1 Introduction: goals and decisions

1.1 How to use this book

This book is structured as two interlocking parts. The first provides an overview of wildlife ecology, as distinct from that portion of applied ecology that is called wildlife management and conservation. The chapters on wildlife ecology (Chapters 2–11) cover such topics as growth and regulation of wildlife populations, spatial patterns of population distribution, and interactions among plants, herbivores, carnivores, and disease pathogens. While these topics are often covered in introductory biology or ecology courses, they rarely focus on the issues of most concern to a wildlife specialist. A solid understanding of ecological concepts is vital in formulating successful wildlife conservation and management policy. In particular, you will need an understanding of the theory of population dynamics and of the relationship between populations, their predators, and their resources if you are to make sensible judgments on the likely consequences of one management action versus another.

The second section deals with wildlife conservation and management (Chapters 12–22). These chapters cover census techniques, how to test hypotheses experimentally, how to evaluate alternative models as tools for conservation and management, and the three major aspects of wildlife management: conservation, sustained yield, and control. In closing, Chapter 22 places the problems of wildlife management into the context of the ecosystem. Species populations cannot be managed in isolation because they are influenced by, and they themselves influence, many other components of the ecosystem. In the long run, wildlife management becomes ecosystem management.

Many of the key issues in wildlife ecology are of a quantitative nature: processes of population growth, spatial distribution, or interactions with the physical environment or other organisms. Coping with these topics demands conceptual understanding of quantitative ecology. Mathematical models are also an essential component of decision-making in both wildlife conservation and management, for the simple reason that we can rarely rely on previous experience to identify the most appropriate choices. Every problem is unique: new species, new sets of challenges and constraints, all taking place in a continually changing physical environment. Mathematical models provide a useful tool for dealing appropriately with these uncertainties. Moreover, mathematical models help to clarify the logic that guides our thinking.

To assist in developing the requisite skills, many of the models and statistical analyses covered in the book can be obtained via a link at Fryxell's departmental Web page (http://www.uoguelph.ca/ib/people/faculty/fryxell.shtml). This provides a set of text files suitable for application using "R," a nonproprietary (i.e. free) software package that has been developed by a hard-working and highly committed group

Wildlife Ecology, Conservation, and Management, Third Edition.
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Companion Website: www.wiley.com/go/Fryxell/Wildlife

of professional scientists and statisticians from all around the world. By learning to perform the examples used to illustrate this book, you will both expand your familiarity with useful mathematical principles and hone the problem-solving skills involved in modern wildlife ecology, conservation, and management. This can prove invaluable in future professional endeavors.

The R package provides a powerful set of integrated tools for numerical computation, statistical analysis, and graphical depiction of data and results. More information about R can be found at the R project homepage, www.r-project.org, while instructions on how to download R can be found at the CRAN repository for R materials, http://cran.r-project.org.

1.2 What is wildlife conservation and management?

The remainder of this chapter explains what wildlife management is, how it relates to conservation, and how it should operate. We discuss the difference between value judgments and technical judgments and how these relate to goals and policies compared to options and actions; we enumerate the various steps involved in deciding what to do and how to do it; and we describe decision analyses and matrices and how they help in evaluating feasible management options.

Wildlife is a word whose meaning expands and contracts according to the viewpoint of the user. Sometimes it is used to include all wild animals and plants. More often it is restricted to terrestrial vertebrates. In the discipline of wildlife management it designates free-ranging birds and mammals, and that is the way it is used here. Until about 25 years ago, "wildlife" was synonymous with *game*: those birds and mammals that were hunted for sport. The management of such species is still an integral part of wildlife management, but increasingly it embraces other aspects too, such as conservation of endangered species.

Wildlife management may be defined for present purposes as the *management of wildlife populations in the context of the ecosystem*. That may be too restrictive for some, who would argue that many of the problems of management deal with people and, therefore, that education, extension, park management, law enforcement, economics, and land evaluation are legitimate aspects of wildlife management and ought to be included within its definition. They have a point, but the expansion of the definition to take in all these aspects diverts attention from the core around which management activities are organized: the manipulation or protection of a population to achieve a goal. Obviously, people must be informed as to what is being done; they must be given an understanding of why it is necessary, their opinions must be canvassed, and their behavior may have to be regulated with respect to that goal. However, the most important task is to choose the right goal and to know enough about the animals and their habitat to ensure its attainment. Hence, wildlife management is restricted here to its literal meaning, thereby emphasizing the core at the expense of the periphery of the field. The broader extension and outreach aspects of wildlife management are dealt with thoroughly in other texts devoted to those subjects (Lyster 1985; Geist and McTaggert-Cowan 1995; Moulton and Sanderson 1999; Vásárhelyi and Thomas 2003).

1.2.1 *Kinds of management*

Wildlife management implies stewardship; that is, the looking after of a population. A population is a group of coexisting individuals of the same species. When stewardship fails, conservation becomes imperative. Under these circumstances, wildlife management shifts to remedial or restoration activities.

Wildlife management may be either *manipulative* or *custodial*. Manipulative management does something to a population, either changing its numbers by direct means or influencing them by the indirect means of altering food supply, habitat, density of predators, or prevalence of disease. Manipulative management is appropriate when a population is to be harvested, when it slides to an unacceptably low density, or when it increases to an unacceptably high level.

Custodial management, on the other hand, is preventative or protective. It is aimed at minimizing external influences on the population and its habitat. It is not aimed necessarily at stabilizing the system but rather at allowing free rein to the ecological processes that determine the dynamics of the system. Such management may be appropriate in a national park where one of the stated goals is to protect ecological processes, and it may be appropriate for the conservation of a threatened species where the threat is of external origin rather than being intrinsic to the system.

Regardless of whether manipulative or custodial management is called for, it is vital that (i) the management problem is identified correctly, (ii) the goals of management explicitly address the solution to the problem, and (iii) criteria for assessing the success of the management are clearly identified.

1.3 **Goals of management**

A wildlife population may be managed in one of four ways:

1 make it increase;
2 make it decrease;
3 harvest it for a continuing yield;
4 leave it alone but keep an eye on it.

These are the only options available to the manager.

Three decisions are needed: (i) What is the desired goal? (ii) Which management option is therefore appropriate? (iii) By what action is this best achieved? The first decision requires a value judgment, the others technical judgments.

1.3.1 *Who makes the decisions?*

It is not the function of the wildlife manager to make the necessary value judgments in determining the goal, any more than it is within the competence of a general to declare war. Managers may have strong personal feelings as to what they would like, but so might many others in the community at large. Managers are not necessarily provided with heightened aesthetic judgment just because they work on wildlife. They should have no more influence on the decision than does any other interested person.

However, when it comes to deciding which management options are feasible (once the goal is set) and how goals can best be attained, wildlife managers have the advantage of their professional knowledge. Now they are dealing with testable facts. They should know whether current knowledge is sufficient to allow an immediate technical decision or whether research is needed first. They can advise that a stated goal is unattainable, or that it will cost too much, or that it will cause unintended side effects. They can consider alternative routes and advise on the time, money, and effort each would require. These are all technical judgments, not value judgments. It is the task of the wildlife manager to make them and then to carry them through.

Since value judgments and technical judgments tend to get confused with each other, it is important to distinguish between them. By its essence, a value judgment is neither right nor wrong. Let us take a hypothetical example. The black rat (*Rattus rattus*) is generally unloved. It destroys stored food, it is implicated in the spread of bubonic plague and several other diseases, it contributes to the demise of endangered species, and it has been known to bite babies. Suppose a potent poison specific to this species were discovered, thereby opening up the option of removing this species from the face of the earth. Many would argue for doing just that, and swiftly. Others would argue that there are strong ethical objections to exterminating a species, however repugnant or inconvenient that species might be. Most of us would have a strong opinion one way or the other but there is no way of characterizing either competing opinion as right or wrong. That dichotomy is meaningless. A value judgment can be characterized as hardheaded or sentimental (these are also value judgments), or it may be demonstrated as inconsistent with other values a person holds, but it cannot be declared right or wrong. In contrast, technical judgments can be classified as right or wrong according to whether they succeed in achieving the stated goal.

1.3.2 *Decision analysis*

In deciding what objective (goal) is appropriate, we consider a range of influences, some dealing with the benefits of getting it right and others with the penalties of getting it wrong. Social, political, biological, and economic considerations are each examined and given due weight. Some people are good at this and others less so. In all cases, however, there is a real advantage, both to those making the final decision and to those tendering advice, to having the steps of reasoning laid out before them as the decision is approached.

At its simplest, this need mean no more than the people helping to make the decision spelling out the reasons underpinning their advice. However, with more complex problems it helps to be more formal and organized, mapping out on paper the path to the decision through the facts, influences, and values that shape it. This process should be explicit and systematic. Different people will assign different values (weights) to various possible outcomes, and, particularly if mediation by a third party is required, an explicit statement of those weights will allow a more informed decision. It helps also to determine which disagreements are arguments about facts and which are arguments about judgments of value.

Table 1.1 is an objective/action matrix in which possible objectives are ranged against feasible actions. The objectives are not mutually exclusive. It comes from the response of the Department of Agriculture of Malaysia to the attack of an insect pest on rice (Norton 1988). It allows the departmental entomologists and administrators to view the full context within which a decision must be made. Each of the listed objectives is of some importance to the department. The next step would be to rank these objectives and score the management actions most appropriate to each. The final outcome is the choice of one or more management actions that best meet the most important objective or objectives. Such very simple aids to organizing our thoughts are often the difference between success and failure.

Another such aid is the feasibility/action matrix. Table 1.2 is Bomford's (1988) analysis of management actions to reduce the damage wrought by ducks on the rice crops of the Riverina region of Australia. The feasibility criteria are here ranked so that if a management action fails according to one criterion there is no point in considering it against further ones. Note how this example effortlessly identifies areas of ignorance that would have to be attended to before a rational decision could be possible.

Our third example of decision aids is the pay-off matrix (Table 1.3). This expresses the state of nature (level of pest damage, in this example) as rows and the options for management action as columns (Norton 1988). The problem is to assess the probable outcome of each combination of the level of damage and the action mounted

Table 1.1 Possible objectives and management actions for public pest management. The initial problem is to assess how each action is likely to meet each objective. (After Norton 1988.)

Actions	Objectives					
	Improve farmers' ability to control pest	Improve farmers' incentives	Strengthen political support	Keep Dept.'s costs low	Reduce damage	Reduce future pest outbreaks
Short Term						
1 Warn and advise farmers						
2 Advise and provide credit						
3 Advise and subsidize pesticides						
4 Advise, subsidize, and supervise spraying						
5 Mass treat and charge farmers						
6 Mass treat at Dept.'s cost						
Medium Term						
7 Intensive pest surveillance						
8 Implement area wide biological control						
9 Training courses for farmers						

Table 1.2 Matrix for examining possible management actions against criteria of feasibility. (After Bomford 1988.)

Control Options	Feasibility Criteria					
	Technically possible	Practically feasible	Economically desirable	Environmentally acceptable	Politically advantageous	Socially acceptable
1 Grow another crop	1	0				
2 Grow decoy crop	1	1	?	1	1	1
3 Predators and diseases	0					
4 Sowing date	1	1	?	1	1	1
5 Sowing technique	1	1	?	1	1	1
6 Field modifications	1	1	?	1	1	1
7 Drain or clear daytime refuges	?	0				
8 Shoot	1	1	?	1	?	1
9 Prevent access, netting	1	1	0	1	1	1
10 Decoy birds or free feeding	?	1	?	1	1	
11 Repellants	1	0				
12 Deterrents	1	1	?	1	1	1
13 Poisons	1	1	?	0		
14 Resowing or transplanting seedlings	1	?	1	?	1	1

1, yes; 0, no; ?, no information.

to alleviate it. Note that the column associated with doing nothing gives the level of damage that will be sustained in the absence of action. It is the control against which the net benefit of management must be assessed. The cells of this matrix are best filled in with net revenue values (benefit minus cost) rather than with benefit/cost ratios, because it is the absolute rather than the relative gain that shapes the decision.

Table 1.3 Pay-off matrix for pest control. (Adapted from Norton 1988.)

State of Nature	Actions			
		Pest Control Strategies		
	Do nothing (0)	(1)	(2)	(3)
Level of Pest Attack				
Low (L)	Outcome L, 0	Outcome L, 1	Outcome L, 2	Outcome L, 3
Medium (M)	Outcome M, 0	Outcome M, 1	Outcome M, 2	Outcome M, 3
High (H)	Outcome H, 0	Outcome H, 1	Outcome H, 2	Outcome H, 3

1.4 Hierarchies of decision

Before we begin manipulating a wildlife population and its environment, we must ask ourselves why we are doing so and what is it supposed to achieve. In management theory, that decision is usually divided into hierarchical components.

At the bottom, but here addressed first, is the management action. This might be to eliminate feral pigs (*Sus scrofa*) on Lord Howe Island off the coast of Australia. The management action must be legitimized by a technical objective; for example, to halt the decline of the Lord Howe Island woodhen (*Tricholimnas sylvestris*). Above this is the policy goal, a statement of the desired end-point of the exercise, which in this example might be to secure the continued viability of all indigenous species within the nation's National Park system.

In theory, the decisions flow from the general (the policy goal) to the specific (the management action), but in practice this does not work because each is dependent on the others, in both directions. Nothing is achieved by specifying "halt a species decline" as a technical objective unless a set of management actions is available that will secure this Obviously, a management action cannot be specified to cure a problem of unknown cause. All three levels of decision must be considered together, such that the end product is a feasible option.

A feasible option is identified by answering these questions:

1 Where do we want to go?
2 Can we get there?
3 Will we know when we have arrived?
4 How do we get there?
5 What disadvantages or penalties accrue?
6 What benefits are gained?
7 Will the benefits exceed the penalties?

The process is iterative. There is no point in persevering with the policy goal thrown up by the first question if the answer to the second is negative. The first choice of destination should instead be replaced by another, and the process repeated.

Question 3 is particularly important. It requires the formulation of stopping rules. This does not necessarily mean that management action ceases on attainment of the objective, but rather that management action is altered at this point. The initial action is designed to move the system towards the state specified by the technical objective; the subsequent action is designed to hold the system in that state. If we cannot determine when the objective has been attained, either for reasons of logic (ambiguous or abstract statement of the objective) or for technical reasons (inability to measure the state of the system), the option is not feasible.

1.5 Policy goals

Policies are usually couched in broad terms that provide no more than a general guide for the manager. The specific decisions are made when the technical objectives are formulated. However, there are two types of policy goal that the manager must know about in case they clash with the choosing of those objectives.

1.5.1 *The non-policy*

Non-policies stipulate goals that are not clearly defined. They are usually formulated in this way on purpose so that the administering agency is not tied down to a rigidly dictated course of action. Policies are usually formulated by the administering agency whether or not they are given legislative sanction. If the agency has not developed a policy, it may fill the gap with a non-policy that commits it to no specified action. Take for example the goal of "protecting intrinsic natural values." This reads well but is entirely devoid of objective meaning.

1.5.2 *The non-feasible policy*

In contrast to the relatively benign non-policy, the nonfeasible policy can be damaging. Although it may give each interest group at least something of what they desire, sometimes the logical consequence is that two or more technical objectives are mutually incompatible.

An example is provided by the International Convention for the Regulation of Whaling of 1946, which had as its goal "to provide for the proper conservation of whale stocks" and "thus make possible the orderly development of the whaling industry." This pleased both those concerned with conservation of whales and those wishing to harvest whales. Unfortunately, the goal is a nonsense, because, for reasons that are elaborated in Chapter 18, species with a low intrinsic rate of increase are not suitable for sustainable harvesting. The two halves of the policy goal contradict each other. The history of whaling since 1948, in which the blue (*Balaenoptera musculus*), the fin (*B.physalus*), the sei (*B.borealis*), the Brydes (*B.edeni*), the humpback (*Megaptera novaeangliae*), and the sperm (*Physeter macrocephalus*) were reduced to the level of economic extinction, is a direct consequence of the choice of a policy goal that was not feasible.

Another form of the nonfeasible policy is one that is so specific that it actually determines technical objectives and sometimes even management actions. If these are unattainable in practice, the policy goal itself is also unattainable. An example is provided by the now defunct policy to exterminate deer in New Zealand. It was always an impossibility.

1.6 Feasible options

Objectives must be attainable. It is the wildlife manager's task to produce the attainable technical objectives by which the policy goal is defined. In contrast to the goal, which may be described in somewhat abstract terms, a technical objective must be stated in concrete terms and rooted in geographic and ecological fact. It must be attainable in fact, and it should be attainable within a specified time. A technical objective should, therefore, be accompanied by a schedule.

1.6.1 *Criteria of failure*

It follows as a corollary that there must be an easy way of recognizing the failure to attain an objective. The most common method is to measure the outcome against that specified by the technical objective. Another is to compare the outcome with a set of *criteria of failure*, set before the management action is begun. These two methods are not the same. Comparison of outcome with objective can produce assessments such as "not quite" or "not yet." Criteria of failure cannot; they take the form, "the operation will be judged unsuccessful, and will therefore be terminated, if outcome *x* has not been attained by time *t*."

1.7 Summary

We view wildlife management as simply the management of wildlife populations. Three important points underlie any management: (i) the management problem is identified correctly; (ii) the goals of management explicitly address the solution to the problem; and (iii) criteria for assessing the success of the management are clearly identified.

Four management options are available: (i) to make the population increase; (ii) to make it decrease; (iii) to take from it a sustained yield; or (iv) to do nothing but keep an eye on it. We have first to decide our goal for the population, which will be largely a value judgment. To help us steer through social, political, and economical influences, we use a decision analysis to reveal these influences and their effects on goals and policies. A series of questions about the selected option must be posed and answered to ensure that it is feasible and that its success or failure can be determined.