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The role of scientists in the environmental policy process: a case study from the American west

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Abstract

Recently, there have been calls among decision makers, interest groups, citizens, and scientists alike for more science-based environmental policy. The assumption is that including scientists and scientific information will improve the quality of complex policy decisions. Others have argued, however, that science and scientists are just one source of expertise concerning natural resource management and increasing involvement will not necessarily lead to better policy. We report on a study examining attitudes of scientists, natural resource managers, interest groups, and the public concerning the role of science and scientists in environmental and natural resource policy. In interviews and surveys with members of the four groups from the Pacific Northwest, we found that there are significant differences among groups about what constitutes science, including the acceptability of positivism; a preference among many respondents for research scientists to work closely with managers to interpret and integrate scientific findings into management decisions; and, for those respondents with positivist orientations, some interest in scientific advocacy and decision-making by ecological scientists. Ecological scientists, on the other hand, are more doubtful of their ability to provide scientific answers and also more reluctant to engage directly in policy processes than others would prefer them to be.

Keywords: Science and policy; Environmental policy; Positivism; Ecological scientists; Policy process; Scientific method

1. Introduction

In recent years, there has been an increasing emphasis among decision makers, interest groups, and citizens alike on the importance of more science-based environmental policy at local, regional, national, and international levels of governance (Johnson et al., 1999; Sarewitz et al., 2000). Many have normative expectations that this can improve the quality of complex environmental policy decisions (Ehrlich and Ehrlich, 1996). The assumption is that scientists can and should facilitate the resolution of public environmental decisions by providing objective scientific information to policymakers and the public and by becoming more involved in policy arenas (Mazur, 1981).

There are others, however, who suggest that science is used for less desirable policy purposes such as rationalizing and legitimising decisions made by elites (Ezrahi, 1980). This latter view has been supported by postmodern perspectives in the sociology of science, which argue that the authority of science and scientific "narratives" is socially constructed by scientists and users of scientific information and is not inherent to science qua science (Hacking, 1999). This model posits the following: science and scientists are considered just one of many sources of authority concerning natural resource management issues; scientific information may itself be biased; and, other types of policy actors, information, and values are more important in arriving at sensible public choices (Collingridge and Reeve, 1986; Ezrahi, 1980; Ravetz, 1990).

This study examines attitudes about science and the scientific process, more specifically those that are part of the "traditional" or "positivist" view of science, and then investigates the relationships between attitudes toward positivist science and the role scientists should play in the environmental policy process. The study examines these attitudinal relationships and preferences from the perspective of ecological scientists, natural resource managers, representatives of public interest groups, and the interested public in the context of the *Long Term Ecological Research Program* (LTER), a multi-site research effort that has been supported by the National Science Foundation (NSF) since 1980. Data were collected from interviews and surveys of four different groups involved in environmental policy and management in the Pacific Northwest (Oregon, Washington, Southeast Alaska, Northern California): ecological scientists at

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universities and federal agencies; natural resource and environmental managers of state and federal programs; members of interest groups (e.g., environmental groups, etc.); and the "attentive public" (i.e., citizens who have participated in the environmental policy process). While this study concerns the American west, it has broader implications for understanding the roles of scientists in other environmental and natural resource policy contexts with multiple stakeholders and participants. Many of the participants included in this research project were directly involved in the US federal government's first major attempt at large scale ecosystem management involving scientists, social scientists and managers—i.e., President Clinton's Forest Ecosystem Management Team to manage late successional and old growth forests in America's west (FEMAT, 1993).

2. Science and the scientific process: the traditional model

Science has been defined as a method or process by which scientists explain and predict natural phenomena, events, or behaviors in the biophysical or social world using a certain form of rigorous, quantifiable inquiry that involves the testing of researchable hypotheses. Science is based on empirical observation and, in the best cases, experimental manipulation of natural variables (Fischer, 1990, p. 10; Goggin, 1986, p. 6). Scientific inquiry involves both modelling and data gathering—scientists are interested in understanding why things occur and the empirical evidence that they do occur in this way. This means that they seek to discover causal patterns in the structure of the natural world, and thus are involved in an enterprise whereby they successively accumulate more and more information about nature over time (Fine, 1999; Hacking, 1999). In the process of doing research, scientists move between the theoretical and observational levels in their investigations, resolving conceptual and empirical problems within the context of "research traditions" (Laudan, 1977). Another important component of this process is the notion of repeatability. That is, an expectation that research findings can be replicated or reproduced with the same results by different scientists in different laboratories and using different equipment.

Thomas Kuhn (1962) in his classic book *The Structure of Scientific Revolutions* challenged this traditional picture in certain respects, arguing that scientists operate within the framework of "paradigms," which are theoretical frameworks or basic models that characterize phenomena in particular scientific disciplines.

In the traditional model of science, scientists typically believe that this "succession from one paradigm to another represents progress from an inaccurate view to an accurate one. No modern astronomer believes that the sun revolves around the earth, for example," though at one time this was "normal" scientific belief (Babbie, 1998, p. 43). One of the "noble goals" of science is "the attainment of truth" either in some total sense or in regard to some particular aspect of nature (Kitcher, 1993). Kuhn, in contrast, suggested that science and scientific inquiry is a dynamic process where contemporary paradigms, or theories, are not necessarily true, but accepted as such within the framework of the dominant, normal science of the day. This has led some to argue: "Few philosophers or scientists today believe that scientific knowledge is only proven knowledge—that nothing exists without absolute proof . . . science is in a continually changing state as a result of scientific criticism" (Lesthaeghe, 1998, p. 3).

Perhaps the strongest and most unquestioning supporters of the potential of science and the scientific method to accurately and objectively predict various phenomena in the biophysical and social world have been adherents to various versions of "positivism." Positivism finds it roots in the scientific revolution and the "Enlightenment" in Europe during the 16th and 17th centuries, and, in the 19th century, came to be specifically identified with the writings of the philosopher Auguste Comte and Ernst Mach, among others. Early supporters of this approach believed that the "scientific method and practice distinguished the people of the West from civilizations that the West had conquered" and that science "was a matter of truth" (Pyeson and Sheets-Pyeson, 1999, p. 5). According to Comte, the scientific method was objective and therefore would bring about a new age of prosperity through the use of quantitative methods to understand both physical and social affairs. Comte believed that "all inquiries into nature would become more like mathematical physics."

Defining and characterizing the positivist conception of science in contemporary times, however, can be difficult because of the diversity of opinion among positivists about the nature of science and the vigorous critique of positivism that has developed over the years (White and Mason, 1999). For example, among the various approaches that have been termed positivist are Francis Bacon's inductionism, David Hume's empiricism, C.S. Peirce's pragmatic positivism, Karl Popper's rational empiricism, and the views of such 20th century logical positivists as Rudolf Carnap, Herbert Feigl, Hans Reichenbach, and Carl Hempel. The logical positivists accepted Comte's scepticism about metaphysical systems and adopted his empiricism; they also agreed with his belief that science provides the most reliable form of knowledge about the world, among its possible competitors, and casts doubt on the possibility of religious and moral knowledge (Ayer, 1936). Finally, another important feature of logical positivism was the idea that the resources of formal logic could be used to provide a symbolic rendering of the logical structure of science, especially in its "context of justification." The positivists conceived of scientific theories as "organized according to the canons of deductive logic" and maintained that a scientific theory should be "a deductive structure such as is exemplified in geometry" (Harre, 1972).

William Bechtel (1998) and others affirm that most contemporary philosophers reject logical positivism in its various, original formulations, and the idea of positivism has come under critical scrutiny in the past 40 years. Few scientists or social scientists today would completely accept Comte's view of a logically ordered, objective reality that we can understand once and for all, even with the powerful resources of scientific research. And many logical positivists, in time, have criticized this point of view as well. As Babbie suggests: "most scientists would agree that personal feelings can and do influence the problems scientists choose to study, what they choose to observe, and the conclusions they draw from their observations" (Babbie, 1998, p. 50). Nobel Prize winner John Charles Polanyi further states: "Science is done by scientists, and since scientists are people, the progress of science depends more on scientific judgment than on scientific instruments" (Polanyi, 1995, p. 7). Moreover, the rise in importance of the history and sociology of science as academic disciplines has led to a more complex characterization and debate about the nature of science. At the same time, Bechtel (1998), p. 49 argues "the Positivists' picture of science remains the most comprehensive we have," and positivism and the traditional model of science in weakened and more simplified forms have filtered down into the "culture" of contemporary science and popular Western culture. This has created a kind of "legendary" or stereotypical view about science that has been extensively criticized by philosophers of science, among others, though it is prevalent in some quarters nevertheless (e.g. Kitcher, 1993).

While there are some doubts about the acceptability of positivism, then, and much diversity evident in positivism itself, there are also some similarities in the common belief that science is the best way to get at truth, to understand the world well enough so that we might predict and then possibly control and manipulate it in specific ways. The underlying assumption inherent here is that the world and the universe operate by laws of cause and effect, which can be discovered through the scientific method. Conceived broadly as a view about the nature of science and its social functions, key elements of positivism then may be summarized as follows: (1) science can provide accurate information about the world; (2) the knowledge produced by science can be unbiased and value neutral; (3) the growth in scientific knowledge leads to general societal progress; (4) scientists must be free to follow the laws of reason in an open system or society; and (5) since science is a matter of truth that is independent of human thought, it is accessible to all peoples regardless of status, culture, belief, and background (see Scruton, 1982, pp. 364–365).

3. Science and the roles of scientists in the environmental policy process

Many contemporary scientists would agree with scientist Levien (1979) that science and scientists can and should play an important and useful role in the environmental policy process. Levien argues there are three ways that this can occur. First, science and scientists can provide a clear understanding of the basic dimensions of environmental problems, identifying both what is known and what is uncertain. Second, science and scientists can then describe and identify options for the appropriate solution of those problems, some of which might not be considered by political decision makers. Finally, science can contribute to the resolution of environmental problems by estimating the economic, social, environmental and political consequences of proposed solutions through time and space, and across population groups (Levien, 1979, pp. 47–48).

Accordingly, scientists have been called upon by citizens, governments, and NGOs to predict the impact of human caused activities on the world's climate, oceans, air, species, and other environmental components. Sarewitz and Pielke (2000), p. 11 have described this situation as follows:

> Policy makers have called upon scientists to predict the occurrence, magnitude, and impacts of natural and human induced environmental phenomena ranging from hurricanes and earthquakes to global climate change and the behaviour of hazardous waste. In the United States, billions of federal dollars are spent each year on such activities. These expenditures are justified in the large part by the belief that scientific predictions are a valuable tool for crafting environmental and related policies.

Sarewitz and Pielke (2000) further argue that prediction—i.e., finding support for a research hypothesis—is not the same as predicting the outcome of an environmental law or policy, which is necessarily more complicated because of the number of ecological, social, economic and political variables involved. Funtowicz and Ravetz (1999) have similarly concluded:

> This situation is a new one for policy makers. In one sense, the environment is in the domain of Science: the phenomena of concern are located in the world of nature. Yet the tasks are totally different from those traditionally conceived for Western science. For that, it was a matter of conquest and control of Nature; now we must manage, accommodate and adjust. We know that we are no longer, and never really were, the 'masters and possessors of Nature' that Descartes imagined for our role in the world.

Even scientists who are very optimistic about their role to inform the policy process are cautious concerning their efforts to provide correct predictions (Allen et al., 2001). For example, Ehrlich and Ehrlich have argued (1996, p. 27):

> ... science can never provide absolute certainty or the 'proof' that many who misunderstand science often say society needs. Certainty is a standard commodity for some religious leaders and political columnists, but it is forever denied to scientists.

At the same time, these same scientists are strong advocates of science and the scientific method and believe that "... science still deserves to be privileged, because it is still the best game in town" (Allen et al., 2001).

Contemporary perspectives on the proper roles of scientists in the policy process are potentially related to how science is defined and understood. As discussed above, the traditional model of the role of science and scientists in the policy process is an outgrowth of the Enlightenment and the philosophy of positivism. The role of scientists in this model is to provide relevant expertise about scientific data, theories, and findings that others in the policy-making process can use to make decisions, not to make the decisions themselves or to be advocates of particular policy positions. The assumption is that they are neither policy experts nor trained in the intricacies of environmental management. Moreover, scientists are not to become biased by involvement in environmental policy or to become "advocates" like Rachel Carson. In this model, science is respected by resource managers and the public and has a special authority in environmental management, because of its independence and its power to objectively interpret the world. However, scientists can lose their credibility as scientists if they cross the line between science and policy, science and management. We then get a "separatist" role for scientists; ideally they are removed from management and policy and serve as experts or consultants only. They are called upon as the need arises and as policy makers, managers, and the public require (Alm, 1997–1998).

A second, emerging model challenges this first model, not so much on the authority of scientific information and the acceptability of positivism, but on the proper roles for research scientists in management (Kay, 1998). It proposes that such scientists should become more integrated into management and policy processes. Research scientists need to come out of their labs and in from their field studies to directly engage in public environmental decisions within natural resource agencies and such venues as courts and public hearings. There is a need for more science in these processes and decisions, the model implies, but this can only be brought about if research scientists themselves become more actively involved. Moreover, this model suggests that scientists should not hesitate to make judgments that favor certain management alternatives, if the preponderance of evidence and their own experience and judgment moves them in certain practical directions. They are, after all, in the best position to interpret the scientific data and findings and thus are in a special position to advocate for specific management policies and alternatives.

This emerging "integrative" model—also called "post-normal science"—calls for personal involvement by individual research scientists in bureaucratic and public decision making, providing expertise and even promoting specific strategies that they believe are supported by the available scientific knowledge (Ravetz, 1987; Steel and Weber, 2001). Funtowicz and Ravetz (1999) have articulated this model as follows:

> . . . there is a new role for natural science. The facts that are taught from textbooks in institutions are still necessary, but are no longer sufficient. For these relate to a standardized version of the natural world, frequently to the artificially pure and stable conditions of a laboratory experiment. The world as we interact with it in working for sustainability, is quite different. Those who have become accredited experts through a course of academic study, have much valuable knowledge in relation to these practical problems. But they may also need to recover from the mindset they might absorb unconsciously from their instruction. Contrary to the impression conveyed by textbooks, most problems in practice have more than one plausible answer; and many have no answer at all.

According to Underdal (2000, p. 10) the ability of scientists to influence the policy process—either directly through the former, traditional model or through the latter, integrative or "post-normal" approach—is dependent on factors such as competence and integrity:

> The principle reason why decision-makers and the attentive public look to science for information and guidance is confidence and competence of scientists as producers and custodians of advanced and reliable knowledge. Similarly, one main reason why they often collectively accept the conclusions produced by research as valid is confidence in scientists as 'truth-seekers,' strongly committed to the professional methods and norms of scientific inquiry, and collecting and analysing evidence independent of any substantive interests that a government or other parties may pursue.

The following analyses will investigate scientist, manager, interest group, and public attitudes toward science and the scientific process, and then examine how these attitudes are related to expectations about the roles of scientists in the environmental policy process. We expect those scientists, managers, interest group representatives, and public participants who accept key elements of positivism to be most supportive of involving scientists in the policy process, while those who are less positivistic and viewing science as biased will be more likely to oppose an integrative and more involved role for scientists. At the same time, these attitudes and beliefs are not the only determinants of respondent expectations about scientists, and there are other factors that influence what members of the groups are likely to believe about these roles. In our pre-survey interviews, we discovered that the "culture of science" affects research scientists in a manner that does not so clearly apply to managers and others in the policy process. Thus, research scientists operate in a communal scientific environment that imposes different demands on their time and energy, and their reputations and identities as scientists depend upon a different system of institutional relationships and rewards. Involvement in management and public environmental policy processes is likely to require that they develop different communication and interpersonal skills, and it may elicit normative opinions in the scientific and policy arenas that can undermine their authority and personal decorum. Other scientists sometimes have reservations about scientists who do become more involved in policy matters, and may question their standing and credibility. These factors, and others, can mean that those scientists will be wary of scientists taking a more active, integrative role. As Jamieson (2000, p. 322) has argued:

> What most scientists want to do is (relatively) basic science: they want to discover the most fundamental particle, understand the human genome, the atmospheric system, the immune system, and so on.

Resource managers, on the other hand, work in an environment that is quite different than that of research scientists. For example, because of bureaucratic imperatives they do not always have the time to wait until "all the evidence is in" or the uncertainties are finally removed from the latest scientific findings. Nor do they have to satisfy their curiosities in research or gain the consequent rewards that scientists receive from interactions with other scientists. They are typically not involved in the scientific community as researchers or generators of biophysical and social knowledge and thus may not share as deeply the values and norms that define the culture of science. This may lead them to view the roles of scientists in a different way than scientists themselves, accepting their authority as scientists but not as advocates. They may believe that policy advocacy and environmental management are part of their organisational and professional prerogatives.

In regard to the public and the various stakeholder groups involved in the environmental policy process, our previous research in Canada and the United States found evidence of strong support for the involvement of scientists in both policy making and policy implementation processes (Steel et al., 2001, p. 145).

> . . . residents in the American and Canadian Pacific West value science and believe it is an important factor in making natural resource decisions and policy. Furthermore, they want scientists to work closely with natural resource managers, citizens, and citizen advisory groups to interpret and integrate their findings in the development of natural resource policy.

4. Research location

This study examines the role of science and scientists from the perspective of ecological scientists, natural resource managers, representatives of public interest groups, and the attentive public in the context of the *Long Term Ecological Research Program*, a multi-site research effort that has been supported by the National Science Foundation since 1980. Ecological scientists at LTER sites around the country, Antarctica, and Puerto Rico are producing basic ecological knowledge that is changing the way scientists and lay people view the natural world (Luoma, 1999). They are also increasingly expected to participate with non-scientists in efforts to develop and even implement natural resource policies.

We were particularly interested in LTER scientists for several reasons. First, scientists working at LTER sites are conducting a variety of basic research projects that are funded by the NSF at least in part because they meet the criteria of "social relevance." Second, scientists at LTER sites represent a wide range of research organizations including colleges and universities, private research laboratories, and federal and state agencies. At the same time, LTER participants also represent a wide range of investigative and policy involvement from early-career scientists, managers, and public participants to "old hands" who have lived through shifts in natural resource policy, public attention, and public values. Finally, some LTER scientists collaborate with natural resource managers and the public in resource decisions and provide input to policy makers at local, state, and national levels. For example, scientists from the H.J. Andrews LTER site located in Blue River, Oregon, in the Oregon Cascade Mountains, participated directly in developing President Clinton's *Northwest Forest Plan* (FEMAT, 1993), and are currently active in the *Cascade Center for Ecosystem Management*, a federal government funded research program that involves cooperation between research scientists, forest managers, local environmental and industry groups, and public activists. Scientists at the H.J. Andrews LTER site have been involved in research for over 50 years, and the data and theories generated by these LTER scientists is applicable to other research locations—both in the national and international context.

5. Methods

In late 1999 and early 2000, survey data were collected from random samples of different groups involved in environmental and natural resource management in the Pacific Northwest (Oregon, Washington, Southeast Alaska, Northern California): natural resource scientists at universities and federal agencies (LTER scientists), managers of state and federal agencies (e.g., US Forest Service, Bureau of Land Management, Oregon Department of Forestry, etc.), members of natural resource organizations who have participated in public hearings and scoping activities concerning the management of public lands (e.g., environmental groups, industry associations), and the "attentive public" (those having participated in a public hearing, providing a comment on proposed plans, or in some other way identifying themselves as aware of and participating in the decision processes of natural resource decision making). Because we focus on the use of science at the government agency level, we did not include elected officials in our research design. Mail surveys were designed on the basis of 50 face-to-face interviews of representatives of each of the four groups and responses to a pre-survey of government/university scientists. Three waves of mail surveys were sent along with a fourth telephone or email reminder if necessary. Sample sizes and response rates are as follows:

Sample	Sample Size	Surveys returned	Response rate (%)
Scientist	189	155	82
Manager	216	167	77
Interest group representatives	198	119	60
Attentive public	255	198	76

As with all surveys, question wording, refusals, and other difficulties implementing surveys can result in error or bias. However, use of mail surveys in this project provides respondents time to read and reflect upon the intent and wording of each question before responding. For all analyses reported in this paper, the widely accepted *Statistical Package for the Social Sciences* (SPSS, version 11.5) was used.

6. Findings and discussion

In order to determine orientations toward science, each respondent was asked their level of agreement or disagreement with a series of statements, which underlie many of the assumptions implicit in positivism, broadly construed. The introduction provided to the statements was as follows: "In recent years there has been increasing debate about what makes for reliable scientific findings that can be used with confidence to make important decisions. Please take a moment to let us know how you characterize science and the scientific process by indicating your level of agreement or disagreement with the following statements." The nine common statements provided in all surveys were developed on the basis of interviews and an exploratory survey with various government and university research scientists, philosophers of science, and social scientists. In the exploratory survey, over 50 university and government ecological scientists were provided with over 40 statements designed to represent or question positivistic perspectives of science. These 40 statements were drawn directly from the positivist Karl Popper's (1961, 1972) work *The Poverty of Historicsim* and *Objectivity Knowledge: An Evolutionary Approach*. Those nine statements that were uniformly identified as "positivist" in the exploratory study were included in the surveys utilized in this study. Using factor analysis (varimax rotation), five of the statements were found to load in the first component and are listed in Table 1[1]. Agreement with these five statements can be generally interpreted as a belief in many of the important principles inherent in a positivistic perspective of science. Therefore, we have included these five items based on theoretical and empirical grounds. We should also note that scientists in disciplines other than ecology—such as physics, chemistry, etc.—or social science may have different perceptions of these items. However, this study only includes ecological scientists and other participants in the environmental policy process.

When comparing group mean scores for the four groups, we find statistically significant differences for four of the positivist statements. The only statement where groups did not differ was: "Science provides objective knowledge about the world." For the remaining statements, the attentive public tends to have the highest mean scores of all groups while managers and scientists have lower scores. When examining the percent agreeing and strongly agree with the statements, a higher percentage of the public agrees with four of the five positivist statements. In contrast, managers had the lowest percent of agreement with three of the statements. A summary index was created by adding all five statements together (index range: 5: little agreement with principles of positivism and 25: high level of agreement). The additive index scores indicate that managers are generally the most critical of the positivist perspective about science and the scientific process followed closely by scientists. Interest group representatives and the attentive public tend to be more positivistic concerning science, with the attentive public having the highest index score.

Ironically, those that are personally most involved in the scientific process and producing research results (scientists), and those responsible for integrating those results in the management of public lands (managers), are the most critical about the scientific process and least receptive to positivist beliefs. On the other hand, representatives of interest groups and the public, who often support and call for science-based environmental management, are the most trusting of the research produced and most accepting of positivist science. For scientists, this may be the result of their traditional training and orientation toward basic or non-applied research in science, which could lead them to accept the a separatist and minimalist role for scientists in the policy process, as identified above. For natural resource managers, these results may be the product of trying to integrate basic research results into everyday management, with little definitive help or guidance by research scientists. On the other hand, the very favorable attitudes of the public and interest group representatives about science and its certainties, and their support for a positivist conception of science, leads them to be more confident about the value of science and to potentially place political pressures on scientists to be more involved in the policy process.

[1] In addition to the five statements listed in Table 1, the following four statements were included in all four samples and the factor analysis: "scientific truth is interpretations based on a combination of scientific and social judgments;" "equally valid, but different scientific interpretations can be made using the same data;" "scientific theories limit how we can understand the results of scientific experiments;" "non-scientists can make valid judgements about the same phenomena studied by scientists using different sources of knowledge (e.g., personal experience, religious belief)." The five statements listed in Table 1 loaded on the first factor with an Eigenvalue of 2.695, explaining 32.15% of the variance.

Table 1
Attitudes toward positivism

Statements	Scientists: % agree[a], mean (S.D.)	Managers: % agree, mean (S.D.)	Interest groups: % agree, mean (S.D.)	Attentive public: % agree, mean (S.D.)
Use of the scientific method is the only certain way to determine what is true or false about the world; *F*-test = 6.427***	27%, 2.47 (1.24)	22%, 2.52 (1.14)	36%, 2.91 (1.36)	37%, 2.96 (1.39)
The advance of knowledge is a linear process driven by key experiments; *F*-test = 23.536***	19%, 2.28 (1.07)	17%, 2.46 (1.00)	21%, 2.93 (1.46)	34%, 3.32 (1.48)
Science provides objective knowledge about the world; *F*-test = 1.621	75%, 3.78 (0.90)	63%, 3.60 (0.80)	70%, 3.83 (0.99)	61%, 3.68 (1.09)
It is possible to eliminate values and value judgments from the interpretation of scientific data; *F*-test = 4.355**	25%, 2.77 (1.15)	26%, 2.53 (1.06)	34%, 2.84 (1.39)	34%, 3.02 (1.48)
Facts describe true states of affairs about the world; *F*-test = 5.338**	37%, 3.09 (1.10)	25%, 2.85 (0.91)	38%, 3.22 (1.31)	40%, 3.34 (1.33)
Positivism index mean	14.37	13.95	15.71	16.37
S.D.	3.45	3.12	4.15	4.19
n	146	160	114	185
Cronbach's alpha	0.73	0.78	0.81	0.83
F-test = 18.379***				

Scale used: 1: strongly disagree, 2: disagree, 3: neutral, 4: agree, and 5: strongly agree.
[a] Percent agree and strongly agree.
** Significance level $P < 0.01$.
*** Significance level $P < 0.001$.

Table 2
Attitudes toward scientific advocacy

Statements	Scientists: % agree[a], mean (S.D.)	Managers: % agree, mean (S.D.)	Interest groups: % agree, mean (S.D.)	Attentive public: % agree, mean (S.D.)
Scientists should only report scientific results and leave others to make natural resource management decisions; *F*-test = 7.588***	39%, 2.86 (1.37)	43%, 3.18 (1.21)	26%, 2.45 (1.25)	31%, 2.72 (1.39)
Scientists should report scientific results and then interpret the results for others involved in natural resource management decisions; *F*-test = 3.696**	87%, 4.18 (0.85)	78%, 3.92 (0.86)	76%, 3.99 (0.89)	68%, 3.86 (1.09)
Scientists should work closely with managers and others to integrate scientific results in management decisions; *F*-test = 1.867	77%, 4.09 (0.94)	90%, 4.30 (0.76)	84%, 4.20 (0.89)	83%, 4.28 (0.89)
Scientists should actively advocate for specific natural resource management policies they prefer; *F*-test = 28.847***	16%, 2.20 (1.17)	8%, 2.19 (1.01)	46%, 3.21 (1.14)	36%, 2.95 (1.32)
Scientists should be responsible for making decisions about natural resource management; *F*-test = 32.110***	4%, 1.66 (0.89)	7%, 1.79 (0.98)	26%, 2.65 (1.13)	21%, 2.47 (1.18)
n	154	167	117	190

Scale used: 1: strongly disagree, 2: disagree, 3: neutral, 4: agree, and 5: strongly agree.
[a] Percent agree and strongly agree.
*** Significance level $P \leq 0.001$.

Another goal of this study was not only to investigate attitudes toward science and the scientific process, but to also investigate orientations toward the proper role of scientists in the policy process and then determine what relationship may exist between the two. Based on the interviews and exploratory survey of scientists discussed above in the methods section, we developed a list of five potential roles for scientists in the policy process. These *ideal types* reflect a complex relationship among expectations of science, attitudes about resource management, and decision-making styles (see Table 2).

The first role limits research scientists to reporting results and letting others make resource decisions. This reflects the "traditional role" for scientists as discussed above. As part of the "emerging role," we described two possibilities for the scientists. The first is for research scientists to interpret scientific results so that others can use them. This is often expressed as a scientist's promise to granting organizations that the results will be "translated" for non-scientific users. Something that is certainly not uncommon for research scientists today. A more involved role for research scientists is to work closely with managers and others to integrate scientific results directly into resource policies and decisions. Implementation of “adaptive management” experiments in forests of the American west is an example of this type of scientific integration in resource decision-making. Another potential role is for research scientists to actively advocate for specific resource policies or management decisions that they prefer or believe flow from their scientific findings. A final role, reflecting the increasingly technical and complicated decisions facing natural resource managers, is to have such scientists make resource decisions themselves.

This list is not technically a scale or index, and we asked respondents to tell us how much they agreed or disagreed with each of these potential roles. The roles are thus not mutually exclusive, although it is unlikely that anyone who favors a minimal role for scientists will also prefer the technocratic role of putting them in charge of resource decisions. We asked respondents to report how much they agreed with each of the roles on a five-point scale from “strongly disagree” to “strongly agree.” Table 2 presents mean scores and percent agreement for the responses of all four groups included in the study.

The two most popular roles for scientists in the natural resource policy process for all four groups are working “closely with managers to integrate scientific results” and interpreting the results of research for others involved in the process. Managers, interest group members, and the attentive public rank helping managers to integrate research results highest (90, 84 and 83%, respectively), while scientists themselves rank interpretation of research results the highest (87%). In general, most respondents were least supportive of scientists making decisions themselves, however interest group representatives and the attentive public also were not enamored with a minimalist scientist role of just reporting scientific results and were more likely to support an advocacy role for scientists. Scientists and managers, on the other hand, were less supportive of an advocacy role for scientists. In general, then, managers and scientists have very similar preferences for the potential roles of research scientists in natural resource decision-making. Both scientists and managers are more likely to agree that integrative roles are more preferable than any of the other roles, including the minimalist traditional role of just reporting results.

Another interesting finding from this research is the level of support for scientific advocacy among interest group representatives and the public. Forty-six percent of interest representatives and 36% of the public sample agreed that scientists “should actively advocate for specific natural resource management policies they prefer.” In addition, a surprising number of these two groups even support a form of technocracy, where scientists would be responsible for making all decisions about natural resource management. Twenty-one percent of the public and 26% of interest group representatives supported such a strong role for scientists. Perhaps this is consistent with Jasanoff’s (1990, p. 9) view that in the United States there has been an “oscillation between deference and skepticism toward experts”. Certainly, we find evidence of both orientations among our interest group and public samples.

6.1. Bivariate analyses

To what extent are the attitudes of scientists, managers, interest group representatives, and attentive public toward science and the scientific process related to orientations toward the proper role of scientists in the natural resource policy process? Previously, we argued that attitudes toward science are likely to influence preferences concerning the role of scientists in the policy process. Table 3 presents correlations between attitudes toward science (positivism index from Table 1) and preferred roles for scientists in the natural resource policy process (items from Table 2).

What is most noticeable in Table 3 is that all of the correlations between attitudes toward science and the various roles for scientists are significant for the attentive public sample. For interest group representatives there are three significant correlations, two for the sample of managers, and one for scientists. Clearly, attitudes toward science are very important to the attentive public’s view of scientists’ proper role in the policy process, and less important for scientists themselves. Regarding the attentive public, those that believe in some key assumptions of positivism are actually less likely to accept a separatist and minimalist role for scientists and significantly more likely than less positivist respondents to agree that: scientists should be involved in the interpretation of research for managers; scientists should help managers

Table 3
Correlations between attitudes toward scientific method (positivism index) and roles for scientists in the environmental policy process

	Scientists	Managers	Interest groups	Attentive public
Report	0.12, $n = 146$	−0.06, n=160	−0.05, n=113	−0.24**, n=177
Interpret	−0.05, $n = 146$	0.02, n=160	0.04, n=112	0.28***, n=180
Integrate	−0.16*, $n = 146$	−0.01, $n = 160$	0.33***, $n = 114$	0.30***, $n = 180$
Advocate	0.03, $n = 145$	0.27**, $n = 159$	0.19*, $n = 112$	0.38***, $n = 180$
Making decisions	0.13, $n = 146$	0.22**, $n = 160$	0.26**, $n = 112$	0.420**, $n = 180$

Note: Correlations (Pearson’s r) are between the positivism index in Table 1 and the various roles for scientists in the policy process in Table 2.
* Significance level $P < 0.05$.
** Significance level $P < 0.01$.
*** Significance level $P < 0.001$.

integrate research into policy; scientists should actively advocate natural resource policies they prefer; and, scientists should actually be responsible for making natural resource management decisions.

When examining the correlations for interest group representatives, we find positive and significant relationships for integrate, advocate, and making decisions. Similar to the attentive public, interest group representatives believe that scientists should help managers integrate the results of research into policy; that scientists should advocate policies they prefer; and, that scientists should be responsible for making natural resource policies. As with the attentive public, more strongly positivistic orientations toward science and the scientific method are correlated with strong support for scientists being directly involved in the policy-making process. In regard to natural resource managers, positivist orientations toward science are significantly correlated with support for scientists as advocates and as decision makers. However, this same pattern is not evident for scientists, where only the correlation between integrate and the positivism index is statistically significant. Interestingly, the correlation is negative suggesting that scepticism about the positivist nature of science is associated with integrating scientists in the policy process. It appears that scientists themselves are not only less accepting of positivism and more careful about the implications of their own research than other policy participants, but they are also more troubled about their exact role in the policy process as suggested above by Funtowicz and Ravetz (1999). Perhaps scientists find themselves in a new and "post-normal" situation where traditional beliefs about the value of science are increasingly called into question.

6.2. Multivariate analyses

The final analyses included in this paper examine the effect of the positivism index on orientations toward the proper role of scientists in the natural resource policy process while controlling for various independent variables. A number of studies have addressed various aspects of the relationship between social values, science, and attitudes toward environmental policy and natural resource management (e.g., Alm, 1997-1998; Steel et al., 2001). These studies imply that the current debate about the role of science and scientists in natural resource policy is not only a professional and technological debate, but also a debate about political and environmental values. In our judgment, attitudes about the preferred role of scientists in natural resource management are influenced by a variety of factors. Primary influences include sociodemographic characteristics, and political and environmental value orientations (Dunlap et al., 2000, 2001). The sociodemographic factors examined as predictors of orientations toward the role of scientists in the policy process include age in years, gender, and level of formal educational attainment. Because the level of formal education obtaining among all four groups is highly skewed, a dummy variable was created which assesses the presence of a graduate degree or not. The indicators used to assess the value orientations of respondents include a self-assessment measure of general political orientation which was recoded into three dummy variables (right, moderate and left),[2] and the measure of environmental attitudes used to predict environmental behavior and participation is Van Liere and Dunlap's (1981, 1980) "New Environmental Paradigm" (NEP) indicator.[3] While Van Liere's and Dunlap's index was originally developed in the 1980s, it is still widely used to measure general orientations toward society and the environment (Dunlap et al., 2000, 2001). Summary and measures and coding information for all control variables can be found in Appendix A.

6.3. Dependent variables

Because the responses to many of the dependent variables are skewed, each variable was dichotomized with 1 representing "agree" and "strongly agree" responses and 0 representing all other responses (see Table 2). Logistic regression models were then used to examine the impact of the various independent variables on attitudes of scientists, managers, interest group representatives, and the attentive public toward the proper role of scientists in the environmental policy process. The coefficient of a particular variable in Table 4 indicates the effect of that variable on agreement or disagreement with the five statements concerning the proper role for scientists in the natural resource policy process. For the series of three dummy variables assessing ideological orientation, it is necessary to omit one dummy variable for

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[2] The question and scale used to ascertain subjective political ideology was, "On domestic policy issues, would you consider yourself to be:"

Very Liberal 1----2----3----4----5----6----7 Very Conservative
/
Moderate

Respondents locating themselves as a "6" or "7" were recoded as "right," those identifying themselves as a "1" or "2" were recoded as "left," and the remaining respondents were recoded as "moderate."

[3] The measure of environmental attitudes used to predict environmental behavior and participation is Van Liere and Dunlap's (1981, 1980) New Environmental Paradigm indicator. The measure of NEP employed contained a subset of 6 of the 12 items found in the original inventory and has been found to generate results virtually identical to those of the 12-item version. The items are as follows: (1) the balance of nature is very delicate and easily upset by human activities; (2) the earth is like a spaceship with only limited room and resources; (3) plants and animals do not exist primarily for human use; (4) modifying the environment for human use seldom causes serious problems; (5) there are no limits to growth for nations like the United States; (6) humankind was created to rule over the rest of nature. A Likert type response format was provided for each item, taking the following format: "strongly agree," "agree," "neutral," "disagree," and "strongly disagree." A pro-NEP position consists of agreement on the first three items and disagreement on the last three items. After recoding items so that higher numbers reflected a biocentric position (New Environmental Paradigm) and lower numbers reflected an anthropocentric position (Dominant Social Paradigm), the responses were summed to form an indicator ranging from 6 to 30. The reliability coefficient (Cronbach's alpha) for the NEP was 0.81, suggesting that respondents were consistent in their response patterns for the additive scale.

Table 4
Logistical regression estimates for roles of scientists in the environmental policy process

Variables	Report: *B* (S.E.)	Interpret: *B* (S.E.)	Integrate: *B* (S.E.)	Advocate: *B* (S.E.)	Making decisions: *B* (S.E.)
Age	0.006 (0.010)	0.003 (0.010)	0.013 (0.012)	−0.003 (0.011)	−0.017 (0.013)
Gender	−0.60** (226)	−0.115 (0.235)	−0.017 (0.281)	−0.281 (0.251)	0.249 (0.289)
Education	−571* (0.273)	0.290 (0.298)	0.025 (0.368)	0.273 (3.43)	0.109 (0.383)
NEP	−0.092*** (0.024)	0.074** (0.025)	0.126*** (0.031)	0.130*** (0.032)	0.126*** (0.040)
Left	−0.458* (0.237)	0.002 (0.260)	0.204 (0.309)	0.668** (0.258)	0.309 (0.305)
Right	0.281 (0.341)	−0.349 (0.350)	−0.230 (0.412)	0.074 (0.437)	0.407 (0.511)
Positivism	−0.032 (0.023)	0.026 (0.025)	0.060*** (0.009)	0.117*** (0.028)	0.133*** (0.033)
Managers	−0.570* (0.298)	−0.222 (0.359)	1.413*** (0.349)	−0.074 (0.432)	1.007 (0.580)
Interest Groups	−0.943** (0.346)	−0.580 (0.381)	0.544 (0.414)	1.591*** (0.383)	1.951*** (0.531)
Public	−1.264*** (0.379)	−0.649 (0.420)	0.839 (0.483)	1.597*** (0.459)	1.836** (0.605)
N	574	574	574	574	574
Percent correctly classified	66.6	76.8	84.5	78.7	87.8
χ^2	65.20***	31.08***	45.05***	130.74***	81.34***

Note: The dependent variable for scientific advocacy (see Table 2) was dichotomized for use in logistic regression (1: strongly agree and agree, 0: else).
* Significance level $P < 0.05$.
** Significance level $P < 0.01$.
*** Significance level $P < 0.001$.

the equation to be estimated. The dummy variable representing moderates is the category omitted. Similarly, for the series of dummy variables assessing the four groups studied here, scientists are the omitted category.

For all five models presented in Table 4, the χ^2 statistic is significant at the 0.001 level, indicating that the specified structure constitutes an acceptable model in the statistical sense. In addition, the percent of cases correctly classified by each model ranges from a low of 66.6% for report to 87.8% for making decisions. In general, it appears that our models work well then in predicting whether respondents support each of the preferred roles for scientists in the environmental policy process. Tests were also conducted for multi-collinearity, heteroscedasticity, and nonlinearity in the models. The results indicate that all the models were appropriate given the nature of the social science data utilized.

When examining the five models presented in Table 4, we find that the positivism index has a positive and significant relationship for three of the roles—integrate, advocate, and making decisions. After controlling for the various independent variables, those respondents who have more positivistic orientations toward science (i.e., scored high on the positivism index) are significantly more supportive than those who are less positivist about science to: support scientists helping managers to integrate research into policy; believe scientists should actively advocate for natural resource policies they prefer; and, support scientists making natural resource management decisions. The positivism index does not have a significant effect for the first two roles, those that concern scientists only reporting or interpreting results (the more minimalist roles). These results reinforce the bivariate findings presented in Table 3.

Concerning the effect of the various sociodemographic and value orientation control variables for the five roles, only the NEP indicator has a significant effect for more than two roles. Those respondents who indicated strong support for the NEP—an indicator of biocentric values and concern for the environment—were significantly less supportive of scientists only reporting results, and were very supportive of scientists interpreting and integrating research results, advocating for policies they prefer, and even making natural resource management decisions. The only other variable that had a significant effect in more than one model is the dummy variable for very liberal/left respondents, who were less supportive than moderates and conservatives of scientists just reporting research and were more supportive of scientists involving themselves in advocacy.

The final set of variables included in each model are the dummy variables, which control for the four groups included in the study. The bivariate data displayed in Table 2 above indicated that interest group representatives and the attentive public were more supportive of active and more inclusive roles for scientists in the natural resource policy process. When controlling for various sociodemographic factors and value orientations, representatives of interest groups and the attentive public are indeed significantly more likely than scientists and natural resource managers to support scientists actively advocating management decisions they prefer and making natural resource management decisions (advocate and making decision models). In addition, managers, interest group members, and the attentive public are significantly less supportive than scientists of a minimalist role of just reporting research results for scientists in the policy process (report model). The only other model with a significant group dummy variable concerns scientists helping managers to integrate research results in management decisions. In this model, managers are significantly more supportive of this role for scientists than scientists themselves.

7. Summary and conclusions

The results reported in this study suggest that the attentive public and interest group representatives who have been involved in natural resource policy and management processes in the Pacific Northwest have high expectations for the ability of science to be objective and to provide important information to managers when making decisions about the management of natural resources. Their acceptance of positivist attitudes about science and the scientific process leads them to support more prominent roles for scientists in the policy process than scientists typically have held. On the other hand, it is interesting to note that many of the scientists included in this study are not only more sceptical about their ability to find "truth" and "facts" than the attentive public and interest group members, they are also more reluctant to support an advocacy role or to believe that they should make natural resource decisions themselves. While there is much more variety and diversity of opinion among scientists about the positivist picture of the scientific process, there is support for "integrative" or "post-normal" science where scientists directly involve themselves in the policy and management.

In our pre-survey interviews, we learned that there will be risks involved for research scientists who work closely with managers, public interest groups, and the public to formulate new environmental policies. Not only will some scientists have to leave the comfort of their labs and field work and their customary interactions with scientist colleagues, they also will have to learn to work more effectively with agency personnel and managers, public interest groups, and the public in unfamiliar contexts. Clearly, their work will inevitably come under closer public and interest group scrutiny than that carried out in the traditional scientific contexts, and our interviews indicated that the more privileged and in some ways more secure role that research scientists currently experience as generators of "objective" knowledge will be called into question, even by some of their peers. However, this study indicates that in the Pacific Northwest, where there has been considerable controversy about environmental policy matters, research scientists do have credibility with the public because of what the public believes about the nature of science and the roles of scientists.

In other parts of the United States and North America, many other kinds of natural resource and environmental policy issues are more salient than those relating to the disposition of forests, fisheries and rangelands. For example, much of the controversy in the Pacific Northwest region has focused on endangered species protection in old growth forests and large riverine systems, while in some other parts of the country environmental controversies have focused on other species, other kinds of ecosystems, and private lands management. In the Pacific Northwest, scientists have been prominently involved in both the management of federal land and water resources and the development of science-based policy about ecosystem restoration. Public groups and resource managers are accustomed to calling on public scientists to aid them in resolving environmental policy questions. These kinds of historical factors, then, could account for some of the attitudes of our four groups with regard to science and the roles of research scientists. However environmental and species controversies are certainly not unique to the Pacific Northwest, and so further research is needed to investigate whether the results of this study are applicable to other regions of the country.

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Appendix A

Control variables for orientations toward scientist advocacy

Variable name	Variable description	Scientists: mean (S.D.)	Managers: mean (S.D.)	Interest groups: mean (S.D.)	Attentive public: mean (S.D.)
Age	Respondent age in years (range: 18–91 years)	47.9 (8.38), $n = 155$	47.5 (6.70), $n = 167$	49.0 (12.01), $n = 118$	56.4 (12.85), $n = 193$
Gender	Dummy variable for respondent gender; 1: female, 0: male	0.31, n=155	0.31, $n = 167$	0.30, $n = 118$	0.29, $n = 192$
Education	Dummy variable for educational attainment; 1: graduate degree, 0: else	0.95, n=155	0.40, $n = 167$	0.34, $n = 119$	0.31, $n = 192$
NEP	New Environmental Paradigm Index; 6: low support for NEP to 30: high support for NEP	25.77 (2.94), $n = 155$	23.79 (3.86), $n = 164$	26.38 (3.75), $n = 114$	23.96 (5.67), $n = 181$
Left	Dummy variable for ideologically liberal respondents; 1: very liberal/left, 0: else	0.44, n=155	0.18, $n = 167$	0.36, $n = 119$	0.15, $n = 198$

Appendix A. (*Continued*)

Variable name	Variable description	Scientists: mean (S.D.)	Managers: mean (S.D.)	Interest groups: mean (S.D.)	Attentive public: mean (S.D.)
Moderate	Dummy variable for ideologically moderate respondents; 1: moderate, 0: else	0.53, n=155	0.77, n = 167	0.56, n = 119	0.68, n = 198
Right	Dummy variable for ideologically conservative respondents; 1: very conservative/right; 0: else	0.03, n=155	0.05, n=167	0.08, n=119	0.17, n = 198

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