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Is there a special conservation biology?

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Conservation biology is special to the extent that it fills useful roles in the scientific and conservation fields that are not being filled by practitioners of other disciplines. The emergence of the "new conservation biology" in the late 1970's and its blossoming in the 1980's and 1990's reflect, to a large degree, a failure of traditional academic ecology and the natural resource disciplines to address modern conservation problems adequately. Yet, to be successful conservation biology, as an interdisciplinary field, must build on the strengths of other disciplines – both basic and applied. The new conservation biology grew out of concern over extinction of species, although the field has expanded to include issues about management of several levels of biological organization. I examine four controversial questions of importance to conservation biologists today: 1) are there any robust principles of conservation biology? 2) Is advocacy an appropriate activity of conservation biologists? 3) Are we educating conservation biologists properly? 4) Is conservation biology distinct from other biological and resource management disciplines? I answer three of these questions with a tentative "yes" and one (3) with a regretful "in most cases, no." I see a need for broader training for students of conservation biology, more emphasis on collecting basic field data, compelling applications of conservation biology to real problems, increased influence on policy, and expansion of the international scope of the discipline. If all these occur, conservation biology will by truly special.

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Whether conservation biology is a distinct discipline with its own theories, methods, and applications – or simply an amalgam of what scientists and practitioners in many disciplines have been doing for years – is a troubling question to conservation biologists who yearn for a disciplinary identity. It is evidently more troubling to the wildlife and fisheries biologists, foresters, range managers, and other applied scientists who feel threatened by this ostensibly new "metadiscipline" that has suddenly grabbed the spotlight of scientific and policy interest. Many natural resources professionals feel that "We were conservation biologists when conservation biology wasn't cool" (Thomas and Salwasser 1989). As one disgruntled wildlife biologist – an acknowledged leader in his field – commented in his review of a conservation biology text, "The new society [Society for Conservation Biology] is either naive about what has been done by conservation biologists and managers in the past or it chooses to ignore it…What the society proposes to be, the profession of wildlife ecology and management has been for all of its history" (Teer 1988).

I must begin by divulging my biases. I call myself a conservation biologist, work for the Conservation Biology Institute, edited the journal Conservation Biology for several years, and I am currently president-elect of the Society for Conservation Biology. I am hardly impartial. To pretend that I can objectively address the question suggested to me by the editors of Oikos and Ecography – "Is there a special conservation biology?" – would be deceitful. Nevertheless, I attempt to address what I feel are the most important questions regarding the specialness of conservation biology: are self-proclaimed conservation biologists filling useful roles in the scientific and conservation communities that have not

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been filled by academic ecology and the resource management disciplines? How can these roles be enhanced?

History

Meanings of "conservation biology"

As hinted in my first paragraph, a professional rivalry of sorts has developed between conservation biologists (as represented by the Society for Conservation Biology) and wildlife biologists (as represented by The Wildlife Society, at least in the U.S.A.). Thus, it is interesting that the first recorded use of the term "conservation biology" was in the inaugural issue of The Wildlife Society's journal, the Journal of Wildlife Management. In that issue Errington and Hamerstrom (1937) began a paper on nest failures of ring-necked pheasant *Phasianus colchicus* with the words, "In the new and growing field of conservation biology..." In those days conservation meant something different from what it means today. Conservation, in America at least, was strictly utilitarian and was opposed to "preservation," which meant protecting the wonders of nature, mostly for the spiritual and aesthetic enrichment of mankind (Fox 1981). Preservation today is interpreted as a hands-off approach, one option in a broad spectrum of conservation strategies. And whereas the early conservation biology of The Wildlife Society was focused exclusively on game species of mammals and birds, and remains strongly oriented in this direction today (Jensen and Krausman 1993, Bunnell and Dupuis 1995), modern conservation biology cuts across all taxa – the obviously useful as well as the seemingly useless – and has a bundle of both anthropocentric and biocentric aims. Ironically, modern conservation biologists would not view favorably the specific subject of Errington and Hamerstrom's paper – an introduced game bird that, in some places, has had harmful, competitive interactions with native birds.

By the time the term "conservation biology" appeared regularly in the late 1970's, the focus had changed considerably. Many conservation biologists would accept as historical fact Ehrlich's (1987: 761) summarization that "the beginning of conservation biology as a unified discipline can be traced to a symposium organized by Michael Soulé and Bruce Wilcox in September 1978 at the San Diego Wild Animal Park, and to the volume they subsequently edited" (i.e., Soulé and Wilcox 1980). This event was preceded, however, by many, scattered journal articles and several books that carried a conservation biological theme, perhaps most notably Readings in Conservation Ecology (Cox 1969) and Biological Conservation (Ehrenfeld 1970). In May 1985 the Second Conference on Conservation Biology was held in Ann Arbor, Michigan. A noteworthy outcome of this meeting (besides Soulé 1986) was the founding of the Society for Conservation Biology (SCB), with the explicit mission "to help develop the scientific and technical means for the protection, maintenance, and restoration of life on this planet – its species, its ecological and evolutionary processes, and its particular and total environment."

Also of significance in the late 1980's was a 1986 National Forum on Biodiversity, sponsored by the National Academy of Sciences and the Smithsonian Institution, which resulted in an influential book (Wilson 1988). The term "biodiversity" subsequently became the guiding paradigm of conservation biology and even resulted in draft legislation in the United States. The journal Conservation Biology began publication in spring 1987. (It is interesting to note that the British journal, Biological Conservation, had been running for 17 years at that time, but never was associated with a scientific society). When the SCB held its first meeting in June of 1987, it already contained > 1500 members and was growing rapidly. Although I can find no comparative statistics to validate the claim, several observers have stated that SCB's growth in the 1990's is the most rapid of any professional society. Membership is now over 5000 and still growing, albeit not as rapidly as in the early years.

Involvement of scientists in conservation

What happened in the half century from 1937 to 1987 was pivotal to the modern interpretation of conservation biology. Scientists and the public had slowly become aware of the extinction crisis. The idea that human civilization and nature were on a collision course did not arise first in the twentieth century. The roots of the conservation movement in the West can be traced at least to the mid-eighteenth century, when several European scientists pointed out the threat colonialism posed to the ecology of tropical areas, especially islands (Grove 1992). Deforestation had been decried by some scientists a century earlier. In the nineteenth century, American writers such as James Fenimore Cooper, Ralph Waldo Emerson, and Henry David Thoreau extolled the values of wilderness and worried about its destruction. The publication of Man and Nature by George Perkins Marsh in 1864 was heralded as a turning point, whence the vulnerability of nature to human intrusions was widely acknowledged. The establishment of national parks, laws protecting wildlife, and other conservation achievements in America, Europe, and Australia followed rapidly in the late nineteenth and early twentieth centuries (Worster 1977, Fox 1981, Zaslowsky 1986, Nash 1989, Grove 1992).

Despite the burgeoning growth of the conservation movement in the twentieth century, most natural scientists – perhaps trying to remain detached, impartial observers – were aloof to the problem of biotic impoverishment. For a time the science of ecology seemed to offer a way for scientists to involve themselves legitimately in conservation activities. In the early to mid 20th century, several British ecologists, including F. W. Oliver and Arthur Tansley, were active in public efforts to establish a system of nature reserves (McIntosh 1985). One of the first actions of the Ecological Society of America after its formation in 1917 was to establish a Committee on the Preservation of Natural Conditions, chaired by Victor Shelford, arguably one of the first scientists to warrant the description "conservation biologist" in the modern sense. For nearly 30 years Shelford's committees sought representation in nature reserves of each of North America's biomes as complete ecosystems including top predators, and supported specific activities such as those of Save-the-Redwoods League and other land preservation groups. Shelford's efforts, however, proved controversial among his fellow ecologists. In 1946 the Ecological Society of America, concerned about Shelford's advocacy, voted to discontinue his committee. Undeterred, Shelford immediately organized an independent group of ecologists, called the Ecologists' Union, to continue conservation work. This organization, in 1950, was renamed The Nature Conservancy (McIntosh 1985) and is today the major land conservation organization in North America. Among the illustrious members of Shelford's committees was Aldo Leopold. Leopold, who served as president of both The Wildlife Society and the Ecological Society of America, not only was able to bridge the gap between the natural resources disciplines and academic ecology, but had a tremendous influence on succeeding generations of conservationists through expression of his "land ethic" (Leopold 1949).

As exemplified by the Ecological Society of America's 1946 decision on advocacy, the post-war attitude in science was far removed from a conservation ethic. Industrial progress was the prominent concern. Some scientists, however, were worried about the environmental impacts of such "progress." In 1948 G. Evelyn Hutchinson warned of the dangers of the expanding human population and the disruption of geochemical cycles, one outcome of which could be global warming. Hutchinson suggested "it ought to be possible to show that it is as much fun to repair the biosphere and the human societies within it as it is to mend the radio or the family car." In 1962 Rachel Carson's Silent Spring alerted the public to the dangers of pesticides and inspired an environmental movement concerned largely with toxic chemicals and pollution. Although Carson was personally interested in other life forms, the environmental movement that arose in the 1960's and continues today has been chiefly absorbed with threats to human health and welfare. Most of the widely heralded American environmental laws of the late 1960's and early 1970's, for instance, speak of the "human environment," not natural ecosystems and native species, thus clearly distinguishing the environmental movement from the older conservation movement (Foreman 1991). Moreover, despite the concerns of some influential ecologists of this period, such as Eugene Odum and George Woodwell, ecologists and other natural scientists were largely silent on such issues as overpopulation (Paul Ehrlich and Garrett Hardin being notable exceptions!), habitat destruction, and the extinction of species. The biology and ecology courses I took in the 1960's and early 1970's scarcely mentioned these issues, aside from passing comments on human population.

Island biogeography

I credit the explosion of interest in potential applications of MacArthur and Wilson's (1963, 1967) theory of island biogeography in the mid-1970's as the primary stimulus for the development of modern conservation biology. Although MacArthur and Wilson published their theory in the 1960's and made brief mention of extension to terrestrial habitat islands, it was the flurry of papers on the application of island biogeographic concepts to nature reserve design by Terborgh (1974), Willis (1974), Diamond (1975), and others – and the ensuing controversy over the appropriateness of these applications (Simberloff and Abele 1976, followed by Diamond 1976, Terborgh 1976, Whitcomb et al. 1976, etc.) – that caught the attention of natural scientists and awakened their interests in conservation. Island biogeography was interesting to ecologists because it was theoretical, it posed testable hypotheses, and it seemed applicable to real-world problems. Even though its predictive capacity proved to be marginal – there are just too many variables in the real world – island biogeographic theory got scientists thinking in new, quantitative ways about spatial issues such as patch size and isolation and how they affect the persistence of populations (e.g., Soulé et al. 1979, Harris 1984, Newmark 1985). This, in itself, was a tremendous contribution; moreover, it led directly to the concepts of minimum viable population (MVP) and population viability analysis (PVA), concepts which defined the new conservation biology. As a graduate student in ecology at the time the controversy over extrapolation of island biogeographic principles to reserve design unfolded in Science (e.g., Simberloff and Abele 1976), I saw many of my fellow students develop a conservation element in their research. Although we were warned, in a genuinely friendly way, by our advisors to emphasize science over application, our personal interests leaned more and more toward the kind of topics that came to dominate the conservation biology literature of the succeeding decade.

This brings us back to the first conference on conservation biology in the late 1970's and, one decade later, the founding of SCB. Just as concerns about deforestation in tropical colonies spurred the interest of European scientists in conservation in the eighteenth century, the loss of tropical forests and scientists' predictions about mass extinction were major factors in the emergence of the new conservation biology (Myers 1979, 1983, Wilson 1988). All four chapters in Part I (ecological principles of conservation) of the book that resulted from the first conservation biology conference (Soulé and Wilcox 1980) contain the words "tropical" or "neotropical" in their titles, and many other book chapters emphasized the tropics. Extinction of species – probably occurring at highest rates in the tropics – was the primary worry of conservation biologists in the 1970's and 1980's. Although extinction and tropical ecology remain major areas of concern, the late 1980's and 1990's have seen greatly increased attention to temperate biotas, other kinds of biotic impoverishment besides species extinction, and especially in the late 1990's, overdue consideration of marine and freshwater biodiversity.

Conservation biology today

I address here four issues that are among the key interests of conservation biologists today: 1) whether principles of conservation biology are sufficiently well established to guide conservation action in particular cases; 2) the controversy over the role of advocacy in conservation biology; 3) education and training in conservation biology; and 4) the professional distinctiveness of conservation biology. The discussions that have arisen over the first three issues are illustrative of the fourth – they make conservation biology distinct.

Principles of conservation biology?

Conservation biology in the 1990's progressed from simple generalizations and rules-of-thumb about population viability, reserve design, and other issues as it was forced to recognize the idiosyncracies of real cases. Some ecologists (e.g., Shrader-Frechette and McCoy 1993) insist that the world is all special cases and that ecological theory offers a poor guide to conservation decision-making. Yet, I think it would be improper to abandon the search for pattern and generalities. Indeed, because case-specific information is always poorer than desired for conservation planning, empirical generalizations derived from prior experience often provide the only reasonable foundation for decision-making. Decisions will be made with or without the input of conservation biologists, so it would behoove biologists to offer whatever legitimate advice they can. The key word, of course, is "legitimate."

Among the generalizations or "principles" that have been offered to guide conservation in the face of uncertainty are: 1) species well distributed across their native range are less susceptible to extinction than species confined to small portions of their range. 2) Large blocks of habitat, containing large populations, are better than small blocks with small populations. 3) Blocks of habitat close together are better than blocks far apart. 4) Habitat in contiguous blocks is better than fragmented habitat. 5) Interconnected blocks of habitat are better than isolated blocks. 6) Blocks of habitat that are roadless or otherwise inaccessible to humans are better than roaded and accessible blocks. 7) The fewer data or more uncertainty, the more conservative (i.e., less reduction or disruption of natural habitats) a conservation or development plan should be. 8) Maintaining viable (i.e., undegraded, fully functioning) ecosystems is usually more efficient, economical, and effective than a species-by-species approach. 9) Biodiversity is not distributed randomly or uniformly across a landscape; in establishing protection priorities, consider "hotspots." I have discussed some of the evidence in support of these principles elsewhere (Noss et al. 1997). Generally, conservation biologists are less able to make specific predictions about future conditions than to generalize about what should not be done (Soulé pers. comm.). That is, they can predict that reducing and fragmenting natural habitat, building roads, and many other human activities will lead to undesirable consequences, but they cannot predict exactly what those consequences will be.

Conservation practitioners frequently rely on principles such as those offered above, sometimes unquestioningly. Nevertheless, each of these empirical generalizations has exceptions. They must be interpreted and applied to particular cases cautiously and only by competent biologists familiar with the region and taxa involved. Simplistic and uncritical application of general principles can lead to flawed advice. Principle 5, regarding connectivity, is a case in point. What conservation biologists are interested in is functional connectivity, which might be defined as the successful movement of individuals across the landscape, ultimately resulting in demographic and genetic interchange among populations (Noss and Cooperrider 1994). Functional connectivity is highly species-specific (Soulé 1991). A corridor to one species may be a barrier to another. One species might require a mile-wide swath of undisturbed, late-successional forest as a corridor, whereas another can meander through the landscape matrix with little difficulty. Populations that are naturally isolated usually should not be connected by artificial corridors. Nevertheless, a "corridor craze" has hit the world, to the extent that conservation planners regularly draw corridors into their designs, with or without evidence that they may work (Simberloff and Cox 1987, Simberloff et al. 1992).

The bandwagon effect notwithstanding, I do not believe that solid empirical evidence of a particular corridor providing functional connectivity should be required before that corridor becomes part of a conservation plan. If it were, we would scarcely ever have a basis for protecting corridors (but see Beier and Noss 1998). We know that fragmentation – the converse of connectivity – is generally bad, so the burden of proof should be on those who would disrupt the natural connectivity of a landscape. A good understanding of the biological needs of the focal species, however, is required to make more specific design recommendations. Poorly designed, narrow corridors with abundant edge habitat, for example, could conceivably do more harm than good by exposing animals to predators (including humans). In designing corridors, it seems wise to focus on the species most sensitive to habitat fragmentation and to protect or restore the pathways that these organisms normally follow through the landscape.

Conservation biologists as advocates

One of the greatest strengths and weaknesses of conservation biology is that it is a normative, value-laden science. From the beginning, the new conservation biologists had a mission. As pointed out by Soulé (1985), "ethical norms are a genuine part of conservation biology, as they are in all mission- or crisis-oriented disciplines." A strength of having ethical norms (comparable, for instance, to the life-affirming norms of medical science) is that there is a strong sense of commitment on the part of practitioners and a shared desire to "do the right thing." A weakness is that those who do not share your norms will attack you on principle. A further weakness is the apparent contradiction with the traditional image of science as neutral, objective, and value-free. The overarching normative assumption in conservation biology is that biodiversity is good and ought to be preserved. Although this might seem a non-controversial proposition, it has caused some scientists to feel uncomfortable with conservation biology and some anti-conservationists to dismiss it as religion, not science.

Biologists remain divided over the proper relationship between science and advocacy. The issue is a complex one that I cannot do justice to here. I view much of the tension as essentially between two core values of any applied science: objectivity and public responsibility (Noss et al. 1997). An objective scientist should make his or her work as free of bias as possible. A publicly responsible scientist, on the other hand, should try to make research relevant to real-world problems. Further, applied scientists have a duty to interpret their findings in ways that will help solve the problems facing society. This interpretation frequently and properly includes explicit recommendations concerning policy and management options. Because they are often the people most knowledgeable about the study area, ecosystem, or species in question, conservation biologists may be in the best position to make such recommendations to society. Whenever one recommends, however cautiously or conservatively, one advocates. The obligation of the conservation biologist, as of any applied scientist, is to make sure that this advocacy is responsible.

Responsible advocacy is honest (i.e., it seeks the truth) and strives to minimize biases (except the commendable bias of biophilia – the love of living organisms and the desire to see them persist). In practice, a responsible scientist would not advocate a particular solution to a conservation problem until or unless there is an objective scientific basis for taking that position. This is a crucial distinction. An unfortunate trend in modern "courtroom science" is the use of expert witnesses as "hired guns," individuals willing to support the biases and preconceived notions of their clients. This trend threatens to undermine science and erode its status as a search for truth. But we must be careful to distinguish such dishonest advocacy from the honest attempt to find the best way to solve a conservation problem. Wanting to solve the problem is advocacy, and it is nothing to be ashamed of. The process of finding a solution, however, must be as objective as possible.

Wiens (1996: 595), in a paper summarizing research on the effects of the Exxon Valdez oil spill, wrote that "[a]dvocacy can erode the objectivity and rigor of the scientific process... Although there is nothing wrong with predicting a result (all good scientific hypotheses offer predictions), advocacy can bolster such expectations to the degree that contrary evidence is not considered or hypotheses are accepted without supporting evidence." Wiens is correct that scientists must consider contrary evidence fairly, not accept hypotheses without rigorously obtained supporting evidence, and take care not to cite data selectively. What he criticizes, however, is dishonesty, not advocacy. Shrader-Frechette (1996) suggested that if scientists refuse to act as advocates, they can inadvertently serve the status quo and perpetuate "ethical and environmental errors in the status quo."

If there is a consensus among conservation biologists on the issue of advocacy, it appears to be that advocacy is proper and unavoidable, but that how and what one advocates must be very carefully considered. An explicit statement of the values and goals underlying any position of advocacy would be helpful, especially in cases where advocacy of a conservation position actually or potentially conflicts with advocacy of other worthwhile goals (e.g., saving a large area of tropical rain forest versus an economic development program for the people of that region).

Educating conservation biologists

The founders of the new conservation biology are now well into middle age. It is not surprising, then, that educational issues are being more regularly discussed among conservation biologists – we want to be sure the generation that replaces us is well trained! Most of today's conservation biologists come from traditional academic backgrounds, i.e., Ph.D.'s in biology, botany, or zoology, followed by faculty jobs at universities (Beissinger 1990, Noss 1997). A smaller number come from resource management fields (in my case, Ph.D. in wildlife ecology) and/or have professional experience primarily with governmental land-managing or environmental agencies or non-governmental organizations (chiefly conservation groups and zoos). Although conservation biology professes to be interdisciplinary, or at least multi-disciplinary (Soulé 1985, Jacobson 1990), it is no secret that the vast majority of members of the Society for Conservation Biology and authors in its journal are traditionally-trained biologists whose abilities in management and policy, if any, are self-taught or acquired by painful experience.

That biology is the core discipline of conservation biology is appropriate, not only to keep the name of the field accurate, but because the first, essential stage in any conservation planning or management endeavor is to understand the biology and ecology of the system – the organisms involved, their interactions among each other and with their environment, and the factors that might make them vulnerable to decline or extinction. An emphasis on biology, as opposed to social science, is also consistent with the observation that human cultural systems are far more adaptable than biological systems. Nevertheless, conservation biologists increasingly recognize that the proximate and ultimate threats to biodiversity virtually all have to do with humans. Conservation solutions, therefore, are dependent on social and political decisions and, ultimately, on social change. In order to interact effectively in the political arena, from the local scale to the global, the conservation biologist must understand social systems and possess reasonably good "people skills" (Jacobson and McDuff 1998, Clark unpubl.).

Conservation biology and related programs at universities have proliferated over the last decade (Jacobson 1990, Jacobson et al. 1995), but they are generally not training conservation biologists for the job opportunities and professional challenges of today (Orr 1990, Noss 1997, Meffe 1998, Jacobson and McDuff 1998, Soulé and Press 1998). Although numbers for quantitative comparison are unavailable, it appears certain that the vast majority of jobs for conservation biologists today are not in universities, but in land-managing and regulatory agencies, conservation groups, consulting firms, research institutes, zoos, and even industry. The multitude of students enrolled in conservation biology and related programs at universities should be trained in the skills required for these jobs. It would be especially helpful if their professors had experience in the "real world" outside of the academy, so that they could pass on the appropriate knowledge. Instead, graduate students are being trained as "little professors," regardless of whether they are seeking a Ph.D. or plan to pursue academic jobs, and the people training them usually have little or no experience elsewhere.

A further problem is that most academic curricula in conservation biology remain rigidly departmental with little opportunity for interdisciplinary training (Noss 1997, Meffe 1998). Professional rivalry and competition for university funds cause department chairs to be highly turf-conscious. Graduate students usually are forced to specialize on narrow research topics, even though the job market increasingly requires broadly-trained, versatile professionals. Essential skills in policy processes and communications are ignored (Jacobson and McDuff 1998, Clark unpubl.). Indeed, Jacobson and McDuff (1998: 263) suggest that "we may, in fact, be training idiot savants – individuals skilled in certain areas – (in this case, the technical biological aspects of conservation) – but largely inept in other aspects of the field."

The recent critics of academic curricula in conservation biology have suggested a number of possible solutions to the problems noted, including 1) development of truly interdisciplinary degree programs, 2) internships to develop job experience outside the university, 3) recruitment of faculty with extensive professional experience outside academia, 4) more coursework outside of biology, 5) increased emphasis on general natural history (as opposed to narrow, taxonomic specialization), 6) promotion of a problem-solving and policy-oriented approach to education, 7) development of strong communication skills in students, and 8) modification of faculty incentive systems to promote cooperation among departments and to reward individual faculty for real-world service to conservation (Beissinger 1990, Noss 1997, Meffe 1998, Jacobson and McDuff 1998, Soulé and Press 1998). Furthermore, all of this increasing breadth of training must be accomplished without sacrificing depth of training in the core discipline of biology (see Soulé and Press 1998). Otherwise, we risk training jacks of all trades who are masters of none.

There seems no escaping the conclusion that education in a field as complex as conservation biology requires degree programs significantly longer in duration than the idealized (but rarely attained) 4-year bachelors, 2-year master's, and 4-year doctoral programs of today. Students and administrators may at first balk at expanded course and internship requirements, but students who are able to complete such a curriculum will come out better trained and more competitive in the job market. Moreover, they might actually be equipped to address the complex and challenging conservation problems of the next century.

Distinctiveness

Considering the above, then, is conservation biology special? Several analyses have shown that wildlife biology and conservation biology are distinct from each other, as reflected in the content of their journals. Jensen and Krausman (1993) compared the subject matter and authors' affiliations in Conservation Biology to the Journal of Wildlife Management and Wildlife Society Bulletin for the period 1987–1991. Compared to the wildlife journals, Conservation Biology had a much broader scope geographically and taxonomically, had far fewer papers on game species, had more papers with modeling and theory and much fewer papers on techniques, and had more diverse author affiliations. A second, more extensive analysis (Bunnell and Dupuis 1995) confirmed that the wildlife journals have emphasized game species and furbearers since their inception, whereas Conservation Biology has had more papers addressing multiple species and spatio-temporal scales. Curiously, Bunnell and Dupuis (1995) concluded that the wildlife journals were more rigorous than Conservation Biology, but their determination of rigor was merely the proportion of papers with methods sections, a highly questionable criterion (Noss 1995).

Soulé (1985) noted two characteristics of the resource management fields that distinguish them from conservation biology: "The first is the dominance in the resource fields of utilitarian, economic objectives...the emphasis is on our natural resources... The second ... is the nature of these resources. For the most part they are a small number of particularly valuable target species." It appears that Soulé's statement is as true today as it was in 1985. Conservation biology generally represents a different, broader agenda and modus operandi than the resource management fields (Table 1). As pointed out by Aplet et al. (1992), however, the perceived differences between conservation biology and resource management are nothing new. They are simply the latest manifestation of the "A-B cleavage" recognized a half-century ago by Leopold (1949), wherein "one group (A) regards the land as soil, and its function as commodity-production; another group (B) regards the land as a biota, and its function something broader." It will be interesting to see if conservation biology draws closer to the status quo (i.e., becomes more utilitarian and less biocentric) as it is increasingly institutionalized in government agencies, where the resource management fields have been for decades.

A comparison of conservation biology with ecology is even simpler. Although extensive overlap exists be-

Table 1. Comparison of traditional resource management with conservation biology. Revised from Aplet et al. (1992), Noss and Cooperrider (1994).

Parameter	Traditional resource management (wildlife and fisheries biology, forestry, range management, etc.)	Conservation biology
philosophical attitude	anthropocentric; confident in human knowledge about resources and human effects on nature; not cautious; emphasizes human control and domination of nature	usually biocentric or ecocentric, sometimes long-term anthropocentric; uncertain and cautious about effects of human activities on nature; emphasizes humans living within limits of nature
orientation	utilitarian; oriented toward human use of natural resources, supplying a harvestable surplus or sustainable yield to humans	oriented toward conservation of all of biodiversity, with or without use by or benefit to humans
taxa or interest	game or food species of mammals, birds, fishes; commercial timber trees; forage for livestock; emphasis on "improved" or introduced species	all taxa; biodiversity at several levels of organization; emphasis on native species
time scale	short-term perspective	long-term perspective
region of interest	narrow, politically defined boundaries	international, ecologically defined boundaries
education	usually strictly disciplinary; rigid boundaries between fields; uniform	strives to be multi-disciplinary of inter-disciplinary; diverse
basis for paradigms	mostly empirical	theoretical and empirical
professional affiliations	primarily agencies and academic	more diverse; primarily academic, but also agencies, conservation groups, etc.
agency programs	fragmented/disciplinary	integrated
interactions among disciplines and agencies	competitive	cooperative
responsiveness	management responsive to bureaucracy, politicians, and commodity users	management responsive to long-term needs of species (including humans) and ecosystems

tween conservation biology and applied ecology (as represented, for example, by the Journal of Applied Ecology and Ecological Applications), the sense of mission is much stronger in the conservation biology journals (e.g., Conservation Biology and Biological Conservation). There is also in the latter a sense of urgency, of needing to act in the face of uncertainty: "In crisis disciplines, one must act before knowing all the facts; crisis disciplines are thus a mixture of science and art, and their pursuit requires intuition as well as information" (Soulé 1985). One finds little appeal to art and intuition in the traditional sciences. The traditional ecology journals (Ecology, Journal of Ecology, Oikos, Oecologia, etc.) and their associated societies generally lack a strong sense of mission or urgency. Paradoxically, many of the conservation planning schemes arising out of conservation biology, such as The Wildlands Project (Noss 1992, Foreman et al. 1992, Soulé 1995, Soulé and Terborgh 1999) are less oriented toward immediate crises and more toward building long-term conservation networks over decades and centuries.

In large part, then, the blossoming of conservation biology over the last two decades reflects a failure of both traditional ecology and the traditional resource management disciplines to address modern conservation problems adequately. Nevertheless, some of the distinction between conservation biology and related fields is breaking down as the techniques and methods of conservation biology are viewed as useful by an increasing sphere of professionals. I view this as a permeation of conservation biology into other fields, a natural and welcome response of professionals to the biodiversity crisis. Articles with a conservation focus are appearing more regularly in the traditional academic journals, such as Science, Nature, and the ecological journals noted above. Moreover, the Ecological Society of America has initiated the on-line journal Conservation Ecology. Practitioners and academics are beginning to talk more often with each other. Although much of the leadership in wildlife biology (for example, Teer 1988 and some recent presidents of The Wildlife Society) has been hostile to conservation biology, an increasing number of wildlife biologists consider themselves conservation biologists, and vice versa. An increasing number of papers published in wildlife journals are essentially conservation biology papers (see, for example, Beissenger and Westphal 1998, Mladenoff and Sickley 1998, Meyer et al. 1998).

Conservation biology tomorrow

Whether the permeation of conservation-biological thinking and values into other sciences will eventually make conservation biology unnecessary as a distinct science is uncertain. I suggest, however, that a need for a robust, integrative field of conservation science will exist for a long time to come. In response to the questions posed at the beginning of this essay, I conclude that conservation biology over the last two decades has made many new and "special" contributions, both to science and to conservation. I predict that conservation biology will continue to make positive contributions, but will gradually become less distinct as its theories and techniques are incorporated into other disciplines.

Continued speculation about how distinct conservation biology is from other fields is counterproductive. Instead, we should identify areas where conservation biology has not fulfilled its promise and where further progress is urgently needed. These needs include: 1) more broadly and rigorously trained professionals inside and outside academia; 2) more emphasis on gathering the basic field data necessary to construct and validate models; 3) compelling applications of conservation biology "on the ground" in land management; and 4) increased influence in the policy arena.

A further need is to expand the international scope of conservation biology. I have written this commentary from a distinctly American perspective, with an emphasis on historical events and trends in North America. This ethnocentrism is defensible, in part, because conservation biology, as it is known today, developed initially in the United States, and the leading professional society and journal are centered here. On the other hand, other nations and regions are well ahead of Americans in several areas of this science. For example, the strong natural history tradition of northern Europe, especially in Fennoscandia and Britain, has allowed biodiversity considerations to contribute meaningfully to forestry, environmental monitoring, and land-use decisions generally. The natural history tradition is much weaker in North America, with the result that much of our conservation theorizing, modeling, and planning is going on in a vacuum. (The weakening continues with the loss of the "ologies," now viewed as old-fashioned, from university curricula). The Australians are leaders in several areas of conservation biology, particularly in the development of efficient, practical methods of selecting and designing networks of nature reserves, but also in several areas of population genetics and PVA.

Increasing international scope and membership is a major objective of SCB. In 1997 83% of the membership was in the United States. The content of the journal is less biased, however. Only 61% of the first authors in 1997 were from the United States, and the trend over the last few years has been increasing representation of international authors. Ultimately, the profession of conservation biology will fulfill its challenge only when the global community of decision-makers looks to it regularly for advice on key issues regarding land-use and environmental policy. That day does not, at present, appear close at hand, but the growing influence of conservation biology will bring it closer.

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