Genetics, Demography and Viability of Fragmented Populations

Habitat fragmentation is one of the most ubiquitous and serious environmental threats confronting the long-term survival of plant and animal species worldwide. As species become restricted to remnant habitats, effective management for long-term conservation requires a quantitative understanding of the genetic and demographic effects of habitat fragmentation, and the implications for population viability. This book provides a detailed introduction to the genetic and demographic issues relevant to the conservation of fragmented populations such as demographic stochasticity, genetic erosion, inbreeding, metapopulation biology and population viability analysis. Also presented are two sets of case studies, one on animals, the other on plants, which illustrate a variety of approaches, including the application of molecular genetic markers, the investigation of reproductive biology and the combination of demographic monitoring and modelling, to examine long-term population viability. This book highlights the value of conducting integrated and inclusive studies for effective conservation management and will be of value to all those working in this crucial area of research.

ANDREW YOUNG is a Senior Research Scientist at the Centre for Plant Biodiversity Research, CSIRO Plant Industry where his research focuses on plant population genetics and ecology. He has published extensively on the genetic consequences of habitat fragmentation and the implications for plant conservation. He is co-editor of *Forest Conservation Genetics* (2000).

GEOFF CLARKE is a Senior Research Scientist at CSIRO Entomology and founder Research Leader of Conservation, Molecular Ecology and Systematics, Australia's first insect conservation biology project. He has worked extensively on insect genetics, particularly on the genetic consequences of habitat fragmentation for insect species. He has been responsible for the preparation of a number of Recovery and Action Plans for threatened invertebrate species in Australia and has also contributed to conservation and biomonitoring programmes throughout the world.

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Foreword

When I was a graduate teaching assistant in vertebrate biology 35 years ago, I could take my students to a location a few miles out of town and show them eight of the nine species of lizards that are found in western Nevada. Now gone as natural habitat, the location is now a subdivision bordered by a strip mall. These same lizard species are also very scarce for several miles beyond the subdivisions. There they have been eliminated by the house cats kept by the owners of 20-acre ranchettes. Farther out into the desert it is very hard to find a lizard within a mile or more of a road; commercial collectors have captured most of them and sold them to pet dealers in the eastern United States. Now I show my students specimens of dead lizards, kept in my laboratory in dusty, alcohol-filled jars.

Similar scenarios are played out relentlessly all over the world as the human enterprise expands and natural habitats disappear. None of the lizards of western Nevada is as yet threatened with extinction, but others in adjacent states are. Of the 10–20 million species of plants, animals, and microbes estimated to be extant, perhaps half will become extinct in the next millennium. Most of these will disappear anonymously – unknown and undescribed by science. Others, with proper scientific names, will vanish quietly, their epitaphs simply stating, 'last collected in 1999.' A few charismatic species – primates, colorful birds, butterflies – will be kept from extinction by captive propagation, but most have no hope of ever returning to their long-since fragmented and degraded natural habitats. The survivors of this massive extinction event will be the ecological generalists, the weeds, the invaders.

Why should we care? Some of the species doomed to extinction may hold the cure for an emerging disease in their genetic codes; others might have become nutritious crop plants or useful domesticated animals. Some species may be keystones in certain ecosystems, their importance unrecognized until they disappear and the ecological services that their ecosystems provided then diminish or fail. Our knowledge base will be poorer; we will

never know the life histories, ecological roles, or potential utilitarian value of many thousands of extinct species. In aggregate, the global depletion of biodiversity – the genetic information, the species, and the ecosystems in which those species occur – will have negative effects on our economic and physical well-being. Even more important, as each extinction erodes the biological legacy that our descendents will inherit, part of our humanity slips away. Stewardship for the planet and its inhabitants will have been lost, replaced by greed, ignorance, and short-sightedness.

Conservation biology emerged about 20 years ago to provide the underlying science needed to slow the extinction crisis. This relatively new discipline draws on information from the basic sciences of population and evolutionary biology, ecology, biogeography, and genetics and from the more applied domains of wildlife biology, fisheries science, forestry, and rangeland management. The focus of conservation biology is simultaneously broad, seeking to understand the interactions among large landscape elements and the species they contain, and narrow, concentrating on individual species that are immediately imperiled. The metapopulation paradigm bridges these two foci, connecting the spatial structure of landscape elements with the population dynamics of individual species.

This book provides the conceptual framework for examination of the impacts of fragmentation, supported by a number of case studies that integrate both demographic and genetic analyses into the conservation of imperiled species in fragmented and degraded landscapes. The applications of sophisticated molecular tools, population viability analysis, spatial modelling, and classical genetics to conservation problems are well represented in these studies.

Recently, a well-known American resource economist Randal O'Toole stated: 'conservation biology is not a science but a political movement based at least in part on nineteenth-century ideals of what an ecosystem is all about.'[1] If those ideals include the notion that the world's biodiversity is worth saving, O'Toole is at least partly right. But anyone who reads this book will understand clearly that O'Toole is wrong in his contention that conservation biology is not science. The material presented here is testimony to how good science may yet slow, and perhaps eventually arrest, the extinction crisis.

Peter F. Brussard
Past President, Society for Conservation Biology

[1] O'Toole, R. (1999). *Subsidies Anonymous, #36*. The Thoreau Institute, PO Box 1590, Bandon, OR 97411, USA.

Preface

Since the publication of Soulé & Wilcox's *Conservation biology: an evolutionary–ecological perspective* in 1980, there has been a steady string of multi-authored works on conservation biology, most notably the other two Soulé books, *Conservation biology: the science of scarcity and diversity* (1986) and *Viable populations for conservation* (1987) and Schonewald-Cox *et al.*'s *Genetics and conservation: a reference for managing wild animal and plant populations* (1983). In addition, there has been a recent surge in the number of conservation biology textbooks available for both undergraduate and post-graduate teaching.

So we might ask ourselves, is there a need for another work in an already overcrowded field, and what makes this volume different from all the others. Many of the earlier works were written at the time that conservation biology was in the process of defining itself and finding its feet as a rigorous scientific discipline. As a result, and as could be expected, many of the individual contributions to these works were written from the perspective of the individual authors' traditional backgrounds in ecology, genetics and resource management and adapted to suit the growing concern of species decline. In addition, the works were very broad in coverage reflecting the very broad scope of conservation biology, ranging from biodiversity loss on large scales through deforestation to impacts on individual species and populations. These works made an invaluable contribution to promoting both an awareness and acceptance of conservation issues both within academia and land-use management agencies and laid the groundwork for much of modern conservation biology as a science.

Over the last 20 years conservation biology has matured, building on the concepts outlined by these early editions, to become a rigorous scientific discipline with its own theoretical framework based on the traditional fields of ecology, genetics and biogeography and applied to small and declining populations. This volume seeks to reflect this new level of maturity. By

focusing on the most ubiquitous and pervasive of all threats to long-term species survival, habitat fragmentation, the book provides the necessary relevance to the bulk of modern conservation efforts. The introductory section provides the theoretical context for explaining and predicting the demographic and genetic consequences of fragmentation. The subsequent two sections present a number of empirical case studies on animal and plant species respectively. These case studies, which integrate ecological, genetic and population biology approaches for assessing impacts of fragmentation, exemplify the development and coming of age of conservation biology as a science. We believe the book will be equally at home in the classroom as on the desk of the professional conservation biologist.

Like conservation biology itself, this book has matured (and grown) since its original concept. The idea for the volume grew out a symposium of the same title held as part of the 12th Annual Meeting of the Society for Conservation Biology in Sydney in 1998. This symposium attracted enormous interest with 11 oral presentations and 20 posters. Many of these contributions form the basis of the empirical studies included in the book. We subsequently decided that these studies needed a theoretical context and thus solicited the contributions included in the introductory section from leading authorities. We have tried to ensure the book is both taxonomically and geographically representative, thus our list of contributors and their study organisms has a global distribution.

The book would not have been possible without the help of our many colleagues. All chapters were peer-reviewed by at least two referees and for this we thank the following: Fred Allendorf, Jon Ballou, Dave Boshier, Dave Coates, Paul Downey, Dick Frankham, Sue Haig, Kringen Henien, Susan Hoebee, Bob Lacy, Gordon Luikart, Georgina Mace, Eric Menges, Neil Mitchell, John Morgan, Phil Nott, David Paetkau, Rod Peakall, Katherine Ralls, Dave Rowell, Kat Shea, Andrea Taylor, Phil Taylor, Pete Thrall, Bob Wayne and Gerry Zegers. Environment Australia provided financial support for the original Society for Conservation Biology symposium. Finally, we thank Alan Crowden and Maria Murphy of Cambridge University Press for their support, encouragement and excellent editorial and production skills.

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