Introduction: the role of science in conservation

The impetus for this book began as the result of a rather fortunate convergence of the careers of the authors at the University of Georgia. Although we were educated in traditional wildlife management programs during the 1970s and 1980s, we both developed an interest in what is now better defined as conservation biology. Interestingly, we underwent an evolution in our thinking, leading to similar ideas relative to what we perceived as weaknesses in our own profession and to how the creation of conservation biology as a profession, while addressing some of these weaknesses, fell short in many areas. We have also become increasingly involved in international issues in wildlife conservation, leading to further career intersections with other collaborators. Indeed, we have discovered that our interest in mixing conservation and science transcends political boundaries and sub-disciplines.

Evolution of conservation science

The integration of science and conservation of wildlife has quite a long history and is found in many forms. Game management in Europe and North America is based on the fundamentals of agricultural management and animal husbandry. This form of conservation biology is essentially the treatment of stocks of wild animals as domestic livestock and has evolved over hundreds of years. In both North America and Europe, wildlife management as a profession developed over much of the twentieth century following a somewhat parallel course that focused on particular species or groups of species and their management. The resulting body of literature and understanding of the population dynamics of those species and their management is enormous and some of the best information is available on vertebrates.

A second development occurred during the latter part of the twentieth century as interest and concern for the diversity of wildlife in mainly tropical parts of the world moved to the forefront. Scientists who worked predominantly in the area of ecology theory began several attempts to integrate ecology as a science with biological conservation. Driven in large part by North American and Australian scientists and coming to fruition by the late 1980s, we see the wholesale movement of scientists who traditionally dealt with empirical questions in ecology adopt an additional strategy concerned with the conservation of biological diversity.
The above developments resulted in several scientific disciplines, each with different strengths, converging to form scientific conservation biology. We believe that each discipline brings different strengths to conservation science. For example, wildlife management in North America has an excellent track record of applying scientific research to management and policy making. By contrast, the discipline of conservation biology has generally excelled at integrating ecological principles and conservation. The third important component here is the popularization of conservation among the general public which has resulted in an enormous influence of popular culture and activism on conservation and biodiversity management.

These developments then leave us with two scientific disciplines – wildlife (and/or game) management and its sister profession conservation biology. These disciplines can aptly be described by the general heading applied ecology, and are driven in part by non-scientific goals. This creates an interesting and sometimes complex series of relationships that can affect the ability of professional “applied ecologists” to strive toward their scientific objectives of obtaining reliable knowledge. We encounter several issues that are critically important at this juncture. First, as with any applied or endpoint-driven research, we must be particularly careful that our research does not simply become a series of self-fulfilling prophecies. Just as in theoretical–ecological research, our preconceptions about how systems operate must not cloud our ability to undertake objective research. In many ways the goal objectivity is easier to attain in theoretical research, because the results of theoretical research might only involve individual egos and career development, rather than ecological systems and biodiversity that we as individuals and conservation biologists hold dear to us. Over the course of history in scientific endeavors someone who develops some “new” theory would be under some pressure to defend the theory and other scientists might strive to find evidence to falsify it. These traditional scientific tensions are also important in applied research; however, there are now the added pressures created by outside forces from those having a stake in the outcome of research. This is because conservation scientists operate within a socio-economic-political “real world” that includes other values and tradeoffs. Even with a sympathetic public, conservation scientists and managers must act responsibly to allow policy makers to make the best decisions possible, often with limited resources and competing demands.

Conservation advocacy versus science

We distinguish between conservation advocacy – where conservationists become directly involved in promoting policies relative to biological diversity – and conservation science – which uses science to help society make more informed decisions. The latter is the target of this book. We believe that by adopting a scientific approach, not only is science better served, but also in the long-term conservation will be better served. The task is to simultaneously increase our understanding of systems in a dynamic world

\footnote{Interestingly, theoretical biologists now find that outside influences are very much invading their realm, including recent debates involving religious organizations in the USA and other countries over evolutionary theory and natural selection.}
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1-Good data, but poor understanding of the system.

Data

Understanding of system

2-Poor data, but good understanding of the system.

3-Good data and good understanding of the system.

4-Poor data and poor understanding of the system.

Fig. 1.1 Classification of the relationship between data collection and understanding of systems. In theory we would like all of our conservation questions and issues to move into Box 3, where we have good data and good understanding of the system. Box 1 represents poor use of conservation effort and money. Boxes 2 and 4 represent the place where conservation biologists are starting their research on a particular issue.

and to provide decision makers with the necessary information. This is why we believe that **modeling** approaches and **adaptive management** are critical components of the conservation research "system."

In this book we will often use **models** to summarize how we think a particular population or other resource behaves and might respond to various factors, including management. Our models will involve a combination of (i) our understanding of basic biological processes, and (ii) data available to support the various model components (Figure 1.1, from Williams *et al*. 2002, p. 112). Typically we will need to increase each of these two factors, as represented by the x and y axes of the graph (Figure 1.1). On the x axis, we wish to move to the right, which represents increasing understanding of the mechanisms driving a particular system. On the y axis, we move vertically as we increase the amount of data available on the system or parts of it. The box itself represents general areas of data quantity and system understanding. Ideally we should be in Box 3, where we have good amounts of empirical data and also good understanding of how particular systems operate. This is why we can use our understanding of gravity, material properties, and other components of physics to build bridges – which generally do not fail. Although this works well in many of the physical sciences, the complexity of combining biological and social/political issues makes this a difficult direction to move in for conservation questions or issues. More likely we are working in Boxes 2 or 4, where we lack data, knowledge, or both. In fact, in dealing with some conservation questions and species outside of the charismatic megafauna or well-studied game species, we are often starting in Box 4 with the proverbial “blank slate.” Making matters worse is the fact that biologists are often in the position where policy and/or management
recommendations are expected after a single inadequately funded study. Although never ideal, this is political reality. Beginning in Box 2 is slightly better because we can use our base knowledge of similar systems to hopefully give us a stronger starting point. In both of these scenarios (Boxes 2 and 4) modeling approaches combined with good data collection will be useful. In wildlife conservation and tradition game or wildlife management in North America and Europe we may also be operating in Box 1. We may have high-quality and long-term biological data, but in many cases our understanding of the mechanisms driving systems for issues we are interested in tackling is still lacking. The integration of science in conservation management will ultimately provide the foundation for more informed conservation decisions and management.

**Good science is cost effective**

One of the common issues in conservation biology is the problem of inadequate funding. Outside of a few areas of conservation that can garner large amounts of money, most conservation biologists are faced with enormous questions and tasks, but limited time and financial resources. Even in programs that are relatively well funded, such as game management in North America and Europe, the scale at which many biological questions should be addressed and the resources that are available often are quite disparate. Conservation research competes for limited funding with conservation implementation (“management”). This means that if funding for research increases then funding for management decreases and *vice versa*. The only way to “win” at this zero-sum game is to improve efficiency. As we will argue in a number of places in this book, bad research is almost worse than no research. It can lead to wrong conclusions and wrong management.

In this book we argue that poorly designed conservation research projects also steal resources from conservation. That is, spending money on bad science not only wastes that money, but also takes money from good science and good management. Thus good science combined with improved efficiency will yield better conservation.

**Conservation under fire**

More and more frequently we are faced with skeptical and even hostile groups, who demand that conservationists “prove” claims of adverse impacts of desired development, ecological benefits of restrictions of forest logging or other resource consumption, proposed reserve systems, or declaring a species endangered, to name a few. While it can never be possible to “prove” (in the logical sense) such assertions, it is possible to collect and analyze data in such a way that the evidence so provided is repeatable and defensible. Conversely, data collected or analyzed in an unscientific way lead to conclusions that, while perhaps intuitively reasonable, are not repeatable, and will not stand up to scientific scrutiny. Increasingly the opponents of conservation projects are technically informed, and will eagerly reveal conclusions made by the conservation community that are based on flawed approaches. Here we emphasize that ethical, scientific conservation
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includes the honest reporting of study and data flaws, so that results may be appropriately interpreted. Improper reporting of results, especially to exaggerate certitude of estimates or effects, is both unethical and, in the long term, counter-productive, because when (inevitably) discovered the resulting loss of credibility can be devastating (Beier et al. 2006; Conroy et al. 2006).

Structure of the book

We envision this book as a practical and hands-on resource for field biologists. This book should be analogous to the field identification guides. It is the book you take with you and use all the time, but is not the one where you go to obtain the in-depth theory or mathematical derivations. We hope it complements some recent volumes, such as Williams et al. (2002), in assisting practitioners and students. We also envision the book being used in short courses for field conservationists. In fact, the impetus for this book came as a result of the participation of I.P.C. and M.J.C. in development of a week-long short course following the main conference in each of the last three International Galliformes Symposia.

Part I covers mainly the background we believe all biologists should review when presented with a conservation problem or question and asked to develop a research program. Chapter 2 provides some basic concepts in modeling. This is not “ugly” and complex modeling that most field biologists fear, but practical modeling that assists us in problem solving. Chapter 3 is a review and application of some basic population models. Chapter 4 deals with the issues of applying models to conservation questions. Chapter 5 provides a basic review of study design. Again, this part of the book is setting the stage for couching conservation questions in a way that makes our research more scientifically sound, economically efficient, and defendable.

Part II moves on to those topics of most importance to field biologists in collecting appropriate data in answering conservation questions. In Chapter 6, we begin with the general principles of estimation. Chapter 7 is a basic overview of occupancy studies. We believe that occupancy research is underutilized, but will eventually be viewed as one of the most important techniques in conservation. Chapter 8 covers the estimation of abundance from sample counts, and introduced the importance issue of incomplete detection, a recurrent theme through the book. Chapters 9 covers the basic principles of distance sampling, including line transect and point counts (the latter are also now called point transects). Chapter 10 provides background on mark-recapture (re-sighting) and mark-removal sampling in abundance estimation. Chapter 11 focuses on the estimation of demographic rates using data from radiotelemetry, nesting success, and age distributions. Chapter 12 expands on the issues of demographic parameters by incorporating some aspects of Chapters 10 and 11. Chapter 13 deals with the issue of habitat use and selection. Finally, in Chapter 14 we touch on some sampling and estimation issues for wildlife communities.

In Part III we begin to apply modeling and estimation tools to conservation decision making. In Chapter 15 we describe how conservation goals can be combined with
predictive models and used as tools for decision making. In Chapter 16 we deal with issues of uncertainty in research and conservation decision making. We remind readers that in the real world we are faced with profound uncertainties, in part because nature cannot be controlled, but also because of our incomplete understanding of how ecological systems work. This leads on to Chapter 17, in which we show how monitoring information can be integrated into decision making, leading to adaptive management. In Chapter 18 we illustrate many of the principles of the book via an example of conservation of grassland birds in North America. Chapter 19 provides a short summary of the book.

We also provide several appendices that we hope readers will find useful. Because many readers will be familiar with some but not all the terminology we use, in the Glossary we provide a comprehensive list of terms. See p. ii of this book for numerical examples in electronic form with a detailed accompanying narrative. In Appendices A and B we provide links to sites where software and other resources can be obtained, much of it at no cost. In Appendix C we provide a comprehensive explanation and cross-referencing for modeling and statistical notation. Finally, in Appendix D we provide a dichotomous key for abundance and parameter estimation that can be used to assist in identifying appropriate estimation techniques, in much the same way that taxonomic keys are used to aid in animal or plant identification.

We especially hope that the chapters in this book give field conservationists the courage to tackle some new ways of viewing conservation problems. This is where we believe this book is most useful – in taking the fear out of quantitative and modeling approaches to conservation, and making field conservationists realize they are not “black boxes” that are to be relegated to “systems ecologists” locked away in an office somewhere.