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Living with wildlife: the roots of conflict and the solutions

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Where there are sheep, the wolves are never very far away.
(Titus Plautus, 254–184 BC)

Introduction

Wildlife, particularly carnivores, ungulates, primates, rodents, raptors, granivores and piscivorous birds, come into conflict with people when they damage property or threaten human safety or recreation by feeding (killing, browsing, grazing), digging and burrowing. A further reason for conflict is that wildlife are carriers of diseases that can be harmful to people and their domestic animals (see Chapter 11). Because conflict applies, in one guise or another, to all sorts of organisms, including invertebrates and even plants, we opt for Conover's (2002) taxonomically mysterious, but nonetheless alluringly convenient, definition of wildlife as free-ranging vertebrates other than fish. That said the principles and dilemmas that we shall reveal here for creatures from sparrows to elephants can almost universally be transposed to humankind's dealings with organisms of every ilk.

In response to perceived wildlife damage or threat, people may retaliate in a manner that may be ineffective or biologically unsustainable, and political discord may ensue between those whose emphasis is conservation of biodiversity and/or the sustainable use of resources, and those defending the economic interests of affected people. In particular, people at the receiving end of wildlife damage tend to oppose conservation agendas, protected areas and conservation practitioners. Hence, the management of wildlife populations involved in conflict raises numerous issues relating to conservation, perceptions of nature, animal welfare, and the politics and economics of natural resources.

Conservationists face a critical challenge to develop workable measures for reconciling human activities and wildlife needs as a deliberate choice (as opposed to earlier views that were polarized between support for either wildlife or people and economic development), and thus minimize the severity or frequency of conflicts for both animals and people. There are strong economic and human health arguments for reducing the costs of plentiful species such as granivorous birds and rats threatening people's lives and livelihoods. Similarly, there are equally strong ethical arguments in favour of preserving species that are threatened as a consequence of human activity. Somewhere in between we may consider conflict between different sectors of society regarding a particular use of wildlife, such as town and country antagonizing over fox hunting in Britain or

supporters of trophy hunting clashing horns with animal welfare flag-bearers.

We thus need general guidelines that can be tailored to each problem, gleaned from experience worldwide, and local strategies that integrate ecological, economic and social realities in the design and implementation of cost-effective interventions that can be monitored. In this essay we briefly review the patterns of human–wildlife conflict and the most commonly used approaches, or tentative solutions showing some promise, to its management. We then focus on gaps in our understanding that impede progress in mitigating human–wildlife conflicts as well as socio-political barriers to innovation that frustrate biodiversity conservation. For example, we still do not know if wild animals with a tendency to damage property or threaten human activities transmit these behaviours to their young, which hampers our analysis and use of negative conditioning from deterrents to lethal control. Affected people can also befuddle conservationists, as exemplified by the common claim that livestock loss to carnivores is more than economic because livestock producers love the animals they annually take to slaughter.

Characterizing conflict

Conflicts between wildlife and humans cost many lives, both human and wildlife, threaten the livelihoods of millions worldwide and jeopardize long-term conservation goals such as securing protected areas and building constituencies in support of wildlife conservation (Sukumar 1994; Treves & Newton-Treves 2005). Elephants, hippopotami, buffaloes, large carnivores (particularly bears and big cats) and crocodiles account for most human deaths or injury; the vast majority of attacks befall people harvesting resources from wildlife areas and those defending their farms from crop raiders (e.g. Treves & Naughton-Treves 1999; Rajpurohit & Krausman 2000). Wildlife damage is widespread; in the USA, for instance, 80% of 2000 farmers surveyed suffered some damage, with 3% reporting losses in excess of $10,000 (Conover 2002). The federal agency charged with controlling agricultural damages caused by wildlife in the USA spent over $60 million in operations during 2000 and the agriculture industry estimated losses at nearly one billion dollars (National Agricultural Statistics Service 2002; see Breitenmoser & Angst (2001) for similar statistics for Europe). In communities with subsistence economies, even small losses can be economically important (e.g. Asian elephants – Sukumar 1989; African elephants – Naughton-Treves et al. 2000; snow leopards – Oli et al. 1994). Conflict sometimes may arise from unexpected quarters, such as tourists feeling threatened by begging macaques in China (and even one tourist dying as a result of a fall when fleeing a macaque – Zhao 1991), martens foraging under vehicle bonnets for plastic wiring in Germany, or fouling by pigeons in London almost bringing about the political downfall of the mayor.

Historically, and still largely today, solutions that are lethal to wildlife have been sought through bullets, poison or traps (Treves & Naughton-Treves 2005). This response is increasingly unpopular or illegal so interest has awakened in non-lethal techniques. In the past, one or two questions have not been answered about lethal versus non-lethal control: first, what is the magnitude of the problem relative to the proposed solution, second, how do lethal versus non-lethal alternatives measure up in cost-effectiveness, sustainability or socio-political acceptability? Furthermore, as values, especially of nature, are increasingly weighed with more than monetary dimensions, these questions, which were always technically difficult to answer, become intellectually and ethically hard too. For example, however threatening a predator or crop raider may be, and whether or not it costs you money, and irrespective of whether killing it diminishes your loss, in a world where biodiversity (and

especially rarity) is valued, and suffering decried, is lethal control the best choice? (Fig. 17.1 also Chapter 18).

Predation on farm animals, game and fisheries

The most widespread source of human–carnivore conflict is competition for resources.

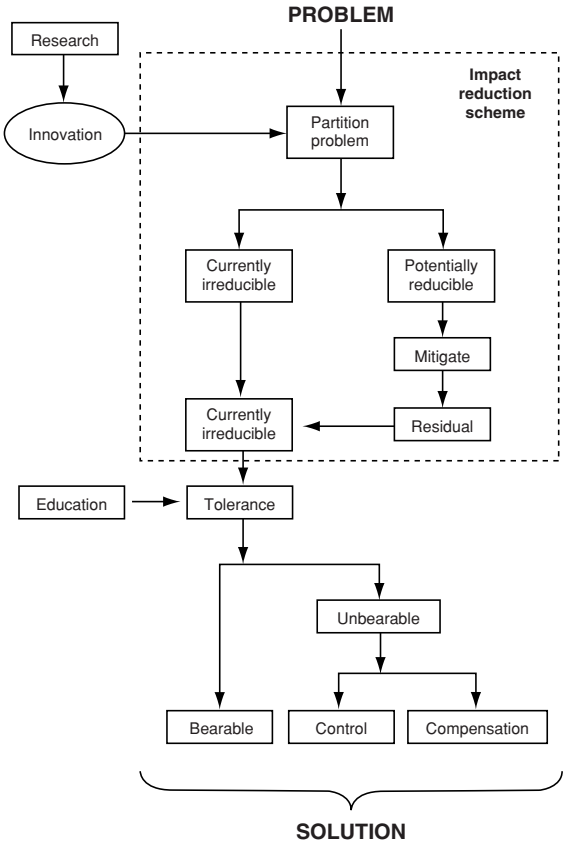

Fig. 17.1 Impact reduction scheme to mitigate conflict representing operational and iterative processes flowing from problem to solution. Problems can be partitioned notionally between reducible and irreducible elements, and the balance between these will shift as currently intractable elements are rendered reducible by new innovation. There could be overlap in the actions represented by the 'mitigation' and 'control' boxes, but these may loosely be partitioned as non-lethal and lethal interventions, respectively. (Redrawn from Macdonald & Sillero-Zubiri 2004.)

Wherever people exploit natural populations, rear livestock, game or fish outdoors, predation is a perennial and controversial complaint (reviewed in Gittleman et al. 2001; Sillero-Zubiri & Laurenson 2001; Conover 2002; Treves & Karanth 2003; Sillero-Zubiri et al. 2004; Woodroffe et al. 2005). The history of this conflict is the root of a deeply ingrained antipathy towards wild carnivores throughout the world that traces back to the development and spread of herding societies (Reynolds & Tapper 1996) and perhaps even further back in prehistory (Kruuk 2002). Domestication, via selection against 'wild' behaviours in stock, led to riches of clustered, accessible, unfit and generally dim-witted prey for opportunistic carnivores (Hemmer 1990).

The ecology of predation is an extremely complex issue. Recent analyses suggest predators can limit prey numbers or exert compensatory mortality depending on a complex array of environmental variables that defy global generalizations (Ray et al. 2005). Habitat loss and fragmentation, along with poaching and competition with domestic livestock can deplete the natural prey base (e.g. Saberwal et al. 1994; Mishra 1997; Jackson & Wangchuk 2001; Mishra et al. 2003), forcing predators to turn to domestic stock for food. The shifting balance of availability of livestock and natural prey can shift predator preferences and incidences of depredation (e.g. Meriggi & Lovari 1996; but see Treves & Naughton-Treves (2005) for some counterexamples).

Predation on domestic stock is affected by breed, stock management, the prey's previous enxperience of predators, predator density and individual predator behaviour (Jackson & Wangchuk 2001; Wydeven et al. 2004). Although larger carnivores are more conspicuous and attract particular wrath, the collective damage of smaller species such as jackals, foxes, coyotes, mustelids and small cats may be greater (e.g. Naughton-Treves 1998; Macdonald & Sillero-Zubiri 2002; Marker et al. 2003). Conflict with carnivores extends to other, 'non-traditional', stock such as cormorant and otters

raiding carp pools and salmon fisheries (Kruuk et al. 1993; Cowx 2003; Britton et al. 2005), bears gorging on bee hives (Meadows et al. 1998) and wolverines and lynx killing semi-domestic reindeer (Pedersen et al. 1999).

Conflict has been exacerbated by changes in husbandry over the past 100 years. It is most acute where modern economic conditions preclude once-traditional livestock-guarding practices, which in many regions were relaxed, such as in the sheep milking regions of eastern Europe (Rigg 2001), or abandoned outright once large predators were removed, as in southern Europe (Boitani 1995; Breitenmoser 1998; Ciuci & Boitani 1998; Vos 2000). The true cost of livestock predation is higher where people's livelihoods depend entirely on livestock such as in many herding societies. Whereas a cow lost to a jaguar in a large South American ranch may be written off as part of this extensive husbandry practice, large carnivores can have disastrous consequences for the 400,000 people living in the Gir Forest Reserve, India, with the 250 odd remaining Asiatic lions (Divyabhanusinh 2005). Local enthusiasm for the lions is diminished by an average of nearly 15 attacks and over two human deaths annually; this may be as high as 40 attacks per year and seven deaths per year, as happened during 1989–91 (Saberwal et al. 1994). Livestock comprises about one-third of the lions' kills, and most villages report losses of about five cows annually to lions, with 61% of 73 villagers interviewed expressing hostility towards the lions, although one is in awe of the placid nature of the remaining villagers!

Humans are in competition with carnivores for prey, as exemplified by the estimated 3.4 million metric tonnes of bush meat extracted from Central Africa annually, which results in a diminished prey base to carnivores there (see Chapter 14), and piscivorous birds, sharks, seals and otters compete with humans for marine resources (Blackwell et al. 2000). Real or perceived competition has led moose and caribou hunters in Canada and Alaska to kill wolves in an attempt to increase the numbers of their quarry (Harbo & Dean 1983; Gasaway et al. 1992), and roe deer hunters in the Alps complain that their quarry populations have declined as a result of lynx reintroduction (Breitenmoser 1998). Raptors and small carnivores are persecuted in the developed world to protect game for humans (Reynolds & Tapper 1996; Thirgood et al. 2000). Interestingly, the nuisance value of these wild carnivores will vary markedly between arable farmers and those that grow livestock or game. Killing red foxes in parts of the UK may benefit the shepherd, but results in loss of income to cereal farmers per fox owing to the numbers of rabbits they thereby do not eat (Macdonald et al. 2003).

More recently, changing public opinion, legal protection, habitat recovery and conservation initiatives are allowing the return of predators such as grey wolves, bears and large cats in many areas, which tend to provoke furious public complaint and requests from farmers and hunters for compensation or carnivore population reduction (e.g. Mech 1995; Breitenmoser 1998; Treves et al. 2002). There is a widening urban–rural divide, with the lifestyles of minorities who live in contact with wildlife being increasingly influenced by city dwellers setting fashions (Naughton-Treves et al. 2003).

Crop damage by wild herbivores

Wild ungulates and primates tend to cause damage when agricultural crops are grown within or near their natural habitats. Crop damage is a major cause of conflict with wildlife, ranging in size from elephants to rodents, complicated by a mix of various ecological, social and political factors (Sukumar 1989; Naughton-Treves 1998; Nyhus et al. 2000; Conover 2002). Animals that damage crops may also injure or kill farm workers. Between 1980 and 2003, more than 1150 humans and 370 elephants died as a result of human–elephant conflicts in north-east India alone (Choudhury 2004), the majority of these

incidents occurring within cultivation and settlement. Serious conflict may result in abandonment of otherwise profitable arable land (good for conservation, bad for the displaced farmers), or escalating costs of farming through investment in fencing and other non-lethal and lethal damage limitation measures (e.g. Studsrod & Wegge 1995; Naughton-Treves et al. 1998, 2000). Distance from the forest edge in Uganda explained the greatest amount of variation in crop damage by ungulates and primates (Naughton-Treves 1998). Farmers residing within < 500 m of protected areas experienced the majority of crop losses, losing 4–7% of their crops to wildlife per season on average. Ecological factors that correlate significantly with crop raiding by elephants include the degree of habitat fragmentation, the higher nutritive value of cultivated crops compared with analogous wild forage, and the higher risk-taking behaviour of individual bulls. Indeed, bulls that are normally solitary during the day often come together in the evening, and gang up before entering agricultural fields (Sukumar 1989, 1991; Hoare 1999). In that way they may be better able to tackle hostile farmers.

People's perception of wildlife damage

In addition to a scientific understanding of wildlife damage, people's perceptions of the conflicts are critical to managing the conflicts (Manfredo et al. 1998; Marker et al. 2003; Naughton-Treves et al. 2003; Naughton-Treves & Treves 2005). Indeed, the two are complementary because individual perceptions of conflict with wildlife are shaped more by catastrophic events than by regular, small-scale events (Naughton-Treves 1997, 1998; Naughton-Treves et al. 2000). Because we talk to neighbours and retain fact and fiction from past generations, alleged and real catastrophic events can shape perceptions for decades and spread across broad regions (Linnell & Bjerke 2002; Naughton-Treves & Treves 2005). Tolerance for losses is strongly influenced by socio-economic factors, such as the legality of retaliation, individual farmers' vulnerability and the availability of farming alternatives to palatable crops or susceptible stock. In the UK for instance red foxes are said to be tolerated by some farmers in a sense if they have any hunting interests. A fragment of evidence for the latter is that significantly more hunting farmers (28.9%) approve of the active conservation of foxes compared with non-hunters (14.7%) (Macdonald & Johnson 1996).

Conservationists should understand both scientific measures of damage and perceptions of the conflict because affected communities tend to value perceptions and anecdotes, whereas policy makers, scientists and outsiders tend to value scientific measures. In designing interventions we must carefully consider tolerance among affected communities for the proposed intervention and the affected wildlife (Manfredo & Dayer 2004). Often those complaining most loudly and bitterly are not the most sorely affected but those who have a voice (Naughton-Treves et al. 2000, 2003), hence one's response to conflicts must be tailored to the perceived losses as well as the actual losses in order to satisfy the politically influential and the politically marginal.

Mitigating human–wildlife conflict

Conflict can occur anywhere along a continuum of species abundance. For those species for which the problem is their abundance (e.g. livestock predation by ubiquitous carnivores), mitigation will seek to reduce contact or manage damage. In contrast, for rare or threatened species the emphasis will be protection, shifting towards sustainable management as a population recovers. A simple scheme (Fig. 17.1) presented by Macdonald & Sillero-Zubiri (2004) proposes a linked and iterative rational process to tackle conflict. A problem can be partitioned notionally between reducible and irreducible elements, and the balance between these will

shift as currently intractable elements are rendered reducible by new innovation brought about by research and experimentation. Reducible problems can be mitigated (e.g. by non-lethal intervention), thereby minimizing the current level of conflict. The irreducible problem that poses the conflict can be partitioned into that which is bearable (more or less willingly) by the afflicted stakeholders, and that which is unbearable. The extent to which these stakeholders will bear a cost (such as predation or crop raiding) will depend on their tolerance which, in turn can be heavily affected by education and value. The latter, which is not merely financial, may be attributed to both a species or an ecological, cultural or political process of which it is a part.

Two interventions are relevant to the unbearable component of current conflict: either to control (most often lethal control) the problematic species, population or individual (Fig. 17.2), or to compensate in some way the aggrieved stake-holder. A third option is to protect the species/population and tell the aggrieved person they simply have to put up with it. Each option raises questions, which can be partly answered by research. In the proposed scheme every box interacts with every other, creating a web of links (e.g. access to compensation might be contingent on improved animal husbandry – a form of mitigation).

We use this scheme to visualize the integrated analysis of human–wildlife conflicts we advocate; combining efforts to reduce the damage caused by wildlife with attempts to increase people's tolerance for wildlife. One can:

1. prevent or, reduce the frequency or severity of encounters between humans and wildlife (e.g. barriers, guards, wild prey recovery, establishment of refuges for wildlife, Fig. 17.2);
2. deal with those individuals that cause conflict (e.g. lethal removal, deterrence, translocation);
3. raise tolerance for conflicts in the affected people through a variety of mechanisms (e.g. incentive schemes tied to conservation, compensation for losses, legal harvests).

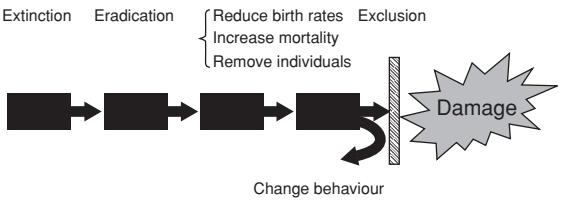

Fig. 17.2 Diagram representing the different levels at which the wildlife component of conflict may be managed by lethal and non-lethal approaches to mitigate damage. (Redrawn from Conover 2002.)

The most successful projects to date combine at least two approaches. For example, Nagarahole National Park in India was the site of a voluntary resettlement project (Karanth 2002; Karanth & Madhusudan 2002). Hundreds of villagers residing within the park were beset by tigers, elephants and other smaller problem species, while at the same time lacking employment, schools, clinics and other services. Through a fully participatory and voluntary negotiated resettlement, the villagers were moved out of the park and closer to the infrastructure and employment opportunities they desired. As a by-product of resettlement conflict declined and fewer wild animals had to be destroyed or relocated by the authorities. The USA Government reintroduced 31 grey wolves from Canada into the Greater Yellowstone Area in 1995–1996 after years of public outreach and comment; the wolf population now numbers over 800 animals. The project is deemed a success not only for reaching the numerical target for wolves but for suffering fewer depredations than expected and bringing a net economic benefit to the area (Bangs & Fritts 1996; Duffield & Neher 1996). Although there was a cost to the local community through predation, the Government and non-government organizations (NGOs) partnered to mitigate it, including an NGO scheme that has paid out nearly half a million dollars to compensate ranchers for the loss of close to 2000 livestock.

Increasing tolerance for damage by wildlife

The attitudes held by people towards wildlife in general and some species in particular, as well as their perceptions of management interventions, play an important role in conservation. For example, in Nepal, people living closer to the Royal Chitwan National Park were more negative towards it than those who visited the park less frequently and who lived further away in larger landholdings (Nepal & Weber 1995). Effective conservation requires government-backed institutions (e.g. legislation and protected area networks), but it also requires local cooperation (Jackson et al. 2001; Sillero-Zubiri & Laurenson 2001). Real local cooperation with government programmes is usually generated by human–wildlife conflicts that local groups see as requiring government intervention.

In the absence of institutions, the importance of individual attitudes is limited by the 'commons problem' dilemma (or 'collective action problem' see Macdonald et al. 2005). (This, by the way, is an understanding that cannot be claimed as new by biologists because it has been common knowledge for a long time, being well-articulated, for example, by Shylock in Shakespeare's *Merchant of Venice*). The commons problem can be exemplified by a forest hunter who, although believing that a primate population must be protected also suspects that if he refrains from shooting a monkey someone else will kill it, and the only practical outcome of his behaviour would be that his children get less than someone else's. The solution to such a social dilemma would lay with developing an incentive system – such as an agreement among hunters of a given village to hunt a certain quota or hunt only at certain times of the year, while preventing outside hunters from using their patch of forest, rather than a change in attitudes.

Having said this, we know little about how attitudes toward wildlife damage change. These are deep-seated and reflect social settings more than individual experience (e.g. Bjerke et al. 1998; Vitterso et al. 1999; Naughton-Treves et al. 2003; Kaczensky et al. 2004). Attitudes may change from tolerance to hostility within one generation within the same community, as has happened in parts of India. For instance, in northern West Bengal an elder in a village community affected by elephant depredation had pleaded with a wildlife official to spare the life of the elephant because such depredation was only nature's way of extracting a tax from the people, and that this was no different from a tax extracted by the government. Two decades later in the same village the younger generation of farmers asserted that the offending elephant would have to be killed (V. Rishi, personal communication 2000). This is a reflection of rapidly changing socio-economic contours in the region. Conservationists often make the simplistic assumption that education and economic incentives can overcome upbringing and improve tolerance for wildlife, but social scientists are less sanguine about the plasticity of values associated with use of wildlife (Manfredo & Dayer 2004).

Increasing tolerance through education

Clearly, the value people place on wild animals will often depend heavily on their knowledge of them, and so education is a major tool in conservation (Sutherland 2000; Mishra et al. 2003). Indeed, Balmford (1999) argues that the most depressing conservation problem is not habitat loss or overexploitation, but human indifference to these problems. However, a dangerous fallacy is that opponents to wildlife conservation are merely ignorant. On the contrary, opponents to black-footed ferrets and prairie dogs in USA (Clark et al. 2001) were extremely knowledgeable, often with first-hand negative experience; changing the attitudes of well-informed individuals presumably requires very sophisticated education

(Reading & Kellert 1993; Kaczensky et al. 2004). We have almost no evidence for individual changes in wildlife valuation over time or following interventions (Manfredo & Dayer 2004).

Education and information in general can improve tolerance in another way if it reduces the perceived threat to more realistic levels. For example, many affected communities perceive the risk posed by wildlife out of proportion to its actual occurrence. Information on actual risk levels – if presented with due respect for the experiences of affected communities – can reassure affected communities and help reduce vulnerability by means of simple modifications to their behaviour or husbandry. In central Namibia, for example, farmers perceived cheetahs to be a major problem in livestock and game farms; farmers that considered them problematic killed an average of 29 cheetahs each year (whereas other farmers removed 14 cheetahs on average), but in a follow up survey after an education campaign had been established the number of annual removals had declined to 3.5 and 2, respectively (Marker et al. 2003).

Likewise, communities beset by wildlife damage problems may be empowered by accessing information on the steps they could take to reduce their own vulnerability. This would suggest that research undertaken by conservation biologists and the effective dissemination of their results to stakeholders is an intervention in itself, whereas research results communicated only to outsiders via the scientific literature would not be adequate solutions to human–wildlife conflict.

Conservation NGOs often are advocates of some issues – to that extent, like all advocates – they may be entirely happy to shift perceptions in the direction they wish irrespective of how that bears on reality? Conservation scientists, we would suggest, should be driven entirely by evidence and thus their current best description of reality.

Increasing tolerance through economic incentives

The prevailing view of nature conservation, at least in western societies, is to protect biodiversity for the benefit of the public as a whole and for future generations. It has been argued that the cost of conservation should be borne by many and not only by particular individuals that live, work or move in or near wildlife ranges (Sukumar 1994; Naughton-Treves 1999; Nyhus et al. 2003; Naughton-Treves et al. 2003; Naughton-Treves & Treves 2005). Mechanisms include direct cash compensation and indirect compensation through co-management, integrated conservation development programmes, or resource use such as ecotourism, game ranching and sport hunting. These measures are not necessarily so much interventions to resolve human–wildlife conflict, but also ways to address economic and social inequities that arise in conservation programmes. The same applies to damage-prevention approaches such as large-scale fencing (Thouless & Sakwa 1995), voluntary resettlement (Karanth & Madhusudan 2002), large-scale incentive schemes (Mishra et al. 2003) and community participation in conservation initiatives (Sillero-Zubiri & Laurenson 2001), which may result in direct economic and social benefits while addressing conflict.

When attempts to prevent wildlife attacks on people's property fail, or are half-hearted, many government wildlife protection programmes deal indirectly with damage by paying compensation for livestock and crop losses (Treves et al. 2002; Montag 2003; Naughton-Treves et al. 2003; Sukumar 1994), but these compensation schemes do not address the root causes of conflict: competition over resources. To be effective, compensation programmes require strong institutional support, clear guidelines, quick and accurate verification of damage, prompt and fair payment, sufficient and sustainable funds, and measures

of success (Nyhus et al. 2003). The majority of compensation programmes fail to deliver one or more of these services (Montag 2003; Naughton-Treves et al. 2003). Moreover the long-term sustainability of compensation schemes is questionable (Hötte & Bereznuk 2001), especially where monetary values are relatively high, because people may eventually stop preventing conflict, make false compensation claims and increase the costs of administering such schemes. On the other hand, when compensation is inadequate or government response unsatisfying, producers take things into their own hands, as did an Israeli farmer who poisoned livestock carcasses in an effort to kill wolves but in the process killed a number of threatened, scavenging birds (Nemtzov 2003).

Managing wildlife to reduce damage

Reducing 'problem' populations

Intervention may take place at different levels in order to reduce the severity or frequency of encounters between humans and wildlife (Fig. 17.2). Some early attempts at reducing predation on livestock or crop raiding resulted in extinction of a species (i.e. Falklands wolves were clubbed and shot to death by early sheep farmers, and passenger pigeons were shot by the millions in the name of sport – Wilcove (1999) reviews such mismanagement), or eradication of whole populations (e.g. grey wolves in USA,Young & Goldman 1944; several carnivore species in Britain, Langley & Yalden 1977). Such mismanagement was accelerated when the wildlife had some value, as leopards and elephants did for colonial British in Uganda (Naughton-Treves 1999; Treves & Naughton-Treves 1999). Reducing predation or crop raiding losses through the systematic and widespread killing of native animals has become uncommon with rising concern over biodiversity loss (Treves & Naughton-Treves 2005).

Killing the competition has been humanity's way of coping for millennia. Lethal control is exerted in various ways, not all of which are a simple response to economic damage. For example, predator control is done to elevate next season's gamebird populations, and the killing of livestock predators is usually done proactively (Treves & Naughton-Treves 2005).

The decline in many wildlife populations along with changing perceptions of nature and a decrease in livestock and crop-based economies in many developed nations has prompted interest in non-lethal methods of preventing damage by wildlife. Non-lethal methods remain in one of two categories: novel and largely untested (e.g. Musiani et al. 2003; Shivik et al. 2003) or ancient and largely unstudied (e.g. Ogada et al. 2003). But lethal control predominates. For example, around Antesana, Ecuador, cattle producers killed nine spectacled bears – a globally threatened species – before they felt satisfied they had eliminated the one cattle-killing bear (Galasso 2002 – see Karanth & Madhusudan (2002) for a leopard example from India). Unnecessary destruction of wildlife occurs in the USA as well – in 2002–2003, USDA-Wildlife Services killed 235,000 wild carnivores to control agricultural damage.

Opponents of lethal control also criticize its indiscriminate use – killing target and non-target animals – and its use as a political palliative or hidden subsidy for economic activities that are inappropriately managed, situated or financed. On the other hand, proponents of lethal control maintain that even killing non-target individuals will reduce future problems. Conservation biologists do not have adequate data to address this debate currently, although evidence is mounting that livestock-killers and crop-raiders are a minority in their populations and removal operations eliminate non-targets in up to 81% of cases with prevention of subsequent conflicts lasting a mode of 1 year (Treves & Naughton-Treves 2005).

Nevertheless, non-lethal methods face an uphill battle against institutional inertia,

affected individuals' desire for revenge or domination of offending wildlife, and the perception that lethal control is the easiest and cheapest method. An alternative to blanket lethal control is the reduction of animal populations by using fertility control methods, but these are still largely experimental (Tuyttens & Macdonald 1998; Bromley & Gese 2001; Chapter 12). Indeed, coyotes are probably the most studied conflict-causing species on the planet and decades of testing non-lethal methods emphasizes the short-lived nature of deterrence, the need for multiple simultaneous defences and the technical challenges of non-lethal controls (Knowlton et al. 1999).

Individual differences among predators are important to managing conflict because one widespread (and generally supported) belief has been that only a small proportion of individuals is responsible for most stock-damage (Knowlton et al. 1999; Linnell et al. 1999; Treves et al. 2002; Wydeven et al. 2004). It was once thought that inexperienced, juvenile, old, infirm and injured predators may be more prone to attack livestock but the vast majority of studies fail to support this conjecture (see Peterhans & Gnoske 2001). Young carnivores, especially males, are more likely to disperse from protected areas into habitats with no wild prey, and where interaction with humans and livestock is much higher (Saberwal et al. 1994). Body size may explain a greater role for male carnivores in killing large livestock, with male bears and large cat males shot or trapped more often following depredation (reviewed in Linnell et al. 1999). Gender-specific predatory behaviour such as the wider-ranging movements or higher risk-taking behaviour of adult males in polygynous mammalian carnivores might also play a part in disproportionate involvement of male cats and bears in livestock predation (e.g. Sukumar 1991; Peterhans & Gnoske 2001). Long-term studies of radio-collared carnivores suggest the majority can coexist with humans and domestic animals without being implicated in conflicts (Wydeven et al. 2004). Indeed, some avoid humans and domestic animals (e.g. Jorgensen 1979; Suminski 1982).

Translocation has often been used to manage problem wildlife despite serious reservations about its application and effectiveness (reviewed by Linnell et al. 1997). Most translocated animals end up causing problems again, fail to form social bonds or end up dead. Asian elephants translocated several tens or even over a hundred kilometres away from their capture locations in the Indian states of Karnataka and West Bengal have invariably gone back to their original homes within a few weeks (Sukumar 2003). Translocated grey wolves in north-western USA follow a similar pattern. Bradley et al. (2005) examined 63 individuals and nine cohesive groups of wolves (out of 105 translocated), mostly moved reactively in response to livestock conflicts. Nineteen wolves (27%) depredated after release, either creating new conflicts (18%) or returning home and resuming depredations in their original territory (9%). Wolves that were preemptively moved appeared no less likely to avoid conflicts; three of seven (43%) depredated after release. Most translocated wolves (67%) were never known to establish or join a pack.

Benefits of non-lethal control

Targeting problem animals with non-lethal methods (e.g. methods that alter individual behaviour include conditioned taste aversion, electric shock, sound, light and chemical repellents, diversionary feeding) could prove more effective than lethal control, because they tend to target problem animals and thus minimize population perturbation, for example, by retaining the predator in its original territory and social position (Jorgenson et al. 1978; Tuyttens & Macdonald 2000; Woodroffe & Frank 2005). For example, a traditional Polish hunting device, fladry, appears to deter grey wolves from entering fenced pastures (Musiani et al. 2003). Probably the single most effective

non-lethal deterrent against crop-raiders and livestock-killers is human presence and supervision of property (Naughton-Treves 1997; Mertens & Promberger 2001; Knight 2003; Ogada et al. 2003; Osborn & Parker 2003) – with the possible and notable exceptions of incursion by elephants, lions and tigers. Surprisingly, the cost-effectiveness of guarding by humans has not been widely tested as a deterrent. This targeting may avoid the density dependent population responses and immigration that can result from culling (for a review see Treves & Naughton-Treves 2005), while allowing the animal to continue with whatever effect it has on limiting other prey numbers or excluding conspecifics (Baker & Macdonald 1999).

One of the simplest but most innovative examples of behavioural modification resulted from the observation that tigers tend to attack people from behind when they crouched to gather firewood in the jungle, possibly mistaking them for a natural prey species (Rishi 1988). A scheme in the Indian Sundarbans to persuade people to wear facial masks behind their heads when venturing into the jungle proved effective in reducing attacks by tigers until a superstitious belief led to people discarding these masks. Tigers are now conditioned through electrified dummies to avoid people in this region, perhaps one of the most effective means to reduce man-eating (Sanyal 1987). Better monitoring of these schemes could have provided objective measures of success.

Whether lethal or non-lethal, all control actions fail sometimes to prevent damage. Some habitual offenders go to great lengths to reach their target. Certain individuals will find ways to pass through electric fencing given enough time (e.g. coyotes, Thompson 1978; elephants, Thouless & Sakwa 1995) and certain individual predators with a taste for livestock or humans become vexingly hard to kill or capture (e.g. leopards, Corbett 1954; lions, Peterhans & Gnoste 2001).

Mitigating encounters

Where integration proves unworkable, limiting the intersection of wildlife and human activities remains one of the most effective ways to preempt conflict (Fig. 17.2). Barriers, guarding and managing livestock are some of the most ancient and still widespread techniques to mitigate conflict (e.g. Thouless & Sakwa 1995; Andelt 1999; Knight 2003; Ogada et al. 2003). Unfortunately fencing sufficiently robust, deep and high to prevent wildlife from digging under or climbing over can be very expensive (Thouless & Sakwa 1995; Angst 2001). However, in Tibet's Qomolangma National Nature Preserve, production doubled in 2 years following use of communal corrals, built cheaply by villagers. They used the time saved from guarding to improve their handicrafts and income generation, and attitudes towards conserving wildlife improved substantially (Jackson & Wangchuk 2001). At the other end of the management continuum some wildlife agencies or NGOs have provided support and capital for fences and deterrent devices (Coppinger et al.1988; Fox 2001; Nemtzov 2003).

Guarding is widely used in many parts of the world, and often does not require large investment of capital. Usually during pre-harvesting and harvesting time, farm family members would take turns guarding field crops using makeshift watchtowers (e.g. against elephants; Sukumar 1989). To avoid heavy losses or high guarding investment, highly palatable seasonal crops such as maize should not be planted on the forest edge (Naughton-Treves 1998). On the broader level, conserving large blocks of forests and reducing edge habitat should be a management priority. More often guarding is undertaken by guard animals (Andelt 1999; Meadows & Knowlton 2000; Rigg 2001), or more rarely electronic guards (Knight 2003; Shivik et al. 2003) and sound systems to scare away animals (Studsrod & Wegge 1995). Trials with potential chemical deterrents such as pepper spray have shown limited success

against African elephants (Osborn & Rasmussen 1995).

In grazing systems where livestock are free-ranging and unattended, the presence of scattered livestock throughout a carnivore's home range may increase the likelihood of encountering, and consequently being killed by, the carnivore in question. This may explain why, even in areas with a good abundance of wild prey, livestock losses are high (Linnell et al. 1999). Small changes to husbandry practices, such as reducing herd size, keeping them in proximity to people and buildings and away from thick cover, not leaving carcasses out in the open and improving construction of holding pens, can improve livestock safety from wild predators (e.g. Naughton-Treves et al. 1998; Landa et al. 1999; Linnell et al. 1999; Naughton-Treves et al. 2000; Stahl & Vandel 2001; Ogada et al. 2003; Wydeven et al. 2004).

What else do we need to know?

With the exception of a handful of case studies, several reviewed above, we remain largely ignorant of the ecology and behaviour of problem wildlife, hence many management techniques often mistakenly encompass all wildlife as potential problems despite evidence to the contrary. There is a need to identify first whether problems are soluble or intractable. Second, how much more knowledge do we need in order to find solutions to many of the challenging cases of human–wildlife conflict that we have been occupied with? This lack of knowledge often promotes population reduction measures when we may really need problem animal identification and removal measures. The effectiveness of lethal control versus non-lethal control needs to be compared systematically and experimentally.

Too often researchers do not design studies in collaboration with managers who might be their immediate and critical audience. Likewise, managers often ignore good research and stick to traditional methods of managing human–wildlife conflicts. For example, the incidence of a few cases of cervid chronic wasting disease was treated as an emergency by deer managers, who decided on widespread culling, ignoring the advice of veterinary epidemiologists about the speed of responses and human dimensions experts about the appropriate response (Heberlein 2004).

A similar gulf separates most social scientists from biological scientists (Manfredo & Dayer 2004). Human–wildlife conflict starkly illustrates how modern conservation problems are primarily people–people conflicts revolving around the use or protection of natural resources and biodiversity. Yet wildlife managers have been slow to appreciate or adopt methods from the social sciences such as participatory planning, co-management and economic analysis. Likewise social scientists have been slow to understand the need for applied research that addresses conservation dilemmas preferring instead to generate theoretical treatises. One interpretation of the generalized failure to deal with the underlying bases of human–wildlife conflict is the assumption that human behaviour and attitudes do not change. This conjecture demands some study and particularly experimental tests of different methods of changing human behaviour and attitudes.

Conclusions – a need to compromise

Most landscapes are now dominated by humans. Where wildlife and people coexist, particularly when large carnivores and ungulates are involved, their biology provokes conflict and the best we can hope for may be an uneasy tolerance (Sillero-Zubiri & Laurenson 2001). Conflict occurs between competing interests for environmental resources; and solutions need compromise and strategies that do not necessarily involve sealing people off from nature but, on the contrary involve a respectful engagement with wildlife (Macdo-

nald 2001). Whereas this may once have typified the interaction of some knowledgeable country-people with wildlife – they killed wild animals when they had to, and tolerated them when they could, and could be at ease with both these outcomes – more recently, additional stakeholders have been added into the mix. These are bringing in a blend of conservation, perceptions of nature, animal welfare, politics and natural resource economics with them. There is an increasing urban-rural divide, brought about chiefly by the enormous political issues associated with city dwellers making decisions, and setting fashions, about the lifestyles of minorities who live in contact with wildlife. This is an extremely complex area requiring innovative, clear-thinking solutions. Thus dealing with conflict now often necessitates an orchestrated, multidisciplinary approach (Heberlein 2004).

Conflict between wildlife and people will continue to exist long into this century if not beyond, and necessitates management, for both imperilled and abundant species. The problems faced by these two categories clearly differ in detail, but both merit the attention of conservationists, and both may be susceptible to similar approaches using the same tools. Successful strategies will have to be based on the integration of many disciplines, including elements from the social and political sciences. Innovation and imagination are required to find solutions to conflict outside protected areas, and these most probably will require a mixture of strategies, including preservation, lethal and non-lethal control, changes in farming and animal husbandry, consumptive and non-consumptive uses, and complicated evaluations of costs and benefits (measured in such incommensurable currencies as biodiversity, money and ethics).

Conflict mitigation would be advanced by conservation initiatives that recognize the dual importance of large, linked areas of suitable habitat and of the protection of the economies and safety of human communities alongside wildlife. Crucially, an important requisite for success is often an involvement of the local community in the decision-making process and the sharing of any revenues accruing from wildlife. A traditional approach to conflict, now hopefully outmoded, characterized rural people as the problem; although this may be partly true it seems essential that they become part of the solution (Sillero-Zubiri & Laurenson 2001). In many cases, education must challenge deeply engrained cultural prejudices, whereas the sources of genuine conflict must be identified, understood and dealt with. Where conflict remains it will often be fitting for wider society to lift the burden, or risk, off individual producers in the interest of preserving species.

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We should find out as much as possible about someone before coming into conflict with him.
(Aesop's Fables, in *Collected Tales from Aesop's Fables*, Smithmark, 1988.)

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