Conservation Biology and Real-World Conservation

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Abstract: *In the 20 years since* Conservation Biology *was launched with the aim of disseminating scientific knowledge to help conserve biodiversity and the natural world, our discipline has hugely influenced the practice of conservation. But we have had less impact outside the profession itself, and we have not transformed that practice into an enterprise large enough to achieve our conservation goals. As we look to the next 20 years, we need to become more relevant and important to the societies in which we live. To do so, the discipline of conservation biology must generate answers even when full scientific knowledge is lacking, structure scientific research around polices and debates that influence what we value as conservationists, go beyond the certitude of the biological sciences into the more contextual debates of the social sciences, engage scientifically with human-dominated landscapes, and address the question of how conservation can contribute to the improvement of human livelihoods and the quality of human life.*

Conservation Biology y la Conservación en el Mundo Real

Resumen: *En los 20 años desde que fue lanzada Conservation Biology con el objetivo de diseminar el conocimiento científico para ayudar a conservar la biodiversidad y el mundo natural, nuestra disciplina ha influido enormemente en la práctica de la conservación. Pero hemos tenido menos impacto fuera de la profesión misma, y no hemos transformado esa práctica en un cometido lo suficientemente grande para alcanzar nuestras metas de conservación. Cuando miramos los próximos 20 años, necesitamos hacernos más relevantes e importantes para las sociedades en que vivimos. Para ello, la disciplina de la biología de la conservación debe generar respuestas aun cuando se carezca de conocimiento científico, estructurar investigación científica en torno a políticas y debates que influyen en lo que valoramos como conservacionistas, ir más allá de la certitud de las ciencias biológicas hacia los debates más contextuales de las ciencias sociales, comprometerse científicamente con paisajes dominados por humanos y abordar la pregunta de cómo puede contribuir la conservación al mejoramiento del sustento y de la calidad de vida de los humanos.*

Introduction

At the September 2005 World Summit, the General Assembly of the United Nations adopted the *Millennium Development Goals,* which Secretary General Kofi Annan characterized as "a once-in-a-generation opportunity" for the international community to address the most pressing global problems. The loss of biodiversity was considered a global problem, but conservation actions were buried deep in the document. I am struck by the diminishment in the importance of conserving biological diversity in the global dialog, especially in comparison with the 1992 Earth Summit in Rio de Janeiro, which launched the Convention on Biological Diversity and the Global Environmental Facility.

This apparent sea change does not appear to be a surprise to the "talking classes." Shellenberger and Nordhaus (2004) proclaim "The Death of Environmentalism," a statement echoed in A. Werbach's question, "Is environmentalism dead?" (Werbach 2004. Speech presented to The Commonwealth Club, San Francisco, California.). Meyer (2004) concludes that we have indeed reached "The End of the Wild" and that efforts to prevent species extinction were misguided enthusiasms. Political movements inspired by environmentalism are thought to be dying on the vine (Leake 2005), and it is left to *The*

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Economist (2005) to advocate "Rescuing environmentalism (and the planet)." Is the conservation of biological diversity still a societal priority?

When the Society for Conservation Biology (SCB) was established in 1986, the assumption was that the lack of scientific knowledge was preventing people from acting in informed ways to conserve biological diversity. If there is a failure to convince people of the importance of conservation, is it partly because we have not provided the appropriate scientific answers? Is conservation science, as epitomized through our journal, *Conservation Biology*, not having the impact that we need it to have? Is Reid (2005) correct when, in a recent editorial on the impact of the *Millennium Ecosystem Assessment,* he bemoans "the weakening influence of scientific information on public attitudes and decision making"?

A number of indicators suggest that the scientific discipline of conservation biology (CB) has never been stronger. Conservation biology programs have flourished in academic institutions, especially in the United States. Membership in SCB has continued its steady growth and now exceeds 9000. Journal subscriptions have matched that growth, as have the number of published journal pages. The budgets of the more science-based conservation NGOs have grown steadily: the Worldwide Fund for Nature "family" of organizations grew from under $25 million in 1981 to over $350 million in 2001; The Nature Conservancy from $40 million in 1985 to over $300 million in 2002; Conservation International, founded in 1987, had a budget in 2004 of $92 million; and the Wildlife Conservation Society invested some $40 million in field conservation in 2004. Is there an incongruity between the growth of CB and the low priority of conservation in national and international debates?

I believe CB has hugely influenced the practice of conservation but has had less impact outside the profession itself. Conservation biology has informed the practice of conservation and has provided analysis relevant to the design and management of protected areas and the conservation of wild living resources, the protection of threatened and endangered species, and the conservation and restoration of habitat and ecosystems. The understanding necessary to manage and conserve populations, species, biological communities, and ecosystems has been significantly increased. Informed by greater knowledge, conservation projects have specified their goals and objectives more precisely, monitored their internal effectiveness, and adapted their programs based on that monitoring.

Despite this, CB has not strongly influenced international or national policy priorities—conservation concerns rarely influence national initiatives—and has not transformed the practice of conservation into an enterprise large enough to achieve our goals. Conservation biology has been most successful where information could be generated by scientific processes and translated into technical solutions, and where the study of biological systems could be disarticulated from the broader human context. Conservation biology has been less successful where our knowledge base has been weak, where analyses are very probabilistic, and where we are asked to predict outcomes in complex socioeconomic contexts.

New Directions for Conservation Biology

I argue that if conservation is to become a societal priority, then CB has to move beyond situations of rigorous experimental design, tightly controlled variables, and manageable scales and become more engaged in the real world. To do so we need to (1) reach scientific conclusions when knowledge is incomplete or not fully available; (2) incorporate our conservation values in the definition of research questions, the design of experiments, and the collection of data; (3) go beyond biological insights by incorporating analyses from the social sciences and humanities; (4) address conservation in a human-dominated landscape; and (5) evaluate the contribution of conservation to human livelihoods.

None of these directions are revolutionary; most are simply reaffirmations of the challenges we set ourselves when SCB was established. In anticipation of the next 20 years, I examine CB's progress in addressing these real-world challenges.

Reaching Scientific Conclusions When Knowledge Is Incomplete

Conservation biology is built on a foundation of rigorous knowledge of the natural world. The writings of early naturalists such as Beebe (Gould 2004) or Chapman (Vuilleumier 2005) generated descriptive knowledge of the natural world. Arguably inspired by Rachel Carson's *Silent Spring* (1962), field biologists over time became increasingly concerned with the preservation of nature, considering in particular the number of individuals remaining and the extent of natural habitats. Knowledge of the natural world and its functioning, however, is not conservation, and it was Soulé and Wilcox's (1980) *Conservation Biology: an Evolutionary-Ecological Perspective* that formally redirected biological understanding of genetics, diseases, population and community ecology, and island biogeography to the mission of conservation. As Lovejoy (1980) states in the foreword: "Science . . . can make freer progress for the benefit of society, especially if it bends some of its energies to highlighting and revealing Man's place in nature."

To accomplish this mission, CB incorporated a number of intellectual approaches, although Caughley (1994) argues that only two of them predominate: the small population paradigm and the declining population paradigm.

The former derived initially from the application of population genetics to conservation by Michael Soulé and his colleagues. This approach generated more robust predictions because whereas ultimate determinants were also derived from human activities, the more proximate determinants of outcomes were assumed to depend on biological characteristics of populations. As such, biological models and information could be applied rigorously. As is demonstrated by early compendia of CB studies—Schonewald-Cox et al. (1983) and Soulé (1986)—it is this paradigm that first dominated the emerging CB field. Being more reductionist, the small population paradigm allows greater control of variables, provides greater opportunity for experimentation, and generates theoretical models and computer simulations. Thus, CB began by concentrating on the knowable, where data, often biological, could be collected to test specific hypotheses. The small population paradigm is less useful in less controlled contexts and in the analysis of complex natural systems (Caughley 1994; Roush 1995; Hedrick et al. 1996). There was even some early discussion (Hall 1987) on whether the large-scale, multiple-variable analysis of ecosystems and landscapes was an appropriate subject matter for *Conservation Biology*, a debate thankfully resolved in favor of inclusion.

The declining population paradigm, in contrast, owes much to the models developed by wildlife and fisheries managers, in which the emphasis was not on understanding the biological mechanisms underlying change but on developing the science to reach specified conservation targets or goals. Many of the factors affecting wildlife populations are linked to human activities, either directly or indirectly, which are difficult to specify and measure. Lacking detailed scientific knowledge of these factors, these models are more holistic, establishing management targets or goals, coarsely manipulating the social and economic context, and monitoring the effect of management interventions. Caughley (1985) argues that much wildlife and fisheries management theory arose from the data collected through this monitoring process.

Conservation biology has depended on both intellectual approaches to generate knowledge. More reductionistic approaches, such as the small population paradigm, have generated good information that is useful at the scale of conservation practice and implementation. More holistic approaches, such as the declining population paradigm, have helped develop consensus on large-scale goals and patterns. Nevertheless, we often lack knowledge linking the two, especially on the interrelations between biological systems and human endeavors. To illustrate, we know a lot about biodiversity at all scales (UNEP 1995), and we know that species diversity is related to system functions in relatively controlled situations (e.g., Tilman et al. 1997). We argue that biodiversity is important for human well-being, and we know empirically that ecological systems can be degraded and human production systems can deteriorate. But we do not know a lot (see Tomich et al. 2004) about the function of biodiversity in the stability of resource production systems or about threshold effects of biodiversity loss on that stability. We cannot quantify the importance of the stabilizing functions of biodiversity compared with its other ecological goods and services. We advocate for biodiversity conservation at a global level, but our understanding of local functional values of biodiversity remains weak. Although we know a lot about the status of individual species (Baillie et al. 2004), and we believe in the relationship between biodiversity and system functionality, we have little information on the contribution of species to economic growth. We have not developed the knowledge or quantified how species loss undermines human livelihoods, security, and economic development.

Arguably, we know correspondingly less about these issues as they have become increasingly important and relevant to human society. These are the areas where scientific knowledge is incomplete or absent (Knopf & Samson 1994; Myers 1995), but these are precisely the areas where the discipline has the opportunity to contribute to the conservation of biological diversity (Kaiser 2000).

Reaching conclusions in the absence of complete knowledge will be necessary in the complex real-world contexts in which problems are often not amenable to classical reductionist approaches and when "action might be required before the full story is known" (Ludwig et al. 2001). The problem is that making recommendations and taking action in the absence of information and analysis would undercut our scientific authority. In response, CB is developing the tools to deal with this risk and uncertainty. Noting how ignorance and lack of knowledge "force ecologists to create and use a variety of models of uncertain validity," Ludwig and his colleagues, for example, advocate the use of Bayesian statistics, which can assign probabilities (and thus incorporate the lack of knowledge) to hypotheses and parameters of the model. Another approach is adaptive management (Lee 1993; Salafsky et al. 2001*b*), which follows a more conceptual approach by requiring scientists to specify their assumptions in the form of conservation targets or goals and conservation plans or conceptual models, which formally lay out the impediments to reaching those goals. The models can be tested by monitoring the effect of conservation actions that are designed to remove those impediments, and adjusting future actions in an adaptive way. These approaches still require enough scientific knowledge to be able to construct viable models.

Incorporating Conservation Values into Scientific Research

From the beginning, we recognized that CB is a goal-oriented discipline and that the goal (the conservation of biodiversity) is defined by conservation values and not determined scientifically. These values helped define the scientific agenda and the research design. Ehrenfeld (2000) draws CB, a life-saving profession, closer to medicine than to pure science. Norton (1988) believes we "cannot hide behind a false façade of value-free science." Many drew inspiration from Aldo Leopold's melding of science and values in *The Land Ethic*: "A thing is right when it tends to preserve the integrity, stability and beauty of the biotic community." And our conservation values were reaffirmed recently in SCB's 2006-2010 Strategic Plan: "Human-caused extinctions and the degradation, destruction, or loss of functionality of natural ecosystems are undesirable."

Conservation biology's approach ignores Max Weber's distinction between facts and values, a distinction that classically separates science and policy: "Scientific thought about society is guided by the ethic of liberty, the *sine qua non* condition in the search for truth. Political action, on the other hand, is submitted to a logic of necessity linked to the world of values and is necessarily contaminated by ideologies and interests, while it is also linked to a constant concern for consequences" (Cardoso 2001:181). Conservation biologists have sought to be both objective and impartial providers of knowledge and advocates for certain values (Rykiel 2001).

Values influence the scientific questions we ask, affect how experiments are designed, and what data are collected. Yet CB has sought not to lose the rigor of its science. The struggle to maintain our objectivity and depend on rigorous hypothesis testing and the scientific method (data collection, peer review, and publication), dates back to SCB's establishment (Murphy 1990) and continues to challenge us today (Mulvey & Lydeard 2000; Fleishman 2002). This straddle between science and values can be uncomfortable, and there has been a debate within CB on how the discipline should evolve. Some argue that we need to stick to the facts and seek to strengthen the scientific underpinnings of our discipline (Murphy 1990; Rodda 1993). We can do so by returning to the biological certainties from whence we came: "If conservation biology is to mature into an effective science, pure systematics must be accompanied by a massive growth of natural history" (Wilson 2000). The alternative approach is to engage more forcefully in the conservation and resource issues and debates of society (Hagan 1995; Ludwig et al. 2001). The argument is that values can be incorporated by building the case for the conservation of biological diversity and then supporting that case with scientifically derived information and a clear exposition of the (objectively defined) consequences of following certain actions.

Each approach poses its own dangers. If we seek to return to the certainties of more reductionist science, CB runs the danger of becoming less relevant to society's debates and the risk of becoming solely technical advisers. Indeed, on environmental and conservation issues, politicians and government administrators are constantly trying to vitiate the interventions of scientists to technical advice, claiming the power of policy as their own. In this extreme, conservation biologists become simply data collectors, providing no assessment of the value of conserving species, no interpretation of available data, no interpretation of critical habitat needs, no judgment on the consequences of climate change, and no recommendations of remedial action.

On the other hand, if values define the scientific questions we ask and scientific data are used to defend value-defined conclusions, then CB runs the danger of slipping down the slope into empty policy statements and advocacy (Rodda 1993; Mulvey & Lydeard 2000). There are those who question the academic standing of CB because of the values that underlie the discipline, and conservation biologists are regarded with suspicion in some policy circles (Attwell & Cotterhill 2000). At one extreme, fundamentalists argue against the very utility of science. At the other extreme, postmodernists argue that scientific objectivity is naive, that all is value, and can only be understood in the political and social context. Postmodernists dispute the very existence of "nature" and "natural" (Soulé 1995). In attacks on conservationists, facts get swept away in the vividly written, contextual narrative. For instance, Dowie (2005) and Cernea and Schmidt-Soltau write compellingly about the insults rained by conservationists onto traditional indigenous people—narratives not informed by scientific data.

But conservation biologists repudiate the relativism of the postmodernists and the certainty of the fundamentalists. Conservation biologists argue that it is not facts *or* values, but can be both. Conservation biologists have sought for a middle ground between the extremes of just stating facts and just becoming another interest group. There is a difference, we argue, between environmentalism and CB (Hagan 1995). The challenge to this straddle becomes even greater when knowledge is lacking. Conservation biologists "often lack crucial data and adequate theoretical models, [and] must participate with the public in a debate regarding the very nature of ecological health, even while trying to protect it" (Norton 1988). Maintaining objectivity and scientific rigor becomes harder when scientific information is unavailable and when knowledge is incomplete. Data interpretations and policy interventions can become more influenced by values and less by scientific certainty.

As we look to the future, I argue that incorporating values into our science is necessary and means that CB should build a case for the conservation of biodiversity, not disinterestedly investigate, for example, the consequences of biodiversity loss. Pointing out that "value derives from knowledge," Wagner (1996) argues that the contribution scientists make lies in their ability to predict the deleterious consequences of actions and to provide analysis of alternative choices. Based on their knowledge, incomplete though it often is, scientists have greater knowledge of consequences. Our science focuses on understanding the means to achieve the ends we value and scientifically analyzing the structure and functioning of biological and human systems with the intent of changing the final outcomes. The incorporation of values in conservation models does not imply a rejection of scientific rigor and analysis. Our science is not transformed by the political and social postmodernist narrative into science fiction (Haupt 1995).

Our conservation values represent the ends to which we aspire or strive, and within conservation practice these can be expressed as management targets. Management targets are those that can be achieved realistically through possible conservation actions. The role of CB is to help set realistic targets and scientifically test our success at reaching them. Research design can be structured to address management questions of how best to conserve biodiversity, with scientific information providing an answer to the consequences of following certain actions. When scientific knowledge is incomplete, this approach leads to adaptive management, with information on the success at reaching targets being used to modify conservation actions and scientific understanding growing with the evaluation of different management outcomes (Salafsky et al. 2002).

Our conservation values also are expressed as policy goals. Here the role of CB is to generate scientific information that elaborates the consequences of following certain policy directions. Objective science is an essential component of analyzing the consequences of how resources should be managed and how they could be allocated among interest groups. Without these analyses, decisions are made solely on the basis of guesswork or power politics. But not all policy goals are easily testable. For instance, Ehrlich and Ehrlich's (1981) conservation model of the "rivets" holding together our Earth is compelling public policy, but whereas the image of rivets popping is powerful, the science underlying the model and our ability to test it are weak. By contrast, the goal of protecting 10% of the world's land surface, which was promulgated at the Bali Parks Congress in 1982, was similarly based initially on little scientific understanding, but the efficacy of the model can and has been tested, and the results of that scientific test can be used to refine or adapt the model (Svancara et al. 2005). There are calls for CB to engage more with this scientific analysis of public policy. One of SCB's sister professional organizations, the Association for Tropical Biology and Conservation, in their publication *Beyond Paradise: Meeting the Challenges in Tropical Biology in the 21st Century* (Bawa et al. 2004; ATBC 2004), explicitly calls for this "policy-oriented research to mitigate threats to biodiversity." Although recognizing the importance of "curiosity-driven" basic research, ATBC advocates "action-oriented" studies designed to address specific environmental threats.

Going beyond Biological Insights by Incorporating Analyses from the Social Sciences and Humanities

In *Conservation Biology*'s first editorial, Ehrenfeld (1987) noted that even "if biology is the foundation of conservation, we are not so arrogant as to think we can go it alone." The SCB structured its board of governors to include social sciences and humanities. The journal has been catholic in its openness to a wide range of academic disciplines. Nevertheless, *Conservation Biology* still derives its intellectual preponderance from the biological sciences. Few articles integrate the approaches of both the natural and social sciences. And CB has had difficulty moving outside its own disciplinary boundaries and especially into human dimensions (Jacobson & McDuff 1998), even as we have repeated the mantra that conservation is really about people, not about plants and animals.

This disciplinary hegemony is seen even as conservation biologists have attempted to use the insights of CB to influence policy makers and resource managers. A series of important manifestos crafted by ecologists and conservationists have sought to provide an ecological analysis that would shift the societal dialog. The Sustainable Biosphere Initiative (Lubchenco et al. 1991) was launched by the Ecological Society of America to do exactly that. In 1995 the *Global Biodiversity Assessment* was published (UNEP 1995)—an impressive compendium of 1140 pages that examines the main issues, theories, views, and use of biodiversity. In 1996, stimulated in part by the Marine Mammal Commission, *Ecological Applications* published "Principles for the Conservation of Wild Living Resources" (Mangel et al. 1996) that laid out a number of principles to guide natural resource management and conservation. In 1998, *Science* published the American Association for the Advancement of Science president's address optimistically titled "Entering the Century of the Environment . . . " (Lubchenco 1998). All these communications draw their inspiration and knowledge from CB and from the biological sciences. But there was little reaction from outside of our own conservation and biological community.

What these manifestos apparently lacked was engagement with the socioeconomic context and the appropriate analyses from the political and social sciences. They were not considered relevant to the broader public or the policy world. Grubb et al. (1991), for instance, critiqued the Sustainable Biosphere Initiative as too concerned with justifying existing and future basic ecological research and for not engaging with real-world natural resource planning and management. The *Global Biodiversity Assessment* had as its audience the national parties signatory to the Convention of Biological Diversity, who studiously ignored it. "Principles for the Conservation of Wild Living Resources" built its argument on an equilibrium model of natural resource use, arguing that harvests should be managed so that harvested populations are not threatened, ecological systems remain within the bounds of natural variations, and resources themselves are not damaged. These are all reasonable ecological ideas, but ignore the reality of how people in most situations actually harvest resources (Hilborn 1996). People overharvest resources and then move or shift to other ways of making a living (e.g., Berkes et al. 2006). They convert ecological systems into those more productive for themselves. They rarely have the management capability or the incentives to regulate their harvest or the populations of wild species.

Comparing "Principles for the Conservation of Wild Living Resources" with the IUCN Sustainable Use Policy (Resolution 2.29, adopted 2000), which addresses the same issues, is instructive. The latter document generated considerable discussion and interest within national governments and in the conservation and development sectors. Although it recognizes the need to understand the biological characteristics of natural resources, the Sustainable Use Policy focuses more attention on the need to understand the socioeconomic context: positive economic incentives, negative sanctions, governance structures, land tenure, access rights, regulatory systems, traditional knowledge, and customary law.

The challenge for CB is to more effectively incorporate socioeconomic considerations into our analysis of conservation problems. By so doing, we can derive conservation conclusions and generalizations in a context that is more accessible and more relevant to society. This is an issue because scientific—and certainly biological—literacy is limited among those who are making decisions affecting the future of biodiversity. For instance, Kristof (2005) notes that the present U.S. Congress contains 218 lawyers, 12 doctors, and 3 biologists and opines that "in terms of the skills we need for the 21st century, we're Shakespeare-quoting Philistines".

Incorporating the more contextual analyses drawn from the social sciences into CB will be necessary to deal with the risk and uncertainty associated with incomplete knowledge and to inform management targets and policy goals. Conservation biology has hugely increased our understanding of the way biological systems respond to perturbation, use, and modification, but it also needs to incorporate understanding of how economic, social, institutional, and cultural factors affect how people engage with the natural world. Folke (1996) calls for a transdisciplinary approach "where human systems and ecological systems are seen as one system with numerous feedbacks across scales in time and space." Links to economics (e.g., Kremens et al. 2000; Ferraro & Kiss 2002), governance and human institutions (e.g., Ostrom et al. 1999), and political science (e.g., Naughton-Treves & Sanderson 1995) must go beyond what Folke (1996) calls "border linkages" and into much fuller integration.

Addressing Conservation in the Human-Dominated Landscape

Based as it was on the biological sciences, CB has focused historically on wilderness, wild species, and natural ecosystems, and has been concerned with conservation of the structure and elements of biodiversity. Callicott et al. (2000*a*) terms this philosophical approach *compositionalism.* People fall outside this sphere of interest, partly because human activities, with the possible exception of traditional peoples, were not considered "natural" (Hunter 1996, 2000) and partly because human-dominated contexts were considered less amenable to analysis. The general expectation was that human use of resources would invariably affect biodiversity in a negative way (Robinson 1993; Redford & Richter 1999), except under the lightest levels of exploitation. Deriving from this philosophy, much conservation practice has had the goal of the preservation and restoration of biological diversity and integrity. The establishment of parks and protected areas historically has been the primary approach to conserving biodiversity; the 2003 United Nations List of Protected Areas shows that protected areas cover some 18.8 million km^2 (approximately 12% of the Earth's terrestrial surface).

CB has examined the efficacy of creating protected areas, incorporated biological requirements of species and ecological communities into the design of parks, and examined the impact of people on natural ecosystems when they are not protected. Conservation biology has contributed significantly to our understanding of how to conserve exploited wild species (e.g., Caughley 1994; Reynolds et al. 2001). Research has provided an understanding of the baseline condition—how natural ecosystems operate under minimal human impact.

There is another intellectual tradition within CB, which Callicott et al. (2000*a*) identified as *functionalism*, that is less concerned with conserving the static structure and elements of biodiversity and more concerned with maintaining dynamic ecological processes. This approach more explicitly recognized that human influence on the world is pervasive (Vitousek et al. 1986; Sanderson et al. 2002*b*), and has generated concepts such as ecosystem health, ecological sustainability, and sustainable development. Functionalism, when taken to the extreme, considers all anthropogenic modification of ecosystems as natural as any other change, no matter how massive and destructive (Callicott 1990, Callicott et al. 2000*b*). In this vision, wilderness is no more than a matter of degree, and humans are a natural part of nature. Although more rooted in international conservation linked to development assistance (Redclift 1987; WCED 1987) than it is in CB, this tradition is increasingly informing our conservation science.

The growth in our understanding of the ecology of disturbance (e.g., Pickett & White 1985) builds on the functionalist tradition and is beginning to provide the scientific tools for analysis of human-dominated landscapes. There is a broad recognition scientifically (Pickett & Cadenasso 1995) and politically (Babbitt 1995) that CB needs to move beyond the boundaries of parks and reserves and engage with the broader landscape. Although the theory of landscape ecology has advanced (Pickett & Cadenasso 1995; Sanderson et al. 2002*b*), our understanding of how landscapes function is inadequate to fully inform the management (WCS 2002; Loucks et al. 2004). Although landscape patterns have been described and categorized, we still do not have a strong framework in CB to analyze the integrity and functionality of heterogeneous landscapes. Although we have some understanding of how human uses of landscapes affect biodiversity (Redford & Richter 1999; Putz et al. 2000), the same cannot be said of the effect of people's land use on ecological functionality.

Nevertheless, CB is moving beyond natural ecosystems into the human-dominated landscape. Some studies focus on how specific ecosystems that have been modified are structured and function (e.g., degraded lands, Daily 1995; the agroecosystem, Vandermeer & Perfecto 1997; urban waterways, Morley & Karr 2002; and urban sprawl, Johnson & Klemens 2005). Other analyses seek to understand how heterogeneous landscapes, which are the product of ecological variation and human land uses, are structured and how they can be managed. A noteworthy example of the latter is Du Toit et al. (2003), which examines the adaptive management efforts in Kruger National Park to create spatiotemporal heterogeneity across the landscape to meet goals of biodiversity, provision of human benefits, wilderness, naturalness, and custodianship. Management is seen as meeting multiple conservation goals while incorporating the interests of people living around the park. Elaborate models predict the interventions necessary to attain those goals, and knowledge generated through monitoring ecosystem response influences future management decisions.

The scientific study of human-dominated landscapes, especially when characterized by multiple land uses, however, remains in its infancy. Drawing on the theories of island biogeography, we know that isolated parks left to their own devices will fail to protect biodiversity (Newmark 1996; Brashares et al. 2001). We recognize that a unit of study is the entire landscape, characterized by a mosaic of different land uses (Pickett & Cadenasso 1995). But we need to ask how landscapes are structured and how different land uses influence one another (Redford 2005). We recognize that different management objectives require different methodologies (Sinclair et al. 2000; Robinson 2005), but conservationists too often still treat heterogeneous landscapes as homogeneous and apply the same conservation approaches across all types of land use (Robinson & Redford 2004).

There are increasing calls for CB to shift the research agenda from undisturbed ecosystems to studies of human-dominated ecosystems. The Ecological Society of America indicates that "a research perspective that incorporates human activities as integral components of Earth's ecosystems is needed, as is a focus on a future in which Earth's life support systems are maintained while human needs are met" (Palmer et al. 2004). When reviewing their research agenda, ATBC began by considering the priorities laid out by the National Academy of Sciences (NAS 1980) in the 1980 publication *Research Priorities in Tropical Biology*, which listed biological inventories, ecosystem studies, study of aquatic systems, and monitoring of forest conversion. Although ATBC does not repudiate these, they stress the need for evaluating human impacts and studying social drivers of change and social responses to conservation. The ATBC concluded that "tropical biologists must now provide the knowledge needed to sustain humanity as well as nature in the tropical areas of the world."

Evaluating the Contribution of Conservation to Human Livelihoods

Two of society's greatest ethical obligations are the stewardship of nature and the concern for the livelihoods of our fellow human beings. Conservation biology's contribution to the former is evident, but its contribution to the latter is less clear. Nevertheless, the two are inextricably linked, and ignoring one undercuts our ability to influence the other.

The Bruntland Commission report, *Our Common Future* (WCED 1987), and the first publication of *Conservation Biology* are contemporaneous. Although primarily a strategy for national development, the Bruntland report recognizes that natural resources are limited and development should "meet the needs of the present without compromising the ability of future generations to meet their own needs." In so doing, the Bruntland report explicitly links conservation and human livelihoods and moves beyond the development philosophy of the Bretton Woods institutions (World Bank, International Monetary Fund), which focus solely on economic growth as the driver of development. Conservation of natural resources is deemed to be critical to development.

Bruntland's interpretation of conservation falls within that of the functionalist philosophy (Callicott et al. 2000*a*), and *Our Common Future* promoted the concept of sustainable development. The concept has been theoretically criticized for its uncritical acceptance that conservation and development are one and the same process and that a win for one is a win for the other (Redclift 1987; Lélé 1991, Goodland 1995; Lélé & Norgaard 1996; Frazier 1997).

Nevertheless, sustainable development was incorporated into conservation practice as integrated conservation and development projects (ICDPs). Although ICDPs have also been criticized theoretically for their internal contradictions (Wells & Brandon 1992; Brandon 2001; Robinson & Redford 2004), there is little scientific analysis of the approach within the CB oeuvre, and the fundamental question of how conservation can contribute to human livelihoods has not been subject to rigorous tests. Partly, this might be because the analysis requires consideration of multiple variables, getting information requires a significant social science perspective, biological and social knowledge is lacking, and testable hypotheses are difficult to specify. Even the central tenet of sustainable development—that improved livelihoods (as measured by poverty alleviation, greater access to technology, more effective resource management, and greater social justice and equity) are concordant with biodiversity conservation—rarely has been tested scientifically (exceptions include Getz et al. 1999; Salafsky et al. 2001*a*).

The lack of scientific information on the biological and social conditions under which ICDPs are, or are not, an appropriate strategy for conservation and development mirrors the decreasing popularity of sustainable development in the international dialog. Sustainable development is being replaced within the development lexicon with the concepts of poverty alleviation, reduction, and eradication, and conservation as integral to development process has been devalued correspondingly.

This devaluation is evident in recent policy documents that relegate conservation to a desirable consequence, not a primary objective. The Biodiversity in Development Project (2001), for instance, argues that conservation in the absence of economic development will fail, but "development may make conservation 'acceptable' to local communities." Recognizing that as human populations grow, change is inevitable, the document argues that "the maintenance of ecosystem functions to ensure productive landscapes for . . . human development . . . [is] even more important [than the issue of species extinction]" (p. 14). The *Millennium Development Goals* (UN 2000) recognize the importance of the environment primarily as a source of "natural resources [which] can become the wealth the poor need to lift themselves out of poverty" (UNDP 2005). The fifth World Parks Congress in 2003 justified parks through their contribution to human livelihoods (Robinson & Ginsberg 2004; Locke & Dearden 2005). The question is raised whether there are already enough parks (Roe & Hollands 2004). And parks are seen as foreclosing future land-use options, with potentially significant opportunity costs (Adams et al. 2004; Chapin 2004). Even the sustainable management of natural resources is challenged if it is seen as preventing poor people access to resources (Brown 2003).

This shifting emphasis toward a poverty-reduction development strategy and away from one both driven and constrained by ecology and resources ignores the failures of previous development efforts of this kind (Sanderson 2004). Indeed, the whole discussion has remained value rich but data poor. If CB is to influence the debate, we need to analyze more fully the contribution of conservation to human livelihoods and quality of human life. There is a literature on the economic contribution of protected areas (e.g., Kremens et al. 2000) and natural resource management (e.g., Bodmer et al. 2004), but there is little on the contribution of conservation to livelihoods and poverty alleviation (with some exceptions, e.g., Demmer & Overman 2001). Few studies exist on the negative or positive impact of park creation on people's livelihoods (Wilkie et al. 2006) or have dissected out the social and economic conditions affecting the impact of local people on protected areas (Broad 1994; Campbell et al. 2001; Brashares et al. 2004; Arambizaa & Painter 2006). There remains a need for empirical studies to understand under what conditions and over what spatial scales people's livelihoods can be enhanced and wild species conserved.

Ultimately, if CB is to be relevant to society, it will be necessary for our science to examine how conservation can contribute to the improvement of human livelihoods. Although the importance of conserving natural ecosystems and wild species is self-evident to conservation biologists, it apparently is not to most people. The approach adopted by the *Millennium Ecosystem Assessment* (MA) can be interpreted in this light. Rather than assessing the state of natural ecosystems, the MA assessed the capacity of ecosystems to provide "ecosystem services" to people (WRI 2003, 2005; Stokstad 2005). Dividing those life-support systems into provisioning services (e.g., food, water, fuel), regulating (e.g., prevention of soil erosion, flooding), cultural (e.g., of recreational or spiritual value), and basic support systems (e.g., soil formation, nutrient cycling), the MA attempts to link ecological systems to human well-being and build those arguments on the back of good science. The MA was careful not to ignore the fact that species and ecosystems have intrinsic value, but did emphasize the utilitarian value. Although it is too soon to know what the impact of the MA will be on the international and national conservation and development dialog, the documents are accessible and relevant to policy makers.

Conservationists are increasingly being asked to address issues of human livelihoods, especially in rural areas in the developing world where people not only depend on but also degrade their natural resources. The argument is that conservation can only be achieved through resource management, by establishing effective governance so that resources are allocated fairly and equitably. The World Commission on Forestry and Sustainable Development (WCFSD 1999), for instance, posits that "problems of conservation cannot be addressed independent of the societal context, and effective conservation requires consideration of the problems of social equity and the need for 'good governance.'" In the case of the tropics, ATBC (2004) concluded that "conservation must be seen as part of the larger agenda of sustainable and equitable development of tropical countries."

The challenge for CB is to provide the scientific knowledge relevant to these questions. Although poverty alleviation and biological conservation are often linked in policy documents (e.g., *Millennium Development Goals,* goal 7), the scientific basis of that linkage is weak. Nevertheless, CB is increasingly engaging with these issues. For example, CB has provided significant insight into natural resource use of traditional people (e.g., Bennett et al. 2000; Robinson & Bennett 2000), there are overlapping interests and shared values between those seeking to conserve biological and cultural diversity (e.g., Chayax & Whiteacre 1997), and conservation programs can directly benefit traditional people (e.g., Getz et al. 1999; Chapin 2004). Conservation biology is still struggling with how to engage with problems of poverty eradication more broadly, although tentative steps that define "conceptual frameworks" that will allow the study of poverty and conservation linkages have been developed by Adams et al. (2004).

Conclusions

True to the intentions of its founders, CB has established itself over the last 20 years as a strong academic discipline. The attraction of scientific certitude and rigor, the "high ground" of science (Schön 1983), is true to our intellectual roots in the biological sciences. A rigorous science and a reductionist methodology have allowed us to improve understanding by controlling variables and undertaking rigorous hypothesis testing, and have led to a robust disciplinary framework. As we look to the future, the challenge is to make CB relevant to the societies in which we live—which was also a stated goal when SCB was founded. As Schön notes: "The difficulty is that problems of the high ground, however great their technical interest, are often relatively unimportant to clients or to the larger society, while in the swamp are the problems of greatest human concern." Here we have not been as successful. To influence these debates and policies about the conservation of the natural world, we need to (1) draw conclusions even when full scientific knowledge is lacking and there is not a high degree of confidence in our predictions; (2) structure our scientific research around policies and debates that influence what we value; (3) go beyond the certitude of the biological sciences into the more contextual debates of the social sciences; (4) scientifically engage with the human-dominated landscapes; and (5) use our science to address how conservation can contribute to the improvement of human livelihoods and vice-versa.

Conservation biology has come a long way in the last 20 years, and has contributed to the increasing professionalism and authority of conservation efforts. Yet we still struggle to be relevant and important to the societies in which we live. I have argued that we need to apply our science to problems and in contexts that seemingly contradict the objectivity and rigor of the biological sciences from whence we came: to address problems where scientific knowledge is limited, to contexts where the insights of the social sciences are more useful, and to highly modified ecosystems. How we respond to those challenges will define how important and relevant our profession will be in 20 years time.

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