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Science and Scientists in the U.S. Environmental Policy Process

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Abstract: Many policy makers, academics, interest groups, environmental managers, and interested citizens have called for a 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 while science is an important source of information for environmental policy, scientists should only supply the public and policy-makers relevant information and avoid advocating for preferred policy outcomes. They argue that scientists can lose their credibility if they cross the line between science and policy. We investigate this debate with a 2007 U.S. study examining the attitudes of scientists, environmental managers, interest groups, and the public concerning the role of science and scientists in environmental policy. In interviews and surveys with members of these four groups, we find 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: Environmental Policy, Science Policy, Positivism, Post-Normal Science

Introduction

IN RECENT YEARS there has been an increasing emphasis among decision makers, interest groups, and citizens about the importance of science-based environmental policy at local, regional, national, and international levels of governance (Johnson et al., 1999; Sarewitz, Pielke, and Byerly, 2000). Many advocates of science have normative expectations that science can improve the quality of complex environmental policy decisions (e.g., Ehrlich and Ehrlich, 1996). The assumption is that scientists can and should facilitate the resolution of environmental policy decisions by providing scientific information to policy-makers and the public, and by becoming more directly involved in policy arenas than they have been traditionally (Mazur, 1981; Tickner, 2003). This assumption suggests a changing expectation for science and scientists from traditional or what Thomas Kuhn (1962) calls "normal" roles to a more "post-normal" or "integrative" model of engagement and involvement (Funtowicz and Ravetz, 1992; Lee, 1993).

The study presented here study builds on a previous pilot study that examined the role of science and scientists in the western United States (Steel et al., 2004). In that study, data

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were collected from interviews and surveys of four different groups involved in environmental policy and management including: (1) ecological scientists at universities and federal agencies; (2) natural resource and environmental managers of state and federal programs; (3) members of interest groups (e.g., environmental groups, industry associations, etc.); and (4), the general public. In general, the pilot study found that while there are limits to the roles that scientists can play in these decisions, there is still broad support for more active involvement by scientists in these decisions.

This new national U.S. study is part of a larger project that examines changing expectations for science and scientists in environmental policy making with several case study sites that control for rural-urban and regional locations, as well as different types of ecosystems (desert, temperate forest, etc.). Using data and interviews conducted with national samples of ecological scientists, natural resource and environmental managers, natural resource and environmental interest groups, and the general public, we examine: (1) attitudes toward science and the scientific method; (2) attitudes toward the roles of scientists in environmental management; (3) the preferred role for scientists in environmental management; and (4) the correlates for the preferred role of scientists in environmental management.

Science and the Roles of Scientists in the Environmental Policy Process

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 (e.g., A.J. Ayer and Karl Popper). Positivism finds it roots in the scientific revolution and the Enlightenment in Europe during the sixteenth and seventeenth centuries, and, in the nineteenth century, came to be specifically identified with the writings of the philosopher Auguste Comte and others (see Achinstein and Barker, 1969). 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.

While there is theoretical diversity evident among positivists themselves, there are similarities in the shared belief that science is the best way to get at truth, to understand the world well enough so that we might predict the future, and then possibly control and manipulate physical and social phenomena in specific ways (see Rescher, 1985). The underlying assumption is that the universe operates through laws of cause and effect, which can be discovered through the scientific method.

Few 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 contemporary scientific research (Bechtel, 1988). As Nobel Prize winner Polanyi explains: "Science is done by scientists, and since scientists are people, the progress of science depends more on scientific judgment than on scientific instruments" (1995: 7). Moreover, the rise of the history and sociology of science and scientific knowledge as academic disciplines has led to a more complex characterization and debate about the nature of science and its relationship to social and personal factors (e.g., Bloor, 1976; Collins and Pinch, 1993; Jasanoff, et al., 1995). At the same time, Bechtel (1988: 49) argues, "The Positivists' picture of science remains the most comprehensive we have," and, in practice, even the reports we provide in our peer-reviewed publications are still framed within the positivistic model.

The role of scientists in this "normal" or "basic research" positivistic 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. Moreover, scientists are not to become biased by involvement in environmental policy or to become policy advocates. In this model, science is revered 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. Scientists can lose their credibility as scientists if they cross the line between science and policy, science and management (Alm 1997-98; Lackey, 2007). This leads to a "separatist" role for scientists; ideally they are removed from management and policy and serve as experts or consultants only; called upon as the need arises and as policy-makers, managers, and the public require. As Lackey has argued (2007: 12): "Scientists are uniquely qualified to participate in public policy deliberations and they should, but advocating for the policy preferences is not appropriate."

An alternative emerging model challenges the normal science model, not so much on the authority of scientific information and the acceptability of positivism, but on the exclusion of scientists and the public in environmental policy and management (Kay, 1998; Lubchenco, 1998). It proposes that 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. This has led former president of the American Association for the Advancement of Science and current director of the National Oceanic and Atmospheric Administration—Jane Lubchenco—to argue for a "new social contract" for scientists with society (1998: 491):

> The new and unmet needs of society include more comprehensive information, understanding, and technologies for society to move toward a more sustainable biosphere—one which is ecologically sound, economically feasible, and socially just. New fundamental research, faster and more effective transmission of new and existing knowledge to policy- and decision-makers, and better communication of this knowledge to the public will all be required to meet this challenge.

There is a need for more science in these processes and decisions, the model argues, 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 (Lubchenco, 1998; Nelson and Vucetich, 2008). 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.

Lubchenco's new social contract has also been called "integrative" and "post-normal" science and is related to Kai Lee's "civic" science (1993). All of these models call for more personal involvement by individual research scientists in bureaucratic and public decision making, providing expertise and sometimes even promoting specific strategies that they believe are supported by the available scientific knowledge (Ravetz, 1987). 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.

In this study, we investigate orientations toward the proper role of scientists in the policy process. Based on interviews and an exploratory survey of scientists, we developed a list of five potential roles of scientists in the policy process. These ideal types reflect a complex relationship among expectations of science, attitudes about environmental management, and decision-making styles (see Table 2). While the categories reflect levels of preference for scientist involvement ranging from minimal to dominant roles, they also distinguish between science as an activity separate from other, non-scientific activities and science as an activity integrated with management and other non-scientific activities.

The first role ("report only"), reflecting the traditional science model, limits research scientists to reporting results and letting others make resource decisions. As examples of emerging and post-normal roles, we described two possibilities: for research scientists to interpret scientific results so that others can use them ("interpret") and a more involved role in working closely with managers and others to integrate scientific results directly into resource policies and decisions ("integrate"). 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 ("advocate"). A final role, reflecting the increasingly technical and complicated decisions facing natural resource managers, is to have such scientists make resource decisions themselves ("make decisions" role).

In the previous western U.S. pilot project, scientists, managers, interest groups, and members of the public were asked to report how much they agreed with each of these potential roles. 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" – descriptions of the emerging role. Managers, representatives from NGOs, and the attentive public most often preferred "helping managers to integrate research results," while scientists themselves preferred the slightly less involved role of only "interpreting of research results." In general, most respondents were least supportive of scientists making decisions themselves; however, NGOs and the public also were not enamored with a minimalist role of "just reporting" scientific results and were more likely than scientists and managers to support an advocacy role for scientists. Scientists and managers were unlikely to support an advocacy role for scientists. In summary, respondents in all four groups were likely to agree that integrative roles are more preferable than any of the other roles, including the minimalist traditional role of just reporting results.

The western U.S. pilot study also found that those scientists, managers, interest group representatives, and public participants who accept key elements of positivism were the most

supportive of involving scientists in the policy process, while those who are less positivistic and view science as problematic when applied to policy-making were less likely to prefer an integrative and involved role for scientists. We expect that this is because those who have more positivistic ideas about science perceive scientists as able to separate their personal agendas from the scientific information they bring to policy discussions and decisions.

Finally, a "culture of science" affects research scientists in a manner that does not so clearly apply to other groups (managers, the public, and interest groups) in the policy process (Steel et al., 2004). Scientists operate in a communal scientific environment that imposes different kinds of demands on their time and energy than other policy participants, and their reputations and identities as scientists depend upon a different system of institutional relationships and rewards. Involvement in resource management and public environmental policy processes requires somewhat different communication and interpersonal skills than those that are effective in the scientific community. Involvement may also elicit normative opinions in the scientific and policy arenas that can undermine scientists' authority and personal decorum. We found in our interviews that scientists tended to express reservations about researchers who do become involved in policy matters, and may question their standing and credibility as a result. These, and other, factors can mean that scientists will be wary of researchers taking a more active**,** integrative role in policy making.

Environmental managers, on the other hand, work in a context that is quite different from that of research scientists. For example, because of bureaucratic imperatives they do not always have the time to wait until science can provide relatively certain recommendations for action. Nor do managers have to conduct basic research in order to gain the kinds of rewards that scientists receive for publishing innovative results. While many managers have been trained within scientific disciplines, they are unlikely to be directly involved in the scientific community and thus may not share as deeply the values and norms that define the culture of science. This leads many of them to view the role of scientists differently than scientists themselves, accepting their authority as scientists but not as advocates for particular policy decisions (Lach et al., 2003). While many scientists and environmental policy participants have normative expectations that including ecological scientists and ecological information will improve complex natural resource decisions, our previous research and other observers have argued there is increasing evidence of tensions between the distinct institutional needs and cultural values of decision makers and scientists, potentially precluding the effective use of science in many environmental decisions (e.g., Allen et al., 2001; Brown and Harris, 1998 and 1992**;** Collingridge and Reeve, 1986; Meidinger and Antypus, 1996). This national study can help expand our understanding of the expectations relevant groups have for the use of ecological information in environmental policy making, how science is perceived in terms of objectivity, and the range and acceptability of appropriate roles that scientists can take in policy making and natural resource management.

Given our literature review and previous findings from the western U.S. pilot study, we expect the following findings:

- The public and interest group representatives will be most likely to support assumptions of positivism when compared to managers and scientists. They are most likely to believe that science can be an objective process that produces value- free information. Scientists and managers, as producers and consumers of scientific information, will more likely know the limitations of science and scientists concerning objectivity.

- Because the public and interest group representatives are more likely to view science and scientists as objective, they will be the more supportive of roles that integrate scientists in policy making when compared to managers and scientists.

Methods

In earlier research (Lach et al., 2003; Steel et al., 2004) we conducted interviews with representatives of four different groups involved in environmental decision making to identify relevant issues and concerns that existed about expectations for science and scientists: scientists, managers, members of non-governmental organizations, and the public. We use these four groups as rough surrogates for social context in that each group has different objectives, expectations and practices, which requires different types of participants and participation as discussed in some detail above.

We developed two separate indexes to measure beliefs and attitudes about science, and preferences for the role of science in policy-making. To measure attitudes and beliefs about science, university and government researchers, philosophers of science, and social scientists were asked about their level of agreement with a series of 40 statements taken from the work of philosopher Karl Popper (1972) that underlie many of the assumptions implicit in positivism, broadly construed. We included ten of these statements that were uniformly identified by respondents as describing "positivistic" approaches to science in the surveys described in this report. Using factor analysis (varimax rotation) on survey results, five of the statements were found to load in the first component and are listed below in Table 1 where we describe the findings. Agreement with these five statements can be interpreted as support for the important principles inherent in a positivistic perspective of science.

Based on interviews and the exploratory survey of scientists, we then developed a list of five potential roles for scientists in the policy process as described above. These *ideal types* reflect a complex relationship among expectations of science, attitudes about resource management, and decision-making styles. This list is not technically a scale or index, and we asked all respondents to tell us how much they agreed with each of the 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 "highly disagree" to "highly agree" (see Table 2 in the findings section).

We also gathered information about the value orientations of respondents (for use in multivariate analyses) through a self-assessed general political orientation on a nine-point scale from one (very left/liberal) to nine (very right/conservative) and a measure of environmental attitudes that has been used widely to predict environmental behavior and participation—Dunlap et al.'s (2000) "New Ecological Paradigm" (NEP). For our surveys, we used a subset of six of the 15 items found in the NEP (see Steel et al., 2004). Previous research shows a strong and significant relationship between the NEP and more active roles for scientists in the policy process (Dunlap et al., 2001; Steel et al., 2004). Similarly, many suggest a strong relationship between political ideology and trust/distrust of science and scientists, with conservatives likely to be distrustful and liberals more trusting (Dunlap et al., 2001; Ehrlich and Ehrlich, 1996). While the sources of distrust among conservatives stems from a variety of reasons (e.g., more literal interpretations of the bible as well as pro-business at-

titudes), it has led one observer to title his recent book *The Republican War on Science* (Mooney, 2006). Finally, we collected data about respondents' gender (self-identification as either "male" or "female"), age, and level of education. Summary measures for all explanatory variables used in multivariate analyses (i.e., gender, age, education, political ideology, NEP, and positivism) can be found in Appendix A.

In 2007, surveys were administered to national random samples of representatives of the four different groups. First, we sampled scientists working through the National Science Foundation's Long Term Ecological Research (LTER) program as a group of relatively homogenous scientists involved in potentially policy-relevant research. These scientists work at universities, state and federal agencies, and private organizations. We also sampled managers of state and federal natural resource and environmental agencies (e.g., U.S. Forest Service, Bureau of Land Management, U.S. Fish and Wildlife Service, National Park Service, state departments of natural resources, parks, environmental quality, etc.). While many of these respondents have graduate science degrees, they identified themselves as resource managers responsible for implementing agency objectives. We also contacted a sample of directors and leaders of natural resource and environmental organizations (e.g., environmental groups, industry associations, recreation groups, etc.). Again, some of these respondents have advanced science degrees, but for the purposes of this study self-identified as part of an organization that advocates for a particular policy position. Finally, we conducted a random sample of the general public. Unlike the other samples, this group tended not to have advanced science degrees.

The scientist sample was provided by the LTER program, the public sample was provided by a national sampling company, and the manager and interest group samples were compiled by systematic random sampling from association and group directories available in print and on the internet. Examples include *The National Environmental Directory* (http://www.environmentaldirectory.net/) which has over 13,000 environmental and conservation groups listed, and the *Conservation Directory 2004* (Island Press, 2004), which has nearly comprehensive lists of conservation and environmental organizations, government agencies, nongovernmental organizations, and colleges and more than 18,000 officials concerned with natural resource use, management and education.

The surveys were designed using Don Dillman's *Mail and Telephone Surveys: The Total Design Method* (1978). For all groups, up to three rounds of mail surveys were sent with a fourth telephone reminder if necessary. Sample sizes and response rates are as follows:

Sample	**Surveys Sent**	**Surveys Returned**	**Response Rate**
Scientists	424	355	84%
Managers	500	272	54%
Interest Group Representatives	500	287	57%
Public	3,147	1,605	51%

Findings

In order to determine orientations toward science, each respondent was asked her/his level of agreement or disagreement with the five statements describing positivistic science. 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." Agreement with these five statements can be interpreted as a belief in many of the important principles inherent in a positivistic perspective of science.

Table 1: Attitudes toward Science and the Scientific Method

		Scientists	**Managers**	**Interest Groups**	**Public**
		Mean (s.d.)	*Mean (s.d.)*	*Mean (s.d.)*	*Mean (s.d.)*
a.	Use of the scientific method is the only certain way to determine what is true or false about the world. *F-test* = 3.14*	3.04 (1.36)	2.86 (1.21)	3.18 (1.24)	3.06 (1.27)
b.	The advance of knowledge is a linear process driven by key experiments. *F-test* = 59.83***	2.55 (1.23)	3.00 (1.06)	3.00 (1.14)	3.18 (1.14)
c.	Science provides objective knowledge about the world. *F-test* = 4.12**	4.05 (0.93)	3.88 (0.76)	4.05 (0.93)	3.91 (0.96)
d.	Science provides universal laws or theories that can be verified. *F-test* = 2.78*	3.73 (1.24)	3.77 (0.80)	3.95 (0.95)	3.84 (0.97)
e.	Scientists are generally more objective than others involved in natural resource management decisions. *F-test* = 8.54***	3.57 (0.99)	3.17 (0.96)	3.36 (1.08)	3.30 (1.08)
	Positivism index mean = (s.d.) = n = *F-test* = 18.379***	16.99 (3.79) 346	16.68 (2.94) 263	17.50 (3.62) 272	17.46 (3.73) 1,591
[*Scale used:* 1=strongly disagree, 2=disagree, 3=neutral, 4=agree, and 5=strongly agree.] Significance levels: * $p < .05$; ** $p < .01$; *** $p < .001$					

F-test results indicate that there are statistically significant differences among the four groups for all five statements. The public and interest groups tend to have the highest mean scores

of all groups while managers and scientists have the lowest scores. Table 1 also displays a summary index created by adding all five statements together (index range: 5=strong disagreement with principles of positivism and 25=strong agreement). Additive index scores indicate that managers have the lowest level of support for the positivist perspective about science and the scientific process followed closely by scientists. Interest group representatives and the public tend to be more positivistic concerning science, with interest group representatives having the highest index score.

Ironically, those who 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 least receptive to positivist beliefs about the scientific process. For the most part, this may reflect their knowledge about the reality of science. For scientists, this may be the result of their actual practice of science, which they've learned doesn't always fit into the strict norms and expectations of positivistic science. 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, representatives of interest groups and the public, who often support and call for science-based environmental management, are more trusting of the research produced and more accepting of positivist science. Favorable attitudes about science and its certainties, and support for a positivist conception of science, may lead public and interest group representatives to be more confident about the value of science in policy making and to potentially place political pressures on scientists to be more involved in the policy process.

In Table 2 we present a variety of roles scientists may play in the policy process and the levels of support for them shown by each group. As in the western U.S. pilot study reported above, the two most popular roles for scientists in the natural resource policy process for all four groups are "work[ing] closely with managers to integrate scientific results" and "interpreting the results of research for others involved in the process." In general, most respondents with the exception of managers, showed the least amount of support for scientists' taking a minimalist role of only reporting results; most respondents were also not enamored with scientists making decisions about natural resource management (this tended to be managers least supported role). When it comes to scientists taking an advocacy role, scientists and managers tended to be less supportive than interest groups and the public. However, while F-test results indicate statistically significant differences between groups, in general respondents in all four groups have similar preferences for the potential roles of research scientists in natural resource decision-making.

Table 2: Attitudes toward Scientist Roles in Policy and Management

Roles		**Scientists** *Mean (s.d.)*	**Managers** *Mean (s.d.)*	**Interest Groups** *Mean (s.d.)*	**Public** *Mean (s.d.)*
a	Scientists should only **report** scientific results and leave others to make natural resource management decisions. *F-test* = 22.64***	2.21 (1.24)	3.02 (1.29)	2.27 (1.24)	2.46 (1.31)
b	Scientists should report scientific results and then **interpret** the results for others involved in natural resource management decisions. *F-test* = 16.48***	4.32 (0.78)	4.02 (1.06)	4.19 (0.87)	3.91 (1.16)
c	Scientists should work closely with managers and others to **integrate** scientific results in management decisions. *F-test* = 10.33***	4.49 (0.70)	4.57 (0.67)	4.53 (0.80)	4.32 (0.99)
d	Scientists should actively **advocate** for specific natural resource management policies they prefer. *F-test* = 25.54***	2.95 (1.26)	2.75 (1.25)	3.23 (1.25)	3.37 (!.27)
e	Scientists should be responsible for **making decisions** about natural resource management. *F-test* = 13.99***	2.55 (1.25)	2.23 (1.14)	2.89 (1.21)	2.64 (1.22)
		n=352	n=262	n=280	n=1,601
[*Scale used:* 1=strongly disagree, 2=disagree, 3=neutral, 4=agree, and 5=strongly agree.] Significance level: *** $p < .001$					

The multivariate analysis included in this study examines differences among the four groups concerning attitudes toward scientific roles while controlling for various explanatory variables, including the positivism index. A number of studies have addressed various aspects of the relationship between social values, science, and attitudes toward natural resource management (e.g., Alm, 1997-98; 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 and others (e.g., Von Roten, 2004), attitudes about the preferred role of scientists in natural resource management are influenced by a variety of factors. Primary influences in the literature discussed above include socio-demographic characteristics, as well as political and environmental value orientations. The socio-demographic variables we examined as predictors of orientations toward the role of scientists in the policy process include gender, age, and level of formal educational attainment, all of which have been shown in the literature

to affect attitudes toward science (Steel et al., 2006). As described above, we used a self-assessment measure of general political orientation and questions from the NEP scale (Dunlap et al., 2000) to assess political and environmental value orientations.

Because the responses for many of the dependent variables concerning the roles of scientists are skewed, each variable was dichotomized with 1 representing "agree" and "strongly agree" responses and 0 representing all other responses. Logistic regression models were run on a pooled sample to explore the impact of the various explanatory variables on attitudes toward the various roles of scientists in the environmental policy process. For the series of dummy variables assessing the four groups studied here, scientists are the omitted category.

Table 3: Logistic Regression Estimates for Roles of Scientists in the Environmental Policy Process

	Report	**Interpret**	**Integrate**	**Advocate**	**Making Decisions**
Variables:	*B* **(S.E.)**	*B* **(S.E.)**	*B* **(S.E.)**	*B* **(S.E.)**	*B* **(S.E.)**
Age	.008 (.004)	.008 (.005)	.004 (.006)	.008 (.004)	.003 (.004)
Gender	-.452*** (.112)	-.045 (.115)	-.004 (.146)	.118 (.097)	.243* (.108)
Education	-.180*** (.047)	.129** (.049)	.156** (.061)	.137*** (.042)	.070 (.048)
NEP	-.069*** (.011)	.086*** (.012)	.113*** (.015)	.036*** (.010)	.054*** (.012)
Ideology	.199*** (.036)	.059 (.037)	.054 (.048)	-.123*** (.031)	-.047 (.034)
Positivism	-.047** (.015)	.065*** (.016)	.065*** (.020)	.066*** (.013)	.143*** (.016)
Managers	1.263*** (.167)	.044 (.190)	.038 (.348)	-.946*** (.158)	-.463* (.193)
Interest Groups	.199 (.181)	.378 (.204)	.295 (.268)	.556** (.191)	.257 (.161)
Public	-.762*** (.137)	-.204 (.153)	-.382 (.273)	1.103*** (.132)	.144*** (.016)
N =	2,072	2,072	2,072	2,072	2,072
Percent correctly Classified =	72.8%	78.4%	87.8%	61.5%	71.4%
Chi-square =	265.708***	86.986***	125.853***	166.896***	201.275***

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 levels: * $p < .05$; ** $p < .01$; *** $p < .001$

When examining the five models presented in Table 3, we find that the positivism index has a significant relationship in all five models, although there is a negative relationship in the "report only" model. This suggests that those respondents who have more positivistic orientations toward science (i.e., scored high on the positivism index) are less supportive of the minimalist role of just reporting findings, but are significantly more supportive of involving scientists in policy making; they support scientists helping managers to interpret research,

integrate research into policy, advocate for natural resource policies they prefer and, making natural resource management decisions.

Concerning the effect of the various socio-demographic variables for the five roles, it appears that respondents' age tends not to affect preferences for different roles, although gender has a significant effect for "report only" and "make decisions," albeit in different directions. Women are less supportive than men of the minimalist role of just reporting results yet more supportive than men for scientists making natural resource decisions. In addition, education had a significant effect in four models with respondents with higher levels of education supporting more active roles for scientists (interpret, integrate and advocacy) while expressing less support for the minimalist role of "report only."

Looking at the effect of value orientation on role preference, the NEP indicator has a significant effect for all five roles. Those respondents who indicate strong support for the NEP–an indicator of bio-centric values and concern for the environment–are significantly less supportive of scientists only reporting results, and yet are very supportive of scientists interpreting and integrating research results, advocating for policies they prefer, and even making natural resource management decisions. For the variable assessing political ideology, we find that very liberal/left respondents were significantly more supportive of advocacy but less supportive of just reporting results. These findings are generally consistent with what we found in the western U.S. pilot study.

The final set of variables included in each model compares the four groups included in the study. The bivariate data displayed in Tables 2 above indicates that interest group representatives and the public are generally supportive of active and more inclusive roles for scientists in the natural resource policy process. When controlling for various socio-demographic factors and value orientations, representatives of interest groups and the public are indeed more likely than scientists and natural resource managers to support scientists actively advocating management decisions they prefer, and for making natural resource management decisions. In addition, the public was significantly less supportive than scientists and managers of a minimalist role of just reporting research results. Managers were significantly more supportive of this report-only role than scientists. This may indicate a preference of managers to maintain more control of the management process for themselves. This theme is also reinforced by managers' significantly lower levels of support for scientists becoming advocates and making management decisions themselves. Once controlling for other factors, we find very little difference among the four groups in their level of support for the more moderate role of scientists—those of interpreting science and integrating the results in management decisions.

One small difference between the findings presented here and the previous western U.S. pilot study is the preference of managers for more limited roles for scientists. Managers in the pilot study were somewhat more open to active roles for scientists, especially in terms of helping to integrate science into management decisions. One potential explanation for this difference is that managers in the western U.S. study were disproportionately working with federal forest management issues—more specifically, the Northern Spotted Owl and other endangered species on public forestlands and watersheds. There has been extreme polarization of these issues with many lawsuits, civic disobedience, etc. Therefore managers may have been looking for some "cover" from scientists when developing management plans. While such issues are not unknown in the rest of the United States, managers in other

geographical locations, particularly those with fewer public lands, may not experience such high levels of frustration and experience with extreme policy polarization.

Conclusion

The results reported in this study suggest that the public and, to some extent, interest group representatives, have higher expectations for the ability of science to provide objective and important information to managers who are 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 and managers 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 skeptical about their ability to find "truth" and "facts" than the 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 variety and diversity of opinion among scientists about the positivist pictures of the scientific process, there is surprisingly strong support for "integrative" or "post-normal" science with scientists directly involving themselves in natural resource and environmental policy and management.

This "post-normal" approach to science calls for increasing involvement by researchers in public and bureaucratic decision-making, providing expertise and helping integrate new information into existing decision routines and practices (Ravetz, 1987; Steel and Weber, 2001). Others, such as Kai Lee, have similarly called for something they call a "civic science" that brings scientists and scientific information into active collaboration with others to craft workable solutions to pressing environmental problems (Lee, 1993). These approaches do bring scientists out of the laboratory and into the political realm, which may be uncomfortable for scientists who aren't familiar or skilled at working in these arenas. It also raises issues of scientific credibility, which is still tied to the positivistic ideals of objectivity and neutrality. Scientists willing and skilled in walking the tightrope that is policymaking will help to familiarize non-scientists with both the strength and limitations of science. It will also help scientists understand more clearly the range of roles available for science and scientists in the "sausage-making" –managing multiple objectives of numerous parties with divergent interests – that is natural resource policy making today.

Our findings provide empirical data that suggest the theoretical and normative calls for a practice of science that involves scientists more directly in policy decisions (e.g., "civic science") would find acceptability among most of the parties typically involved in natural resource policy including the scientists themselves. The findings also suggest that most potential users of science (and scientists themselves) have a relatively nuanced view of the practice of science that is neither strictly normal nor post-normal in nature. This may be a reflection of the complexity of many natural resource phenomena such as endangered species recovery, water resource allocation, conservation management and others that require a full spectrum of knowledge including local, technical, social, and political along with scientific information. It may also be a methodological artefact of the way we framed our questions or research design; it will be important to continue examining these questions in different policy and scientific settings to determine whether ecological science and/or natural resource policy arenas are unique or representative in their changing expectations for the role of science and scientists in policy making.

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Appendix A: Explanatory Variables for Orientations toward Scientist Roles

Variable Name	Variable Description	Scientists Mean (s.d.)	Managers Mean (s.d.)	Interest Groups Mean (s.d.)	Public Mean (s.d.)
Age	*Respondent Age in Years*	49.99 (10.89) n=350	51.35 (8.37) n=260	53.73 (11.66) n=279	50.90 (12.36) n=1,598
Gender	*Dummy variable for respondent gender* 1= female 0= male	.34 n=354	.18 n=262	.32 n=287	.51 n=1,603
Education	*Dummy variable for educational attainment.* 1=grade school to 7=graduate school	6.03 (.421) n=352	5.39 (.614) n=262	4.36 (1.80) n=287	5.16 (1.16) n=1,599
NEP	*New Environmental Paradigm Index.* 6=low support for NEP to 30=high support for NEP	23.93 (4.12) n=348	20.75 (4.63) n=269	23.13 (5.12) n=276	20.73 (5.52) n=1,592
Ideology	*Dummy variable for ideologically liberal respondents.* 1=very liberal/left to 9=very conservative/right	3.29 (1.58) n=350	4.89 (1.50) n=257	4.36 (1.80) n=287	5.47 (1.74) n=1,599

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