Restarting the conversation: challenges at the interface between ecology and society

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The exchange of information between researchers, resource managers, decision makers, and the general public has long been recognized as a critical need in environmental science. We examine the challenges in using ecological knowledge to inform society and to change societal actions, and identify a set of options and strategies to enhance this exchange. Our objectives are to provide background information on societal knowledge and interest in science and environmental issues, to describe how different components of society obtain information and develop their interests and values, and to present a framework for evaluating and improving communication between science and society. Our analysis strongly suggests that the interface between science and society can only be improved with renewed dedication to public outreach and a wholesale reconsideration of the way that scientists communicate with society. Ecologists need to adopt new models of engagement with their audiences, frame their results in ways that are more meaningful to these audiences, and use new communication tools, capable of reaching large and diverse target groups.

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In contemporary society, scientists hold a considerable degree of respect, trust, admiration, and authority. Surveys show that North American and European citizens hold a deep belief in the promise of science to solve problems, as well as to improve quality of life and the economy (Eurobarometer 2008; NSB 2008; Pew Research Center on People and the Press 2009a). Even on controversial topics such as climate change, many Americans believe scientists have comparatively greater expertise, are less self interested, and should have greater say in policy decisions that affect the environment than industry leaders, elected officials, and/or religious leaders (NSB 2008).

If scientists have earned this almost unrivaled cultural authority and public respect, then what explains continued societal inaction and political gridlock on pressing problems related to global climate change and environmental degradation? Many environmental scientists feel that the need for renewed efforts at the interface between science and society has reached a critical state (Moser and Dilling 2004). Data on the severity and causes of global environmental problems abound, and the likely future trajectories related to these problems are remarkably consistent. In most cases, our understanding of what drives these changes, albeit incomplete, is sufficient to inform societal action to curb or even reverse these trends. Yet, the availability of this knowledge does not seem to have affected the current trajectories projecting continued environmental degradation.

For ecologists, public communication and engagement have long been recognized as major priorities and as mechanisms for catalyzing societal action (Lubchenco 1998; Jordan *et al.* 2009). However, many scientists continue to base public communication efforts on a set of false assumptions that limit their effectiveness (Nisbet and Scheufele 2009). Although several factors contribute to societal inaction in resolving environmental problems, scientists must recognize that they share part of the blame. In this paper, we examine the barriers and bottlenecks in the use of ecological knowledge to change societal actions and then identify a set of options and strategies that may help overcome these difficulties.

The objectives of the Cary Conference on *Effective communication of science in environmental controversies*, on which this Special Issue is based (May 2009 – Cary

In a nutshell:

- Effective communication of science to the public requires understanding that most learning occurs outside of the classroom and is influenced by learners' interests, prior knowledge, social networks, and values/beliefs
- A "deficit model", which assumes that public perceptions of science controversies are rooted in ignorance, is not effective for communication; instead, scientists need to "frame" issues in ways that resonate with the public
- New communication tools and social science research can help scientists to interact with the public more effectively

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Institute of Ecosystem Studies in Millbrook, New York), were to (1) evaluate successes and challenges in the use of information produced by basic ecological research in applied environmental science, policy, and management, and (2) produce specific recommendations on how individuals, institutions, and agencies can promote the "broader impacts" of their research. The dominant finding of the conference was that improving the use of ecological information in environmental decision making and problem solving requires a rededication to outreach and a thorough re-evaluation of our audiences and the public responsibilities of ecologists. In particular, ecologists must make greater efforts to reach non-scientific audiences and need to think more deeply about the social networks that influence these audiences.

The objectives of this paper are to (1) review the state of societal knowledge and concerns regarding environmental issues, (2) describe how different societal groups obtain information and develop their interests and values, and (3) present recommendations for evaluating and improving communication between scientists and society. In the sections that follow, we briefly summarize research on public understanding and concern about the environment across the US; review relevant research from the social sciences on how people acquire information, form opinions, and learn about environmental issues; and describe several possible new public engagement initiatives that follow from this research. Subsequent papers in this issue of *Frontiers* provide analysis and recommendations for how specific groups – including scientists, academic institutions, management and policy agencies, interface organizations (eg USDA's Cooperative Extension Service, which provides advice to farmers), and advocacy groups – can improve the flow of information from science to society. We also direct the reader to recent general guides to science communication (Cox 2009; Olson 2009), as well as recent compilations of research from the field of science communication (Bucchi and Trench 2008; Cheng *et al.* 2008; Holliman *et al.* 2008a,b; Kahlor and Stout 2009; Nerlich *et al.* 2009).

Does the public know and care about environmental issues?

Public understanding of, and concern about, environmental quality vary markedly in time and space. Between 2001 and 2009, the proportion of US residents, surveyed in Jones (2009), who rated the overall quality of the environment as "excellent" declined from 46% to 39%, while those who considered it to be "poor" increased from 6% to 16% over the same time period. These results show that many people in the US are aware of, and concerned about, environmental quality. This may be due in part to increased media coverage of environmental issues, especially climate change (Figure 1). However, while 65% of interviewed US residents were able to identify carbon dioxide as a gas linked to rising temperatures, only 49%

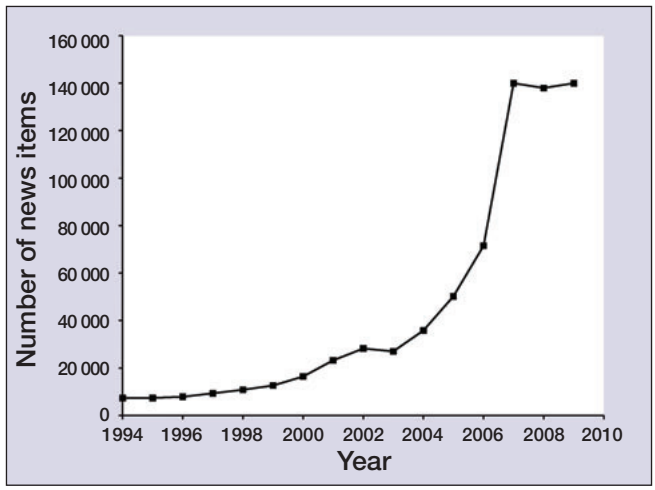

Figure 1. *News items on climate change published in English from 1995 to April 2009. Data retrieved from Google News using the search term "climate change".*

believe that the Earth is getting warmer because of human activity (Pew Research Center for People and the Press 2009b). Awareness of, and concerns about, environmental quality also vary greatly within the US population, with poorer, black, and urban residents favoring environmental protection efforts more than non-Hispanic white, middle-class, college-educated, and suburban residents (Greenberg 2005).

In Europe, the proportion of surveyed citizens that consider themselves to be informed on environmental issues ranged from a high of 78% in Denmark to a low of 30% in Romania (Eurobarometer 2008). Global comparisons show even wider divergence; eg although 99% of Japanese citizens polled report knowledge of climate change, only 15% of Beninese citizens who were interviewed and less than 30% of people sampled in most African and many Asian countries are aware of this issue (Pelham 2009).

Temporal variation in concern about environmental problems is driven by the emergence of other issues, particularly economics, that become more important to people. A recent poll (Pew Research Center for People and the Press 2009b) indicates that the proportion of US residents that feel that protection of the environment should be given priority is at a 30-year low. In a list of 20 priorities, "environment" ranked 16th, and "global warming" ranked 20th, well below concerns about "jobs", "economy", "education", and "health care". These results likely reflect the difficult global economic conditions of 2008 and 2009. In contrast, European Union residents consider the state of the environment to have as much bearing on their quality of life as economic and social factors. Indeed, they rank environmental issues, such as food and water scarcity and climate change, as the most serious problems affecting the world, and consider legislation and expenditure on environmental protection to be a priority (Eurobarometer 2008).

Even though climate change and environmental problems continue to be perceived as a lower-tier priority by the

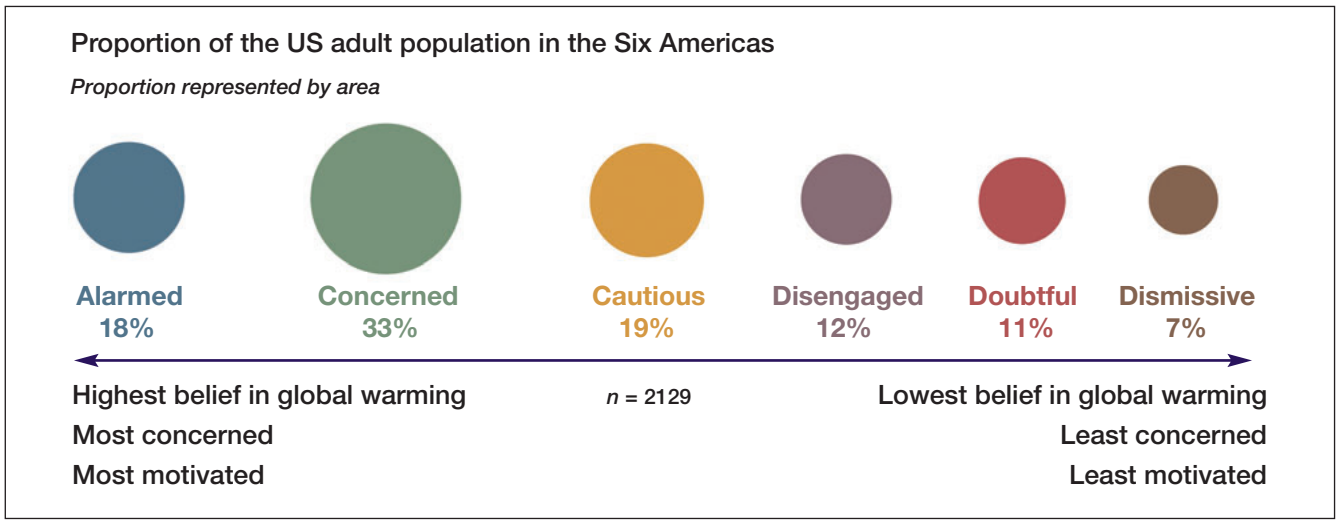

Figure 2. *Unique audience segments (the Six Americas) on climate change among US adults, 2008. From Maibach* et al. *(2009).*

American public, a recent analysis of US public opinion on climate change shows that roughly half of a sample of interviewed US residents (51%) accept the reality of the problem, are concerned, and are motivated to take action (Maibach *et al.* 2009; Figure 2). An additional 19% of the US public who were polled believe that climate change is a problem, but are not sure whether it is a personal threat or what can be done about it. This analysis showed that nearly 70% of US residents surveyed accept that climate change is a problem. However, it also suggests that different segments of American society need to connect the complexity of climate change to their personal lives and values, and are looking for direct advice on how they can address the problem. Ecologists need to effectively join with other societal groups to enable and empower these members of the public to participate in policy debates and to make personal and consumer choices.

How does the public learn about environmental issues?

If environmental scientists are going to motivate, enable, and sustain public action on climate change and other environmental issues, they will need to apply insights from social science research on how people learn about science, the sources of this knowledge, and the conditions under which learning can be enhanced. Science experiences in classroom settings certainly affect students' knowledge, interest, and attitudes towards science, both as children and as adults. However, it may come as a surprise to many scientists that most people learn about science not through formal schooling, but through informal sources, such as the media, science centers or museums, and interpersonal contacts (Falk and Dierking 2000; Nisbet and Kotcher 2009). This informal learning is individually motivated, voluntary, collaborative, occurs at irregular intervals, and is open-ended (Falk and Dierking 2000; NRC 2009). It occurs throughout one's life and encompasses a range of outcomes, including different dimensions of knowledge, awareness, interest, motivation, social competencies (ie the ability to succeed as a member of society), civic participation and expression, and consumer or individual choices (Maibach *et al.* 2008; NRC 2009).

In the US, the primary source of news and information about science and technology is television, primarily local television news broadcasts (NSB 2008; Pew Research Center on People and the Press 2008; Figure 3). The internet is second to television for general news and is the source that members of the American public say they are most likely to turn to for more information about a specific, science-related topic, such as climate change (Pew Research Center on People and the Press 2008).

As a two-way avenue, the internet has led to an explosion of blogs, "citizen-science" journalism, and other web-based vehicles that are competing with traditional information providers, including professional journalists and traditional news organizations (Brumfiel 2009). It also offers a potentially effective means for scientists to develop relationships and connections with engaged members of the public and to directly respond to erroneous information and false claims (eg the RealClimate blog maintained by professional climate scientists; www.realclimate.org). There are, of course, limits and tradeoffs to these digital media initiatives; the chief limitation is that because of the selective interests of audiences, the availability of high-quality scientific information online does not mean that the public will be aware of, have access to, and use it (Nisbet and Scheufele 2009).

Increases in science awareness and knowledge can also derive from entertainment media, such as primetime television series, popular films, and new genres of documentaries (eg Flagg 2005; Houck 2006), as well as from emerging interactive media like educational video games and participation in virtual worlds (online communities through which users can interact with one another and use and create objects; Neulight *et al.* 2007). Indeed, modern society has transitioned from offering relatively few media providers to enveloping the public in a "media

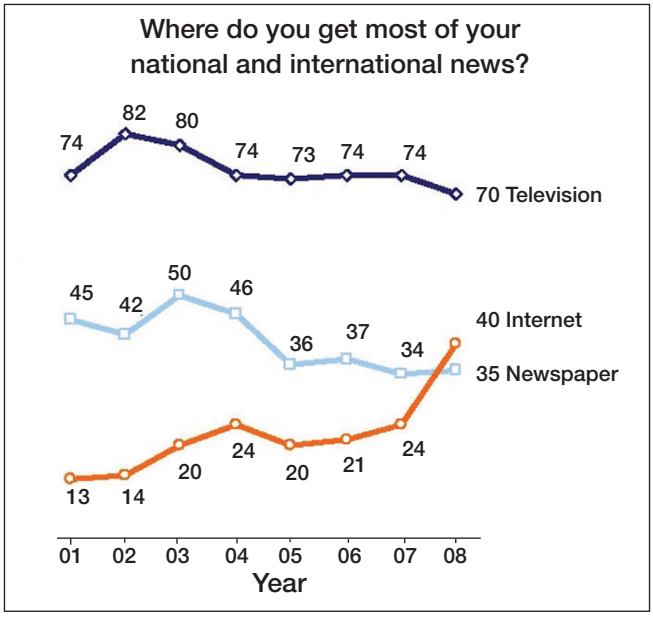

Figure 3. *Changes in sources of national and international news for US residents from 2001–2008. From Pew Research Center on People and the Press (2008).*

haze" that includes numerous television and radio channels, print and online news publications, and online social networking opportunities. Research shows that, above and beyond any demographic background factors, each of these outlets serves as an important information context that can alter and/or reinforce the views of their respective audiences (Besley and Shanahan 2005).

Several studies suggest the media can affect public understanding of science, although the most common impacts are increased awareness of, interest in, and attention to a science-related issue (Brothers *et al.* 1991; Miller *et al.* 2006). Indeed, simply increasing public awareness of an environmental issue can enhance its perceived importance, with an issue such as climate change becoming part of the criteria by which the public may judge the performance of elected officials, corporations, and other institutions (Scheufele and Tewksbury 2007).

Of course, audiences do not receive science information in a vacuum. Interpretations of what they see, hear, and/or read are often contingent upon demographic variables (eg gender, age, socioeconomic status), psychographic variables (eg sense of self, beliefs, values, interest, motivation), and mental models (prior knowledge and an understanding of the way the world works; eg Chan *et al.* 1999; Brossard *et al.* 2009). The influence of beliefs and values is particularly relevant for environmental issues, which often touch on morality, questions of right and wrong, and potential changes in individual, collective, or even institutional behavior. Furthermore, individuals are not likely to assimilate information reported in a news story if it is not consistent with their existing knowledge and values, or they may do so in a way that strengthens rather than dispels misconceptions (Miller *et al.* 2006; Storksdieck 2006; NRC 2009). As "free-choice learners", audiences may simply avoid science or environment-related media that do not align with their beliefs, values, and attitudes (Falk 2005; Ho *et al.* 2008). Finally, a reporter's description of an issue will also influence how it is received. For example, audiences will likely question the certainty of climate change when stories lack context and inflate controversy (Corbett and Durfee 2004), giving equal weight to viewpoints that lack merit or represent a minority opinion (Boykoff and Boykoff 2004; Nisbet 2009). This type of distortion typically occurs when coverage of an issue shifts from the traditional science journalism beat to broader coverage by political reporters and through opinion-driven outlets, such as cable news, the editorial page, blogs, and political talk radio (Nisbet and Huge 2006). Overall, reporting of environmental issues often lacks depth and context and is framed by conflict and controversy, while scientific consensus receives less attention (Zehr 2000; Boykoff and Boykoff 2004).

New models for how scientists can engage with society

Given the variation in societal knowledge and concern about environmental issues, and the complex ways that people learn about these issues, scientists need to reconsider the means by which they transmit scientific information and recommendations for action. A still-dominant assumption among many scientists and policy makers is that, when controversies over science occur, ignorance is at the root of public inaction. In this "deficit model", science communication initiatives are directed at filling in the "knowledge deficit", in the hope that if uninformed members of the public only understood the scientific facts, they would be more likely to see the issue(s) as experts do (Bauer *et al.* 2007; Nisbet and Scheufele 2009; Table 1).

The narrow emphasis of the deficit approach does not recognize that knowledge is only one factor among many that guide how individuals reach judgments; as noted above, ideology, social identity, and trust often have stronger impacts. The public and decision makers need more than information and technical knowledge – they need mental frameworks, or models, for "connecting the dots" between otherwise apparently isolated events, trends, and policy solutions. These linkages make it easier for them to recognize the connection between their everyday lives, specific values, and various environmental problems (Maibach *et al.* 2008; Nisbet 2009). In this regard, past research and theory in the specialty of framing can be especially useful to public engagement initiatives.

"Framing" is a conceptual term, taken from the social sciences, that describes interpretative storylines that communicate what is at stake in a societal debate and why the issue matters (Nisbet 2009; Table 2). At a theoretical and descriptive level, framing research offers a thorough explanation for how various actors in society define complex policy debates in politically strategic ways, how journalists from various beats selectively cover

these issues, and how members of a diverse public differentially perceive, understand, and participate in these controversies (Scheufele 1999). Frames help to simplify complex issues by placing greater weight on some considerations and arguments rather than others, showing why an issue might be a problem, who or what might be responsible, and what should be done. In this manner, frames provide common points of reference and meaning between experts, the media, and the public.

In one prominent example of reframing the debate over climate change, strategists suggested that climate change should not be defined as a "pollution problem" that requires additional regulation but rather as an "energy problem" that provides an opportunity for economic growth and job creation in the field of "clean" technology (Nordhaus and Schellenberger 2007). Similarly, a public health frame can be used to emphasize the possibility that climate-change effects may increase the incidence of infectious diseases, heat stroke, and other familiar health problems, especially among low-income or high-risk groups (eg the elderly and children). A more general strategy was offered by scientists such as EO Wilson (Wilson 2006) and evangelical Christian leaders such as Richard Cizik, who frame environmental stewardship in terms of morality and ethics, engaging an audience that might not pay attention to appeals regarding climate change made on a scientific basis.

New tools, media, and approaches for scientific engagement with society

As scientists consider new approaches for engaging society, they also need to consider new research approaches and communication tools (WebPanel 1). Although specific examples are described elsewhere in this Special Issue, here we focus on general approaches that will help scientists understand how a public engagement model can be put into practice and to consider how they might incorporate new principles into their research and outreach activities.

Involvement of scientists in research-based communication initiatives

The challenges reviewed in this article suggest the need for large-scale social science research on the nature of audiences, the influence of the media, and the effectiveness of specific types of public engagement activities. Efforts at public communication need to be truly interdisciplinary, bringing environmental scientists into collaborations with social scientists, communication experts, and media professionals who can conduct formative and evaluative research, produce state-of-the-art media presentations, and design effective public engagement initiatives (Maibach *et al.* 2008; Nisbet and Scheufele 2009).

Table 1. A comparison of selected aspects of the deficit and public engagement models

Aspect	*Deficit model*	*Public engagement model*
Major influence(s) on public beliefs and decisions	Science literacy or the lack thereof	Values, trust, identity, and social networks
Proposed solution to societal inaction	To improve science literacy (ie to fill in the "deficit" in the public's technical understanding of an environmental problem)	To connect an environmental problem to public values while building trust and empowering public participation
Communication is a process of…	…transmission, which means "popularizing" and "simplifying" technical information that flows from experts to the public	…dialogue and the two-way exchange of perspectives; both the public and experts learn from this process
The definition of "reaching the public"	Increasing the amount and technical accuracy of science news coverage, focusing on traditional outlets such as the newspaper science beat, popular science magazines and books, or public television programming	Reframing a complex issue around relevant and familiar dimensions; engaging in local community forums and dialogue; partnering with opinion leaders and other societal groups; and complementing traditional science coverage with novel entertainment genres and social-media initiatives
Scientists and their organizations…	…are under attack in society; any communication failures are blamed on public ignorance, the media, or "politicization" and "anti-science"	…hold almost unrivaled trust, authority, and respect in society; scientists need to use this communication capital effectively and wisely, otherwise scientists share some of the blame for communication failures
The ultimate goal	To improve science literacy – once the public is brought up to speed on the science, they will view issues and decisions as scientists do, controversies will go away, and progress will occur in dealing with environmental problems	To motivate, enable, and empower the public to make decisions about environmental problems – yet, no matter how accurately communicated and understood the science, public decisions cannot be separated from values, political context, and necessary tradeoffs between costs, benefits, and risks

Table 2. Example "frames", or models, that make it easier for individuals to recognize the relevance of various environmental problems to their everyday lives and specific values

Frame	*Defines science-related issue as…*
Social progress	…improving quality of life, or as a solution to problems; focus on harmony with nature instead of mastery, "sustainability"
Economic development/competitiveness	…economic investment, market benefits or risks; local, national, or global competitiveness
Morality/ethics	…right or wrong; respecting or crossing limits, thresholds, or boundaries
Scientific/technical uncertainty	…expert understanding; what is known versus unknown; either invoking or undermining expert consensus, calling on the authority of "sound science", falsifiability, or peer review
Pandora's box/Frankenstein's monster/runaway science	…a call for precautions in the face of possible impacts or catastrophes; out-of-control technology, or fatalism, ie action is futile, path is chosen, no turning back
Public accountability/governance	…research in the public good or serving private interests; a matter of ownership, control, and/or patenting of research, or responsible use or abuse of science in decision making, "politicization"
Middle way/alternative path	…finding a possible compromise position, or a third way between conflicting/polarized views or options
Conflict/strategy	…as a game among elites; who's ahead or behind in winning a debate; battle of personalities or groups; (usually journalist-driven interpretation)

Communication and public engagement training for young scientists

As discussed by Whitmer *et al.* (2010), courses and training in communication skills should be made available to both undergraduate and graduate students majoring in the sciences. These efforts should focus on the relationships between science, the media, and society, and improve students' ability to communicate effectively with public groups and the media. A more comprehensive option would be the creation of new interdisciplinary degree programs that include course work in communication, the sciences, policy, law, sociology, and other fields (Nisbet and Scheufele 2009).

Greater participation of scientists in local public forums

Community-based forums that bring motivated members of the lay public and stakeholders into a two-way exchange of information and perspectives are perhaps the major innovation in science communication over the past decade. At these meetings, subject-matter experts are joined on stage by a variety of local stakeholders and leaders (Einsiedel 2008). Studies have shown that participants gain a better understanding of technical and social aspects of the topic or problem and feel more confident about their ability to get involved in science-related decision making. Participants also often perceive relevant institutions as more responsive to their concerns, and scientists, policy makers, and other experts as being more receptive to feedback and respectful of public concerns. Thus, previous forum participants may be more likely to take part in related future discussions and to accept and be satisfied with an eventual policy outcome, even if the decision is contrary to their original preference (Besley and McComas 2005; Powell and Kleinmann 2008).

"Going deep" through local/regional digital news communities

As discussed earlier, most learning about climate change and other environmental problems occurs via the news media. Local media outlets, in particular, serve as the "connective tissue" that enables communities to identify, coordinate, plan, and respond to challenges. Unfortunately, in recent years, many newspapers have cut their coverage of science and environment-related topics substantially (Brumfiel 2009). Government agencies (at all levels), in collaboration with research universities, can step in and fill this news gap, through the formation of innovative digital news communities that focus on the local and regional implications of climate change and other environmental problems. These digital news communities would involve collaborations between scientists, journalists, community organizers, lay people, museums, and libraries. Local university scientists and other experts would contribute content in the form of blog posts, web-based articles, digital video stories, and other non-traditional media (WebPanel 1). This type of contribution presents considerable challenges; both scientists and their institutions will need to expand their perspective beyond

the narrow view that their communication to society primarily occurs through publications in scientific journals (Ashlin and Ladle 2006; Wilkins 2008).

Public participation in ecological research

In addition to participating in local science forums and contributing to digital news communities about local environmental problems, engaged lay citizens can also become involved in citizen-science initiatives (Bonney *et al.* 2009). Engaging the general public in ecological research provides an excellent opportunity to share basic ecology with citizens and to educate and inform them about natural resource management and policy (Overdevest *et al.* 2004). Studies have shown that individuals involved in citizen-science projects – like those attending public forums – gain not just technical knowledge of ecological science but also an understanding of how this knowledge is generated and verified (Trumbull *et al.* 2000; Overdevest *et al.* 2004; Jordan *et al.* in review).

Recruiting opinion leaders on environmental issues

Many of the most active lay participants in community forums, digital news sites, and citizen-science initiatives are likely to have strong "opinion-leading" attributes. For more than 60 years, communication researchers have traced the influence of news and advertising messages in local communities, identifying a small group of "opinion leaders" and "influentials" who pay close attention to public affairs and advertising, discuss what they learn from the media with diverse stakeholders, and appear to be more persuasive in convincing others to adopt an opinion or course of action (Nisbet and Kotcher 2009). These opinion leaders do not necessarily hold formal positions of power or prestige, but rather serve as the communication go-betweens and information hubs who alert their peers to what matters among political events, social issues, and consumer choices. Scientists and their organizations have traditionally overlooked this important dimension of public engagement. However, techniques for identifying individuals with opinion-leader-like qualities exist and could be readily applied to environmental science issues (Nisbet and Kotcher 2009).

■ Conclusions

This is an exciting but difficult time in environmental science. Societal interest in environmental issues is high and participation in international efforts to address these issues has increased. However, it is difficult to provide relevant scientific information in a coherent way that resonates with the general public, environmental managers, and policy makers. We suggest that scientists need to re-evaluate the way that they interact with society. As scientists, ecologists need to become active, rather than remaining passive, in their communication with the public. To do this, we must engage with our audiences in new ways, frame our results in ways that resonate with these audiences, and use new communication tools that can reach a wide range of target groups. Fortunately, there are new conceptual and practical tools and approaches available to help with this transition. The effectiveness of these tools and approaches will depend on the willingness of individual scientists (with the support of their institutions) to use them to establish new partnerships and reach out to broader audiences. This transition may not be easy and will require hard work and persistence, but this step is clearly necessary to promote and inspire action to counteract the environmental problems currently facing the world.

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