Towards an Integrated Approach to the Conservation and Sustainable Use of Biodiversity: Lessons Learned from the Rideau River Biodiversity Project

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Abstract

In the quest to conserve global biological resources there has been a growing recognition that conventional scientific methods and institutional arrangements are not always effective in dealing with the biophysical complexities and sociopolitical dimensions of biodiversity issues. Meeting these challenges requires an integrated approach that combines scientific methods with societal values. Community-based research promotes social change, by building the capacity of communities to find collective and culturally appropriate ways to achieve sustainable development on their own terms. Ecosystem management recognizes the interconnectedness of social and ecological systems and attempts to link science, policy and societal goals through interdisciplinary research and multistakeholder decision-making. In 1998, the Canadian Museum of Nature in Ottawa, Canada, in partnership with government agencies, educational institutions and community groups began a three-year multidisciplinary study of the ecosystem health of the Rideau River in eastern Ontario, Canada. This paper presents the Rideau River Biodiversity Project as a case study in the application of an integrated approach to assess the biodiversity of an aquatic ecosystem. Ultimately, we present a framework for an integrated approach to the conservation and sustainable use of biodiversity that combines the strengths of community-based research and ecosystem management through a process of social learning and transdisciplinary inquiry.

Keywords: *biodiversity, monitoring, community-based research, ecosystem management, local knowledge, multi-stakeholder, public awareness*

Introduction

Biodiversity is decreasing at an alarming rate due to the impact of the increasing human population, rising natural resource consumption rates and inequity in the ownership, management and flow of benefits from both the conservation and use of biological resources (McNeely et al. 1995). In the quest to conserve global biological resources there has been a growing recognition that conventional scientific methods and institutional arrangements are not always effective in dealing with the biophysical complexities and sociopolitical dimensions of biodiversity issues (IREE 1995; Machlis et al. 1997; Redclift 1994). Increasingly, research questions require an integrated approach that incorporates the values and preferences of groups that have traditionally been left out of the scientific and technological system (Gibbons et al. 1994).

Recognition of the world-wide impact of declining biological resources prompted the global community to negotiate, in 1992, the United Nations Convention on Biological Diversity (UNEP 1994). The Convention recognized the importance of involving local communities in the development and implementation of remedial action in areas of degraded biodiversity (Article 10-c) and the need for more public education and awareness with respect to conservation and sustainable use of biological resources (Article 13-a, b). The Convention also established the need to identify and monitor the components of biodiversity (Article 7-a, b), and to develop an integrated approach to the management of biological resources (Articles 6-b and 10-e) (UNEP 1994).

In response to the directives of the Convention, scientists, governments and communities have focused their attention on developing integrated approaches to deal with the deepening biodiversity crisis. To date, the combined strengths of community-based research and ecosystem management offer the most hope to achieve this purpose. The goal of community-based research is to build the capacity of communities to find collective and culturally appropriate ways to achieve sustainable development (Johnson 1992; Scoones and Thompson 1994). Ecosystem management focuses on understanding the interconnectedness of social and ecological systems in order to link science, policy and societal goals

for the management of biological resources (IREE 1996; Machlis et al. 1997).

Despite its conceptual appeal, the implementation of an integrated approach faces a number of methodological and practical problems. For instance, how can scientific disciplines with different discourses and diverse methodologies be successfully integrated? How can ecosystem health be measured? How can the public be effectively represented and engaged in a participatory process? Finally, how do integrated approaches to the conservation and sustainable use of biodiversity fit with existing institutional arrangements?

In 1998, the Canadian Museum of Nature (CMN) in Ottawa, Canada, in partnership with government agencies, educational institutions and community groups, began a three-year multidisciplinary study of the biodiversity of the Rideau River in eastern Ontario (Figure 1). The goal of the Rideau River Biodiversity Project (RRBP) was to assess the biodiversity in the river from Smiths Falls to Ottawa (about 100 km), and to work with local communities to ensure the long-term conservation and sustainable use of the river's biological resources (Poulin 2001). The RRBP integrated different scientific disciplines, community concerns, local knowledge, education and public awareness about biodiversity. Thus, it combined elements of both community-based research and ecosystem management to address biodiversity issues.

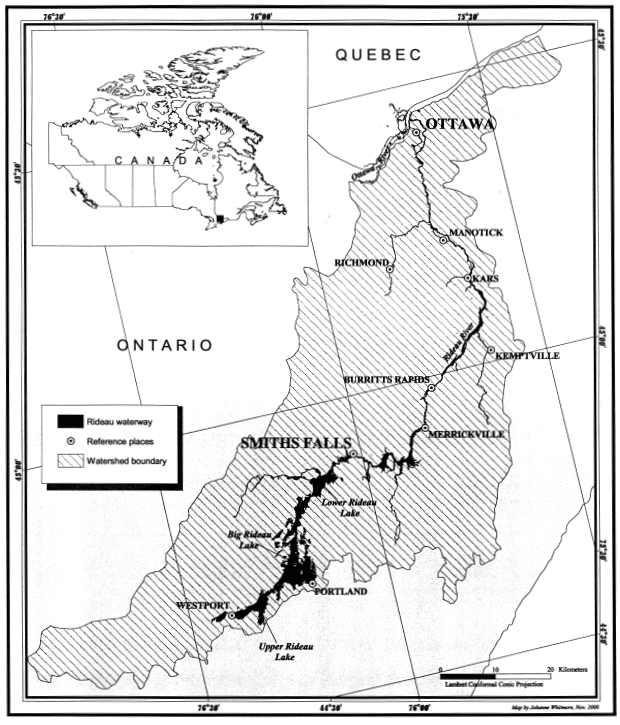

Figure 1. Map location of the Rideau River watershed in eastern Ontario, Canada.

This paper presents the RRBP as a case study in the application of an integrated approach to assess the biodiversity of a freshwater aquatic ecosystem. The authors consist of one social scientist, one natural scientist and one museum manager who are interested in breaking down disciplinary and institutional barriers to address biodiversity issues. The paper is a reflection of our thoughts and experiences as members of the project team.[3] In addition to our observations, semi-structured interviews were conducted with Museum scientists and community participants to gain a broader perspective of the lessons learned. The goal of the paper is twofold: (1) to highlight the lessons learned from the project and (2) to propose a framework for an integrated approach to the conservation and sustainable use of biological resources.

Community-Based Research

Over the past two decades community-based or participatory action research has emerged, particularly in developing countries, and among North American indigenous peoples (e.g., Couto 1987; Gaventa 1988; Johnson 1992; Scoones and Thompson 1994; Slim and Thompson 1993). Community-based research has its origins in community development and adult education. It arose in reaction to the dominant and elitist methodology of social science research which focused on theoretical constructs as the basis for field research (Anyanwu 1988). While models of community-based research vary according to the community and the issue, the basic principle is the involvement in the entire research process of the people who are the intended beneficiaries of the research. Through their direct participation in research design, data collection and project development, projects are adapted to local needs and values (Anyanwu 1988; Johnson and Ruttan 1993; McTaggart 1997; Ryan and Robinson 1991, 1996). Community-based research is often more time consuming and costly than traditional methods because of the additional effort required to involve people throughout the process and, in some cases, to provide specific training to build community capacity. However, without local participation and support, many conservation and sustainable use efforts fail (Wells 1995; Zazueta 1995).

Ecosystem Management

Parallel to the development of community-based research in the social sciences has been the emergence of ecosystem management approaches within the environmental sciences (Grumbine 1994; Machlis et al. 1997; Slocombe 1993). The roots of ecosystem management are ultimately in ecology and systems thinking. Ecosystem management has no single, universally accepted definition. However, consen-

sus is developing on the basic principles and the major challenges facing practical applications which are discussed below.

Ecosystem Health. Ecosystem health is a term used to describe desired or ideal states of the environment (CCME 1996). Ecosystem health goals, objectives and indicators are valuable tools to guide ecosystem management by integrating the biophysical and social sciences with human values (Ehrenfeld 1992; Gaudet et al. 1997; Nielsen 1999; Rapport 1998b). Thus, whether an ecosystem is healthy or not becomes a social judgment as well as a scientific one. However, there is no simple way to define or measure ecosystem health and this has been a major criticism of the concept (Callicott 1992; CCME 1996; Ehrenfeld 1992; Gaudet et al. 1997; Lackey 1996; Rapport 1998b).

Bioregional Perspective. In most instances, political jurisdictions are drawn up with a view to managing a single resource area primarily for utilitarian purposes and not necessarily to reflect natural features and human settlement patterns (Environment Canada 1996; Mitchell 1997; Slocombe 1993; Westley 1995). Ecosystem management is based on a bioregional perspective that acknowledges the importance of using natural features combined with a community's "sense of place" and use of the land to define management units within a region (Aberley 1993; IREE 1995; Mitchell 1995).

Cross-scale Management. Cross-scale management recognizes that ecosystems function at different geographic and time scales (Haila 1998; Holling 1995). Small-scale ecosystems are embedded within larger ecosystem complexes (IREE 1996; Kay and Sneider 1994). Cross-scale management is achieved by making global and long-term goals consistent with local, short-term goals and by government agencies and non-government organizations working cooperatively together (Costanza and Greer 1995; Force and Machlis 1997). This is not easy to achieve when jurisdictional boundaries limit the ability to manage across different scales and management horizons are aligned with political agendas rather than natural system cycles and a changing socio-economic realm (Grumbine 1994; IREE 1996).

Interdisciplinary Research. In a multidisciplinary research project such as the RRBP, different disciplines study a problem using their respective methodologies, but there is little integration of knowledge. Interdisciplinary research concerns the transfer of methods from one discipline to another and at least a partial integration of two or more fields (IREE 1996; Rapport 1998a; Slocombe 1993). One of the major challenges of interdisciplinary research is reconciling different concepts, terminology and approaches to problem solving as experts of different backgrounds strive to think in new ways to comprehend whole ecosystems (Pickett et al. 1994). Invariably, experts from one discipline value elements they consider important and dismiss others they do not (Bingham et al. 1995). There may also be differences among professionals as to how they see the relationship between theory and action. An ideology of action and decision characterizes engineers in contrast with social scientists who, by comparison, are more critical and reflective (Rickson et al. 1998). Although progress has been made in the development of environmental criteria and theoretical models to measure the health and sustainability of natural ecosystems, equivalent social theories and parameters for measuring community health and sustainability are poorly developed (Bouthillier et al. 1997; Carpenter et al. 1999; Machlis et al. 1997; Parson and Clark 1995). Even more lacking are theoretical frameworks for studying the interactions between community social systems and the long-term stability of natural ecosystems (Berkes and Folke 1998; Carpenter et al. 1999; Machlis et al. 1997; Parson and Clark 1995). The tendency is for ecologists to model ecological systems and for social scientists to model human systems or human values. At best, these separate activities are linked at some later activity rather than initially building an integrated model as part of a focused effort (Blood 1994).

Adaptive Management. Adaptive management acknowledges the unpredictable interactions between people and ecosystems as they evolve together (Gunderson et al. 1995; Holling 1978; Walters 1986). The process is iterative and involves two-way feedback between research and management. Surprises are viewed as inevitable; hence, policies should always be adaptive and organizational structures flexible, to respond to changes. Policies are treated as hypotheses and management as an experiment from which social learning can take place at the individual, societal and institutional level (Ostrom 1990, cited in Berkes 1999). A major barrier to adaptive management is the political risk of having a clearly identified policy "failure" (IREE 1996). Thus, adaptive management requires creative and innovative persons within institutions who have a high tolerance for risk (Lee 1995).

Multistakeholder Processes. Partnership is an essential characteristic of sustainable communities (Capra 1999; IREE 1996). Multistakeholder processes build upon earlier models of community-based research by broadening the representation and responsibility for decision-making to include community groups, the private sector, universities and governments. Through partnerships research priorities and management issues can be addressed in a more cooperative and transparent manner (Hemmati 2002; IREE 1996; Mitchell 1997). Multistakeholder processes promote consensus decision-making and foster social learning by encouraging different partners to better appreciate the values and needs of others and to work together towards a common goal (Ellsworth 1995).

One recurrent challenge with multistakeholder processes is the difficulty of ensuring a "representative" public (Burdge and Vanclay 1998; Mitchell 1997; Westman 1985). Not all members of the public will be interested in or significantly affected by the action. The public generally participates in commenting and decision-making in proportion to the extent to which it is affected and to the extent to which solicited comments will influence decisions. The process of "involving the public" begins by identifying those multiple publics ("stakeholders") that are, or should have, a substantial interest in the proposed action, based on the extent to which they, or interests they represent, will be affected (Westman 1985). Multistakeholder processes may take many forms including roundtables, co-management boards, task forces, and/or action-oriented stewardship initiatives. Stakeholder participation may range from token consultation and information sharing to joint planning and delegated authority at the top (Berkes 1994; IREE 1996; Pinkerton 1994; Tester 1992).

Achieving co-operative partnerships among stakeholders with different agenda and resources is not easy. Power is a central and under-addressed issue in many multistakeholder arrangements (Hemmati 2002; Mason and Boutilier 1996; Slocombe 1993). A great sensitivity about the redistribution of power on the part of those with the most resources is critical, but not easily accomplished (Gardner and Roseland 1989; Westley 1995). Those who have traditionally prevailed often resist change because a true participatory process demands that power be progressively shared with groups normally excluded from the decision-making process (Zazueta 1995). Achieving consensus decision-making on contentious issues may also be difficult among a diverse and often highly fragmented group of stakeholders (Costanza and Greer 1995). In some cases it may be necessary to take a decision favoring one side over another, in the interest of the public good.

The Rideau River Biodiversity Project: A Case Study

During the unsettled period following the War of 1812 between the British and the Americans, the Rideau waterway served as an important link between Montreal, Quebec, and Kingston, Ontario (Canadian Heritage Parks Canada 1996). Today this historic river winds through a mixture of urban and rural communities, providing water for homes, farms and businesses and habitat for a diversity of plants and animals. Its rich cultural heritage and biodiversity offer excellent recreational opportunities to local residents and tourists. There are signs, however, that the environment is under pressure from natural events (e.g., storms) and human-induced activities (e.g., introduced species, altered shorelines, damming, agricultural practices, recreation, contamination of water). These impacts have resulted in a loss in the number and quality of wetlands, fish and wildlife habitats, and natural shorelines, and deterioration in water quality (Poulin 1999b).

Management of the Rideau waterway cuts across federal, provincial, regional and municipal jurisdictions. The number of regulatory agencies and the variety of scientific studies and local environmental initiatives point to the need to develop a more coordinated approach to river management (Johnson et al. 1999). Recognition of the important ecological, socio-economic and political dimensions of managing the Rideau River are reflected in the Canadian Heritage Parks Canada (1996) management plan which endorsed the application of an ecosystem management approach. The guiding principles for the long-term sustainable management of the river include: (1) co-operative research and monitoring efforts; (2) partnerships with communities, stakeholders and the private sector; (3) coordinated activities between the public and governments; and (4) education programs and opportunities for public involvement in river stewardship.

The CMN's mandate is to promote public understanding of Canada's natural environment through research, education and the maintenance of the country's natural collections. Research at the Museum and the focus of the RRBP is biosystematics — the naming and classifying of organisms, identifying geographic distribution and the study of their interrelationships. Despite the critical role that biosystematics plays in understanding the genetic, species and ecosystem diversity, the field is still little known to most politicians and the general public. As a result, many museological institutions have seen their funding drastically reduced over the years and fewer students are entering a field that offers an uncertain future (Efford 1995; Poulin and Williams 2002).

The RRBP began as a fundraising exercise to secure support for research on water chemistry and phytoplankton diversity in the river. In an attempt to make the study more attractive to potential funders, whose interests were primarily in applied and socially relevant environmental research, the project scope was broadened to include other scientific disciplines and a community involvement component. At first, Museum scientists were reluctant to become involved in the project. They were concerned that the extra time required to meet with communities and to incorporate their concerns into the research design would compromise the time needed to pursue research and publishing in peer-reviewed scientific journals, the basis of their professional evaluation. They were also skeptical about the value of including local knowledge in the study.

The Rideau Valley Conservation Authority (RVCA) agreed to become a partner and added significantly to the sci-

entific expertise of the CMN. As an inter-municipal environmental protection and advisory agency, the RVCA had extensive knowledge of the watershed, a well-established network of contacts and valuable experience in public consultation. The project team, with staff from the CMN and RVCA, began a series of meetings to solicit support for the project from municipal, regional, provincial and federal government agencies, schools and local environmental, business and other community organizations. The idea was to make "biodiversity" a household word and to link it to issues of aquatic ecosystem health. The project team believed that if broad sectors of the public were convinced that the health of the river was everyone's responsibility, it might eventually lead to communities wanting to become directly involved in biodiversity conservation. In turn, this would generate long-term support for research and education.

Following discussions with community groups, a research proposal was prepared based on the ecosystem management approach outlined by Canadian Heritage Parks Canada (1996). The project framework focused on the study of eight taxonomic groups and involved residents and other stakeholders through a model of community-based research developed for northern indigenous communities (see Johnson and Ruttan 1993; Ryan and Robinson 1991, 1996). After a year of developing the project and fundraising a substantial research grant was obtained from a private Canadian foundation that supported the idea of applied science research being conducted within a community-based and multidisciplinary framework.

Community Involvement Framework

The main goal of the community-based component of the RRBP was to facilitate dialogue between the scientific research team and the community. Prior to the first field season in 1998, two Community Advisory Groups (CAGs) were formed to facilitate links. The creation of two CAGs reflected the different lifestyles of the seven communities along the river, with the northern part being predominantly urban/suburban and the southern reaches mainly rural (Figure 1). Its membership was drawn from broad sectors of the community including education, tourism, environment, business and agriculture. The RVCA and the CMN invited potential members to join according to their known affiliation with an interest group or their identification with a particular sector of the community (e.g., farmer, business person). Once a year, a joint meeting of both the rural and urban CAGs was held to ensure that the concerns of residents from both sections of the river were heard in a forum of shared discussion. Representatives from regional and federal government agencies were also invited to participate as observers in the process in an attempt to facilitate understanding and communication between the community and the various regulatory authorities along the river. The CMN and the RVCA community coordinators facilitated the meetings, with both organizations contributing financial and in-kind resources.

The CAGs had four objectives, (1) incorporating community concerns and local knowledge into the research design, (2) communicating science issues and research results to the community, (3) building a community-based biodiversity plan, and (4) fostering community responsibility and advocacy for the health of the river (Poulin 2001). Over the course of the project, a total of 11 meetings were held, four in each of the rural and urban areas and three joint meetings. The initial meetings prior to the first field season focused on explaining the objectives of the scientific research and defining the objectives of community involvement in the project. Members were asked to provide input into the scientific research design by identifying specific community concerns about the health of the river. At subsequent meetings after the first field season, research results were presented to the CAGs followed by discussions about the future direction of the science and the community's evolving role in the project.

As part of the project team's commitment to include local knowledge in the research, two community mapping workshops, one in the urban and one in the rural region, were held prior to the first field season to identify residents' concerns about the river and to gather local knowledge. The workshops were highly successful with over 100 local citizens in attendance. People were invited to mark down on large maps of the river everything they knew about the organisms under study. Members of the scientific team were present and interacted on an informal basis with the public. The workshops provided an important link between science and the community allowing residents to share their local knowledge and for scientists to establish a network of key contacts for follow-ups. In general, more information was provided about the species most familiar to people (e.g., fish, birds, turtles). People also raised concerns about habitat and shoreline destruction as well as general pollution issues related to water quality (Poulin 2001).

Another effort to include local knowledge in the study was the establishment of a public sighting registry for turtles. There was an overwhelming telephone response to this initiative with hundreds of calls being received over the course of two field seasons. The volunteer registry revealed that there are a number of people in the community making observations and taking notes about turtles as well as a number of other species. Additional resources would have made this activity more effective (Poulin 2001).

Challenges and Observations. Although CAG members demonstrated initial enthusiasm for the community involve-

ment process, attendance at the meetings waned over the course of the project and the turnover rate was high. Museum and RVCA staff and representatives from some government agencies often outnumbered the community representatives at the meetings. This irregular attendance made it difficult to achieve progress in terms of meeting the CAGs' objectives. A lack of community engagement in the RRBP may be attributed to several factors.

(1) Health status of the river. The RRBP began as a scientific research project and was not in response to any perceived environmental crisis. In other words, it was pro-active as opposed to being re-active in its approach. A crisis situation or perceived problem might have enhanced the numbers of people involved in the project (IREE 1995). A pro-active approach provided the opportunity to establish baseline data and to work with the public to address issues of biodiversity and river health before a real crisis occurs.

(2) Differences between a northern indigenous and a southern Canadian context. Although small indigenous settlements are not without their own internal differences, community boundaries and interest groups are generally easier to identify than they are in larger urbanized, culturally diverse populations where there is a greater diversity of socio-economic and political interests spread over a broader geographical area. Community boundaries along the Rideau River were defined by the CMN and the RVCA for practical purposes. In reality, the urban/rural division of the CAGs did not reflect the heterogeneity of many of the communities along the 100-km stretch of the river where a diversity of urban and rural lifestyles are found in each. Nor did the division necessarily reflect residents' perceptions of resource use and "sense of place."

It could also be argued that with the exception of farmers, the average Rideau River resident, with an urban/suburban lifestyle, does not have the same close relationship with nature as do many indigenous peoples for whom local knowledge and involvement in resource management are closely tied to issues of cultural identity, subsistence and self-determination (Johnson 1992; Sejersen 1998). Among non-indigenous peoples, government is the primary regulator of resource use and science is regarded as the principal source of expert knowledge. Developing a role for communities in biodiversity management is not easy if there is no cultural background of self-regulation or stewardship ethic (Berkes et al. 1989; Lerner 1994). Nevertheless, the presence of local environmental groups along the Rideau River and the interest of some members of the community to participate in the CAG process demonstrate a certain level of environmental consciousness.

(3) Mechanism to link local knowledge and community values with science and policy issues. Museum scientists acknowledged that they had come to appreciate the value of local knowledge in the project. Both scientists and CAG members remarked that there should have been more workshops held, perhaps one in each community, and that in future projects, the information should be compiled in a format that could be more easily used later by the communities and the scientists. CAG members expressed concern that there was no clear mechanism to link local knowledge and community values with science and policy issues. If local people are to be actively engaged in biodiversity management, community perceptions and indicators of ecosystem health need to be combined with scientific criteria and information. Several CAG members felt that their roles and responsibilities were unclear. It was suggested that the assignment of specific tasks to CAG members at the beginning of the project might have helped focus their efforts more to provide the link between community, science and policy issues.

(4) Effective leadership. The fourth obstacle faced by the RRBP was the lack of continuous leadership throughout the project. Less than six months into its operation, the CMN replaced a number of original project staff in an effort to better coordinate the various expanding activities. The change halted the community-based, team-building approach until the new staff could rebuild trust within the community and with the scientists. Scientists should lead research projects to ensure full credibility of the study within both scientific and local communities (Environment Canada 1996). At the same time, having a local champion to promote the project within the community can help ensure local support. Although a community leader to champion the project had been discussed it was never realized.

(5) Communication and team approach. Open communication, trust and respect are essential for any partnership (IREE 1995; McNicoll 1999). In addition, issues of power relations that include control of resources and decision-making need to be addressed early on. Otherwise, unresolved power struggles can lead to feelings of mistrust and lack of a common vision among participants. Several CAG members felt that the community involvement process did not extend to decisions being made about major changes in project direction, nor did they have much input into the research design. Successful community involvement in biodiversity research and management requires a willingness to share decision-making and responsibilities among all partners. This implies that larger bureaucratic institutions need to give up some control and delegate responsibility to community groups that demonstrate the interest and ability to take over certain tasks. Further, all of the CAG members were volunteers and maintaining such commitment requires continual cultivation and recognition of their contributions.

(6) Adaptive management. Governmental-oriented insti-

tutions like the CMN are necessarily constrained by political agenda and issues of public accountability and, therefore, are more risk aversive. Such organizations tend to have more limited flexibility in reacting to new proposals than do many non-governmental organizations whose role is often to focus more on a single issue, to advocate change and to challenge the status quo. The RRBP was a project that often demanded quick reaction to unplanned opportunities with uncertain outcomes. Also, plans often changed, including the broadening of initiatives and enlarged financial demands. The CMN viewed these uncertainties with some hesitation and in a top-down approach tried to control the process rather than work out a more consultative approach with the community partners. Once the costs and benefits were clearly understood, the CMN became much more supportive of its activities and willing to collaborate with the community partners.

Science Framework

The RRBP studied approximately 100 km of the Rideau River, which originates from three headwater lakes and flows through a mix of urban and rural communities interspersed with wetlands, parks and conservation areas (Figure 1). The CMN's expertise in biosystematics had been sought in previous studies to evaluate the water quality in the downstream sector of the river which revealed high levels of phosphates, bacterial coliforms and phytoplankton after major rain events in the downtown Ottawa area (Hamilton et al. 1997).

Initially, six taxonomic groups were studied, including microscopic algae, aquatic plants, native and exotic molluscs, fishes, amphibians and reptiles. In the second year, invertebrates associated with aquatic vegetation and waterfowl were added. Water chemistry was also tested at several sampling sites. The general objectives can be summarized as (1) documenting the biological diversity, (2) monitoring indicator species, (3) identifying sensitive areas, and (4) recommending remedial actions (Poulin 2001). Before each field season, the science team discussed the sampling protocols to be used for the various biological groups. Nearly 600 species of freshwater organisms have been identified among the eight groups of plants and animals investigated which required multiple sampling approaches. For instance, the sampling protocols and equipment differ significantly between aquatic microorganisms, aquatic plants and vertebrates (Poulin 2001). Water samples were collected twice a month, from May to October during the entire project at 18 sites along the river and at 3 sites in each of the headwater lakes, and a suite of chemistry analyses was performed (e.g., carbon, nitrogen, phosphorus, aluminium, copper, lead) (Poulin 2001). Bacterial concentrations, namely *E. coli*, which is used to determine provincial levels safe for public recreational activities, were measured simultaneously with the chemistry analyses. Additionally, oxygen, pH, temperature and conductance were directly measured with a Hydrolab® field meter (Poulin 2001). Biodiversity data about the river are still being compiled, analyzed, and integrated with the abiotic variables of the Rideau River watershed. Scientific publications and popular articles will be forthcoming for all disciplines investigated over the three-year period of the project.

Challenges and Observations. The integration of CMN scientists into a cohesive team to conduct the RRBP was a major challenge. The nature of the scientific research conducted at the CMN emphasizes the study of the classification and evolution of species as opposed to considering ecological processes within an ecosystem management approach. Like many researchers, museum scientists felt more comfortable tackling research problems for which they had been specifically trained (one taxonomic discipline). They were not used to working as members of a multidisciplinary team that required them to collaborate across disciplines and to consider their research objectives within a broader integrated framework.

The RRBP lacked a sufficient planning exercise at the beginning of the research and sampling activities. Even though scientific meetings helped to direct the project, they failed to establish agreement on a cohesive science program to maximize the collection of samples and, ultimately, integrated analyses and interpretation. Nevertheless, the three sampling seasons have provided, for the first time, an important data set for the complete spatial and temporal biodiversity assessment for the entire Rideau River, as well as offering baseline information for long-term monitoring.

Even further outside the range of expertise of most museum scientists was working within a community-based framework. Despite the fact that museums play a lead role in the dissemination of scientific information to the public through various educational and exhibit programmes, most institutions are unfamiliar with community-based approaches to research and education.

Scientists aspiring to involve the public in their research should expect to invest time and effort in getting to know and to appreciate the community with whom collaboration is sought. This means regular attendance at community meetings, gathering local knowledge and finding effective ways to consider the collaborators' input into the research process. Unless scientists receive proper support and professional recognition for their efforts to work with the public, they are unlikely to devote the time and effort required to make the process work. Scientists who actively tried to integrate local knowledge with their own research findings in the RRBP stressed that researchers must be prepared to invest the time to collect and validate the information and that this task has to be carefully weighed against the many other research pri-

orities. A significant difficulty in gaining the involvement of scientists in such a process is that there is little professional incentive. Performance measures and professional peer-recognition rarely recognize efforts that do not culminate in a scholarly publication.

Community-based research and ecosystem management are slow and frustrating for scientists who are used to carefully planning and controlling the progress of their research in the absence of public debate. The challenges posed by these new approaches caused initial reluctance among the scientists to participate in the project. However, all of the scientists interviewed agreed that they had benefited from the experience and had come to appreciate the value of multidisciplinary and community-based research.

Education and Public Awareness Framework

The final goal of the RRBP was to increase public awareness about biodiversity and, in particular, about specific issues related to the health of the Rideau River. Since the project's inception, the Museum has ensured good local, regional and national news coverage in print media, as well as through radio and television. Two popular vehicles used to inform local communities included the production of two newsletters describing the project and reporting on scientific results and an eight-page tabloid addressing specific issues related to the biodiversity along the river. A co-produced half-hour television documentary with the private sector entitled, *Rivers: Reflections of Life / Les rivières: Reflets de la vie*, presented river biodiversity with a particular focus on the RRBP to illustrate how scientists and community groups can work together. The Museum also created a Web site in both English and French (www.nature.ca/rideau/index-e.html and www.nature.ca/rideau/index-f.html) about the project and put together a small exhibit for a local museum. Research results continue to be disseminated both in scholarly journals and popular magazines (Martel et al. 2001; Phelps et al. 2000; Poulin 1999a).

Other public awareness activities included presentations by members of the RRBP at local, regional, national and international meetings (Poulin 1999c; Poulin et al. 1999a, 1999b, 2000). Workshops for the public on how to identify microalgae, aquatic plants and molluscs in the Rideau River were held in the communities. Boat tours explaining the biodiversity of the river were organized for the media and other key community organizations. A local boat tour operator, also a CAG member, sponsored one of these trips. This event is but one example of the potential partnerships that can develop between science and local businesses.

The RRBP successfully contributed to the science training of students in the field of biodiversity and limnology by providing them with the opportunity to participate in fieldwork and to gain experience sampling, using field gear and sorting organisms. University students worked as summer assistants and two enrolled at the local university in a Master's programme to study fish and aquatic plants (Makkay 2002; Phelps 2001). Biologists were also hired to assist the project on a part-time basis and a geography student helped with the design of a geographic information system. The added value through student involvement was critical to the success of the scientific activities in the field. In addition, many non-research staff of the Museum benefited from the RRBP by spending time with the science team in the field, and for several of them, this was their first hands-on experience with science. This effort has greatly increased cross-sectoral understanding and appreciation of science and in particular biodiversity, within the institution. On occasion, volunteers from the general public assisted Museum scientists with their field sampling (Poulin 2001).

Challenges and Observations. In terms of educational achievements, the involvement of university students in the scientific research represents a highly positive step in promoting biosystematics research within the context of a larger multidisciplinary study. In addition, the variety of communications media employed served to reach a number of different public and academic audiences. One of the major challenges faced by the RRBP was the involvement of youth in the study. Despite efforts to collaborate with local high school science teachers, this educational aspect of the project was never fully realized, mainly due to insufficient human and financial resources available to develop a program within the limited 3-year timeframe.

Ecosystem Management Framework

The CMN was the lead institution throughout the three years of the project in close collaboration with the RVCA. In addition, over 20 partnerships were established with various municipal, regional, provincial and federal government agencies, local community organizations, corporations and universities. The nature of these partnerships included shared expertise and financial and in-kind support for research, educational and public awareness activities.

By the end of the second year of the RRBP, it became apparent that the CAGs needed to be re-evaluated both in terms of project goals and for the longer-term management of the river's biodiversity. Building upon the groundwork of the CAGs, the Rideau River Roundtable (RRR) was established in the final year of the project to facilitate the co-ordination of research activities, educational projects and community monitoring initiatives. The RRR's membership was drawn from the community, universities, and government scientific and regulatory agencies. The Roundtable is presently involved in a number of conservation, monitoring and public

awareness activities. For instance, the RRR is currently preparing a community action plan to address different conservation priorities along the river. A research and monitoring team is involved in the identification of environmental indicators to serve as baseline information necessary for ongoing monitoring of the river ecosystem. The database of biological and environmental variables gathered over the three years of the RRBP project will ultimately serve the RRR in the preparation of a state of the river report.

Challenges and Observations. The creation of the Rideau River Roundtable was an important outcome of the RRBP. It was intended to carry forth the original objectives of the CAGs with their emphasis on consultation and dissemination of information through community-based research, by broadening the scope to an ecosystem management framework that is more suited to deal with the social and ecological complexities of biodiversity monitoring. It may provide the mechanism necessary to link local knowledge and community values with science and policy by applying a proactive and integrated approach that combines long-term vision with action oriented projects. Its two main challenges will be to establish its role in relation to government scientific and regulatory agencies and local stewardship initiatives and to ensure that initiatives are developed in a spirit of partnership where no one group dominates the process. The key to its success will be whether or not government views it as a benefit to achieving its mandate and communities see it as representing their interests.

One form of partnership that needs to be more actively cultivated in the future is the link between science and the local business community. Healthy ecosystems should not only be ecologically sound, but should also be economically viable and able to sustain healthy communities (Rapport 1995). The business sector needs to understand the link between a healthy river, a healthy community and a healthy economy (Costanza et al. 1997). That understanding will facilitate business support for research and educational activities related to the conservation and sustainable use of biodiversity.

Discussion

The Rideau River Biodiversity Project represented the first attempt by the Canadian Museum of Nature to develop an innovative science project using an integrated approach to biodiversity research. The participation of communities in a multidisciplinary research study represented a new paradigm for the Museum's more narrowly focused biosystematics research program. The experience presented new challenges and the lessons learned provided valuable insights regarding the conceptual, methodological and practical implications of applying an integrated approach to biodiversity initiatives.

The RRBP has demonstrated how an integrated approach needs to reflect the unique ecological and socio-cultural features of a particular region, as well as the cultures of the various institutions and groups involved. No two ecosystems are the same and no two communities or institutions will be the same either. Therefore, it is unlikely that any single integrated approach will be applicable to all situations. Community-based approaches developed for one social context (e.g., indigenous communities) may need to be adapted to suit larger, more diverse communities where government exercises an important regulatory role. Further, the notion of communities as homogeneous, static and harmonious units often conceals power relations within communities and masks biases in interests and needs based on, for example, age, class, ethnicity and gender (Cooke and Kothari 2001). Here an ecosystem management approach that includes a broader representation of stakeholder interests may be more appropriate. This is particularly relevant when dealing with a common property resource like water that requires collective decision-making, cooperation in resource use, and enforcement of agreed-upon rules among group members (Berkes 1995).

Projects that involve complex, interdisciplinary problems and many different stakeholders also require an organizational structure that is flexible and adaptive enough to meet the evolving needs of the research and the interests of the different partners. At the same time, it is important to recognize the different roles and contributions each partner makes to the process and to understand the limitations they may also face in their ability to address certain issues.

Côté and Bouthillier (1999) have argued that government should have a predominant role in ecosystem management since it is the only institution accountable to the interests of a whole nation. Since governments ultimately decide how policy is made and implemented and who participates in public decision-making, their willingness to initiate dialogue with many sectors of society is key to building new structures of governance (Zazueta 1995). Partnerships with government can provide links to the existing decision-making structures and help bring recommendations to action. Government agencies can also offer technical and financial support to build community capacity to manage their natural resources (Grant 1997; IREE 1996).

For their part, communities can help government agencies understand issues that are most meaningful to them. NGOs, citizens and the business sector can move beyond criticizing governmental action or inaction and build their own capacities to propose viable options that address the problems they articulate (Mitchell 1997; Zazueta 1995). How citizen participation will take place and the extent of its role in decision-making will vary by situation (Zazueta 1995).

Roundtables should not be an attempt to replace government, rather they should complement government initiatives by providing a framework for long-term, multistakeholder assessment of sustainability options (Mitchell 1995).

One of the criticisms of citizen participation in environmental management is that the role and stature of the professional manager is diminished. The general public represented by a diverse mixture of interest groups and individuals may not be sufficiently informed to make sound decisions (McMullin and Nielsen 1991; Mitchell 1997). However, as Mitchell (1997) points out, users can make informed decisions if the data are presented to them in an understandable format. When properly trained, citizen volunteers can collect reliable data and make assessments comparable to those made by professionals (Fore et al. 2001). Ultimately, there needs to be an understanding that science is just one type of input into the decision-making process. The role of scientists should be to conduct research and provide technical information in a form the public understands so that decision-makers can use this information along with local knowledge to make better managerial decisions (IREE 1996; Rapport 1998b).

The use of the ecosystem health concept to frame research objectives was one that the public could easily relate to in the RRBP. Nonetheless, the challenge remains to better define the concept both in ecological and social terms so it can be used more effectively as a guide to constructive societal decision-making (Haskell et al. 1992; Lackey 1996). This requires the input of natural scientists to determine the biophysical indicators of ecosystem health and social scientists to understand the socio-economic and political dimensions of biodiversity conservation and sustainable use. While the RRBP was reasonably successful in integrating a number of disciplines from the natural sciences, little attempt was made to include the social sciences as part of the study. The misperception that social data are somehow "soft" or "less credible" remains an obstacle to overcome as well gaining recognition for the contribution social scientists make to understanding the human dimensions of biodiversity issues (Coakes 1998). Ultimately, ecosystem management is "people management" (Berkes and Folke 1998). "We have to learn that we don't manage ecosystems, we manage our interaction with them" (Kay and Schneider 1994, 33). Human perceptions of environmental quality play significant roles in ecosystem management decisions (Cairns et al. 1993; Lopez and Dates 1998). Valued ecosystem components are determined by culture context and can only be ranked in terms of cultural priorities (Meredith 1992). To ignore societal values is to ignore the potential to involve society in the discussion of and solutions to ecosystem health problems (Rapport 1998b). It will not be possible to change societal attitudes regarding biodiversity conservation and sustainable use unless there is some understanding of the factors that influence knowledge creation and institutional and societal response to information and change (Ellsworth 1995; Long and Villareal 1994). This requires a greater understanding of the implications of changing power relations as a result of multistakeholder processes and the institutional needs of managing the interdependencies of interdisciplinary and cross-scale problems (Folke et al. 1998; Parson and Clark 1995; Redclift 1994).

While ecosystem management holds great promise for understanding and managing the complex social and ecological dimensions of biodiversity, one area that is often not well developed is capacity building in the public's awareness of biodiversity issues. This is probably because most environmental research initiatives are generally led by natural scientists whose main interests and expertise lie outside the realm of education and social change. Yet it is one area that is fundamental to achieve the goal of societal change expressed in Article 13 of the Convention on Biological Diversity (UNEP 1994). For communities to be sustainable they should be adaptable, and to be adaptable, communities require a high degree of social capacity (Beckley and Reimer 1999). The public will not support science if they do not benefit from it (IREE 1996). In order to ensure active citizen engagement in biodiversity conservation, it is essential to create a sense of community ownership of the process. Initiatives that link science with local knowledge can go far in bringing about a deeper understanding of biodiversity to all involved. These initiatives also ground people's individual experiences in the larger effort of inventorying, monitoring and assessing biological resources — a necessary precursor to their sustainable use (Ham and Kelsey 1998; Lopez and Dates 1998). Paramount to raising environmental consciousness is the involvement of youth in educational initiatives that teach them about biodiversity and encourage them to take an active role in the conservation and sustainable use of biological resources. Access to information for all parties involved is also a crucial element of capacity building. To level the playing field, governments need to open up access to accurate and useful information to all involved. Similarly, citizen's groups should gather and disseminate information that helps both stakeholders and decision-makers fully understand the issues at stake (Zazueta 1995).

Some scholars suggest that the growing interest in integrated research, local knowledge and increased public involvement in science and decision-making has resulted in the emergence of a new mode of knowledge production based on transdisciplinary inquiry (Fuller 1993; Gibbons et al. 1994; Wilson 1998; Wolfenden 1999). According to Gibbons et al. (1994) transdisciplinary inquiry operates within a context of application in that problems are not set within a disci-

plinary framework, but within broader transdisciplinary social and economic contexts. Transdisciplinary inquiry tries to integrate and synthesize many different disciplines to develop its own distinct theoretical structures, research methods and practices to understand the functioning of the overall system in order to develop appropriate responses to complex, multidimensional problems (Gibbons et al. 1994; Wolfenden 1999). One way it does this is by focusing more directly on the problems, rather than the particular intellectual tools and by encouraging people to work together towards some shared vision or common understanding (Wolfenden 1999). Through the process of social learning all of the actors working in the context of application become more sensitive to the values and preferences of each other and the broader social implications of what they are doing. While the holistic approach of transdisciplinary inquiry provides the context and framework to understand the overall ecosystem, it does not detract from the disciplinary (reductionist) investigations necessary to provide the detail and substance for systemic study (Gupta 1999; Wolfenden 1999).

Framework for an Integrated Approach

In the final section of this paper we propose a framework for an integrated approach to the conservation and sustainable use of biodiversity. While we recognize that it would have been useful to provide more in depth analysis of the socio-political issues of knowledge production and the power relations that underlie interdisciplinary research and multi-stakeholder collaboration in our discussion of the proposed framework, the focus of this paper is one case study, and the framework is the outcome of this particular experience. In addition, we have consulted a broad range of literature from many disciplines that examines community-based research and ecosystem management from both theoretical and applied perspectives. Thus, the framework is based on the lessons learned from the RRBP and adapted from the experience of others who have attempted to develop similar initiatives based on the combined principles of community-based research and ecosystem management (i.e., Bingham et al. 1995; CCME 1996; Environment Canada 1996; Gaudet et al. 1997; Ham and Kelsey 1998; Hemmati 2002; IREE 1995, 1996; Mitchell 1997; Wells 1995; Wolfenden 1999; Zazueta 1995). The framework consists of a set of key principles and procedural steps represented in the schematic diagram (Figure 2).

Key Principles

Problems set within broad socio-political and ecological context. Any integrated approach should reflect the interrelated and multidimensional aspects of the issue. While ecosystem boundaries are preferable, it may be logical under certain circumstances to use jurisdictional political units, community perceptions of economic use and cultural value of biological resources or some combination of all features. Ultimately, the scope of the project will depend on the research questions and the different stakeholders involved.

Collaborative partnerships. Broad representation of stakeholders ensures a cross-scale perspective of biodiversity issues and alternative approaches to problem solving. Strong linkages and networks need to be built among universities, government, community groups and the private sector to share technical, educational and financial resources and expertise. Effective leadership and clearly defined project goals and roles for all partners are essential to ensure continuous support and interest.

Adaptive and innovative approach. Goals and objectives are redefined as new information resulting from research and monitoring continually feeds into the evolving knowledge base. Initiatives are regarded as experiments — opportunities to develop new modes of knowledge production and to test new institutional arrangements. At the same time, all participants must have realistic expectations about what can be accomplished and a willingness to acknowledge uncertainties and the imprecision of results.

Social learning. Social learning requires a sensitive handling of barriers to change and an understanding of what it may take to create a functioning dialogue between professionals and citizens from different backgrounds. All participants should try to understand the world views of the others. This does not mean that they must adopt them, only that the components of those world views that might contribute to sound biodiversity management should be considered for the common good.

Institutional recognition and support for capacity building. Senior management from all organizations involved must support the legitimacy of the process. In order to ensure active citizen engagement in biodiversity initiatives, it is essential to build community capacity to foster their involvement in local activities. At the same time, a community's ability to successfully carry out new initiatives will depend on their receiving adequate scientific, technical and financial support.

Transdisciplinary inquiry. An integrated approach should be transdisciplinary in order to understand the interactions between human behaviour and ecological processes. It should cut across and build bridges between the social and natural sciences and facilitate the links between scientists, communities and policy makers. An integrated framework needs to be developed as a focused effort at the beginning of an initiative and research should promote new forms of knowledge production and lead towards sustained action.

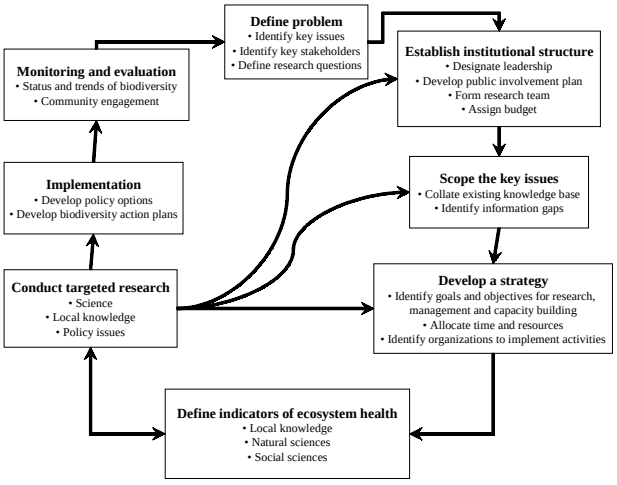

Figure 2. Schematic diagram of procedural steps for an integrated approach to the conservation and sustainable use of biodiversity.

Procedural Steps

Figure 2 illustrates the procedural steps to developing and implementing an integrated approach to the conservation and sustainable use of biodiversity. While the schematic diagram presents the steps following a chronological sequence, it is not a strictly linear process. As research results become available, represented by the box "Conduct targeted research," they may feed back to the previous steps and further define the indicators of ecosystem health and the scope of the key issues. This in turn may affect changes in the institutional structure of the project and the strategy to achieve research, community and policy objectives. Thus, an integrative approach is an iterative and adaptive process that exhibits both linear, feedback and cyclical patterns.

Conclusion

The experience of the Rideau River Biodiversity Project has revealed the theoretical and practical challenges of implementing an integrated approach to the conservation and sustainable use of biological resources. On the theoretical side, the combined strengths of community-based research and ecosystem management provide essential elements for an integrated approach. Community-based research fosters social change through capacity building and community empowerment. Ecosystem management promotes a holistic understanding of social and ecological interrelationships through interdisciplinary research and multistakeholder decision-making.

On the practical side, the integration of scientific disciplines and working with many stakeholders require significant planning initially, careful management throughout the project and institutional understanding and support. It is critical that project goals and objectives be realistic and in line with the financial, technical and personnel resources available. Integrated approaches need to be adapted to the unique ecological and social characteristics of each region, as well as to the particular research problem and the interests of the stakeholders involved. Societal values need to be recognized as a valuable component of understanding ecosystem health and capacity building as the tool to promote biodiversity conservation and sustainability.

While integrated approaches to the conservation and sustainable use of biodiversity may be as diverse as the issues and communities they represent, their ultimate success will depend on the willingness of different stakeholders to transcend disciplinary boundaries and political agendas to solve the pressing problems associated with the conservation and sustainable use of biological resources. The RRBP linked science with local knowledge and community awareness about biodiversity. Through a process of social learning and transdisciplinary inquiry, all participants now have a better understanding of the scientific and social issues that relate to them and are beginning to realize that together they can be part of the solution, paramount for preserving the river's biological resources.

Endnotes

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3. This paper was prepared while M. Johnson was a student/consultant and, therefore, does not reflect the views of Indian and Northern Affairs Canada.

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