CONSERVATION STRATEGIES, SPECIES ACTION PLANS, AND TRANSLOCATION

Catherine Souty-Grosset and Frédéric Grandjean
Université de Poitiers, Poitiers, France

Keywords: conservation biology, paradigm of small populations, metapopulation, evolutionary significant units, management units, paradigm of declining populations, population viability analysis, minimum viable populations, conservation management strategies and plans, biological corridor, species action plan, intentional release of animals (translocation)

Contents

Summary

A major threat to biological diversity is the reduction in geographic range of species mainly as a consequence of human overpopulation, habitat modification, and/or species introductions. In the past, conservation biology has been influenced mainly by ecology, but the necessity of genetic approaches has been widely recognized since 1995. Effectively, a more insidious threat is the accompanying loss of genetic diversity, which ranges from local extinctions within historically connected populations through the extirpation of entire historically isolated populations. Another often suggested threat to geographic diversity is that posed by genetic introgression following translocation.

Saving biodiversity means taking steps to protect genes, species, habitats, and ecosystems. The best way to maintain species is to maintain their habitats. Saving biodiversity therefore involves efforts to prevent the degradation of key natural ecosystems and to manage and protect them effectively. The program must include measures to maintain diversity on lands and in waters that have already been disturbed by human uses of agriculture. A third component is restoring lost species to their former

habitats and preserving species in gene banks, zoos, and botanic gardens.

One of the best ways to ensure that the various institutions involved in conservation are in general agreement on priorities is to prepare a strategy that defines the basic problems and agrees to appropriate objectives. Strategies are turned into action through a more tactical process of planning specific activities to address the broad strategies; this often involves the preparation of an action plan. Such a strategy, dealing with all aspects of biodiversity, was prepared by a coalition of the World Resource Institute, the World Conservation Union (IUCN), and the United Nations Environment Program (UNEP), in close collaboration with the World Wildlife Fund, Conservation International, the World Bank, the Asian Development Bank, and other key governmental and nongovernmental institutions in both tropical and temperate nations.

1. Introduction

The twentieth century has proven as significant for changes made by humans in the landscape—its soils, waters, atmosphere, climate, habitats, and wildlife—as for its technological advancements. The risks as we progress through the twenty-first century are not just with extinction or restriction of wildlife; there are serious economic ramifications associated with the continued loss of biological diversity. As species disappear, human capacity to maintain and enhance agricultural, forest, and rangeland productivity decreases. And with the degradation of ecosystems, the valuable services that natural and seminatural systems provide will be lost.

Essentially the problem involves the proliferation of human populations and associated land conversion which is powerfully changing the form and shape of the landscape.
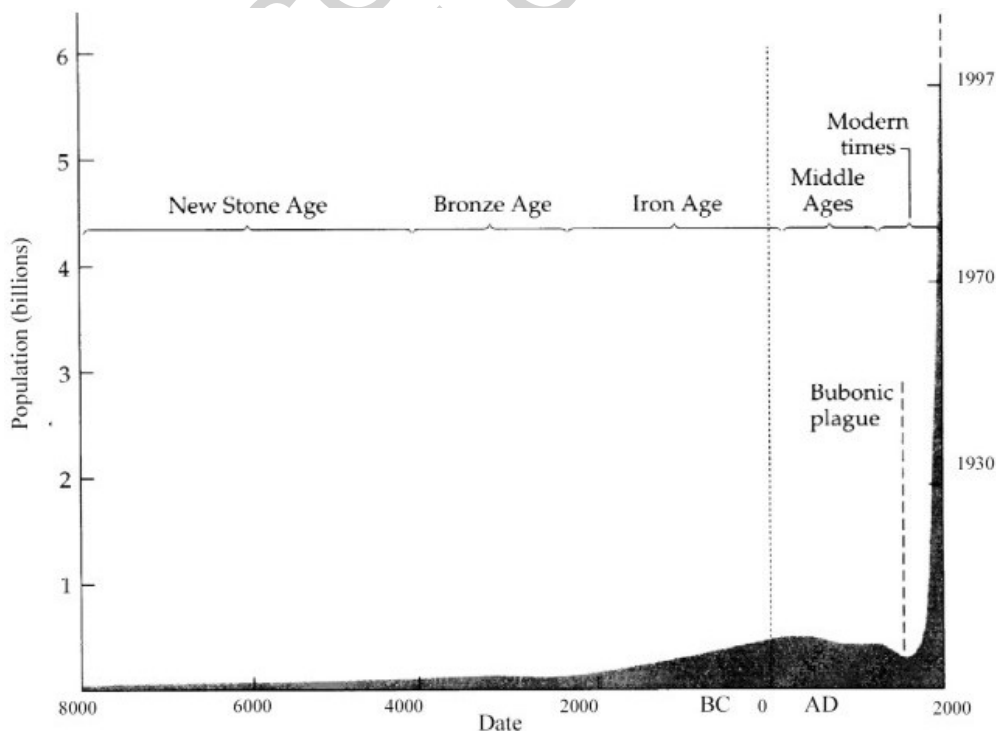
Figure 1. Evolution of worldwide human population

People now constitute a pressure on the global environment that is evident everywhere. There are no longer any unoccupied frontiers; every square centimeter of Earth's surface is affected by the activities of human beings. This results in insufficient habitat for many species or situations in which habitats are isolated in separate pieces too small or too unstable to sustain viable populations of species and thus biological diversity. The theory of biogeography reveals that species richness is a function of land area. All environmental variables being equal, the greater the area, the more species it supports.
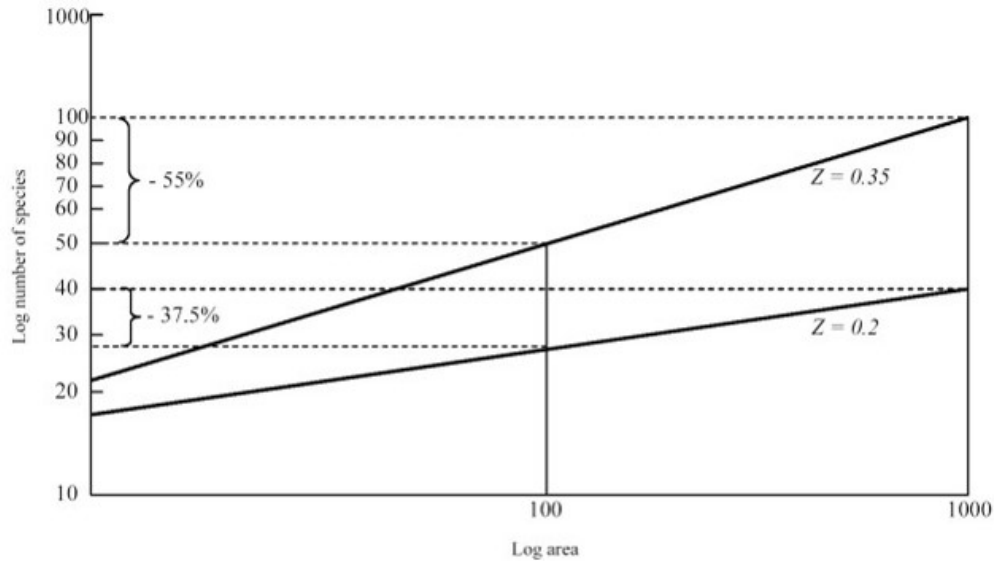

Figure 2. Number of species as a function of area

Thus, as habitats are fragmented and isolated into small islands, they lose the capacity to support wildlife diversity. Humans have been involved and interact with fauna and flora for many thousand years. Thus it is often difficult to separate the human impact from the changes that have taken place due to more natural processes. However, over the last 200 years, and particularly over the last few decades, various new and intense pressures have been applied and many species have declined in range and numbers. Some of the more important pressures include industrial and domestic activities, acid deposition, land use (farming and forestry), industrial development (including roads), changes in the landscape (for example river obstruction, drainage, canalization, reservoirs), and introduction of nonnative species.

If we consider the example of freshwater fish, the main implied factors are the following.

Pollution and human use: The pollution of freshwaters is probably the single most significant factor that causes major declines in the populations of many fish species. Most pollution comes from domestic, agricultural, or industrial wastes, and can be totally toxic, killing all the fish species present, or selectively toxic, destroying a few sensitive species and altering the environment so that some species are favored and others not. At present, suitable water-quality criteria are available in relation to

freshwater species. However, heated effluents are also responsible for eutrophication, which is thought of as a mild form of pollution, and recent acidification from atmospheric pollution has shown that even waters far away from urbanization are not necessarily safe. The impacts of various forms of land use on many species are considerable. Land-drainage schemes can totally alter the hydrology of the adjacent river systems. The type of crop grown on the land can also have a major effect, especially with extensive monocultures. Forests of conifers have led to excessive water loss from catchments through evapotranspiration together with increased acidification of the water. Further, river and lake engineering have been responsible for the immediate elimination of species in freshwater systems all over the world.

Habitat loss: Engineering works can also completely destroy the habitat of freshwater species by dredging or siltation of rivers or lake beds. Rivers are repositories of enormous amounts of human waste, including toxic industrial chemicals, acid rain, agricultural slurries and herbicides, and domestic sewage.

Overexploitation of species: The impact of fisheries on the populations which they exploit can lead to the virtual extinction of populations. Apart from physical and chemical habitat alterations created by humans, there are also various biological perturbations. The major perturbation is the introduction of alien (nonnative) species. If these species become established, they can alter the community structure radically and lead to the extinction of sensitive native species. The ways in which introduced species can interact with native species can be summarized as follows: the introduced species could (a) be rejected because there is no vacant niche or because predators eat out the population at an early stage; (b) either hybridize with very closely related stocks formerly adapted to the ecosystem, or eradicate or suppress a stock that is either an ecological homologue or an easily available prey; or (c) adapt to resources that are not fully exploited by native species and thus be able to survive as a member of the community. Many of these pressures are linked and the final combination often results in a complex and unpredictable situation.

Consequently, many species are endangered by different factors, such as loss of habitat. Habitat loss is probably the most important factor causing species declines worldwide. In the United States, the mission of the Biological Resource Division (BRD) of the US Geological Survey (USGS) is to provide the scientific understanding and technologies needed to support the sound management and conservation of national biological resources. The Endangered Species Act is a species-based protection mechanism which has evolved over time. The first endangered species legislation was the 1966 Endangered Species Preservation Act. This act established a list of animals that were endangered by extinction, but directed federal agencies to protect species only to the extent practical and consistent with the primary purposes of the agencies. The most significant part of this first act was to establish the National Wildlife Refuge System for the protection of those habitats on which endangered species depended. In 1969, Congress passed the endangered Species Conservation Act, which extended protection to invertebrates and extended the Lacey Act's prohibitions on commerce in fish, wildlife, and plants to cover interstate commerce in illegally taken reptiles, amphibians, and some invertebrates. This 1969 law called for international protection of endangered species and an international conference to develop conventions for conserving species.

The conference, finally held in 1973, resulted in the Convention in International Trade in Endangered Species of Wild Fauna and Flora (CITES). In 1973, the Endangered Species Act (ESA) was passed and is the only major US federal law that specifically seeks both to save all US wildlife from extinction and to preserve the ecosystems on which this wildlife depends. The US Fish and Wildlife Service (FWS; for terrestrial and freshwater species) and the National Marine Fisheries Service (NMFS; for anadromous and marine species) have the responsibility of implementing all aspects of the ESA; elaborating lists, developing recovery plans, and providing consultation to other federal agencies. In the fiscal year 1997, a budget of less than US$89 million was designated to these agencies for implementing the ESA.

Thus it is crucial to understand the causes of habitat loss. Various methods have been developed for the objective assessment of the conservation status of plant and animal species (for instance, by the Nature Conservancy Council). The major classification system used internationally for assessing the status of threat to species is that adopted by the International Union for the Conservation of Nature and Natural Resources. The Red Data Book categories, following, are used by the IUCN to indicate the degree of threat to individual species in their wild habitat.

Extinct: This category is used only for species which are no longer known to exist in the wild after repeated searches of appropriate localities and other known or likely places. As interpreted by the IUCN, this includes species which are extinct in the wild but surviving in captivity.

Endangered: This important category is defined as including taxa in danger of extinction whose survival is unlikely if current causal factors continue operating. It includes taxa whose numbers have been reduced to a critical level or whose habitats have been so drastically reduced that they are deemed to be in immediate danger of extinction. It may also cover species with populations so critically small that a breeding collapse due to the lack of genetic diversity becomes a possibility.

Vulnerable: This group includes taxa believed likely to move into the endangered category in the near future if current causal factors continue operating. Included here are taxa of which most or all of the populations are decreasing because of overexploitation, extensive destruction of habitat, or other environmental disturbance; taxa with populations which have been seriously depleted and whose ultimate security is not yet assured; and taxa that are under threat from serious adverse factors throughout their range, despite abundant populations.

Rare: This group includes taxa with small populations which are not at present endangered or vulnerable but are at risk. These taxa are usually located within restricted geographical areas or habitats or are thinly scattered over a more extensive range.

Indeterminate: This includes taxa thought to be extinct, endangered, vulnerable, or rare, but where there is not enough information make a more specific classification. The primary function of this classification is to consider the status of each species over its entire range and not specifically in any one geographic region. Thus a species could be endangered or even extinct in one part of its range, but still not be under any significant

threat as a whole. Normally, to be considered for conservation, the taxa concerned must be indigenous to the geographic area concerned. The species is likely to be more important if they are quite distinct taxonomically and are not members of a closely related species group.

2. Aims of Conservation Biology

At present, a third of all known species have become extinct or being endangered. Many of them have small fragmented populations whose future is in doubt. For example, 20% of the world's freshwater fish species are extinct or threatened.

Conservation biology studies the causes for the decline in such populations and assesses their viability, so that they can be managed in a way that will assure their long-term survival. This discipline was developed at the end of the 1970s in the United States. Conservationists became aware of the increasing extinction of species, of the concept of biodiversity, and of the problem of human overpopulation. A conference held in 1980, titled "Conservation Biology, an evolutionary–ecological perspective," is considered the beginning of conservation biology. The Society for Conservation Biology was founded in 1985. This is a multidisciplinary discipline involving not only zoology, botany, and ecology (these three are together considered the life sciences); but also geography, geology, and chemistry (together considered the physical sciences); as well as socioeconomics and law (together termed the social sciences). The discipline is based on theories based on the concepts of fragmented and isolated populations. Conservation biology generates theoretical models which can be applied to practical situations, assigns the same values to commercial and noncommercial species, includes nonbiological disciplines such as economics and the social sciences, and attempts to provide the bases needed for rational long-term management of ecosystems and their resources while maintaining the evolutionary processes.

Conservation biology is based on two fundamental paradigms summarized in the following two subsections.

2.1. The Paradigm of Small Populations

Small populations are affected by their restricted size on their survival. This paradigm deals with the risk of extinction and applies to all species and is the subject of stochastic theories.

The dynamics of a small population and its rate of increase depend on both environmental fluctuations (which amplify the rate of population increase depending on frequency and intensity) and demographic fluctuations (which constantly vary in recruitment, mortality, etc.). The genetic diversity of these small populations may play a role in the chances of survival. The genetic variability is usually estimated from the mean heterozygosity (proportion of heterozygous genotypes). Heterozygosity varies greatly between taxonomic groups and depends on which genetic marker is used in evaluation. A reduction or loss of genetic variability is caused by two main factors which are both related to population size: (a) The founder effect: a small number of

individuals not representative of the parental population found a new population, or (b) the demographic bottleneck: exceptional high mortality leaves only a few individuals to continue the affected population.

The lack of genetic diversity is the result of the processes that initially endangered the species. The concept of metapopulation (literally, a "population of populations") is included in this paradigm and is very strongly related to habitat fragmentation. Some habitat changes result in the fragmentation ofpopulations, which then become a metapopulation. There are three types of metapopulation. (a) The model in which a series of local populations originating from source patches colonize other patches. Some local populations may disappear, but the entire metapopulation is resistant to extinction. (b) The model in which a large permanent central population is the source for the colonization of peripheral patches which then may disappear. (c) The source–sink model which is similar to (a), but where there are a few source populations but many sink populations, independent of patch size. There is therefore a random dispersion between patches in a metapopulation which is responsible of the mixing of individuals and therefore of exchanges of genetic information. The concept of permanent and temporary connectivity is essential for the mixing of individuals in a metapopulation.
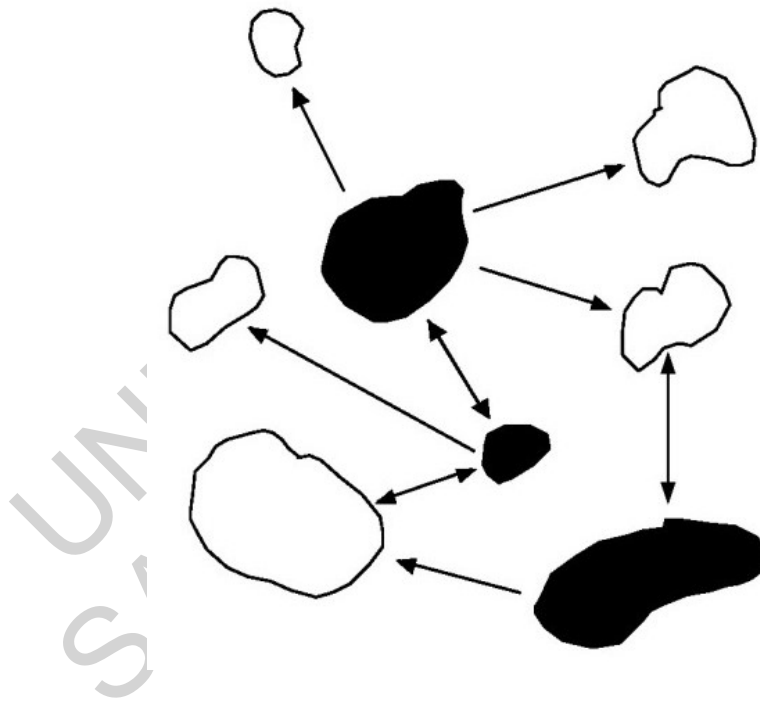

Figure 3. Principle of a metapopulation
In a metapopulation, source habitats (shaded) provide excess individuals which emigrate to sink habitats (nonshaded). The sink habitats could be larger than the source habitats, and may even have more animals, but because of lower habitat quality, subpopulations in sink habitats would go extinct without an influx of animals from the source habitats. Arrows indicate the direction of animal movements among patches of habitat. Source: Meffe G.K. and Carroll C.R. (1997). Genetics: conservation of biodiversity within species. *Principles of Conservation Biology, second edition* (ed. G.K. Meffe, C.R. Carroll, et al.), pp. 161–201. Sunderland, MA: Sinauer Associates.

Thus metapopulation theory has important implications for wildlife species that occur in patchy or fragmented habitats. The persistence of the metapopulation is dependent on the persistence of each subpopulation and the movement of individuals among subpopulations; in fragmented habitats, subpopulations become isolated from other subpopulations. Because the size and the quality of habitat fragments vary, some of these subpopulations will have a fecundity rate that is higher than the mortality rate. These habitats are called source habitats because they produce extra individuals that can disperse and colonize other habitats. Other subpopulations will have mortality rates that are higher than the fecundity rates. These habitats are called sink habitats, because the persistence of these subpopulations depends upon regular influx of individuals from the source subpopulations. Thus, the lower-quality sink habitats are drawing the individuals from source habitats, and perhaps the entire metapopulation. The metapopulation depends on the dynamics between the source and sink habitats. Population ecologists believe that most subpopulations will go extinct naturally within an interval of 100 to 1000 generations. A subpopulation that goes extinct and is later recolonized is said to "wink" on and off. As subpopulations become isolated and patches become smaller, the probability that the metapopulation will go extinct increases.

Because many species do depend on source and sink habitats, every protection and recovery plan for species should investigate the need to include (a) spatially distributed populations that are linked through migration and (b) special protection of the most stable, high-quality habitats.

According to US Endangered Species Act (ESA), listing a species as threatened or endangered is the first step in conferring legal protection. It is the conclusion to a decision-making process that draws heavily on ecological science, particularly in assessing the level of risk to a species and developing priorities for listing. Species are proposed for protection because they are thought to be in danger of extinction or at risk of becoming endangered with extinction. There is no scientific reason why listing, which is an administrative decision based on the available information, should require much time or agency resources.
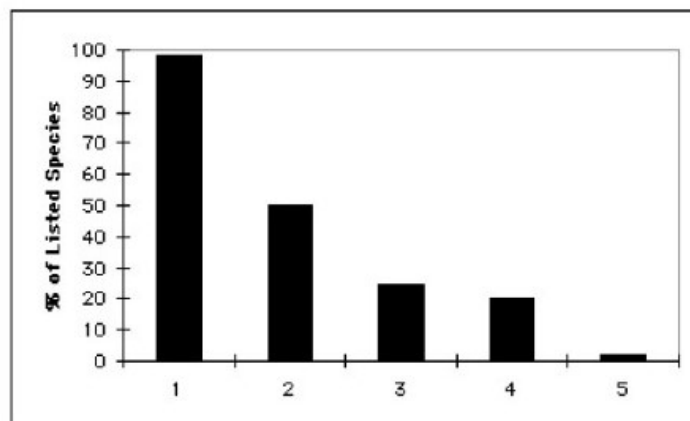

Figure 4. Reasons that species are listed under the US Endangered Species Act
Species can be added to the list of endangered or threatened species for five reasons: (1) current or threatened destruction of habitat; (2) overuse of the species for commercial,

recreational, scientific or educational purposes; (3) disease or predation; (4) ineffective regulatory mechanisms; and (5) other natural or human factors affecting the species chances of survival.

In the language of the Act, a "species" is taken to include any subspecies of fish or wildlife (including invertebrates such as insects, crustaceans, and mollusks) or plant (as well as fungi). The meaning of "species" is, therefore, somewhat imprecise, but the wording recognizes that a species is made up of an assemblage of individuals that collectively express genetic, morphological, and behavioral variation, and that this variation is the basis of evolutionary change and adaptation. The scientific justification for extending protection to distinct population segments of species is that genetic diversity provides the raw material for adaptation of a species to changing conditions. A wide geographic range decreases the likelihood that a catastrophic event such as wildfire, disease, or alien species introduction could wipe out an entire species. The capacity to respond to environmental change through ecological and evolutionary processes is enhanced by large population size, extended geographical distribution (including spatial structure among its populations), and intraspecific genetic diversity. Therefore, because loss of specific population segments can contribute to the decline of a population and increase the probability of its extinction, protection of population segments is biologically appropriate. The National Marine Fisheries Service has thus proposed the new concept of evolutionary significant units (ESUs; which is strongly related to the metapopulation concept, to population genetics, and to evolutionary processes and systematics). This concept appeared in the early 1980s in the United States when priorities had yet to be established, conservation units had yet to be defined, and management had yet to be undertaken for the Pacific salmon as part of a rehabilitation project under the provisions of the US Endangered Species Act. The definition of ESUs was the following: "A population or group of populations that is substantially reproductively isolated from other conspecific population units and represents an important component in the evolutionary legacy of the species." Both genetic and ecological diversity is taken into account in this definition.
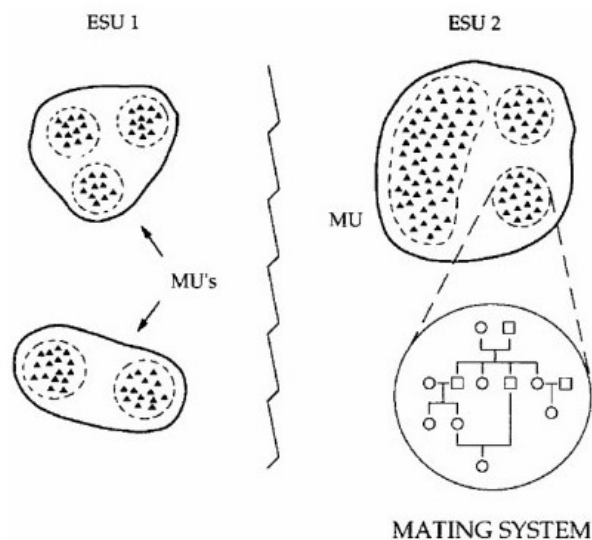

Figure 5. Illustration of ESUs and MUs.

It was redefined by applying exclusively genetic criteria; he suggested that there should be a distinction between two types of conservation unit: on one hand management units (MUs) representing sets of populations that are currently demographically independent and on the other hand evolutionary significant units (ESUs), which represent historically isolated sets of populations that together encompass the evolutionary diversity of a taxon. An ESU can include several different MUs, but a MU is not necessarily enough distinct to constitute an ESU. Finally, in 1998, Dodson et al. defined the operational conservation unit (OCU) as "the unit of conservation that results from the interplay between biological requirements and socioeconomic issues. The biological requirements are largely found within ESUs. The OCU reflects the ESU and its interaction with socioeconomic issues. In some cases, sufficient economic resources and desire may exist within society to preserve all ESUs and thus the ESUs become the OCUs. In most cases, however, the OCUs may be larger than individual ESUs, encompassing several ESUs into a single OCU."

Given the limited resources available for endangered species protection, assigning high priority to species that serve as protective "umbrellas" for other species makes good ecological sense.

For example, the Florida scrub jay (*Aphelocoma coerulescens coerulescens*) is restricted to scrub oak habitats on the Florida peninsula. Many rare species of reptiles, insects, and plants inhabit, and are restricted to, those scrub habitats. Many of them benefit from the land that is managed for the protection of the jay. Similarly, many, but not all, the species requiring old-growth temperate rain forest will benefit if the habitat of the spotted owl is protected. The umbrella species approach must be used carefully because every acre of land or body of water will contain large numbers of species. Thus, virtually any organism could be considered an umbrella species at some scale. Moreover, an important fact about endangered species is that they rarely have exactly the same requirements. Therefore, even when a suitable umbrella species exists, the ecological needs of other community members must also be considered. The most useful umbrella species are ones whose habitats harbor numerous endemic, rare species. Thus, umbrella species should be given priority for listing, in proportion to the number of other endemic, rare species that co-occur with them.

The species must play an especially important role in the ecosystem in which it lives. It is why keystone species—an organism whose impact on its community or ecosystem is large, and disproportionately large relative to its abundance—merit special attention in the listing process.

On scientific grounds, the more evolutionarily distinct an organism is, the higher should be its priority for protection. All things being equal, therefore, saving the sole surviving member of a genus may have a higher priority than saving an imperiled species within a large genus that contains many other species. Similarly, protecting full species would normally be given a higher priority than protecting subspecies and populations.

2.2. The Paradigm of Declining Populations

The paradigm deals with the causes of restricted population size and with methods to remedy their restriction. This has no theoretical basis but is related to processes that lead to species extinction.

The paradigm aims at identifying the cause of the decline of well-sized populations. The three main causes for population declines are habitat destruction and fragmentation, exploitation (commercial exploitation, hunting, fishing), and the impact of introduced species, at least over short timescales, although at geological timescales, climatic changes and catastrophic natural events may be more important. The aim is first to list the factors contributing to the decline of a species by comparing areas where the species still occurs with those where it has disappeared.

With the progress in computers and the development of user-friendly software, there is an increasing trend in conservation biology towards the use of computer models to predict the future outcome of populations: the most widely known is population viability analysis (PVA). For example, the immediate consequence of listing a species under the US Endangered Species Act is to trigger a series of processes that can recover the species and enable it to be "delisted." Recovery is much more complex and difficult than listing, and the development of a recovery plan usually requires the generation of substantial new information in addition to the evaluation of existing information. Once a species is listed, a "critical habitat" is designed, because loss of habitat is the cause of endangerment of most species. Then, the scientific procedure used to estimate the probability of survival of a population for a specified period of time is known as population viability analysis, or PVA. Although there is no strict definition of what is or is not included, each PVA should include an analysis of the best available information on the focal species. Most PVA analyses combine data from field studies with simulation modeling of the possible impacts of various extinction factors. Species with low population densities and small geographic ranges (most endangered large vertebrates, for example) and small geographic ranges (many plants) require a PVA that includes analysis of the genetic and demographic factors affecting small populations. In practice a minimum viable population (MVP) is typically defined as one that has a 90% probability of persisting for 200 y. A PVA was performed for the Acorn Woodpecker (*Melanerpes formicivorus*), a nonendangered bird which lives in small, isolated populations in the oak woodlands of the western United States and Mexico. A simulation model showed that most of these populations would become extinct within 20 y if they were totally isolated from one another. However, with a small amount of migration among populations, the model indicated that most of the populations would last more than 1000 y. Historical records indicate that local populations of these woodpeckers have survived more than 70 y, suggesting that migration must be important in maintaining them. Population viability can seldom be assessed by focusing on a single patch of suitable habitat and the organisms living in it. Most organisms live in islands of suitable habitat, among which there is an exchange of individuals embedded in a larger landscape. Because the populations in the various patches are linked by the movement of dispersing individuals, the fates of the populations are interconnected. Studies of population viability of many organisms will therefore need to consider the importance of factors that link subpopulations.

The long-term survival of metapopulations can be strongly affected by the spatial and

temporal distribution of suitable and unsuitable habitat patches. Populations living in high-quality habitats (referred to as "source" habitats) have birth rates greater than death rates. The excess individuals may migrate into lower quality habitats ("sink" habitats) where birth rates are less than death rates. The viability of metapopulations depends on the existence of sufficient high-quality habitats, but a large fraction of the individuals may live in the suboptimal habitats. To determine the needs of the critical habitat of such species, identification of source and sink habitats is required, which may be difficult. Not every rare and endangered species is patchily distributed in a spatially structured habitat mosaic. Some species live in just a few continuous or in completely isolated habitats. Some species have a "core–satellite" structure in which one very large population (the core) determines the population dynamics in the small (satellite) populations. Nonetheless, because many species do depend on source and sink habitats, every protection and recovery plan for species should investigate the need to include (a) spatially distributed populations that are linked through migration, and (b) special protection of the most stable, high-quality habitats. For some species, the designated critical habitat may need to include more than habitat actually occupied by the species. This is especially true in cases where the quality of critical habitats is dependent on land use in the surrounding area. Although this is a general concern, the need for a larger scale of focus in the designation of critical habitats is most apparent for aquatic species. If the watershed that supplies river and lake ecosystems is degraded, the critical habitats needed by the endangered species may also be destroyed. The data available for most candidate species will not allow for a precise determination of MVP or critical habitats.

-
-
-

TO ACCESS ALL THE **38 PAGES** OF THIS CHAPTER,
Click here

Bibliography

Caughley G. (1994). Directions in conservation biology. *Journal of Animal Ecology* **63**, 215–244. [This article states the foundation of conservation biology in two fundamental paradigms.]

Dodson A.P., Gibson R.J., Cunjak R.A., Friedland K.D., Garcia de Leaniz C., Gross M.R., Newburym R., Power M.E., and Roy S. (1998). Elements in the development of conservation plans for Atlantic salmon (*Salmo salar*). *Canadian Journal of Fisheries and Aquatic Science* **55**, 312–323. [These authors created the Operational Conservation Unit (OCU), defined as the unit of conservation that results from the interplay between biological requirements and socioeconomic issues.]

Erwin T.L. (1991). An evolutionary basis for conservation strategies. *Science* **253**, 750–752. [This paper presents the goal of conservation strategy as the protection of future maximum biodiversity as well as preservation of contemporary species of human interest.]

Griffith B., Scott J.M., Carpenter J.W., and Redd C. (1989). Translocation as a species conservation tool: status and strategy. *Science* **245**, 477–480. [This paper describes disease transmission during translocation

events.]

Groombridge B. (1992). *Global Diversity: Status of the Earth's Living Resources*. London: Chapman and Hall. [This book gives an exhaustive IUCN red list of endangered species.]

Harwood J. (2000). Risk assessment and decision analysis in conservation. *Biological Conservation* **95**, 219–226. [This paper explains how a formal approach to risk assessment and management could help to combine the two paradigms of conservation biology.]

Meffe G.K. and Carroll C.R. (1997). Genetics: conservation of biodiversity within species. *Principles of Conservation Biology, second edition* (ed. G.K. Meffe, C.R. Carroll, et al.), pp. 161–201. Sunderland, MA: Sinauer Associates. [This book describes how both systematic and ecological views have philosophical roots that extend back through human history.]

Moritz C. (1994). Defining "evolutionary significant units" for conservation. *Trends in Ecology and Evolution* **9**, 373–375. [This paper gives new definitions of two types of conservation units: evolutionary significant units (ESUs) and management units (MUs).]

Prendergast J.R., Quinn R.M., Lawton J.H., Eversham B.C., and Gibbons D.W. (1993). Rare species, the coincidence of diversity hotspots and conservation strategies. *Nature* **365**, 335–337. [This article presents the importance of hotspots for defining some conservation strategies.]

Soulé M.E. (1986). *Conservation Biology: the Science of Scarcity and Diversity*. Sunderland, MA: Sinauer Associates. [This book presents the novel fundamental rules of conservation biology.]

Soule M.E. and Wilcox B.A., ed. (1980). Conservation Biology. An evolutionary-ecological perspective, 395 p. Sunderland: Sinauer Associates, Inc. [This book is considered to be the birth of conservation biology.]

Waples R.S. (1998). Evolutionary significant units, distinct population segments and the Endangered Species Act. *Conservation Biology* **12**, 718–721. [This paper introduces the new concept of evolutionary significant units (ESUs).]

World Conservation Union (formerly International Union for Conservation of Nature and Natural Resources; IUCN) (1987). *Position, Statement on the Translocation of Living Organisms*: *Introductions, Re-introductions, and Restocking*. Gland, Switzerland: IUCN Council. [This presents the guidelines intended to act as a guide for procedures on the basis of the different types of translocations.]

Biographical Sketches

Catherine Souty-Grosset was born in La Rochelle (France) on 23 January, 1954. She has been a research scientist in CNRS (Centre National de la Recherche Scientifique) since October 1980, working in a joint research laboratory named UMR CNRS 6556 "Génétique et Biologie des Populations de Crustacés" (University of Poitiers) as the coordinator of Population Genetics Research. She received her PhD degree from the University of Poitiers in 1978 and obtained State Doctor es Sciences in 1984 (vitellogenesis in terrestrial and marine isopods); she obtained HDR (empowered to supervise research) in 1985. From 1984 to 1992, research was devoted to ecophysiology in terrestrial and marine isopods. Since 1992, her scientific interest has been directed to population genetics of isopods, penaeids, and conservation genetics of a native European crayfish. She coordinates all projects on conservation biology of *Austropotamobius pallipes* that are financed by Higher Fisheries Council, Ministry of Environment, CNRS (Centre national de le recherche Scientifique)/MAE (Ministère des affaires étrangères)/Enterprise Ireland. In 1993, she organized the lab session on Cell Signalling in the Erasmus Winterschool (Aahrus, Leiden, Poitiers, Würzburg) on mitochondrial genomes and evolutionary biology. She was coordinator and editorial committee member of three special issues devoted to native European crayfish in BFPP (Bulletin Français de la Pêche et de la Pisciculture; translated, "knowledge and management of aquatic systems"). She wrote a book review for the American Zoologist on the biology of terrestrial isopods (1996) and wrote a chapter "vitellogenin synthesis in marine invertebrates" in *Marine Biotechnology* (1997: ed. M. Fingerman, Tulane University, Louisiana). She is the author of more than seventy papers

and more than sixty oral presentations at invited conferences and seminars. Recently she organized an Euroconference entitled "Knowledge-Based Management of Native European Crayfishes" (Poitiers, France, 13–15 September 2001). Since December 2002, she has been coordinating the eleven-country European thematic network CRAYNET, focusing on European crayfish as a keystone species that link science management and economics with sustainable environmental quality.

Frédéric Grandjean was born in Epinal (France) on 12 March, 1967. He has been a lecturer since October 1998 in the same joint research laboratory named UMR CNRS 6556 "Génétique et Biologie des Populations de Crustacés" (University of Poitiers). He obtained a PhD in 1997 on " Morphometric and genetic variability of populations in *Austropotamobius pallipes*: biogeographical implications" (under the direction of C. Souty-Grosset). He is lecturer in aquatic ecology and population genetics and researcher in all crayfish projects of the UMR CNRS 6556 and has written 12 papers on the subject.