the U.S.G.S., 2209 values).
### SUMMARY OF DAILY AWQM VALUES FOR THE ST. CROIX RIVER AT MILLTOWN

Period from 01-APR-88 to 30-APR-88

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<table>
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<tr>
<th>Day</th>
<th>Dissolved Oxygen mg/l</th>
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<tr>
<td></td>
<td>Min</td>
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<tr>
<td>4-7-88</td>
<td>10.8</td>
<td>11.0</td>
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</table>

Figure 17. An example of the output of automatic water quality data provided using the station at Milltown, with a satellite data retrieval system.
INTRODUCTION

It is often proposed that monitoring is a potentially useful approach to measuring effects of air quality on forest resources. However, development of workable plans has proved quite difficult.

In the U.S., two separate forest monitoring systems are maintained. One is an inventory system which is used to determine periodically the location, quality, and quantity of timber and other forest resources. The second is a reconnaissance system which detects outbreaks of insects and diseases so that authorities can assess potential impacts and design appropriate control strategies. Neither system was designed for detecting effects of air quality and, at present, neither is capable of performing that function.

GENERAL STRESS SYMPTOMS AND CAUSE-EFFECT RELATIONSHIPS

This is not to say that existing forest monitoring systems are of no value in detecting air quality effects. Existing systems can be used to detect general stress symptoms such as foliage loss, growth reduction, etc. (Table 1). West Germany and other nations conduct annual "air pollution damage surveys" which measure the incidence and severity of general stress symptoms.

Table 1.

<table>
<thead>
<tr>
<th>General Stress Symptoms</th>
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<tr>
<td>Foliage amount and color</td>
</tr>
<tr>
<td>Growth Reduction</td>
</tr>
<tr>
<td>Mortality</td>
</tr>
<tr>
<td>Unusual phenology</td>
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<tr>
<td>Tissue damage</td>
</tr>
<tr>
<td>Water or nutrient stress</td>
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</table>
The problem with monitoring general stress symptoms is that such symptoms may be caused by many natural factors as well as by air pollutants (Table 2). Forests, like all plant communities, are constantly changing. Change occurs through natural and man-made disturbance and through the processes of evolution, succession, and biomass accumulation. Frequently, the cause of observed change cannot be determined. German scientists have been investigating episodic mortality of silver fir since the early 1800s but have been unable to identify the principal cause or causes. In North America, severe unexplained diebacks of red spruce in the Adirondacks were reported in the 1800s, a time when regional air pollution was probably not a significant stress factor. Many foresters are aware of the dynamic nature of forest conditions and are skeptical of the value of general stress symptoms as indicators of air quality effects.

### Table 2.

**Possible Causes of Stress Symptoms**

- Age
- Competition
- Drought, flood
- Wind
- Fire
- Pests
- Land use
- Air pollution
- Interactions

How then can we determine whether or not air pollutants are a significant threat to our forests? There appear to be at least three approaches: (1) pollutant gradient studies, (2) dose-response studies, and (3) development of diagnostic indicators of pollutant stress.

**Gradient Studies**

Gradient studies attempt to correlate the occurrence of general stress symptoms with the level of pollution. This kind of study has documented pollutant impacts along well defined gradients near strong point sources such as the smelter at Sudbury. Unfortunately, gradient studies of suspected regional-scale pollution impacts have been less successful. There are several reasons for this. First, the difference in air quality across a perceived gradient is very much less in the regional case; even at the high end of the gradient, the concentration is quite low.
and any effects are likely to be subtle and variable. Second, the pollutant loading at any point along a regional-scale gradient is usually poorly defined due to high spatial variability in deposition rates and the scarcity of air quality monitoring stations in rural areas. Third, there is the problem of distinguishing pollutant effects from effects of the many natural factors which vary along a regional gradient covering tens or hundreds of kilometres; effects of soil, climate, and vegetation are confounded, in a statistical sense, with those of the presumed air pollution gradient. The net result is that regional gradient studies of general stress symptoms could easily fail to detect real pollutant effects or indicate effects where none exist.

DOSE-RESPONSE STUDIES

Dose-response studies involve determining the response of trees species to known pollutant levels in controlled experiments. Potentially harmful levels of pollutant exposure are identified and compared with levels of exposure which are measured in the forest.

Dose-response studies are the most important sources of information for assessments of pollutant effects on forests. Availability of reliable air quality monitoring data for forest regions is essential.

DIAGNOSTIC INDICATORS

A reliable diagnostic method for detecting pollutant stress in tree tissues is not yet available. Such a method would be useful for evaluating the cause of general stress symptoms and for early detection of potential pollutant problems in forests without obvious symptoms.

Research on diagnostic indicators has not received adequate support. Potential indicators can be classified as chemical, structural, or spectral. Potential chemical indicators include element concentrations in tree tissues and the ratios of certain enzymes in foliage involved in detoxifying pollutants. Potential structural indicators include the appearance of cuticular waxes and the frequency of cell mortality in the mesophyll. Spectral indicators are changes in the wavelengths of light reflected from a tissue or canopy and detected by ground-based or airborne instruments.

CONCLUSIONS

Air quality monitoring is essential to the assessment of possible air pollutant impacts in forests. The dose-response approach to assessment is the
state-of-the-art and requires reliable air quality data. Better information about pollutant levels above and within forests is needed.

Monitoring general stress symptoms can be accomplished by routine forest resource inventories and insect/disease surveys. Relating the occurrence of general stress symptoms to position on a presumed regional-scale pollution gradient is problematic. Application of the gradient survey approach to regional pollution questions requires more precise definition of gradients and development of procedures that distinguish pollutant effects from effects of other stresses.

**DISCUSSION**

Q. The problems with spatial gradient studies seem to be severe. Can temporal gradients contribute?

A. It is theoretically possible to identify two adjacent stands of different ages which are very similar in terms of species composition, management history, soil type, and other factors. In such a case, one could use tree ring data or recorded tree diameter measurements to compare the growth rates of the two stands during a particular stage of development, e.g. from 20 to 30 years of age. An air pollutant effect might be indicated if the younger stand grew less than the older stand during the selected developmental stage. The problem, of course, is to demonstrate that the two stands are in fact similar with respect to natural factors and different with respect to pollutant exposure. Lack of historical records is a severe impediment.

Q. Are there any adverse effects of forest management practices on ecosystems?

A. Forest management practices generally have small environmental effects compared to other land use practices. Problems can occur, however, when management practices are not properly applied. For example, failure to mark stream boundaries during pesticide spray operations can lead to impacts on water quality. Potential long-term effects of forest management on soil fertility are also of interest. Several investigations have estimated the nutrient content of harvested biomass and compared it to the nutrient content of the soil. In most cases, total soil reserves appear to be adequate for many centuries. However, some nutrients are tightly bound in minerals and it is not clear what fraction of total soil reserves will be available to trees. Similarly, the amounts of nutrients leached from soils by acid rain are small compared to total soil reserves, but there perhaps could be
long-term effects on available reserves. Intensive long-term studies of acid deposition, nutrient leaching, and soil/biomass nutrient pools will help determine potential effects on soil fertility due to acid rain and timber harvest. This kind of intensive site-specific investigation should be incorporated as a necessary component in forest monitoring plans.

Q. Is long-term monitoring best suited to the needs of the gradient approach or to the requirements of dose-response studies?

A. There is a sizable amount of atmospheric monitoring data already available, but if the gradient method is in mind, then it must be remembered that much improved measurements may be required to provide the necessary spatial resolution. There are vertical as well as horizontal gradients with which we must be concerned. If the dose-response approach is to be used then it must be determined what time resolution is required. There are good arguments that suggest hourly data are needed for some purposes.

Q. Can pathological studies be used to establish past histories of existing stand exposures. For example, chemical analyses of trace elements in tree rings can provide data on deposition in the distant past.

A. There is currently considerable interest in the chemical analysis of tree rings. Some studies near smelters have shown that changes in trace metal emissions may be reflected in the trace metal concentrations of tree rings from near-by forests. At sites remote from point sources, some investigators hypothesize that changes in tree ring chemistry are indicative of accelerated soil acidification due to acid deposition. Further research on this hypothesis is needed.

Q. What about pollen and seed studies?

A. The information provided by pollen studies applies to much longer time scales than those considered in pollution work. Pollen studies do show that dramatic changes in species composition have occurred in many regions over periods of hundreds or thousands of years.

Q. Is there much use of remote-sensing data, such as from satellites?

A. Satellite systems can detect evidence of stress, but the spatial resolution is presently limited and the cause or causes of stress cannot be diagnosed reliably.
Q. Can satellite-based techniques be used in a large-scale way? Remote-sensing methods in general are not standardized.

A. The need for standardization is recognized, but we still have a lot to learn about how to detect and interpret damage. Concerns about standardization in the context of pollution damage assessment are probably premature.
To better understand the adequacy of the monitoring programs on the St. Croix River perhaps a history of the activities on the river would certainly lend itself to an insight to part of our monitoring requirements.

Sawmill activities prevailed on the river into the early part of this century; the most notable were the mills in the vicinity of Baring, Maine. The deposit of organic debris below Baring probably had its origin from the mills. Woodland pulp and paper activities started at the turn of the century. The first mill was a sulfite and groundwood mill. There were no recovery systems for fiber or spent sulfite liquor. The spent liquor consumed large amounts of oxygen and sulfite and groundwood fibers were released to the river probably depositing at the mouth of the Stony Brook area. It was the late sixties, when the kraft process replaced sulfite pulp, before a recovery process was installed. It was the early seventies before primary clarification of the effluent was in place. It was not until later in the seventies that secondary treatment facilities were started and the gigantic task of constructing an 80-acre area consisting of a settling pond, an aeration cell, and a secondary suspended solids settling cell was undertaken. Because it was felt seepage would occur if a secondary lagoon was built at the river, a site was selected a mile away and 200 ft. higher than the mill, which required three 1000 H.P. motors to lift the effluent from the mill site. This system is still in use at present.

The towns and smaller communities had no sewage treatment facilities until the sixties and even now we are discovering areas which are not connected to sewage treatment facilities.

From this brief history we must now look at the adequacy of our monitoring programs and the exchange of monitoring information. First, we must decide what we expect from the river and then plan our monitoring programs as to why the expected cannot be obtained.
When I was first approached about addressing the International Joint Commission (IJC) during this workshop, I was most pleased to accept. When I received a copy of the agenda, my topic was the socio-economic impacts and public response to the improved water quality in the river system. At first glance I thought that I did not know the water quality was that poor to begin with, nor was I aware that it had improved measurably, however upon considering the question there is undoubtedly an improvement in the water quality of the St. Croix Water System.

First, I would like to take this opportunity to briefly mention the history of the St. Croix River and its watershed. The exploitation of the system began in the early 18th century with the establishment of the fishing industry in the estuary and surrounding waters and later the great forests of this area began to be exploited. The towns on both sides of the international border flourished in those early years with fish canneries and many saw mills exporting their products to Europe, the United States, and other parts of the world. Many dams were constructed throughout the watershed to facilitate the movement of saw logs and pulpwood to the mills down river. In fact, approximately 130 years ago a sluice, one mile long, was built on Palfry Brook through a rocky part of its water course. The many boulders in LaCoute Brook were removed by a man with a team of oxen, some blasting powder, and a Spanish winch in the mid-19th century. One hundred years ago there were 42 men and 20 horses employed in forest harvesting on Fifth Lake. This forest harvesting continues to this day but the number of people employed has reduced dramatically. For example, in the mid to late 1800s it was common to have as many as 2,500 employees on the spring log drives. According to the book, in 1948 an international community on the St. Croix River had only 35 employees on the pulp drive. I was interested in this footnote, since I was one of those employees, and if I recall correctly, we were paid $5.00 per day with bunk and board supplied.

The employment opportunities in the forest industry has declined markedly during the past century of so, but the forest industry is still a mighty force in the economy of this area. At the same time our working time has decreased from 60 hours or more per week to 40 hours and sometimes less per week and wages have
increased. This change, resulting in more money and more leisure time has changed the fabric of our living. We spend much more time on leisure activities and this fact is true throughout North America and indeed most of the world, and this has a direct effect on our tourism industry. According to a report by Amulet Consulting Limited, the tourism industry above the St. Croix - Vanceboro line alone, could be worth two million dollars annually. The decline of one industry is somewhat offset by the increase in the other which brings us to the four pertinent questions which I have been requested to address. I will answer question number two first which was, "Based on your understanding, do the existing monitoring efforts provide adequate information to quantify the environmental quality in the region, to detect problems in environmental quality and/or show trends?" The quick answer is, "no," and in all due respect to the International Joint Commission and the St. Croix Waterway Commission, I submit that one definition of "expert" is "someone who is a long way from home." This is true in that the International Joint Commission essentially operates from Ottawa and Washington, and the St. Croix Commission from Boston and Halifax. The other three questions obviously give me some latitude in that they ask about environmental quality not just water quality and environmental quality is certainly a much broader subject.

The major landholder along the St. Croix, to which I must limit my remarks, is Georgia Pacific Corporation, who not only owns many thousands of acres of woodland, but also controls the water flow through their dams along the system. Fortunately Georgia Pacific have proven themselves good corporate citizens in their cooperation with various interest parties. About two years ago, a committee was formed with representatives from the State of Maine and the Province of New Brunswick to look into all of the aspects of the St. Croix watershed. The major recommendation was to form a commission shared by the two jurisdictions to continue these efforts to insure the best usage of the system for industry as well as the public. While this commission has been funded by the State of Maine and the Province of New Brunswick, to my knowledge no members have yet been named. In my opinion the formation of this commission is urgently required. There are any number of problem areas which must be discussed and where cooperation must be sought between the various users of the system so that everyone can benefit from the negotiations. For example, the water flow through the system must be maintained at a minimum level to meet Georgia Pacific's needs, as well as environmental needs, while recreational enthusiasts want high flow of water for canoeing and rafting. How do we make this trade off? Cutting regulations for both big companies and private individuals should be reviewed and recommendations made to standardize cutting practices along the water courses. The change from river driving to truck driving can have serious consequences as well. The building of roads throughout our woodlands can pose a serious silation problem if bridges and culverts are not properly constructed. When I originally spoke of water quality I thought of the old cliché where you start pointing your
finger at everyone else, and if you keep pointing long enough, you end up pointing at yourself.

The Village of McAdam is an excellent example of a pollution problem that has been identified and corrected to a great degree, but much work is still to be done. For over 100 years the Village dumped its sewage into a 1,000 gallon septic tank and then on into our lake, which is part of the St. Croix River system. Can you imagine a 1,000 gallon tank for nearly 3,000 residents and a very large Canadian Pacific Rail industry? Our lake died. Nearly half the lake registered a zero oxygen level and the algae bloom in August was so thick that you could almost walk on it. The smell was indescribable. In 1975 a modern pollution control plant was constructed to handle 250,000 gallons per day. This was a great stride forward, but unfortunately our sewer and sanitary systems were not separated and at times the plant’s intake was 350,000 gallons per day. We have been able, through grants from the federal and provincial governments to separate most of our storm and sanitary systems but the job is still incomplete. I know that other towns and villages have the same problem. Unfortunately the federal government sometime ago stated that funding of municipalities sewage systems would be severely limited and it appears that this source has completely dried up, no pun intended. More recently still, I received a letter from the provincial government stating that no funds were available from the province for our sewage system. Ironically, this week is National Environment Week and we have been requested by the federal Minister of the Environment to urge people everywhere to work to promote sustainable economic and social development that does not jeopardize the natural resources available to future generations. We naturally applaud the sentiment, but deplore the government’s lack of funding to control effluents that are damaging our environment.

Finally, I would like to comment on a couple of problems associated with inland fisheries management. In a paper entitled "Recreational Fishery Potential" by Peter J. Cronin and Pamela D. Seymour, of the New Brunswick Department of Natural Resources, not yet published, the authors identify two problems that they believe have adversely affected the sport fishing potential of the Upper St. Croix River watershed. Again, according to the Amulet study, sport fishing is the mainstay of the outfitters of the region. First is the water drawdown, especially in Spednic Lake and second, the inadvertent introduction of alewives into the system. The first problem has not satisfactorily been resolved and directly concerns Georgia Pacific Corporation who controls the dams on the watershed. Again I must comment that Georgia Pacific has shown good cooperation in recent years and that the summer drawdown has been much less than allowed them under existing IJC regulations. The winter drawdown, however seems to still be a problem. The second problem with the alewife is where a good intention has created a monster. In approximately five years since a new fishway was put in place by N.B. Power,
the alewife migration population has increased from 20,000 per year to approximately two million per year. These fish were able to get into Spednic Lake and some of its watershed lakes, and we fear the possibility of an invasion. These two points in my opinion have been studied to death and we are surely at a point where positive steps must and can be taken to enhance the fishing and tourism potential of the Upper St. Croix River. On this point the remaining three questions posed to me can be answered.

Question No. 1 - What are your needs for environmental monitoring data and how would you or your organization use the data?

We certainly need environmental monitoring data to cover the points raised earlier and others that will arise. The data would be used in negotiating flows in the system, cutting regulations, road building, etc.

Question No. 2 - Do the networks measure the variables that are necessary to address environmental quality and/or to design remedial strategies? Are the networks sufficiently flexible that they might be used to address future environmental pollutants?

While both Maine and New Brunswick have made very positive steps the final results on environmental quality and remedial strategies have not been decided, but I firmly believe the flexibility is there to address these problems and any future problems.

Question No. 3 - What steps (studies or actions, short-term or long-term) could be made to improve the existing measurement programs?

A big question. I strongly support the quick formation of the commission mentioned earlier with representatives from the State of Maine and the Province of New Brunswick. This commission should study and make recommendations for the regulation of all aspects of the situation, bearing in mind the necessity to satisfy, insofar as possible, the requirements of the forest industry, the tourism industry and the public environmental conditions that will enhance the multiple use of the St. Croix waterway.
DISCUSSION

Q. Are there problems with alewife?
A. Alewife effect mainly bass spawning grounds. We must remember that bass fishing is very important - although salmon are the game fish that receive the most attention.

Q. Other than through the activities of the IJC, how are the problems being dealt with? Presumably, the IJC was formed because there were problems that existing systems were not dealing with.
A. There continues to be need for improved coordination among the bodies concerned, and a need for wider attention to the controls and strategies that are employed. I have emphasized that Georgia Pacific is showing cooperation, especially in the area of water flow management and its effects on canoeing. Canoeists in this area are very vocal, and have received most attention as a result. But there is room for greater recognition of the fact that river flow will increase in September, regardless of what management strategies can be imposed.

We might break down the socio-economic issue into its two main branches, social and economic. From the economic perspective, the main concern is common property resources — that is, a resource so large that it is not possible for it to be owned or controlled by any single entity — such as the sea, the land, or the atmosphere. One of the basic flaws underlying an efficient economic system is that anything of value can be privately secured, and thus it can be bartered, traded, sold, and (most importantly of all in this context) it can be protected. The market forces that work well for exploration of resources that have values in terms of scarcity, processing, and distribution, work the opposite way in the use of common property. Unfortunately, the common property resource tend to be viewed as a big open dump for anyone who wants to use it.

To protect the common property resource requires government intervention primarily in four ways: making the use of common property materials more expensive, slowing down materials flow, generating acceptable quantities of residual materials (through recycling etc.), and reducing the degradation of the environment.
The migration population has increased from 20,000 per year to approximately two million per year. These fish are able to get into Spanish Lake and some of its watershed lakes and can face the possibility of an exotic species. Two points in my opinion have been studied in depth and also dealt with in other areas. These include the environmental and economic alternatives. Two questions that can be asked are: "Can special steps be taken to enhance the fishery and increase the fish harvest?"

I also believe that the activities of the New Brunswick and the U.S. Authorities must be coordinated so that each has a beneficial effect on the other. My concern is whether or not the necessary steps are being taken to ensure that the fishery in the St. Croix River can maintain and enhance its status. Are there any other actions that are necessary to address future management strategies? Are the necessary steps being taken to ensure the sustainability of the fishery?

While both Maine and New Brunswick have made very positive moves, the need for environmental quality and remedial strategies have not been eliminated. In order to ensure the feasibility is there to address these problems, what steps are needed?

For Question 5. a. Why is it essential to implement an action plan in the near-term or long-term? Could it be made to improve the existing situation?

I strongly support the quick formation of a commission composed of representatives from the State of Maine and the Province of New Brunswick. This commission should study and make recommendations for the regulation of all aspects of the situation, bearing in mind the necessity to satisfy, as far as possible, the requirements of the forest industry, the tourism industry and the public environmental conditions that will enhance the multiple use of the St. Croix waterway.
SOCIO-ECONOMIC IMPACTS AND PUBLIC RESPONSE TO THE
IMPROVED WATER QUALITY IN THE RIVER SYSTEM - II

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INTRODUCTION

The present intent is to extend some of the remarks made by Mayor Annis, starting with consideration of water quality, and ending with a discussion of socio-economic effects.

Some people consider the socio-economic viewpoint to be a recent development. In fact, the skills involved are not new, although recent developments have been quite rapid. As the recognition of socio-economic factors has increased, industrial activity has been changing and ordinary people have increased their awareness of pollution, and a new expectation of high standards and safety has emerged. The concern about environmental quality and clean-up has been with us for a very long time, as indeed has the practice of dumping industrial residues into inappropriate areas.

We might break down the socio-economic issue into its two main areas: social and economics. From the economic perspective, the main concern is common property resources — that is, a resource so large that it is not possible for it to be owned or controlled by any single entity — such as the sea, the land, or the atmosphere. One of the basic levels underlying an efficient economic system is that anything of value can be privately accrued, and thus it can be bartered, traded, sold, and (most importantly of all in this context) it can be protected. The market forces that work well for exploration of resources that have value, in terms of efficiency, processing, and distribution, work the opposite way in the case of common property. Unfortunately, the common property resources tend to be viewed as a big, open dump for anyone who wants to use it.

To protect the common property resource requires government intervention, primarily in four ways: making the use of common property materials more expensive, slowing down materials flow, generating acceptable quantities of residual materials (through recycling, etc.), and reducing the degradation of the environment.
The social resource, in general, consists of two components. The psycho-social component is a quite elusive "quality-of-life" aspect associated with how people view their associates, community, and their environment. The techno-social aspect is related to the material factors that are in support of the exclusive "quality of life" factors.

The connection between social factors and economic impact is rather hard to identify, possibly because it is necessary to deal with the intersection of two completely different natural systems: the ecological and environmental system on the one hand, and the human system on the other. The matter is complicated because humans respond in different ways at different times and in different circumstances. It is generally acknowledged, however, that the presence of environmental pollution and the degradation of environmental quality creates an anxiety, which tends to increase as we move from global to local effects.

WATER QUALITY

Water quality is possibly the greatest issue in the context of socio-economics: water is fundamental to human life and is probably our most ubiquitous resource. Next to air, it is probably our largest common property resource. It is also important to recognize, however, that water receives and accumulates input from other large common property resources, such as large landscapes (e.g. due to the widespread use of pesticides) and the air (e.g. due to acid rain). The matter of such connections is rather problematic, however, because the socio-economic aspects of water quality are largely perceptual, relying on the three senses of touch, taste and smell. It is very difficult to define, in technical terms, what is meant by acceptable limits related to color, odor, and visual appearance. As an illustrative example, a major city near where I live is split into a north and south side, separated by a river. The northside residents are now receiving southside water, and the northside residents perceive that the water quality is now deficient in terms of taste and smell, even though the technical quality of the water has improved. The northside residents are unhappy because of a difference to which they are not accustomed. Such problems create large difficulties for generating standards, and for passing appropriate legislation. In poorly developed areas, washing and cleansing can be done in the same waters as others are using to dispense wastes.

In France, water quality is unusually high, yet the residents have an especially high per-capita consumption of bottled water; 60 l. per capita per year, versus, 1 l. in the USA.

There is a concept of a graduated perception of water quality, influenced by how the water is used: highest quality is required for drinking, lesser quality for food preparation, cleansing and finally recreation. However, better quality water
might be required for swimming than for fishing, and even within the category of fishing we might wish to divide between commercial and sport fishing. The setting of policy is quite difficult, as a result of this complexity; even human drinking water standards have not been unchanging.

**THE ST. CROIX SYSTEM**

The St. Croix river system covers about 200 km², draining large areas on both sides of the border. The quality of the water has noticeably improved over the last 20 years, particularly in the 12 to 14 km downstream of the Georgia Pacific pulp mill. The improvements have led to several improvements in certification of the water resource, e.g. in the introduction of salmon (which were not previously there) and less fortunately in the introduction of alewife. The river is now used by about 6000 canoeists per year. Moreover, there has been an effect on the operation of water purification systems in Calais and St. Stephens. All such changes have economic consequences. There has been significant planning related to recreational uses of the waterway. The waterways have been designated part of the Canadian heritage river system. As a result, there have been several recent initiatives related to tourism.

These developments have generated a cycle that will take great care to maintain. The clean-up has improved values, but has increased utilization, which threatens to damage the system. By improving water quality, we have initiated a cycle which will lead to further degradation and eventual clean-up.

**SOCIO-ECONOMIC EFFECTS ON THE ENVIRONMENT**

So far we have considered the socio-economic impacts of improved water quality. We should also consider the impacts of socio-economic changes on the river system. Maintaining the cyclical balance requires an appreciation of the carrying capacities; economic, physical, and sociological. The sociological carrying capacity is a function of the amount of use, the group size, the method of travel, and the behavior pattern of the uses. Methods have been developed to help assess what levels of impact will result, in terms of which physical attributes of the resource face specific kinds of insult. Much of this deals with the kinds of experience users are trying to obtain, and with the number of contacts between such users and components of the resource.
From the viewpoint of physical impacts we must consider

soils: physical comparisons done to walking, campsites, chemical change due to dispersal of wastes.

floor: deforestation due to building campfires, shelters, vegetative trampling.

habitat alteration:

water quality degradation: dispersion of pollutants.

CONCLUSIONS

All aspects of the environment should be monitored, but we need to discuss carefully what should be measured. There are three major themes: ground and social observation, surveys, and remote sensing (or indirect observations). In general, it is important that monitoring take into account what is important to people, what are their aspirations, and what are the qualities of the environment that they perceive to be important, and how are these changing with time.

DISCUSSION

Q: What public response has there been to the present monitoring activities?

A: There was not enough time to conduct a telephone survey before this meeting, to answer this sort of question. Instead, we might rely on the experiences of the various state, provincial and local agencies; these suggest that the public response has been good. An overriding problem of all socio-economic studies is that the baseline of hard data is very poor.

Q: What might you monitor to get a quantifiable socio-economic index?

A: The emphasis so far has been on management techniques rather than monitoring methods. Such properties as water quality can be measured, but soil compacting, for example, is very hard to quantify. Even tree harvesting and other indexes of the use of a habitat are very difficult to quantify.
Q: Is the purpose primarily to look at the consequences on the environment of its utilization, or at the effects on this utility of the environment due to its change?

A: It has to be both ways.

Q: Can we explore a bit more what we can monitor? How can we place an economic volume on any environmental modification?

A: In some cases, it is possible to quantify the economic benefit. In concept, we could monitor things like the catch of salmon. This could then be related to the local economy, and we could then quantify the economic benefit of each salmon in terms of a economic resource. For the river system as a whole, perhaps the most appropriate concept is numbers of users, and their view of the improved aesthetics. The environment has become more valuable than just an economic issue, so it seems we will have to deal with perceptions and indices of satisfaction. Then, QA/QC becomes a problem.

Q: The forest industry has moved from clear-cutting to selective cutting. Are there any resource management questions that arise, such as with visual aspects and socio-economics?

A: I know of no studies that have been undertaken that would help provide an answer. However, the fact that we have a 200 m exclusion zone on the banks of rivers is probably a consequence of the desire by canoeists to see natural surroundings as much as possible.

Q: Do you think it is a fundamental idea of the IJC to take steps to provide appropriate socio-economic baseline information?

A: Some sort of survey is required, to document what sort of qualities people want. Related monitoring seems appropriate, such as to record changes in usage and traffic, but this does not lend itself to the development of protective strategies. Socio-economic considerations should be integrated into the whole process.

Q: Are there developing techniques for quantifying psycho-sensual aspects of environmental quality? In general, how advanced are the economic indices?
Q: Is canoeing a recent activity?

A: Canoeing is presently a major use, but we lack baseline data to verify that canoeing usage is increasing.

A: Some of the econometric indices are quite well accepted. Some of the social aspects can now be better qualified than previously, e.g. by Delphic methods. But we are based with changing perceptions of the same environment, based on the social background of the observers.
MONITORING PROGRAMS ASSOCIATED WITH OTHER ENVIRONMENTAL ISSUES IN THE REGION — FORESTRY

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INTRODUCTION

The presentations prepared for this workshop are directed towards answering four questions, as outlined earlier. None of these questions can be answered easily. However, it is in response to these questions that the following discussion will focus on how Canadian programs are monitoring the forest environment, how researchers in the Maritime Provinces are dealing with some specific issues, and how we might be able to do better.

THE ARNEWS PROGRAM

The Canadian forest provides great economic benefit to the country. It is not only Canada's most important renewable natural resource, but is also a major supplier of oxygen without which we cannot exist. It provides for many of the amenities that contribute to the quality of life. The health of the forest is therefore of great concern to the Canadian Forestry Service. This concern was heightened in recent years by reports regarding the change in the health of forests elsewhere in the world, particularly the damage to forests observed in parts of Europe as a possible result of acid rain and/or air pollution.

In recognition of these concerns, in 1984 the Canadian Forestry Service established the Acid Rain National Early Warning System, a national program to detect early signs of acid rain damage to Canada's forests (see Figure 18, showing ARNEWS sites in the Maritime Provinces). Here, the term "acid rain" is used in its loosest sense, to include any type of acid deposition both wet and dry, and air pollutants of any kind, regardless of the source, if they can influence the health of Canada's forests. The effect may be the result of any of these causative factors alone or in combination, which directly or indirectly interfere with the normal development of forests, the production of wood, or with the role of forests in providing a healthy environment.
d. the effect of acid rain on the condition of the various economically important tree species, and

e. changes in the chemical composition of foliage and soil.

The underlying rationale is that, without close monitoring of all relevant factors, the expected, initially subtle, effects of acid rain cannot be isolated and identified.

Monitoring is carried out in a standardized, uniform manner across the country, based on procedures documented in a detailed procedures manual. The ARNEWS Procedures Manual is divided into two main sections. The first section discusses the basic principles and guidelines. The second section presents the procedures to be followed, step by step, on completing one of the ARNEWS forms designed to collect data for one of the parameters to be assessed. Completed forms are coded for computer input, and submitted to a central location where all information relating to the ARNEWS program is handled.

ARNEWS OPERATIONS IN THE MARITIME PROVINCES

There are 17 ARNEWS plots in the Maritimes; most are less than 150 miles from the border and would so be within the transboundary region of interest at this workshop. Each plot satisfies at least some of the plot selection criteria already mentioned but only three of them, plots 210 and 211 in Nova Scotia and plot 201 in New Brunswick are near a genuine acid rain monitoring station.

The plots are 10m x 40m (0.04 ha) in size. They are clearly marked, are surrounded by a substantial buffer zone and are registered with the appropriate provincial forestry authorities. All trees exceeding 10 cm diameter on the plot are tagged, mapped and measured. Most parameters are assessed on plot trees but, because no destructive sampling is allowed on the plot, additional data gathering is necessary on outside trees (such as for increment cores, foliage for chemical analysis, etc). An initial assessment is made in the base year (1984, for the case of all ARNEWS plots in the Maritime Provinces), after which re-examination is conducted at either every year or every five years. Figure 19 shows an example of the distribution of species, for Plot 208, at Goose River, P.E.I.

Measurements are made of a lot of factors that are standard in forestry, including forest pest conditions. In addition, parameters that are — or are perceived to be — indicators of acid rain damage are assessed. These parameters include shoot length; bud condition; foliage color, size, and damage; needle retention; presence of lichens; etc. Some parameters, notably forest pest conditions
through a given season, are assessed more than once. Several visits are required to assess some other parameters reliably, such as the size of the seed crop, the distribution of ground vegetation, and the timing of the general fall discoloration. In the Maritimes each ARNEWS plot is visited a minimum of four times a year. Table 4 shows the work schedule that is presently being followed, the parameters being measured, the ARNEWS form number used and the frequency of assessment for each parameter.

As already mentioned, completed assessment forms are computerized for analysis at both the regional and at the national level. The forms and the computer program have been designed to allow the analysis of interactions among the various components, in an attempt to facilitate the detection of damage associated with acid rain.

In addition to the work on permanent plots, the results of observations for signs of possible acid rain damage are recorded at most of the locations annually where detailed pest condition assessments are made. Special attention is directed to the number of years of needle retention on coniferous species and to foliage discoloration. In 1987, detailed stand assessments were done in the Maritime Provinces at over 440 locations, as shown in Figure 20.

THE MULTIDISCIPLINARY BIRCH STUDY ALONG THE BAY OF FUNDY

The ARNEWS program — the plots and the auxiliary observations combined — is a system designed to detect change from the "normal" that cannot be explained by the standard factors. The purpose is to identify suspect areas, to seek and monitor deviations from the normal, and then if necessary to work with researchers within multidisciplinary teams to determine the cause of the disorders.

Early leaf browning and premature leaf drop of white birch has been observed along the Bay of Fundy annually since 1979, 5 years before the formation of the ARNEWS program. The condition generally occurs along a coastal strip of 1 to 15 km wide and extends inland as far as 30 km, mainly along low lying areas. Discoloration has been severe each year except in 1982, 1986, and 1987. We have established a series of permanent plots in the effected area, and have found — through monitoring — that tree condition is deteriorating.

In only four years, from 1982 to 1986, the percentage of healthy trees has dropped by almost 80 percent, from over 90 percent to less than 15 percent (Table 5). Insects and diseases have been eliminated as the possible cause and we have suggested as early as in 1980 that acid rain, or some other form of air pollution, could be involved. Figure 21 shows the geographical extent of the deterioration that has been observed. Because of the apparent association of the condition with
the famous Fundy fog, we have added acid fog as a possible factor. This factor was added to the list of possible causes in 1984, the year of the birth of the ARNEWS program!

In 1986, a multidisciplinary, interdepartmental, intergovernmental research effort was launched to investigate the factors that could be causing the condition. Among the organizations involved in the 1987 project were the Canadian Forestry Service (both researchers and the FIDS), the New Brunswick Department of Municipal Affairs and Environment, and Environment Canada (the Atmospheric Environment Service, the Conservation and Protection Branch, and Parks Canada). Studies currently underway include intensive investigations of birch along the Bay of Fundy, and routine monitoring of general tree condition, forest pest levels, ozone, rain and fog acidity, nutrient availability in soil (including consideration of acidity levels), corresponding Septoria behaviour, and fertilization.

The fertilization issue relates to the matter of possible remedial action.

MEASUREMENT GUIDELINES

In the initial stages of development of the program, some guidelines were adopted to guide the design of measurement protocols.

1. Since there is a wide range of interest and a corresponding variety of requirements for data, there must be enough flexibility to let individual researchers focus on their own particular efforts, to a point.

2. Since there is only one overriding problem, that of birch deterioration, the various facets of the program, while independent of each other, must be organized to a certain extent. Efforts must be made to keep each other informed on a regular basis.

3. If we are to avoid the need for assumptions and interpolations, common sites must be used. In other words, integrated monitoring plots are required.

4. Finally, it is necessary to refine the conventional notion of air quality monitoring, both at such integrated sites and elsewhere, to monitor the air flowing into the area. There is a corresponding need to work closely with the appropriate air quality monitoring community.

Most success so far has been in the context of the first three of these four points. Measurements made at study plots include the use of fog monitors, ozone monitors, ozone biomonitors, and acid rain collectors, located at fertilization plots, birch deterioration plots, and ARNEWS plots.
A project just underway, potentially of considerable interest in the context of the transboundary region and the IJC, is the North American Sugar Maple Decline Project, involving the border Provinces of Nova Scotia, New Brunswick, Quebec and Ontario and the States of Maine, New York, New Hampshire, Vermont, Michigan, Wisconsin and Massachusetts. Researchers are presently setting up and assessing plots, following strict protocol and quality assurance procedures.

THE NEED FOR INFORMATION EXCHANGE

Chlorotic foliage has been observed on a patch of white spruce trees in a particular area of eastern Nova Scotia (area about 20 ha) since 1985. No need for details here, only to mention that we feel strongly that the condition is not caused by insects, diseases or any of the usual weather-related problems. A possible explanation came to light during an interdisciplinary workshop; the instance provides a good example of the way in which structured but informal meetings among researchers from different disciplines can be invaluable.

The specific meeting in question in this particular case was the Atlantic Region LRTAP (Long Range Transport of Air Pollutants) Monitoring and Effects Working Group Annual Meeting, in late 1987. During this meeting, a representative of the Water Quality Branch of Inland Waters and Lands of Environment Canada showed some maps, admittedly preliminary, related to an invited talk, "Seasonal Dynamics of Major Ions in Streams in Southwestern Nova Scotia." An example of these maps is shown here as Figure 22. A representative of the CFS ARNEWS program was also invited to participate in a session at the same meeting, on integrated monitoring. The forester noted a patch on the stream quality map in the same area as the white spruce concern. The question immediately arises as to whether there is a connection. As yet, no answer has been reached, however the association would not have become apparent had not a suitable forum existed for the necessary interdisciplinary exchange (in this case, the LRTAP Monitoring Working Group in Atlantic Canada). Moreover, it was essential that the forum was sufficiently informal, friendly, and flexible to permit the free exchange of preliminary information, and that researchers with the necessary background were in attendance.

There seems a clear need for a forum of free and informal information exchange that is loose enough to allow specialists in different fields to do their "thing" their way, but at the same time organized enough to make everybody's information available to everybody else.

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CONCLUSIONS

Forestry researchers already have an adequate system of monitoring for change in the health of forests, with a better than fair chance of detecting problems. However, supporting air quality monitoring data are sadly lacking; these data are required to help determine the cause if a problem is detected. More air quality monitoring stations are needed, on both sides of the border, distributed and located in areas where they are really needed to allow meaningful interpretation. The range of air pollutants measured at these stations should be expanded to include those variables known to be related to environmental effects.

Coordinated multidisciplinary research is needed to answer specific problems with good communication, open minds, and without professional jealousies. In particular, there is a strong need for organized, but not over-organized, information exchange forums, such as the Atlantic Region LRTAP Monitoring and Effects Working Group, where people can exchange ideas, and where information and data would be readily available to those needing it.

In closing, a final point should be made. Even if air (and/or water) quality monitoring systems are put in place, to tell us how much of what is in the air or in the water that should not be there, and even if we learn of all the pathways along which the damage occurs, we will not contribute towards saving fish, trees, or buildings unless steps are taken to clean up the environment. Monitoring the situation is important, but it must not be a system which is permitted to exist for its own sake. Monitoring of the environment must be more than documenting our own self-destruction, it must be a step towards solving the problem of pollution.

DISCUSSION

Q: The ARNEWS deposition monitoring activities appear to focus on rain and cloud droplet (and fog) interception. Is snow monitored?

A: Snow is not collected directly. However the consequences of pollutants delivered by snow will be measured in the soil monitoring program.

Q: The finding of effects on forests in the area around the Bay of Fundy raises an interesting question. Would you have detected this problem with the ten sites that are deployed as part of the present early warning system?

A: The answer must be both yes and no. We already had the problem and were already monitoring it previous to 1984 when the ARNEWS system was established. So we did not detect the problem because
of the existence of the ARNEWS plot. But we have detected it as a result of another phase of the program — that of general surveillance — which we have been doing for some fifty years.
<table>
<thead>
<tr>
<th>Month</th>
<th>Procedures</th>
<th>ARNEWS Form</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>June</td>
<td>Pest conditions</td>
<td>8 and 9</td>
<td>annual</td>
</tr>
<tr>
<td></td>
<td>Ground vegetation</td>
<td>6</td>
<td>annual</td>
</tr>
<tr>
<td></td>
<td>Hardwood seed crop</td>
<td>4 (col. 56)</td>
<td>annual</td>
</tr>
<tr>
<td>July</td>
<td>Pest conditions</td>
<td>8 and 9</td>
<td>annual</td>
</tr>
<tr>
<td></td>
<td>Ground vegetation</td>
<td>6</td>
<td>annual</td>
</tr>
<tr>
<td></td>
<td>Hardwood seed crop</td>
<td>4 (col. 56)</td>
<td>annual</td>
</tr>
<tr>
<td>August</td>
<td>Plot tree assessment</td>
<td>4</td>
<td>annual</td>
</tr>
<tr>
<td></td>
<td>Regeneration survey</td>
<td>5</td>
<td>annual</td>
</tr>
<tr>
<td></td>
<td>Ground vegetation</td>
<td>6</td>
<td>annual</td>
</tr>
<tr>
<td></td>
<td>Conifer-tree assessment</td>
<td>7, 13</td>
<td>annual</td>
</tr>
<tr>
<td></td>
<td>Conifer-pest assessment</td>
<td>8, 13</td>
<td>annual</td>
</tr>
<tr>
<td></td>
<td>Hardwood-tree assessment</td>
<td>9, 13</td>
<td>annual</td>
</tr>
<tr>
<td></td>
<td>Hardwood-pest assessment</td>
<td>10, 13</td>
<td>annual</td>
</tr>
<tr>
<td></td>
<td>Hardwood-foliage sample</td>
<td>--, 13</td>
<td>5-year</td>
</tr>
<tr>
<td>September</td>
<td>Pest conditions</td>
<td>8 and 9</td>
<td>annual</td>
</tr>
<tr>
<td></td>
<td>Conifer-foliage sample</td>
<td>--, 13</td>
<td>5-year</td>
</tr>
<tr>
<td></td>
<td>Soil sample</td>
<td>11</td>
<td>5-year</td>
</tr>
<tr>
<td></td>
<td>Increment cores</td>
<td>12, 13</td>
<td>5-year</td>
</tr>
<tr>
<td>Any time</td>
<td>Plot establishment</td>
<td>1</td>
<td>base year</td>
</tr>
<tr>
<td></td>
<td>Plot mapping</td>
<td>2</td>
<td>base year</td>
</tr>
<tr>
<td></td>
<td>Plot tree data</td>
<td>3</td>
<td>5-year</td>
</tr>
</tbody>
</table>
TABLE 5. Change in the condition of white birch along the Bay of Fundy in New Brunswick on 11 permanent plots between 1982 and 1986. Each plot consists of 50 tagged trees.

<table>
<thead>
<tr>
<th>Tree condition class</th>
<th>1982</th>
<th>1986</th>
</tr>
</thead>
<tbody>
<tr>
<td>No dieback</td>
<td>92.9</td>
<td>14.5</td>
</tr>
<tr>
<td>Twig dieback only</td>
<td>1.5</td>
<td>47.3</td>
</tr>
<tr>
<td>Twig and branch dieback</td>
<td>4.7</td>
<td>31.3</td>
</tr>
<tr>
<td>Tree mortality</td>
<td>0.9</td>
<td>6.9</td>
</tr>
</tbody>
</table>
Figure 18. The distribution of stations of the Acid Rain Early Warning System (ARNEWS) in the Maritime Provinces.
Figure 19. The distribution of tree species recorded for ARNEWS plot 208, in Prince Edward Island. Species shown are spruce, aspen, fir, white spruce, wire (grey) birch, and black cherry.
Figure 20. Areas of the Maritime Provinces where detailed forest health assessments (including needle retention and "acid rain symptom" assessments) were carried out in 1987 by the Forest Insect and Disease Survey of the Canadian Forestry Service. Each grid square represents one U.T.M grid (10 km x 10 km).
Figure 21. Areas of deterioration of birch, as detected by an aerial survey of forest browning in 1985, showing areas of severe and light effects.
Figure 22. A map of the distribution of ions in streams in Nova Scotia. Shading indicates areas of high and low acidity; no shading indicates that no measurements are available. The general area of white spruce yellowing (as indicated) corresponds to a spot on all such maps. (With permission from G. Howell, Environment Canada.)
Figure 25: A map of the distribution of ions in glacial ice from Canada. The map highlights areas of high and low ion content and provides information on the geographic variations of ion concentrations.
INTRODUCTION

The Micmac Indian word, Kejimkujik, can be loosely translated as "integrated monitoring of watersheds." More precisely, it means "meeting of the waters." Beginning in 1978 three watersheds in Kejimkujik National Park (Park) in southwestern Nova Scotia were developed into an active study site for the study of acid precipitation with participants from several agencies of numerous disciplines. The study does indeed provide an example of integrated monitoring.

The Kejimkujik Calibrated Lake Catchments Acid Precipitation Program was initiated as an outgrowth of a joint Canadian Wildlife Service (CWS) - Parks Canada investigation of the limnology of lakes of the Park conducted between 1970 and 1972. The Canadian Forestry Service had also cooperated with Parks Canada in completing a biophysical survey of the Park which provided a valuable addition to the background information available for a watershed study. In looking for a site both sensitive to acidification and under the influence of a marine dominated Long Range Transport of Air Pollutants (LRTAP) loading, an ad hoc committee composed of science managers from four Federal agencies met in 1978 to review proposals advanced by CWS for a joint study in cooperation with Parks Canada in Kejimkujik National Park. Because of the location in the highly sensitive region of Nova Scotia, the existence of considerable background information and prospect of long-term assurance of site control under Parks Canada, the decision was made to commit the major Maritimes LRTAP study to the Kejimkujik National Park site.

Preliminary work began in the watersheds and a CANSAP station (Canadian Network for Sampling Precipitation) was installed in 1978. Regular sampling of the streams and lakes commenced in 1979 along with a systematic study of the terrestrial vegetation and soils, and the sampling of fish populations. An APN station (Atmospheric Precipitation Network) was put in operation in June 1979. The study was broadened in 1980 to include various aspects of the biological...
components of the study lakes (e.g. microbiology, phytoplankton, zooplankton, paleolimnology, amphibians and fish).

The research that is conducted is mainly a combination of intensive survey and monitoring activities. Continuous measurements were also made of precipitation, surface waters and routine measurements was also made of the forests and of the lake biota. The current research activities are listed in Table 6.

Communication among the participants was maintained by occasional workshops (1980, 1983, and 1986). The proceedings of these workshops (extended abstracts of the papers presented) were distributed to the participants and other interested parties. A symposium to review the findings of the Kejimkujik studies will be held in October 1988.

Most of the important conclusions obtained in the Kejimkujik basin studies were based on data obtained using simple monitoring methods. Thus, now when the study is changing into a monitoring phase (Table 7) we anticipate that the continuing monitoring will provide sufficient information to quantify certain aspects of environmental quality in the region and to detect problems in environmental quality as they may develop. Biological monitoring is still very weak, but it should evolve and improve as we go along.

We can be confident that a reasonably adequate foundation of integrated monitoring exists in Kejimkujik and we need to encourage other environmental researchers to use the study area for their investigations when possible. To maintain communication among disciplines future workshops on monitoring are needed to allow researchers from different specialties to compare notes and to make rapid use of new data and new findings.
TABLE 6. Kejimkujik Basin LRTAP Studies, ongoing in 1987-88

<table>
<thead>
<tr>
<th>Agency</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atmospheric Environment Service Downsview, Ontario Network</td>
<td>Canadian Air and Precipitation Monitoring (CAPMoN).</td>
</tr>
<tr>
<td>Canadian Forestry Service Maritimes Fredericton, New Brunswick</td>
<td>Terrestrial effects of the long range transport of air pollutants in two catchments of Kejimkujik National Park.</td>
</tr>
<tr>
<td>Canadian Wildlife Service Ottawa, Ontario</td>
<td>Wetland-surface water linkage in Kejimkujik calibrated catchments.</td>
</tr>
<tr>
<td>Canadian Wildlife Service Sackville, New Brunswick</td>
<td>Benthic invertebrate survey of Kejimkujik watersheds.</td>
</tr>
<tr>
<td>Department of Fisheries &amp; Oceans St. Andrews, New Brunswick</td>
<td>Assessment of aquatic bird populations in Kejimkujik National Park.</td>
</tr>
<tr>
<td>Department of Fisheries &amp; Oceans Halifax, Nova Scotia</td>
<td>Monitoring of black ducks on the Kejimkujik-Little River area.</td>
</tr>
<tr>
<td>Inland Water Directorate Moncton, New Brunswick</td>
<td>Monitoring the effects of acid rain on fish populations.</td>
</tr>
<tr>
<td></td>
<td>Ozone levels at Kejimkujik National Park.</td>
</tr>
<tr>
<td></td>
<td>Water quality monitoring at Kejimkujik basins.</td>
</tr>
<tr>
<td></td>
<td>Organic and mineral acidity in brown waters.</td>
</tr>
<tr>
<td>Agency</td>
<td>Title</td>
</tr>
<tr>
<td>---------------------------------------------</td>
<td>-----------------------------------------------------------------------</td>
</tr>
<tr>
<td>Inland Waters Directorate</td>
<td>Water discharge monitoring.</td>
</tr>
<tr>
<td>Dartmouth, Nova Scotia</td>
<td></td>
</tr>
<tr>
<td>Burlington, Ontario</td>
<td>Particulate dynamics (metals), alkalinity regeneration studies in the Kejimkujik watersheds.</td>
</tr>
<tr>
<td>Parks Canada</td>
<td>Aquatic effects of acid precipitation, models and applications.</td>
</tr>
<tr>
<td>Woods Hole, Marine Biological Lab.</td>
<td><em>In situ</em> brook trout egg and fry survival in Kejimkujik National Park Streams.</td>
</tr>
</tbody>
</table>
### TABLE 7. Long Term Integrated Monitoring Activities in Kejimkujik Basins LRTAP Study Beginning in 1988-89.

<table>
<thead>
<tr>
<th>Agency</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atmospheric Environment Service Downsview, Ontario Network</td>
<td>Canadian Air and Precipitation Monitoring (CAPMoN).</td>
</tr>
<tr>
<td>Canadian Forestry Service</td>
<td>Acid Rain National Early Warning System (ARNEWS)</td>
</tr>
<tr>
<td>Canadian Wildlife Service</td>
<td>Black duck breeding pair survey study block.</td>
</tr>
<tr>
<td>Department of Fisheries &amp; Oceans</td>
<td>Monitoring of fish and invertebrate populations (four lakes).</td>
</tr>
<tr>
<td>Inland Water Directorate</td>
<td>Streamflow (Mersey River)</td>
</tr>
<tr>
<td>Parks Canada</td>
<td>Lake level (Kejimkujik)</td>
</tr>
<tr>
<td></td>
<td>Water quality monitoring</td>
</tr>
<tr>
<td></td>
<td>Climate station.</td>
</tr>
<tr>
<td>Table 7</td>
<td>Team Name</td>
</tr>
<tr>
<td>--------</td>
<td>-----------</td>
</tr>
<tr>
<td>Burlington, Ontario</td>
<td>Monitoring of nutrient levels and their impact on water quality.</td>
</tr>
<tr>
<td>Canadian Arctic Wildlife Research Study</td>
<td>Monitoring of wildlife populations and their interaction with the environment.</td>
</tr>
<tr>
<td>Manitoba (CARI)</td>
<td>Monitoring of water discharge and its impact on the ecosystem.</td>
</tr>
<tr>
<td>And Firth National Park, England</td>
<td>Monitoring of water quality and its impact on the local ecosystem.</td>
</tr>
<tr>
<td>Guelph (ARENS)</td>
<td>Monitoring of water quality and its impact on the local ecosystem.</td>
</tr>
<tr>
<td>Western Canada</td>
<td>Monitoring of water quality and its impact on the local ecosystem.</td>
</tr>
<tr>
<td>National Water Research Institute</td>
<td>Monitoring of water quality and its impact on the local ecosystem.</td>
</tr>
<tr>
<td>Environment Canada</td>
<td>Monitoring of water quality and its impact on the local ecosystem.</td>
</tr>
<tr>
<td>Environment Canada</td>
<td>Monitoring of water quality and its impact on the local ecosystem.</td>
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</tr>
<tr>
<td>Environment Canada</td>
<td>Monitoring of water quality and its impact on the local ecosystem.</td>
</tr>
</tbody>
</table>
THE ATMOSPHERIC REGION OF INFLUENCE FOR KEJIMKUJIK, NOVA SCOTIA

Peter W. Summers
Atmospheric Environment Service
Toronto, Ontario

INTRODUCTION

The concept of an "airshed" or "atmospheric region of influence" was first put forward by Summers and Young as an extension to the watershed concept used in hydrology. The analogy is not complete because a watershed is fixed in space by topographical features whereas air is generally free to move without physical constraints. The atmospheric region of influence (ARQI) is unique to each observing site and can only be expressed in statistical probability terms. A full description of how the ARQI is calculated for the Great Lakes basin is given by Summers and Young. A brief description of the technique and some results for Kejimkujik National Park, Nova Scotia are given below.

THE ONE-DAY REGION OF INFLUENCE

Air mass trajectories at a height of 925 mb (approximately 2500 ft. or 800 m above sea-level) are used. This is representative of the flow of the near-surface layer through which human-caused pollutants are mixed. For each of the eight major wind sectors, the end points of the trajectories going back in time for 24 hours from Kejimkujik are plotted. The distances containing 25 percent, 50 percent (the median value) and 75 percent of the end points, as well as the absolute maximum distances, are determined. By joining the distance for each sector Figure 23 is produced which is interpreted as follows: half of the time, air arriving at Kejimkujik originated from within the 50 percent line 24 hours earlier. In some cases the travel distance is short (25 percent of the time it is less than about 400 km) and in some cases long (25 percent of the time it is greater than about 1000 km). The extreme maximum distance travelled is 1840 km from James Bay. The maximum (100 percent line) encloses all cases over the 7-year period analyzed, and this defines the outer limit for the "one-day region of influence." For pollutants that can persist in the atmosphere for only one day or less, then this line represents the closest atmospheric analogy to a watershed.

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DIRECTION OF AIR-MASS ARRIVAL

In terms of the long-term impact of a pollution source within the ARQI, not only is the travel distance (or time) important but also the frequency with which the air arrives from a given sector. Figure 24 shows the frequency with which the air-mass trajectories arrive at Kejimkujik. The most common directions are W and NW, together accounting for more than half (52.5 percent) of the time. In contrast, air masses arrive from the directions NE through S only 19 percent of the time.

EXTENDED REGION OF INFLUENCE (UP TO FIVE DAYS)

Exactly the same procedure as used to produce Figure 23 can be used for any number of days, although beyond five days the accuracy of trajectory calculations has rapidly increasing errors. For simplicity only the median (50 percent) travel distances are shown in Figure 25 for periods of one to five days.

Note that the 5-day travel distance from the NW and N is about double that from the S.

CONCLUSIONS

Although the results presented are for one site, the large-scale meteorological features are such that a very similar pattern would apply around any receptor site chosen in the Maritime Provinces or New England.

The results presented here on travel distance over various time periods are interesting in their own right from a strictly meteorological point of view. However, the practical application in terms of a region of influence for the potential impact of pollutant sources on a given receptor requires, among other things, knowledge of the lifetime of the pollutant in the atmosphere. Whilst we have good information for some pollutants, especially the various sulphur species, much less is known on the lifetimes of others such as nitrogen species and many of the priority toxic chemicals. Thus, in order to more firmly establish the source region of concern for deposition of pollutants in the Maritimes - New England region, more effort is required to establish their lifetimes in the atmosphere.
Figure 23. Lines enclose regions for which the starting points for air arriving at Kejimkujik were located one day earlier, for various percentages of the days considered. The 50 percent (or median) line indicates that half of the time the air originated within this line one day earlier. The 100 percent (maximum) line encloses all cases and therefore defines the outer limit of the "1-day region of influence."
Figure 24. The trajectory wind-rose indicates the frequency with which the air originated in each sector, one day prior to arrival at Kejimkujik.
Figure 25. Lines showing the median location of the air parcel starting points one to five days prior to arrival at Kejimkujik.
REPORTS ON WORKING GROUP DELIBERATIONS:

1. Atmospheric Group

Peter Summers, Chairman

INTRODUCTION

The conclusions reached regarding integrated monitoring sites are similar to those of the Ecosystems Group. The discussion started with consideration of some of the issues that require atmospheric monitoring as input to their resolution. The issues that were identified include (not in order of priority) visibility degradation, effects on forests including mountain fog and low cloud, coastal cloud, ozone and possibly other ambient levels, the acidification of lakes and streams, and the effects of increased wood burning (it appears that wood burning is likely to increase in this region in the future).

Toxic air pollutants constituted a major uncertainty because none of the panelists at this particular workshop knew of any accumulation of toxics in the biosystem in the region of interest, but certainly it is an issue that is on the horizon.

In terms of atmospheric measurements themselves, we discussed the existing networks, the time and space scales influencing the region we are dealing with, and database management.

VISIBILITY DEGRADATION

Visibility is more important in the U.S.A. than in Canada, at least from the regulatory point of view. Degradation of visibility does occur over much of the eastern part of North America and in the transboundary region; it is a problem on both sides of the border. The effects are primarily associated with aesthetics, transportation safety, and the decreased level of operation of optical instruments. The degradation in this region is mainly due to salt particles from the sea and lakes, to sulfate particles associated with long-range transport from distant sources, and to carbonaceous particles. The range of distance scales for the visibility problem is extremely large; emissions from local point sources are associated with local influences on visibility, while large episodes of impaired visibility in the east are associated with continental scale episodes which reach one to two thousand kilometres across.

On the local scale, there is need to monitor compliance with imposed standards. It might well be asked how much of such locally-measured data is being
collected around point sources and could be used, in terms of establishing regional scale background levels by suitably stratifying the data according to meteorological information to distinguish between data that are upwind and downwind of the local source. To the knowledge of the panelists, this kind of stratification is not being done in any systematic way; it may well be worth looking at.

On the semi-continental scale, the desire to look at regional episodes of visibility degradation at integrated monitoring sites was not felt to impose constraints on the selection of sites, since the phenomenon is so large in spatial coverage. For the integrated monitoring sites that are selected with some fairly simple and not too expensive measurement techniques, visibility-related monitoring could be conducted. Automatic cameras might be used to take pictures of distant targets at specific times during the day. Measurements of concentrations of airborne particles in the optically-active size range could also be used.

**FOREST EFFECTS**

For the case of forests there was a recognized need for air quality and meteorological monitoring. It is not practical to make detailed air pollution measurements at every ARNEWS site (Acid Rain National Early Warning System) already in place or being set up in the transboundary region. However, selected sites need to have some additional monitoring in terms of air quality and basic meteorological measurements. Such special sites should be selected to deal with different types of ecosystems on both sides of the border.

**FOG IMPACTS**

Fog monitoring has been under way for four or five years along the east coast. Recognizing that some of these measurement programs could end in the near future, it was felt desirable to pick at least two sites for continuing measurements. It would be best for a site to be on each side of the border; both sites should be in carefully-chosen locations to characterize the changes in fog in terms of its chemistry. Some indication would also be obtained of the gradient along the coast. These main sites would be reference sites for special studies involving more detailed short-term measurements.

At the present time, there are no air measurements supporting the fog measurements. Such measurements are definitely needed. Furthermore, there is a need for air mass trajectory information.
DEPOSITION TO AQUATIC ECOSYSTEMS

The patterns of wet deposition in the region are fairly well defined. When you look at the national, provincial, and state networks there is a fairly good density of stations. At least the wet deposition component into the water systems is well defined. Since the dry deposition component in this region is thought to be rather small, estimated at about 20 percent of the total for sulfur and nitrogen species, then wet deposition is a good surrogate for the impact of the input to the water systems.

TIME AND SPACE SCALES FOR INTEGRATED MONITORING SITES

We had some discussion of the time and space scales of measurements that has a bearing on the selection of where you would put integrated monitoring sites. As pointed out above, the precipitation chemistry patterns are fairly well defined. The air quality and fog chemistry patterns are not adequate at the moment.

The panel did not perceive a need for a large number of fully integrated sites, however a need to resolve time changes taking place over time scales shorter than one day was emphasized.

SITE SELECTION

We felt that there were several factors that need to be considered in the selection of sites. The climatic zones need to be considered; in this regard, coastal zones, of great interest from the forestry perspective, are considerably different from the inland zones like central New Brunswick or central Maine. Using the information on specific ecosystems, selection of sites should be arranged so as to provide an integrated monitoring site in each of the major biomes in the region. Also, exposure to local pollution should be taken into account. If it is known that there is a hot spot where there is already a problem, or a potential problem in the future, due to human-caused pollution, then this might help identify a good site. It is then necessary to have some background sites that are not going to be affected, to provide some reference point to compare.

For integrated monitoring sites the ability to conduct multidisciplinary research is important. Not only is it desirable to have shared facilities, but it is important that other groups are invited to come in and use the sites where there is a program of integrated monitoring. Visiting research teams could come for short-term research projects, instrument developments, etc. The number of fully integrated sites would appear to be about five in this region, from the atmospheric perspective.
THE EXISTING AIR MONITORING SITES

The inventory of monitoring activities lists national monitoring networks on either side of the border, that were in place as of 1985. There may have been one or two additional stations added in recent years, but not many more. Figure 26 indicates that the array that presently exists, showing north of the border the stations of the Canadian CAPMoN monitoring network (Canadian Air and Precipitation Monitoring), and south of the border, the U.S. NADP/NTN network (National Atmospheric Deposition Program/National Trend Network) and the air quality and dry deposition monitoring network that has recently been initiated. The open circles show where only precipitation is being measured. The solid circles indicate stations where there are both precipitation and either daily or weekly air concentration measurements going on. It is immediately evident that even at the national scale, there is a greater density of precipitation monitoring sites than air monitoring sites.

Two other networks conduct daily monitoring in the U.S., they are the MAP3S network operated by the Department of Energy and the UAPS network operated by Electric Power Research Institute (EPRI). These sites are shown in Figure 27. Both of these networks report daily measurements of precipitation and air concentrations.

There is quite a dense coverage of provincial wet deposition networks in Canada, also shown in Figure 27. Newfoundland has about seven stations, Nova Scotia has about five, plus a small network operated by Environment Canada around Halifax. New Brunswick has about seven stations with more now being added, and there is a fifty station network in Quebec, but only those close to the border are shown.

Inspection of Figures 26 and 27 reveals that the wet deposition network is fairly dense in the Atlantic transboundary region. There are far fewer air quality stations. Some of these stations are already multidisciplinary in their approach. Sutton, just north of the border, offers low and high elevation measurements. South of the border, there are several multidisciplinary stations, e.g. Hubbard Brook in New Hampshire, and Whiteface Mountain in New York.

Measurements of fog are rarer. There are five stations up the coast of Maine, extending into Kent Island, New Brunswick. On the Canadian side of the border, there are measurements being made by the Canadian Forest Service, northeast of Saint John, New Brunswick, at a series of sites extending inland to about 30 km from the shore. There is presently no commitment to long-term monitoring in these sites. Even if such a commitment were made, it is not clear whether the sites in question should be operated as fully-integrated monitoring sites.
It was felt by the panel that each might better constitute a second level of monitoring site at which there is continuous monitoring, but not as complex as with the main system.

CONCLUSIONS AND RECOMMENDATIONS

It was the conclusion that there should be a hierarchy of networks. The few most-complicated sites would constitute an integrated monitoring network for multidisciplinary measurement. But there would also be other networks, such as precipitation monitoring networks which measure precipitation chemistry on a much wider-space scale.

Systems for managing the database that would result are already in existence. A first step might be to take steps to introduce data from existing networks into the existing large databases that are relevant. For example, very few of the state network measurements are getting into the ADS database in the United States. In Canada, there is an existing national database; efforts are now taking place to include provincial network data in this database. It was felt important to make sure that provincial and state network data are included in the national databases, on both sides of the border.

Comparisons among network measurement systems and operating protocols were also strongly recommended. Such work is already going on at the agency level and there already sites at which several different networks are running collocated samplers. For example, there are three sites in Canada and three sites in the U.S. where CAPMoN and NADP/NTN networks are being compared.
Figure 26. Location of National Network Monitoring Sites, as identified in the IJC inventory. In Canada, the CAPMoN stations take daily measurements. In the U.S.A., the NADP/NTN and air sampling stations take weekly samples.
Figure 27. Locations of Regional Network Monitoring Sites in the eastern transboundary area. In Canada, most provincial networks take weekly samples. In the U.S.A., the MAP3S and UAPS networks take daily samples. Note that many stations further than 400 km from the border are not shown, e.g. in Quebec.
2. Ecosystem Group

Dave Radloff, Chairman

The first task was to compile a complete list of monitoring activities for the Atlantic transboundary region. The final listing of 55 operations (as listed in Table 8) includes a few overlaps. Moreover, it is likely that many of the activities listed are more appropriately identified as research projects. It should be remembered, however, that these research activities offer the possibility of baseline measurement sites for future monitoring programs.

The discussion led to a recommendation for a three-level approach to monitoring. The three levels represent intensive (research) sites, ecosystem characterization sites, and regional state-of-the-ecosystem sampling sites (which might not be continuously operating sites but an array of locations where similar measurements could be made at different times over a protracted period).

The intensive sites are viewed as specific geographic locations where one would make detailed biological measurements, with closely coupled intensive air chemistry and deposition monitoring. The sites would be operated on a continuing basis, with ongoing activities directed to improving the understanding of ecosystem processes at the sites. Each intensive site would be a focus for broad extensive programs.

Some examples of intensive sites already exist in the region. The Kejimkujic research site is a good example; it has most of the research activities that are envisioned for an intensive site. It also is very probably in a location that one would want to continue for International Joint Commission-type activities (IJC). Howland, Maine is another intensive site, started under the auspices of the U.S. Acid Rain Program and with many of the same characteristics as the Kejimkujic site. The Howland site is in a location that appears suitable for IJC. In addition to these, there are probably a couple of other types of stressed ecosystems in which one might want to locate intensive sites. These include the coastal forests (a rather special type of ecosystem in this region of North America), and the coastal wetlands (salt-water coastal wetlands, or brackish water coastal wetlands).

It is not certain how many potentially sensitive ecosystems can be identified, nor how many intensive sites would be required to address the problems that might arise. However, it is thought that the total number of such sites would not be greater than ten in the Atlantic transboundary region.
Ecosystem characterization sites are sites where rather complete information on the vegetation would be collected, including information on the structure of the vegetation, as well as providing a base for observing plant community dynamics. These would be sites where one could go back periodically to see if there are changes occurring in the vegetation. At these sites, it would probably suffice to have periodic measurements of air chemistry rather than continuously operating stations. These sites might be visited on the order of every five years. Again, it seems likely that about ten such sites would be required to cover the region. However, it is possible that much more would be required.

Regional sampling sites are locations that would be used to actually give some sort of regionwide estimate of state of the terrestrial ecosystems. At these sites, a few very simple measurements of the vegetation would be made, such as periodic measurements of the volume, to provide a measure of growth over time, simple observations of visual characteristics of tree crowns (e.g. foliage coloration), and similar indicators that can be observed rapidly and could have a variety of diagnostic purposes. Sampling at these sites would probably be annually (or maybe less frequently), to yield a regionwide idea of the state of the ecosystem and therefore to detect changes if they occur. The number of sites would likely need to number in the hundreds.

Discussion at this workshop did not address the advisability of using paired stations, with one on either side of the border for a specific ecosystem.

For all sites, there is need to consider the role of bioindicators. The research community tends to view bioindicators with some caution, but generally agrees that they can provide unequaled information on ecosystem effects in some situations. In the present context, it appears that they may be of considerable benefit at regional sites where they might be looked at on an annual basis to see if there are significant changes with time.

The intensive sites would be the focus of a considerable amount of research, to learn everything possible without programmatic constraints limiting the scope of the studies (such as to specific chemicals, in specific circumstances). This would then provide the ability to respond when something unusual, ominous, or away from the expected standard is detected. In essence, this is the key component of an early-warning kind of activity.
TABLE 8. Locations of ongoing monitoring programs addressing issues related to ecology in the Atlantic transboundary region.

1. Howland Maine Intensive Site (NAPAP).
2. NAPAP Wet and Dry Deposition Sites.
3. Hubbard Brook and Mt. Moosilauke, NH (USFS, EPA).
4. Maine DEP (O₃ gradient, SO₂, NOₓ, HC, TSP, visibility).
5. NPS visibility monitoring.
6. Coastal Maine O₃/acid fog (from N.H. to N.B.) (also Sugar Loaf Mt.)
7. EPA and U. of Maine soil and water chemistry (manipulated watersheds).
8. Maine Yankee nuclear power plant.
9. Maine Land Use Regulation Commission air chemistry info for unincorporated areas.
10. Whiteface Mt. air and forest measurements (NAPAP, EPRI).
11. Camels Hump (UVM vegetation monitoring)
12. ARNEWS 17 plots in Maritimes (CFS).
14. CAPMoN wet deposition sites (Canada).
15. New Brunswick wet deposition sites.
17. CFS precipitation monitoring at Fredrickton.
18. Fundy fog/rain chemistry at 7 forest sites (N.B.).
19. Ombotrophic bogs metal concentration (not ongoing, but baseline).
20. Forest floor heavy metals in New England (Fernandez).
21. Canopy leaching (Cronan).
22. Late 1930s fog pH, SO₄, Cl from Cape Cod to Maine.
23. Peatlands vegetation characterization in Maine.
25. USFS (Hornbeck) tree ring work on growth rates.
26. AES Air Pollution Network site at Kejimkujic.
27. National Trends Network (NAPAP).
28. Mountain Cloud Chemistry Program (NAPAP).
29. Spruce trendplots/acid rain symptomatology plots (60 plots throughout northeast - New York, Vermont, New Hampshire).
30. USFS Forest Inventory Analysis plots (includes some insect/disease).
31. Sugar maple decline project (USFS, EPA, CFS).
32. Forest health surveys (USFS - Forest Pest Management in Vermont, Maine) baselines (may be repeated).
33. Insect/disease damage survey (USFS Forest Pest Management).
34. UNH remote sensing research.
TABLE 8 (ctd). Locations of ongoing monitoring programs addressing issues related to ecology in the Atlantic transboundary region.

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<tr>
<td>35</td>
<td>USFS Class I area monitoring (methods development for O₃ monitoring - sensitive species).</td>
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<td>36</td>
<td>Mt. Washington acid fog (Appalachian Mt. Club).</td>
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<td>37</td>
<td>Spruce budworm and gypsy moth monitoring (low population level monitoring).</td>
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<td>38</td>
<td>FWS (State of Maine) and U. of Maine wildlife monitoring.</td>
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<td>39</td>
<td>NE States Clean Air M. particulates network in rural areas.</td>
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<td>40</td>
<td>Spruce-fir photointerpretation throughout NE (to be refloyn by USFS).</td>
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<tr>
<td>41</td>
<td>Timber company continuous forest inventory plots.</td>
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<tr>
<td>42</td>
<td>USDA APHIS pesticide tracking (milk and meat).</td>
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<td>43</td>
<td>Heavy metals in sewage sludge applied to forests (also dioxin into dairy cattle).</td>
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<tr>
<td>45</td>
<td>N.B. pesticides in streams (aerial spray drift).</td>
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<td>46</td>
<td>Population trends (Statistics Canada).</td>
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<tr>
<td>47</td>
<td>Survey of recreational use of St. Croix watershed.</td>
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<td>48</td>
<td>CFS Forest Insect and Disease survey systematic survey.</td>
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<tr>
<td>49</td>
<td>Canadian Inland Waters tracking 15 organics in the air.</td>
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<tr>
<td>50</td>
<td>Weather Services/Coast Guard weather data.</td>
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<tr>
<td>51</td>
<td>A variety of historical soil chemistry studies.</td>
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<td>52</td>
<td>U. of Maine Holt Forest vegetation and wildlife inventory.</td>
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<tr>
<td>53</td>
<td>Carey Arboretum (Institute of Environmental Studies).</td>
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<tr>
<td>54</td>
<td>Maine DEP and LURC measure herbicides (draft, soul, water).</td>
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<td>55</td>
<td>Critical Areas Program (Maine State &quot;planning office&quot;).</td>
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Major efforts on monitoring of water quality are currently active in transboundary areas that include the St. Croix River basin, at the Kejimkujik Research Station in Nova Scotia, and in Atlantic coastal waters. A large number of agencies in Canada and the United States are involved in measurements of variables that range from water pH to bioaccumulation of toxic substances. At least five of the projects are considered long-term and continuous. Needs expressed most often by the working group were for greater accessibility by various user groups to data from multiple sources and more continuous monitoring efforts for toxic organic substances. Many of the working group members were particularly concerned with efficient use of available data for addressing problems as perceived by the public.

Studies and monitoring in the St. Croix River basin have been taking place for nearly 30 years and a great deal of progress has been made in improving the water quality in the St. Croix River. Several members of the working group expressed the opinion that monitoring activities in the basin and the uses of the resulting data provide examples of success that could be followed by other projects.

A great deal of information on monitoring in the St. Croix River basin will appear in the report of the workshop held in September 1987 by the International Joint Commission St. Croix Pollution Advisory Board. This report will contain summaries of presentations and results of discussion groups on waste management, flow management, and fisheries. In the lower portions of the river, government and private groups cooperate to routinely monitor conditions. In the upper portions of the river and its tributaries, much of the attention is focused on treatment of municipal wastes, regulation of water levels for recreational purposes, and control of fish populations for sport fishing.

Members of the working group made several specific recommendations with regard to the St. Croix River basin, which are repeated here without implication of approval or disapproval by the Working Group as a whole. For the lower St. Croix River, it is desirable that hourly data on dissolved oxygen be made available more often than daily, perhaps by satellite data retransmission. A program on monitoring toxic organic compounds needs to be established, both by chemical measurements and use of bioaccumulators. At the present time, more data on fish species are needed for decision making with respect to conflicting priorities of sport fishing. It was also stated that monitoring does not necessarily cover the entire St. Croix River basin, which would obviously be desirable for anticipation of future
problems. Information on construction, dredging, and pesticide spraying should be more readily available.

Some general recommendations apply to the St. Croix River. A complete tabulation of existing monitoring activities and recent surveys is needed. The information needs to be put in a readily accessible database, for use in management decisions, for regulatory purposes, and for research that might anticipate or help explain current problems (e.g. short-term fish kills). For anticipating questions or problems, key stations need to be set up (or continued) for research.

Studies of water quality in lakes and small streams, including those at the Kejimkujik Research Station, have addressed long-term observations of pH, major ions, metals, and inventories of biota. Documentation for some studies appears to be quite extensive. Intensive observations are made in some cases, less frequent sampling in others. Some members of the working group recommended that pristine sites be set up for long-term monitoring. In addition, biomonitoring methods should be investigated and applied where possible. A specific suggestion, one generally applicable to integrated transboundary monitoring, is that an environmental monitoring working group be set up, not limited to any specific organization, to compile and catalog all monitoring activities (federal, provincial, state, industry, university). Also, environmental monitoring workshops should be held every one or two years to assemble and publish current activities. No attempt was made to obtain the endorsement of the entire working group for these recommendations.

Many of the needs expressed above also apply to Atlantic coastal waters. Monitoring of shellfish and water quality has been taking place for many years. New projects are currently being proposed to expand these activities.
In general, it seems that integrated monitoring should address two questions:
(1) "How we can protect the environment for the benefit of future generations?"
and (2) "How will ecosystems respond to various stresses that come along?"
Monitoring should be designed to answer questions about the total load (stress) on
the environment: both what is happening now in a region and what will be coming
in the future. It should also help identify the important pathways, which in
particular, will tell us something about how the stressed system operates.

Figure 28 helps us understand our current monitoring focus versus a possible
focus for integrated monitoring. On a figure that plots the Needs/Goals of the
monitoring against the Problems/Characteristics, we would find that most current
monitoring would be located in the lower left-hand corner. It is short-term either
in focus or design, tending to be reactive, issue specific, sometimes remedial,
measuring limited parameters or processes with very rigorous measurements hoping
to solve a problem. This type of monitoring will always be needed, but a broader
base of monitoring is needed that fills out the plot and moves out to the axes.

It is clear that carefully arranged goals or objectives are needed for any
integrated monitoring system, or else insufficient characteristics may be measured.
It is necessary to focus on why are we monitoring and for whom? One possible
broad objective is to improve, enhance, and maintain the ecosystem as a resource
base. In this context, the resource base could be designed such that one or more
of the following definitions/characteristics is applicable:

- a resource base which provides aesthetically attractive environments to
  support a range of appealing experiences for a variety of aquatic and
  terrestrial recreation activities;

- a resource base which provides a level of environmental quality necessary
  to maintain health populations of aquatic and terrestrial biota;

- a resource base such that social, economic, and environmental variables
  and parameters, as considered necessary to adequately manage the
  resource base are maintained;

- a resource base which would be manipulated in a way to maximize social,
  economic and environmental benefits through appropriate decisionmaking; and
a resource base which can be described so that the public is aware of what's going on, and so that an outreach program to other jurisdictions which need this kind of information is possible.

It is also possible to prepare a concept of how monitoring and research could fit together in an ecosystem concept as shown in Figure 29. Consider a very large ecosystem, or region, that is being influenced and we have a large number of streams, organisms, lakes, etc. that may all be feeding into one system. A number of intensive research sites could be arranged, nested among simpler long-term monitoring sites. Intensive research sites would have measurement activities going on in all media, dealing with all the issues of the ecosystem, trying to understand where possible all the processes, and why things respond the way they respond. These research sites would be selected to be representative of all or a major part of the region, so that the research information can be utilized to understand the rest of the region. The long-term monitoring sites would measure fewer parameters, and would measure them less frequently. Integration requires that the appropriate measurements are made at all sites, just with different intensities. The system must be designed so as to integrate all the information and draw conclusions about the region, or the ecosystem as a whole. This is a concept of integrated monitoring and research that fully defines the system.
Figure 28. The relationship of programmatic needs and goals to perceived problems.
Figure 29. A possible nested-network approach, adapted to the case of a watershed. Solid circles indicate sites where intensive studies are made. Open circles indicate long-term monitoring sites (measuring less intensively, monitoring the same quantities at all locations).
Conclusions of the First IJC Workshop on Integrated Monitoring

Protection of the quality of the environment in which we live has been a social issue for many years. History records many instances in which pollution control measures have been taken to prevent or limit environmental damage. In most instances, the problems were related to an obvious cause, such as emissions from a particular source that were affecting water or air quality in a way that was found to be offensive and/or damaging to the environment. The effects were convincingly related to the cause. Controls could be designed and the environmental benefits predicted with certainty.

As time has progressed, the nature of environmental degradation has changed. To a large extent, in developed countries, the simple and obvious problems have been resolved. An administrative machine has been set up to regulate and control most of the emissions which are known to have severe local consequences, such as the discharge of raw sewage. More recently our attention has turned to the environmental consequences and pollutants with more subtle cause effect relationships and often characterized by large areas and long term damage rather than with the local and immediate issues that led to the existing regulatory machinery. The environmental effects that are of contemporary concern are more "chronic" than the "acute" problems of the past. This is not to say that the effects are any less; indeed the potential damage of extended exposure of the environment to small modifications of the normal values of air and water quality is known to be quite significant. Acid rain, is a good example. It is caused by a variety of pollutants from a number of sources and damage to soil, water, and buildings results from exposure over many years.

It is much more difficult for both the public and for the research community to understand the nature of such complicated problems. We can no longer focus on single pollutants in single media (air, water, soil, etc.). We must focus on interactions among many pollutants, mixing among the various media, and potentially affecting many components of the environment in direct and indirect ways.

Understanding and controlling the problems require very detailed, high quality scientific information. The workshop described here was designed to explore the benefits of integrated monitoring, a concept that is not new but which is becoming increasingly attractive and necessary to cope with the complexities of environmental issues.
Several points were repeatedly made in the papers presented by the speakers, and in the deliberations of the four working groups.

1. The need to integrate many aspects of environmental study was confirmed:
   i) specialists must communicate across disciplinary boundaries. This can be accomplished in specially-organized interdisciplinary workshops;
   ii) whenever appropriate, there is benefit in multidisciplinary laboratories, at which specialists from different disciplines are organized into groups to address problems that cross several specialties; and
   iii) there is an increasing need for transdisciplinary scientists, who are conversant with the details of several specialties and who can therefore provide objective guidance on the way that the overall environmental effects can be studied and on how appropriate models can be assembled.

2. The utility of selecting a few species as suitable indicators of ecosystem health was endorsed, as in the case of salmon studies on the St. Croix River.

3. The general perception was that there are indeed social and economic benefits associated with improved water quality in the St. Croix River basin. However, further work is necessary to quantify these benefits.

4. The wide variety of existing sampling networks should not be interpreted as an indication of redundancy, although some efficiencies might result from streamlining existing activities. In particular, it is clear that we should not try to force all site operations into the same confining mold. Some sites have research as the major objective, whereas others focus on routine monitoring, and many fill in the spectrum that lies between these extremes. The research networks are designed to provide answers to specific scientific questions and to anticipate new problems. These questions relate to our ability to understand the environmental response to pollution stress and especially to our ability to predict the changes that will result if controls or regulations are imposed to limit emissions (or other stress). Integration of these research networks could logically take the form of collocation of different activities and the workshop endorsed such collocation.

On the other hand, it may require some redundancy of efforts to detect spatial differences and time trends of environmental quality. In this case, the integration may take the form of combining similar activities, arranging for uniform procedures and related quality controls and shared databases.
Each working group endorsed the concept of routine measurement stations being supported by a subset of more intensive research sites.

5. The pollution control experience of the St. Croix River points strongly to the benefits of cooperation between governments and industry. In this context, the desired integration may well be a coordination of efforts, so that goals related to the best use of limited environmental resources are clearly identified and appropriate actions are taken in a cost effective manner.

6. No clear answer was given to the general question of how we might best assess the overall environmental and economic value of remedial actions that are taken to protect the environment. This subject is likely to be an issue at other workshops in this series.

7. Underlying many of the discussions was an increasing awareness that the maintenance of a pristine site is not always the environmental goal. The situation in the St. Croix River region provides an excellent example; some of the sporting activities that are now basic to the lifestyle and economic development in the area are the result of management of the river system, rather than of the reversion to a previous natural condition. In particular, the bass fishing is based on an imported species, and the white-water that is a magnet for canoeists in the warm summer months is a consequence of flow control exerted primarily by the paper industry via their control structures. Thus, the local issue has become one of environmental management designed to satisfy the recreational and economic demands of the community rather than environmental protection, or of reverting to a pristine state.

The participants at the first workshop, as reported here, agreed on the utility of integrated monitoring, as an idea "whose time has come." Subsequent workshops, to be conducted in other parts of the transboundary region, will address issues of special importance in each region. On the basis of these regional workshops a set of general conclusions will be drawn. These final conclusions will be presented by the IJC Expert Group on Monitoring in its final report, due to be presented in 1991.

The issue of human health was not addressed at the St. Andrews workshop. This subject will be a topic for the following workshop, tentatively scheduled for Burlington, Vermont, in February 1989.
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APPENDIX A

A (1) Membership of the IJC "Expert Group on Monitoring"

Chairmen: Dr. Tom Brydges
           Atmospheric Environment Service
           4905 Dufferin Street
           Downsview, Ontario, Canada M3H 5T4

Dr. Brydges is a senior member of the Canadian acid rain research community. He conducts research on the environmental effects of air pollution, primarily involving data analysis related to aquatic ecosystems and recently involving integrated research on acid deposition and its effects.

Mr. Bruce Hicks, Director
NOAA/Atmospheric Turbulence and Diffusion Division
P.O. Box 2456
Oak Ridge, Tennessee 37831, U.S.A.

Mr. Hicks leads research programs on atmospheric pollution transport, dispersion, and deposition. These programs involve field and laboratory measurements, and modelling. Mr. Hicks is chairman of the Atmospheric Chemistry Task Group of the U.S. National Acid Precipitation Assessment Program.

Members: Dr. Ken Demerjian, Director
         Atmospheric Sciences Research Center
         State University of New York at Albany
         1400 Washington Avenue
         Albany, NY 12222

The Atmospheric Sciences Research Center is part of the research system of the State University of New York; Dr. Demerjian is the Center director. He is an atmospheric chemist, managing and conducting research on measurement and prediction of atmospheric exposure regimes, involving both field programs and modelling.
Dr. Claire Franklin, Chief
Environmental and Occupational Toxicology Division
Environmental Health Directorate
Health and Welfare Canada
Room 118, Environmental Health Centre
Tunney's Pasture, Ottawa, Ontario,
CANADA K1A OL2

Dr. Franklin is chief of a division that has both research and regulatory responsibilities in the area of toxic chemicals and human health effects. One of the major programs in the division is to assess the risk to health posed by airborne pollution that is subjected to long-range transport and to monitor the influence of abatement programs.

Dr. Ian Morrison
Canadian Forestry Service
Great Lakes Forestry Centre
P.O. Box 490, 1219 Queen St. East
Sault Ste. Marie, Ontario,
CANADA P6A 4J4

Dr. Morrison is a research scientist with the Great Lakes Forestry Centre, where he conducts research within an integrated watershed study, viz. the Turkey Lakes Watershed Study. His own specialty is forest biogeochemistry, with emphasis on forest soils. His work is part of the Canadian program on the Long Range Transport of Air Pollutants. Dr. Morrison is a recent addition to the group, whose appointment has yet to be approved by the IJC.

Dr. David Radloff
Forest Fire and Atmospheric Science Research
U.S.D.A. Forest Service
P.O. Box 96090, RPE-1206
Washington, DC 20090

Dr. Radloff manages field research and modelling programs conducted by the U.S. Forest Service in the general area of the detection and assessment of air pollution effects. He is chairman of the Terrestrial Effects Task Group of the U.S. National Acid Precipitation Assessment Program.
Dr. Peter Summers  
Senior Research Scientist  
Atmospheric Environment Service  
4905 Dufferin Street  
Downsview, Ontario,  
CANADA M3H 5T4

Dr. Summers is a meteorologist with the Canadian Long Range Transport of Air Pollutants research program. His work mainly involves field studies and data analysis, and interpretation, with current emphasis on integration of air quality data with water quality and health effects data.

Dr. Marvin Wesely  
Head, Atmospheric Physics and Chemistry Section, BEM/CER  
Argonne National Laboratory, D-203  
Argonne, Illinois 60439, U.S.A.

Dr. Wesely is a meteorologist specializing in research on atmospheric transport and air-surface exchange. He is closely associated with recent work on dry deposition for the U.S. National Acid Precipitation Assessment Program. He also manages projects on precipitation scavenging, atmospheric numerical modelling, boundary layer meteorology, modelling of aquatic processes, and atmospheric organic chemistry.

Secretary:  
Ms. Barbara Levinson  
Acid Deposition Staff, RD-680  
U.S. EPA  
Washington, DC 20460, U.S.A.

Ms. Levinson is the EPA representative to the Task Groups on Atmospheric Chemistry, Materials Effects, and Deposition and Air Chemistry Monitoring of the U.S. National Acid Precipitation Assessment Program.
APPENDIX A (continued)

A (2) Terms of Reference of the IJC Expert Group on Monitoring

1. Duties and Responsibilities

(i) The Expert Group on Monitoring (hereafter referred to as the Group) shall advise the International Air Quality Advisory Board (hereafter referred to as the Board) on scientific and technical matters pertaining to transboundary monitoring and the programs of the Board to provide analyses of existing monitoring networks and their databases and specifically to:

(a) Develop methods to integrate monitoring data which could be used to report to governments and jurisdictions on the state of the environment within the entire transboundary region.

(b) Recommend the need for new or modified networks which optimize components of existing networks.

(c) Define, if a new or modified network is desirable, its purpose, structure, size, activities, costs of establishment and maintenance.

(ii) The Group shall prepare, in loose consultation with the Board, a workplan during its first 120 days and present it to the Board for approval. The Group shall keep the Board informed of any changes in the workplan, and any developments, actual or anticipated, which are likely to impede or otherwise affect the carrying out of the Group’s responsibilities.

(iii) The Group shall undertake such studies as may be necessary or appropriate to advising the Board.

(iv) To the extent possible and relevant, the Group shall make maximum use of available resources, information and technical data from the agencies of Canada and the United States, as well as from other sources.
2. Membership and Reporting

(i) The Expert Group on Monitoring shall consist of an equal number of members from the United States and Canada that are appointed by the Board with the approval of the commission. All members serve the Commission in their personal and professional capacity rather than as representatives of their agencies or employers interests.

(ii) The Group will have co-chairmen appointed by the Board, one from the United States and one from Canada. The Chairmen of the Group and of the Board shall be responsible for maintaining adequate liaison between the Group and the Board. The Chairmen of the Group may attend Board meetings.

(iii) In the interest of maintaining close liaison between the Group and the Board, a formal mechanism for reporting will be contained in the workplan.

(iv) Reports to the Board and other Groups, records and documents remain privileged between the Group and the Board.

(v) If, in the opinion of the Group, there is a lack of clarity or precision in any instruction, directive, work assignment or authorization received from the Board, the matter shall be referred promptly for appropriate action. The Board may amend its instructions or issue new instructions to the Group at any time.
APPENDIX A (continued)

A (3) Technical Guidance for the IJC Expert Group on Monitoring

The following guidance has been provided by the Board, in addition to the statements on Duties and Responsibilities of the Expert Group on Monitoring (hereafter "the Group") which appear as Appendix A (2) of this document.

1. The Board* takes a broad view in its initial consideration of ongoing or proposed monitoring programs to watch the environment using in-situ instrumentation, sample collections, surveys, etc. This document suggests bounds to the Group's recommended monitoring efforts. Arguments by the Group for greater stringency or relaxation will be resolved jointly by the Group and the Board as they arise.

2. The purpose of the Group's report is to advise the Board and the Commission on how existing or future resources can be most efficiently used to describe the current state of the environment and to suggest what new efforts are needed for the same purpose. The geographical area covered by the ongoing and proposed monitoring efforts include the regions within about 400 kilometres of the Canada-United States border. The dimensions of this area are subject to change. One may assume that suggested monitoring will continue for at least a decade into the future unless there are reasons for earlier cessation.

3. The Board suggests that the Group consider two or more categories of recommendations for monitoring. Monitoring ideas which might be considered somewhat remote in time because of technical limitations, high cost, or uncertainties of need should be placed in one category. In the second category will be those for which relatively immediate implementation and improvement of existing monitoring networks (in terms of protocol, numbers of stations, etc.) should be sought. Within each category, each project should be ranked in terms of cost and technical feasibility.

4. There should be a reason for each set of measurements. However, even if a quantity might have a potential but currently unknown or uncertain impact—if that likelihood is reasonable in the opinion of the Group—it may be included in the second (more remote) category of recommendations. Effects research necessary to decide whether a monitoring program is needed should not be recommended.

* The International Air Quality Advisory Board of the IJC.
APPENDIX B

LIST OF ATTENDEES, AND WORKING GROUP ASSOCIATIONS

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A: Air (P. Summers, Chairman)
E: Ecology/Vegetation (D. Radloff, Chairman)
M: Management (G. Foley, J. Young, Co-chairmen)
U: Unassigned
W: Water (M. Wesely, Chairman)

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