

Engaging the public in biodiversity issues

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To engage people in biodiversity and other environmental issues, one must provide the opportunity for enhanced understanding that empowers individuals to make choices and take action based on sound science and reliable recommendations. To this end, we must acknowledge some real challenges. Recent surveys show that, despite growing public concern, environmental issues still rank below many other problems, such as terrorism, health care, the economy, and (in the U.S.) family values. Moreover, much of the recent upswing in interest in the environment is due to the marked shift in attention to global warming away from other environmental problems such as destruction of ecosystems, water pollution, overpopulation, and biodiversity loss. Such a change in public focus often comes with a tendency to decouple various environmental problems and ignore their synergistic effects. Exacerbating this problem are arguments from the media and other sources that discourage public interest in environmental topics by characterizing the science behind them as overly complex, immersed in debate and controversy, and detached from human interests. Educational programming, media, exhibitions, and other means of public outreach should build on the welcome increase in public interest in global warming by demonstrating the interplay of various environmental disruptions. In the case of biodiversity, the importance of species in providing ecosystem services, natural beauty and pleasure, and sustaining human lives is a message that requires constant attention and recrafting to impact diverse audiences.

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The last decade of the 20th century was the first time a sense of urgency about the global-scale degradation of natural habitats, and the resultant threats to potentially millions of species, galvanized an effort to both study and conserve what was at risk. Edward O. Wilson (1) was the first to publish the word “biodiversity” in the 1988 proceedings from a conference held in 1986 organized by W. J. Rosen, who originally coined the term. The current decimation of species, commonly called the biodiversity crisis, was the subject of Wilson’s landmark book entitled *The Diversity of Life*, published in 1992 (2). Subsequently, many other publications (3–9) have addressed this problem. By the late 1990s, biodiversity became the subject of elementary, secondary, and college courses, public journalism, television specials, and major museum exhibits. If biodiversity was still not a commonly recognized word, a broader public at least seemed to be getting the message that precious natural habitats and their species were under intense siege. In addition, scientific institutions, nongovernmental organizations (NGOs), and other groups pushed for more science and more effective policy to improve our stewardship of biodiversity under threat. Some governments reacted by adopting laws, regulations, and programs that limited overharvesting of both marine (10, 11) and terrestrial (12) species, controlled selected invasive species (13), and secured protection for selected natural habitats (14, 15).

Given all this enlightenment, commitment, and effort, it is sobering to reflect, nearly 20 years later, on the continued deterioration of the situation. Despite impassioned pleas and elaborate strategies for conserving rainforests, the rate of loss has hardly abated. Brazil, which holds $\approx 62\%$ of all Amazonian rainforest, lost on average $\approx 18,100 \text{ km}^2$ per year⁻¹ between 1988 and 2006 but registered a loss of $27,400 \text{ km}^2$ per year⁻¹ in 2004. Brazilian deforestation rates decreased by 2006 to $\approx 14,000 \text{ km}^2$

per year⁻¹, but this trend could be temporary, because falling prices of soya and the increased strength of Brazilian currency and government intervention contributed to the decrease (16). Africa, with a significantly smaller amount of forest cover, lost an amount of forest comparable to that for South America for the same time period (17). Other regions of the world, notably southeast Asia, are recording similarly serious losses (18, 19). The situation for many freshwater habitats in both temperate and subtropical areas is, if anything, worse (20, 21). Marine ecosystems have likewise suffered from devastating reductions in fisheries (22) and the degradation of $>50\%$ for most coral reef systems (23). At the same time, there is even less investment in study and conservation of marine habitats than in terrestrial ones (24).

The obvious question, then, is why has a massive, international effort to deal with the biodiversity crisis failed to launch? Much of the current stasis is ascribed to the antagonism of corporate interests and lack of vision, and even resistance, of leaders and governments (25, 26). Accepting these as factors does not, however, obviate the need for broader and deeper public understanding. The “power of the people” is well demonstrated as the primary force behind new, more enlightened, measures by governments and corporations. Conversely, if a lack of public understanding or concern persists, it is highly unlikely that either governments or businesses will change course.

So, what can we now do to improve the situation? Scientists are obviously a critical part of any effort, because they continually improve the database for both species diversity and loss and thereby provide an ever clearer picture of the scientific realities of the biodiversity crisis. However, given the urgent and serious nature of biodiversity degradation, scientists also must have a voice in a dialogue that fosters broad public interest, commitment, and engagement. Here, I further probe the current state of public awareness of the biodiversity crisis, describe the challenges to achieving broad-based effective engagement on the issue, and offer further suggestions for dealing with these challenges.

Strategies for Engagement. To engage people in environmental issues such as the biodiversity crisis, one has to inspire a connection with nature. That linkage should be built from a clear and compelling message about the importance of biodiversity and what we risk in depleting it. However, these are only the first stages of a strategy that leads to engagement. As various dictionaries define the word, “engage” also means to develop meaningful connections with others; to bring into association or aid; or to attract, hold, or draw others into some agreed-upon action or service. It is clear that much of the effort to generate interest in environmental problems stops short of a follow-through that could be characterized as engagement. Surveys on

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“green” consumerism (27) have shown that environmental awareness does not necessarily affect behavior and purchases. Increased public interest in environmental issues (25) by no means ensures that people will engage in ways that may modify their behaviors, adjust their priorities, and advocate the need for change.

The numerous impediments to achieving both public understanding and engagement on biodiversity issues, as related in the seminal 1998 Biodiversity Project “roadmap” report (28), include science illiteracy, the related lack of public familiarity with ecological and evolutionary processes that inform conservation issues, an uncertainty as to why biodiversity conservation is good for individuals and society, a lack or impoverishment of experiences that put people into nature, the disinterest or even antagonism of media and other potential partners in outreach, mistrust of government, information overkill, and competitive choices (even often subliminal ones), such as unsustainable consumerism.

So, then, how shall we carry on with the mission? Recommendations, both specific and general (28), include a clearer identification of the attitudes and understanding of diverse target audiences, greater investment on the part of scientists in public education and policy dialogue, notable improvements to science education, more strategic use of the media to reach the public, increased use of the Internet to reach new and expanded audiences, and more strategic ways of contacting and influencing policymakers and government and corporate leaders. These recommendations are embedded in the missions of numerous outreach programs, agencies, and nongovernmental organizations. Many of these recommendations are infrastructural, and they represent intensive long-term investments. This is commendable, but the approach may not develop at a rate fast enough for urgent response. For example, the poor state of science education in the U.S. and certain other countries (29) is an enormous problem that requires major correction. However, educational investments that might optimistically benefit emerging generations will not have an impact on people who have already experienced the system (30). These are the adult populations who must engage now to deal with the crisis at hand. Mechanisms are required to deliver clear messages to very large and diverse audiences and elicit action over a short time scale.

In this article, I offer a few thematic recommendations, some of which blend with those already proposed, some of which add to them, and some of which reflect more recent shifts in public attitudes toward environmental topics, such as global warming. With this come suggestions for a few course corrections. The basic goal, namely to promote broader and deeper understanding and more committed stewardship of biodiversity, requires a multidimensional strategy, but one that focuses on three major objectives: (i) improved understanding of the diverse public audiences we are trying to reach, (ii) crafting of the messages suitable for those diverse audiences, and (iii) enhancements of the mechanisms for delivering those messages and eliciting engagement.

Understanding the Audiences. Any strategy for engagement starts with the knowledge of who is being engaged and what they already know and do not know. Accurate information on the level of understanding of various target audiences is essential. Unfortunately, substantive research on the public understanding of biodiversity is still deficient, to a large extent because it has glossed over the relationship between people’s understanding (as opposed to perception or opinion) and their decisions and actions (31). This is a serious gap in information, because studies expectedly show that acquired knowledge of a subject has a heavy influence on subsequent attitudes and behavior (32–34).

Some Public Misperceptions. That a deficit in knowledge leads to ambivalence or ill-advised conclusions and actions is clearly evident in the case of biodiversity conservation. An immediate obstacle, one noted from the outset (28), is the use of the word biodiversity itself, hardly a word of common parlance. Surely biodiversity does not have the immediate recognition of phrases denoting other environmental aspirations, for example, “pure water” or “clean air.” Even when one moves closer to its real meaning, the word biodiversity suggests only that there is a great variety of life forms; it does not lead one to recognize the interconnectedness of these forms in ecosystems. At the very least, the word requires vigilant and repeated explanation when communicating with the public, and this is a disadvantage in an age when metaphors and sound bites carry so much weight (35, 36).

Even if people have grasped the meaning of biodiversity, they are often unfamiliar with the meaning and significance of biodiversity loss. There is a persistent widespread misperception, for example, that what we are witnessing is merely the current wave of extinctions that are part of the normal turnover in the history of life (37). In other words, life on the planet has experienced myriad extinction events over billions of years, and it will continue to thrive, offering new opportunities for new better-adapted species. (Ironically, those who accept this pattern of life’s constant turmoil often comfort themselves by exempting humans.) Indeed, the difference between mass extinction vs. background extinction rates is not one that has been readily absorbed by a large segment of the public (37). In addition, there is a tendency to place greater value on the more familiar and charismatic in nature rather than recognizing the integral roles and importance of all species, even insects, worms, fungi, and microbes, in various ecosystems (2, 8).

Both of these misperceptions clearly impede the cultivation of a sense of concern and stewardship for the planet’s eroding biodiversity. The notion that current rates of extinction are “normal” obviously prevents a focus on the urgency of the problem. Indeed, this perspective has fed an attitude, often expressed in the political arena, that action is unwarranted for something that, according to scientists, is no problem at all. A lack of appreciation for the richness and interconnectedness of diverse species, from elephants to soil bacteria, yields a distorted picture of what is really at risk. With such a narrow vision, even conservation efforts may place too much attention on a few endangered species rather than the ravaged habitats within which they live.

Evidence of Positive Public Response. However, there is also evidence the public is prepared and motivated to understand the biodiversity crisis more accurately and profoundly. Since the mid 1990s, several surveys have monitored public attitudes on biodiversity loss and biodiversity conservation. Prominent among these were the polls of Americans in 1996 and 2002 conducted by the Biodiversity Project (25, 38). Respondents in both polling years showed a high level of concern for the loss of species and degradation of environments. When they were given a definition for biodiversity, 47% of the respondents in 2002 (25) and 41% in 1996 (38) stated that stemming the loss of species was very important to them personally. In the 2002 poll, 69% stated they had a personal, and 65% said they had a moral, responsibility to protect all plant and animal life. Also, half (in 1996) or slightly more (in 2002) of the respondents strongly supported the Federal Endangered Species Act.

Another important aspect of public attitudes toward biodiversity is the high level of influence of aesthetic, ethical, patriotic, familial, and religious values in motivating a sense of responsibility for stewardship. In the 2002 Biodiversity Project poll, 64% regarded a wide variety of animals and plants as one of the most important things in their lives, and 71% felt that nature provided them with inspiration and a peace of mind.

Respect for God's work, respect for nature for its own sake, the need to provide for future generations, the appreciation of the beauty of nature, the need to maintain a balanced healthy life, and the expectation as an American citizen to protect natural resources all were regarded as "extremely important" reasons for protecting the environment by a large percentage of respondents. These are important connections, because they pave the way to educating the public on biodiversity issues in ways to which they personally respond.

Shifts in Public Attitude: The Example of Global Warming. As noted, public awareness of the biodiversity crisis has risen slightly since the mid-1990s. However, this trend is now overshadowed by a greatly increased interest of global warming and climate change. The shift in public attention to this issue in the last few years is remarkable. In earlier polls (25, 38), people who "identified extremely serious [environmental] problems" ranked global climate change below virtually every other category, including land development, loss of rain forests, and damage to the oceans. More recent surveys, including notably the recently published Massachusetts Institute of Technology (MIT) poll (39), show a radical reversal in public interest. Global warming now clearly occupies the top of the list of serious environmental problems faced by the U.S. by a wide margin, as judged by nearly 50% of respondents in 2006 as opposed to only 20% recorded by an MIT poll in 2003 (40). By contrast, primary concern over other environmental problems since 2003 either was virtually unchanged (destruction of ecosystems and overpopulation) or had markedly declined (water pollution, toxic wastes). It is noteworthy that endangered species ranked very low as a primary concern ($\approx 5\%$) in the MIT polls for both 2003 and 2006. What accounts for this dramatic shift in public interest toward global warming? Answers could be potentially instructive in efforts to deliver a more multidimensional and realistic message, one where biodiversity loss still looms important in the public arena. Climate change, like biodiversity loss, has its scientifically complex and more subtle facets. Yet climate-change scientists have consistently related their conclusions to easily understood events, rising temperatures, storms, droughts, sea level rise, and other phenomena that people already accept as important and consequential. It "only" remained for scientists to demonstrate to people that the climate change necessary to increase these events and intensify their consequences was already happening. The scientific community worked doggedly to this end, translating and explaining the accumulating scientific discoveries in ways that effectively reached the public and the media (41). The breakthrough that came with powerful messages by notable leaders like Al Gore (42) built on this long-term cultivation of the scientific side of the story.

Such attention, of course, is warranted; global warming is an extremely serious and far-reaching environmental problem. Yet the swamp-out effect that the current focus on global warming is having on other environmental topics once again illustrates the problem of changes in public opinion that are not adequately informed. There is now a tendency in public dialogue to decouple various environmental problems and ignore their synergistic effects. Thus, people may find it hard to recognize that it is the "double whammy" of climate change in combination with fragmented degraded natural habitats, and not climate change alone, that is the real threat to many species and ecosystems, including human populations marginalized and displaced by those combined forces (16, 43). The destructive impacts of other forces in addition to climate change must be brought back into the dialogue, because some of their deleterious impacts are already apparent, or will be so, on a time scale much shorter than the one we are calibrating for the effects of global warming (44).

Public Priorities: Where Does Biodiversity Rank? It would be unfortunate to dwell at length on the unbalanced public perception of various environmental issues without recognizing perhaps the most fundamental obstacle in communicating the urgency of these problems. We humans, of course, are confronted with many problems, environmental or otherwise, and without some sense of priorities, we would be totally overwhelmed by them. Recent surveys (39) show that in the U.S., environmental issues, even with the added concern over global warming, still rank below terrorism, the Iraq war, health care, the economy, education, the quality of government leaders, Social Security, illegal immigrants, and family values. One may have scientific, political, and social views that lead them to disagree with the higher rankings of some of these topics, but it would be absurd to claim that terrorism and health care do not warrant our serious attention. Nonetheless, environmental issues should elicit greater concern, simply because they are so integral to many of the high-ranking problems on the public radar screen. Biodiversity provides enormous actual and potential benefits in the form of food, pharmaceuticals, and other resources and commodities. The degradation of habitats and biodiversity has huge implications for human health, economics, political instability, and even conflict. As discussed below, the key approach lies in better communicating an essential message: biodiversity is not really in direct competition with many issues that people regard as critical to their health, wealth, welfare, and sense of responsibility to family and future generations.

Assessing Diverse Audiences and Attitudes. Many of the above-noted surveys are useful in detecting some general signals of response from the public. However, these surveys also show diverse responses that relate to particular levels of education, economic background, cultural affiliations, and religious beliefs. Environmental educators argue that the true complexity of the audience has not been sufficiently sampled and analyzed (31). For example, we are just beginning to survey people in developing countries faced with difficult choices because of their very poor standard of living (45). Here, we can take a lesson from business marketing strategies, wherein target audiences are identified and parsed for different approaches. This underscores the need for more surveys that identify groups according to their onset knowledge, economic status, cultural identities, and motivations (30). Of course, this targeted sampling should be accompanied by the kind of general assessments that identify some of the overarching concerns shared by many different audiences.

Crafting the Message. A consistent result in surveys of public attitudes is that the basic message, that the biodiversity enormously important to the sustainability of the environment and the quality of our own lives is at serious risk, is not getting across to many of the target audiences. Moreover, the message carries some unfamiliar terminology, as noted above in the case of the word biodiversity itself, that requires constant attention and clarification. When people are given a definition of the word, they respond in ways compatible with efforts to protect biodiversity, expressing concerns over the destruction of habitats and the loss of species.

This leads directly to a consideration of those messages that have been more effective than others in reaching the public. Such an assessment is difficult; surveys, for the most part, have been aimed at eliciting the very general responses noted above. The limited insights gained from those responses, however, suggest that the most penetrating messages are those that clearly relate scientific insights concerning biodiversity and biodiversity loss to more general environmental problems and, in turn, to problems rooted in common experience: poor water quality, depletion of fisheries, zebra mussels and other invasive species, forest clear-

ing, open-pit mining, urban sprawl, and many others. For example, the concept of shifting baselines in fisheries (46) describes a tendency to assume that ocean life is abundant and ocean ecosystems are healthy, even though they have experienced steady, albeit slow, deterioration. Thus, putative “recovery” in the populations of some species by no means indicates the species has been fully restored to earlier historic levels. The concept has resonance, because not only is it scientifically instructive, but also it directly relates to the availability of a food resource vitally important to humans. Likewise, arguments that relate biodiversity to land use (14) not only illuminate basic scientific principles concerning the necessary interaction of species in providing habitats rich in resources; they also provide useful options for agriculture that achieve a balance between providing productive cropland and sustaining biodiversity. Biodiversity science, collecting, surveying, identifying, classifying, mapping, and analyzing species, of course provides the important database for all these arguments (2), but the public recognition of the importance of this work is elusive without themes that address more familiar issues.

Such themes then offer a chance to respond to the frequent question raised by people: Why should we care? The framework for the answer to this question was established some time ago by Ehrlich and Wilson (47), namely, (i) we have, as Earth’s dominant species, an ethical and moral responsibility to protect diverse life; (ii) biodiversity has conferred enormous economic benefits to humans in the form of foods, medicines, and industrial products; and (iii) species are the working parts of natural ecosystems that provide the essential services necessary to sustain life. We can use this framework to develop examples of messages that might more effectively intersect with current public attitudes.

The Ethical, Moral, and Aesthetic Argument. Because biodiversity is also synonymous with nature enriched, it appeals to what might be characterized as more noble human qualities; ethical and moral responsibilities; altruistic concern for our future generations and companion creatures; and aesthetic responses to the wonder, beauty, and tranquility of nature. As noted above, surveys show these motivations are strongly influential in raising public appreciation for biodiversity and concern for its erosion. Developing messages that draw on these instincts, what E. O. Wilson (48) originally coined as “biophilia,” the human need and love for nature, can only be advantageous. In museum exhibitions dealing with biodiversity, for example, the first step is often to place people in a stunning environment, one that reminds them of the beauty and wonder of nature, as a way of telling them what is at risk. A multipoint proclamation for a biodiversity agenda is not a way to greet visitors. A diorama of a rainforest or a wall displaying the extraordinary diversity of life forms is a more effective gateway. Some of the most effective television and film programs, such as the Discovery Channel 2007 series *Planet Earth* (49), that speak to biodiversity themes use a similar approach in reinforcing the biophilia of viewers.

Many moral and aesthetic values that connect people with nature are inspired by people who, by relating their personal experiences, make a compelling case for stewardship. Humans are interested in other humans, not only what they do but also what passion drives them to do it (50). The roots of environmentalism are found in places like Walden Pond, where emotion, art, and experience play a critical role in defining the value of nature. Not everyone can write like Thoreau, but when a biologist effectively relates his or her personal and emotional, and intellectual, experiences in the field and the laboratory, people respond.

The Economic Argument. As Ehrlich and Wilson (47) stated, biodiversity has unquestionable economic value in terms of

foods, medicines, and other benefits. Nonetheless, elaboration of this point must be carefully crafted. The economic argument may encounter objections from people who fail to understand why it is more important to preserve habitats than to log, farm, or develop them for more immediate and competitive economic needs. Conflicts in economic perspectives are also now apparent even in different groups who identify themselves as environmentalists. Some favor accelerated economic growth as way of producing the wealth, education, and technological breakthroughs necessary to solve the big environmental problems (26). However, there are those who advocate a massive return to local “green” economies, that depend critically on both individual and cooperative behaviors for moderation and the reduction of consumerism (51). Connections must be made between the stewardship of biodiversity and different models for putatively compatible economies. We also need to understand much better the complex economic, traditional, cultural, and environmental interrelationships of low-income people in developing countries, many of whom live in the most biologically diverse regions (45). An effective argument here is that biodiversity emphatically plays a role in strategies for more sustainable agriculture, one that calls for the development of croplands that mix agriculture with natural components and thus provide both crop foods and restored ecosystem services (14).

Another way of demonstrating the economic importance of biodiversity is to use examples of negative impacts of biodiversity loss. Such losses can destabilize relationships of communities, even countries. A perfect ecological, economic, and political storm is brewing in West Africa because of the complex interplay of overfishing by both African and European nations offshore, the accelerating devastation of wildlife on land for bushmeat, and periods of massive food shortages (52). Human population densities in Africa are higher where biodiversity is higher, suggesting that biodiversity is itself a better index for comparative wealth than we once had realized (53). Biodiversity enrichment, in its transformed mode, means arable land, a great enticement for needy and opportunistic nations. Such pressures lead to conflict. Many important areas rich in biodiversity lie on international borders, especially tropical rainforests between nations that have not always maintained the most peaceful relations. History shows that people have made war over gold, oil, and water; they may do so over biodiversity.

The Ecological Argument. That species are the fabric of ecosystems, which in turn provide essential services, is a powerful concept, but one that may escape many of those unfamiliar with biological principles. Again, in many instances, it is best to enter these discussions from a practical and experiential starting point, often with a focus on current news. For example, animal pollination of plants is not only central to the function of terrestrial ecosystems, but it is also essential to the survival, sustainability, and economies of human populations (54, 55). The distressing recent decline in the health and number of managed bee colonies in the U.S. (56, 57) can be mitigated by greater reliance on wild populations of pollinators, so long as we maintain the natural habitats adjacent to agricultural areas that are necessary to support these wild species (58, 59). Thus, an effective public message is one demonstrating that putting more biodiversity into service can improve crop yield and save more than a little biodiversity-enriched land in the process.

This argument relates to one that inculcates a more general appreciation for the preservation of the natural world: pollination of plants by diverse species is not only important in food production of humans but is also critical to the sustainability of many terrestrial ecosystems. In other words, the world that is so familiar to us is strongly shaped by an extraordinary collaboration between flowering plants and pollinating insects (as well as some mammals and birds), a proof of concept with a 100

million-year-old history (8). Huge losses of species that participate in this system have the potential to disrupt ecosystems in ways documented for plants and insects at the time of the end-Cretaceous extinction event (60). That history records such disruptions is a lesson of the past that people respond to; it induces them to think about what life might be like in a similarly degraded world of the future.

Relating Biodiversity to Other Environmental Issues. Explanations of the importance of biodiversity should also be contextual. How we deal with the synergy of destructive environmental forces will define our future. Importantly, the combined effects of climate change, fragmented and degraded habitats, and threats to biodiversity need a more compelling presentation to reach many audiences preoccupied with global warming as the one big environmental problem. Disturbing examples of synergistically driven devastation are all too common. The traumatic effects of both predicted climate change and the fragmentation of natural habitats may force near-term extinction of many species in the extraordinarily beautiful Fynbos flora of South Africa (61). Overharvesting, pollution, ocean warming, and coral bleaching have irreparably damaged many of the world's coral reefs (23). Large-scale eutrophication in many coastal regions of the world has resulted in hazmat environments deadly to marine fish and plants and harmful to humans (62). In terms of solutions that address global warming, biodiversity-enriched forests are important in reducing our carbon footprint (63) or in mitigating the effects of urban heat islands (14). Educational programming, media, exhibitions, and other means of public outreach should build on the welcome increase in public interest in global warming by demonstrating the synergistic effects of other environmental disruptions.

Delivering the Message and Eliciting Engagement. The next step in the process of engaging the public, the delivery of the message, is perhaps the most challenging to the scientific community. This endeavor relies on such activities as market testing and targeting; media networking; exhibitry; filmmaking; legal, policy, and economic consulting; and organizational and collaborative programming that generally lie outside the expertise and experience of scientists most familiar with the problem. At an early stage in the biodiversity conservation effort, this challenge was recognized. Strategies were developed for convening, collaboration, and communication among professional groups, NGOs, media, and others. Subsequently, many NGOs (including those staffed with biodiversity experts) have been active. A comprehensive examination of these mechanisms and strategies for delivering the message lie beyond the scope of this article. Here, I focus on some practical issues that involve a few key elements in the process: the media, venues for public science education, and public participation, sometimes also referred to as "citizen science."

The Media as Audience and Partner. Effective linkages between the scientific and conservation community and the public must be made through the main channel of dissemination, namely media in the form of news and educational programming. Most adults learn about science through television, with print media running a distant second (64). Some biodiversity conservation strategies recommend that media be "used" to influence sectors of the public (28). Initially, however, the news media should be recognized as another segment of the public audience, not as a partner. Journalists do not think of themselves as collaborators. Rather, they are tasked to observe and relate, although the expectation for even-handed treatment does not eradicate a slant in a story that arises from a particular point of view (65). Thus, media can be ambivalent, even antagonistic, to the idea that a particular scientific result and its implications are credible and

important. News outlets are sensitive to popular tastes and, as such, rank the importance of many topics far higher than the loss of biodiversity (28). Also, in many cases, media either tend to oversimplify scientific results and conclusions or overstate the lack of resolution on an issue, even when there is only a modicum of uncertainty to a result (66). One outcome is that news outlets can discourage public interest in environmental topics by characterizing the science behind them as overly complex, immersed in debate and controversy, and detached from human interests. Another reality of news coverage that frustrates an effort to cultivate public interest in an issue such as biodiversity loss is that stories die easily. The discovery of a hirsute deep-sea crab (67) or a new species of centipede in Central Park (68) may make front-page and network prime-time news, but the resonance of the story is quickly lost.

Yet the capacity of the news media to respond to environmental issues and transmit them to a very broad and diverse public has been resoundingly demonstrated. Again, the example of the global-warming issue is relevant here, because it has somehow caught the current of a media deluge (69) that has clearly had an impact on the public and ultimately on at least some of the legislators they vote for (70). Contributing factors here are doubtless persuasive and influential communicators like former Vice President and Nobel Laureate Al Gore (42), new and cumulative scientific discoveries, and the continued reinforcement (sometimes fallaciously) with human experience, where every sign from nature—hurricanes, drought, melting ice, or disease outbreaks—is associated with global warming. Finally, practical and pressing issues, such as the rising price of oil and the need for energy options in everyday life, have been linked to the agenda for mitigating the effects of climate change (51). Media (and public) attention to global warming is instructive and underlies some of points already made about connecting biodiversity issues with practical public concerns and needs.

At the same time, it is instructive to consider some of the downside to the media obsession with the global-warming issue. One, as noted above, is the obfuscation of the multidimensional environmental crisis, of which global warming is part but not all of the problem (43). Second, many news reports and media stories have both oversimplified and oversensationalized the global-warming scenario, a serious liability in light of the decreasing level of trust the public has in the media (69). Finally, it is unclear to what extent the media is helping to explain options for action and the choices we may face to deal with global warming.

An important strategy for raising the newsworthiness of the biodiversity issue and helping to ensure its accurate portrayal is ultimately educational. This means providing opportunities for journalists and reporters to encounter more translated versions of scientific stories or to convene as groups or individuals with scientists over an extended period. Journalists often express a need to get a bigger picture, but this is impractical with a pressing deadline for a story on a new scientific discovery. News and views items in widely circulated scientific journals like *Nature* or *Science* are important links to other news agencies. At the next level, special sections like the *New York Times* "Tuesday Science Section" allow for the development of themes over several weeks or months. Scientific institutions devoted to public education can be effective cultivators and conveners in this way.

Educational programming can be powerfully transmitted by media, as indicated by the large audiences that view nature programs and other science series on television. Over the past 10 years, the number of programs on network and cable devoted to science has proliferated, but this is not necessarily accompanied by an increase in the average quality and effectiveness of these offerings (71). Some programming, notably certain nature shows, in its superficiality may fail to challenge nonscientific notions like Creationism and Intelligent Design and may even

implicitly endorse them (71). However, selected programs, such as the 2007 Discovery Channel series *Planet Earth*, whose premier attracted >12 million viewers (49), project both the beauty of nature and an artful message that encourages stewardship of nature, one fully compatible with the agenda for biodiversity conservation. Such programs need to be emulated for their high quality, and they should stimulate further collaborations between scientists and skilled producers and filmmakers.

The obvious shift in media and communications since the inception of the biodiversity agenda involves the use of the Internet. Indeed, the Internet is redistributing news audiences in radical ways that are seriously threatening some traditional news organizations, particularly local newspapers (72). Many web sites, including those offered by university programs, public science institutions, and conservation NGOs, provide effective status reports on species and habitats at risk and steps taken toward remediation. Web-based initiatives that network scientific research results and, at the same time, provide broad access, such as the *Encyclopedia of Life* (www.eol.org) (73), could potentially engage very large new audiences outside the scientific community and allow them to contemplate the staggering richness, beauty, and importance of biodiversity.

Venues for Public Science. Even in countries where science literacy is much higher than in the U.S., there are limited opportunities for the lay public to stay abreast of the rapid rate of scientific discovery (30). Aside from popular science books, periodicals, films, television specials, and web offerings, the responsibility for providing lifelong exposure to science falls to museums, botanical gardens, zoos, aquaria, science centers, and similar venues devoted to the public education of science. These institutions are thus critically important in educating people on biodiversity issues and other environmental problems. That such institutions can offer an encounter with nature that is both vivid and authentic defines their cultural impact (74). Many people, especially in urban areas, will rarely, if ever, see a relatively unspoiled tract of woodland in their region, let alone a tropical rainforest. For these individuals, an encounter with nature means a visit to a museum or the like. The enthusiastic response of visitors to this opportunity can be appreciated in terms of the huge audiences such institutions attract. Over 865 million people visited museums (including gardens, zoos, nature centers, science centers, and others) in 1999 in the U.S. alone (75).

One important strength of such institutions as venues for communicating science is the feeling of trust they invoke in the public. Surveys show that natural history and science museums have extremely high credibility ratings (75). However, there is also evidence that such institutions have not fully capitalized on their reputation. Exhibits and educational programs that not only dazzle but also address issues of substance, including the biodiversity crisis, have been slow in coming. Many permanent museum exhibits with environmental topics have not been revised since they first opened decades ago or are not complemented by new halls that address current themes (74). Aggravating this problem is the uneven commitment to scholarly activity in many such institutions (76). A shift away from fundamental research in some institutions prevents them from taking on topics dealing with leading-edge science or major issues, topics where expertise is critical and in-house expertise particularly advantageous. Top-flight scientific research in an institution devoted to public education is not an oxymoron, especially where those researchers are strongly motivated and skilled communicators.

In more recent years, there are notable signs of improvement on this front. Exhibits dealing with current environmental issues, including biodiversity, have proliferated. The California Academy of Sciences will reopen in 2008 in an entirely new structure devoted to both exhibition and research and collections, one of

the largest high-grade green buildings in the U.S. (77). New partnerships among institutions have allowed the sponsorship and nuanced development of timely exhibits on such themes as endangered species, climate change, evolution, and water that offer clear and consistent messages as they travel to various destinations and new audiences both in the U.S. and abroad. This momentum is encouraging, but at the same time, many of these public institutions are facing severe financial pressures (78) and other forces that may move them to dilute both their scholarly and educational programs. Their support is paramount if we expect to elicit improved public understanding of important issues like biodiversity loss.

Public Participation: Citizen Science. A relatively new effort aimed at eliciting public engagement, dubbed citizen science, involves public-professional partnerships that allow people of all ages an opportunity to participate in real scientific research and to interact with scientists in the process (79, 80). Although the formulation of the idea has some novel aspects, it is rooted in the activities of amateur naturalists dating back in European culture to the 1700s (81). The hope is that this kind of proactive participation not only will contribute new data on species and habitats but also will increase the participants' understanding of the process and results of the relevant science (80, 82). Such enlightenment, it is further hoped, will strengthen participants' connections with both science and the environment in ways that cultivate a sense of stewardship.

The citizen science approach seems well founded, but there are a few impediments. First, developing programs that foster citizen science requires intensive investment of time and energy on the part of the professional community, entailing often greater commitment than lectures, editorials, popular writing, and other efforts to communicate with the public. As a result, the number of people that actually have the opportunity to become citizen scientists is limited. The problem seems surmountable as more efficient programs linking scientists with science educators are being developed (83). A second problem resides in the poor understanding of the impacts of citizen science programs to date (80). Some of the few studies available show that, although participants improved their knowledge and familiarity with a particular scientific topic, they did not achieve a better understanding of the scientific process or change their attitudes toward science and environmental issues (80).

However, there are now many examples of citizen science programs in the biodiversity area that seem to have beneficial outcomes. The *Bioblitz* biodiversity surveys (84) carried out in New York's Central Park, Washington, DC, and many other sites yielded new scientific results that not only further enthused participants and galvanized their activities but also attracted media interest. It seems that programs in citizen science have much potential if they allow more people to participate, their impacts are more thoroughly analyzed, and participants are better familiarized with the environmental issues that relate to their contribution (80).

Conclusions

A very large and diverse public demonstrates a connection with nature and a sense of concern about environmental problems (25). However, these attitudes often are not accompanied by real understanding of biodiversity or a sense of how to take more effective measures in protecting and sustaining natural habitats and species. Moreover, the public places much greater priority on other problems, such as terrorism, health, and the economy, than on biodiversity loss. People also often do not recognize the implications of biodiversity loss in exacerbating many problems more familiar and more important to them. Nonetheless, the capacity of the public (and the media) to respond in a more massive and emphatic way to some environmental issues, such as

global warming (69), points the way for greater connections with the public on biodiversity issues. Given the recent transformation of public response, it is more important than ever to show that environmental degradation represents a multidimensional problem in which biodiversity loss and other factors, in addition to climate change, have serious impacts. We are thus still challenged with the goal defined for the biodiversity agenda nearly 20 years ago. We must provide the enhanced understanding of biodiversity and its degradation in a way that empowers people to make choices and take action based on sound science and reliable recommendations. In the meantime, many avenues for attaining this goal—communications through media, environmental NGOs, contributions of public science institutions, and the development of citizen science programs—have been established. Investments in these actions must be strengthened

and their strategies revisited and refined. Most importantly, the critical roles of species in providing ecosystem services, natural beauty and pleasure, and sustaining human lives bear a message that requires constant attention, recrafting, and improved deliverance to impact diverse public audiences.

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Note Added in Proof. A 2008 Gallup Poll shows that more Americans than ever recognize that the effects of global warming may have already begun but are not as concerned about this as they are other problems, including the pollution of drinking water. (85).

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