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Excerpt
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1 Introduction

1.1 What Plant Conservation Is About and Why Biodiversity Should Be Conserved

Defining plant conservation as a discipline is simple. It is part of an applied science called conservation biology, specifically focusing on plants. Thus, the majority of theoretical developments of conservation biology apply to plant conservation and are utilized in it.

Conservation biology, in turn, is a young, multidisciplinary science, which provides the principles and tools to deal with the crisis confronting biological diversity, and which is fundamentally different from other branches of science in several aspects (Soulé 1985). One is that, because of its concern with imminent threat and extinction, it is under severe time constraints and in constant need of actions. The second is its holistic nature, making it a synthesis of a variety of other disciplines, namely population and community ecology, population genetics, biogeography, landscape ecology, environmental management, and economics. Another important aspect of conservation biology, at least until recently, was its moral obligation, i.e., the implicit assumption that it is morally wrong for our species to drive other species to extinction. This aspect, however, is now challenged by those who call themselves "new conservation biologists" (Kareiva and Marvier 2007, 2012; Daily *et al.* 2009; Marvier and Kareiva 2014) and neo-Marxist social scientists (Fletcher 2010; Büscher and Dressler 2012; Büscher *et al.* 2017), who share the view that biotic diversity does not have an intrinsic value independent of providing humans with goods and services. Apologists for these movements, which according to Büscher *et al.* (2017) "are more democratic, equitable and humane" than traditional conservationists, adopt the position that nonhumans can be morally relevant only to the extent that they affect human well-being, and the latter must be given priority in any conservation efforts. This issue is discussed further in Section 1.3, but a few points must be made clear. Virtually every text on the socioeconomic aspects of nature conservation repeats a common mantra that land acquisition for conservation means missed economic opportunities for a society. A truth, however, is that under rapid and accelerating human population growth the "economy first" or "feeding poor first" principles will inevitably result in: (1) every patch of land eventually undergoing one or another form of anthropogenic transformation that will be extremely difficult or impossible to reverse; (2) many fragile ecosystems becoming bare lands useless for any human activity; and (3) a mass extinction of animals and plants. Is this what we want?

Another line of reasoning for rejecting the priority of the "economy first" principle in decision-making regarding biodiversity is provided by Kormos and Zimmerman (2014). Analyzing existing practices of commercial logging, the authors came to the conclusion that "industrial logging of tropical hardwoods from natural forests is biologically unsustainable under virtually any scenario that approximates financial viability" and therefore "logging in these forests will end in the not-too-distant future." Their following rhetoric question is "Sooner or later protection will be necessary to prevent conversion: why not keep tropical forests intact, a much easier task when there are few or no roads (Laurance *et al.* 2009), rather than seeking to protect them after they have been degraded?"

Instead of sacrificing wilderness and biodiversity to economic requirements, we need to deal with and solve the root cause of the conservation crises: a growth in human population and per capita consumption, a trend that shows no signs of slowing down (Barnosky *et al.* 2017).

1.2 THE OLD CONCEPT

The emergence of the discipline of conservation biology is demarcated by the publication of the book *Conservation Biology: An Evolutionary-Ecological Perspective* in 1980 (Soulé and Wilcox 1980). The papers in this book, which employ the principles of the theory of island biogeography and population biology, explicitly address issues of the "decay of biological diversity" and "the rampant pace of habitat destruction."

A detailed overview of the history of conservation biology is beyond the scope of this book. However, it is important to mention the major steps in the development of the discipline. The first is the island biogeography theory (MacArthur and Wilson 1967), which established a causal link between the size of the area, distance from the source of propagules, and species richness, a central principle for explaining the effects of habitat fragmentation. The second, coined by Jared Diamond, known as the SLOSS dilemma (single large or several small) laid the foundations for the planning of protected areas. Large reserves are better than small ones; reserves closer together are better than those far apart; reserves grouped and linked together are better than those that are separated and arranged in a straight line; and round reserves are better than elongated reserves (Diamond 1975).

Subsequent contributions were made by population biologists investigating demographic and genetic processes in populations. Mark Shaffer coined the concept of minimum viable population (MVP), the minimum size of a population to survive, with a specified probability and a specified number of generations (Shaffer 1981). He was also the first to define four types of stochastic causes that can drive small populations to extinction: environmental, demographic, and genetic stochasticity, and natural catastrophes. Similarly, Ian Franklin analyzed the minimum size of a population to avoid negative effects of inbreeding depression and genetic drift, and derived what is known as "Rule 50/500": 50 individuals are required to avoid inbreeding and 500 individuals to guarantee adaptability (Franklin 1980).

This research direction of investigating processes that take place in small populations was dubbed the "small population paradigm" by Caughley (1994). Because this paradigm concerns population smallness and because it is based on the biological characteristics of populations, it can give robust predictions. The small population paradigm dominated the conservation literature of the 1980s (Frankel and Soulé 1981; Schonewald-Cox *et al.* 1983; Soulé 1986, 1987). Despite its strengths (well-established theoretical grounds, ease of computer simulations, and relative ease of experimentation), this paradigm turned out to be less useful in real conservation settings (Caughley 1994). The "declining population paradigm," according to Caughley (1994), in contrast to the "small population paradigm," focuses on detecting population declines and their external causes. This paradigm does not have such a strong theoretical basis as the small population paradigm, but is more applicable in many situations. The 1990s witnessed rapid development of this paradigm into a subdiscipline of conservation biology called population viability analysis (PVA). Later, it became evident that the small population paradigm and the declining population paradigm, summarized in Table 1.1, can tackle the same problem in complementary ways (Beissinger 2002), and both are incorporated in modern PVA (Boyce 2002). Although less numerous than we would expect, there are quite a few examples of how PVA enabled estimation of MVP and identified optimal population and habitat management strategies to sustain it (e.g., Drechsler *et al.* 1999; Oostermeijer 2000; Hunt 2001; Quintana-Ascencio *et al.* 2003; Volis *et al.* 2005; Maschinski *et al.* 2006). A review of the use of PVA in recovery planning for plant species listed under the US Endangered Species Act revealed 223 publications describing 280 PVAs for 246 species (Zeigler *et al.* 2013).

Other important theoretical developments that greatly contributed to the evolution of conservation biology into a truly applied science include metapopulation theory (Gilpin and Hanski 1991; Gotelli 1991; Hanski and Simberloff 1997), ecological niche modeling (Stockwell and Peters 1999; Hirzel *et al.* 2002; Phillips

Table 1.1 *Comparison of the proposed concept (habitat restoration paradigm) with the two existing conservation paradigms*

	Small population paradigm	Declining population paradigm	Habitat restoration paradigm
Major concern	Small population size	Population decline	Degradation of a habitat
Focus	Within-population processes	Identification of external threats to a population	Causes and effects of habitat degradation
Solutions	Protection and population management	Protection and removal of a threat by a population or habitat management	Restoration of a degraded habitat
Emphasized actions	Actions increasing within-population genetic variation and population growth, population augmentation	Optimal disturbance regime management, pest, disease, and invasive species control, reintroduction, and augmentation	Appropriate species choice in restoration plantings, addressing plant–animal interactions, assisted migration

et al. 2006), and the development of algorithms for reserve selection (Kirkpatrick 1983; Margules *et al.* 1988; Nicholls and Margules 1993).

As a result of the development of conservation biology in the last 50 years, we have seen impressive achievements in understanding processes that occur in intact versus human-affected habitats and populations, and an explosion in the variety of conservation tools.

At the same time, there have been vast investments during this period in nature conservation both financially and in terms of the extent of protected areas. For example, the total budgets of the Worldwide Fund for Nature were over US$350 million in 2001, the Nature Conservancy were over US$300 million in 2002, and Conservation International were US$92 million in 2004 (Robinson 2006). The protected areas, according to the 2014 United Nations List of Protected Areas, cover approximately 15.4% of the Earth's terrestrial surface. However, it is now clear that mere designation of protected areas, which has been the primary approach to conserving biodiversity, will fail to protect biodiversity (e.g., Brashares *et al.* 2001; Tang *et al.* 2010; Gardner 2011; Clark *et al.* 2013; Leisher *et al.* 2013). It is also clear that there is a weak link between theoretical developments in conservation biology and implementation of this knowledge in real-world situations. The reason is that conservation biology research conducted over the last 50 years has provided us with quite a good understanding of how natural ecosystems operate under either no or minimal to moderate human impact. But human population growth and expansion are so quick, and their effects on nature so devastating, that existing conservation practices have become ineffective and obsolete. With respect to the conservation of plants, what are these conservation practices? Briefly they include:

1. assessments of biodiversity summarized in the International Union for Conservation of Nature (IUCN) species categorization and lists of threatened species;
2. global and regional prioritization of species, habitats, and areas for conservation;
3. establishment of protected areas preserving natural habitats and species that are under risk of extinction;
4. no intervention in strictly protected areas; minor interventions in less strictly protected areas usually limited to control of invasive species and prescribed burning;
5. preservation of threatened species in *ex situ* seed banks and botanic garden living collections with minimal coordination between *ex situ* and *in situ* actions;

6. reinforcement or reintroduction of endangered species usually conducted at single or very few locations;
7. focus on conservation plans for single species rather than on groups of species or species assemblages.

The realization that the existing methods do not work and cannot put a halt to the rapid disappearance of nature requires new conceptual thinking in conservation and a search for novel approaches. In my view, the theoretical tools to address new challenges already exist. What is needed is to use them in a new way, adapted to the modern-day reality of the Anthropocene.

1.3 NEW CHALLENGES AND TWO ALTERNATIVE SOLUTIONS

Although some anthropogenic disturbances may have no, little, or even positive impacts on natural ecosystems, the vast majority are negative or extremely negative (Figure 1.1). Among the main threats to biodiversity (habitat loss, overexploitation, spread of exotic species, environmental change), habitat loss and associated fragmentation are the most serious ones. Rates of landscape modification and habitat fragmentation became so dramatic in the twenty-first century that few, if any, ecosystems remain untouched by the impact of human activity. Loss of natural habitat reached such critical levels (Figure 1.2) that we will never know how many species we have driven to extinction even before they have been described. The combined effects of invasions, altered disturbance regimes, changing climate, species loss, and ecosystem degradation has, at times, exceeded the ability of ecosystems to maintain their structure and function. While the ecosystem effects of individual drivers can usually be predicted, their combinations introduce a lot of uncertainty and complexity. Not surprisingly, historically authentic, coevolved biotic assemblages rapidly disappear, being replaced by new combinations of species living under environmental conditions that have no historical analogs.

Witnessing rapid loss of biodiversity, despite all the conservation efforts, and realizing that all the above anthropogenic effects

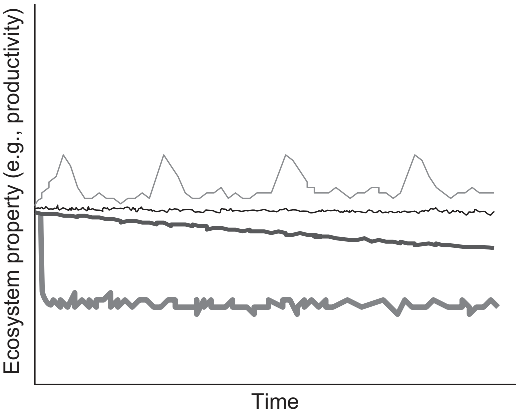

FIGURE 1.1 Four possible ecosystem trajectories under anthropogenic disturbance. Line width corresponds to the probability of occurrence: no change (black), periodic successional changes (green), gradual directional reversible change (blue), and sudden irreversible change (red). *A black and white version of this figure will appear in some formats. For the color version, please refer to the plate section.*

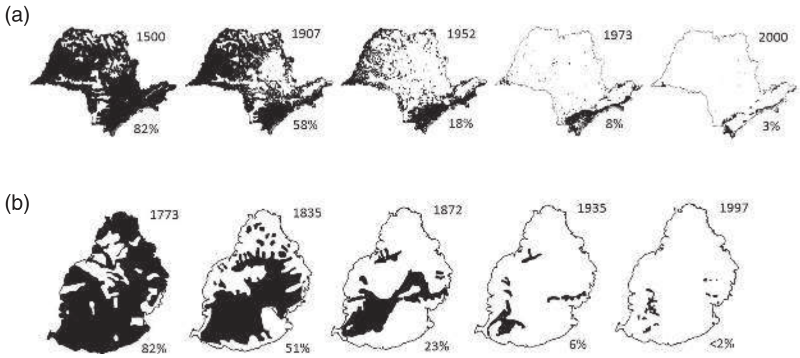

FIGURE 1.2 Two examples of fragmentation and disappearance of indigenous forest. (a) Atlantic coastal forest in São Paulo state of Brazil from 1500 to 2000 (after Oedekoven 1980, modified from Burkey 1997). (b) Mauritius island from 1773 to 1997 (modified from Florens 2013). The percentages denote the extent of remaining native forest cover.

move ecosystems outside of their historical range of variability should we accept the changes passively or keep trying to revert the altered habitats to historical conditions? Knowledge of historical conditions is essential in both conservation and restoration to identify reference states. However, historical records are either nonexistent or fragmentary and ambiguous. Nowadays, global climate change, the shift from a static to a dynamic view of ecological communities, the ambiguities of the past, and uncertainties of the future make the use of historical reference increasingly problematic and impractical.

This crisis of reference baselines is, to a large extent, responsible for a dichotomy of two global views of nature conservation, being forward and backward looking (Alagona *et al.* 2012). One wing of the conservation community, so-called "new environmentalists" or "new conservationists," declares that the whole baseline concept is obsolete, and suggests abandoning history, focusing not on the past but the future. The other wing is trying to refine or redefine the reference concept, often placing the baseline in the deep, distant past, adopting so-called "rewilding" or "resurrection ecology."

The forward-looking view proposes dropping the term "restoration ecology," seeing its historical focus as inappropriate, and wishes to replace it with terms emphasizing the new focus on intervention and creation of communities that have no historic analogs. These terms include "intervention ecology," "reconciliation ecology," "win–win ecology," and "futuristic restoration" (Choi 2004, 2007; Allison 2007; Halle 2007; Choi *et al.* 2008; Hobbs *et al.* 2011), with the goals of the latter being to repair or reinstate the key ecosystem services. This would be done through the creation of "novel ecosystems" (Hobbs *et al.* 2013) that may contain new combinations of species as a result of deliberate or inadvertent introduction, anthropogenic disturbance, changes in land use, pollution, or rapid climate change. The concept of the "novel ecosystem" goes back to the paper of Chapin and Starfield (1997) describing Arctic tundra transitioning to boreal grassland steppe under an altered climate and fire regime. This term has since been applied to a diverse range of ecosystems, e.g., mixed exotic–native forests established on degraded lands in many tropical regions, tussock grasslands that replaced forests in New Zealand or stands of exotic pines that replaced fynbos in South Africa (Lugo and Helmer 2004; Hobbs *et al.* 2006). All these ecosystems have one thing in common – they have no analogs in the past ecosystems, and are expected to dominate in the future. While many conservationists consider this an ecological disaster, the "new conservationists" view this change optimistically, as an opportunity to build "a new, more positive and forward-looking environmentalism" (Marris *et al.* 2012) that will secure ecosystem goods and services rather than species from extinction. The latter movement tries to shift the emphasis from preserving biodiversity *per se* to creation and management "of those natural systems that benefit the widest number of people, especially the poor" (Kareiva and Marvier 2007; Kareiva *et al.* 2012). This concept, welcoming free migration of any species across the globe and utilization of the last remaining pristine habitats until their complete disappearance, gets considerable support from the public, mostly a lay audience understanding much more about social rather than life or environmental sciences (Marvier and Wong 2012). Not surprisingly, we are witnessing the rapid proliferation of these views in the literature (e.g., Marris 2011; Theodoropoulos 2013; Kirksey 2015; Pearce 2015; Emmett and Nye 2017). Clearly, this movement has no sentiment for preserving species that do not fulfill an important functional role in novel "natural systems." Although advocates of the novel ecosystem concept state that it does not abandon the conservation of historic habitats and endangered species as central goals of natural area management (Kueffer *et al.* 2013), those people whose activities interfere with traditional nature conservation perceive these novel ecosystems in exactly that way (examples can be found in Simberloff *et al.* 2015).

Thus, while one of the two extreme views of conservation and restoration treats ecosystems as static and looks backward for a reference, the other one celebrates completely transformed landscapes and looks forward to ecological novelty. But, is there a third way of