Genetics and Conservation

A REFERENCE FOR MANAGING WILD ANIMAL AND PLANT POPULATIONS

Edited by

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FOREWORD

Management of populations of wild animals and plants is as old as settled civilization itself – after all, domesticated species started their careers as their wild ancestors, and the genetic distance between them may not be very great. Basic lessons and useful practices were learned from domestication, the most basic being the avoidance of consanguineous matings, which was enshrined in social and religious precepts of ancient communities and has remained the focal point in the management of wild animal populations to this day. But settled civilization brought a parting of the ways: domesticates began to be managed – and gradually to be selected – for productivity, and wild species were there to be exploited, for their products such as meat, skins, or pelts, or for the enjoyment they gave, mostly to the privileged, in killing them. Ancient civilizations saw nature as created to serve man's uses as he chose, and man's stewardship for nature, at best, was "a minority tradition" in western civilization (Passmore, 1974). Neither the authorities of the church nor the poets and philosophers of the enlightenment deviated from the basic assumption of man's dominance over nature. Indeed, the drastic change of attitudes is a contemporary development, the result of the dramatic changes in the ecology of the world brought about by the destructive exploitation of the world's resources.

Once the conservation of threatened environments and resources became a recognized objective, it was natural that the emerging science of ecology stepped in to provide the theoretical infrastructure and the principles of management for the reserved or protected areas that began to be set aside a hundred years ago. Recently, population biology became an integral part of what is now termed conservation biology (Soulé and Wilcox, 1980). When it was postulated that genetic diversity may be a condition of long-term survival (Frankel, 1970; Frankel and Soulé, 1981), population and evolutionary genetics were seen as having a significant role in conservation biology.

The symposium from which this book emerged was planned to make managers of nature reserves, botanical and zoological gardens, and other forms of preservation aware of genetic principles and technologies of relevance in the management of biological resources. The aim of the symposium was to bring this new knowledge with the least possible delay to those best placed to apply it. This book will make it available to a wider circle.

The book addresses itself to population dynamics, which are liable to affect rates of survival or extinction in protected areas, and to the genetic principles and practices by which survival can be enhanced. The alternatives are clearly evident in the choice of topics: decline and extinction of species, in juxtaposition with the founding of new populations; isolation of populations in protected areas versus the merging of separated populations and taxa. A focal theme is the maintenance of genetic diversity as the genetic base for continuing evolution.

Readers concerned with reserve management may discern a bias toward animal problems. This is clearly not deliberate. There are a number of botanical chapters, but they deal largely with the basic issues of population genetics. Indeed, it is hard to see how it could be otherwise. There is little scope for the management of plant species with the exception of those with scientific or economic connotations, such as forestry species or wild relatives of domesticates. For this there are two reasons. The first is the great diversity of breeding systems—for many species totally unknown—as against the bisexual simplicity in the majority of likely animal target species. The second is the ecological difficulty of "managing" plant species without acute interference with the ecosystem.

Indeed, the genetic management of particular species—usually rare or endangered ones—as a means of securing their survival may affect the stability of the ecosystem of which they form a part, if the effect of management is to increase the population size and hence the demand on resources within the ecosystem. There are, of course, situations in which the species of concern is so far removed from natural conditions or of such focal concern that an impact on other biota is either absent or irrelevant. Captive preservation is the paradigm of such situations. But, to paraphrase John Donne, under natural conditions "no species is an island." Managerial support for one species is likely to be at the expense of others, and managers will have to attempt a balance sheet of the short- and long-term effects that can be expected.

The opportunities for genetic management are determined by a number of variables—primarily the population size, which in turn depends on area size and on body size. This is brought out clearly in an ingenious model presented in the final chapter, with demographic data for three size classes of mammals related to area size. Clearly in the smaller reserves there is scope, and need, for genetic management to avoid or reduce inbreeding. Only large reserves have the potential to generate and maintain genetic diversity for adaptation to environmental change. This does not mean that smaller reserves have no evolutionary role to play. Indeed, they have, though perhaps not for the long-term preservation of the larger vertebrates, which now occupy the prime attention of conservationists. Moreover, the future is unknown, and long-term models, plausible as they seem, should not discourage concerted conservation efforts on a less than ideal scale.

Whatever the opportunities for genetic management, genetic information should prove valuable to reserve managers in shedding light on processes in populations that neither facilitate nor require management, but are full of interest for the observant biologist. Besides, awareness of genetic principles and, even better, of genetic variation in populations facilitates intelligent intervention, or helps to avoid disturbances and harmful interference. Estimates of levels of genetic diversity have become possible and are widely obtained; and, as this book shows, they provide information of managerial relevance and scientific interest. Indeed, it is perhaps the heightening of scientific insight, as much as the application in management, that is the most significant contribution made by this book.

O.H. Frankel

PREFACE

It is commonly agreed that genetic diversity should be preserved. Considerable confusion exists, however, as to what exactly is meant by the term genetic diversity, within its several different contexts of use. As it *can* mean

- species diversity,
- allele diversity (including polymorphisms),
- allele frequency differences (between individuals within populations and between populations), or
- the combination of species diversity with allelic variations (so vital in providing for long-term phylogenetic evolution),

we found ourselves wondering how often policy makers and field managers of wildlife resources understand the wide-ranging implications of mandates that involve the protection and preservation of species for future generations. Unfortunately, our observations at both the policy-making and field-managing levels suggested that very few often understand.

For example, if we would ask a number of wildlife resources' policy makers and field managers what they perceive is required to preserve a resource, we could probably expect that many would want to return the species to a former point in time and preserve those qualities of the species present at that particular time. They may not realize that this requires a tightly managed, often farmlike system. On the other hand, what they probably would want, if made aware of the choice, would be to preserve a resource's ecological and natural evolutionary processes. This, in contrast to the former strategy, requires allowance for processes to take place, including speciation and natural extinction.

Our goal in *Genetics and Conservation* is to contribute to the preservation of the natural diversity of species with a view to preserve the evolutionary potential of species by exploring the relationship between today's advances in genetics and their potential contribution to the quality of wildlife (animal and plant) conservation.

Our immediate objectives are to help clarify the meaning of genetic diversity and, simultaneously, to elucidate to those who plan or implement programs the various implications that accompany their objectives in managing, protecting, preserving, or restoring wildlife. As the entire field of conservation is too broad for one book, we have focused here upon the application of genetics to conservation. This follows from our primary concerns, which center around the genetics and evolutionary consequences of certain – sometimes perceived as negative – naturally occurring as well as management-induced phenomena: isolation, extinction, population bottlenecks, founding of new populations, and merging of naturally disjunct populations.

Those working in the field of conservation are accustomed to the urgency that overshadows restoration projects and programs that hope to stave off extinctions. Unfortunately, new knowledge and tools useful to conservation are slow to reach the field scientist or manager. In contrast to short-range, economically profitable enterprises, the conservation of wildlife (animals and plants) does not now provide the economic incentives to ensure that the best and newest information is immediately made available for use and for further testing. It remains the responsibility of concerned individuals to voluntarily bridge the gap between scientific findings and application. For example, unusually successful attempts have been made in the management of fire and of mammal populations in zoos, and in the development of live storage of genetic material such as semen, tissues, and seeds. Although developments such as these are revolutionizing practices in conservation in a few places, their beneficial effects are just beginning to be recognized across the entire field of conservation. Therefore, this book has been written *primarily* to contribute to the translation and transfer of knowledge from the fields of population and evolutionary genetics to the field of conservation, including its management practices.

Isolation, already a major conservation problem, will surely become the state of nearly all remaining natural areas and populations requiring undisturbed habitats (particularly large and migratory species) unless there is some intervention. Isolation predisposes species or groups – particularly those of small populations – to extinction, the fate that the majority of large vertebrates and other ecologically inflexible species will face. Conservationists have a choice, however, whether many of these foreseen extinctions will occur. The choosing of the positive answer sounds simple and obvious, but it is riddled with complexities and, therefore, neither simple nor obvious. Nonetheless, conservationists must choose whether they will maintain certain habitats for the majority of species and allow declining species to reach critically low population sizes and disappear, or whether they will help species estimated, at least, as having a chance of temporary survival by use of specifically developed management programs of restoration. The latter choice will involve reducing the actual genetic isolation between populations and potentially founding new populations.

As populations are manipulated, particularly if they are manipulated in ignorance of genetic or taxonomic consequences, they inadvertently may be brought into contact with other populations to which they are sufficiently closely related to interbreed. The probability that adaptation will occur is low, but, paradoxically, such interbreeding may be beneficial occasionally. Such merging of disjunct populations is of major importance to a resources manager, and it is a fortunate one who can anticipate both the beneficial and possible deleterious responses of species to this contact. It cannot be overemphasized that one should gather some knowledge of species *before* attempting to manipulate either species or their habitats.

Another problem we address is communication, for frequently we hear criticism of wildlife management curricula and publications, charging that these do not meet the professional standards required in academic fields; on the other hand, we also hear that academic curricula and publications do not provide new knowledge or new discoveries in usable form for those in applied disciplines. Therefore, all the chapters included in this book have been reviewed by geneticists, applied scientists, and managers. They have been included because of their high academic quality *and* practicality. Additionally, the presentation of the material is in a format that can be read and appreciated by a variety of professional audiences and students. The most that is required is that the reader have a working acquaintance with basic biology, botany, zoology, and ecology. Because of all these facts, the book should serve well as an upper-division or graduate-level text for courses in conservation biology, wildlife and plant (including forestry) conservation, and resources management. For field managers and scientists, it should prove a valuable reference for wisely planning the specific, optimal directions that conservation programs can take and the techniques that it may be necessary to employ. Naturally, *Genetics and Conservation*, with its focus on genetics, should be used in conjunction with similar references on topics of conservation that omit such a focus. For example, there is little detail on the role of botanical gardens in conservation in this book. For more on that subject, see Brumback (1981), Simmons et al. (1976), and Synge and Townsend (1979).

The stimulus for producing this volume was the United States' Man and the Biosphere symposium and workshop, "Application of Genetics to the Management of Wild Plant and Animal Populations" held in Washington, D.C., August 9–13, 1982. Several of the speakers at the symposium were asked to contribute to this book, which we, the editors, regard as an attempt to advance the state of the art in conservation techniques.

Genetics and Conservation is the first book in the series *Advances in Conservation Biology* to be published by Addison-Wesley Publishing

Company. The purpose of this series is to accelerate the transfer of scientific knowledge and technology as they develop to the applied scientist, manager, and policy makers. For the series as well as this book, the term conservation is inclusive for a range of topics: reserve management and design, forestry, range management, wildlife management, fisheries biology, management of zoological park populations, and other similar fields connected with the long-term protection of the entire spectrum of biological diversity. (It also includes the individual treatments of habitat types or major biomes that contribute to developing management techniques specifically required for different climates and ecosystems.) We hope that this effort will promote a long-term and responsible coexistence of man and the biosphere.

Note: The editors' contributions were not made as part of their government positions and no statements by them necessarily reflect any Federal policy.

Christine M. Schonewald-Cox

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CHAPTER

1

The Place of Management in Conservation

O. H. Frankel

Introduction: Management in the Context of Conservation

When I received an invitation to prepare a key chapter for a book on the genetic management of wild species, the question arose in my mind: To what extent is management of wild species supportive of conservation, and to what extent could it negate the purposes of conservation? Of course, management of wild species can have many objectives other than conservation. Yet the guidelines I received established conservation as the central theme in emphasizing the role of genetics in attempts "to enhance the survival of wild plants and animals." Indeed, the application of genetics suggests a long-term concern, unless the main objective is commercial or recreational exploitation, which clearly is not the case here.

Enhancement of survival does not necessarily mean protection in formal reserves. Indeed, rare or endangered species can and do survive without specific protection, although it is widely recognized that in times to come many species, especially in the tropics, may have little chance of survival except through conservation. Of course, conservation may take various forms, from the strict nature reserve to the wildlife park, fishing reserve, zoo, or botanical garden. There is a similarly broad spectrum for the time factor of conservation, from the inevitably short-term, fire-brigade-like salvage of a near-vanished species, to ecosystem and habitat conservation, notionally forever. And obviously there is a similarly broad spectrum for forms and intensities of management.

Whatever its objectives, *management* is *not* a notional concept but a program and a procedure, executed or at least programmed in our time, with an impact intended to take effect on a measurable and predictable time scale. Yet this time scale – in other words, the period over which the management, its impact, or both are to be operative – can be a notional concept, since it can extend from the shortest conceivable period – say, one season or one generation of manipulating a breeding system – to a long-term commitment – for example, to maintain heterozygosity at a set level. The measures may be similar, or indeed identical, but the objectives, and, as a rule, the biological system in which management operates, will be widely different.

Thus, three basic elements of conservation are emerging. The *first* is the objective or the principal target – a species, an association, a community, an ecosystem, or a group of ecosystems. In the context of this book the target can be defined as a "rare or endangered species." The *second* element is what I have called the "time scale of concern" (Frankel, 1974), which is the time dimension for which a program is expected or projected to remain operative. This may be as short as a generation – for example, the preservation of a specific tree; or it may be in perpetuity – that is, without a perceived end point. The *third* element is management. All forms of management, even its ostensible absence, may drastically affect numerical relations between species, even their survival or extinction. Obviously these three elements of conservation interact. In general, the broader the objectives, the longer the projected time scale will be, and vice versa. For the *long-term* preservation of a single species, be it the orangutan (*Pongo pygmaeus*), the tiger (*Panthera tigris*), or the coast redwood (*Sequoia sempervirens*), preservation in a designated "orangutan," "tiger," or "redwood" reserve is a figure of speech or a public relations exercise: long-term conservation is conceivable only within the confines of the ecosystem, which becomes the real target of conservation. This will be discussed further.

The theme of this chapter is the role and effect of population management in conservation. Although the emphasis is on conservation in perpetuity, the consideration of management, as we have already seen, focuses attention on the present. This, we need to remind ourselves, is inevitable, since any generation, indeed any government of the day, has the power to maintain or to destroy the heritage from the past. Destruction or damage may come from obvious sources such as fire or the bulldozer, the shotgun or the axe, or simply from neglect. Even management measures intended to benefit the cause of conservation can be fraught with danger,