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The impact of human–wildlife conflict on natural systems

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INTRODUCTION

This book is concerned with resolving conflicts that occur between people and threatened wildlife. Wildlife are often subject to control if they are perceived to harm the livelihoods, lives or lifestyles of people. Many wildlife species can thrive despite such control: our continued need for mouse- and cockroach traps is testament to the resilience of some species in the face of extensive lethal control. While a panoply of invertebrate (especially insect) pests, and adaptable vertebrates such as coyotes (*Canis latrans*), ground squirrels (e.g. *Spermophilus californicus*) and red-billed quelea (*Quelea quelea*) continue to out-wit pest control experts, other species are not so well equipped to resist the effects of lethal control, Many have become seriously endangered as a result. This raises a serious challenge: what do we do when a highly endangered animal genuinely causes serious damage to human lives or livelihoods? How can we reconcile the need to conserve the species with the need to protect the rights and property of people who share its environment? Resolving such conflicts will be crucial to the success of conservation development plans that require coexistence of people with wildlife. For many sensitive species, effective conservation will be near-impossible to achieve unless such conflicts can be resolved or at least mitigated.

The scope and structure of this book

In this book, we seek resolutions to the most widespread and serious conflicts involving people and threatened wildlife: crop raiding, livestock depredation, predation on managed wildlife (such as farmed or otherwise managed game species) and, least common but most emotive, killing of people. We term this phenomenon *human–wildlife conflict*. These conflicts

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involve a taxonomically diverse array of wild species, but many of the solutions may be generally applicable. To preserve this generality, we have omitted some less common forms of conflict, such as control of wildlife to limit the spread of infectious disease. We have focussed on the best-studied systems, which leads to an inevitable bias towards studies of large vertebrates. Nevertheless, this is not a book about *vertebrate pest management*. An extensive literature on vertebrate pest management has developed over the past 30 years, particularly in the USA, which has recently been summarized by Conover (2002). Our book differs in that we seek solutions that will result in an improvement of the conservation status of wildlife that come into conflict with people. Our perspective is the management of species of conservation concern, and we consider the management of common, successful species only insofar as this contains lessons for more threatened species. However, we are aware that some of the approaches that we discuss may have local application to the management of common species. We have also chosen to focus entirely on terrestrial ecosystems. Conflicts between people and wildlife do exist in the marine and freshwater environments, such as the debate over the role of marine mammals in preventing the recovery of commercial fisheries (Yodsis 2001), but the solutions to such issues are likely to be very different from those in terrestrial systems.

This book falls into three parts. The first section (Chapters 1 and 2) sets the scene by reviewing the impact of lethal control on wild populations of threatened species (this chapter), and the impacts of threatened species on human lives and livelihoods (Thirgood *et al.*, Chapter 2). Our second section (Chapters 3 to 10) reviews various approaches to resolving conflicts between people and wildlife, including technical measures to mitigate wildlife impacts (e.g. guard dogs, electric fencing: Breitenmoser *et al.*, Chapter 4), economic incentives that may offset the costs of wildlife impacts (e.g. ecotourism: Walpole and Thouless, Chapter 8) and policy approaches (e.g. zoning: Linnell *et al.*, Chapter 10). The third section (Chapters 11 to 23) presents a broad array of case studies which discuss specific attempts to resolve conflicts between people and threatened wildlife. Finally we present (in Chapter 24) our conclusions and our hopes for the future.

LETHAL CONTROL

Where wildlife cause – or are perceived to cause – serious damage to human livelihoods, a common response has been to kill them. We choose to term this practice ‘lethal control’ because an alternative word, ‘persecution’, implies that such control is unjust or unwarranted. To the contrary, wild animals – even beautiful, charismatic and highly endangered wild animals – can and do kill people, destroy their crops and kill their livestock (Thirgood *et al.*, Chapter 2). If we fail to appreciate this crucial fact, we can never fully understand the causes of conflicts, and will never successfully resolve them.

People have been subjecting wildlife to lethal control for centuries if not millenia. As early as AD 800, the Emperor Charlemagne employed a cadre of professional wolf-hunters tasked with ridding the Holy Roman Empire of this menace (Boitani 1995). Some societies have taboos against killing particular species, even if they cause serious damage (e.g. Menon *et al.* 1998), but this is rare. Cultural factors strongly influence people's willingness to tolerate wildlife damage (Woodroffe 2000), but in many cases a primary limitation on the level of lethal control has been people's ability to capture and kill wildlife. Deliberate killing of wild animals perceived as pests has taken place on all of the inhabited continents, as well as in the sea and fresh water, and involves threatened species as diverse as orang utans (*Pongo pygmaeus*: Rijksen and Meijaard 1999), snow leopards (*Uncia uncia*: Ahmad 1994), peregrine falcons (*Falco peregrinus*: Thirgood *et al.* 2000b), prairie dogs (*Cynomys* spp.: Miller *et al.* 1996) and fur seals (Wickens 1996).

Wildlife perceived as 'problem animals' are killed both legally and illegally, by private individuals, informally organized communities, bounty hunters, and local and national governments. In developed countries the most common methods are shooting, trapping and poisoning, but traditional methods are also used. For example, in East Africa large carnivores are not infrequently killed with spears (Frank *et al.*, Chapter 18), as are African elephants (*Loxodonta africana*), and chimpanzees (*Pan troglodytes*: Ghiglieri 1984; Moss 2001). Innovative (if sometimes grisly) new methods have also been devised. In India, for example, farmers may deliberately modify power lines to electrocute crop-raiding Asian elephants (*Elephas maximus*), or pack explosives into jackfruit baits (Menon *et al.* 1998). Novel methods may also be highly selective; for example protective collars fitted to livestock ensure that coyotes are killed only when they bite the throat of a sheep and pierce the collar's reservoirs of 1080 poison (Burns *et al.* 1996).

HISTORICAL IMPACTS OF LETHAL CONTROL

Species extinctions

Lethal control has led to the extinctions of several species. The Guadelupe caracara (*Polyborus lutosus*), a raptor species confined to the island of Guadelupe off the Pacific coast of Mexico, was reported to kill juvenile goats and was shot and poisoned by local people for this reason

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(Greenaway 1967). While the last few individuals were killed by collectors, lethal control is believed to have been the principal factor leading to the species' extinction in 1900 (Fuller 2000). Likewise, conflict with people over sheep depredation led to the extinction of two carnivorous mammals, the thylacine or marsupial wolf (*Thylacinus cynocephalus.*, in 1930), restricted to Tasmania, and the Falkland Island wolf (*Dusicyon australis*, in 1876: IUCN 2002). The Carolina parakeet (*Conuropsis carolinensis*) was killed as a pest of fruit crops, and this is believed to have been a primary cause of the species' extinction in 1904 (IUCN 2002). Reports from the time describe how, once one parakeet was shot, others would hover and scream above the carcass, making it easy to destroy entire flocks (Greenaway 1967).

Range collapses

Only a handful of species have been completely extirpated through human persecution, but many species have experienced massive contractions of their geographic ranges. Some of the most impressive range collapses occurred in North America, perhaps because the 'pioneer spirit' of European settlers pitted well-armed and highly motivated people against wildlife with very little experience of lethal control. In 1900, colonies of prairie dogs – not, in fact, dogs but burrowing squirrels – are estimated to have covered 410 000 km^2 of North America's short grass prairies. However, the farming industry perceived them as vermin which could compete with livestock for forage, and they were subjected to a massive government-sponsored poisoning campaign. By 1960, prairie dogs' geographic range had collapsed to less than 2% of their former distribution, and this range was still further reduced by the end of the twentieth century (Reading *et al.*, Chapter 13). Likewise, wolves (*Canis lupus* and *C. rufus*) were formerly distributed throughout the USA south of Canada, but, following a concerted (and, once again, government-sponsored) attempt to eradicate a species perceived as a threat to livestock, by 1960 they were confined to northeastern Minnesota and Isle Royale National Park in Lake Superior (*C. lupus*) and to a small area on the Texas–Louisiana border (*C. rufus*). Hence, wolves were extirpated from nearly 8 000 000 km^2 of their former range in North America alone (Fig. 1.1a). African wild dogs (*Lycaon pictus*) were eradicated from 25 of the 39 countries they formerly occupied (Fig. 1.1b), not only because they were considered a threat to livestock but also because they were thought to suppress densities of 'game' species inside protected areas (Bere 1955). Similar range collapses have affected most of the larger mammalian carnivores and are almost too numerous to mention. Both lions (*Panthera leo*) and cheetahs (*Acinonyx jubatus*) were all but eradicated from Asia by the early twentieth century, and today occupy greatly reduced distributions in

Figure 1.1. Range collapses of wildlife species in conflict with people. Maps compare historic distributions with more recent distributions. (a) Grey wolves in North America: 1700 (light grey) vs. 1970 (dark grey), based on data from Thiel and Ream (1992); (b) African wild dogs: ~1800 (light grey) vs. 1997 (dark grey), based on data from Fanshawe *et al.* (1997); (c) hen harriers in Britain (1825–1975; (for colours see key), based on data from Watson (1977).

Africa (Nowell and Jackson 1996). Brown bears (*Ursus arctos*), lynx (*Lynx lynx*) and wolves had disappeared from most of western Europe by the end of the nineteenth century (Woodroffe 2001a). Jaguars (*Panthera onca*) have shown a similar range contraction in Central and South America (Sanderson *et al.* 2002), as have dingoes (*Canis familiaris dingo*) in Australia (Glen and Short 2000).

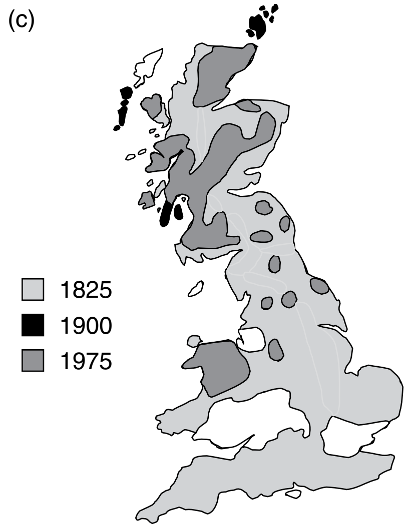

Figure 1.1. (*cont.*)

Avian predators have shown similar patterns of range collapse. Birds of prey come into conflict with hunters and farmers because of their predation on livestock and on game species, and lethal control has had a major impact on the status and distribution of numerous species throughout the world (Newton 1979, 1998; Manosa 2002; Vinuela and Arroyo 2002). This has been particularly well documented in Scotland where conflicts have been intense, and where there is a strong tradition of ornithology to assess the impacts of sustained killing of raptors (Galbraith *et al.* 2003). A good example is the hen harrier (*Circus cyaneus*) which comes into conflict with grouse (*Lagopus lagopus*) hunters and landowners because of the impact of its predation on grouse harvests (Thirgood *et al.* 2000a, b, c; Thirgood and Redpath, Chapter 12). Hen harriers were historically widespread in Scotland, but sustained killing during the nineteenth century eradicated them from the mainland leaving a few remnant populations in the Western Isles (Watson 1977) (Fig. 1.1c). Harriers recolonized the mainland during the 1940s, but have not reoccupied their original geographic range.

Similar patterns of range collapse have been recorded for Scottish populations of golden eagles (*Aquila chrysaetos*) and white-tailed eagles (*Haliaeetus albicilla*), although in these cases conflicts were perceived to be with sheep-farmers as much as grouse-hunters (Watson 1977). Range contractions have also occurred in other European countries where game-bird shooting is a significant form of land use. Of particular concern is the situation in Spain, where deliberate killing of raptors involves extremely endangered species such as Bonelli's eagles (*Hieraetus fasciatus*) and Spanish Imperial eagles (*Aquila adalberti*: Vinuela and Villafuerte 2003).

CURRENT POPULATION IMPACTS OF LETHAL CONTROL

Large-scale population suppression

Where lethal control has not caused local extinction, it may still cause local declines or suppress populations. Multiple studies have shown that carnivore populations are limited by human interventions. For example, wolves living in human-dominated landscapes are almost invariably limited by people. Where wolf-hunting is legal, this accounts for much of the offtake, but human activities can still limit local populations even where wolves are legally protected (Boitani 1992; Fuller 1989; Bangs *et al.*, Chapter 21). Likewise, lion, red fox (*Vulpes vulpes*), dingo and European badger (*Meles meles*) populations may be suppressed below carrying capacity by control efforts (Allen and Gonzalez 1998; Heydon and Reynolds 2000; Le Fevre *et al.* 2003, Frank *et al.*, Chapter 18).

Estimates of the impacts of lethal control on elephant populations are few in number. In southern India, 17% of female elephant mortality was due to either shooting or electrocution carried out by people in defence of their crops (Sukumar 1989). While demographic modelling suggested that this level of control was just sustainable, small increases in mortality were projected to cause declines. Among males (which have tusks), retributive killing (8–17% of deaths) was apparently dwarfed by poaching (48–57%) as a cause of mortality; this combined offtake caused marked decline of the male population (Sukumar 1989). Unconfirmed reports suggest even more severe impacts of lethal control on Asian elephants in Sri Lanka (Sri Lanka Wildlife Conservation Society 2000).

As in Asia, estimating the impact of retributive killing on African elephant populations is difficult, in part because studying elephant demography requires expensive long-term studies, and in part because data are complicated by the issue of ivory poaching. However, the available data indicate that problem animal control is an important cause of mortality. Information presented to the Convention on International Trade in Endangered Species (CITES) in 1997 suggests that problem animal control may be as serious a mortality cause as ivory poaching. Of 1224 elephant deaths recorded in Botswana in 1989–96, 230 were due to problem animal control and 259 were poached (CITES 1997). Likewise, in Kenya 467 elephants were recorded killed in problem animal control during 1993–8, compared with 355 poached (R. Hoare pers. comm.). Figures for Namibia suggest a somewhat smaller impact of retributive killing, with 148 poached during 1990–6 and 29–50 killed as problem animals (CITES 1997). While these data do not provide quantitative estimates of the impact of retributive killing on local elephant populations, they do suggest that if the current level of ivory poaching is a threat to Africa elephants, problem animal control is an equally serious threat (see also Western and Waithaka, Chapter 22). Killing of crop-raiding elephants is a widespread phenomenon in Africa (e.g. Dudley *et al.* 1992; Tchamba 1996), but its impact on regional elephant populations appears largely unknown.

Almost no quantitative data are available on the impact of retributive killing on crop-raiding primates, in part because few population studies have been carried out where primates are in direct conflict with people.

Local effects: source–sink dynamics

Because populations are connected with one another through animal movement, even localized lethal control can influence populations over wide areas. Frank *et al.* (Chapter 18) show how lethal control of livestock-killing lions on a single 180-km^2 ranch generated a sink affecting the lion population over at least 2000 km^2. Mace and Waller (1998) described a similar impact of localized mortality on a regional grizzly bear (*Ursus arctos*) population. On a still larger scale, Etheridge *et al.* (1997; see also Thirgood and Redpath, Chapter 12) showed that illegal killing of hen harriers on moorland managed for commercial hunting of red grouse transformed an entire habitat type into an extensive population sink, sustained only by immigration from moorland not managed in this way. Of course, the more widely individuals of a species range (or disperse), the greater the spatial scale across which source–sink effects may operate.

Source–sink dynamics can have especially damaging effects when they involve nominally protected populations. Where people use lands adjacent to reserves, their activities can threaten wildlife nominally protected by the park. One of the best examples of such edge effects comes from Algonquin Park, Canada, where the wolf population was driven into decline by persistent killing of animals that ranged beyond park boundaries (Forbes and Theberge 1996). Banning the killing of wolves close to the park border dramatically reduced overall mortality in the park (Forbes and Theberge 1996). Likewise, most of the African elephant mortality recorded in a population under study in Amboseli National Park, Kenya, was due to spearing by neighbouring cattle-farmers (Moss 2001). Edge-related mortality of this kind is extremely common among large carnivores, occurring in all species for which data are available (Woodroffe and Ginsberg 1998, 2000). Mortality is particularly severe where reserves are surrounded by high densities of people (Harcourt *et al.* 2001).

Such localized edge mortality need not necessarily contribute to overall population decline. For example, the Amboseli elephant population was increasing at 2.2% per year despite regular offtake due to conflict with neighbouring cattle-farmers. However, if edge mortality is high enough, it can cause population decline or even local extinction. Woodroffe and Ginsberg (1998) showed that these effects are a globally important cause of extinction among nominally protected carnivore populations. Wide-ranging species such as grizzly bears and African wild dogs are particularly sensitive to extinction through these effects, and persist only in the very largest national parks and reserves. This is almost certainly because they are especially likely to wander over the borders of protected areas and into contact with people.

Indirect effects

Even where lethal control has relatively small direct impacts on population density, there is a possibility that its effects might be magnified by social factors. For example, killing of seven male chimpanzees (from a community of about 80) in a crop-raiding incident profoundly affected the social structure of a group under study in the Taï Forest, Côte D'Ivoire (Boesch and Boesch-Achermann 2000). This social disruption was believed to have reduced the group's ability to counter leopard attacks, which subsequently led to high mortality. Likewise, Courchamp and Macdonald (2001) argued that quite small reductions in pack size of African wild dogs (as might occur through lethal control) could dramatically affect the group's ability to hunt and raise young, thus having disproportionately large impacts on population density.

Behavioural responses to lethal control

Lethal control has very clear population impacts, but it may also have indirect effects through its impact on behaviour. Local extinction may occur because all the animals in an area are killed, but it can also occur because all the animals move elsewhere. Collapse of African elephant populations in areas of high human density (Hoare and Du Toit 1999) probably occurs through such behaviour. Elephants will move away from areas where conspecifics are killed (Whyte 1993), and this may disrupt natural seasonal migrations (Tchamba *et al.* 1995), with unknown consequences for population viability. One result of such movements is that elephants may become compressed in relatively small protected areas (e.g. Wittemyer 2001), a situation that is probably not sustainable in the long term. Fortunately, savanna elephants also become aware quite rapidly when formerly dangerous areas become safe, and will recolonize areas surprisingly readily if habitat connectivity has been preserved (e.g. Thouless 1995).

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Animals' ability to recognize areas that are dangerous may, of course, greatly reduce human impact on their populations. Frank *et al.* (Chapter 18) suggest that lions may avoid areas where they face high mortality risks. This behavioural response may help to explain why lions have historically been highly extinction-prone outside protected areas, yet persist well, and at high densities, in quite small reserves (Woodroffe 2001a).

IMPACTS OF HUMAN–WILDLIFE CONFLICT ON ECOSYSTEM FUNCTION AND HABITAT DESTRUCTION

Trophic cascades

The outcome of conflicts between people and wildlife may extend beyond populations, to affect entire ecosystems. Many 'conflict' species (e.g. elephants, large carnivores) are also keystone species whose removal affects the structure of entire ecosystems. Extirpation of grey wolves and grizzly bears from parts of the northern Rocky Mountains has been shown to influence, through its impacts on ungulate density and behaviour, habitat suitability for neotropical migrant birds (Berger *et al.* 2001), and restoration of grey wolves has affected many facets oft his montane ecosystem (Smith *et al.* 2003).

Perhaps the best example of a trophic cascade triggered by human–wildlife conflict involves prairie dogs. Prairie dog colonies constitute a unique grassland habitat which support a remarkably biodiverse community (Kotliar *et al.* in press). Systematic attempts to eradicate prairie dogs from very large areas will have adversely affected all members of this community, but its most high-profile (and expensive) impact was the extinction in the wild of the black-footed ferret (*Mustela nigripes*), a highly specialized species that is an obligate predator of prairie dogs (Miller *et al.* 1996). Black-footed ferrets in the last wild population to go extinct (prior to intensive recovery efforts and multiple reintroductions) were very few in number and ultimately killed by infectious disease; hence initial recovery issues focussed primarily on these issues (Seal *et al.* 1989). However, it was deliberate destruction of the ferrets' habitat and prey base that drove their decline, and which continues to dog recovery efforts (Miller *et al.* 1996).

Sea otters (*Enhydra lutris*) are another strongly interacting species affected by human–wildlife conflict. For many years, conflict with lucrative shellfish fisheries on parts of the California coast prompted local laws to prevent sea otter recovery in designated 'no otter zones' (US Fish and Wildlife Service 2003c). Sea otters' role in structuring marine communities is very well established (Estes *et al.* 1996); hence this management decision could have had a very marked effect on many aspects of California's coastal ecosystems, beyond its influence on fisheries.