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Non-lethal Alternatives for Predation Management

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Introduction

The ethical milieu in which wildlife biologists and livestock producers work continues to change as the concepts of environmentalism and animal rights and welfare have become introduced and normalized (Singer, 1975). The American public, including livestock producers, are mired within a typically human psychological quagmire of having a high demand for benefit, but a low tolerance for cost — that is, economic forces. Americans tend to demand a cheap, reliable food supply, while simultaneously demanding the existence of animals that, through predation activities, drive up production costs. Ironically, members of the urban public who may find fault with food and fiber production practices are also the customers on which livestock producers are dependent.

In the United States, predation management has evolved from an attempt to eradicate or limit predator populations to the application of focused approaches for minimizing the damage done by predators. For coyotes, very large scale population suppression (using 1080), was restricted and sometimes apparently ineffective (Wagner, 1988). Other authors could find little correlation between the number of coyotes removed and the number of sheep kills at a California ranch (Conner et al., 1998). Further studies suggested that at least in some areas, dominant territorial coyotes are responsible for most sheep predation but typical lethal control methods tend to bias capture toward coyotes that are less likely to be livestock killers, thus, typical lethal methods such as trapping, snaring, and using M-44s are sometimes inefficient for solving depredation problems (Sacks et al. 1999, Blejwas et al. 2002).

Lethal control methods are also often at odds with conservation needs (Shivik et al., 2003; Haber, 1996) and the general public favors the use of non-lethal methods of predation management in many situations (Reiter et al., 1999). Non-lethal methods provide a means of keeping predators established, while protecting livestock from predation and thus, a great amount of effort has been spent identifying and evaluating non-lethal predation-management options (Linnell et al., 1996).

Effects of territoriality may improve efficiency of non-lethal methods relative to lethal control. Because predators, such as coyotes and wolves, are territorial and relatively long-lived, multi-year effects of management actions are possible, in contrast to lethal control which tends to be required annually (Bromely and Gese, 2001a,b). One goal of non-lethal methods with territorial species is to develop a bioexclusive effect such that resident predators do not kill livestock themselves, but further prevent losses by excluding other predators from the area.

The field and body of knowledge on non-lethal techniques is growing, and a need exists to categorize and understand the plethora of methods that are being advertised by both scientists and charlatans. The objective of this paper is to provide a descriptive outline of non-lethal methods for predation management and to identify hindrances to their use and future development. I have performed a basic search of non-lethal methods that are available. These methods have been categorized and then discussed. Note that inclusion of a method in this paper is not an endorsement or guarantee of effectiveness of the technique; the effective application of any management method will depend upon the particulars of the management situation. Many methods that are applicable in small pasture situations, for instance, may have little or no applicability in large, open-range situations.

Materials and Methods

Categories of Non-lethal Methods

Conflicts between humans and predators occur when food-acquisition behaviors of predators vie with food-production behaviors of humans. Thus, decreasing the level of conflict is largely a matter of altering specific behaviors of either humans or predators (or both).

Humans can alter food-production behavior (e.g., husbandry) to prevent conflict. However, human conflicts with wildlife also have a psychological (i.e., the degree of conflict is a matter of perception and personal opinion) and/or economic component. Therefore, some non-lethal methods of resolving predation problems can alter human behavior by assuaging the perception of the conflict. If the source of conflict is economic loss, other methods can address economic concerns.

Altering Human Behavior

Niche marketing. In some circumstances, it may be possible to influence what level of loss is economically and socially acceptable. For livestock producers, aggressive and innovative marketing through value-added products may help to shift the costs of damage onto the members of the public that prefer the use of non-lethal methods of damage control. For instance, prices of "wolf-friendly" goods could capitalize on a niche market that will support non-lethal wolf management practices.

Compensation. Individuals may be able to take advantage of subsidized compensation programs. Various governments and non-governmental organizations approach systems of compensation differently, and the use of compensation for losses remains controversial, with a requirement to proactively understand the agrarian system where compensation is to be applied (Angst et al., 2003; Montag, 2003). Surveys indicate that although non-lethal methods of predation management are preferred by the general public, government compensation for damages is not (Wagner et al., 1997). Some private organizations have been willing to fund compensation programs and encourage public support where damage due to predation is linked to particularly valued species such as wolves. However, the economic logic of compensation programs is limited because they do not actually address the cause of the problem and may be much more expensive (including administrative, predation culpability evaluation, and actual payment costs) than the impact of the damage that they are designed to reduce (Wagner et al., 1997). Two points that should be understood when considering implementing a compensation program are that compensation does nothing to manage or reduce the level of predation, but that it may help to increase public acceptance of predation while acknowledging the economic hardships caused by predators. The topic of compensation is complex and is therefore addressed more completely elsewhere in this issue.

Insurance. Some insurance companies will insure against livestock losses. Problems associated with instituting insurance programs include the need to find and positively identify predator damage, and agreeing on real market value of dead livestock. Insurance programs are most easily instituted when the threat of damage is low, but spatially extensive; however, in most current predator-damage situations, the threat of damage is high on small areas. but minor at the industry scale. The basic administrative needs of an insurance program require significant amounts of capital investment with only a small pool of livestock owners from which to draw insurance premiums. Without subsidies, the associated premiums of insurance may be too costly for programs to be financially solvent. The topic of insurance is complex and is therefore addressed more completely elsewhere in this issue.

Zoning lands. A concept that has recently been examined is the physical separation of predators and livestock by zoning lands for livestock use or predator conservation (Linnell et al., 1996). This concept acknowledges the need for different management goals and priorities in different areas and adapts methods, rules, and recommendations to vary within individual geographic zones. For example, some areas would be managed to be free of predators and designated for livestock, but other areas would be designated as wild places where predators roam with minimal human disturbance. Success of zoning would depend on identifying the appropriate size of zones and buffers such that conservation needs are met (Linnell et al., 1996). However, changing the use of large tracts of land after a long history of one use (e.g., changing grazing lands into a predator zone) may be politically intractable.

Altering Husbandry

Animal armor. A fairly new and untested method of livestock protection uses plastic collars to prevent canids from being able to grasp and kill sheep. The King Collar (Gray King, South Africa [046] 685 0645) is a brand of animal armor developed in South Africa for protection from jackals, a species that closely resembles coyotes in appearance and behavior. The manufacturer claims that the collar prevents jackals from gripping the cheek and biting the trachea. Its application to wolves or bears, which have different killing patterns than jackals, is unknown. It is possible that the novelty of protective collars may deter predation for some period of time, but because predators are very adaptable and quick to learn alternative methods of killing, animal armor that is both practical and effective in the long term will be difficult to develop. However, more research and development is required for a more thorough evaluation of its potential.

Herding/vigilance. North American predators tend to be wary of human presence, and a good herder who is able to stay with and monitor livestock can be an effective method of protection (Linnell et al., 1996). Furthermore, humans are able to observe when predators enter an area, employ aversive or disruptive stimuli, and identify the characteristics and timing of predators and predation. It is possible to maintain a human guard that walks through the pasture throughout the day and night watching for and chasing away wildlife. In most situations, hiring a human guard may be cost prohibitive; however in situations with sponsors, e.g., the Wildlife Guardian program (Defenders of Wildlife), outside parties can assist private producers by providing a free service of human guards for livestock.

Fencing. Fencing is a predation mitigation method that involves constructing a physical barrier that will keep human resources and predators apart and has been studied for centuries (Jardine, 1908). Because of previous thorough reviews, discussion of fencing is limited in this paper (Wade, 1982), but the topic is an important concept for consideration. Exclusionary devices can be as simple as an easily-strung, electric-energized temporary corral, or as complex and expensive as a dingo-proof fence stretching from one side of Australia to the other. Barriers can be extremely expensive to construct and maintain, and attention to detail in barrier construction and maintenance is extremely important. The general assessment is that fences can be very effective, but due to construction and maintenance costs fences are most practical for small night-time enclosures (Dorrance and Bourne, 1980; Linhart et. al., 1982; Linnell et al., 1996).

Night and seasonal enclosures. Robel et al. (1981) suggested that night penning is effective for minimizing losses to predators. Some producers herd animals back to corrals in the evening, and a few have proposed training beef cattle to return to barns at night by feeding them regularly in the evening, similarly to how dairy operations bring cattle in for milking. Shed lambing, i.e. keeping ewes inside a shed when they are giving birth to lambs, can reduce lamb losses due to predators and other factors. It is also common to calve near human habituations to assist cows with parturition.

Clearly, this technique is most possible in small operations, especially near human habitation, when small- to medium-sized flocks and herds can be grouped tightly and enclosed by a human herder. However, corralling livestock tightly can likely lead to localized damage to the range, and increase disease transmission and stress for the animals. Furthermore, this intensive husbandry may require additional labor costs that are prohibitive.

Timing of breeding. Predators are often more likely to kill livestock at specific times of year, e.g. coyote-killing of lambs often coincides with the need to provision their pups (Till and Knowlton, 1983; Bromely and Gese, 2001a). If livestock are bred earlier in the season, they are larger earlier and may be less vulnerable to predation, thus Robel et al. (1981) concluded that fall lambing reduces sheep losses. Altering breeding may allow for optimization of market price and predator-damage economics, but market and range conditions may be more important economically, making altering reproduction for predation management economically unfeasible. Other limitations include the biological limits to the alteration of lambing seasons and the increased husbandry and veterinary costs involved with altering reproductive cycles.

Selective pasturing, lambing, and calving. Certain pastures and range areas may have a record of high predation, i.e., be "hot spots" of predation (Linnell et al., 1996). Spatially intense predation may be due to some intrinsic aspect of the land, e.g., it may have a nearby rendezvous site with cover and prey that attracts predators, or the land may be near a source population of wolves. Coyote predation on livestock tends to be associated with the availability of stalking cover and land features (Pearson and Caroline, 1981). Sometimes, it may be possible to not use an area for grazing, and it may be economically advantageous to do so if predation pressures are high. In rotational grazing schemes, incorporating probability of predation into the management plan may be useful. Of course, when grazing areas are most beneficial to livestock, they may also be most attractive to predators, so simply altering timing or use of land may not be feasible economically or logistically. Also, moving livestock around repeatedly can cause additional stress and affect weight gain.

Altering herd composition. The composition of herds may influence the degree of depredation. For instance, sheep are generally much more vulnerable to predation than cattle (Fritts, 1982; Gee, 1979). An interesting husbandry practice employs a combined livestock operation. Mixing cattle with sheep (i.e., forming a "flerd") may lead to a better use of the landscape, with the added benefit that cattle may be more aggressive toward small predators, thus providing some degree of livestock protection (Hulet and Anderson, 1991). However, cattle and sheep operations are different in terms of market conditions, timing, and land use, and switching to raising both animals may be difficult or impossible for some producers. Furthermore, cattle and sheep do not stay together naturally and efforts at bonding the two must be made, for instance by raising young heifers with lambs for 30 to 60 days. Mixed composition livestock operations, however, have yet to be thoroughly investigated for their degree of protection from predators, and because cattle too are subject to predation, the effectiveness of using cattle for deterring predation by large predators is questionable.

Sanitation. Eliminating food resources in the form of bone yards or carcasses can reduce the attractiveness of an area to predators and other species of wildlife. Some research suggests that regular carcass removal and sanitation around livestock operations may help to lessen the severity of canid predation (Robel et al., 1981), while other research is less clear on the benefits of carcass disposal as a method to reduce wolf predation (Mech et al., 2000). As with most non-lethal methods, the degree of effectiveness using carcass removal is mostly unknown. Destroying carcasses may be beneficial indirectly, for instance, by limiting food supplies for predators, thus limiting their attraction to an area where livestock reside. Thus, many experts recommend removing carcasses and food sources when possible. However, in large livestock operations, logistical constraints on the ability to remove or destroy carcasses can be formidable, thus limiting the application of this management technique.

Altering predator behavior

Humans can reason paths away from conflict, but with other animals, the only options are to alter or prohibit specific predatory behaviors. Two broad behavioral modification approaches have been widely used, confused, and misused for depredation management (Bangs and Shivik, 2001). First, primary repellents use disruptive stimuli, which are stimuli that disrupt predatory behaviors by causing a "fright" or "startle" response. The limitation of primary repellents is that predators will quickly habituate to, i.e. learn to ignore, the stimuli, which leads to a loss of effectiveness. Second, secondary repellents use aversive stimuli, which are paired with a behavior in order to condition a predator against the behavior. The difficulty with using aversive stimuli is that achieving effective and specific conditioning against behaviors such as attacking cattle may be extremely difficult under natural conditions (Shivik et al., 2003; Shivik et al., in press). It is important to understand that putting flashing lights in a pasture will not aversively condition wolves to not enter the pasture; to the contrary, wolves will learn to ignore the stimulus. Similarly, shooting wolves with rubber bullets when they enter a pasture will not necessarily condition the wolves to generalize and avoid the area or to avoid killing calves; rather, they are more likely to learn to avoid the person shooting at them.

Primary Repellents: Disruptive Stimuli

Simple Visual Stimuli. One of the most ancient disruptive stimulus techniques is a scarecrow. The concept can be extended to almost anything out of the ordinary that is placed in a pasture or area and startles or frightens predators away. A light in a field or a vehicle or some other large object in a pasture may keep some predators from entering, at least for a short time. As with scarecrows, of course, animals quickly become accustomed and habituated to passive disruptive stimuli. Moving the object or light around intermittently and randomly may slow the habituation process (Shivik and Martin, 2001). Simple disruptive stimuli are beneficial because they are fairly inexpensive and easy to apply. However, they are usually useful in small pens or pastures only. It is presumable that a bigger object may be more of a deterrent, but some pastures may not be accessible with vehicles. If protection is needed for a very short time, then simple stimuli may be useful. Because rapid habituation by predators is likely, other methods will probably be required to achieve a significant degree of protection.

Noise. As with visual disruptive stimuli, sounds can frighten or startle a predator and limit access to an area. Radios, ultrasonic devices, and other noise placed in a pasture or pen and played loudly during the night will likely frighten intruding predators for a limited time (Blackshaw et al., 1990; Bombford and O'Brien, 1990; Koehler et al., 1990). Exploder cannons are propane-powered disruptive stimulus devices that intermittently fire, producing a loud boom that may deter coyote predation for about 31 days (Pfeifer and Goos, 1982; Andelt, 1996). Ultrasound is often touted as an animal-damage panacea for everything from mice to large ungulates, but as with any other simple stimuli, animals are likely to habituate to it very quickly (Bombford and O'Brien, 1990). Noise-generating devices, especially ones with sirens or other emergency sounds, require the notification of neighbors and law-enforcement personnel in order to prevent worry and confusion. As with other simple auditory stimuli, predators will habituate to sounds quickly; moving them frequently may increase longevity of effectiveness.

Flashing lights, Electronic Guards. Linhart et al. (1992), in an operational study of a strobe light/siren device (Electronic Guard), determined that Electronic Guards reduced sheep losses by 60%. Electronic Guards are randomly activating light and siren disruptive stimulus devices. According to APHIS guidelines, more than two units must be used in small fenced pastures, or one unit per 10 acres in larger areas. The devices may be purchased from the United States Department of Agriculture, Wildlife Service's Pocatello Supply Depot. They appear to be beneficial in areas, such as bed grounds, and are small, portable and flexible for various-sized areas. Electronic Guards are limited, however, in that their noise and lights can annoy people, and habituation by predators is likely at about 91 days for coyotes (Linhart et al. 1984). Use of Electronic Guards requires notification of neighbors and law-enforcement personnel to prevent undue alarm. Other researchers have extended the Electronic Guard concept to Radio Activated Guards for wolves, which activate in response to the presence of a radio-collared animal and may delay habituation (Breck et al., 2003).

Fladry. An ancient Eastern European technique used to capture wolves is to drive them along a narrowing boundary constructed of flags hung beneath a rope. Wolves tend to not cross the human-constructed line and can be driven into a corral or net-trap. Some research indicates effectiveness of fladry with captive wolves, but reports of effectiveness under field situations with other predators have varied (Musiani and Visalberghi, 2001; Shivik et al., 2003; Musiani et al., 2003). Fladry is likely to be limited to small- and medium-sized fenced areas because the flags require maintenance, especially in places with high winds. One study estimated longevity of effectiveness with wolves of 1 to 60 days (Musiani et al., 2003).

Chemical Repellents. Although applying chemicals over a wide area can be less expensive and easier than using other methods, there are a number of difficulties associated with using chemical repellents in the environment. First, there are no selective chemical repellents that affect only individual species (Lehner, 1987). The sensory physiology of all mammals is similar, and thus a selective chemical repellent which will repel predators, but not affect livestock or humans has not been identified. However, some manufactures claim efficacy of their predator repellents. Renardine, for example, is bone tar oil that is claimed to be a repellent for coyotes. The product is used to coat fence-lines and posts. Like any novel stimulus, strange smells posted around a pasture may deter predators from entering and predating on livestock. It may be applied to small- to large-sized pastures, but is costly and messy to apply and, due to habituation, its effectiveness may be limited.

Burns et al. (1984) determined that non-lethal amounts of chemicals in collars did not stop predation, but new chemical-filled collars are available. The Vichos anti-predator collar, for example, incorporates a chemical repellent in its construction. When punctured, a formulation of 3% capsaicin oleo resin is dispensed. In one study, researchers determined that the Vichos collar was ineffective for deterring predation because the collars did not prevent a second attack, which was usually launched at the hind-quarters of lambs instead of at the neck (Burns and Mason, 1996).

Biological odor repellents. Predators, such as wolves and coyotes, use scent marking to delimit territories, and although territoriality does not ensure complete exclusion of conspecifics (Shivik et al., 1996), it may be possible to mimic territorial behaviors by surrounding pastures with artificial scent marks that could repel intrusions. This technique can be used on areas of various sizes, but it has not been thoroughly evaluated and its effectiveness is in question. For example, other behavioral (e.g., howling) cues may be necessary to effectively prevent intrusions, and maintenance of scent stations may require frequent (i.e., daily) visits around the protected area's perimeter. Individual scent marks are also attractants for coyotes and wolves (e.g., scat and urine are used as lures to selectively capture them), and the method of applying artificial scent marks such that they repel predators has not been determined.

Disruptive harassment. In some situations, it may be possible to guard an area and then, if a predator enters a livestock area, use rubber bullets or other non-lethal projectiles to prevent a predation event. This technique may be beneficial because it is selective for predators presenting an immediate threat of depredation, but is limited due to logistics and cost of the required effort — a trained person must be nearby to observe and harass the predator. Clarkson (1989) reviewed shotgun weapons and Hunt (1985) examined multiple methods for bears. A variety of weapons exist, and newly developed devices for crowd control include paint-ball type weapons which use rounds filled with capsicum powder (the active ingredient in hot pepper). Low power lasers have been developed for military and law-enforcement applications. Some tests indicate that lasers are effective for dispersing some birds, but may not be effective on many mammals. Further testing is required, however, to determine types of lasers that may be used to repel predators such as wolves.

Guarding animals. The use of guard animals is an interesting avenue for research in that guard animals exhibit all of the attributes required of primary repellents for delaying habituation: multi-sensory stimuli and behavior contingent activation (Shivik and Martin 2001). The use of guard dogs originated in Europe and Asia thousands of years ago, and Americans have been using guard dogs and other guard animals since the mid-1970s. Some studies have shown that producers who use dogs are pleased with their effectiveness, and that guard dogs are a cost-effective means of reducing predation for coyotes and other predators (Andelt, 1992). The use of other guard animals has also been investigated (Meadows and Knowlton, 2000). Smith et al. (2000) produced a comprehensive review on the subject of guardian animals, and there is another discussion of this topic in this volume by Andelt.

Secondary Repellents: Aversive Stimuli

Aversive Harassment. Harassment, if performed very intensively, may condition predators to avoid livestock. The projectiles or other aversive stimuli must occur whenever predators are threatening the resource so that they do not identify conditions when they may obtain the prey without receiving a negative experience.

Conditioned Taste Aversion. Conditioned taste aversion (CTA) is a powerful training technique. CTA uses a less-than-lethal poison that is fed to a predator after it has consumed a type of food; the poison causes illness and the illness causes an intense aversion to the flavor of the food. The method was championed as an effective technique by Gustavson et al. (1974), and CTA seemed promising as an effective means of minimizing predation. However, due to a variety of logistical and biological constraints, the technique does not appear to be effective in field situations, and is thus not used widely (Dorrance and Roy, 1978; Conover and Kessler, 1994). For example, CTA is excellent for deterring eating behaviors, but is not especially effective at modifying killing behaviors, and a strong aversion to a tainted meat baits does not necessarily translate to a strong aversion to killing live prey. Attack and kill behaviors may continue after an animal is successfully conditioned using CTA. Another significant obstacle in the United States is the lack of a proper odorless, tasteless, environmentally safe poison that will cause violent illness, but not injure the predator or a non-target species.

Electronic Training Collars. It is possible to condition some predators to not attack specific prey. Some researchers used training collars (electronic collars used to train domestic dogs) to keep coyotes from attacking sheep (Andelt et al., 1999) and reported promising results, but other researchers were unable to overcome logistical difficulties and show an effective way to use them in actual management situations (Shivik et al., 2003; Shivik et al., 2003). The economic costs of implementing this strategy might also be unacceptably high.

Diversionary feeding, altering prey populations. It may be useful to increase game availability, or place carcasses or other alternative food supplies in areas near livestock and allow predators to consume these resources, so that livestock remain unmolested. Bear damage to trees was limited by alternate feeding (Ziegltrum, 1990), but other authors suggested that alternative feeding may not be effective in the long-term (Boertje et al., 1992). However, even well-fed predators may harass and kill livestock, and multiple years of diversionary feeding may result in increased numbers and concentrations of predators and a larger potential for conflict.

Reproductive inhibition. Reproductive inhibition may be a useful tool for minimizing predation by territorial predators. Earlier work indicated that coyotes without pups killed fewer sheep (Till and Knowlton, 1983), and some researchers investigated the use of surgical sterilization as a means of limiting coyote predation (Bromely and Gese, 2001a,b). Predators that have to provision pups require more food than those that do not have offspring. Thus, predators that have been sterilized are not as likely to damage livestock as intact animals are. It is also most likely to be effective in areas where losses are seasonal and proportional to coyote reproductive activity. Reproductive inhibition, it should be noted, is primarily a means of predation management, and not necessarily for population control, although it could slow population growth if employed on broad spatial and temporal scales. However, appropriate chemical contraceptives and delivery systems have not yet been developed, so no inexpensive and practical methods for reproductive inhibition are currently available.

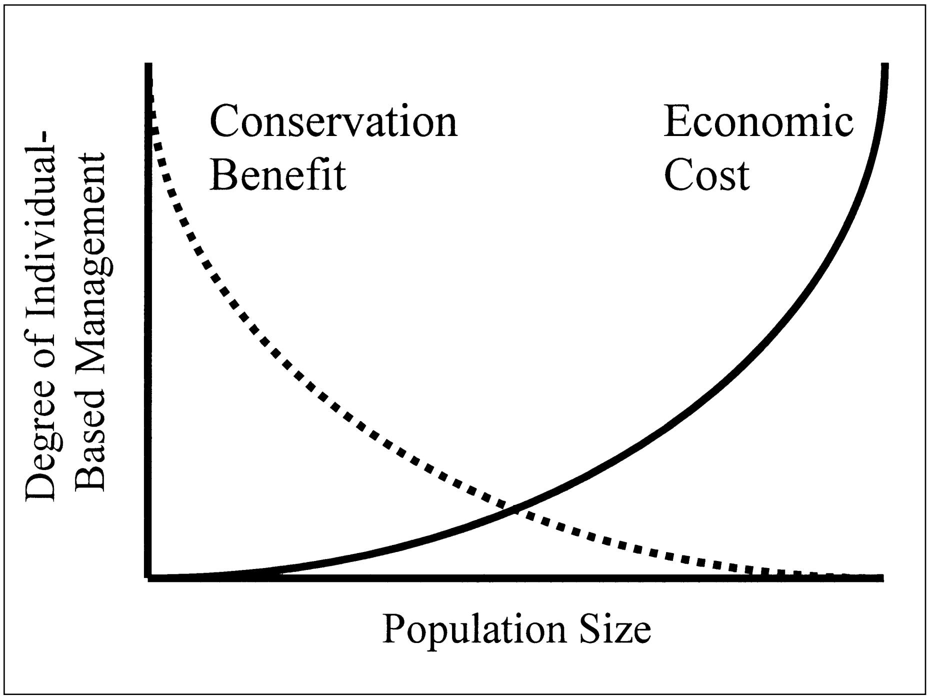
Translocation. If predators and livestock do not occupy the same place, they cannot interact, and thus translocation is sometimes advocated as a damage management strategy. Some studies reported a decline in killing after predators were removed (Armistad et al., 1994; Waite and Phillips, 1994; Stander, 1990). Moving a predator can be effective and more acceptable to many people since the predator is not immediately or apparently killed. However, translocated predators will often attempt to return, cause similar or worse conflicts, or die (Linnell et al., 1996).

Discussion

What non-lethal methods should be used? The answer depends on the circumstances of the predator, livestock, economics, and the social and political context in which methods are applied (Primm and Clark, 1996). In general, however, primary repellents tend to be logistically more simple and easier to apply than secondary repellents (Shivik et al., in press), but their drawback is an often short duration of effectiveness. Habituation can be decreased as the complexity of primary repellents increases, but increasing stimulus complexity tends to increase cost and decrease ease of use. Finding an appropriate primary repellent requires simultaneously trying to lessen the effect of habituation while minimizing costs and logistical difficulties associated with a device or technique.

Non-lethal methods tend to be selective toward particular predators, especially toward particular behaviors of predators. From an endangered species point of view, a high-degree of individual-based management is worth the cost of elaborate non-lethal techniques, but when predators are abundant, the simple economic model pressures toward population-based methods (Fig. 1).

Figure 1. Conceptual cost-benefit model of individual-based predator management by conservation need. When predators are rare and highly valuable (in terms of genetics and conservation), the cost-benefit ratio favors the use of individual-based, non-lethal methods. When predators are abundant and not as valuable individually, the costs of individual-based management approaches rises dramatically, altering the cost:benefit ratio away from efficiency of individual-based management techniques.



Most methods described in this paper are most appropriate at small scales, such as a pasture, and new non-lethal methods are needed that work on a larger scale (e.g. within a region or across allotments).

In reviewing the previous list of techniques, it is possible to conclude that non-lethal techniques are expensive, impractical, have a limited degree of effectiveness, and are sometimes controversial. However, due to socio-political constraints, the most appropriate method may not be the least expensive or logistically easiest one. That is, due to the changing world view of the American public, it may be important to understand that although non-lethal techniques may not be the most efficient, they are certainly necessary to develop, understand, and apply, especially as a part of an Integrated Pest Management (IPM) strategy.

Conclusion

Because of the varying quality of information and research about non-lethal techniques, the future of development and application is dependent upon good science in a complex social and political environment. Given the preceding list of methods, a producer or scientist may inquire which method is the best, but there is no one best solution to all animal damage situations. The type and degree of damage is important to realize before choosing the most appropriate method. In order for management methods to be effective, the mechanism by which they work must be considered and understood (Linnell et al., 1996). Future efforts in research must not only realize effectiveness or ineffectiveness of a given technique, but must provide knowledge and detail that shows why a method did or did not work. Efforts must be made to understand and limit habituation, to produce non-lethal techniques that work at the landscape and population scale, and to devise methods with maximal effectiveness but minimal cost and complexity. Producers should be educated about techniques available and in development, not only to take advantage of new methods that may reduce losses, but also to prevent the waste of time and money on inappropriate applications.

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