Conservation Biology

By: Leah Gerber (*Department of Ecology, Evolution, and Environmental Science, Arizona State University*)

Citation: Gerber, L. (2010) Conservation Biology. *Nature Education Knowledge* 3(10):14

What is conservation biology? Conservation biology is a multidisciplinary science that has developed to address the loss of biological diversity.

What is Conservation Biology?

Conservation biology, said to be a "mission-oriented crisis discipline" (Soulé 1986), is a multidisciplinary science that has developed to address the loss of biological diversity. Conservation biology has two central goals: 1. to evaluate human impacts on biological diversity and 2. to develop practical approaches to prevent the extinction of species (Soulé 1986, Wilson 1992). The field seeks to integrate conservation policy with theories from the fields of ecology, demography, taxonomy, and genetics. The principles underlying each of these disciplines have direct implications for the management of species and ecosystems, captive breeding and reintroduction, genetic analyses, and habitat restoration.

The concept of conservation biology was introduced by Dasmann (1968) and Ehrenfeld (1970). Soulé & Wilcox's (1980) contribution, *Conservation Biology: An Evolutionary Ecological Perspective*, served as an impetus for the development of the discipline. Over the next six years, many scientists began to refer to themselves as conservation biologists. *Conservation Biology: The Science of Scarcity and Diversity* was published, a Society for Conservation Biology formed, and a journal was established (Soulé 1986).

Several factors contributed to the development of the field. Scientists began to realize that virtually all natural systems have been damaged by what Diamond (1986) referred to as the "Evil Quartet": habitat loss and fragmentation, overharvesting, introduced predators and competitors, and the indirect effects of these threats on ecological interactions. None of the traditional applied disciplines, such as wildlife management, agriculture, forestry and fisheries, were comprehensive enough by themselves to address critical threats to biological diversity (Primrack 1993). Also, these traditional applied disciplines often overlooked threatened species that were of little economic or aesthetic value. Theories and field studies in community ecology, island biogeography, and population ecology were subjects of major investigation and development in the 1960s and 1970s, and while these disciplines have direct relevance to conservation, they traditionally emphasized the study of species in their natural environments, in the absence of human activity. The growing separation of "applied" and "basic" disciplines prohibited the exchange of new ideas and information between various academic assemblages and to management circles (Soulé 1980).

Conservation biology as a discipline aims to provide answers to specific questions that can be applied to management decisions. The main goal is to establish workable methods for preserving species and their biological communities. Specific methods have been developed for determining the best strategies for protecting threatened species, designing nature reserves, initiating breeding programs to maintain genetic variability in small populations, and reconciling conservation concerns with the needs of local people (Primrack 1993). For this to be successful, communication among all sectors of the conservation community is necessary.

The interface between theory and practice in conservation biology, especially from the point of view of resource managers, has been somewhat neglected (Soulé 1986). Because we do not understand community and ecosystem structure and function well enough to make reliable predictions, uncertainty has inhibited scientists from providing concrete answers to managers. The availability of statistical and computational tools has been integral in the development of analytical methods critical to addressing the issue of uncertainty in conservation biology. Management tools such as population viability analysis (PVA), Bayesian statistics, and decision analysis have been developed to provide "objective" methods for making conservation decisions. These approaches have been key in the transformation of conservation biology from an idea to a discipline.

Statistical and Computational Tools Used in Conservation Biology

Population Viability Analysis (PVA)

PVA is a process used to evaluate the likelihood that a population will persist for some particular time in a particular environment.

Gilpin and Soulé (1986) conceived of *population vulnerability analysis* as an integrative approach to evaluate the full range of forces impinging on populations and to make determinations about viability. PVAs have become a cornerstone of conservation biology, and it is likely that their importance will increase in the future. The precise role of PVA in conservation biology is still emerging.

Minimum Viable Population: What's the Magic Number?

In the 1970s, empirical studies and ecological and genetic theory converged on the idea that a species becomes exceptionally vulnerable to extinction when it includes only a few small populations (MacArthur & Wilson 1967, Richter-Dyn & Goel 1972, Leigh 1975). The observation that once a population was reduced below a certain threshold, it began to dwindle toward extinction led to the concept of minimum viable population size (MVP), the smallest number of individuals necessary to prevent a population from going extinct. The concept of MVP officially emerged in response to an injunction from the United States Congress to the US Forest Service to maintain "viable populations" of all native vertebrate species in National Forests (National Forest Management Act of 1976, 16 USC 1600-1614; Gilpin & Soulé 1986). The concept encompasses theories that had been developed and tested to varying degrees in the fields of population genetics and demography. The critical feature of MVP is that it allows a quantitative "rule of thumb" estimate of minimum population size to be made.

MVP remains a tenuous concept among conservation biologists. In light of the complex and dynamic nature of single species population dynamics, conservation biologists have frowned upon the "magic number" concept. They argue that the job of conservation biologists should be to recommend or provide more than just the minimum number necessary for a species' persistence (Soulé 1987). Yet the term has not been abandoned and actually remains a central theme in conservation biology. As human population growth continues to encroach upon the habitat of endangered and threatened species, the MVP concept is likely to become a critical tool for conservation biologists to assure the continued existence of species.

Decision Analysis and Multiple-Criteria Approaches

Decision analysis, which was developed for guiding business decisions under uncertainty, has been proposed as a useful tool for endangered species management (Raiffa 1968, Behn & Vaupel 1982, Maguire 1986). Statistical approaches make explicit the logic by which a decision is reached under conditions of uncertainty. Mace & Lande (1991) and the International Union for Conservation of Nature (IUCN) have attempted to apply decision analysis theory to put the MVP and PVA concepts into practice for determining a species' status on the Red List of threatened and endangered wildlife.

Broad Speculation on the Future of Conservation Biology

Conservation biology has become a burgeoning discipline since it originated in the early 1980s. Theories from the fields of island biogeography, genetics, demography, and population ecology have been broadly applied to the design and management of reserves, captive breeding programs, and the classification of endangered species. Since 1980 we have witnessed the rapid expansion of a professional society and the emergence of active graduate programs.

Nonetheless, the course of development of the discipline has not altogether been smooth sailing; lack of adequate funding remains a critical problem. The financial and institutional supports for conservation biology, in both its research and educational roles, need to be strengthened (Soulé 1986). Furthermore, while some advances have been made in the realm of interdisciplinary cooperation and communication between scientists and managers, significant progress is necessary before the original goals of conservation biology can be met.

The caveats with various analytical methods necessitate further research in order to reach their full potential as predictors of extinction. It has become clear that PVA is not currently a viable method for predicting the precise time to extinction for a species. Further, requiring quantitative data for conservation decisions may unduly place the burden of proof on scientists in a manner detrimental to the species of concern. PVA is useful, however, for comparing the relative extinction risks among species and populations, and for prioritizing research and management actions.

Similarly, the MVP concept has thus far been limited in its potential for application to conservation decisions. Because lack of genetic variability does not generally pose extinction risks for large populations, the concept is only relevant to small populations. However, even for small populations, a temporary reduction below any MVP does not necessarily imply a high probability of extinction. Consensus among conservation biologists about the selection of appropriate assumptions for estimating effective population size and about the timeframe under which we are concerned about extinction, offers potential for the use of MVP as a tool in conservation biology.

Because conservation decisions are often confounded by uncertainty, decision analysis appears to be a particularly useful method for conservation biologists. The IUCN classification scheme offers a risk-averse approach to species classification in its use of multiple criteria, wherein data would typically be available to evaluate at least one of the criteria. However, additional analyses are necessary to develop and refine analytical tools suggested by the IUCN as status determination criteria.

Source: https://www.nature.com/scitable/knowledge/library/conservation-biology-16089256

Until these issues are resolved, the status of conservation biology as a predictive science will remain in serious doubt (Soulé 1986). Given the imperfect nature of the analytical tools integral to the field of conservation biology, the apparent gap between theory and practice, and the continued loss of biodiversity, what is the future for conservation biology? The models of today may undoubtedly become the "broken stick models . . . and other strange and wonderful debris" that Soulé (1987) envisions as littering the field of mathematical population biology. Nonetheless, population models will continue to evolve as critical tools to conservation biologists.

The gap between theory and practice is narrowing as a function of the prominence of conservation biology as a field of study. Because the field is interdisciplinary, it necessarily unites basic and applied scientists with natural resource managers. Scientists will continue to work with policy makers in developing appropriate and workable approaches to species conservation.

A central theme in conservation biology is developing compromises between conservation priorities and human needs. However, the precise role of conservation biologists as advocates has yet to be formalized. Soulé himself disobliges scientists from taking on an advocacy role: "Most biologists and most economists are not trained to be advocates. They're trained to think and teach, to encourage students and support and advance their disciplines. So to expect that most scientists will turn themselves into effective community activists, politicians, or managers is unfair and unrealistic."

Instead, the role of the conservation biologist remains simply to advocate for good science and to make salient findings available to managers and scientists in other fields. Advocating "values" under the auspices of doing science undermines the objectivity of science. The distinction between advocacy and science should be clear for conservation biology to persist as a legitimate discipline.

Finally, the dichotomy referred to by Caughley (1994) as the "small population paradigm," which needs more empirical evidence, and the "declining population paradigm," which needs more theoretical development, has generated substantial debate among conservation biologists about where the field is going. Caugley pointed out that many of the theoretical underpinnings of conservation biology are misguided in that they treat an effect, such as small population size, as if it were a cause. He suggested that conservation efforts should instead be focused on determining causes of population declines and the means by which agents of a decline can be identified (Caughley 1994). This idea has reoriented many theoreticians to consider the broader scope of their work and has encouraged field biologists to more closely align their research to conservation-related questions. Thus, the stage has been set for the future development of both the theoretical constructs and the natural history investigations critical to the persistence of conservation biology as a scientific discipline.

Source: https://www.nature.com/scitable/knowledge/library/conservation-biology-16089256

References and Recommended Reading

Caughley, G. Directions in conservation biology. *Journal of Animal Ecology* **63**, 215–244 (1994).
Dashman, R. F. *Environmental Conservation*. New York, NY: John Wiley and Sons, 1968.
Ehrenfeld, D. W. *Biological Conservation*. New York, NY: Holt, Rinehart, and Winston, 1970.
Gilpin, M. E. & Soulé, M. E. "Minimum viable populations: Processes of species extinction." In *Conservation Biology: The Science of Scarcity and Diversity*, ed. M. E. Soulé (Sunderland: Sinauer & Associates, 1986): 19–34.
Ginzburg, L. R. *et al*. Quasiextinction probabilities as a measure of impact on population growth. *Risk Analysis* **2**, 171–181 (1982).
Leigh, E. G. "Population fluctuations and community structure." In *Ecology and Evolution of Communities*, eds. J. M. Diamond & M. L. Cody (Cambridge, MA: Harvard University Press, 1975): 51–73.
MacArthur, R. H. & Wilson, E. O. *The Theory of Island Biogeography*. Princeton, NJ: Princeton University Press, 1967.
Mace, G. M. & Lande, R. Assessing extinction threats: Toward a reevaluation of IUCN threatened species categories. *Conservation Biology* **5**, 148–157 (1991).
Primack, R. B. *Essentials of Conservation Biology*. Sunderland, MA: Sinauer & Associates, 1993.
Richter-Dyn, N. & Goel, N. S. On the extinction of a colonizing species. *Theoretical Population Biology* **3**, 406–433 (1972).
Soulé, M. E. "Thresholds for survival: Maintaining fitness and evolutionary potential." In *Conservation Biology: An Evolutionary-Ecological Perspective*, eds. M. E. Soulé & B. A. Wilcox (Sunderland: Sinauer & Associates, 1980) 151–169.
Soulé, M. E. *Conservation Biology: The Science of Scarcity and Diversity*. Sunderland, MA: Sinauer & Associates, 1996.
Wilson, E. O. *The Diversity of Life*. Cambridge, MA: The Belknap Press of Harvard University Press, 1992.

Source: https://www.nature.com/scitable/knowledge/library/conservation-biology-16089256