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Improving Natural Resource Management
Ecological and Political Models

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Dedicated to the next generation of ecosystem managers
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Preface

This is a how-to book for finding the most politically acceptable but effective plan for managing an at-risk ecosystem. In this book, finding such a plan is accomplished by first fitting mechanistic political and ecological models to a data set composed of both observations on political actions that impact an ecosystem and observations on variables that describe the ecological processes that are occurring within it. Then, the parameters of these fitted models are perturbed just enough so as to produce desired ecosystem state endpoints. This perturbed model gives the ecosystem management plan needed to reach the desired ecosystem state. To construct such a set of interacting models, topics from political science, ecology, probability, and statistics are developed. These group decision-making models capture group belief systems in their structure and parameter values. Hence, perturbing parameters to achieve needed shifts in behavior to cause desired ecosystem responses is equivalent to asking the question: ‘What is the smallest change in group belief systems that would cause behavioral changes towards the ecosystem that would, in turn, result in the ecosystem responding in a desired way?’ By focusing on belief system change, the tool is ideally suited to a non command and control ecosystem management system. Such non hierarchical management systems describe many at-risk ecosystems including those that straddle country boundaries. The book’s running example is of one such trans-boundary ecosystem management case: conservation of cheetahs across Kenya, Tanzania, and Uganda (East Africa).

To demonstrate the proposed management tool’s wide applicability, a sketch of how the tool could be used to manage the world’s remaining population of blue whales is given in Chapter 2. These two examples of managing at-risk species are appropriate for a book devoted to managing natural resources when biodiversity is viewed as a natural resource.

Two types of readers will get the most from this book. The first type of reader is a person who is in, or is training for, a job in environmental and/or wildlife management wherein one of the decreed management goals is the protection of some part of the ecosystem, for example, wildlife that is at threat from anthropogenic forces. This first type of reader might be a student in a natural resources management program – or a member of a forestry, fish and game, national park, environmental protection agency, or other conservation-focused agency. This reader might also be employed by a wildlife advocacy organization such as the African Wildlife Foundation or the World Wildlife Fund. The prerequisites needed by this first type
of reader are some familiarity with natural resources and elementary statistics. This type of reader should read Chapters 1–5 to acquire a working knowledge of how to use the book’s methods to manage an at-risk ecosystem. Section 4.3 in Chapter 4 does, however, contain material that is best understood by a reader possessing a knowledge of calculus-based probability and statistics along with the notion of a vector of random variables.

The second type of reader is one who is trained in both the social sciences and mathematical statistics and is interested in how social science theory, ecology, probability, inferential statistics, and computers can be synthesized to create a decision support system for the scientific management of an at-risk ecosystem. This second type of reader would typically be a student or academic in political science, political economy, ecology, natural resources management, or statistics. This type of reader would be best prepared by having some background in one or more of the areas of political science, ecology, or mathematical statistics. This reader should read all of the book’s chapters in order.

This book has the following pedagogical features:

1. The East African cheetah management application of the proposed ecosystem management tool is used as a running example through all of the chapters.
2. Exercises are at the end of most chapters – making the book suitable for a graduate lecture course on natural resource and/or wildlife management.
3. A companion website (www4.uwm.edu/people/haas/cheetah.emt) contains all computer code and data used in this book. Specifically, this website contains the software for, and an example of, the book’s main contribution: a web-based Ecosystem Management Tool (EMT). The following can be freely downloaded:

   • All software described in the book (namely, the id software package) in the form of Java source (.java) and Windows class (.class) files.
   • A user’s manual for id.
   • The political actions data set for the East African cheetah EMT along with the data collection protocol and a suite of web-based data acquisition aids.
   • The ecosystem data set for the East African cheetah EMT.
   • Output files from (a) the East African cheetah EMT’s ecosystem management plan search, (b) statistical estimation of the EMT simulator, and (c) the simulator’s sensitivity analysis.
   • A web-based tutorial that covers the basics of probability, statistics, and influence diagrams.
   • Answers to all of the book’s exercises.
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<td>ASCII</td>
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<td>Socially Optimal Management Problem</td>
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<tr>
<td>subID</td>
<td>Sub-influence Diagram</td>
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<td>TEEB</td>
<td>The Economics of Ecosystems and Biodiversity (Project)</td>
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<td>UN</td>
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<td>USA</td>
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<td>USDA</td>
<td>US Department of Agriculture</td>
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Part I

MANAGING A POLITICAL-ECOLOGICAL SYSTEM
1

Introduction

1.1 The problem to be addressed

In this book, biodiversity is considered a nonrenewable natural resource (USAID 2005, p. 6, USGS 1997, Wikipedia 2010, UFZ 2008). Many species are headed for extinction in habitats that straddle two or more developing countries. With our current understanding of biological processes (circa 2010), the loss of a species is irreversible. Because of this irreversibility, it can be argued that this problem should be of high priority to all countries. This book gives one way to address this problem.

Two characteristics of this problem make solutions difficult to find. First, within developed countries, constituencies prefer their policy makers to spend most of their conservation budget on internal conservation programs. Because of this internal focus, developing countries, with inadequate budgets for conservation programs, can expect to receive (currently) only modest supplemental conservation resources from developed countries. Second, because the habitat of many at-risk species straddles the political boundaries of several developing countries, conventional wildlife conservation strategies (such as government-run command and control programs) may not be implemented with sufficient completeness to achieve a species’ long-term survival.

These considerations have motivated the development here of an approach to ecosystem management that does not assume central control but instead, after building scientific models of both the political processes at work in the habitat-hosting countries and the dynamics of the ecosystem in which the managed species is a participant, searches for politically feasible management plans. In other words, this book proposes a two-step procedure: first understand how the political–ecological system works at a mechanistic level and only then begin a search for management
plans that require the least change in human belief systems in order to effect behavioral changes that result in a sequence of actions that leads to the survival of the species being managed. The term political–ecological system is used rather than socio-ecological system to emphasize the active, institution- and ecosystem-changing tendencies of human groups across an ecosystem.

Such an approach to ecosystem management is different from so-called ‘adaptive management’ because it emphasizes a positivist and reductionist understanding of the entire political–ecological system before attempts are made to manipulate it. Adaptive management, on the other hand, can be viewed as a sequence of ecosystem management experiments that are conducted with the hope that a successful strategy will be found before the managed species becomes globally extinct. For example, Moir and Block (2001) argue that adaptive management’s eight-step cycle of Propose Actions, Form Hypotheses, Determine Data Needs, Design Monitoring Program, Install Monitoring Program, Monitor, Analyze Collected Data, Implement a Management Action results in a monitoring protocol over a time scale that is not derived from an understanding of the ecosystem’s dynamics but, rather, is short in duration so that feedback (adaptation) can be used to possibly adjust the management plan. These authors argue that this forced short time interval in the feedback loop invites ‘False Effects’ to drive management action revisions. Further, many applications of adaptive management depend on statistical hypothesis testing which, in turn, usually relies on linear statistical models of ecosystem processes rather than mechanistic, (possibly) nonlinear models of ecosystem dynamics that may be dominated by cycles with long periods (Moir and Block 2001).

But in this author’s view, wildlife management is in a state of crisis. Environmental degradation and loss of biodiversity are occurring at unprecedented rates while efforts to stem this often-irreversible damage are on the whole inadequate. Funding for these problems, however, is low relative to other fields such as defense or human health. In developing countries, where most species reside, such funding is glaringly inadequate. The ecosystem management problem on the other hand is complex in that effective management strategies need to take into account how political realities impede or promote the implementation of options that could protect an ecosystem. If a freely available system, based on the best available science, existed and was capable of finding politically feasible but effective (this book’s definition of ‘practical’) ecosystem management plans, managers and observers of at-risk ecosystems could use this tool to develop specific, defensible proposals for stemming this destruction. Because of their practicality, these proposals would have the best chance of actually being implemented.

There is a dearth of books that combine the social sciences and conservation and few individuals have training in both areas. The need to integrate the social sciences and conservation disciplines, however, has been recognized by the conservation community, see Fox et al. (2006) and Liu et al. (2007) for extended discussions of this deficiency.

Decisions to actually implement an ecosystem management policy typically have a political component. The majority of current ecosystem management research, however, is concerned with ecological and/or physical processes.
Management plans that are suggested by examining the output of these models and/or data analyses may not be supported by the affected human population unless the option addresses the goals of each involved social group (hereafter, \textit{group}).

As a step towards meeting this need, this book describes an Ecosystem Management Tool (EMT) that links political processes and political goals to ecosystem processes and ecosystem health goals. Because of this effort to incorporate the effects of politics on ecosystem management decision making, the EMT described in this book is referred to as a \textit{politically realistic EMT} – or simply the \textit{EMT}. This tool can help managers identify ecosystem management plans that have a realistic chance of being accepted by all involved groups and that are the most beneficial to the ecosystem. Haas (2001) gives one way of defining the main components, workings, and delivery of an EMT (referred to there as an Ecosystem Management System). The central component of this EMT is a quantitative, stochastic and causal model of the ecosystem being managed and the social groups involved with this management. This model is called the \textit{political–ecological system simulator} (hereafter, \textit{simulator}). In this simulator, group decision-making models and the ecosystem model are developed in a probabilistic form known as an influence diagram (ID) (see Pearl 1988, p. 125). The other components of the EMT are links to data streams, freely available software for performing all ecosystem management computations and displays, and, lastly, a web-based archive and delivery system for the first three of these components.

The two main uses of the EMT are first to find practical ecosystem management plans, and second to allow any literate person with access to the Web the ability to assess for themselves the status of a species being managed with the EMT. This second use is intended to make more accessible to developed countries the status and challenges of managing critical ecosystems in distant, developing countries.

A core message of this book is that ecosystem analyses and optimal management plan studies cannot be one-off and performed at only one time point. Rather, such applied ecosystem research needs to be on going and constantly updated. Present journal publishing practices encourage one-off studies but ecosystems are on going and dynamic. The tools contained in this book’s EMT are in part meant to make such on going analysis easier to perform repeatedly and more cost effective in both hardware and labor.

\section{1.2 The book’s running example: East African cheetah}

To fix ideas and to show feasibility, a politically realistic EMT for the management of the cheetah (\textit{Acinonyx jubatus}) in a portion of East Africa is developed and applied as a running example throughout the book. The cheetah is listed as \textit{vulnerable} in the Red List of Threatened Species maintained by the International Union for Conservation of Nature (IUCN) (Cat Specialist Group 2007). The portion of East Africa studied in this example is the land enclosed by the political boundaries
of Kenya, Tanzania, and Uganda (Figure 1.1). This ecosystem involves at least the cheetahs themselves, their prey, and the habitat in which these animals live. Humans are also a part of this ecosystem but here are modeled separately from the nonhuman aspects of the ecosystem. Specifically, along with an ID of the ecosystem, this EMT’s simulator represents the following groups: (a) within each of the countries