MANAGEMENT ALTERNATIVES RELATIVE TO PREDATORS

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***Abstract*:** Predator management to protect livestock, big game, and other species of wildlife is controversial. Lethal methods, while frequently effective, are increasingly criticized. This criticism reflects misconceptions about the availability of effective and economical non-lethal strategies, uncertainty about the effects of lethal control on predator populations, and the fact that predation continues even when lethal management practices are in place. This paper reviews various methods available for predation management, with a special focus on the availability and practicality of non-lethal strategies for game management. The overall conclusion is that few non-lethal methods are available, although new strategies are being sought. At present, the most ecologically and economically sound methods of predator control remain the selective lethal removal of individuals or groups of predators.

INTRODUCTION

The basic principles of predator management for game protection are well-known. These principles are central to the discipline and have been recognized as such for 75 years. Game Management (1933) was the first text for wildlife professionals; it remains an important contribution today.[1] Aldo Leopold wrote that managing a property to increase game species concurrently increases the number of predators for several reasons (e.g., increases in both game and buffer species, changes in predator habits, and influx of predators from surrounding areas). He cautioned that game managers should expect predation to increase as an unavoidable consequence of successful management. The question was whether losses would increase to levels that had significant negative impacts on game (Leopold 1933:235).

Historically, predation management has involved the lethal removal of problem animals (Knowlton et al. 1999). While lethal control remains an important method for game protection, these methods are increasingly unacceptable to the public (Reiter et al. 1999). Because social values drive the management of natural resources (Schmidt et al. 1992), considerable efforts are being devoted to a search for non-lethal alternatives (Mason 1997). Such alternatives are now useful components of strategies to manage damage by avian species and some mammalian herbivores (e.g., deer, beavers; Mason 1997). But non-lethal options for the management of losses to predators remain few (Knowlton et al. 1999), particularly in relation to the protection of wildlife.

Below, the methods available for predator management are reviewed, and the relative utility of these methods in different contexts is assessed. Because more is known about coyotes (*Canis latrans*) than other species, and since nearly all non-lethal methods have been developed with coyotes in mind, this species is emphasized. Lethal and non-lethal methods are presented sequentially, but the reader should note that effective management is always a blend of strategies and techniques (Slate et. al. 1992).

And, prior to any management action, several fundamental issues should be considered (Leopold 1933). These are:

1. The density of the game population;
2. The species and densities of predator populations;
3. The food preferences of the predator species;
4. The physical condition of game and the quality of habitat available to it;
5. The availability and species of buffer prey available to predators.

Information pertinent to these concerns can determine whether predator control is biologically warranted, which species of predators require management, and what practices should be implemented. Most important, the manager can objectively decide when management objectives have been met. A decision model that subsumes the issues above is used to guide decision-making in wildlife damage complaints by USDA-Wildlife Services (Slate et al. 1992). In the present context, the useful components of this model are (a) assess the nature of damage, (b) evaluate wildlife damage control methods, (c) formulate a wildlife damage control strategy, and (d) monitor and evaluate the results of control actions.

LETHAL METHODS

Most of the lethal methods that are effective for livestock protection also can be implemented to protect big game and game bird populations. Where state and/or local regulations permit[2], methods include the selective removal of individual predators by calling and shooting (e.g., Blejwas, unpublished manuscript), and population suppression by aerial hunting, trapping, snaring and, where livestock are present, the use of M-44 cyanide ejectors and Livestock Protection Collars (LPCs) (Knowlton et al. 1999). Factors affecting selection of the specific method include (a) the nature of the problem, (b) the presence or absence of historical loss, (c) the relative size of the area involved, (d) season of the year and timing with regard to predation or anticipated predation, and (e) the efficiency, selectivity, and efficacy of various methods of removal (Knowlton et al. 1999).

Population suppression is most often used when every individual in a predator population poses a potential threat to game (Guthery and Beason 1977, Connolly 1978, Smith et al. 1986, Teer et al. 1991, Cypher and Scrivner 1992, Henke 1995). Meeting the goal of suppression usually involves removing significant numbers of animals (e.g., $\geq$ 60%) over relatively large areas (Stoddart et al. 1989, Pitt et al. 2001)[3]. Effecting removals as close as possible to the anticipated risks both in time (Knowlton 1972) and proximity (Stoddart et al. 1989) is critical. Even under the most severe removal regimes (e.g., >90%), coyotes (*Canis latrans*) can repopulate areas within 4-5 years (Pitt et al. 2001). Population suppression is most effective in reducing predation when removals occur after the dominance and territorial patterns of predators are set in any given year, and immediately prior to whelping. This timing reduces the possibility that other individuals can repopulate an area, establish pair-bonds, and produce offspring (Knowlton 1972, Connolly 1978, 1995). At least for coyotes, this is important because livestock, and, quite likely, big game fawns are preferred in many areas by coyotes feeding pups.

Once suppression is accomplished,

the timing of additional predator control will vary among situations depending on the species and fecundity of the predators in question, their rates of immigration into removal areas and territory size, and game abundance in relation to habitat.

In many instances, the selective removal of individual predators can accomplish the same management objectives as population suppression (Conner 1995). This reflects the fact that territory holders are typically responsible for depredation on livestock, and by extension, big game (Till and Knowlton 1983, Sacks 1996) within their territorial boundaries (Blejwas et al. unpublished manuscript). Selective removal has the additional advantage of only removing offending animals, leaving other individuals to prey on rodents and other species that degrade habitat, or in some instances, act as predators on game themselves(e.g., mesopredators that feed on game birds and their eggs).

However, the methods used for selective removal require a high degree of skill (Knowlton et al. 1999), are time-consuming, and relatively expensive. As for population suppression, the timing of removal is important (Knowlton 1972).

The most selective method for the removal of territorial animals is calling and shooting with or without the use of decoy dogs. For coyotes, this method is easiest to implement during denning and pup-rearing (Alcorn 1946, Coolahan 1990), and it can be used to remove bobcats and fox in some situations. Although data bearing directly on the issue are unavailable, selective removals may be useful in settings where the threat to big game is analogous to the threat to breeding livestock. Another highly selective method for the removal of canid predators that kill livestock is the Livestock Protection Collar or LPC (Burns et al. 1988, 1996, Connolly and Burns 1990, Connolly 1993, Rollins 1995). It is probable that removing coyotes that have learned to kill sheep could benefit big game in the vicinity of the livestock.

While all predators have the potential of causing loss, control actions should be implemented only when predator impacts on game populations are sufficient to warrant concern. The mere presence of predators in an area is insufficient motive for management action. Efforts should be made to systematically census game numbers and gauge recruitment by young into the general population in relation to carrying capacity (Bartmann et al. 1992). There are situations when the positive impacts of predators outweigh the losses they might cause (Gese and Grothe 1995). Predators control rodent and lagomorph species that compete with game for food. In addition, larger predators such as coyotes will hunt and kill mesopredators (e.g., Abrams 1992, Palomares and Caro 1999), including raccoons (*Procyon lotor*), skunks (*Mephitis spp., Spilogale putorius, Conepatus leuconotus*), and foxes (*Vulpes fulva, Urocyon cinereoargenteus*) that are highly effective avian predators (and arguably more effective than coyotes; see also Henke and Bryant 1999). Finally, when game populations are stable and at carrying capacity (as determined by management objectives), the presence of predators that cull surplus animals and thus foster the production of trophy animals is beneficial (Bodenchuk et al. 2001).

NON-LETHAL METHODS

The majority of non-lethal methods developed for livestock protection are not suitable for the protection of wildlife. Of those methods with potential application, most have not been evaluated with game management in mind.

Guard animals

Dogs, llamas, and donkeys are the most commonly used livestock guardian species. The most extensive evaluations have been with dogs (Linhart et al. 1979, Coppinger et al. 1983, Black and Green 1984, Green et al. 1984, Green and Woodruff 1983, 1987), and the evidence shows that canines are effective in some settings (e.g. Linhart et al. 1979), but not others (Timm and Schmidt 1989, Conner 1995). Reasons for these differences are not well-understood, but sheep, for example, can be difficult to protect when they are in large flocks, dispersed over rough terrain, and where there is cover that effectively conceals predators. Whatever the case, while dogs are sometimes useful with livestock, there are few or no situations where they can be used to protect game. Wildlife typically prefer habitats where dogs are least effective, and dogs harass and kill game (Timm and Schmidt 1989). Moreover, the presence of dogs precludes the use of other techniques (e.g., traps, snares, M-44s) that might otherwise by implemented to protect game.

Unlike dogs, llamas may have applications for game protection in some settings. Recent evaluations with livestock are promising (Cavalcanti 1997; Meadows and Knowlton, 2000). Llamas do not require special feeding programs, are usually tractable with humans, have a long working life compared with dogs, and do not interfere with the implementation of other predator control methods. For species of big game that aggregate during fawning, or for species of game birds that prefer grass pastures, the presence of llamas in fenced pastures could serve as a deterrent to coyotes, foxes, and feral dogs.

There is little or no evidence that donkeys are effective guardians for livestock or wildlife. In fact, donkeys can behave aggressively towards lambs (W. Andelt, personal communication). Because donkeys might also behave aggressively towards fawns, the use of this species for wildlife protection s not recommended.

Husbandry

A number of husbandry practices have been developed to protect livestock from predators, but few have been systematically evaluated in terms of efficacy, cost or benefit. Some of the more frequently mentioned techniques include: confining or concentrating flocks during periods of vulnerability, using herders, shed lambing, removing livestock carrion from pastures that might attract predators, synchronizing birthing to reduce the period of maximum vulnerability, and pasturing young animals in areas with little cover and in close proximity to humans (Robel et al. 1981, Wagner 1988).

Several livestock husbandry methods could have applicability for wildlife protection. Removing carrion that attracts predators, and synchronizing births among big game would both be beneficial. For mule deer and other species, synchrony can be facilitated by allowing animals to concentrate during the rut without harassment or hunting (T. A. Messmer, personal communication).

Habitat manipulation

There are situations in which invasive exotics, such as tamarack (*Tamarix ramosissima*) or undesirable native vegetation, such as dense stands of juniper (*Juniperus communis*), can degrade habitat and provide cover for predators. The removal of this vegetation by prescribed burning or other methods (e.g., chaining) can improve habitat for native species, increase beneficial forage plants, and diminish predation risk.

Fencing

Barriers can exclude mammalian predators and deter their use of specific areas (DeCalesta and Cropsey 1978, Linhart et al. 1982, Shelton 1984, 1987, Nass and Theade 1988). Fencing also can increase the efficiency with which predators can be removed when necessary (Knowlton et al. 1999). However, no fence is completely predator-proof, and at the very least, periodic selective removals of predators that cross fences may be necessary (e.g., Shelton and Wade 1979). Most likely, electric fences are more effective than non-electric fences, with effectiveness dependent upon post and wire spacing, number of wires, fence height and fence maintenance (Green et al. 1994)[4]. Existing fences can be retrofitted with electric strands attached to offset insulators to exclude canid predators. Hi-tensile electric fences are effective against mountain lions (*Felis concolor*) and bears, as well as canids (Pratt 1990). An important caveat is that predator fencing can hamper the movement of wildlife (e.g., antelope, *Antilocapta americana*).

Fladry

Recent reports suggest that cloth or plastic flagging on single strand fences (i.e., fladry) can prevent wolf depredation on livestock and game (Musiani et. al. 2000). At the least, this possibility remains controversial. Whether or not fladry is an effective deterrent to wolves (*Canis lupus*) and whether they have any utility for the protection of big game is untested. No data have been collected with coyotes or other predators (e.g., bobcats, *Lynx rufus*). Because flagging is attractive to cats and commonly used as a visual trap attractant for coyotes (Mason et al. 1999), the technique is unlikely to be effective except in specialized circumstances.

Electronic devices

Apparatuses that periodically emit bursts of light or sound can temporarily (3-4 weeks) deter predation on livestock in fenced pastures (Linhart et al.1992, Linhart 1984a,b, Linhart et al.1984) and on the open range (Linhart et al. 1992, Bomford and O'Brien 1990, Koehler et al. 1990). The duration of effectiveness can be increased when devices (such as the Electronic Guard available from the Pocatello Supply Depot) are used in appropriate numbers (approximately 1 per 10-15 acres), moved periodically, and programmed to vary the temporal pattern of stimulus presentations. Use of such frightening devices is not widespread even for livestock protection, in part because operating sirens and strobe lights at night near people is unacceptable, and because the strategy is costly and labor-intensive[5]. Although there are no published data, the likelihood is that devices that frighten predators will also frighten big game, and that habituation to the devices by big game will approximate habituation by predators. The devices might be less upsetting to game birds and, when used in combination with other strategies, frightening devices might have utility for small game protection. There are anecdotal reports consistent with this possibility (R. Johnson, personal communication).

Repellents and learned aversions

There are no commercially available predator repellents with demonstrated effectiveness[6]. While sensory repellents such as quinine hydrochloride and capsaicin discourage coyote damage to inanimate objects (Werner et al. 1997), these substances are not commercially available for this purpose, and there is no evidence that they deter attacks on live prey (Lehner 1987). Instead, the available data suggest that predation continues despite the presence of these materials, although predators sometimes redirect attacks to avoid sites treated with highest concentrations of repellent (Burns and Mason 1997).

There are a few repellents that reduce food consumption by captive predators. These include pulegone, cinnamaldehyde, and allyl sulfide (Hoover 1996). The possibility exists that these or similar substances may be useful to deter predators from feeding on eggs. However, none of these substances are registered with the U.S. Environmental Protection Agency, a prerequisite for their sale (Hushon 1997). Registration costs are invariably high, and sometimes exceed several million dollars. This is true even when the materials in question are harmless, and already approved for use in human and animal feeds by other federal agencies[7].

Conditioned taste aversion (CTA), using lithium chloride or other emetic compounds to make animals sick, has been tested as a way to reduce depredation by coyotes, resolve nuisance issues with black bears (*Ursus americanus*, Ternent and Garshelis 1999), and curtail egg predation by raccoons, skunks, mongooses, ravens and crows (*Corvus spp.*) (e.g., Semel and Nicolaus 1992, Nicolaus et al. 1982, 1983, Nicolaus and Nellis 1987). Although no CTA method has been approved for use by the U.S. EPA, the available evidence concerning egg depredation is promising. Provided that 'poisoned eggs' resemble the eggs to be protected, and that alternative foods are readily available, significant reductions in loss are usually observed. Not so with livestock predation. So far as sheep-killing by coyotes is concerned, the results are equivocal. Some investigators report success (Gustavson et al.1974, Ellins and Martin 1981, Gustavson et al.1982, Forthman-Quick et al.1985a,b), and others reporting failure (Conover et al. 1977, Burns 1980, Bourne and Dorrance 1982, Burns 1983, Burns and Connolly 1985). Ten years after the most extensive field trial involving use of lithium chloride (Gustavson et al. 1982, Jelinski et al. 1983), a survey of participating sheep producers showed that while 54% of the participants initially considered CTA "successful" or "somewhat successful," only one still used it (Conover and Kessler 1994). There are no data that bear directly on the use CTA to protect big game. CTA, as attempted to date, should not be considered as a method to protect livestock or big game.

Reproductive interference

For more than 25 years, sterilants and abortifacients have been tested as strategies to control over-abundant wildlife such as while-tailed deer (*Odocoileus virginianus*) and non-migratory populations of Canada geese (*Branta canadensis*) (Miller 1995, DeLiberto et al. 1998). The results of these investigations have been ambiguous. Despite continuing public support of sterilization as an alternative (Lauber and Knuth 2000), no reproductive inhibitor has been used to successfully drive declines in wildlife numbers regardless of the species considered.

Reproductive interference to control predator behavior (rather than to reduce their numbers) is now receiving considerable attention as a strategy to control coyote damage. The strategy is predicated on research showing that depredation can be reduced by removing pups of depredating coyotes (Till and Knowlton 1983, Sacks 1996, Zemlicka 1995).

Recently, Bromley and Gese completed an investigation of sterilization as a method of reducing coyote predation on domestic sheep (Bromley 2000). In the winter of 1998, these investigators surgically sterilized and radio-collared members of 5 coyote packs, while 6 packs remained intact. The following summer, the 5 sterile packs killed one lamb, while the 6 intact packs killed 11 lambs. During the winter of 1999, the investigators monitored 4 sterile packs and 8 intact packs. The following summer, the sterile packs killed 3 lambs while the intact packs killed 22 lambs. The significance of these results for wildlife management is twofold. First, surgical sterilization could have benefits for the protection of big game fawns. Second, surgical sterilization is a tool that could be used almost immediately by any game manager following training in the relevant surgical procedures.

Important caveats to the use of sterilization to manage depredation are first that the method only has demonstrated utility with coyotes, and second, that it is probably effective only when fawning and pup-rearing coincide. When these events are asynchronous, sterilization may not influence loss. For example, in north-coastal California, depredations peak during a lambing season which is out-of-phase with pup-rearing (Scrivner et al. 1985, Conner 1995, Sacks 1996). In this situation, presence of lambs, not the presence of pups, is the important determinant of predation patterns in some situations. Because birthing seasons in some areas of Texas may be asynchronous with pup production, sterilization may be useful in some areas but not others.

CONCLUSIONS

Integrated strategies, involving both lethal and non-lethal methods, are required for effective predator control. However, despite extensive on-going research, effective non-lethal strategies do not exist for many wildlife applications. Every situation is different, and no simple solutions apply. There will be settings in which reductions in predator numbers are unwarranted. These include instances where game is close to carrying capacity, or when the removal of relatively unimportant predators (e.g., coyotes in relation to quail) permits the number of relatively important predators (e.g., foxes, raccoons, skunks) to increase. Whenever possible, small properties should band together in coordinated management plans that increase the acreage under control. Otherwise, predators will move into managed ‘sinks’ from surrounding unmanaged areas, and swamp whatever benefits might accrue from individual management plans.

Whatever the strategy, habitat manipulations alone are often insufficient to increase game numbers, so that they meet management expectations. Large sums can be expended acquiring and improving habitat, but the success or failure of an entire management scheme may depend on whether or not predator management is a component of the overall management plan.

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[1] Aldo Leopold's classic text on this subject is clear and informative. Reading this book is beneficial to anyone interested in the basic principles of habitat and wildlife management.

[2] Wildlife damage control methods are subject to legal and administrative constraints. Some methods are legal in one state but not in others, or only in portions of a state. The status of the target species (state or federally listed as threatened or endangered), or the presence of listed species in the area where control activities are proposed may preclude use of a method. Also, wildlife damage control programs may restrict the use of specific methods by policy or agreement with other parties. The important questions are: (a) is the method legally and administratively permissible with the species in question, (b) is the method legally and administratively available to resolve the damage in question, (c) is the method legally and administratively available for use at the specific site in question or are there restrictions because of land class, other land use patterns, or the presence of listed species near the site of damage. Finally, there are additional constraints that vary from state to state concerning who is authorized to apply methods.

[3] As a general rule, the larger the area of supression, the better the result (Stoddart et al. 1989). Smaller properties should consider cooperating in predator management efforts.

[4] Practical information about fencing and other options for coyotes and other predators is available in Prevention and Control of Wildlife Damage, published by the Cooperative Extension Service of the University of Nebraska, the Great Plains Agricultural Council, and USDA-APHIS-WS.

[5] Scientists at the National Wildlife Research Center are developing considerably smaller units than those currently available. These new apparatuses also have the option of activation only when a predator is detected nearby (J. Shivik, personal communication).

[6] There are products containing bone tar oil that are sold as predator deterrents in Canada and in the United Kingdom (e. G., Renardine). These substances are not repellents and may in fact attract some predator species (Zemlicka and Mason 2001).

[7] As an example, methyl anthranilate is the active ingredient in a number of bird repellents. This chemical has been commercially available as an FDA-approved human and animal food flavoring for more than 50 years. In order to obtain a registration with the U. S. EPA for this product, the company involved spent 5 years and $5 million dollars (P. Voght, ReJex-It Incorporated, personal communication).