Part I

The integration of two disciplines: conservation and behavioral ecology

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Introduction: the whys and the hows of conservation behavior

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Our planet is changing at a startling pace. The rate of species extinction is alarmingly high (Barnosky *et al*. 2011) and unique ecosystems such as coral reefs and tropical forests are rapidly diminishing and disappearing. It is very clear that the only way to prevent, or at least slow down, this mass extinction, is by direct action. The science of conservation biology stands before the ongoing environmental crisis, offering some hope that through the implementation of our accumulating interdisciplinary scientific knowledge we can prevent, and even reverse, the decline of the diversity of life on Earth.

The behavior of an organism is, in a sense, the mediator between the organism and its environment and provides flexibility so the organisms can maintain a adequate fitness over a wider range of environmental conditions. This, of course, has limits, and under extreme changes the organism's behavior will fail to provide a sufficient buffer from the changing environment. Knowledge of a species' behavioral attributes provides, therefore, important insights into how anthropogenic actions (direct or indirect) will impact the species, and what actions can be taken to minimize this impact.

In this chapter we will start by giving a brief general overview of conservation biology's interdisciplinary foundations. Many excellent volumes have been dedicated to this field (e.g. Groom *et al*. 2006, Primack 2006, Hunter & Gibbs 2007), and they give a far more comprehensive picture of the history, practice and many challenges of conservation biology. However, we hope we provide enough background in the first part of this chapter to make our readers better understand the goals of conservation, and to have these goals stay in their minds, as they continue reading about the more specific aspects of using behavior in conservation. Before considering the

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role of behavior in conservation, we will first consider the roots of behavioral ecology, and then discuss the short history of conservation behavior – a field dedicated to the use of the knowledge of animal behavior in conservation biology. To conclude this introductory chapter, we will outline the principles of the conservation behavior framework that serves as the basis for the structure of this book.

Conservation biology has three objectives: (1) Documenting the extant biological diversity on Earth. (2) Locating, defining and investigating anthropogenic threats to biodiversity. (3) Developing and implementing practical approaches to reducing or eliminating these threats (Groom *et al.* 2006, Primack 2006). To achieve these objectives successfully, conservation biologists must understand the ultimate goals for protecting nature. Namely: What do we wish to conserve? Why do we wish to conserve it? And, how can we actually do it?

1.1 WHAT TO CONSERVE?

The answer is seemingly self-evident. We aim to conserve nature. But what is nature? A popular response would be – that which is not made or influenced by humans. However, humans are an important part of most ecosystems, and they have played a significant part in the shaping of these ecosystems, with many species evolving or co-evolving with humans. More than 83% of the Earth's land surface is directly influenced by anthropogenic activity (Sanderson *et al.* 2002), and it is logical to assume that much of the remaining 17% "pristine" landscape is indirectly influenced by humans through global processes such as climate change and pollution. Nevertheless, despite this fact, most of us have an inherent notion as to what nature is, and we could easily say that Yellowstone National Park is much more "natural" than downtown Los Angeles, for example. Therefore, we do not define nature by whether or not it is influenced by human activities, but rather by what is the magnitude of this influence. The less an area is *disturbed* by humans, the more natural it is.

For many years ecologists believed that nature is at a stable equilibrium and ecological systems can reach a stable steady state. According to this view, in order to conserve ecological systems, all we have to do is return the system to its steady state and protect it from further disturbances. However, we know now that nature is dynamic and constantly changing (Pickett *et al.* 1992), and that ultimately, the process that governs these changes across species, communities and ecosystems is evolution by natural selection (see Chapter 2 for a short review of evolutionary processes). Theodosius Dobzhansky's famous saying: "Nothing in biology makes sense except in the light of evolution" applies to conservation biology as well. Evolution is the basic axiom of biology and therefore we need to approach the question of what to conserve from an evolutionary point of view (Groom *et al.* 2006). This may be best understood through what is known as "Hutchinson's metaphor" that depicts nature as a performing art, namely "The ecological theater and the evolutionary play" (Hutchinson 1965). Human disturbances alter the course of the play by changing the evolutionary trajectory of many species, and in some cases, by stopping evolutionary processes altogether. Conservation biology aims to preserve the one process that keeps the play running and that is at the foundation of nature – evolution. More specifically, the aim of conservation is to prevent or minimize the foreclosure of evolutionary opportunities (Ehrlich 2001) as these opportunities provide the ecological systems (the theater) with the plasticity necessary to respond to unforeseen future changes.

1.2 WHY CONSERVE?

Ever since humans began to make use of nature's resources, altering their environment in the process, different philosophical and religious beliefs regarding the relationships between human societies and nature arose (Primack 2006). While there are many different reasons for conserving nature, they can roughly be divided into two main approaches:

(1) The intrinsic approach: According to this approach every organism has intrinsic value, and therefore a right to exist. This approach can be expanded to include the intrinsic value of ecosystems, evolutionary principles and nature in general (Rolston 1988). Since the current biodiversity crisis is the direct result of anthropogenic activity, nature conservation, in this context, is our ethical obligation.

(2) The utilitarian approach: Nature provides humans with irreplaceable and vital services (for example: carbon sequestration, nutrient cycling, water purification, crop pollination and many more). The monetary value assigned to these services has been estimated to be between 16 to 54 trillion US$ per year (Costanza *et al.* 1997). Thus, according to this approach, we conserve nature in order to continue and benefit from the various services it

provides. This approach also includes biomes and species that provide no known direct services to humans, both because they can interact with biomes and species that do provide services, and because they might provide important services in the future that we are yet to discover (e.g. industrial and medicinal plants in the rainforests of Madagascar [Rasoanaivo 1990]). The only ethical issue involved in this approach is the obligation of the human population to its future generations (Norton 2003), so the key focus is not a specific organism or ecosystem, but rather the sustainable use derived from them.

While nature conservation has been practiced in one form or another all over the world, in many ways the roots of modern conservation biology stem from the three main conservation philosophies that arose in North America in the late nineteenth to mid twentieth century (Callicott 1990).

(1) The romantic transcendental conservation ethic was derived from the writings of three prominent figures: Ralph Waldo Emerson, who in 1836 referred to nature as a temple in which people can achieve spiritual enlightenment; Henry David Thoreau, who believed that in wilderness lies the preservation of the world (Thoreau 1863); and John Muir, who advocated that natural areas have spiritual values that are superior to the material gain provided by their exploitation (Muir 1901). Thus, this philosophy represents an intrinsic and spiritual approach to nature, giving it a value in and of itself, apart from its value to humanity.
(2) The resource conservation ethic was preached by Gifford Pinchot, the first head of the US Forest Service, at the turn of the twentieth century. According to this utilitarian philosophy, nature is a collection of natural resources that are either: useful, useless or noxious to people. Useful resources should be conserved in a way that will ensure their sustainable use over time, while noxious resources should be removed (Pinchot 1947).
(3) The evolutionary land ethic was developed by Aldo Leopold in the mid twentieth century. This philosophy grew from Pinchot's resource conservation ethic, but with a realization of its scientific contradictions and inaccuracies. Leopold claimed that nature is not just a collection of individual resources but rather a complicated and integrated system of interdepended processes and components that function together like a fine Swiss watch (Leopold 1949).

Hence, we should strive to conserve even parts of nature that may seem unimportant to our eyes, since they may be vital to the long-term health of the system. According to this philosophy, the most important goal of conservation is to maintain the health of ecosystems and natural processes. Unlike Pinchot's anthropocentric approach that puts humans in the center of the natural world exploiting it for its purposes, the evolutionary land ethic is an ecocentric approach, considering humans as an integral part of the ecological community. It is Leopold's evolutionary land ethic that provides the philosophical foundation for modern conservation biology. However, whether this is a utilitarian, pragmatic approach to conservation where the only ethical consideration is our obligation to our children (Norton 2003, Minteer 2012) or whether it is founded on a belief in the intrinsic value of nature (Callicott 1999) is still being debated (Callicott *et al.* 2011). While most of Aldo Leopold's writings advocate the land ethic in a manner reflecting concern for the future existence of mankind, it is also clear that he considered nature and its components as having an intrinsic value (e.g. his description of a dying wolf in "Thinking Like a Mountain": *"We reached the old wolf in time to watch a fierce green fire dying in her eyes. I realized then, and have known ever since, that there was something new to me in those eyes – something known only to her and to the mountain. I was young then, and full of trigger-itch; I thought that because fewer wolves meant more deer, that no wolves would mean hunters' paradise. But after seeing the green fire die, I sensed that neither the wolf nor the mountain agreed with such a view,"* Sand County Almanac 1949). Thus, both the pragmatic school of thought focusing on the future well-being of mankind, and the intrinsic-value school of thought valuing nature for itself are valid approaches and, in fact, complement each other such that their joint consideration provides the optimal approach to support decision-making in conservation biology.

1.3 HOW TO CONSERVE?

In the second half of the twentieth century, with the acceleration of the biodiversity crisis and with ecosystems and species disappearing at an alarming rate throughout the world, it was becoming clear that there is a pressing need for an interdisciplinary approach that will bring together the growing number of people of different backgrounds and disciplines that were thinking and conducting research on conservation issues. In addition, the biodiversity crisis led to a series of legislations and agreements in the US and around the world (such as the US Endangered Species Act (ESA) in 1973 or the Convention on International Trade in Endangered Species of wild fauna and flora [CITES] in 1975), which increased the need for rigorous scientific input into conservation decision-making (Meine 2010). The first international conference on conservation biology was organized by Michael Soule and held in 1978 at the San Diego Wild Animal Park. Soon after the meeting, Soule and colleagues such as Paul Ehrlich and Jared Diamond began developing conservation biology as a discipline combining the practical experience of wildlife, forestry and fisheries management with the theoretical knowledge of population biology and biogeography (Primack 2006). A few years later Michael Soule wrote: "disciplines are not logical constructs; they are social crystallizations which occur when a group of people agree that association and discourse serve their interests. Conservation biology began when a critical mass of people agreed that they were conservation biologists" (Soule 1986).

Groom *et al.* (2006) define three guiding principles that are at the core of the science of conservation biology: The first principle states that *evolution* is the basic axiom that unites all of biology. Thus, conservation biology does not aim to stop evolutionary change and keep the status quo, but rather to conserve the ongoing evolutionary processes in order to ensure that populations may continue to respond to environmental change in an adaptive manner. The second principle states that the ecological world is *dynamic* and largely nonequilibrial. Therefore, we do not try to restore systems to some point of equilibrium, but rather to understand and preserve the nonequilibrial processes that maintain communities and ecosystems. The third principle is that *human* presence must be considered and included in conservation planning. Whether we like it or not, humans are an integral part of the ecological systems of our planet, and therefore any conservation attempt that does not take humans into consideration is doomed to fail.

We have established that we aim to conserve evolutionary and ecological processes. However, how can we preserve and protect something as intangible as evolution? The answer is biodiversity. It is this diversity that generates the evolutionary opportunities (Ehrlich 2001) and allows systems and organisms to change and adapt in response to a changing world. By preserving and protecting biodiversity, we are conserving the evolutionary process. There is a strong paradigm underlining this assumption: the loss of diversity reduces the ability of the system, and the populations and individuals it is comprised of, to respond to a change in the environment.

1.4 WHAT IS BIODIVERSITY?

The term "biological diversity" (or simply "biodiversity") has received many different definitions and interpretations, and although they are all variants of the same basic theme, the difference in content can have significant implications for determining conservation policy and action (Faith 2008). Gaston (1998) gives a detailed account of the different definitions for biodiversity and their consequences. For our purposes, we use the 1992 Convention on Biological Diversity definition, which is widely accepted among conservation biologists: "'Biological diversity' means the variability among living organisms from all sources including, *inter alia*, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems" (Johnson 1993).

According to this definition, biodiversity must be considered on three hierarchical levels: genetic diversity, species diversity and ecosystem diversity. These levels of biodiversity are nested, i.e. higher levels enclose lower levels (Noss 1990). When an ecosystem is destroyed, all species within it are also destroyed, and with them all the genes that were stored in the DNA of all these species. A comprehensive approach to biodiversity must address the multiple levels of biodiversity on different spatial and temporal scales (Noss 1990).

1.4.1 Genetic diversity

Genetic diversity is the ultimate source of biodiversity at all levels. Without genetic variability there can be no selection, and therefore no evolutionary process. Low genetic variability decreases the ability of populations to adapt to environmental changes and increases their susceptibility to diseases. This, in turn, impacts the ability of the ecosystems that the species are a part of to respond to changes.

We can consider three levels of genetic diversity within a species: (1) Between populations of the same species – different populations can differ genetically because of different selection pressures, genetic drift and founder effect. Remote or isolated populations are of special importance to conservation, as their genetic composition may be unique, paving the way for the emergence of new species. (2) Within populations – different individuals within a given population differ from each other genetically.

A genetically diverse population will be more adaptable to changes and diseases than a genetically homogenous population. (3) Within individuals – since the genetic code is composed of pairs of alleles sampled from a population of one or more alleles, an individual can be homozygote or heterozygote in each allele, i.e., some individuals are more genetically diverse than others.

1.4.2 Species diversity

Species diversity includes all species found on our planet. It is what most people think of when they hear the term "biodiversity," and is the primary subject of the majority of conservation laws (such as ESA and CITES mentioned above). Most people understand the concept of species and of species diversity and best relate to such a tangible idea. Thus, species diversity is conceptually, legally and also practically the most considered and established form of biodiversity, and indeed natural scientists and conservation biologists have been focusing for many years on categorizing and studying different species.

Many conservation biologists measure species diversity by simply counting the number of different species within a community, a measure called species richness. This is a powerful and easy method to assess species diversity; however, it gives all species the same relative weight, regardless of how abundant they are. Other methods have been developed to include the relative frequencies of species within a community. Regardless, one of the more common methods of measuring species diversity is by separating it into geographical components (Whittaker 1960). Alpha diversity refers to local species diversity within one patch or habitat. Gamma diversity refers to regional species diversity – the diversity of species in a large collection of sites that make up a whole region of interest. Beta diversity links between the local and regional scales. It represents the rate of change in composition among sites within a region, and can be calculated as the gamma diversity for a region divided by the average alpha diversity for the sites in the region.

An important aspect of species diversity is biodisparity (Jablonski 1994), which is the range of morphologies or other attributes within a clade (a phylogenetic "branch"). If we aim to maximize the evolutionary potential of living organisms in nature, biodisparity can sometimes provide a better tool for setting conservation priorities than biodiversity (Jablonski 1995, Myers 1996), since some species display traits that are unique to their clade compared to other species whose traits are common (e.g. many of the traits of a panda are unique in nature compared for example to the traits of many fly species).