Chapter 1
Introduction: Influences of Human Population on Biological Diversity

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1.1 Introduction

This volume is the result of an effort to document the state of research and promote progress in addressing a fundamental question facing conservationists: What can the dynamics of *Homo sapiens*' demographic and geographic distributions tell researchers and conservation practitioners about the status of, and prospects for, biological diversity? This question lies at the core of a field of study that, despite its logic and promise, remains remarkably underdeveloped. Yet finding answers to that question and applying general lessons learned from the answers may well be essential to maintain what remains of Earth's biological diversity.

From our vantage point, biodiversity conservation may have only modest hope of achieving any measurable degree of success. Human activity currently consumes roughly 40% of our planet's *annual gross terrestrial primary productivity* (the biomass produced through photosynthesis). Our species has already converted almost one-third of the terrestrial surface to agricultural fields and urban areas (United Nations Development Program et al. 2000; Vitousek et al. 1997). And this wholesale transformation of our planet's biosphere is anticipated to continue at an alarming rate. Global human population, which reached the 2.5 billion mark in 1950, has been estimated by the United Nations Population Division (2009) at about 6.9 billion in mid-2010. According to their most recent revision, UN demographers project that by 2050, human population will range between 7.8 billion (the UN low fertility variant) and 10.8 billion (high fertility variant), with a best guess of about 9.2 billion (the UN medium fertility variant). Unlike the past, much of this growth will occur in the humid tropics in and around ecosystems that support the planet's richest concentrations of endemic species (Cincotta and Engelman 2000; Cincotta et al. 2000). It is reasonable to expect that these people's rights to decent housing and adequate nutrition, clean water, sufficient energy, and a means to participate in their state's economy will supersede efforts to protect nonhuman species from extinction. Several researchers have reported relationships suggesting various influences of human population density, growth, and migration on biodiversity, at the global and regional scale (Gorenflo 2002; Holdaway and Jacomb 2000; Martin 1984; McKee et al. 2003), and the composition of biological communities, at the

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local scale (Hoare and Du Toit 1999). The research in this volume provides further evidence on how the settlement patterns of humans, the densities at which they live, and the ways they connect these settlements to others set limits on the richness of species on Earth and pose challenges to attempts to conserve them.

1.2 Objectives

In assembling this volume, we endeavored to review a significant breadth of the human geographic and biogeographic research literature that addresses the relationships between human settlement, locally native species, and their ecosystems. This breadth emerges as analyses at three geographic scales: the global scale, the level of the biome, and the level of local ecosystems. Approaches range along a spectrum, from work that is almost purely theoretical to highly empirical research that organizes and analyzes available data.

In writing their chapters, the authors of this volume were asked to review relevant theories, both established and those arising from their own research, and to identify empirical indicators and observations that they found germane to investigating relationships between populations of native species and aspects of human demography and geography. We charged them to suggest where such theories and observations should lead researchers in the future and to identify gaps where theory and empirical reinforcement appeared to be lacking. Both social and biological scientists have contributed chapters to this effort, though they have presented their work in a manner accessible to a wide audience. By compiling within a single volume papers that share a focus on human settlement and biological diversity, we hope to provide readers with both a sense of the varying relationships between human populations and other species and a range of possible approaches to assessing problems in the human sciences of relevance to conservation biologists.

1.3 Status of the Field

Why is this field so underdeveloped? One possible answer lies in the expansive social, economic, and cultural variation found within the current human species and the complex changes occurring to populations of *Homo sapiens* within these domains. Because of this variation, researchers find it difficult to characterize trends in the relationship of a human settlement to communities of other biotic species without considering the array of production systems and their human-associated species, the access of its human inhabitants to economic assets and technology, and their attachment to a broader economy.

Another reason for this field’s lack of development is its unique placement along the well-guarded boundary separating the biological sciences from the social sciences – a *no-man's land* infrequently traversed in academia that requires researchers to venture into areas beyond their area(s) of specialization. Several contributors to this volume are trained or experienced in both the biological and social sciences, and most conduct research programs either outside university settings or within academic institutes of applied analysis, where interdisciplinary traditions survive and are encouraged. The role of humans in biodiversity conservation is of interest to social scientists, and its problems could benefit from social scientific analyses – *Homo sapiens* is a primate of remarkable adaptive and cooperative abilities, with highly developed facilities for tool invention, production, and use and a unique capacity for communication. These are the foundations of *culture*, the means by which people adapt to, and transform, their natural and human environmental surroundings (Steward 1955). By developing and transmitting culture, humans have acquired behavioral flexibilities that free them from the constraints of biological adaptation which limit the distribution of other species. In so doing, our species has imposed its populations and their behaviors, and populations of associated species and their behaviors, on an unprecedented range of interrelated ecological systems.

1.4 Organization and Content

The volume is divided into three sections. The first comprises chapters presenting general theories and broad empirical relationships, which help explain dramatic changes in the patterns of occurrence of terrestrial and aquatic species that have developed in parallel with human population growth, migration, and settlement. The second section focuses on specific biomes and ecosystems as the context for human interactions with other species. Beyond their informational content, these chapters provide insights into the utility of using demographics and human geography to evaluate relationships between human settlement and the population dynamics of both native and nonnative species. The third and conclusive section comprises a discussion of the prior two sections by geographers Thomas Crawford and Deirdre Mageean.

The volume begins with a chapter by Lee Hachadoorian, Stuart Gaffin, and Robert Engelman, who present a map of the world's population future (Chap. 2). To generate a map of spatially distributed human population for the year 2025, the authors apply two simple, but well-considered, extrapolation techniques to project gridded population data. To test their extrapolation techniques, to identify systematic weaknesses in these methods, and to help them produce an algorithm that circumvents methodological pitfalls, they apply their techniques to a time series of spatial population estimates of the United States published by the US Census Bureau. Their research wrestles with basic problems of projection anomalies that need to be considered if demographers are to project human population's spatial distribution, whether globally, regionally, or locally, and it subdues these problems with reasonable, applicable solutions. The essay should prove extremely valuable to those undertaking similar challenges of spatially explicit projections of human population.

The essay by Christopher Small (Chap. 3) characterizes the global physiographic distribution of human population using overlays of Earth's physiographic features with that of temporally stable lights sensed at night from satellites. Small's objective is to provide a quantitative description of modern population distribution using a few basic environmental factors that may also influence the spatial distribution of biodiversity. His results suggest that because the vast majority of human population growth is projected to occur in and around urban areas, or in urbanizing areas, continued population growth in the biologically rich humid tropics and subtropics will likely focus on specific physical environments where urbanization is currently taking place. However, population remains stable or slowly growing in most of the rural areas of tropical and subtropical regions. Small's findings suggest that human adaptation to climate will cause expansion of the human habitat, whereas clustering with respect to the physical landscape will result in a simultaneous spatial concentration of population within the expanding habitat. The spatial distribution of population is strongly localized with respect to continental physiography (elevation, coastal, and fluvial proximity) but much less localized with respect to climatic parameters (annual mean and range of temperature and precipitation), resulting densities varying considerably.

In their chapter, Jeffrey McKee and Erica Chambers (Chap. 4) explore the role of human population in biodiversity loss, considering both total population and behavioral characteristics of population. Taking a global perspective, this study expands on McKee's previous arguments that sheer numbers of people and population density in the prehistoric and historic past has led to considerable biodiversity loss. Here the authors consider two variables that introduce characteristics of human behavior, addressing the important consideration that it is not necessarily just the number of people present but *what people do* that affects biodiversity. Their regression analyses of global population and biodiversity data, using information presented at the national level, indicate varying importance of gross national product and agriculture in determining the number of threatened species per nation, though ultimately preserving the importance of population density as a key factor in global biodiversity loss in modern settings as well as the past.

In Chap. 5, Richard Cincotta reviews three models that he considers relevant to human–biodiversity relationships and suggests that these could be modified and applied by researchers to help conceptualize, hypothesize, and in some cases, predict system dynamics. The first model, which applies the average adult body weight of *Homo sapiens* to statistical models predicting mammalian herbivore and predator density, suggests the degree to which our species has modified the landscape and channeled energy and nutrient flux in order to achieve densities that are today nearly three orders of magnitude greater than predicted for preagricultural humans. The second model examined by Cincotta makes explicit three types of risks to the viability of populations of native species: risks within the protected area, risks from between-area hazards, and risks at the reserve perimeter. The third model examined appears as a graphic representation of Boserup's (1965) theory that the demands of increasing human population drove agricultural innovation, in an attempt to make this theory more useful to ecologists.

Katalin Szlavecz, Paige Warren, and Steward Pickett review a very important, and much neglected, aspect of the human population–biodiversity interface, namely that existing in and near urban settings (Chap. 6). Although much of the focus on biodiversity, and indeed much of the focus of the chapters in this volume, involves more remote settings, an increasing amount of the Earth's surface is covered by dense human settlement and infrastructure best described as "urban." In their overview of biodiversity in such settings, Szlavecz and colleagues describe a variety of studies that document remarkable species richness in localities with high densities of human population. Several of the studies discussed explore how biodiversity changes with the ecological shifts accompanying dense concentrations of people in highly altered environments. As urban growth continues at unprecedented rates over the coming decades, the potential role of densely settled places in global biodiversity will grow markedly, as will the need to increase our understanding of this biodiversity.

Robin Abell, Michele Thieme, and Bernhard Lehner (Chap. 7) note that the literature on the use of landscape indicators to assess aquatic ecological integrity has grown substantially, but primarily through studies conducted in the developed, data-rich temperate world. In their chapter, they show how global and regional threat assessments can be undertaken, inclusive of data-poor regions, using human population density estimates as a "coarse proxy" for more specific indicators of disturbance. They warn, however, that although such proxies can correlate with biotic and abiotic measures of threats to freshwater species viability, they are best used for priority setting at the global, regional, and large-watershed scales. And they argue that such surrogates provide the conservation planner with neither an indication of the specific nature of local aquatic-ecological threats nor of possible policy solutions. Abell and her colleagues contend that research should address key data gaps that hinder scientists' ability to identify thresholds and ultimately mitigate threats to native aquatic populations, such as the relationships between local land use patterns and disturbances, and aquatic habitat quality. The authors conclude by noting a fortuitous shared interest: human communities' desire to safeguard freshwater quality overlaps significantly with the goal of bio-conservationists to maintain native aquatic communities.

The essay by Flora Lu and Richard Bilsborrow (Chap. 8) focuses on five distinct indigenous peoples in the Ecuadorian Amazon, examining how they differ demographically and how these demographic differences influence economic activities and, ultimately, environmental impacts. This sort of study, which examines humans as part of ecosystems composed of people and a range of other species, is of interest in its own right. The insights it provides on human adaptation – essentially on the *ecology* of people with respect to various demographic characteristics – are useful to bio-conservationists and reserve planners because it explores how the peoples in question use their resources and how varying patterns in resource use effect local biodiversity. To some, its greatest contribution may be in revealing some of the rich complexity of the ecology of indigenous peoples, emerging as contrasting

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