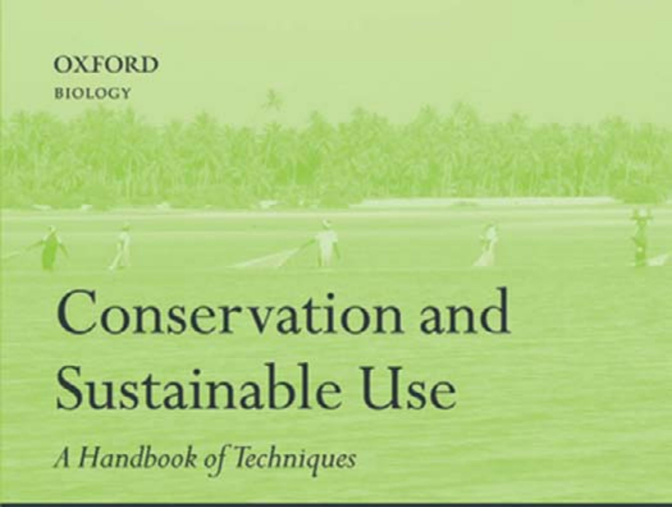

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Conservation and Sustainable Use

A Handbook of Techniques

E. J. MILNER-GULLAND
J. MARCUS ROWCLIFFE

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Introduction

1.1 Who is this book for?

This book is a practical handbook setting out the methods needed to conserve wildlife that is hunted or harvested. We are aiming at anyone who is interested in carrying out scientifically based conservation of exploited species. This includes managers who need to interpret the information available to them to decide on conservation actions, and those who carry out research to gain understanding of a problem and then act on that knowledge. It also includes people who are primarily carrying out scientific studies, but with the hope of making usable recommendations, for example, students who are working on the conservation of an exploited species for an MSc or PhD thesis.

We hope to provide a toolbox that covers the many aspects of conserving exploited species. The bedrock of effective conservation is to understand the biology of the exploited species, its habitat requirements and the effects of threatening factors on its population dynamics. If we are not correct about what is it that is causing a population to decline, then all other actions will be in vain. On the other hand, biological understanding is just the first step on the long road towards actually doing something to reverse declines. This requires an understanding of the **human setting** within which the threatening process is happening; who is involved, what their motives are and how the culture and institutions within which their activities occur drive their exploitation patterns. Action is even more difficult, as it requires engagement with people and institutions, so that **patterns of behaviour** can be changed; action needs to be at multiple scales, from passing laws to changing the perceptions of people in daily contact with wildlife.

We will look at techniques for getting information about the exploitation process, covering biological, social, economic and institutional angles. We then discuss how this information can be analysed to produce a scientifically based understanding of the dynamics of the system. Finally we discuss some of the considerations involved in translating this understanding into action. Overarching all of these is the issue of **uncertainty**—how do we make sound decisions when we don't have perfect knowledge, and how do we monitor the situation so that we can improve our understanding and pick up the warning signs of things going wrong?

We have to limit the range of issues we can consider. We focus here on species that are killed by humans for gain, for example, for subsistence food use or the international trade in traditional medicines. When we use the words use, exploitation, hunting, harvesting, then unless otherwise stated we are treating them as synonyms meaning killing an individual for gain. But we do not consider large-scale commercial harvests, such as are common in the forestry and fisheries sector, nor human-manipulated ecosystems such as plantations or fields. Instead we focus on the conservation of species that are hunted in their natural habitat, and at a relatively **small scale**. Our personal taxonomic bias is towards terrestrial vertebrates, but most of what we say is equally applicable to other living organisms that are similarly harvested; plants, corals, fish, fungi . . . It is also to some extent applicable to commercial operations and to use that does not kill (e.g. harvesting plant parts). Where methods are not broadly applicable, we point this out.

We necessarily take a **population-level approach**, because hunting is targeted at populations. Even when it is relatively non-selective, there is a limited taxonomic range taken in any one exploitation operation. This is another reason why we exclude commercial forestry and fisheries, some components of which, such as clear-cutting and bottom-trawling, destroy entire ecosystems. Of course even targeted hunting can have profound ecosystem-level effects, but we focus predominantly on studies that are concerned with the target organism itself. On the social side we focus our attention at the level of the individual harvester and their community, rather than at the national and international levels. Inevitably this means that some issues are treated in a cursory manner, but we do point out where processes at different scales have an important role to play in local sustainability.

Ignoring large-scale commercial operations does not imply that they are unimportant ecologically or socially. Commercial logging was a major factor in the 14% reduction in tropical forest area between 1990 and 2000 (FAO 2001), the collapse of the Grand Banks fishery had profound impacts on the local economy (Ruitenbeek 2001), and the over-exploitation of marine megafauna in the last few centuries has altered the ecology of the Caribbean beyond recognition (Pandolfi *et al.* 2001). But by focusing on the smaller scale, we aim to fill a gap. By and large, commercial forestry and fisheries operations are overseen by professional managers and scientists. In these systems, management may fail and science may confront profound uncertainties, but the focus is strongly on the species as a resource to be managed. Conversely, in situations where there is a conservation problem, there are generally no resource managers overseeing operations. Instead **conservationists** must diagnose the problem and devise methods for improving the situation. These are the people to whom this book is addressed.

1.2 Assessing threats and sustainability

1.2.1 Is exploitation the threat?

Because you are reading this book the assumption is that the species you are interested in is exploited. However, it is a further step from observing that exploitation is taking place to diagnosing it as the key threat to be tackled. Caughley and Gunn

(1995) give many examples of cases in which conservationists are quick to diagnose a threat, only to find that their interventions are unsuccessful because the obvious threat was not the true cause of a population's decline. For example, the decline of the large blue butterfly in the UK was at first attributed to collecting, then to habitat changes. It was only when its parasitism of a particular species of ant was discovered that the true cause of the decline was known and appropriate action could be taken (Elmes and Thomas 1992; Caughley and Gunn 1995).

The 'Bushmeat Crisis' is a major conservation issue (BCTF n.d.). There is much concern that hunting wildlife for food, particularly in the forests of West/Central Africa, is causing whole faunas to be wiped out, leaving empty forests behind them. On the broad scale, it is undoubtedly true that hunting is unsustainable over much of West and Central Africa (Fa *et al.* 2003). But when deciding on conservation priorities at the local scale this may not be true. When people have been eating their local wildlife for centuries, it may be that their use has reached sustainable levels. This is likely to be the case for Takoradi market, Ghana (Cowlishaw *et al.* 2005a). Bushmeat also illustrates the need to disentangle animal welfare concerns and cultural differences in attitudes to wildlife from the issue of whether hunting is actually a threat to population survival in a particular location.

The first two steps in conserving an exploited species are to decide first whether and why the species is of conservation concern; and second whether an intervention that aims to reduce hunting of that species actually is the best approach to addressing this concern. The most widely accepted method to judge whether a species is of conservation concern is its IUCN—World Conservation Union red list status (IUCN-SSC 2006). The IUCN red lists categorise species according to their risk of extinction, based on criteria such as the rate of population decline, small population size, limited range area and fragmentation. The most usual (but not the only) reason why exploited species are placed on the IUCN red list is rapid population decline. However, there are other valid reasons why a conservationist may be concerned about the impact of exploitation on a species. These include its cultural or economic significance, its importance as a component of the ecosystem, or its vulnerability to future over-exploitation. In these cases, the population may not currently be declining but an intervention is still appropriate.

Once we know why we are concerned about the species, we then need to assess the relative importance of exploitation compared to the plethora of other potential threats (such as habitat loss, hybridisation, alien invasives, disease). Rarely does a single factor act alone to cause extinction. Even if hunting is the main cause of decline, other factors are likely to come into play as the population becomes more threatened. Which factor should be tackled first is a product of the urgency of the problem, its seriousness and the cost-effectiveness of measures that could be taken. For example, Damania *et al.* (2003) used a model to suggest that the main threat to tiger populations in Indian Protected Areas is not direct killing of the tigers for sale, but depletion of their prey base for crop protection. Tigers have a comparatively high population growth rate and can withstand a fairly high level of hunting, so long as they have adequate prey to sustain the population.

Damania *et al.* argue that the focus of much conservation effort is on reducing tiger poaching rather than the potentially more effective strategy of reducing poaching of the tiger's prey. This contrasts sharply with the view of the Wildlife Protection Society of India that tiger poaching is driving the species rapidly to extinction (EIA-WPSI 2006). Despite the need to assess rigorously all the factors threatening a population, in many cases the issue that needs tackling is clear. For example, O'Brien *et al.* (2003) showed that despite other factors, particularly habitat loss, the Madagascan radiated tortoise is declining in range and population size principally because of high levels of exploitation to supply urban demand for tortoise meat.

Having decided why we are interested in a particular population, and what threats are acting on it, we next have to decide what outcomes we would like to see. The concrete objectives of a conservation intervention may include reversing a population decline, safeguarding a particular area for conservation or changing local attitudes towards a species. But the most usual objective cited for interventions to conserve exploited species is to ensure 'sustainable use'.

1.2.2 Defining sustainable use

The meaning of sustainable use is often not clearly defined by conservationists, because it is a difficult concept (Hutton and Leader-Williams 2003). It is useful to think about it as having three main components—biological, social and financial sustainability (Sample and Sedjo 1996). **Biological sustainability** implies that the activity does not compromise the integrity of biological systems—in the case of hunting a single species, this might translate into the population staying at a density high enough to ensure that it and the components of the ecosystem that it influences can persist into the long term. **Social sustainability** requires cultural appropriateness, social support and institutions that can function into the long term, and **financial sustainability** that the activity outcompetes unsustainable alternative activities in profit-generation. A simple and widely accepted definition, which is broad enough to encompass these aspects is the one used in Article 2 of the Convention on Biological Diversity:

> Sustainable use means the use of the components of biological diversity in a way and at a rate that does not lead to the long-term decline of biological diversity, thereby maintaining its potential to meet the needs and aspirations of present and future generations. (CBD 1993)

The first part of this definition refers to biological sustainability, while social and financial sustainability are required in order to fulfil the second part. Hence biological sustainability is necessary but not sufficient for long-term sustainability of a conservation activity. An alternative broad-brush definition is that of the Brundtland Report (WCED 1987), which defined sustainable development as development that 'meets the needs of the present without compromising the ability of future generations to meet their own needs'. Sustainable use of natural resources is one aspect of sustainable development, and the definition works as well for use as for development more broadly.

Sustainability is partly a difficult concept because hunting systems are **dynamic**—they change over time, rather than being at a single equilibrium position. This is because there is variability in the system—the weather, chance events like accidents, political changes and so on. This variability knocks the system out of equilibrium, and acts at different scales in time and space. Table 1.1 gives some examples of the kinds of processes acting on sustainability at different scales. Some of these involve predictable and non-trending variation (e.g. seasonal food availability), some are not so predictable (short-term weather variation). Some involve sudden shifts in the system (e.g. wars), others relatively deterministic trends (e.g. human population growth). Sometimes, events do not have the expected effects on sustainability. For example, the Critically Endangered Virunga mountain gorilla population actually increased during the 1990s, a period of unparalleled civil unrest. One of the reasons for this is that the conservation programme put in place in peacetime was robust enough, and had built enough local support, to continue even when the rest of civil society was in disarray (Kalpers *et al.* 2003).

Given the range of scales at which these effects act, and their ubiquity, it is clear that assuming that human-environmental systems are at equilibrium is often

Table 1.1 Examples of social, financial and biological events that can affect sustainability of exploitation at different time-scales and spatial scales.

	Few days	Few months	Few years	Many years
Few km^2	Cold/wet weather. Hunter health. Village festivals.	Food availability for prey. Alternative activities for hunters.	Village head changes. New job opportunities. Human and prey population size changes.	Change of culture and social institutions. Local prey adaptations.
Few hundred km^2	Major regime change.	Fires, Droughts, Harsh winters, Floods,	Food preferences in city change. Changes in national government.	Evolutionary change.
Continental/ Global	Commodity price changes. Internet information transfer.	El Nino effects, e.g. coral bleaching. Reactions to commodity prices.	Wars. Environmental treaties.	Climate change.

going to be very unrealistic. It can also be extremely difficult to disentangle the effects of different processes acting at different scales, and hence to assess how best to intervene to move the system to a sustainable state. Sustainability, then, is more of a process than an equilibrium—it means that the system is able to maintain itself and to adjust to shocks (in biological language, how resistant and resilient it is).

This complexity means that when we say that exploitation is 'sustainable', we need to surround this statement with caveats. We need to define the temporal and spatial scale over which we are talking, and we need to acknowledge that the diagnosis of sustainability holds into the future only inasmuch as we are able to predict future changes. We can also assess how 'future-proof' the **system** is—how able it is to adapt to any changes that might occur; this is also an important component of sustainability (see Chapter 6 on the development of robust adaptive management strategies). This means that our sustainability assessments need a number of components. For example, if we were assessing the sustainability of fishing on a reef near a small village, we might ask:

Is the fished population roughly stable, and for how long has this been the case? [biological]
Is the ecosystem as a whole in good health? [biological]
Is the management of the fishery accepted by the community? [social]
Are fishermen making a good living from the fishery? [financial]
Is the system able to withstand any threats that are on the horizon? [future-proofing]

First, however, we need a framework for understanding the dynamics of the bio-economic system whose sustainability we are trying to assess.

1.3 The dynamics of bio-economic systems

In this section we give a brief overview of the underlying theory of harvesting, from the biological and economic perspectives. This is needed in order to understand some of the material in Chapters 2–4, particularly the section on biological reference points in Chapter 4. We come back to the theory and practice of modelling as a tool in the conservation of exploited species in Chapter 5.

1.3.1 The essentials of population dynamics

Some species can remain abundant under heavy exploitation, while others disappear under even the lightest harvesting. The explanation for this variation lies in the feedback between population size and population growth. Termed **density dependence**, this feedback is a central principle in population dynamics in general, and in the biology of sustainable use in particular. In a population regulated by density dependence, per capita growth rate (the net number of new individuals entering the population per existing individual per unit time) declines with increasing density. For example, under crowded conditions, food resources might be depleted, predation might intensify, or disease might take a bigger toll, any of which could cause increased mortality rates or reduced reproduction. Regardless of the mechanism of density dependence, the net result is a declining per capita population growth rate with increasing density.

The implications of density dependence for exploitation can be understood by imagining what happens when a population first becomes subject to a regular harvest. At its un-harvested equilibrium, births balance deaths and the net growth of the population is zero. The first harvest reduces the population below its natural equilibrium, internal competition eases and net growth becomes positive, resulting in a partial recovery by the time the next round of harvest starts. As the population falls, successive harvests become smaller while net growth increases. Finally, a new equilibrium is reached at which the harvest is exactly balanced by growth, and we have, in theory, a biologically sustainable harvest. Of course, a sustainable equilibrium is only achievable if the offtake does not exceed a certain limit, which we can define as a reference point.

1.3.1.1 The logistic model

The logistic is the simplest model of density dependent population growth. Being easy to analyse and understand, it has been used as the basis of much theory of sustainable use. This theory forms important background for understanding how models can be used to define sustainability benchmarks, and we therefore provide a brief introduction here. For more complete coverage of harvesting theory, see Clark (1990), Getz and Haight (1989) and Milner-Gulland and Mace (1998). Despite its simplicity the logistic model can also be used to model specific systems, and the theory can therefore be translated directly into practical applications in some cases.

The logistic is characterised by a linear decline in per capita growth rate with increasing population density (Figure 1.1(a)). At a very low population size this rate is maximal, while at the other end of the scale equilibrium population size (or carrying capacity) is defined by the point at which the growth rate falls to zero. Carrying capacity is commonly denoted K, while the maximum per capita growth rate is commonly denoted $r_{\max}$, and these two parameters alone define logistic growth. Net growth in the population is the product of population size and per capita growth, and has a domed relationship with population size (Figure 1.1(b)). At small population size, although per capita growth is high, the small size of the population leads to little overall growth. Conversely, at large population size, low per capita growth leads to low net growth, despite the large population. Maximum net growth occurs at intermediate population size. The maximum sustainable yield (MSY) is equal to the net growth at this maximum. Assuming that harvest is directly proportional to harvester effort, we can also express equilibrium growth, and hence yield, as a function of a consistently applied effort. In this case equilibrium population size is linearly and inversely related to effort, and the yield–effort curve is therefore also domed (Figure 1.1(c)).