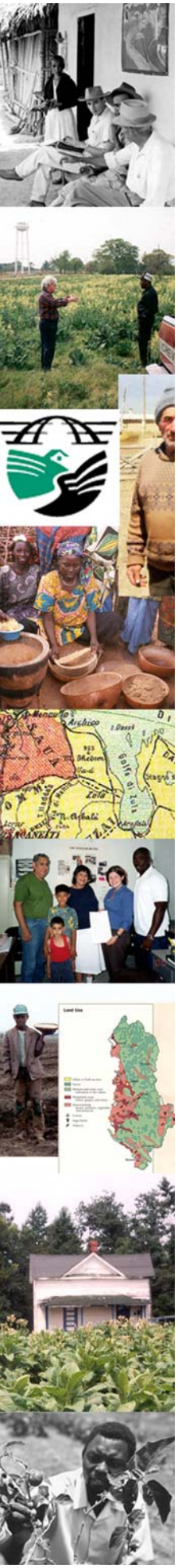

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Land Tenure Center

PARTICIPATORY PLANNING OF INTERVENTIONS TO MITIGATE HUMAN-WILDLIFE CONFLICTS

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PARTICIPATORY PLANNING OF INTERVENTIONS TO MITIGATE HUMAN-WILDLIFE CONFLICTS

Abstract: Conservation of wildlife is especially challenging when the targeted species damage crops or livestock, attack humans, or take fish or game. Affected communities may retaliate and destroy wildlife or their habitats. We summarize recommendations from the literature for 13 distinct types of interventions to mitigate these human–wildlife conflicts. We classified eight types as direct (reducing the severity or frequency of encounters with wildlife) and five as indirect (raising human tolerance for encounters with wildlife) interventions. We analyzed general cause-and-effect relationships underlying human–wildlife conflicts to clarify the focal point of intervention for each type. To organize the recommendations on interventions we used three standard criteria for feasibility: cost-effective design, wildlife specificity and selectivity, and sociopolitical acceptability. The literature review and the feasibility criteria were integrated as decision support tools in three multi-stakeholder workshops. The workshops validated and refined our criteria and helped the participants select interventions. Our approach to planning interventions is systematic, uses standard criteria, and optimizes the participation of experts, policy makers, and affected communities. We argue that conservation action generally will be more effective if the relative merits of alternative interventions are evaluated in an explicit, systematic, and participatory manner.

INTRODUCTION

Conserving wildlife that damage crops or livestock, attack humans, or take fish or game poses a special challenge for policy makers and managers (Thirgood et al. 2000; Karanth & Madhusudan 2002; Sillero-Zubiri et al. 2007). The traditional human response is to clear wildlife habitat or retaliate against wild animals for real or perceived threats (Marker et al. 2003; Treves & Naughton-Treves 2005; Woodroffe & Frank 2005). Such responses undermine broad conservation goals. For example, the removal of large-bodied predators has cascading effects on the populations of their prey and smaller predators (Estes et al. 1998; Terborgh et al. 2002; Ripple & Beschta 2004). Similarly the removal of elephants significantly alters vegetation cover and diversity (Wing & Buss 1970; Chapman et al. 1992; Kahumbu 2002). Yet efforts to protect problematic wildlife have turned affected communities against wildlife or against conservation efforts (reviewed in Treves 2009). Indeed many human societies attach strong positive and negative symbolism to large animals (Knight 2000, 2003; Nie 2002; Treves 2008). Thus policy and management of large animals are contentious topics.

Worldwide efforts to balance human needs with those of wildlife have fueled interest in the alternatives to retaliation. Among these are nonlethal management and ways to raise human tolerance for wildlife. Attention has also focused on the participation of affected households in planning responses to conflicts with wildlife and inclusion of a range of interest groups and values (Hill 2004; Raik et al. 2005; Treves et al. 2006). Striking an optimal balance requires solutions that are scientifically sound and politically acceptable.

We reviewed the literature and considered our experiences of working with affected communities to list and describe distinct types of methods used to mitigate human–wildlife conflicts (interventions). Then we classified these methods as direct interventions that aim to

reduce the severity or frequency of encounters between wildlife and property or people or indirect interventions that aim to raise people's tolerances for such encounters. We summarized the recommendations about the interventions with three complementary criteria: cost-effective design, selectivity and specificity for the problematic wildlife, and sociopolitical acceptability. These three criteria are not prescriptions. Rather they capture experiences of strengths and weaknesses of each method under different conditions, so users can assess whether the interventions are feasible (i.e., "possible and practical to achieve easily or conveniently" [www.askoxford.com/concise_oed/feasible?view=uk]) in their particular sociopolitical and biophysical situations. Finally our framework dovetails with recent standards for conservation planning (Salafsky & Margoluis 1999; Salafsky et al. 2002; Groves 2003).

METHODS

Literature review

Since 2001 A.T. has compiled information on interventions intended to mitigate human–wildlife conflicts worldwide. These include peoples' preventive and reactive responses to wildlife damage as well as factors that exacerbate or lessen wildlife threats or people's perceptions of them. This literature search focused on terrestrial vertebrates >2 kg of body mass and on carnivores in particular. From >800 sources we cite 37 peer-reviewed articles that synthesized recommendations for numerous methods or provided detailed recommendations for a particular method.

Participatory intervention planning (PIP)

We held three workshops in which participants used a simple method for PIP to assess alternative types of interventions based on participants' evaluations of feasibility. The goals of our PIP workshops were to help participants consider all possible types of interventions and weigh the relative merits of the alternatives with standard criteria. Although it may appear as though we simply brainstormed various methods and the participants then made educated guesses about the relative feasibility, this brainstorming was structured and preceded by a critical first step that defined the cause-and-effect relationships underlying a given human–wildlife conflict (Fig. 1). This step exposed multiple possible focal points of intervention. The causal chains are analogous to those advocated for conservation planning (Salafsky et al. 2008).

After brainstorming the participants used three criteria—cost-effective design, wildlife specificity and selectivity, and sociopolitical acceptability—to evaluate candidate interventions. A cost-effective design, understood broadly, considers the resources, time, and expertise needed to install and maintain the intervention in its most effective form. Effectiveness must be evaluated against the goal, which is either to reduce the frequency or severity of encounters between wildlife and people or raise tolerance among people for wildlife encounters (Fig. 1). Wildlife specificity and selectivity are the effects of the intervention on targeted problematic wildlife and unintended targets. Sociopolitical acceptability is the tolerance for the installation, maintenance, and consequences of the intervention among affected individuals and households, more remote interest groups, and the broader populace.

We used the PIP method in three multistakeholder planning workshops to improve and refine our definitions, criteria, and procedures for eliciting stakeholder deliberations. Participatory intervention planning was first used by A.T. and R.W. as part of the Wildlife Conservation

Society's program in La Paz, Bolivia, and A.T. and S.W. subsequently refined it for Fundacio´n Cordillera Tropical, Cuenca, Ecuador.

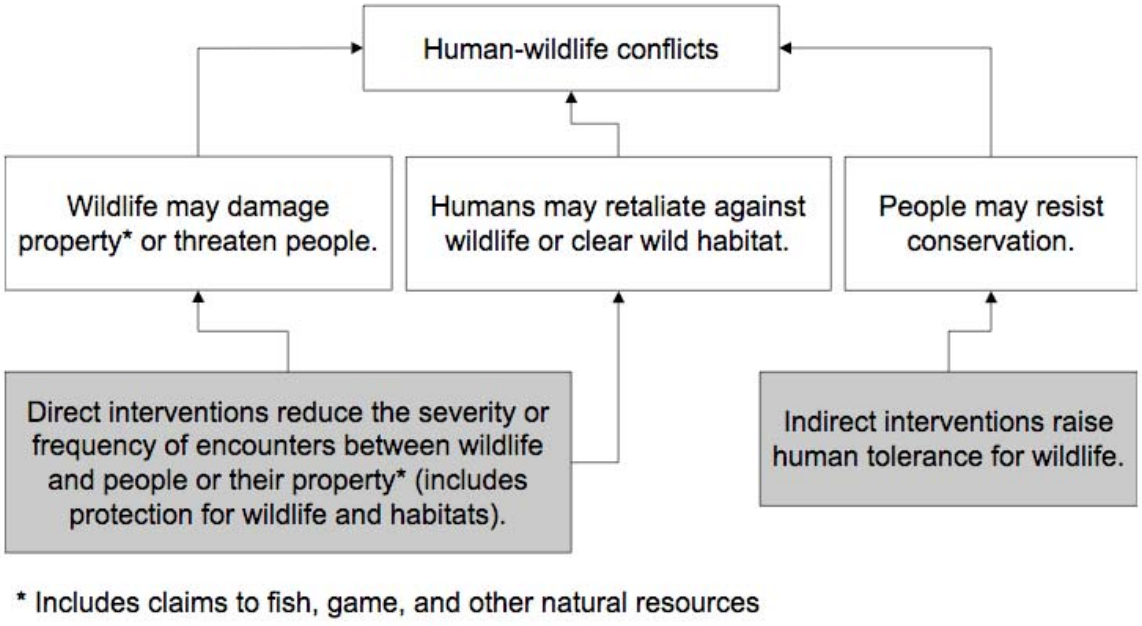

Figure 1. Cause-and-effect relationships underlying human–wildlife conflicts and their associated interventions. An asterisk indicates inclusion of claims to fish, game, and other natural resources.

The workshops involved an array of stakeholders. The first pair of the 2-day workshops (January 2005 and May 2006) convened 40 Bolivian policy makers, managers, and wildlife researchers to guide nationwide policy recommendations. The third workshop (August 2007) in the village of Zhoray convened 57 Ecuadorian landowners to build consensus on coexistence with wildlife in and around Sangay National Park.

In each workshop the facilitators (the authors plus two to four staff assistants) listed all methods for intervention derived from the literature and asked the participants to identify additional methods—which added three to our list (see Results). We were wary of prejudicing later decision-making and evaluation by providing definitive judgments on the effectiveness of any one method. Instead we briefly summarized the research on conditions under which each type or method of intervention was more or less effective. A thorough knowledge of intervention types and methods was a valuable prerequisite for effective PIP.

Participants working in groups or in plenary were asked to discuss the entire range of interventions and consider the cause-and-effect relationships underlying human–wildlife

conflicts and their associated interventions (Fig. 1). As a first cut the participants discarded interventions that were unanimously seen as impossible. For example, S.W. ruled out lethal interventions against Andean bears (Tremarctos ornatus) because it is a legally protected species in Ecuador and is on the International Union for Conservation of Nature Red List (2008). Changing national laws and overcoming international pressure for the sake of a regional wildlife management plan would have been impossible. Thereafter the participants were asked to consider the feasibility criteria. Assessments of the criteria reflected the participants' knowledge of applicable law, national or local sociocultural norms, economic and material constraints, and biophysical conditions; hence, the assessments were subjective. Nevertheless, by designating subgroups randomly (Ecuador) or by species expertise (Bolivia), we anticipated complementarity within subgroups relating to formal and informal knowledge and experience. Such complementarity was expected to promote a more thorough and objective assessment.

Once the list of feasible interventions was compiled the participants were asked to consider the potential compatibility of combined interventions. The interventions were considered functionally incompatible if the same individuals, time, materials, or funds would be needed for both interventions but could not be divided adequately between the two. The interventions were considered logically incompatible if one proposed intervention would produce a change that excluded the other (e.g., hunting wildlife is often incompatible with wildlife viewing at the same or nearby sites). The participants could have been asked to rank or rate the alternatives, but we did not take this step because the Bolivian workshops were aimed at national policy rather than at a specified site and many of the Ecuadorians made independent land management decisions.

Results

We identified eight distinct types of direct interventions to reduce the severity or frequency of encounters between wildlife and people or their property and five distinct types of indirect interventions intended to raise people's tolerance for wildlife encounters (Table 1). Within each type there were one to seven methods (i.e., subtypes). Four methods were a combination of the direct and indirect interventions: hunting of problematic wildlife may reduce property damage and raise tolerance for wildlife among hunters and affected communities; wildlife laws or policies that give affected communities ownership or authority of wildlife may raise tolerance and prevent retaliation against the wildlife seen as "property"; incentive schemes that combine payments for surviving wildlife with changes in husbandry or management of wild habitat may combine direct and indirect intervention steps; and voluntary, negotiated household relocation or resettlement projects may reduce threats from wildlife. If outcomes include improved human safety or livelihoods, one may also see higher tolerance for wildlife. Several methods of mitigating human–wildlife conflicts were unknown to the authors before the PIP workshops. The participants in Bolivia introduced us to chaku (wildlife drives) (Table 1)—a multimodal repellent procedure in which large numbers of community members move through grazing areas making noise, holding lit firecrackers, and generally clearing the way of predators and grazing competitors. The same participants introduced us to captura y castigo, wherein a problematic wild animal is live trapped, punished in a cage, and then released in hopes that it will not dare to

approach humans or their property again. Ecuadorian participants introduced us to planting tree or brush cover near poultry coops so that poultry can find safety from aerial attack in its dense branches or hop and climb onto low branches to avoid some ground predators.

The participants readily narrowed the 13 types of interventions to four to six that seemed possible. This winnowing was rapid: approximately 2 h in the Ecuador workshop and 4–8 h in the two Bolivia workshops, longer in the latter probably because of larger area of land and greater number of wildlife species considered. The participants reported no problems in conceptualizing the feasibility criteria. Nonetheless, cost-effective design seemed to require the most time and produced the greatest uncertainty. The participants were unanimous that sociopolitical acceptance had to be considered carefully. We included a fourth criterion—monitoring demands or constraints—but we found no evidence that the participants thought it was important (A.T., personal observation).

Although direct interventions at first glance may seem the most straightforward and effective way to prevent wildlife damage or avert retaliation, in practice, the participants commonly cited three reasons to prefer indirect interventions. Illicit killing of wildlife and private landowners' conversion of wild habitat were often deemed impossible to prohibit or enforce, so methods to change motivations underlying these behaviors were sought instead. Direct interventions often require the legal authority to interdict, relocate, or confiscate, which few participants imagined themselves holding. Many participants understood that retaliation or opposition to conservation stemmed from common, contributing factors or indirect threats (e.g., lack of education, poverty, unwise legislation, or lack of management capacity). Therefore, the direct threats or proximate contributing factors might respond efficiently to a cascade of "upstream" changes triggered by one indirect intervention (e.g., education, policy reform, or training). For example, training farmers to detect and deter transgressing wildlife seemed more efficient than inviting central authorities or an outside team to do so. Likewise changing policy sometimes seemed more feasible than trying to stop every infringement of existing rules.

Discussion

Our literature review and PIP workshops revealed 13 types of interventions and several dozen subtypes intended to mitigate human–wildlife conflicts in one situation or another (Table 1). Although we believe that our types are exhaustive, we also expect that additional methods will be added as researchers and practitioners around the world report on their observations and experiments. Several types ("reduce attractiveness of property/people. . ." and "policy/legal reform/devolution") will likely benefit from greater resolution and further analysis. For example, the former could encompass changes as diverse as livestock owners switching breeds, vaccinating herds, removing carcasses, and improving pastures and farmers switching crops, rotating fields, and clearing brush (Mech et al. 2000; Osborn 2002; Wydeven et al. 2004). Addition of other methods to this catch-all category might materially change our recommendations.

Although our classification of the interventions into direct and indirect types is a useful heuristic device and helps clarify the cause and effect, it fails to capture the manifold actions of at least four complex interventions. (1) Hunting problematic wildlife may reduce property damage and raise tolerance for wildlife among hunters and affected communities (Linnell et al. 2001;

Mincher 2002). Its effectiveness at both these goals needs systematic study. (2) Similarly wildlife laws or policies that give affected communities ownership of or authority over wildlife may raise tolerance and prevent retaliation against wildlife because they are valued as "property" (Du Toit 2002; Virtanen 2003). (3) Incentive schemes that combine payments for surviving wildlife with changes in husbandry or management of land engage both direct and indirect interventions (Mishra et al. 2003). This too needs study to formulate general recommendations (Zabel & Holm-Muller 2008). (4) Similarly interventions involving voluntary, negotiated property relocation or resettlement may reduce threats from wildlife. If human safety and livelihoods improve as well, this intervention may also raise tolerance for wildlife. The feasibility and effectiveness of such schemes still need to be verified independently and generalized to other settings (Karanth & Madhusudan 2002; Karanth 2005). These dual-purpose interventions represent complex, manifold collaborations between users, managers, and policy makers. This underscores the importance of integrating social science with ecological science to understand human–wildlife conflicts and the importance of conducting research to test hypothesized cause-and-effect relationships between threats and interventions.

Conservation Planning

Standard definitions and practices of conservation are gaining wide acceptance. Salafsky et al. (2008) call for systematic classifications of conservation actions to permit comparison across projects and better information sharing. Although we prefer the term intervention as more explicit and more generally understandable than conservation action, we offer just such a detailed classification scheme as it pertains to human–wildlife conflicts.

Another goal of our paper was to address three common problems in planning interventions. The first is the assumption that only one or a few solutions exist for a given threat. Our results challenge this assumption. First we showed that several paths to intervention exist if one explicitly identifies the causal chains underlying a conservation problem (Fig. 1). Second, our thorough review of the literature demonstrated how many alternative methods exist for the same general set of threats (Table 1). Admittedly human–wildlife conflicts have been studied for decades and solutions attempted for millennia (Smith et al. 2000a, 2000b), but we maintain that finding several alternative interventions (direct and indirect) is not unique to our topic. Acknowledging multiple paths to intervention and listing alternative methods for intervention spurred our participants to suggest varied solutions. Furthermore our PIP method separated the identification of solutions from the assessments of relative feasibility among the alternatives—a step toward more explicit, systematic planning.

The second, related problem is the selection of the first solution that comes to mind to the exclusion of others. For example, ecotourism is often proposed as a way to make conservation pay for itself, and other forms of incentives (e.g., conservation performance payments and sustainable use) are not explored fully. Any proposed intervention should be weighed against alternatives with explicit criteria, lest conservation be more art than science.

We do not propose that threats can be equally well abated by multiple, alternative interventions. Instead two or more candidates always exist because direct and indirect pathways to intervention are universal—and the pathways and methods should be weighed explicitly by their relative merits. Nor do we argue that the instincts and experiences of experts are a poor guide to planning

because experts will be needed to evaluate alternatives, in addition to other key roles. Rather we believe that a systematic, explicit examination of alternative interventions for a given threat will improve the design and success of interventions. Such deliberation and discussion likely will stimulate creative thinking that can result in new solutions or catalyze the integration of different ideas. Furthermore we believe that conservation expertise is not the sole province of formally trained scientists or field-tested conservation practitioners, but it should also engage civilians, policy makers, and other organizations (Treves et al. 2006; Danielsen et al. 2007). This is particularly true when planners strive to balance human and biodiversity needs so that the eventual intervention (or lack of action) reflects sociopolitical acceptance.

Third we argue that the selection of interventions in any field should be based on feasibility, not just effectiveness, which includes cost-effective design, wildlife specificity and selectivity, and sociopolitical acceptability. Our participants supported this idea to the extent that they estimated feasibility from pragmatic estimates of constraints on resources and effort, effectiveness, target wildlife, and sociopolitical acceptability. To wit affected households may reject the intervention that prevents wildlife damages if it fails their evaluations of local practicality or impinges on the other realms of life. For example, Indian communities undermined effective barriers to wildlife because they sought resources on the other side (Karanth & Madhusudan 2002; Gubbi 2007). Likewise the most popular intervention may not be costeffective. For example, many surveys show public preference for capture and relocation of problematic carnivores (Manfredo et al. 1998; Naughton-Treves et al. 2003), yet wildlife authorities balk at the costs of such interventions and research shows that they rarely reduce damages in the long run (Linnell et al. 1997). Similarly the effects of interventions on target wildlife and unintended consequences for non-target wildlife may lower the relative feasibility of any given intervention, especially when managing valued or protected species (e.g., Burns et al. 1991). Our PIP workshop participants grasped these ideas readily. They did not embrace a fourth criterion that we tried to introduce: monitoring demands. This supports one expert's assertion that ". . .you want to pick the best strategy for the job and then figure out how to monitor it as best you can" (N. Salafsky, personal communication). Weighing one criterion over another is likely to be a subjective decision and one well suited to participation and consensus building through debate and discussion.

Optimal Participation

Participation in conservation planning should be optimized. Participation has costs and benefits that are well known from democratic theory and natural resource participation theory (Gillingham 2001; Halvorsen 2003; Raik et al. 2005). For PIP methods potential costs of participation include the transaction costs of meeting, communicating, and building a shared vision; the risk that opponents consolidate to disrupt planning or implementation; and the risk that participants are unrepresentative of interest groups that then undermine their decisions. Potential benefits include the generation of diverse ideas: participation in decision making may raise tolerance for wildlife or management even in the absence of measurable reductions in threats; participants may offer help to implement or monitor interventions; and participants may gain skills in negotiation, democracy, and coalition building. Ideally planners will consider optimal participation. For example, our method for strategic choice of interventions based on feasibility requires local knowledge, scientific judgments, and broader sociopolitical experiences. Thus we caution against centralized, rigid, technocratic scoring systems that replace intuition and informal knowledge.

Planners may not be so free, however, because some threats or interventions engender strong emotions or economic self-interest. Hence individuals and organizations may demand to be involved in planning interventions, regardless of their capacity to contribute. Excluding influential or interested stakeholders from planning can itself trigger opposition, regardless of any good intentions. Indeed some interventions become saddled with broader sociopolitical issues that interest many stakeholder groups. For example, wolf reintroduction in the United States was slowed by long-standing debates about public use of federal lands for grazing and mining (Bangs et al. 1998; Nie 2002).

Disagreements and intractable conflicts of interest can bog down participatory processes. For example, Raik et al. (2005) described PIP-like procedures to resolve human–deer (Odocoileus virginianus) conflicts in suburban and rural U.S. communities. Some of the dozen communities considered in the study took years to decide on interventions, most often because the participants disagreed about killing deer. We believe that deadlocked meetings can be avoided if facilitators articulate goals clearly (top down) or build a shared vision among participants (bottom up) at the outset. For example, the goal of balancing deer needs and human needs will generate different sets of interventions than the goal of reducing deer damage to property. The latter would more likely promote lethal control. The appropriate choice of top-down or bottom-up planning of interventions depends in part on whether participants are formulating policy recommendations (cf. our Bolivian workshops) or implementing interventions. Then implementers who act independently may opt for different goal statements than would communal implementers. In the former case the goal statement may be general because each participant takes away her or his preferred method (cf. our Ecuadorian workshop), whereas in the latter case, facilitators should relinquish control and allow consensus goals to surface.

We expect intervention planning will stand on a firmer footing when the choice of conservation interventions is systematized and made explicit. One step in that direction is to be clear about cause and effect of direct and indirect interventions. We also advocate the use and refinement of the criteria for evaluating alternative interventions, while optimizing the level of participation in planning.

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LITERATURE CITED

Andelt, W. F. 2001. Effectiveness of livestock guarding animals for reducing predation on livestock. Endangered Species Update **18**:182-185.

Bangs, E. E., S. H. Fritts, J. A. Fontaine, D. W. Smith, K. M. Murphy, C. M. Mack, and C. C. Niemeyer. 1998. Status of gray wolf restoration in Montana, Idaho and Wyoming. Wildlife Society Bulletin **26**:785-793.

Bulte, E. H., and D. Rondeau. 2005. Why compensating wildlife damages may be bad for conservation. Journal of Wildlife Management **69**:14-19.

Burns, R. J., H. J. Tietjen, and G. E. Connolly. 1991. Secondary hazard of livestock protection collars to skunks and eagles. Journal of Wildlife Management **55**:701-704.

Chapman, L. J., C. A. Chapman, and R. W. Wrangham. 1992. *Balanites wilsoniana*: elephant dependent dispersal. Journal of Tropical Ecology **8**:275-283.

Danielsen, F., M. M. Mendoza, A. Tagtag, P. A. Alviola, D. s. Balete, A. E. Jensen, M. Enghoff, and M. K. Poulsen. 2007. Increasing conservation management action by involving local people in natural resource monitoring. Ambio **36**:566-570.

Du Toit, J. T. 2002. Wildlife harvesting guidelines for community-based wildlife management: a southern African perspective. Biodiversity and Conservation **11**:1403-1416.

Dunwoody, S. 2007. The challenge of trying to make a difference using media messages. Pages 89-104 in S. C. Moser and L. Dilling, editors. Creating a climate for change. Cambridge University Press, , United Kingdom.

Estes, J. A., M. T. Tinker, T. M. Williams, and D. F. Doak. 1998. Killer whale predation on sea otters linking oceanic and nearshore ecosystems. Science **282**:473-476.

Fritts, S. H., W. J. Paul, and L. D. Mech. 1985. Can relocated wolves survive? Wildlife Society Bulletin **13**:459-463.

Gillingham, S. 2001. Social organization and participatory resource management in Brazilian ribeirinho communities: A case study of the Mamiraua □Sustainable Development Reserve, Amazonas. Society and Natural Resources **14**:803-814.Groves, C. 2003. Drafting a blueprint for conservation. Island Press, New York.

Gubbi, S. 2007. Tiger habitats and integrated conservation and development projects: a case study from Periyar Tiger Reserve, India. Durrell Institute for Conservation and Ecology, University of Kent, Canterbury, United Kingdom.

Halvorsen, K. E. 2003. Assessing the effects of public participation. Public Administration Review **63**:535-543.

Hill, C. M. 2004. Farmers' perspectives of conflict at the wildlife–agriculture boundary: some lessons learned from African subsistence farmers. Human Dimensions of Wildlife **9**:279-286.

Jacobson, S. K., and M. D. McDuff. 2009. Communication as an effective management strategy in a diverse World. Pages 301-314 in D. J. Manfredo, J. J. Vaske, P. Brown, D. J. Decker, and E. A. Duke, editors. Wildlife and society: the science of human dimensions. Island Press, Washington, D.C.

Kahumbu, P. 2002. Forest elephant ecology at Shimba Hills. Deptartment of Ecology and Evolutionary Biology, Princeton University, Princeton, New Jersey.

Karanth, K. K. 2005. Addressing relocation and livelihood concerns: Bhadra Wildlife Sanctuary. Economic and Political Weekly **40**:4809-4811.

Karanth, K. U., and M. D. Madhusudan. 2002. Mitigating human-wildlife conflicts in southern Asia. Pages 250-264 in J. Terborgh, C. P. Van Schaik, M. Rao, and L. C. Davenport, editors. Making parks work: identifying key factors to implementing parks in the tropics. Island Press, Covelo, California.

Knight, J., editor. 2000. Natural Enemies: People-Wildlife Conflicts in Anthropological Perspective. Routledge, London.

Knight, J. 2003. Waiting for Wolves in Japan. Oxford University Press, Oxford, United Kingdom.

Linnell, J. D. C., R. Aanes, J. E. Swenson, J. Odden, and M. E. Smith. 1997. Translocation of carnivores as a method for managing problem animals: a review. Biodiversity and Conservation **6**:1245-1257.

Linnell, J. D. C., J. E. Swenson, and R. Andersen. 2001. Predators and people: conservation of large carnivores is possible at high human densities if management policy is favorable. Animal Conservation **4**:345-349.

Manfredo, M. J., H. C. Zinn, L. Sikorowski, and J. Jones. 1998. Public acceptance of mountain lion management: a case study of Denver, Colorado, and nearby foothill areas. Wildlife Society Bulletin **26**:964-970.

Marker, L. L., A. J. Dickman, M. G. L. Mills, and D. W. Macdonald. 2003. Aspects of the management of cheetahs, *Acinonyx jubatus jubatus*, trapped on Namibian farmlands. Biological Conservation **114**:401-412.

Mason, J. R., J. A. Shivik, and M. W. Fall. 2001. Chemical repellents and other aversive strategies in predation management. Endangered Species Update **18**:175-181.

Mech, L. D., E. K. Harper, T. J. Meier, and W. J. Paul. 2000. Assessing factors that may predispose Minnesota farms to wolf depredations on cattle. Wildlife Society Bulletin **28**:623-629.

Meriggi, A., and S. Lovari. 1996. A review of wolf predation in southern Europe: Does the wolf prefer wild prey to livestock? Journal of Applied Ecology **33**:1561-1571.

Mincher, B. J. 2002. Harvest as a component of Greater Yellowstone Ecosystem grizzly bear management. Wildlife Society Bulletin **30**:1287-1292.

Mishra, C., P. Allen, T. Mccarthy, M. D. Madhusudan, A. Bayarjargal, and H. H. T. Prins. 2003. The role of incentive schemes in conserving the snow leopard, *Uncia uncia*. Conservation Biology **17**:1512-1520.

Montag, J. 2003. Compensation and predator conservation: limitations of compensation. Carnivore Damage Prevention News **6**:2-6.

Naughton-Treves, L., R. Grossberg, and A. Treves. 2003a. Paying for tolerance: the impact of livestock depredation and compensation payments on rural citizens' attitudes toward wolves. Conservation Biology. **17**:1500-1511.

Naughton-Treves, L., J. L. Mena, A. Treves, N. Alvarez, and V. C. Radeloff. 2003b. Wildlife survival beyond park boundaries: the impact of swidden agriculture and hunting on mammals in Tambopata, Peru. Conservation Biology **17**:1106-1117.

Naughton-Treves, L., and A. Treves. 2005. Socioecological factors shaping local support for wildlife in Africa. Pages 253-277 in R. Woodroffe, S. Thirgood, A. Rabinowitz, editors. People and Wildlife, Conflict or Coexistence? Cambridge University Press, Cambridge, United Kingdom.

Nie, M. A. 2002. Wolf recovery and management as value-based political conflict. Ethics, Place and Environment **5**:65-71.

Noss, A. J., and R. L. Cuéllar. 2001. Community attitudes towards wildlife management in the Bolivian chaco. Oryx **35**:292-300.

Osborn, F. V. 2002. Capsicum oleoresin as an elephant repellent; field trials in the communal lands of Zimbabwe. Journal of Wildlife Management **66**:674-677.

Raik, D. B., T. B. Lauber, D. J. Decker, and T. L. Brown. 2005. Managing community controversy in suburban wildlife management: Adopting practices that address value differences. Human Dimensions of Wildlife **10**:109-122.

Ratnaswamy, M. j., R. J. Warren, M. T. Kramer, and M. D. Adam. 1997. Comparisons of lethal and nonlethal techniques to reduce raccoon depredation of sea turtle nests. Journal of Wildlife Management **61**:368-376.

Ripple, W. J., and R. L. Beschta. 2004. Wolves and the ecology of fear: Can predation risk structure ecosystems? BioScience **54**:755-766.

Salafsky, N., R. Margoluis, K. Redford, and J. G. Robinson. 2002. Improving the practice of conservation: a conceptual framework and research agenda for conservation science. Conservation Biology **16**:1469-1479.

Salafsky, N., D. Salzer, A. J. Stattersfield, C. Hilton-Taylor, R. Neugarten, S. H. M. Butchart, B. Collen, N. Cox, L. L. Master, S. O'Connor, and D. Wilkie. 2008. A Standard Lexicon for Biodiversity Conservation: Unified Classifications of Threats and Actions. Conservation Biology **22**:897-911.

Schultz, R. N., K. W. Jonas, L. H. Skuldt, and A. P. Wydeven. 2005. Experimental use of dog-training shock collars to deter depredation by gray wolves. Wildlife Society Bulletin **33**:142-148.

Shaw, H. G., N. G. Woolsey, J. R. Wegge, and R. L. j. Day 1988. Factors affecting mountain lion densities and cattle depredation in Arizona. Arizona Game and Fish Department, Phoenix.

Shivik, J. A. 2006. Tools for the edge: What's new for conserving carnivores. BioScience **56**:253-259.

Sillero-Zubiri, C., R. Sukumar, and A. Treves. 2007. Living with wildlife: the roots of conflict and the solutions. Pages 266-272 in D. MacDonald, and K. Service, editors. Key Topics in Conservation Biology. Oxford University Press, Oxford, United Kingdom.

Smith, M. E., J. D. C. Linnell, J. Odden, and J. E. Swenson. 2000a. Review of methods to reduce livestock depredation: I. Guardian animals. Acta Agriculturae Scandinavica, Section A Animal Science **50**:279-290.

Smith, M. E., J. D. C. Linnell, J. Odden, and J. E. Swenson. 2000b. Review of methods to reduce livestock depredation II. Aversive conditioning, deterrents and repellents. Acta Agriculturae Scandinavica, Section A Animal Science **50**:304-315.

Terborgh, J., L. Lopez, P. Nunez, M. Rao, G. Shahabudin, G. Orihuela, M. Riveros, R. Ascanio, G. H. Adler, T. D. Lambert, and L. Balbas. 2002. Ecological meltdown in predator-free forest fragments. Science **294**:1923.

Thirgood, S., S. Redpath, I. Newton, and P. Hudson. 2000. Raptors and red grouse: Conservation conflicts and management solutions. Conservation Biology **14**:95-104.

Treves, A. 2008. Beyond Recovery: Wisconsin's Wolf Policy 1980-2008. Human Dimensions of Wildlife **13**:329-338.

Treves, A. 2009. The human dimensions of conflicts with wildlife around protected areas. Pages 214-228 in M. Manfredo, J. J. Vaske, P. Brown, D. J. Decker, and E. A. Duke, editors. Wildlife and Society: The Science of Human Dimensions. Island Press, Washington, DC.

Treves, A., and L. Naughton-Treves. 2005. Evaluating lethal control in the management of human-wildlife conflict. Pages 86-106 in R. Woodroffe, S. Thirgood, and A. Rabinowitz, editors. People and Wildlife, Conflict or Coexistence? Cambridge University Press, Cambridge, United Kingdom.

Treves, A., R. B. Wallace, L. Naughton-Treves, and A. Morales. 2006. Co-managing human-wildlife conflicts: A review. Human Dimensions of Wildlife **11**:1-14.

Virtanen, P. 2003. Local management of global values: Community-based wildlife management in Zimbabwe and Zambia. Society and Natural Resources **16**:179-190.

Wing, L. D., and I. O. Buss. 1970. Elephants and forests. Wildlife Monographs **19**:1-92.

Woodroffe, R., and L. G. Frank. 2005. Lethal control of African lions (*Panthera leo*): local and regional population impacts. Animal Conservation **8**:91-98.

Wydeven, A. P., A. Treves, B. Brost, and J. E. Wiedenhoeft. 2004. Characteristics of wolf packs in Wisconsin: Identification of traits influencing depredation. Pages 28-50 in N. Fascione, A.

Delach, and M. E. Smith, editors. People and Predators: From Conflict to Coexistence. Island Press, Washington, D. C.

Zabel, A., and K. Holm-Muller. 2008. Conservation performance payments for carnivore conservation in Sweden. Conservation Biology **22**:247-251.

Table 1. Direct and indirect interventions for mitigating human-wildlife conflicts characterized by three criteria for feasibility.

		Design criterion			
Intervention type	Examples of methods	cost-effective design	wildlife selectivity / specificity	sociopolitical acceptability	Source[a]
Direct[b]					
barriers	buffer zones, fences, moats, nets, trenches, walls	consider placement, size, permeability, and materials / labor / maintenance costs; can include escape paths, alarms, deterrents (e.g., electric, thorns, non-palatable crops)	with time, intelligent, motivated animals may penetrate; consider impact on migration / dispersal movements.	generally familiar and popular among those who feel threatened; consider impact on local people's access to resources. Metal fence wires have been used as snares. Livestock may injure themselves on barriers. Wide barriers (e.g., buffers) must be profitable if land is scarce.	1-5

guards	supervision by dogs, humans, or other animals	Consider timing relative to wildlife activities. Guards may be exposed to disease, attack, weather. Consider behavior of guards: feeding, health, ranging, social system, vigilance, vocal.	Consider risk of disease transmission between guard and wildlife. Consider if guard competes with or preys on wildlife. Human guards may fail to deter habituated wildlife, hence more effective in areas with hunting.	generally familiar but the time required may limit acceptance; risk to guards and indirect costs (stay home from school), or unintended effects (barking dogs, wandering dogs) may reduce acceptance; consider opportunity costs carefully;	4-7
Repellents	Acoustic: sirens, explosions, predator sounds; Chemical: odor / taste repellents, conditioned taste aversion (CTA); Visual: colors, lights, predator mimicry	From most to least effective: behavior-contingent, motion-activated, random, unpredictably mobile, stationary. For chemical, consider persistence in various climates. For CTA, determine if the predatory response is inhibited or simply feeding.	Consider chemical toxicity. Consider circadian behavior, intelligence, and the visual and acoustic acuity of target, non-target wildlife, people, domestic animals.	generally familiar but acceptance of loud sounds, lights at night, noxious odors, toxic chemicals, attraction of predators may vary	2, 4, 8-10

Manipulate problem animals (lethal / permanent)	Culling, eradication, hunting, relocate to captivity, selective removal, or sterilization	Selective removal of culprits is difficult. Goals of hunters (e.g., food, sport) may not match those of complainants (e.g., safety, income) or managers (e.g., conservation, revenue). Complex methods of capture and animal handling demand professional supervision and are costly. Public collaboration (e.g., hunting) demands professional communications, monitoring, enforcement.	Risky for endangered species. Generally possible to target problem species, but varies by method (shooting versus traps, explosives, poison). Selection of individual culprits is difficult. If released, consider disease transmission and capture-related injury.	Generally familiar but certain methods (e.g., poison, traps), certain sites (private lands, densely settled areas), and certain targets (social, intelligent, charismatic species) will provoke opposition by common interest groups.	2, 3, 11-17
Manipulate problem animals (non-lethal / temporary)	Capture followed by deterrence (e.g., punish or affix electric shock collar), release, or relocate	Selective removal of culprits is difficult. Released animals often return or cause problems at new site. Complex methods of capture and animal handling demand professional supervision and are costly.	Consider accidental mortality risks and disease transmission. Traps vary in selectivity. Some species return to home range sites over great distances.	Capture of problem animals is familiar but subsequent handling may not be. Generally more acceptable to urban, wealthy populations. Affected communities may distrust release.	9, 18, 19

Manipulate habitat or other wildlife	Alter resources required by problem wildlife (food, shelter, breeding sites, etc.) to discourage use of human areas	Demands information on behavioral ecology of problem wildlife or comparisons of affected and unaffected properties / people. Improvement of habitat through remediation and restoration activities may discourage wildlife damage to property or degradation of habitat may diminish wildlife abundance.	Suitable for endangered wildlife if the habitat is improved (e.g., restoring wild prey).	Improvement may be unfamiliar whereas degradation of habitat is generally familiar. Few data exist on acceptability. Biodiversity interests may oppose degradation.	20-22
Protect wildlife or habitats	Prevent retaliation against wildlife or habitat destruction via law enforcement, interdiction, or physical barriers to access	Depends on frequent and sensitive monitoring or surveillance at local scales; clear rules that govern access and use of natural resources; physical barriers and obvious delimiters; and trained staff to communicate, enforce, and prosecute.	Far-ranging animals that cross jurisdictions will elude protection. If retaliation and habitat destruction are inconspicuous activities then interdiction and enforcement will be difficult.	Generally familiar but opposed when traditions or broader policies allow access to and use of natural resources. Enforcement may generate political clashes and local ill-will.	3, 11, 21, 23
Reduce attractiveness of property / people	Removing attractants (e.g., food, garbage); relocating property or activities; switching contested resource to less desirable varieties.	Reducing attractiveness of property / people demands information on behavioral ecology of problem wildlife, comparisons of affected and unaffected properties / people. Changer locations, timing, or attributes or vulnerable	Suitable for endangered wildlife if the habitat is improved (e.g., removing human influences). Difficult for damage patterns that are uniform, extremely variable in space or time, or difficult to	Few people like to change their livelihood practices or living conditions. Cost-benefit analyses and opportunity costs are key. High potential risk for vulnerable people.	2, 4, 21, 23-25

		property / people.		ascribe to target wildlife.	

Class 2. Indirect interventions raise tolerance for wildlife encounters

Co-management (Collaboration in planning, intervention, or monitoring)	Involving interest groups or stakeholders in planning, implementation, or monitoring.	Should include affected households, consensus, social learning, long-term investment in relationships, fair representation of affected households, technical experts, and legal "owners" of wildlife.	Most effective for wildlife with value (material or nonmaterial). Less effective for inconspicuous wildlife or those with little value to any interest group.	Generally familiar but acceptance depends on whether participants and processes are seen as legitimate, representative and fair. Majority views may dominate and mislead planners.	4, 11, 21, 23, 26-31
Compensation / insurance reimbursements	Payments for damaged property or injury to people (cash or equivalent)	Vulnerable to fraud, corruption, inefficiencies, moral hazards. Difficult to phase out. Administration may demand training.	Most effective for rare wildlife or small populations or costs rise. Demands generous donor base so most effective for charismatic wildlife.	Generally familiar but acceptance varies with political clashes between donors, payers, and recipients. Acceptance may decline as costs rise. Payments do not turn recipients into pro-wildlife advocates. Some recipients may reject payments in favor	32-34

				of wildlife control.	
Incentives / performance payments	Adding value to live wildlife as a commodity or through direct payments for living wildlife	See recommendations for compensation / reimbursements. Link to wildlife survival is key. Tourism can have negative impacts on wildlife if not designed with the behavioral ecology of wildlife in mind. Administration may demand training.	Demands a market or donors so most effective for valued wildlife.	Unfamiliar to most except for tourism revenue-sharing. Some recipients may reject payments in favor of wildlife control. Markets are volatile and complex.	4, 21, 35
Information sharing	Communication of information generated by research via environmental education, consulting, media, training, writings)	Salience to target audience, clarity, novelty, and communication medium are key. Broadcast may reach many but persuade few whereas interpersonal communication may reach few but persuade effectively. Goal is often to change behavior among receivers.	Works for any wildlife but dissemination / persuasion for non-charismatic species is difficult.	Generally familiar but acceptance improves with trusted messengers, whereas unfamiliar advocates may engender skepticism. Deeply held values and beliefs change slowly.	36, 37

Policy / legal reform or devolution of authority	Changing legal relationships to wildlife or habitats (tenure and rights of property, use, access etc.)	Ownership may enhance perceived control over wildlife and their damages. Use rights may enhance the perceived value of wildlife and habitats. Policy and legal reforms must be communicated to stakeholders effectively and clearly. Misincentives for over-harvesting or misuse are common. Regulation of use / access may still be needed. Vulnerable to fraud, corruption, inefficiencies, moral hazards.	Most effective for wildlife with value (material or nonmaterial). Less effective for inconspicuous wildlife or those with no traditional value to affected households.	Generally familiar but acceptance varies with rules of use and ownership. Political clashes between past and current owners are likely.	23, 29-31

[a]Sources: 1-Angst 2001; 2-Hoare 2001; 3-Karanth & Madhusudan 2002; 4-Osborn & Parker 2003; 5-Ogada et al. 2003; 6-Smith et al. 2000a; 7-Andelt 2001; 8-Smith et al. 2000b; 9-Shivik 2006; 10-Mason et al. 2001; 11-Noss & Cuellar 2001; 12-Burns et al. 1991; 13-Ratnaswamy et al. 1997; 14-Treves & Naughton 2005; 15-Treves in review 17-Woodroffe & Frank 2005; 18-Linnell et al. 1997; 19-Schultz et al. 2005; 20-Meriggi & Lovari 1996; 21-Mishra et al. 2003; 22-Wydeven et al. 2004; 23-Naughton & Treves 2005; 24-Mech et al. 2000; 25-Shaw et al. 1988; 26-Treves et al. 2006; 28-Raik et al. 2005; 30-Du Toit 2002; 31-Virtainen 2003; 32-Montag 2003; 33-Bulte & Rondeau 2005; 34-Treves et al. unpubl.; 35-Zabel & Holm-Muller 2008; 36-Dunwoody 2007; 37-Jacobson & McDuff 2009.