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Improving the flow of scientific information across the interface of forest science and policy

Linda A. Joyce*

Rocky Mountain Research Station, 240 West Prospect, Fort Collins, CO 80526, USA

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Abstract

The ever-expanding knowledge base of forest science is a challenge for scientists, the public and decision-makers to incorporate into forest policy and management. Scientific assessments have been used as a process to synthesize information on a variety of resource issues, including climatic change. As a process of communication, three attributes of assessments, assessment capacity, stakeholder participation, and articulation of uncertainty, can strongly influence the ability of the assessments to communicate scientific information. The institutional structure of the USDA Forest Service to conduct resource assessments has allowed a sustained effort to conduct periodic synthesis of scientific information and to address new policy issues, such as climate change. The US National Assessment on Climate Variability and Change engaged diverse stakeholders, such as public and private decision-makers, resource and environmental managers, the general public and scientific experts in a broad national and regional dialogue about changes in climate, their impacts, and what can be done to adapt to an uncertain and continuously changing climate. Both the National Assessment and the Third Assessment Report of the International Panel on Climate Change incorporated a language of uncertainty to describe consensus of the scientific community on the report's conclusions. These attributes are important elements of improving the flow of information across the science–policy interface.

Keywords: Natural resource assessments; Assessment capacity; Stakeholder engagement; Participatory approaches; Climate change; Language of uncertainty; Likelihood

1. Introduction

The ever-expanding knowledge base of forestry and forest economics is a challenge for scientists, the public, and decision-makers to incorporate into forest policy and management (Clark et al., 1998). Calls for the increased use of scientific information in policy-making have often led to scientific assessments where scientists synthesize a wealth of information on particular resource issues. These assessments can be viewed as a process of communication between science and policy communities where communication can vary from occasional to regular interaction (Farrell et al., 2001). Cash and Clark (2001) described the interface between science and policy as a fuzzy, dynamically shifting boundary that is ultimately constructed by scientists and policy makers in the

*Tel.: +1-970-498-2560; fax: +1-970-498-1314.
E-mail address: ljoyce@fs.fed.us (L.A. Joyce).

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process of balancing three tensions: (1) maintaining scientific credibility, (2) assuring practical saliency and (3) legitimising the process to multiple participants. Using the assessment process as a way to communicate across the science–policy interface raises questions about assessment attributes and their impact on that communication.

Stakeholder participation and assessment capacity are two elements of design that can strongly influence the scientific assessment (Farrell et al., 2001). Participatory approaches have been suggested to overcome criticisms about the use of models in natural resource assessments where the nature of the model assumptions and uncertainties has been difficult to communicate (Van der Sluijs, 2002). Further, communication of scientific uncertainty as information has been seen as critical in environmental policy formulation (Bradshaw and Borchers, 2000).

For the last 20 years, the international and national scientific communities have been grappling with the issue of climatic change (Smith and Tirpak, 1988; Houghton et al., 1990). This issue includes the changes in climate, the impact of climate changes on forests and of forests on climate, the impact on socio-economic values of trees and forests, the role of forests in the global carbon cycle, and a possible suite of forest management responses for adaptation and mitigation. This issue is complex and diverse and a number of scientific assessments have been initiated to synthesize scientific information with respect to the forest sector. This paper explores the value of institutional structures or assessment capacity, the stakeholder engagement process, and the articulation of uncertainties in the communication of scientific information about climate change to forest managers and policy-makers.

2. Institutional structure contributing to policy analyses: the forest service and RPA

Farrell et al. (2001) defined assessment capacity as 'the ability of relevant groups, organizations or particular political jurisdictions to meaningfully engage and participate in an assessment and to sustain that ability over time.' The strategic planning structure within the USDA Forest Service has sustained periodic resource assessments over time and this assessment capacity allowed for the expansion of topics.

Since the late 1800s, the US federal government has conducted periodic analyses of the condition of forest and rangelands (USDA Forest Service, 2001). The Appropriations Act of 1876 provided for a report on forest conditions. The McSweeney-McNary Act of 1927 authorized the US Secretary of Agriculture to cooperate with states, private owners, and other agencies in 'keeping current a comprehensive survey of the present and prospective requirements from timber and other forest products in the US and potential productivity of forested land therein and of such other facts as may be necessary in the determination of ways and mean to balance the timber budget of the United States' (USDA Forest Service, 1975). The Renewable Resource Planning Act of 1974 (RPA) expanded the Forest Service responsibility to: …prepare a Renewable Resource Assessment …updated …each tenth year and shall include but not be limited to:

(1) An analysis of present and anticipated uses, demand for, and supply of the renewable resources of forest, range, and other associated lands with consideration of the international resource situation, and as emphasis of pertinent supply and demand and price relationship trends;

(2) An inventory, based on information developed by the Forest Service and other federal agencies, of present and potential renewable resources, and an evaluation of opportunities for improving their yield of tangible and intangible goods and services…,

(3) A discussion of important policy considerations, laws, regulations, and other factors expected to influence and affect significantly the use, ownership, and management of forest, range, and other associated lands.

The institutional structure created to manage these periodic assessments included a shared oversight by the Research and Development branch and the Programs and Legislation branch of the Forest Service. Scientists within the Research Branch of the Forest Service, and experts outside of the Forest Service, were drawn on to provide the technical and scientific analyses. The results of the RPA assessment are used as the factual basis for formulating future renewable resource management programs. As the process has evolved, the summary of information for policy makers has become its own document and the supporting technical information and data are published separately (see summary document, USDA Forest Service, 2001 and one supporting document, Mitchell, 2001). The structure of these on-going assessments provides a mechanism by which current scientific information is synthesized periodically to address policy questions identified in the Act (USDA Forest Service, 1989, 1994, 2001).

In 1988, the Forest Service released the draft technical document 'Analysis of the timber situation in the United States: 1989–2040,' a highly detailed study of the future supply and demand for timber and wood products. The summer of 1988 was a summer of record-breaking warm temperatures across the United States. The RPA timber assessment did not address the potential impact of climate change. This omission prompted concerns by one Senator that such an omission in a document planning over the next 50 years was inexcusable. The structure of the RPA process lent itself to the inclusion of such concerns and, the Forest Service responded in the short-term with a synthesis of the current understanding of the potential effects of global climate change on US forests (Joyce et al., 1990).

The 1990 Food, Agriculture, Conservation, and Trade Act amended the 1974 Resources Planning Act and required the Forest Service to assess the impact of climate change on the condition of renewable resources on forests and rangelands, and to identify the rural and urban forestry opportunities to mitigate the buildup of atmospheric carbon dioxide. Thus, a new policy issue was added to the structure already in place. RPA assessments have since included an analysis on the vulnerability of US ecosystems to changes in climate, and the potential impact on the forestry social and economic systems (Joyce, 1995; Joyce and Birdsey, 2000) as well as the potential for carbon sequestration in forests (Joyce and Birdsey, 2000).

In conclusion, this institutional structure sustained sufficient capacity to conduct periodic assessments over a long period of time and was flexible enough, or had sufficient capacity, to include new and novel policy issues such as climate change. In addition, it also afforded new opportunities to capitalize on inventory data already collected within the agency for new policy issues such as the use of forest inventory data in quantifying carbon in forests (Birdsey, 1992) and wood products (Heath et al., 1996; Skog and Nicholson, 2000). These assessments facilitated opportunities to identify new research that built on existing agency policy models (Joyce et al., 1995), and new research activities with other emerging research programs (Birdsey et al., 1996) as well as opportunities to address new data needs for these new policy issues. The results of these analyses provided the basis for US analyses to international discussions on climate change and carbon sequestration (US Department of State, 2000).

Farrell et al. (2001) concluded that maintaining assessment capacity over time requires a dedication of resources and that institutionalized mechanisms for long-term funding of assessment and monitoring should be considered where there is a perceived long-term need for these activities. An important factor that contributed to the long-term maintenance of assessment capacity in the cases that Farrell et al. (2001) examined was 'broad framing' that is the ability of the institution to pursue connections between the initial resource objective and various associated resource issues. In this example, the expansion to include climate change and the extension of the inventory analysis into carbon accounting reflect a 'broad framing' in this institutional structure.

3. Capturing stakeholder input in policy-making: US national assessment

Participatory approaches have been described as institutional settings that bring together various interests at some stage of the environmental policy-making process (Farrell et al., 2001; Van den Hove, 2000). The climate change issue has all of the characteristics such as complexity, uncertainty, large temporal and spatial scales and irreversibility, all of which necessitate participatory approaches according to Van den Hove (2000). The National

Assessment on Climate Variability and Change involved the active participation of a diverse set of stakeholders nationally, regionally and sectorally (National Assessment Synthesis Team, 2001).

The Global Change Research Act of 1990 requires the National Science and Technology Council (NSTC) to: (1) assess current human-induced and natural trends in global change; (2) analyze effects of global change on the natural environment, agriculture, energy production and use, land and water resources, transportation, human health and welfare, human social systems and biological diversity; and (3) project major trends for the subsequent 25–100 years. The NSTC coordinates science, space and technology policies across the US federal government. While the technical details of the assessment were described in the Act, no process was outlined to conduct the assessment.

In 1997, a series of workshops initiated by the US Global Change Research Program were used to develop a process for the scientific assessment. A National Assessment Synthesis Team (NAST) was convened and their 1998 plan described the administrative structure of a national synthesis team, regional assessments and sector assessments, and coordination with federal agency staffs (National Assessment Synthesis Team, 1998). Objectives for the assessment were identified and included the objective of involving a broad spectrum of stakeholders from state, local, tribal and Federal governments; business; labor; academia; non-profit organizations; and the general public. The assessment would link research by scientists to specific needs of the stakeholders; and provide planners, managers, organizations and the public with the information needed to increase resilience to climate variability and cope with climate change. Such a large-scale involvement of stakeholders in the climate change issue had not been attempted in the US.

Guiding principles developed for the regions and sectors suggested that a broad range of stakeholders be involved in the design of the assessment approach, the review of reports and, as appropriate, the analyses (National Center for Environmental Decision-making Research, 1998). Stakeholders were to be informed clearly and honestly of the goals and motives associated with the invitation to participate and, for longer-term network development, were to be included in the goal definition process. Implementation of these guiding principles varied. Stakeholders participated as members of regional and sector teams, analysts, and in regional, sectoral and national workshops. Stakeholders were from universities, federal agencies, state agencies, county agencies, planning organizations, tribal organizations, non-profit organization and businesses such as agriculture and energy (National Assessment Synthesis Team, 2001).

In the Mid-Atlantic Region, over 90 stakeholders from diverse backgrounds comprised the Advisory Committee which helped identify the information needed to make decisions in the context of climate change, reviewed reports, and advised the Mid-Atlantic Team on ways to disseminate the results (O'Connor et al., 2000). Stakeholders placed a strong emphasis on ensuring that the assessment would be responsive to climate-related issues most important to the region, such as the need for reliable seasonal climate projections by water systems managers and farm operators.

The Pacific Islands regional assessment team developed a program of structured interactions that allowed individuals and institutions to combine their experience and expertise to collectively assess the consequences of climate variability and change. For example, focused, small-group discussions were held with representatives of the Pacific Basin Coastal Zone Management, with the Hawaii Congress of Planning Officials; with participants in a workshop on ENSO and water resources held in Fiji, and with participants in a workshop on climate and health held in Samoa (Shea, 2001).

Stakeholders from the very first workshop in the Northern Great Plains region emphasized the need to have access to ongoing, accurate, accessible information and technology about the changing climate and environment (Seielstad, 1998). Additional workshops facilitated the hands-on training in the use of geospatial technologies in classrooms for grades 8–12, and the use of remote sense technology to improve the economic competitiveness of farming and ranching while minimizing adverse effects on the environment.

Through focus group meetings, the Central Great Plains Assessment team invited diverse groups of stakeholders to identify critical issues associated with water, range and livestock, croplands, conservation and natural areas, to synthesize the climate and ecological scenarios, and to develop possible strategies for dealing with climate change (Ojima et al., 2002). Stakeholders stressed that the involvement of local communities in any policy developments for climate change was critical to the success of those adaptation or mitigation strategies.

Stakeholder participation enhanced the focus and quality of the National Assessment. Stakeholders demanded that complex issues be addressed in ways that the public could understand. The original vision was that such a dialogue would lead naturally to more confidence in the information generated in the Assessment, greater understanding of the incomplete nature of existing information (uncertainty) leading to more public support for future research initiatives or greater understanding of the need to make decisions in the face of such uncertainty. This type of participatory approach is similar to the pre-decision scoping activities in forest planning where no management or policy activities had been actually proposed and both Germain et al. (2001) and Buchy and Hoverman (2000) observed that stakeholders are more likely to have a positive experience when invited to participate at this stage. The examples above and others indicate that stakeholder participation was positive, however, the need for ongoing participation but no institutional structure to foster stakeholder participation (Wilbanks, 1999) may have altered the final enthusiasm for stakeholder participation and the possibilities for continued stakeholder involvement in science–policy discussions (Wolfe et al., 2001).

4. Incorporating uncertainty into the assessment conclusions

Natural resource assessments are a synthesis of information from laboratory experimental results, field experimental results, meta-analysis reviews of the extant scientific literature, integrated modeling analyses, and the experience and judgment of the assessment scientists. There is uncertainty in each component including the final synthesis by the report writers. More attention has been focused on these uncertainties as the scientific methodology of projecting change and assessing impacts has developed (Moss and Schneider, 1996; Smith and Heath, 2000; Rotmans and VanAsselt, 2001). Only recently, however, has the assessment community attempted to quantify the uncertainties associated with report conclusions (Moss and Schneider, 1996).

Assessments of the impact of climate change often include the use of large-scale climate, ecological and economic models to quantify the impacts on ecological and economic systems. Each large-scale model is associated with a suite of assumptions, hence uncertainty, about model parameters, input data which often require some form of interpolation or other large-scale manipulation, and assumptions about how climate systems, ecosystems and economic systems will function under novel climate and atmospheric chemistry conditions. Assumptions about future greenhouse gas emissions are based on assumptions about future economic development, e.g. population and economic growth, technological change and energy supplies (National Assessment Synthesis Team, 2001). Suggestions for handing uncertainty in integrated assessments where more than one scientific discipline is involved (Lindner et al., 2002) have included: (1) tracking uncertainties throughout the assessment modeling process and indicate how initial uncertainties influence key results downstream; (2) use scenario analysis to show how linked systems (climate–ecological–economic) respond to critical factors, and compare to real-world observations of such interactions and (3) use quantitative methods to establish the variability in the results associated with the integrated models.

While it is important to track and quantify the individual uncertainties in the assessment, particularly the model component, there still remains the problem of summarizing these individual uncertainties in a meaningful way in the overall assessment report (Moss and Schneider, 2000). Climate change assessments integrate information from a variety of sources. Conclusions about the likely outcomes associated with climate change

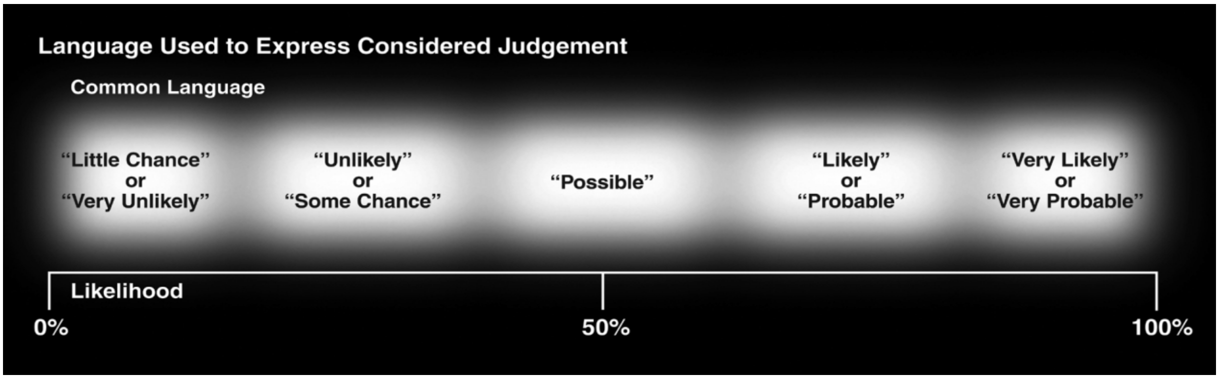

Fig. 1. Language used to express considered judgment in the National Assessment on Climate Variability and Change (National Assessment Synthesis Team, 2000).

are based on the variety of this information as well as the experience and judgment of the assessment scientists. Two recent assessments have attempted to describe the uncertainty in report conclusions: US National Assessment of Climate Variability and Change (National Assessment Synthesis Team, 2000) and the third assessment report of the International Panel on Climate Change (Houghton et al., 2001). These recent assessments used a language of uncertainty to develop statements about the likelihood of outcomes.

The uncertainty in each National Assessment conclusion was developed as follows (National Assessment Synthesis Team, 2000):

> 'To integrate a wide variety of information and differentiate more likely from less likely outcomes, the NAST developed a common language to express the team's considered judgment about the likelihood of results. The NAST developed its collective judgments through discussion and consideration of the supporting information. Historical data, model projections, published scientific literature and other available information all provided input to these deliberations, except where specifically stated that the result comes from a particular model scenario. In developing these judgments, there were often several lines of supporting evident (e.g. drawn from observed trends, analytic studies, model simulations). Many of these judgments were based on broad scientific consensus as stated by well-recognized authorities including the IPCC and the National Research Council. In many cases, groups outside the NAST reviewed the use of terms to provide input from a broader set of experts in a particular field.'

The language used to express considered judgment was little chance or very unlikely, unlikely or some chance, possible, likely or probable, very likely or very probable. These words were placed over a likelihood scale that ranged from 0 to 100%. Possible centered over 50%. No discrete boundaries were drawn for each of the categories (Fig. 1). Examples of conclusions using this language include the following, italicized print added for this presentation here (National Assessment Synthesis Team, 2000).

> 'Through time, climate change will *possibly* affect the same resource in opposite ways. For example, forest productivity is *likely* to increase in the short-term, while over the long-term, changes in processes such as fire, insects, drought and disease will *possibly* decrease forest productivity (page 8).'

> 'Climate change will *very likely* magnify the cumulative impacts of other stresses, such as air and water pollution and habitat destruction due to human development patterns (page 9).'

> 'Many ecosystems are highly vulnerable to the projected rate and magnitude of climate change. A few, such as alpine meadows in the Rocky Mountains and some barrier islands, are *likely* to disappear entirely in some areas. Others, such as forests of the Southeast, are *likely* to experience major species shifts or break up into a mosaic of grasslands, woodlands and forests. The goods and services lost through

the disappearance or fragmentation of certain ecosystems are *likely* to be costly or impossible to replace (page 9).'

The Third Report of the International Panel on Climate Change also developed a common language of uncertainty (Houghton et al., 2001). The language or words were used where appropriate to indicate judgmental estimates of confidence: virtually certain (99% or more), very likely (90–99%), likely (66–90%), medium likelihood (33–66%), unlikely (10–33%), very unlikely (1–10%) and exceptionally unlikely (1% or less).

Examples of conclusions with this language (Houghton et al., 2001) include the following:

> 'New analyses of proxy data for the Northern Hemisphere indicate that the increase in temperature in the 20th century is *likely* to have been the largest of any century during the past 1000 years (page 2). It is *very likely* that precipitation has increased by 0.5–1% per decade in the 20th century over most mid- and high latitudes of the Northern Hemisphere continents, and it is *likely* that rainfall has increased by 0.2–0.3% per decade over the tropical land areas (page 4). Based on recent global model simulations, it is *very likely* that nearly all land areas will warm more rapidly than the global average, particularly those at northern high latitudes in the cold season (page 13).'

The criticisms of both of these approaches are similar and focus on the nature of how the experts derived the uncertainties, how specific the conditional statements are, the understanding and breath of experience of the experts quantifying these uncertainties, and the scope of projections for which these uncertainties/impacts are applicable (Reilly et al., 2001). Approaches that use expert judgment to associate likelihoods with outcomes of impacts (such as climate change) are also not without controversy (Morgan and Henrion, 1990). It stills remains the challenge of synthesizing all of the information in the assessment report to provide some indication of the uncertainty of the outcomes reported. Both of these assessments have pushed the scientific community further to address this need of policy makers (Parsons et al., 2003).

5. Conclusions

The value of an assessment is in the succinctness and the balanced description of issues and knowledge. When the periodic assessment process is institutionalized, it offers the opportunity for the scientific literature to be periodically synthesized with respect to new policy issues in a form directed to policy makers. The USDA Forest Service RPA assessments are an example of such a periodic assessment institutionalized by law. Increasingly, it is also being recognized that these assessments need a broader dialogue with stakeholders. The US National Assessment engaged diverse stakeholders, such as public and private decision-makers, resource and environmental managers, and the general public. These workshops initiated a broad national and regional dialogue between scientific experts and these stakeholders about changes in climate, their impacts, and what can be done to adapt to an uncertain and continuously changing climate. Repeatedly the stakeholders reminded the scientists about the specific needs of their region or sector, and that complex issues be addressed in ways that the public can understand. Finally, the value of incorporating some measure of uncertainty within the assessment synthesis was seen in both the National Assessment in the United States, and the Third Assessment Report of the International Panel on Climate Change. In each, a language of uncertainty was used to describe consensus of the scientific community on the report's conclusions. These attributes are important elements of improving the flow of scientific information across the science–policy interface.

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