Title: Predator control in the modern world

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Abstract: As predators' conservation value is increasingly recognised, decisions about predator control need to integrate strong evidence with social acceptability.

Main Text:

People respond to predators with strong, and often conflicting, emotions. In the past, wild predators were overwhelmingly viewed as threats to livestock, to wild "game", and even to public health. Over time, however, public perceptions have broadened to include recognition of predators' intrinsic value, as well as their role in structuring ecosystems. Nowhere are these changing perceptions better illustrated than in Yellowstone National Park, where the United States government deliberately eliminated wolves in the 1920s, only to actively restore them in the 1990s. With large carnivores now recovering across much of North America and Europe but declining elsewhere (*1, 2*), predator control which was once widely accepted by the public has become a source of intense social conflict (*3, 4*). We argue that, in the modern world, those charged with managing native predator populations may need to engage with stakeholders to identify – and often to conduct – robust scientific studies to inform the decision-making process.

Predator control may be controversial, but there is strong evidence to show its impacts on wild prey populations. Since Darwin noted that "*there seems to be little doubt that the stock of partridges, grouse and hares on any large estate* *depends chiefly on the destruction of vermin*", randomised controlled experiments have repeatedly shown that predator control can indeed bolster populations of prey species, including many of conservation concern (*5, 6*). However, the complexity of ecological systems means that predator control does not invariably benefit wild prey. In some systems, factors such as habitat loss or weather conditions influence prey numbers more strongly than does predation. Where there are multiple predator species, suppressing the populations of one predator may cause others to increase in number, leaving prey to face unchanged or even elevated predation rates. For example, a recent experiment showed that control efforts reduced mammalian predation on bobwhite quail nests, but these benefits were offset by increased predation from snakes (*7*). Similarly pronghorn (which are prey of coyotes but seldom wolves) appear to have declined in response to the extirpation of wolves, which caused a dramatic expansion of coyotes across North America (*8*).

Because predator control is not invariably beneficial, decisions about its use need to be informed by case-specific evidence. The highest quality evidence comes from experimental studies, and experimentation is likely to be especially important in ecological systems which, by their nature, entail multiple interacting components. Although experiments have been widely used to understand the effects of predator control on wild prey, decisions about controlling predators to protect livestock or manage disease have often been based on much weaker evidence. For example, despite the enormous effort invested in controlling populations of red foxes, coyotes, and wolves, we are not aware of any randomised experiments which show that such control reduces livestock predation as intended. Observational studies of livestock predation risk are difficult to interpret: control usually occurs in response to livestock attacks, making it challenging to untangle the effects of predator control from those of local conditions such as wild prey density.

The ability of experimentation to improve evidence in such cases is illustrated by the management of bovine tuberculosis in Britain. European badgers' role in transmitting tuberculosis to cattle was recognised in the 1970s, but decades of badger culling failed to prevent the infection from spreading across Britain. Subsequently, a randomised controlled trial revealed that culling consistently increased infection rates in badgers, spreading the disease in space and, under some circumstances, elevating disease risks for cattle (*9*). This failure of predator control to effect disease control was linked to badgers' social behaviour: killing territorial animals opened up breeding opportunities, creating a "vacuum effect" which attracted immigrants. The resulting social instability is thought to have increased opportunities for disease transmission (*9*). A similar behavioural response was reported among red fox populations culled across Europe in the 1970s with the aim of controlling rabies (*10*). Such fox control efforts were gradually abandoned as practical experience revealed that fox vaccination was far more effective (*10*).

Because predators have strong interactions within ecological communities, predator control conducted for a specific purpose often has broader consequences, which may be as unwelcome as they are unintended. Control or elimination of large carnivores, primarily to address livestock depredation, has been linked to increased deer numbers across Europe and North America, causing damage to forestry, crops, and road safety as well as cascading effects on ecosystems (*11*). Coyote increases following wolf extirpation in North America created a new depredation problem for sheep farmers. Likewise, culling badgers for disease control purposes doubled the numbers of another farm pest, the red fox (*12*). Such unintended consequences are frequent enough that decision-makers should seriously consider the potential for predator control to cause unwanted side-effects.

In deciding how and whether to manage predation, it is important to bear in mind that the need for predator control is itself often a consequence of human action. For example, in Patagonia puma predation appears to prevent recovery of indigenous herbivores such as guanaco, because puma numbers have been bolstered by the introduction of non-native prey including sheep, deer and hares (*13*). Similarly, Canadian oil developments have opened up the boreal forest, allowing deer numbers to increase and improving access for wolves. As a consequence, endangered woodland caribou face unsustainable predation, triggering wolf control (*14*). More generally, human-caused habitat fragmentation has been repeatedly linked to increased nest predation. Many predator control efforts aimed at conserving threatened prey are in fact addressing the symptoms of human-caused changes to ecosystem functioning.

Decisions about how to manage predation in such human-altered systems will be driven as much by the priorities of decision-makers as by rigorous scientific evidence. For example, if responses to woodland caribou declines prioritised biodiversity conservation, habitat restoration might be preferred over wolf control because this approach would preserve predation as an ecosystem process and an evolutionary force. By contrast, if short-term economic gains were prioritised, the need for wolf control (or indeed the loss of woodland caribou) might be considered a small price to pay for the prosperity achieved through oil exploitation. The caribou inhabiting Canada's boreal forest have come to resemble the partridges struggling to survive in England's wheatfields; both may be reliant on predator control because society is currently unwilling to restore their habitat to the wilderness it once was.

Effective predator management will be as reliant on social acceptability as it is on robust scientific evidence. Pragmatic conservationists have long recognised that allowing some predator control – whether or not it achieves its stated aims – can help to build tolerance among land managers who might otherwise block conservation efforts (*3*). Unfortunately, such compromise is not always effective. For example, small-scale culling of badgers on an around farms experiencing tuberculosis would be more socially acceptable than widespread badger control. However, such localised culling consistently increases cattle tuberculosis (*9*), facing policymakers with a stark choice between near-elimination of a native carnivore (unpopular with the public and possibly unlawful) or no badger control at all (unpopular with farmers).

Controversy about predator management can lead to intense social discord which may – rightly or wrongly – undermine management decisions. For example, in Britain conservation efforts for hen harriers have been hampered by persistent illegal killing, while attempts to control cattle tuberculosis by killing badgers have been disrupted by dedicated protestors. Where social conflict is intense, scientific evidence is often used selectively, contested, or dismissed. In such situations, involving stakeholders in the design, implementation, and interpretation of experimental studies may help to build trust and improve social learning. For example, in Banff National Park, Canada, controversy over grizzly bear management was successfully resolved by engaging stakeholders in a problem-solving group which shared responsibility for interpreting scientific evidence and making management decisions (*15*). Similar approaches might benefit the management of ecologically complex and socially divisive issues such as tuberculosis in badgers, wolf predation on caribou, and hen harrier predation on grouse (*4*). Approaches such as adaptive co-management have the potential to improve understanding of why control is ultimately pursued or rejected, promoting acceptance of such decisions. The challenge, especially in more intense social conflicts over predators, is that polarised views may prevent parties from engaging with the process at all. If policymakers, scientists, and stakeholders from all sides can show leadership in overcoming this challenge, predator management might become more evidence-based, as well as more responsive to changing social perspectives.

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FIGURE OPTION 1

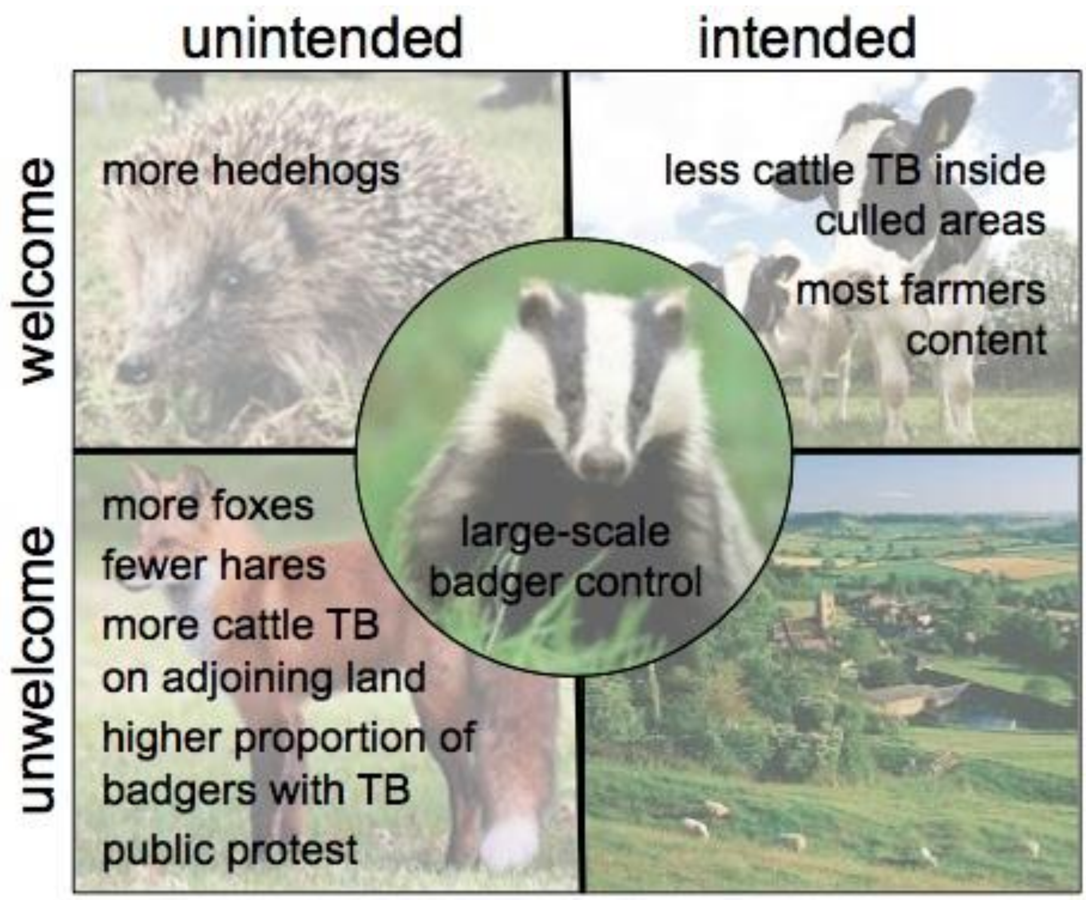

Figure 1 – Outcomes of controlling badgers in Britain, as revealed by a randomised controlled trial. Large scale badger culling was intended to reduce ruberculosis (TB) in local cattle but also had unintended consequences, both welcome and unwelcome. High badger densities themselves reflect farming methods favourable to badgers, and the nationwide elimination of larger carnivores. Based on evidence from refs (9) and (12).

Note to editors – These photos are illustrative; they are taken from the internet and we don't currently have copyright.

FIGURE OPTION 2