United States
Department of
Agriculture

Forest Service

Pacific Northwest
Research Station

General Technical
Report
PNW-GTR-441
September 1998

Integrating Science and Policy in Natural Resource Management:

Lessons and Opportunities From North America

Roger N. Clark, Errol E. Meidinger, and others

Authors

ROGER N. CLARK is a research social scientist, U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station, Forestry Sciences Laboratory, 4043 Roosevelt Way N.E., Seattle, WA 98105-6497; ERROL E. MEIDINGER is a professor of law, State University of New York, School of Law, 529 O'Brian Hall, North Campus, Buffalo, NY, 14260; GORDON MILLER is acting director general, Canadian Forest Service, Science Branch, 580 Booth Street, 7th Floor, Ottawa, ON K1A 0E4; JEREMY RAYNER is an instructor, Malaspina University College, Political Science Department, 900 5th Street, Nanaimo, BC V9R 5S5; MANUEL LAYSECA, is subdelegado de recursos naturales, Av. Irrigacion s/n, Planta baja, Celaya, Guanajuato, C.P. 38030; SAUL MONREAL is subdirector de Plantaciones, Forestales Comerciales, Secretaria del Medio Ambiente, Recursos Naturales y Pesca (SEMARNAP), Progreso No. 5, Col. Del Carmen, Del., Coyoacan, C.P. 4100; JORGE FERNANDEZ is Departamento de Estimulos e Incentivos, Secretaria del Medio Ambiente, Recursos Naturales y Pesca (SEMARNIP), Progreso No. 5, Col. Del. Coyoacan, C.P. 4100 ; MARGARET A. SHANNON is an associate professor, Maxwell School of Citizenship and Public Affairs, 400E Eggers Hall, Syracuse, NY 13244-1090. Responsibility for the final content and interpretation rests with the two primary authors. Contributing authors provided substantial additions and insights to this paper.

Paper prepared for the North American Forestry Commission, September 1996.

Abstract

Clark, Roger N.; Meidinger, Errol E. [and others]. 1998. Integrating science and policy in natural resource management: lessons and opportunities from North America. Gen. Tech. Rep. PNW-GTR-441. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 22 p.

Relations between science and policy concerning many issues (e.g., health, energy, natural resources) have been changing worldwide. Public pressure to resolve such complex and often controversial issues has resulted in policymakers and policy implementers seeking better knowledge on which to base their decisions. As a result, scientists have become more actively engaged in the creation and evaluation of policy. In this paper we summarize the literature and experience in how Canada, Mexico, and the United States approach the integration of science and policy; we describe some apparent barriers and lessons; and we suggest some issues that may prove fruitful for discussion and future collaboration.

This paper represents a beginning to understanding science and policy interrelations in North America: we found that we have much to learn from one another. We must avoid, however, the tendency to overgeneralize from one country, or even from one case, to another. The particulars of the situation and context surrounding the cases make drawing firm conclusions and generalizations a risky business. There are some important differences among the three countries that help to explain different approaches to seemingly common problems in the integration of science and policy.

Keywords: Science, policy, natural resources, integration, forestry, North America.

Introduction and Background

Relations between science and policy concerning many issues (e.g., health, energy, natural resources) have been changing worldwide. Public pressure to resolve such complex and often controversial issues has resulted in policymakers and policy implementers seeking better knowledge on which to base their decisions. As a result, scientists have become more actively engaged in the creation and evaluation of policy. During the last several decades, the literature on the general practice of policy formulation and issues surrounding the role of science and scientists has grown markedly (Meidinger and Antypas 1996).

Natural resource management in North America, as well as elsewhere around the world, is controversial, and diverse stakeholders have increasingly polarized perspectives. As policymakers create broad policy and specific programs in keeping with changing and often conflicting societal values and demands, there is a growing recognition that the knowledge base on which to make informed decisions is weak (Friedman 1996). With the high stakes surrounding resource decisions (locally, regionally, nationally, globally), more stakeholders and interests are calling for scientific scrutiny and involvement in making important resource allocation and management decisions, particularly on public lands in the United States and Canada and on both public and private lands in Mexico. Consequently, integration of science into policymaking would, on the surface, seem to be not only the right thing to do but also straightforward. As we will describe in this paper, however, this is not always the case.

A number of concerns and opportunities make this a timely topic within and among Mexico, Canada, and the United States.

- With long-standing traditions between the three countries, they are becoming increasingly interdependent. Natural resource values and uses transcend the borders; e.g., air, water, wildlife, imports and exports, tourism, employment.

- The three countries face an increasing array of complex and controversial issues with demands for new information to formulate solutions and to evaluate consequences of alternative actions.

- There is a high cost for mistakes socially, culturally, economically, politically, and environmentally when making decisions about complex, controversial problems.

- Recent agreements, such as the North American Free Trade Agreement (NAFTA), create new expectations and opportunities for collaboration and cooperation; e.g., the Commission for Environmental Cooperation and the North American Forestry Commission.

- Although the three countries share a common land mass, each has its own legal, political, and cultural traditions, thereby providing the opportunity to observe and learn from one another.

The purpose of this paper is to summarize the collective experience of the three North American countries in integrating science into natural resource policy. We summarize the literature and experience in how the countries approach the integration of science and policy; we describe some apparent barriers and lessons; and finally we suggest some issues that may prove fruitful for discussion and future collaboration.

We have taken a nontraditional approach to present the results from this review. The findings have been organized into a set of "propositions" (shown in **bold text**). A proposition is a supposition or conclusion derived from one or more of the information sources described above. Initial propositions were developed by Meidinger and others (1996) based on cases from the United States. These have been modified and augmented to reflect the situation and experience in Mexico and Canada. The propositions reflect the authors' judgments and are tentative in nature, but they are grounded in findings from our review. We have acknowledged apparent differences among the countries where information allows. We recognize, however, that these propositions may not apply in every case. We believe they provide a beginning framework useful for discussion and comparative analysis of past, present, and future attempts to integrate science into natural resource policy and management, both within and among our countries.

Findings From the Literature and Case Studies

Numerous examples are described in the literature and ongoing research where attempts have been made to integrate science and policy. We drew on several sources to identify and understand examples of science-policy projects in North America. These included reviewing the formal literature and written descriptions and critiques of past (as well as ongoing) projects, and interviewing people familiar with specific projects or the general topic. We will not describe the specifics of any particular case in this paper, but the cases reviewed and used to form the basis for our conclusions are given (see "Case Studies Reviewed"). We found that information about the topic of this paper is scattered and fragmented, making it difficult to draw easy conclusions.

This paper represents a beginning to understanding science and policy interrelations in North America: We found that we have much to learn from one another. We **must avoid, however, the tendency to overgeneralize from one country, or even from one case, to another.** The particulars of the situation and context surrounding the cases make drawing firm conclusions and generalizations a risky business. **There are some important differences among the three countries that help to explain different approaches to seemingly common problems in the integration of science and policy.** Before turning to the findings from our review, we first describe some general differences that may serve as context for understanding and interpreting the specific propositions that follow.

United States

Generalizing from the U.S. experience can be misleading with respect to Canada and Mexico. Because of a strong Federal Government in the United States, and the deliberately fragmented and open character of decisionmaking authority under the U.S.

Constitution, **unresolved conflicts about an issue may slowly work their way through the legal and political system, sometimes paralyzing attempts to resolve them.** Federal Forest Service researchers in the United States are in a separate branch of the Agency and conduct basic and applied research on both public and private lands. **The U.S. Forest Service model of having a large number of Federal scientists in formal research roles located across the country is less familiar in Canada and Mexico.** Recently in the United States, several major, intensive efforts have occurred to resolve natural resource disputes with scientific involvement. These efforts have covered vast areas (e.g., the Forest Ecosystem Management Assessment Team [FEMAT], and the Columbia River Basin Ecosystem Assessment) and have attempted to integrate biological, physical, social, cultural, and economic considerations. Often called "scientific assessments," these have been initiated by the Federal Government because of the focus on Federal forests, various threatened and endangered species, or other issues such as forest health or the preservation of old-growth forests. The United States has a Threatened and Endangered Species law not found in the other countries; **this has been an important impetus for many cases.**

Canada

In contrast to the United States, Canada has more centralized and autonomous decisionmaking with a Westminster system of prime-ministerial government (Hoberg 1993a, 1993b). In resource and environmental policy, the authority of the provinces is stronger compared to the Federal Government than is the authority of the states in the United States. **Science often plays an important role in a a "blame avoidance" strategy by decisionmakers who have ultimate and undivided authority to make a decision** (Harrison 1996). Members of scientific and technical panels in Canada (and in the United States in some cases [Jasanoff 1990]) are often explicitly chosen to reflect the perceived balance of interests in the underlying conflict, and they are expected to ensure that a scientific consensus is acceptable to affected interests. In the case of the BC Biodiversity Field Guide Technical Committee, for example, both forest industry and environmental associations were directly consulted about committee membership. Often, **government technical specialists in nonresearch roles in Canada play a more important scientific role, in comparison to the United States, because of the lack of critical mass of agency scientists in some provinces.** The provinces play a more central role in deciding who will be included in research on most natural resource issues, due to the strong provincial government role in managing natural resources on public (Crown) lands. In general, Federal research scientists in Canada are either invited by the provincial governments to participate, or are automatically included in specific issues where the Federal Government has jurisdiction. **All scientists in government are increasingly being driven by policy**, and the public and politicians would like scientists to be more involved in public debates on resource management. A perception exists, however, that **policymakers and politicians expect scientists to say the "right thing" from the policy or political perspective.** Obviously, this is problematic if science and policy are not in agreement. The Clayoquot Sound Scientific Panel is an example where this problem was anticipated and avoided, largely **because scientists took care in negotiating their role and objectives and maintained control of the agenda throughout the process.**

Mexico

Mexico's Federal forest science capabilities recently were separated from the forest management agency, Secretaria del Medio Ambiente, Recursos Naturales y Pesca (SEMARNAP), into a separate research branch, National Forestry, Agriculture and Livestock Research Institute Natural Institute of Forestry and Agriculture Resource (INIFAP)–a situation not unlike the U.S. Forest Service. Because of their more intense involvement in applied research and policy science, Mexican researchers are more keenly aware of the political process than are their counterparts in the United States. **Ejidos (communal land ownership arrangements) provide the opportunity for involving scientists with indigenous communities in solving ongoing policy questions and issues.** Ejidos cover an estimated 70 to 80 percent of Mexico and are important forms of social organization (Bray 1995, 1996). In some of the more successful projects, mechanisms have been put into place to join indigenous knowledge with knowledge from science and technical information from practitioners to community-based projects. **Scientists, policymakers, and residents work together to develop and implement policies that provide sustainable resource use while providing opportunities for residents to make a living from the land.** Some successful examples are the research by the INIFAP in social forestry enterprises belonging to the land owners in the ejidos and indigenous communities in the States of Chihuahua, Durango, and Oaxaca. In an approach similar to the Canadian Model Forest Program, Mexico has projects demonstrating sustainable silviculture with strong local community participation. Mexico also has recently begun a commercial forest plantation program that has necessitated the application of scientific knowledge to develop suitable policy for its implementation. This program has involved private enterprise, local universities, and research institutions. **Documentation of the results of such arrangements is limited** (Bray 1995).

Science and Policy Projects

Origins

Controversy is the impetus for many cases. **Most of the well-known science-intensive policy efforts have had their origins in serious difficulties or crises over government policy**. These situations created a level of political, social, and economic significance for policy often outside the experience and expectations of researchers and managers. Consequently, there are few guidelines to respond to and by which to evaluate effectiveness. Such situations often are described as having been triggered by particular government policies, laws, and lawsuits (particularly in the United States), but those **controversies usually reflect larger changes in social values and concerns that the government failed to notice or adequately address.** Forest policy-related science assessments often are driven by the need to demonstrate (often in court in the United States) that there are "scientific reasons" to believe the agency is or is not following the law. In Canada, issues come to be defined as a policy problem in a more directly political way, and policy science will often be used to underwrite a political solution that brings together diverse interests. Both approaches may be unsettling to scientists. **In some instances, scientists fear that policymakers and politicians will tell them what the results should be before the research is initiated.**

Many of the cases were interrelated. Sometimes parts of the cases grew out of each other, while in others they shared key personnel. Expertise was used across the border between the United States and Canada and the United States and Mexico in some instances. **Although there is nothing wrong with treating the cases separately, they might appropriately be viewed as part of a larger emerging trend and not just the products of discrete management needs in a particular location.** These trends may be observable at several levels, including (1) the more direct involvement of scientists in resource policy or "reflexive science" (Giddens 1991), wherein the object of study is rapidly changing in response to science itself; (2) the contemporary prestige of science and scientists that makes them useful political resources; and (3) the increasing chance that individual scientists and managers have previous experience in science-intensive policy development.

Most of the large-scale scientific assessments or panels were able to build to some degree on prior government-supported research, but **emerging or ongoing conflicts, new laws, and the threat of lawsuits were critical to focusing, intensifying, and often upgrading policy-relevant research.** Accordingly, these crises and legal and political changes might be understood as potential assets for initiating responsive and relevant research and policy, and not just as problems.

Setting Objectives for Integrating Science and Policy

The clarity and specifics of objectives differed considerably among the cases studied–some having no written objectives at the beginning of the project, and others having very detailed objectives. Although it seems apparent that at least some clearly stated objectives will be required to effectively integrate science and policy, **there is no apparent correlation between the initial degree or detail of objectives and the ultimate success of the project.** We recognize, however, that the definition of "success" is problematic and may differ among projects.

It is clear that objectives ordinarily will need to be determined, reviewed, clarified, and communicated during the course of a project. In addition, widespread understanding of and commitment to objectives by project staff may be as important to ultimate success as formal specification at the outset. Who sets the objectives is a concern in each of the countries. Are they set by policymakers, politicians, scientists, citizens, or some combination? The appropriate approach differs by country and is determined by the cultural and political norms of each. **Objectives may include several dimensions.** First, how well is the problem defined? Is the science directed at a clear policy or a surrogate issue (Rayner 1996)? Is there a valid role for science or are scientists being used to stall or avoid decisions that may be unpopular? Second, is the scientific team able to make sense of its objectives, refine them if necessary, and commit to them? This likely will depend on numerous factors, including the experience and personalities of the individuals involved.

Roles and Relations Between Scientists and Policymakers

In all three countries, **the distinction between science and policy roles in modern natural resource management is both very important and difficult to define.** If scientists are defined as generating new knowledge, and managers as allocating land to particular uses, then the relations between the two may be changing significantly. Many past cases as well as ongoing projects show **resource managers becoming**

increasingly involved in research and knowledge production, and scientists becoming increasingly involved in designing management technologies and prescriptions.

If this is an appropriate change from traditional roles, **scientists must become more comfortable with the history and practice of resource management, and resource managers must become more comfortable with the history and practice of science.** This may be difficult, because the traditions and reward systems define themselves, to some extent, as in opposition. In particular, owing to the criticism that management-sponsored research is of variable scientific quality, these changes may be problematic if care is not taken to ensure that management "studies" are well designed and appropriately reviewed before their results are used in decisionmaking. Similarly, science intended for application in policy formulation will not be useful if inappropriate attention is given by scientists to setting objectives and acquiring information relevant to management.

This challenge may be especially difficult for scientists, who traditionally have stressed the distinction between those who qualify as scientists and those who do not (Gieryn 1983). This is often done by emphasizing the use of formal titles such as "Dr." or debating who is qualified to provide peer review, sit on graduate committees, and so forth. **The primary effect has been to decide who does and does not have expertise-based authority to speak about an issue** (Gieryn 1983). As administrative research and adaptive management become increasingly widespread, so presumably will the debate about such authority and the meaning of "expertise."

As science issues and legal or political challenges gain importance, managers feel themselves losing the capacity to direct agency activities. Controversy and declining resources exacerbate the sense managers have of being unable to direct events or obtain sufficient research to respond effectively to a turbulent environment. In some of the cases reviewed, managers were not invited or allowed to participate in scientific assessments or panels. Experience suggests that **excluding managers and agency specialists from scientific panels and assessments makes implementation of policy difficult.** "Tacit knowledge" (Polanyi 1966) is used frequently in the actual practice of science. Some way of recognizing its importance would help bring managers and scientists together both during and after policy formulation.

Furthermore, **all forms of knowledge (from science, managers' experience, and indigenous knowledge of citizens) should be given more credibility by scientists and policymakers.** The preoccupation with technical knowledge held by experts has limited our ability to understand complex relations among biological, human, and physical systems (Clark and others, in press). Indigenous knowledge is by itself incomplete (Bray 1995), but the same is true of scientific knowledge, or knowledge from managers' experience. **When scientists reject such knowledge as invalid or not useful, this is seen as arrogant and has been stated as a major obstacle to developing and maintaining constructive, mutually supportive relations among scientists, policy-**

makers, and stakeholders. In comparison to the United States and Canada, Mexico has more experience in working with indigenous populations in ejidos to use local knowledge along with technical information to develop sustainable forestry practices relative to community needs. Documentation is poor, however, about the success and failures of these efforts (Bray 1995).

When science is driven by immediate policy concerns, the tendency is to view the science and policy interrelations as a single process and to evaluate one effort in terms of its implications for the other. In contrast to more traditional science, scientists engaged in policy-driven research often have little control over the agenda and timing of their work; sometimes experience difficulty getting information they need; usually have their work scrutinized and evaluated by nonscientists; frequently have difficulty adapting to political and legal norms to defend their scientific conclusions (Salter 1988); are concerned about involvement with controversial management issues and problems; and worry about being held responsible for failed policy and management or being compromised by political agendas and motives. In all cases, highly charged political controversy may be difficult for scientists when there is strong government control of financial resources and the research and policy agenda.

Science and policy projects can, but do not always, lead to more effective interagency relations. For those relations to develop, the following factors seem to be important: interdependence of agency policy objectives; mutual interest in improved science and science-based management; recognition of the ineffectiveness of strategies based on protecting turf or simply blaming one another; and effective “boundary spanners” who are personally interested in maintaining ongoing relations between scientists and policymakers and among agencies. **In all countries, we observed that adversarial relations can become valuable resources over time.** As professionals (managers and scientists) from different organizations learn about one another and recognize the value of their different perspectives and expertise, they often become mutually supportive and more effective at jointly understanding and resolving complex problems.

Organizing and Managing of Science and Policy Projects

Attempts to integrate science into policy differ considerably in their essence. Some examples were not defined or organized as discrete “projects” until well along in their history. Others (often called scientific assessments in the United States and scientific panels in Canada) were planned and understood from the outset as focused efforts to address a particular policy problem as systematically and comprehensively as possible. Some examples, particularly in Mexico, were not “projects” in the sense found in Canada or the United States, but represented ongoing activities in community-oriented settings or ejidos.

The move toward increasing community inclusion in forest policy and management issues poses interesting opportunities and challenges for policymakers and scientists. The long-term experience in Mexico’s ejidos, and the potential offered in Canada’s Model Forests and the Adaptive Management Areas of the U.S. Pacific

Northwest, have a common focus on redefining relations among communities, science, and policymakers. Each of our countries would benefit from evaluation of the successes and failures of these arrangements.

Reactions to efforts to involve the public directly in science processes are mixed, but positive on the whole. Managers perceive that public science meetings help scientists to understand public concerns and to explain themselves clearly, as well as help lessen public misunderstanding and opposition. Scientists generally agree but also note significant drains on their time. A central issue facing managers of science and policy projects is clarifying the role that the public will play in such efforts. Is it a one-way or a two-way learning process?

Organizational structure can either constrain or facilitate the integration of science and policy. Although some assessments had formal organizational structures based on the traditional hierarchical model shown in figure 1, scientific assessments and panels seem to operate most effectively in the loosely coupled model depicted in figure 2 (Meidinger 1997). In general, the situation in Mexico is more likely to resemble the loosely coupled model at the project level than would similar situations in the United States or Canada.

Leadership is important in both models (figs. 1 and 2) to effectively integrate science and policy and is not necessarily related to position in the formal organization. Scientists do not necessarily respond to what they detect to be "orders," even if the orders are coming from the top of a traditional hierarchy. Major leadership challenges include setting and meeting goals and objectives (that may be inconsistent with traditional science and policymaking expectations), obtaining and distributing resources, creating and nurturing appropriate interrelations and integration between nontraditional science and policy, ensuring accountability and quality, and maintaining both internal and external communication.

The tenor and level of trust between science and management differ considerably among countries and across agencies. Local history, individual personalities, and responsiveness of scientists to management problems may help to explain the differences. One mechanism for improving science and management relations is to hold intensive policy and science discussions at the outset of the project to decide the issues that need to be addressed and how to address them.

Though perhaps rare, **there have been cases where policymakers or policy implementers have edited science publications to make management policies seem less questionable.** Because this has the capacity to seriously undermine the credibility of both research and policy, directly prohibiting such actions and living with a higher level of ongoing public questioning may be appropriate. **This problem may be less likely to occur in formal organizations where scientists and science management are separate from policymakers.**

Resource managers often express a desire to do "just-in-time science"-science that is ahead of management, but not too far. How to recognize and foster just-in-time science in practice, however, needs further development. **"Just-in-time-management" also may be an important focus**–a recognition of the need for managers to better track changes in social and cultural values and concerns to be able to ask for science that is "ahead of management, but not too far." **Policy generally moves faster than science, and the capacity of scientists to provide information may require more time than policymakers are willing to accept, especially for politically hot issues.**

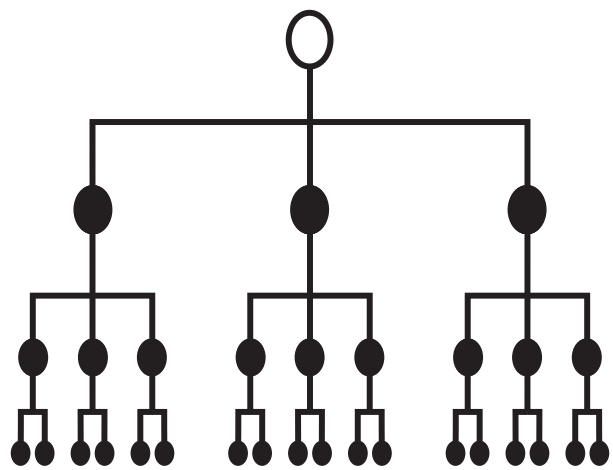

Figure 1–Classical bureaucracy.

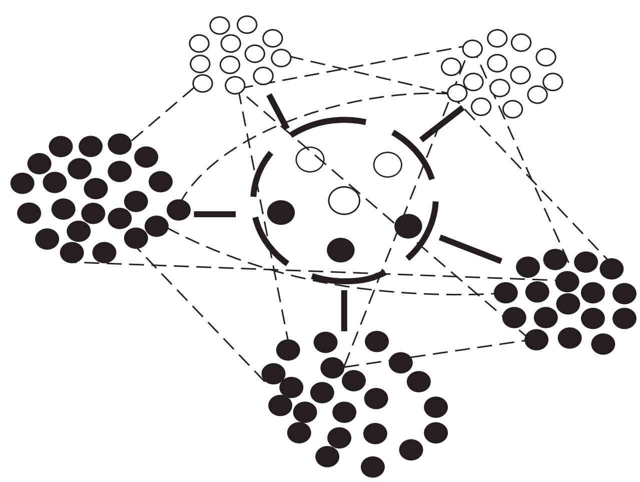

Figure 2–Loosely coupled organization.

Managers increasingly view science as something that can provide them with "management technologies" or "operational tools," by which they mean a workable mix of management activities, guidelines for when and how to use them, and indicators that should be measured and worried about. This may be particularly true in developing countries because of limited budgets and scientific personnel. **Some scientists are concerned that this will divert them from what they perceive to be the "real business" of long-term science.**

Science Relationships in Policy

Substance–Many scientific assessments that started with a particular species or problem orientation ended up with a broader ecosystem focus. Even when assessments evolved to a broader orientation, the original focus may have been helpful in clarifying the nature of work that needed to be done and preventing the effort from spinning off to attack an infinite number of questions. **In Canada, the evolution is toward ecosystem-based studies without formal, large-scale scientific assessments as background.**

Scientists involved in the cases often question whether their work constitutes "science." Authors of one major assessment in the United States clearly state that their work was an instance of scientists involved in policy analysis (FEMAT 1993). Jasanoff (1990) found the same sentiment in her research on regulatory policymaking: "The experts themselves seem at times painfully aware that what they are doing is not science in any ordinary sense, but a hybrid activity that combines elements of scientific evidence and reasoning with large doses of social and political judgment." Rather than taking these observations at face value, however, **it might be useful to ask whether policy assessments can be seen as or made into parts of a larger scientific enterprise.** In such an approach, preliminary choices could be made based on the best available evidence and then be treated as hypotheses whose effects are to be tested over time with appropriate monitoring and evaluation research (Campbell 1969).

There are two divergent perspectives about the roles of scientists. One emphasizes rigorous testing and evaluation, a sharp distinction between facts and values, and a preference for models over metaphors. In this perspective, a clear boundary exists between traditional science and science for policy. The other perspective emphasizes uncertainty, the existence of multiple competing hypotheses, collective learning (Haas 1991, Lertzman and others 1996, Sabatier and Jenkins-Smith 1993), and incremental change (Collingridge 1983). **The latter perspective is likely more amenable to integrating science and policy than the former.**

An important question facing integrative policy science across North America is how to train people to do this work effectively. **The most common hypothesis is that this ability comes only from direct experience in policy-science projects.** An alternative explanation is that science-policy integration is teachable, but only by requiring better information and education. A synthesis about what works well, when, and why in science and policy interrelations would facilitate learning.

Organization and process of science–As science and policy projects proceed, **informal divisions of scientific labor often emerge based on interest, access to data, and prior work.** Although productive, this "comfortable" arrangement poses the risk of devolving into disciplinary subgroups with inflexible definitions of problems and solutions, whose work is difficult or impossible to integrate with that of other subgroups. **One of the biggest challenges in recent science efforts is the integration of diverse forms of knowledge, data, and perspectives into a single product or set of conclusions.** There is disagreement about the level of integration actually achieved in the projects, but there is general agreement on the importance of integration. **Numerous personal, group, and organizational barriers to integration need to be resolved** (Clark and others, in press). Key among these barriers are refusing to accept some kinds of knowledge as legitimate, hidden agendas, distrust, unclear definitions and expectations, failure to address policy-relevant questions or problems, lack of appropriate access by stakeholders to the policymaking process, keeping important decisions off the table, lack of incentives (or presence of disincentives), and conflicting laws within and among agencies.

The life spans of the projects studied, which ranged from a few months to several decades, had a major influence on both the conduct and content of the science. Because of the time involved in gathering, analyzing, and reviewing field information, which is often seasonal, many assessments involving new empirical research are likely to last several years. In these cases, important questions are shared with disciplines at large, extending well beyond those formally involved in the project. In other situations, where there is a need for a relatively quick solution to diffuse a contentious issue, the development and acceptance of special techniques, such as the expert judgment panels used in FEMAT (1993), may be fundamental to success. Work is needed to develop such techniques and the means for evaluating them because there likely will be additional issues that take agencies by surprise, however hard agencies try to anticipate them.

High levels of controversy have sometimes increased the capacity of university-based researchers to obtain external funding for policy-relevant research. Where it can, government might wish to treat research as an opportunity to obtain improved information and formalize arrangements for obtaining results on an ongoing basis. In some instances in Canada, however, concerns exist about the ties of university researchers to industry and industry-funded research. Such "guilt by association" occurs in both the United States and Canada, particularly in controversial issues. **The closer a scientist (whether in universities or government agencies) is perceived to be linked to either side of a controversial issue, the more tainted he or she is and the more likely results will be questioned or ignored.** For example, a significant problem is whose data to use when multiple data sets exist. This can set up conditions where substantial energy goes into battles in and out of court to discredit the other party's data or the assumptions on which they are based.

Broad, multistakeholder science-policy conferences, in which scientists gather to assess the state of knowledge relevant to policy problems, can play an important role in focusing and clarifying science issues, as well as shaping policy needs. These gatherings are useful to determine whether a consensus exists on the state of scientific knowledge in the problem area. In some situations, **a need may exist to find a means of achieving consensus around the major concepts or metaphors that will guide the research.** These metaphors are the key to policy-relevant science because they pull together fact and value, and span the conceptual boundaries that scientists otherwise try to defend. **"Bridging concepts," such as ecosystems and forest health, have been important in major scientific assessments and panels in the United States and Canada.**

Peer review has been used increasingly to legitimatize science-intensive policies. In the cases studied, approaches to peer review differed. Some projects included the public in peer review, even **though many scientists dispute whether nonscientists are peers.** Some agreed to call it technical review instead of peer review. In that way, people besides scientists could be included in the review. **Peer review for policy-oriented science is less common in Canada than the United States, largely because of a tradition in Canada of relatively closed bureaucratic decisionmaking.** There has been, however, a practice of advocacy review in Canada (and in the United States in some cases)–the practice of affected interests commissioning reviews from scientists or analysts known to be sympathetic to their policy position. **Provided that all interests can afford to do this, it can provide a useful way of improving the quality of the policy discussion by focusing on areas of scientific disagreement and uncertainty.**

Standards and procedures for peer reviews differ greatly. There are few uniformly accepted criteria for selecting reviewers beyond basic competence. Thus the science manager (or journal editor) usually has considerable discretion in selecting reviewers who are likely to be more or less favorable to a given piece of work. **Criteria for selecting reviewers should be made clear to all parties involved in or interested in the project.** It appears, furthermore, that **the closer internal scientists are to policymaking about controversial issues, the greater the need for external review and oversight.** Jasanoff (1990) suggests the need for processes that are both "transparent" and "publicly witnessed."

It is important to document policy decisions in a way that can be easily explained and understood. Clearly explaining how management and policy discretion was used, and where science did or did not play a role, can do a great deal to make policy decisions understandable and acceptable (Waddell 1989) and protect the credibility of science. **One barrier to using science in policymaking is the use of scientific jargon that neither policymakers nor the public understand.**

Advocacy and values are difficult to avoid–Advocacy of personal or professional positions is a matter of intense concern and considerable disagreement between scientists and policymakers, particularly in the United States. **Inappropriate advocacy and value judgments by scientists can make the integration of science and policy difficult.** Value judgments arise in various contexts and sometimes cannot be avoided. **The dividing line between science and advocacy assumes a basic distinction between facts and values, and that facts should be the province of science and values the province of managers.** In reality, this position is problematic on several grounds:

- **Scientists frequently advocate the importance of specific kinds of research.** This is brought about by the competition for limited research funding among disciplines, such as silviculture and forest ecology or biological and social sciences. Choosing one over the other is a value judgment with the result often affecting scientific capacity to support responsive public policy about complex issues.

- **Scientists assert that their proposed research will do more to solve important problems than competing research.** Of course, doing so requires a definition of "important" problems and solutions. Those definitions often reflect fundamental premises that are both normative and empirical but generally cannot be proved or disproved empirically (at least in real time).

- **Scientists often disagree sharply about the implications of uncertainty. Their respective views are probably related to transscientific values and assumptions about nature.** Uncertainty is a pervasive attribute of science. Regardless of whether it can be meaningfully quantified, scientists will always be faced with how to deal with uncertainty (Thompson 1986). The view one takes, however, has major policy implications.

- **Some of the most important work in natural resource science involves developing unifying concepts.** Examples include ecosystem integrity, sustainability, community stability, social resilience, ecosystem health, and the like. **Although such concepts help organize otherwise incomprehensible data, and may be essential to analysis, they also contain normative implications about appropriate policy;** e.g., do what preserves ecosystem integrity or community resilience. Some of the cases studied involved significant discussions and negotiations about unifying concepts, in part because of their policy implications.

- Considerable evidence supports the proposition that **scientists may have to successfully advocate policy proposals before they will have any chance of proving or disproving their hypotheses** (Latour 1987). Getting a fair test of any significant hypothesis or proposition may involve persuading nonscientists to accept it in a policy context. This may increase in the future, as policy needs increasingly drive science and technology programs.

Policy and Decisionmaking

Underdal (1989) argues that the impact of policy-oriented science is likely to be strong when, among other things, there is a definite or at least consensual conclusion, a feasible cure is available, the problem develops rapidly and surprisingly, effects are experienced by or at least visible to the public, and there is low political conflict.

In contrast to Underdal, others suggest that depending on the political system, **the impact of science on policy can often be strongest when there is at least an intermediate level of political conflict (Sabatier 1988) that forces entrenched interests to take their opponents' claims seriously.** For example, it could be argued that the uncontested adoption of the Clayoquot Sound Scientific Panel's recommendations in British Columbia is a result of the very intense conflict that gave rise to them. **The recommendations were seen as offering all involved a chance to step back from a confrontation that had exceeded Canadian cultural norms.**

Management problems or natural disasters, although typically viewed as situations for which science should have answers in hand, might often be better understood as providing opportunities for scientific research and development (Campbell 1969, Lee 1993). The blowdown caused by Hurricane Hugo in the Francis Marion Forest in 1989, for example, created an opportunity to test largely unproved "artificial cavity" nesting techniques recently developed for birds. As a result, progress on the research occurred much faster than otherwise would have been the case. At the same time, **there may be reasons, typically political, why managers cannot wait for more research, however opportunistic, before making decisions.**

Managers often are frustrated by conflicts among scientists who argue contrary points of view and by science "answers" that frequently change. A common rebuttal is that science is an evolutionary (and at times even revolutionary) process, often with competing explanations for why things are as they are. As new theory, concepts, and empirical "facts" emerge, conclusions can shift quickly, making it difficult for policymakers to formulate policy with any "scientific certainty."

Intensive research can create new information that conflicts with existing management policies developed or implemented by field specialists. Field specialists may resist the new information or its management implications. To address this problem, managers have, among other things, arranged for their field specialists to participate in research and communicate regularly with researchers and have provided mechanisms for directly overriding (or even replacing) their field specialists. In many cases, **outside pressures or legal challenges forced policymakers to seek and adjust to new information.** Because these challenges ultimately may strengthen the ability to gather policy-relevant information, **mechanisms that regularly force policy consideration of new information may be necessary; e.g., use of science advisory committees or public panels.**

Intensive science efforts seem to have the capacity to either dampen political conflict or amplify it. Graham and others (1988) reach the same conclusion in their study of setting appropriate standards for formaldehyde and benzene; scientific advances do not predictably correlate with reductions or increases in policy conflict. **Scientists must use extreme caution in claiming how far their efforts will go towards solving what are inherently political, as well as scientific, problems.**

Adaptive management often is offered as a mechanism to facilitate the integration of new scientific information into policy. As Lee (1993) suggests, this may have immediate extra costs but long-term benefits.

- The continuing flow of new information produced by intensive research programs suggests adaptive management as a means to absorb and adapt to the new information. **There is a serious question about how well current planning processes fit with adaptive management.** Perhaps a mode of continuous scientific assessment and aggressive monitoring, coupled with long-range goals, would help produce more effective management than do current planning models.

- **There is considerable disagreement about the type of policy guidance that should flow from scientific assessments and panels. Some cases have led to direct land allocations with detailed standards and guidelines.** Others led to more general guidelines, allowing a **higher degree of field level discretion.** The reasons for choosing one kind of policy over the other merit discussion; their effects on management should be reviewed empirically.

- **The role of research might change under an adaptive management framework.** Some argue that research should be more intensively involved in designing, sampling, and monitoring, and use both social and natural resource sciences to determine when things work (or not) and why. Others submit that this would erode scientific credibility and diminish the ability of science to focus on long-term questions.

Contrary to the oft-repeated assumption that science can contribute significantly to policymaking if it is sufficiently sound and responsive, Collingridge and Reeve (1986) argue that science is by nature unsuited to policy processes. This is because science always encounters either an “under-critical” or an “over-critical” policy environment. In an under-critical environment, a broad policy consensus exists before any research is undertaken. Accordingly, scientific claims that support the policy are too readily produced and accepted; there is little support for or interest in scientific claims unsupportive of the policy. In an over-critical environment, by contrast, scientific claims are made by various scientists associated with different camps; all claims are subjected to a debilitating level of scrutiny by opponents. **In an over-critical policy environment, no scientific claim stands up, endless debate occurs, and science suffers reduced public respect.** “Inevitably, science cannot deliver on its promise, often leaving the public and policymakers disappointed and angry, and scientists equally angry about the harsh treatment they received in the vicious policy process (Meidinger and Antypas 1996:13). This is particularly evident when science goes to the courtroom.

Some Lessons and Challenges for the Future

Responses to the combination of complex natural resource issues, controversial decisions, and incomplete knowledge on which to base decisions (and to evaluate the results) have differed within and among the three countries. These differences likely are a function of various factors, including the historical, political, social, and cultural differences among Canada, the United States, and Mexico as well as the natural and physical diversity. Several propositions follow that seem to apply across North America and may serve as potential lessons or testable hypotheses.

We must recognize and honor the differences among the three countries in the policy approaches adopted for natural resource management, as well as the engagement of science in setting policy direction. Appropriateness of science, policy, and their integration must be judged in context of each country's legal, cultural, and institutional context. Approaches from one country may compound, rather than help solve problems, when applied inappropriately in the context of another country.

There are no obvious right or wrong ways to integrate science into policymaking in natural resource management. Diverse problems likely will require diverse responses suited to particular circumstances. There are certainly areas where each of the cases we reviewed could have been improved. But a serious question is whether a standardized approach is needed or appropriate. Although arguments can be offered for both perspectives, improved documentation, monitoring, and evaluation are needed in all cases. **There are several prerequisites to successfully integrating science and policy:** clarity of objectives, processes, and desired outcomes; clarity of roles and responsibilities of scientists, policymakers, and the public; quality control through open peer and public review; and effective communication and involvement of stakeholders throughout the process.

Political or legal issues cannot be "solved" by more or better science. The turn to science often reflects a failure of other processes (political, management, legal, regulatory, negotiation). It is imperative that the roles, strengths, and weaknesses of science in resolving policy problems be clear from the onset of a project. **There is a need to define the limits, boundaries, and capacity of science to avoid creating situations where science is involved in ways not suited to the problem needing resolution.**

The focus on crisis-driven scientific assessments or panels should not overshadow the need for day-to-day integration of scientists and scientific information into resource policy and decisionmaking. In some respects, the increasing number of large assessments and scientific panels indicates a failure of ongoing activities to ensure that science is readily available to policymakers in a usable form. Or, perhaps the failure is due to policymakers not using what information is available. Whatever the reason, the failure to deal with manageable issues or problems in small ways over time can result in a "tyranny of small decisions," ultimately leading to a crisis requiring a major response. **These intensive and expensive efforts may distort the primary issues underlying the conflict, and they can polarize the debate as competing interests contend for political or legal favor.** Then again, when the need arises, these large efforts provide opportunities to focus substantial energy on complex problems facing society.

Boundaries can be a major impediment to easy integration of science and policy. International and geographically drawn boundaries, such as those between countries or management agencies, or "boundaries of the mind," such as cultural differences, scientific discipline, or management functional area, make effective integration difficult. **"Boundary spanners" are very important to science-intensive policy processes** because their efforts are generally aimed at evaluating, formulating, or altering management policy; these efforts must be both scientifically credible and administratively implementable.

1. Boundary spanners are individuals who can link the worlds of science and management and translate the concerns of one to members of the other.
2. Boundary spanners can be either managers who are conversant (or willing to become so) in the knowledge and culture of science, or scientists who are conversant (or willing to become so) in the knowledge and culture of management.
3. Because of the educational and socialization processes in most management and science cultures, boundary spanners are, by definition, quite rare.
4. If organizations seek to achieve effective assessments on a routine basis, then they will have to routinely produce boundary spanners.
5. Routinely producing boundary spanners will probably require altering incentive structures in both management and science branches and may require increased opportunities for staff crossover experience.
6. The concept of boundary spanners applies to the three countries as well. Boundaries and borders get in the way in a number of ways and often separate problems from solutions (Ingram and others 1995).

For issues that transcend the borders, there is an opportunity and need for workgroups to organize around common issues. The move toward the study of whole ecosystems (including humans), that rarely respect national or subnational boundaries, makes this need especially urgent. Some informal links already exist among scientists that could be used for developing more permanent structures if needed. **The involvement of scientists and managers in cross-boundary working groups offers an important way to build a genuinely informed understanding of each other's unique problems and areas where existing research and management experience can be readily transferred from one jurisdiction to another**. These informal working groups also can build on the experiences from collaborative science and policy development, represented by efforts such as the Canada-US and Mexico-US International Boundary and Water Commissions (Dworsky and others 1995, Mumme 1993).

Incomplete information about what is occurring in the science and policy arena within and among the three countries confounds drawing definitive conclusions. Part of the problem is the difficulty in finding documentation about past or ongoing activities. This is hard in one country, but even more so when looking at a continent. A criticism often made about resource management institutions is their failure to develop mechanisms to identify, gather, organize, and make available the knowledge resulting from the trial and error of policymaking and management. **This lack of institutional memory makes certain the inability to learn the lessons of the past.** Yet, with the high stakes involved in making decisions about valuable public as well as private resources, and the equally high costs of conducting intensive scientific assessments, **we need to do a better job in learning what works and why so that we can apply the lessons elsewhere.** This will require improved processes for documentation and critiques of efforts to integrate science and policy in natural resource management and policy. Certainly this is a cornerstone of effective adaptive management.

We recognize that our review represents only a cursory look at an increasingly important issue within and between our countries. We believe that our collective diversity and experience provides an important opportunity to learn valuable lessons from one another. **We strongly recommend that a more intensive, collaborative assessment be conducted in the future to test and build upon the propositions we draw in this paper.**

References

Bray, David Barton. 1995. Peasant organizations and “the permanent reconstruction of nature:” grassroots sustainable development in rural Mexico. Journal of Environment and Development. 4(2): 185-204.

Bray, David Barton; Wexler, Matthew B. 1996. Forest policies in Mexico. Journal of Environment and Development. 4(2): 216-218.

Campbell, Donald T. 1969. Reforms as experiments. American Psychology. 24: 409-429.

Clark, Roger N.; Stankey, George H.; Brown, Perry J. [and others]. [In press]. Towards an ecological approach: bringing together social, economic, cultural, biological, and physical considerations. Paper presented at the ecological steward ship workshop; 1995 December 4-14; Tucson, AZ. [Place of publication unknown]: [Publisher unknown].

Collingridge, David. 1983. Technology in the policy process: controlling nuclear power. London; New York: St. Martin’s Press.

Collingridge, David; Reeve, Colin. 1986. Science speaks to power: the role of experts in policymaking. New York: St. Martin’s Press.

Dworsky, Leonard B.; Utton, Albert E.; Allee, David J. 1995. The Great Lakes: transboundary issue for the mid-90s. The University of Toledo Law Review. 26: 347-385.

Forest Ecosystem Management Assessment Team [FEMAT]. 1993. Forest ecosystem management: an ecological, economic, and social assessment. Portland, OR: U.S. Department of Agriculture; U.S. Department of the Interior [and others]. [Irregular pagination].

Friedman, Sharon T. 1996. People sustaining forests. In: Proceedings of the 1995 SAF convention; [Dates of meeting unknown]; Portland, ME. Bethesda, MD: Society of American Foresters: 96-101.

Giddens, Anthony. 1991. Modernity and self-identity. Stanford, CA: Stanford University Press.

Gieryn, Thomas F. 1983. Boundary-work and the demarcation of science and non-science: strains and interests in professional ideologies of scientists. American Sociological Review. 48: 781-795.

Graham, John; Green, Laura; Roberts, Marc. 1988. In search of safety: chemicals and cancer risk. Cambridge, MA: Harvard University Press.

Haas, Ernst. 1991. Collective learning; some theoretical speculations. In: Breslauer, George; Tetlock, Philip, eds. Learning in US and Soviet foreign policy. Boulder, CO: Westview Press: 72-76.

Harrison, Kathryn. 1996. Passing the buck: federalism and Canadian environmental policy. Vancouver, BC: UBC Press.

Hoberg, George. 1993a. Environmental policy: alternative styles. In: Atkinson, Michael, ed. Governing Canada: instruments and public policy. Toronto, PQ: Harcourt, Brace, Jovanovich.

Hoberg, George. 1993b. Regulating forestry: a comparison of institutions and policies in British Columbia and the US Pacific Northwest. Work. Pap. 185. Vancouver, BC: UBC Forest Economics and Policy Analysis Research Unit.

Ingram, Helen; Varady, Robert G.; Milich, Lenard. 1995. Enhancing transboundary environmental policy: some principles for the new border transboundary coopera tion commission (BECC). Transboundary Resources Report. [Place of publication unknown]: University of New Mexico School of Law; International Transboundary Resources Center; 9(2): 4-7.

Jasanoff, Sheila. 1990. The fifth branch: science advisors as policymakers. Cambridge, MA; London, England: Harvard University Press.

Latour, Bruno. 1987. Science in action: how to follow scientists and engineers through society. Cambridge, MA: Harvard University Press.

Lee, Kai. N. 1993. Compass and gyroscope. Washington, DC; Covelo, CA: Island Press.

Lertzman, Ken; Rayner, Jeremy; Wilson, Jeremy. 1996. Learning and change in the BC forest policy sector: a consideration of Sabatier's advocacy coalition framework. Canadian Journal of Political Science. 29(1): 111-133.

Meidinger, Errol; Antypas, Alex. 1996. Science-intensive policy disputes: an analytical overview of the literature. Report prepared for the People and Natural Resources Program. On file with: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station, Forestry Sciences Laboratory, 4043 Roosevelt Way NE, Seattle, WA 98105.

Meidinger, Errol E. 1997. Organizational and legal challenges for ecosystem management. In: Franklin, Jerry; Kohm, Kathryn A., eds. Creating a forestry for the 21st century: the science of ecosystem management. Washington, DC; Covelo, CA: Island Press.

Meidinger, Errol E.; Clark, Roger N.; Shannon, Margaret A. 1996. Science and policy in natural resources: conceptual propositions drawn from case studies and the literature. Report for the Renselaerville Science and Policy workshop. On file with: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station, Forestry Sciences Laboratory, 4043 Roosevelt Way NE, Seattle, WA 98105.

Mumme, Stephen. 1993. Innovation and reform in transboundary resource management: a critical look at the international boundary and water commission, United States and Mexico. Natural Resources Journal. 33: 93-120.

Polanyi, Michhael. 1966. The tacit dimension. London: Routledge and Kegan Paul.

Rayner, Jeremy. 1996. Implementing sustainability in west coast forests: CORE and FEMAT as experiments in process. Journal of Canadian Studies. 31(1): 82-101.

Sabatier, [Name unknown]. 1988. An advocacy coalition framework of policy change and the role of policy-oriented learning therein. Policy Sciences. 21: 129-168.

Sabatier, Paul; Jenkins-Smith, Hank, eds. 1993. Policy change and learning: an advocacy coalition approach. Boulder, CO: Westview Press: 13-39.

Salter, Leora. 1988. Mandated science: science and scientists in the making of standards. Dordrecht; Boston; London: Kluwer Academic Publishers.

Thompson, Paul B. 1986. Uncertainty arguments in environmental issues. Environmental Ethics. 8: 59-75.

Underdal, Arlid. 1989. The politics of science in international resource management: a summary. In: Andresen, Steinar; Ostreng, Willy, eds. International resource management: the role of science and politics. London; New York: Belhaven Press.

Waddell, Craig. 1989. Reasonableness versus rationality in the construction and justification of science policy decisions: the case of the Cambridge experimentation review board. Science, Technology, and Human Values. 14(1): 7-25.

Appendix

Case Studies Reviewed

Canada–Clayoquot Sound Scientific Panel, Great Lakes-St. Lawrence River Basin, BC Commission on Resources and the Environment, BC Biodiversity Field Guide Technical Committee.

United States–Columbia River Basin Ecosystem Assessment, Forest Ecosystem Management Assessment Team, In-Stream Flow Adjudication Processes, Interregional Habitat Conservation Assessment, National Acid Precipitation Assessment Project, Northern Goshawk Habitat Assessment, Anadromous Fish Habitat Assessment, Red Cockaded Woodpecker, Southern Appalachian Ecosystem Assessment, Tongass Land Management Plan.

Mexico–Ejido El Largo Forest Management Plan, Ejido La Victoria Forest Management Assessment, Oaxaca Ejidos and Forest Communities Union Assessment, International Paper Forest Plantations Project, Pulsar Group Forest Plantations Project.

Clark, Roger N.; Meidinger, Errol E. [and others]. 1998. Integrating science and policy in natural resource management: lessons and opportunities from North America. Gen. Tech. Rep. PNW-GTR-441. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 22 p.

Relations between science and policy concerning many issues (e.g., health, energy, natural resources) have been changing worldwide. Public pressure to resolve such complex and often controversial issues has resulted in policymakers and policy implementers seeking better knowledge on which to base their decisions. As a result, scientists have become more actively engaged in the creation and evaluation of policy. In this paper we summarize the literature and experience in how Canada, Mexico, and the United States approach the integration of science and policy; we describe some apparent barriers and lessons; and we suggest some issues that may prove fruitful for discussion and future collaboration.

This paper represents a beginning to understanding science and policy interrelations in North America: we found that we have much to learn from one another. We must avoid, however, the tendency to overgeneralize from one country, or even from one case, to another. The particulars of the situation and context surrounding the cases make drawing firm conclusions and generalizations a risky business. There are some important differences among the three countries that help to explain different approaches to seemingly common problems in the integration of science and policy.

Keywords: Science, policy, natural resources, integration, forestry, North America.

Pacific Northwest Research Station
333 S.W. First Avenue
P.O. Box 3890
Portland, Oregon 97208-3890