5-2009

Application of Electrified Fladry to Decrease Risk of Livestock Depredation by Wolves (Canis lupus)

Nathan J. Lance

Utah State University

5-1-2009

Application of Electrified Fladry to Decrease Risk of Livestock Depredations by Wolves (Canis lupus)

Nathan J. Lance
Utah State University

APPLICATION OF ELECTRIFIED FLADRY TO DECREASE RISK OF LIVESTOCK DEPREDATION BY WOLVES (*CANIS LUPUS*)

by

Nathan J. Lance

A thesis submitted in partial fulfillment
of the requirements for the degree

of

MASTER OF SCIENCE

in

Wildlife Biology

Approved:

John A. Shivik Major Professor	Stewart W. Breck Committee Member
Fred D. Provenza Committee Member	Byron Burnham Dean of Graduate Studies

UTAH STATE UNIVERSITY
Logan, Utah

2009

ABSTRACT

Application of Electrified Fladry to Decrease Risk of Livestock Depredation by Wolves (*Canis lupus)*

by

Nathan J. Lance, Master of Science

Utah State University, 2009

Major Professor: Dr. John A. Shivik
Department: Wildland Resources

Wolf (*Canis lupus*) predation on livestock can cause economic and emotional hardships for livestock producers, complicating the balance of wolf conservation with other human interests. New management tools that decrease risk of predation may offer additional flexibility or efficiency for both livestock producers and management agencies. I examined 1) the efficacy of electrified fladry compared to fladry at protecting a food source from wolves in captivity, 2) the efficacy of electrified fladry for reducing wolf use of pastures and preventing depredations, and 3) the applicability of electrified-fladry. In captivity I tested the reaction from 15 groups (46 wolves) to the presence of fladry, electrified fladry, or no barrier within their enclosures. During trials, a deer carcass was provided in one corner of the pen, and a strand of fladry (n = 5 pens), or electrified fladry (n = 5 pens), was strung across the pen to protect the food resource. Failure of the barriers was defined by at least one animal in a group moving across the barrier. Both fladry and electrified fladry effectively excluded wolves from a food resource for short durations of time (1-14 days), but electrified fladry was more effective. My research indicated that although electrified fladry has the potential to reduce wolf depredations, animal learning, motivation, and personality play critical roles in the effectiveness of fladry systems. In Montana, I assigned 9 livestock operations to randomly receive a treatment (electrified fladry, n=6 pastures) or control (not receiving electrified fladry, n=6 pastures). I measured cost per kilometer for purchasing materials, number of people and hours required for installing and maintaining, as well as recording observations of potential difficulties with electrified fladry. I formed and distributed an exit-survey to each rancher who participated in the study to assess opinions about the use of the technique. Wolf activity at the ranches was insufficient and I was not able to determine if electrified fladry was successful or unsuccessful for preventing livestock depredations. I found, however, that electrified fladry may be limited by costs associated with its purchase and that the application and effectiveness of electrified fladry may limit its usefulness for addressing wolf-livestock conflict. The understanding of human perceptions of management tools is critical to determining the success of implementing management techniques and fostering participation and cooperation among stakeholders.

(90 pages)

ACKNOWLEDGMENTS

I would like to thank the United States Department of Agriculture's Wildlife Services' National Wildlife Research Centers' Predator Ecology Unit; Montana Fish, Wildlife & Parks; United States Department of Agriculture's Natural Resource Conservation Service; and the Animal Welfare Institute's Christine Stevens Award for funding portions of my research. In addition, I would like to thank the United States Department of Agriculture's National Wildlife Research Center; United States Department of Agriculture's Wildlife Services Montana Program; Montana Fish, Wildlife & Parks; and the Confederated Salish and Kootenai Tribes of the Flathead Reservation for logistical and design support.

Thanks to my advisor and co-advisor, Dr. John A. Shivik and Dr. Stewart W. Breck, for their fortitude, guidance, endless encouragement, and having trust in my abilities to conduct research. Thanks to my committee member, Dr. Fred Provenza. Thanks to Dr. Susan Durham and Mike Lewis for their valuable statistical and survey design expertise. Thanks to Kurt VerCauteren for providing invaluable camera equipment for my research. I am grateful to Renee Seidler, Kari Signor, Lynne Gilbert-Norton, Arion Vandergon, Suzanne Gifford, Ryan Wilson, and other graduate students for the mental gymnastics, continual support, and encouragement on my journey.

Thanks to Kyle Malsom, Matt Row, Mike Buckman, Jerry Cade, Bob Ebson, and the Wildlife Science Center staff and volunteers for long hours and patience during daunting captures. Special thanks to my surrogate family and close friends, Peggy Callahan, Mark Beckel, and Megan Beckel, for their vast generosity and indefatigable moral support throughout my endeavors.

Thanks to Carolyn Sime, Montana wolf specialists, Montana Wildlife Services' specialists, and Stacy Courville for all of their logistical support and their help in landowner relations. In addition, I owe thanks to Ty Smucker, Josh Nowack, Sammy Sears, Dan Thompson, Jason Miller, Jen Greer, John Greer, Dave Lance, Jean Lance, Cody Reitz, Pam Hofferber, Mike Hofferber, Janelle Holden, Dean Rankin, Justin Paugh, and Karen Nave for their dedicated assistance, humor, and friendships in the field. I would like to thank Keith and Marie Engels, Curtis Arlian, Roger Hammersmark, Emma Ellison, Brian Finnan, Chuck and Sally Sanders, Doug King, Karl Roesch, Ross and Reese Middlemist, and Scott and Jennifer Schall for their cooperation and hospitality. I am indebted to Reed for his endless alliance, outlook on life, and our tireless conversations during our long hours behind a windshield and in solitude.

This research would have not been possible without the help, sacrifice, and encouragement of these diligent and supportive individuals and organizations. My deepest gratitude goes to my close friends and family, Dave, Jean, and Jason, for believing in me, encouraging me, and helping me to get here. And finally, I thank my wife, Robyn, for keeping me balanced and smiling. I dedicate this thesis to my family, wife, and closest friends for their moral and emotional support through all of my crazy adventures.

Nathan J. Lance

CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

Wolves and Historical Predation Management

The conflicts between humans and predators and our drive to dominate nature led to the initial extirpation of gray wolves (Mech 1970). Wolf (*Canis lupus*) conflict can arise from concerns of human safety, livestock depredation, and influence on natural prey abundance. Although rare, and often lacking consistent and sound documentation, wolf attacks on humans have occurred in many areas of the world (Mech 1970; Rajpurohit 1999; McNay 2002). Wolf depredations on livestock such as cattle, sheep, goats, horses, and domestic fowl are more common and can cause economic loss (Mech 1970; Ciucci and Boitani 1998; Bangs and Shivik 2001; Treves et al. 2002). The return of the wolf to the western United States has re-established wolf predation and has had various effects on predator prey dynamics (Boyd and Pletscher 1999; Berger et al. 2001; Smith et al. 2004; Atwood et al. 2007).

Following the protection under the Endangered Species Act, wolf populations in the U.S. increased due to natural emigration and successful reintroduction programs in areas they were previously extirpated or significantly reduced. In 1995 and 1996 wolves were reintroduced to Yellowstone National Park and central Idaho. The Montana gray wolf population grew from 2 wolves in 1979 to a minimum of 422 by late 2007 (Sime et al. 2008). Expanding predator populations from public lands onto private lands with livestock operations have the potential to increase predator-livestock conflicts and increase animosity towards predators.

Resolving conflicts, both perceived and real, between wolves and livestock is a dominant social issue for state and federal management programs (Sime et al. 2007). For example, the number of wolf complaints investigated from 1987-2006 increased as the population increased and expanded its distribution into Montana after reintroduction and natural expansions (Sime et al. 2008). From 1987- 2006, 314 incidents of injured or dead livestock were confirmed by United States Department of Agriculture's Wildlife Services to be caused by wolves in Montana (Sime et. al 2008). However, confirmed losses probably represent only a fraction of actual wolf losses (Sime et. al 2007). Wolves can encounter livestock on both public grazing allotments and private land. In the past 25 years, the vast majority of livestock depredations confirmed in Montana occurred on private lands (Sime et al. 2007).

Wolf predation on livestock is probably insignificant to the livestock industry as a whole, but it can create significant economic adversity for individual producers and require local management intervention to enable coexistence of humans and wolves. The balance of stakeholders' interests and wolf conservation depends on understanding relationships between wolves, humans, and livestock (Weaver 1983). Wolf conservation must include the ability to mitigate conflict and build social tolerance of predators and predator management techniques. Wolves with histories of depredation and conflict were typically removed by lethal control from populations (Bangs et al. 1998). Thus far, removal of problem individuals is a common management technique used by state, federal, and tribal managing agencies (Knowlton et al. 1999; Bradley et al. 2005; Sime et al. 2008). Nationally, however, public support for lethal management has decreased while the value of carnivores has increased (Mech 1996; Reiter et al. 1999), which has resulted in a need for alternative, non-lethal, management strategies that provide flexibility in management. The Montana Wolf Conservation and Management Plan and the developing Montana wolf reimbursement program both outline the need and potential application of novel strategies to decrease risk of predation and to offer additional flexibility or efficiency for both livestock producers and management agencies.

Of note is the concern that applying alternative methods may waste resources while only delaying the inevitable lethal removal of a depredating wolf. A competing criticism, however, is that lethal removal is ineffective because it only delays the inevitable colonization and damage by another wolf. Thus, alternative and traditional forms of management have been criticized because they require resources and actions that seem doomed to fail in the long term. However, predation management is an ongoing process that requires continual input to achieve short-term reduction in livestock depredation. Management, by definition, attempts to minimize the impact of ongoing conflicts; because there is no one long-term solution, perpetual management of wolf conflicts is necessary.

The choice of which approach (lethal or non-lethal) to use depends on knowledge of a method's effectiveness in a particular situation and the economic and social environment where management is needed. A number of lethal and non-lethal methods have attempted to lower risks of depredation and limit conflict. However, these strategies are often based on anecdotal evidence, rather than scientific testing for efficacy and cost-benefit in management scenarios. In the absence of structured field trials, anecdotal information will continue to be the basis for controversial agency decisions and result in heated public debate. Management agencies are forced to apply limited knowledge while navigating competing opinions to make management decisions. What scientific evidence does exist is minimal, warranting additional research before full implementation into management programs. Clearly, more information about the appropriate application of alternative techniques is needed.

Novel Techniques for Wolf Predation Management

Efficacy of predator repellents has been tested on the individual level with limited success (Dorrance and Bourne 1980; Linhart et al. 1982; Fritts 1982; Ternent and Garshelis 1999; Musiani and Visalberghi 2001; Musiani et al. 2003; Shivik et al. 2003), and various non-lethal techniques have been applied by researches, managing agencies, private citizens, and non-governmental organizations to prevent wolf and coyote depredations to livestock. For example, guard animals such as llamas and dogs reside with herds of sheep to protect them from predators (Linhart et al. 1979; Green and Woodruff 1983; Cavalcanti 1997; Meadows and Knowlton 2000). Scare devices consisting of loud noises and strobe lights have been used to repel wolves from pastures and protect food resources in free-ranging and captive environments (Linhart et al. 1992; Breck et al. 2003; Shivik et al. 2003; Shivik 2006; Sime et al. 2008). These auditory and visual scare devices include pyrotechnics, sirens, strobe lights, electronic guards, and radio- or movement-activated guards. Additionally, physical or visual barriers such as electric fences and fladry (flags interspersed on a rope developed in ancient Europe to capture wolves) have been used to prevent movements of wolves and coyotes (Gates et al. 1978; Nass and Theade 1988; Musiani and Visalberghi 2001; Musiani et al. 2003; Mettler 2005). Many new predation management techniques have untested efficacy, and testing new technologies in management scenarios is required (Shivik 2006). Thus far, the combination of lethal and non-lethal techniques has been most effective in proactively and reactively addressing wolf-livestock conflicts (Sime et al. 2008).

Primary repellents such as fladry act through a generalized avoidance of a novel stimuli (Shivik et al. 2003). The repellent effect results from an innate avoidance of novel stimuli as exhibited by fear of a novel stimulus. As with all primary repellents, fladry has the potential to be rendered ineffective through the process of habituation, which is essentially the loss of novelty, and thus fear, of a stimulus.

Alternatively, teaching animals to avoid a stimulus by pairing a negative experience with the stimulus can create secondary repellents. Aversive conditioning can be described as an evasion impetus, where a behavior is instigated by discomfort, pain, or a general negative experience (Elliot and Covington 2001). For example, electric shock is a common method used to prevent predation by coyotes and red fox (*Vulpes vulpes*) (Gates et al. 1978; Nass and Theade 1988; Andelt et al. 1999; Poole and McKillop 2002). Because conditioning, rather than neophobia is the mechanism of action, the process is not subject to habituation and should be more effective for a longer period of time (Shivik et al. 2003).

It is also possible that multi-level repellents can be developed that rely on both primary and secondary approaches. Reinforcing neophobia with a negative experience can lead to synergistic effectiveness of repellents. The fladry design known as “Turbo-fladry” (Carol’s Creations, Arco, ID; Jonco Industries Inc, Milwaukee, WI), incorporates electrical stimuli with flagging, thus combining novelty with conditioning. The neophobic and avoidance behaviors created by non-electrified fladry are likely to decrease through time due to habituation and animal learning. However, electrified fladry could increase or prolong the repellent effect because of the supplemental aversive conditioning element. Storer et al. (1938) suggest that bears will investigate an electric fence by touching it with their nose or lips. Recent observations of captive and wild wolves (Nathan Lance, unpublished data) indicate that wolves often bite the rope that suspends fladry. Thus an electrified fladry barrier may at first frighten, and then strongly condition wolves to avoid any such barrier. The experimental evaluation of electrified fladry is limited to one example with anecdotal evidence suggesting that electrified fladry can protect fish in a holding pond from free-ranging wolves (Rick Williamson, personnel communication). Further testing may prove the usefulness of electrified fladry as a management tool for mitigating wolf-livestock conflicts.

Developing and testing of tools is often difficult in management situations. A captive setting is an ideal for initially developing and testing products. However, testing new tools in the field is vital for a complete evaluation of their success, especially in relation to their limitations. In review of the efficacy of non-lethal tool research, I found very little data highlighting the success or failures in the applicability of the various tools in actual management situations (Linhart et al. 1976; Andelt et al. 1999; Musiani and Visalberghi 2001; Musiani et al. 2003; Shivik et al. 2003; Mettler 2005; Darrow 2006). More importantly, research tends to highlight success in changing animal behavior, and ignore the monetary costs or social willingness to apply such tools.

Importance of Biology and Sociology for Wolf Predation Management

An adequate understanding of both biological and sociological factors in human wildlife conflict is essential for successful predator conservation and management; to optimize coexistence, behavioral modifications of both predators and humans are required (Treves and Karanth 2003). Social attitudes influence tolerance of predators and predator management techniques, and the success of predator conservation and management will come from a balance of biological, economic, and sociological factors.

The biological study of wolves in regards to conservation and management seems to be the most common and well document research (Mech et al. 1988; Seip 1992; Mech 1995; Musiani and Visalberghi 2001; Ripple et al. 2001; Musiani et al. 2003; Smith et al. 2003; Shivik 2004, 2006; Mettler 2005). Biological success of a management tool is the ability to change or limit an animal's behavior, especially when linked to livestock depredations.

When managers are deciding on a course of action to alleviate a wildlife problem, another important factor is public perception of damage and how the problem should be managed (Reiter et al. 1999). While biological factors are the easiest to manipulate, economic loss and social perceptions of predators and management are the most common cause of predator-livestock conflicts and perhaps the most difficult to manage. Thus, with the recent reintroductions and natural reestablishments of wolves, researchers have paid special attention to stakeholders' perceptions of wolves and management (Tucker and Pletscher 1989; Williams et al. 2002; Ericsson and Heberlein 2003; Naughton-Treves et al. 2003). Yet, an insufficient amount of research highlights the attitudes towards the efficacy, applicability, and economic limitations of non-lethal predation management tools. A more complete understanding of stakeholders' attitudes towards predators, management, and the efficacy and applicability of non-lethal tools may aid the managing social perceptions of predators and predators themselves (Primm and Clark 1996; Shivik 2006).

Thesis Objectives

The objective of this research was to determine the effectiveness and usefulness of electrified fladry for preventing wolves from accessing a pasture or protected food resource. My first set of experiments compared the efficacy of electrified fladry to passive fladry to determine if electrified fladry more effectively protected a food source from captive wolves. I then conducted an experiment to determine if electrified fladry could reduce wolf use of pastures and prevent depredations in an actual management scenario. Lastly, during field trials, I determined the costs, logistical difficulties, and limitations associated with using electrified fladry in field conditions.

Literature Cited

Andelt, W.F., R.L. Phillips, K.S. Gruver, and J.W. Guthrie. 1999. Coyote predation on domestic sheep deterred with electronic dog-training collar. Wildlife Society Bulletin 27:12-18.

Atwood, T.C., E.M. Gese, and K.E. Kunkel. 2007. Comparative patterns of predation by cougars and recolonizing wolves in Montana’s Madison Range. Journal of Wildlife Management 71:1098-1106.

Bangs, E.E., S.H Fritts, J.A. Fontaine, D.W. Smith, K.M. Murphy, C.M. Mack, and C.C. Neimeyer. 1998. Status of gray wolf restoration in Montana, Idaho, and Wyoming. Wildlife Society Bulletin 26:785-798.

Bangs, E.E., and J. Shivik. 2001. Managing wolf conflict with livestock in the northwestern United States. Carnivore Damage Prevention News 3:2-5.

Berger, J., J.E. Swenson, and I. Persson. 2001. Recolonizing carnivores and naïve prey: Conservation lessons from Pleistocene extinctions. Science 291:1036-1039.

Boyd, D.K., and D.H. Pletscher. 1999. Characteristics of dispersal in a colonizing wolf population in the Central Rocky Mountains. Journal of Wildlife Management 63:1094-1108.

Bradley, E. H., D. H. Pletscher, E. E. Bangs, K. E. Kunkel, D.W. Smith, C. M. Mack, T. J. Meier, J. A. Fontaine, C. C. Niemeyer, and M. D. Jimenez. 2005. Evaluating wolf translocation as a nonlethal method to reduce livestock conflicts in the northwestern United States. Conservation Biology 19:1498-1508.

Breck, S.W., R. Williamson, C. Niemeyer, and J.A. Shivik. 2003. Non-lethal radio activated guard for deterring wolf depredation in Idaho: Summary and call for research. Vertebrate Pest Conference 20:223-226.

Cavalcanti, S. M. C. 1997. Evaluation of physical and behavioral traits of llamas (Lama glama) associated with aggressiveness toward sheep-threatening canids. M. S. Thesis, Utah State University, Logan, Utah, USA.

Ciucci, P., and L. Boitani. 1998. Wolf and dog depredation on livestock in central Italy. Wildlife Society Bulletin 26:504-514.

Darrow, P. 2006. Habituation and variable captive coyote response to behavior contingent stimuli. M. S. Thesis, Utah State University, Logan, Utah, USA.

Dorrance, M.J., and J. Bourne. 1980. An evaluation of anti-coyote electric fencing. Journal of Range Management 33:385-387.

Elliot, A. J., and M. V. Covington. 2001. Approach and avoidance motivation. Educational Psychology Review 13:73-92.

Ericsson, G., and T.A. Heberlein. 2003. Attitudes of hunters, locals, and the general public in Sweden now that the wolves are back. Biological Conservation 111:149-159.

Fritts, S.H. 1982. Wolf depredation on livestock in Minnesota. Research publication 145. U.S. Fish and Wildlife Service, Washington, D.C., USA.

Gates, N. L., J. E. Rich, D. D. Godtel, and C. V. Hulet. 1978. Development and evaluation of anti-coyote electric fencing. Journal of Range Management 31:151-153.

Green, J. S., and R. A. Woodruff. 1983. The use of three dog breads to protect rangeland sheep from predators. Applied Animal Ethology 11:141-161.

Knowlton, C. E., E.M. Gese, and M.M Jaeger. 1999. Coyote depredation control: an interface between biology and management. Journal or Range Management 52:398-412.

Linhart, S.B., G.J. Dasch, R.R. Johnson, J.D. Roberts, and C.J. Packham. 1992. Efficacy under range conditions and operation use. Vertebrate Pest Conference 15:386-392.

Linhart, S.B., J.D. Roberts, and G.J. Dasch. 1982. Electric fencing reduces coyote predation on pastured sheep. Journal of Range Management 35:276-281.

Linhart, S.B., J.D. Roberts, S.A. Shumake, and R. Johnson. 1976. Avoidance of prey by captive coyotes punished with electric shock. Vertebrate Pest Conference 7:302-306.

Linhart, S. B., R. T. Sterner, T. C. Carrigan, and D. R. Henne. 1979. Komondor guard dogs reduce sheep losses to coyotes: a preliminary evaluation. Journal of Range Management 32:238-241.

McNay, M.E. 2002. Wolf-human interactions in Alaska and Canada: a review of the case history. Wildlife Society Bulletin 30:831-843.

Meadows, L. E., and F. F. Knowlton. 2000. Efficacy of guard llamas to reduce canine predation on domestic sheep. Wildlife Society Bulletin 28:614-622.

Mech, L.D. 1970. The wolf: the ecology and behavior of an endangered species. Doubleday/Natural History Press, Garden City, New York, USA.

Mech, L.D. 1995. The challenge and opportunity of recovering wolf populations. Conservation Biology 9:270-278.

Mech, L.D. 1996. A new era for carnivore conservation. Wildlife Society Bulletin 24:397-401.

Mech, L.D., S.H. Fritts, G.L. Radde, and W.J. Paul. 1988. Wolf distribution and road density in Minnesota. Wildlife Society Bulletin 16:85-87.

Mettler, A.E. 2005. Investigations into behavioral responses of predators to novel visual stimuli. M. S. Thesis, Utah State University, Logan, Utah, USA.

Musiani, M., C. Mamo, L. Boitani, C. Callaghan, C. C. Gates, L. Mattei, E. Visalberghi, S. Breck, and G. Volpi. 2003. Wolf depredation and the use of fladry barriers to protect livestock in western North America. Conservation Biology 17:1538-1547.

Musiani, M., and E. Visalberghi. 2001. Effectiveness of fladry on wolves in captivity. Wildlife Society Bulletin 29:91-98.

Nass, R. D., and J. Theade. 1988. Electric fences for reducing sheep losses to predators. Journal of Range Management 41:251-252.

Naughton-Treves, L., R. Grossberg, and A. Treves. 2003. Paying for tolerance: Rural citizens' attitudes toward wolf depredation and compensation. Conservation Biology 17:1500-1511.

Poole, D. W., and I. G. McKillop. 2002. Effectiveness of two types of electric fencing for excluding the Red Fox (*Vulpes vulpes*). Mammal Review 32:51-57.

Primm, S.A., and T.W. Clark. 1996. Making sense of the policy process for carnivore conservation. Conservation Biology 10:1036-1045.

Rajpurohit, K.S. 1999. Child-lifting: wolves in Hasaribagh, India. Ambio 28:162-166.

Reiter, D. K., A. D. Dayton, F. R. Henderson, R. L. Meduna, and C. W. Spaeth. 1999. Public attitudes towards wildlife damage management and policy. Wildlife Society Bulletin 27:746-758.

Ripple, W.J., E.J. Larsen, R.A. Renkin, and D.W. Smith. 2001. Trophic cascades among wolves, elk and aspen on Yellowstone National Park's northern range. Biological Conservation 102:227-234.

Seip, D.R. 1992. Factors limiting woodland caribou populations and their interrelationships with wolves and moose in southeastern British Columbia. Canadian Journal of Zoology 70:1494-1503.

Shivik, J.A. 2004. Non-lethal alternatives for predation management. Sheep and Goat Research Journal 19:64-71.

Shivik, J. A. 2006. Tools for the edge: what's new for conserving carnivores. Bioscience 53:253-259.

Shivik, J. A., A. Treves, and P. Callahan. 2003. Non-lethal techniques: primary and secondary repellents for managing predation. Conservation Biology 17:1531-1537.

Sime, C.A., V. Asher, L. Bradley, K. Laudon, M. Ross, J. Trapp, M. Atkinson, and J. Steuber. 2008. Montana gray wolf conservation and management 2007 annual report. Montana Fish, Wildlife & Parks. Helena, Montana, USA.

Sime, C.A., E. Bangs, E. Bradley, J.E. Steuber, K. Glazier, P.J. Hoover, V. Asher, K. Lauden, M. Ross, and J. Trapp. 2007. Gray wolves and livestock in Montana: A Recent history of damage management. Proceedings of the Wildlife Society Wildlife Damage Management Working Group Conference.

Smith, D.W., T.D. Drummer, K.M. Murphy, D.S. Guernsey, and S.B. Evans. 2004. Winter prey selection and estimation of wolf kill rates in Yellowstone National Park, 1995-2000. Journal of Wildlife Management 68:153-166.

Smith, D.W., R.O. Peterson, and D.B. Houston. 2003. Yellowstone after wolves. Bioscience 53:330-340.

Storer, T.I., G.H. Vansell, and B.D. Moses. 1938. Protection of mountain apiaries from bears by use of electric fences. Journal of Wildlife Management 2:172-178.

Ternent, M.A., and D.L. Garshelis. 1999. Taste-aversion conditioning to reduce nuisance activity in black bears in a Minnesota military reservation. Wildlife Society Bulletin 27:720-728.

Treves, A., R.R. Jurewicz, L. Naughton-Treves, R.A. Rose, R.G. Willging, and A.P. Wydeven. 2002. Wolf depredation on domestic animals in Wisconsin, 1976-2000. Wildlife Society Bulletin 30:231-241.

Treves, A., and K.U. Karanth. 2003. Human-carnivore conflict and perspectives on carnivore management worldwide. Conservation Biology 17:1491-1499.

Tucker, P. and D.H. Pletscher. 1989. Attitudes of hunters and residents toward wolves in northwestern Montana. Wildlife Society Bulletin 17:509-514.

Weaver, J. 1983. Of wolves and livestock. Western Wildlands 8:37-39.

Williams, C.K., G. Ericsson, and T.A. Heberlein. 2002. A quantitative summary of attitudes towards wolves and their reintroduction (1972-2000). Wildlife Society Bulletin 30:575-584.

CHAPTER 2

COMPARISON OF ELECTRIFIED FLADRY TO FLADRY FOR PROTECTING A FOOD RESOURCE FROM WOLVES IN CAPTIVITY

Abstract

Lethal methods are important for predator management but new and innovative techniques may allow wildlife managers to reduce conflicts in ways that are most acceptable to the greatest number of people and optimize human-carnivore coexistence. Fladry is a suspended line of flagging used to exclude wolves from livestock; it has limited effectiveness because wolves habituate to the barrier. Electrified fladry is an extension of fladry, where flags are suspended from an electrified wire instead of a rope and designed to decrease the potential for wolves to habituate to the barrier. Using captive wolves I compared the effectiveness of fladry versus electrified fladry for protecting a food resource. Both fladry and electrified fladry effectively excluded wolves from a food resource for short durations of time (1-14 days). However, latency to cross and feed significantly differed between fladry ($\bar{x}$ = 1.2 days, SE =0.2) and electrified fladry ($\bar{x}$ = 4.6 days, SE = 0.5) (χ^2= 8.721, d.f. =1, $P < 0.003$). Caution should be used when evaluating mean survival time; electrified fladry mean survival times were underestimated because the largest observations were censored and the estimation was restricted to the largest event time. Our research also indicated that although electrified fladry has the potential to reduce wolf depredations, animal learning, motivation, and personality all influence effectiveness.

Introduction

Wolf (*Canis lupus*) predation on livestock can cause economic adversity for livestock producers and can increase animosity towards wolves, thus complicating the balance of wolf conservation and other human interests. Predation management and conflict resolution between wolves and livestock producers has historically depended on lethal control (Knowlton et al. 1999). However, public support for lethal predator management has decreased (Mech 1996; Reiter et al. 1999) creating a strong need for alternative management strategies that help alleviate depredation pressure from wolves and minimize the need for reactive lethal management.

Many non-lethal methods have been used in wolf management: translocations of depredating animals (Fritts et al. 1984; Bradley et al. 2005), using guard animals (Linhart et al. 1979; Green & Woodruff 1983; Cavalcanti 1997; Meadows & Knowlton 2000), scare devices (Shivik & Martin 2001; Shivik et al. 2003), physical and visual barriers (Gates et al. 1978; Nass & Theade 1988; Musiani & Visalberghi 2001; Musiani et al. 2003), and livestock husbandry (Robel et al. 1981). Some non-lethal techniques may be effective on a short-term basis, but additional testing and implementation of new methodologies in actual management situations is needed (Shivik 2006).

Recent studies using the barrier technique known as fladry (flagging interspersed on a single strand of nylon twine) document that captive wolves avoided the flagging and thus access to food for short durations (Musiani & Visalberghi 2001; Musiani et al. 2003). Free-ranging predators also avoided fladry, which impedes wolves from crossing to access food for short time periods (Okarma 1993; Okarma & Jedrzejewski 1997; Musiani et al. 2003; Shivik et al. 2003). Because fladry is a primary repellent, it relies on producing a flight or startle response to disrupt predatory behavior (Shivik et al. 2003; Shivik 2004). As with all primary repellents, fladry is rendered ineffective through the process of habituation, which results in an extinction of an animal's fear of the novel object (Shivik et al. 2003). In the context of predator management, habituation to a novel object is determined by the intensity of a stimulus and the motivation of an animal (Shivik et al. 2003). Musiani and Visalberghi (2001) found that levels of excitement and motivation play a strong role in the habituation to fladry by wolves in captivity. Free-ranging wolves that kill sporadically may be highly food motivated and habituate quickly to primary repellents such as fladry.

Conversely, secondary repellents rely on conditioning using aversive stimuli in order to prevent a behavior (Shivik et al. 2003; Shivik 2004). Aversive conditioning can also be described as avoidance motivation, where flight behavior is initiated by discomfort, pain, or a general negative experience (Elliot & Covington 2001). Aversive conditioning using electric shock can prevent predation (Gates et al. 1978; Linhart et al. 1982; Nass & Theade 1988; Andelt et al. 1999; Huygens & Hayashi 1999; Poole & McKillop 2002; Breck et al. 2006), and a modification of the fladry design, electrified fladry, incorporates electrical stimuli. Electrified fladry is similar to fladry in that it consists of flagging; however, the nylon twine that supports flagging is replaced with an electrified wire (Gallagher Turbo-wire, North Kansas City, MO). Although the effectiveness of fladry is expected to decrease through time due to habituation, electrified fladry also relies on aversive conditioning to increase its effectiveness after habituation has begun. Poole and McKillop (2002) suggest that animals will investigate an electric fence or unfamiliar object by touching it with their nose, and thus by combining primary and secondary repellents electrified fladry may at first frighten, and then condition wolves to avoid the barrier, therefore providing a better non-lethal tool. Thus, the objective of this research was to compare the effectiveness of fladry to electrified fladry in captivity to test the premise that reinforcing a primary repellent with a secondary repellent will create a more effective non-lethal tool.

Methods

I conducted controlled pen experiments during the winter of 2006 using 15 captive wolf groups at the Wildlife Science Center (WSC), Forest Lake, Minnesota under the National Wildlife Research Center's Institutional Animal Care and Use Committee QA-1332. Specifically, I used 45 wolves, including 36 gray wolves (*Canis lupus*), 3 Mexican gray wolves (*Canis lupus baileyii*), and 6 red wolves (*Canis rufus*). All wolves were ≥ 1 years of age and were wild born or originated from previous wild captured wolves (Table 2.1). Wolf group sizes ranged from 1-7 animals and each group had its own enclosure ($105 m^2$ – $925 m^2$ chain-link fenced areas) that contained one 19 liter water bucket, 1-2 den boxes (2-5 m^2) and natural vegetation, including shrubs and trees. I assumed that all species and subspecies exhibited the same behavior, motivation, and predatory characteristics and would differ only in morphological characteristics.

Throughout the study all wolves remained under the care of the WSC with no changes in animal husbandry (i.e. caretakers continued to feed, water, and clean pens as part of their normal scheduled activities). On a daily basis WSC personnel monitored wolves for injuries and alterations in physical condition and when required, physically restrained and immobilized wolves with approximately 3.3 mg/kg ketamine and 0.3 mg/kg xylazine (based on a 45 kg average weight of wolves).

Because it was difficult to distinguish individuals within a pack, I attempted to use 6.6 cm engravable band collars (Ritchey Manufacturing, Brighton, CO) with unique black symbols on a white background to identify individuals. Technicians physically restrained wolves using pin sticks and hand nets to place identification collars on wolves a week before the baseline data were collected. However, even with the collars, I was usually unable to identify specific individuals with the photography equipment I used. Thus, all analyses used the wolf group and not individuals as the sample unit.

I collected baseline data for two weeks before treatments began to ensure pen familiarity and conditioning to novel objects (i.e. chained carcass and cameras). During baseline collection we placed passive infrared motion activated cameras (Reconyx RM30, Holmen, WI) on the outside of the pen fence, where they remained in place throughout all of the treatments. Cameras had a 40° field of view with a range of 18.3 meters from the camera, which covered the entire 8.5 m distance across the pen. I programmed cameras to take a series of photos at 4 frames per second upon activation. Barriers were monitored 24 hours a day (cameras were equipped with infrared illumination for night time use) and cameras recorded treatment information, time, and date of activation on every picture taken. I mounted cameras on the outside of the fence 1.2 meters high, and aimed them along the barrier line. Therefore, when a wolf approached the barrier, cameras recorded their behavior. I recorded average number of approaches per day, total number of approaches weighted by number of wolves, days fasted, and latency to cross barriers during two-week trials. I defined an approach as a single wolf occupying a location $\leq$ 2 meters from a barrier line in a single recorded photo data image. Latency to cross was defined as the elapsed time between the start of trial to an event of a single wolf crossing the barrier line and freely feeding on the carcass.

The food resource was one whole eviscerated road-killed white-tailed deer (*Odocoileus virginianus*) carcass previously collected in the surrounding area and was the normal maintenance food. I placed deer carcasses in the corner of the pen near the camera and chained them to the fence corner using 1.2 m of 0.47 cm stainless steel chain.

To assign treatments, I randomly selected five pens to receive fladry barriers, five to receive electrified fladry barriers, and five to receive no barrier (controls). Trials were run in phases: Baseline, where all pens received tethered carcasses and no fladry barriers, Phase I, where 5 pens had fladry, 5 had electrified fladry, and 5 controls had no barriers, and Phase II when the treatments in fladry and electrified fladry pens were swapped, and controls remained with no barriers. Each pens' trial lasted two weeks or until failure of the barrier. Failure was defined as one or more wolves crossing into the part of the pen with the carcass and freely consuming the food resource.

For the fladry and electrified fladry treatments, I sectioned off an 18 m^2 area within the pen by running the barrier from one side of the pen to the other. The fladry systems protecting the resource we constructed following the method of Musiani and Visalberghi (2001). That is, fladry and electrified fladry systems (Carol's Creations, Arco, ID) consisted of red plastic flags (50 x10 cm) interspersed at 50 cm intervals on a 0.2 cm diameter blue nylon twine. I suspended the nylon twine 50 cm above the ground and attached it to fiberglass posts set at 3 meter intervals. During fabrication of the electrified fladry system, the nylon twine that typically held the flagging was replaced with a 0.2 cm electric mixed metal strand twine (Gallagher Turbo Wire, North Kansas, MO) of nylon and wire. I suspended the electrified fladry from fiberglass posts in the same manner as the fladry. I suspended a second 0.2 cm electric ground wire (Gallagher Turbo Wire) 13 cm above the ground and attached it to the fiberglass posts. A 12-volt battery powered fence energizer (Gallagher B260) electrified the wire and produced a pulsed energy output of ≥ 2000 volts with 2.6J of stored energy and a resistance of 500 ohms. Three 1m copper rods grounded the circuit.

The feeding protocol at the Wildlife Science Center used a randomized feeding schedule that provided food for wolves five out of seven days with varying portion size. I incorporated my testing into the feeding schedule and began trials after a 2 day fasting period. At the start of a trial, I placed a deer carcass at the most distant corner within the experimental area. A carcass remained in the protected area for 5 days; on days 6 and 7. I supplied carcasses in the unprotected area and replaced the carcass in the protected area.

Statistical Analyses

I analyzed the difference in latency to crossing events between treatments and made statistical comparisons between fladry and electrified fladry using the Wilcoxon signed-ranks tests and Kaplan-Meier survival estimator (SAS Institute, Inc, Cary, North Carolina, USA). To provide a more detailed representation of wolf behavior in relation to barriers and fasting, I also made descriptive comparisons of average approaches for overall trends by treatment and wolf group.

Results

Latency

During baseline, all 15 (100%) wolf groups crossed the camera line and fed on the deer carcass. During Phase I, control wolves crossed to carcasses within 296 seconds (SE

= 192) while fladry was effective for up to 1 day and electrified fladry was effective up to 14 days at excluding wolf groups from protected food resources (Table 2.2). Latency to crossing by wolves significantly differed between the fladry (1.0 ± 0.0 days) and electrified fladry (4.6 ± 0.5 days) treatments in Phase I ($\chi^2 = 9.00$, d.f.=1, $P < 0.003$). Due to censored data, the mean survival time is grossly underestimated for electrified fladry because the estimation was restricted to the length of the observation period. During Phase II, control wolves again crossed to carcasses within 9 seconds (SE = 2) while fladry (Phase I- electrified fladry) and electrified fladry (Phase I- fladry) barriers effectively prevented wolves from accessing the protected food resource for up to 14 days (Table 2.3).

Approaches

In Phase I, no trend in approaches emerged with the fladry treatment as all groups crossed the fladry barrier in ≤ 1 day with a mean approach of 47 ± 3.2 seconds during the short time period. With electrified fladry, approaches through time during Phase I decreased during the 2 week trial and exhibited a dramatic decrease subsequent to feedings in the unprotected area on days 6 and 7 (Figure 2.1). In Phase II, fladry and electrified fladry trials started with fewer average approaches compared to treatments in Phase I (Figures 2.2 and 2.3), and wolves continued to test both treatments throughout the trial. Fladry and electrified fladry treatments in Phase II dramatically decreased approaches when wolves were fed in unprotected areas on days 6 and 7. Total approaches to electrified fladry weighted by number of wolves in a group exhibited high variation among groups from 0 to 776 seconds (Figure 2.4).

Discussion

My results are consistent with other studies in demonstrating that fladry is effective at interfering with foraging behavior of captive canids for short durations (Musiani & Visalberghi 2001; Mettler 2005). The success of fladry apparently relates to its novelty in addition to human scent as a stimulus (Okarma and Jedrzewski 1997). Musiani and Visalberghi (2001) and Mettler (2005) imply that the success of fladry relies more on the attributes of the repellent than human scent. For my experiments, WSC personnel set and removed equipment and carcasses due to habituation by the wolves to routine animal husbandry practices. All treatments set were not uniformly avoided indicating an additional aversive element because wolves in control trials freely feed on carcasses and showed no aversion towards human scent.

Success of fladry is thought be the fear of a novel object and indecision to jump over or pass under the barrier (Mussiani and Visalberghi 2001). In the process of learning, animals change behaviors to avoid or overcome stimuli (Shivik and Martin 2000). The failure of one pen of electrified fladry involved a single subordinate animal eventually biting the ground wire, crawling under the flagging, and freely feeding on the carcass on multiple occasions; other higher and lower ranking pack members remained in the unprotected area and did not cross. A second pen exhibited a flight response to personnel during the trial and one wolf jumped over the electrified fladry barrier and back out the other side shortly after the trial began. Subsequently this pen eventually failed as a wolf jumped into the protected area and fed on the carcass a few days later.

Electrified fladry was substantially better than fladry at protecting a food resource from motivated captive wolves. Similarly to the fladry treatments, wolves demonstrated an initial wariness in approaches and then began to more frequently investigate the barrier during the habituation process. I observed wolves beginning to bite at the flags and electrified wire. Instead of rapid barrier failure, wolves decreased the number of approaches and bites while scratching the ground in front of the barrier and targeting bites towards the flagging or ground wire and avoiding the electrified wire. In this case, the combination of primary and secondary repellents greatly increased the efficacy of this non-lethal predation management tool.

Wolves are adapted to feast and famine cycles and they can survive for up to 17 days between feedings (Mech 1970). Compared to previous work (Musiani and Visalberghi 2001), our data suggests that the duration of habituation to fladry is less when coupled with an increase in food motivation. A decrease in the average number of approaches in all trials had a strong correlation to the days that the wolves were fed in the unprotected area of the pens. I suggest that increases in approaches are related to food motivation and the willingness to take more risks to obtain a resource in conjunction with the process of habituation, while decreases in approaches are explained by conditioned avoidance and decreased motivation through satiation. Wilson et al. (1993, 1994) demonstrated that pumpkinseed sunfish (*Lepomis gibbosus*) and guppies (*Poecilia reticulate*) take greater risks to obtain food when food motivated. Further research with canids has the potential to identify the threshold where behaviors shift in relation to food motivation and the willingness to risk investigating novel objects.

Although the limitations of repellants are generalized to a mean or summary of many animals, time until habituation, the duration of success and rate of habituation is dependent on individual behavioral variations. The ability to challenge risky situations is a balance between the potential benefits and dangers of the behavior, which change with context. The shyness-boldness continuum is essential to describing individual behavioral variations in risk assessments. Wilson et al. (1994) describe shyness and boldness behaviors in three-spined sticklebacks (*Gasterosteus aculeatus*) and pumpkinseed sunfish that vary across time and situations. Studies have identified personality traits for groupings of behavioral variations including shy, persistent, and bold with animals such as spotted hyenas (*Crocuta crocuta)* (Gosling 1998) and coyotes (*Canis latrans*) (Darrow 2006). I did not successfully identify individuals and test the concept of behavior and risk at the individual level. However, pack approach behaviors varied greatly with approaches and biting behaviors in my electrified fladry experiments. An individual's willingness to take risks, especially when motivated, likely limits the success of non-lethal tools like fladry and electrified fladry. Thus failure of non-lethal tools may partly depend upon persistent and bold individuals within a population.

While animal learning can render fladry ineffective, the ability of an animal to learn is the key to the success of conditioned avoidance of electrified fladry. A carryover effect of conditioned avoidance was seen in Phase II with the fladry treatment where two groups did not cross for two weeks while eliciting guarded approaches, even with the lack of negative electrified fladry stimulus. A third group also demonstrated conditioned avoidance with guarded approaches and did not cross for 9 days during Phase II with only fladry. Even with two failures of electrified fladry in Phase I, these two groups were reluctant to cross the fladry barrier in Phase II and still exhibited conditioned avoidance behaviors. The cautious approaches and delayed crossing behaviors may also be explained by the lack of food motivation at the start of the trial. Response to fladry treatments in Phase II eventually showed an increase in mean approaches that may be explained by constant testing by wolves with stronger personalities and the lack of negative reinforcing stimulus.

Management Implications

Predator conservation and management involves managing predators as well as humans to increase tolerance of predators and management techniques. While lethal control is successful in some applications, it has ecological drawbacks and remains controversial. Just as lethal tools are successful and have limitations, non-lethal tools have limited and contextual success and are not replacements for lethal control. Non-lethal tools are enhanced when used in combination with other lethal and non-lethal tools (Sime et al. 2008). Wolf-livestock predation management is an adaptive method, which uses a multi-faceted approach to foster tolerance of predators, predator management, and acceptable predation management tools.

Caution should be used when extrapolating the success and failures of these tools in captivity to management situations. Captive wolves' behaviors and risk assessment vary due to factors such as no alternative food choice, high levels of habituation, and a limited environment. Fladry can be effective at confining and deterring wild wolves (Okarma and Jedrzejewski 1997; Musiani and Visalberghi 2001); I expect electrified fladry to be more effective when utilized in proactive and reactive management scenarios in natural settings.

Fladry and electrified fladry are effective at protecting food resources for short durations and have the potential to be used to reduce wolf-livestock conflict. The process of habituation, however, renders simple fladry ineffective faster than electrified fladry.

Electrified fladry appears to be substantially better at protecting a food resource, with all else equal (e.g. cost, maintenance, installation), and should be used instead of fladry. Because wild wolves' ability to learn, level of motivation, and individual and group behavioral variations will vary across time and situation, variability in behavior and response will affect the success of electrified fladry in management arenas. With the potential of electrified fladry as an additional tool to manage wolves, further testing in actual proactive and reactive management situations should be performed.

Literature Cited

Andelt, W.F., R.L. Phillips, K.S. Gruver, and J.W. Guthrie. 1999. Coyote predation on domestic sheep deterred with electronic dog-training collar. Wildlife Society Bulletin 27:12-18.

Bradley, E. H., D. H. Pletscher, E. E. Bangs, K. E. Kunkel, D.W. Smith, C. M. Mack, T. J. Meier, J. A. Fontaine, C. C. Niemeyer, and M. D. Jimenez. 2005. Evaluating wolf translocation as a nonlethal method to reduce livestock conflicts in the northwestern United States. Conservation Biology 19:1495-1508.

Breck, S.W., N. Lance, and P. Callahan. 2006. A shocking device for protection of concentrated food sources from black bears. Wildlife Society Bulletin 34:23-26.

Cavalcanti, S. M. C. 1997. Evaluation of physical and behavioral traits of llamas (Lama glama) associated with aggressiveness toward sheep-threatening canids. M. S. Thesis, Utah State University, Logan, Utah, USA.

Darrow, P.A. 2006. Habituation and variable captive coyote response to behavior contingent stimuli. M. S. Thesis, Utah State University, Logan, Utah, USA.

Elliot, A. J. and M. V. Covington. 2001. Approach and avoidance motivation. Educational Psychology Review 13:73-92.

Fritts, S.H., W.J. Paul, and L.D. Mech. 1984. Movements of translocated wolves in Minnesota. Journal of Wildlife Management 48:709-721.

Gates, N. L., J. E. Rich, D. D. Godtel, and C. V. Hulet. 1978. Development and evaluation of anti-coyote electric fencing. Journal of range Management 31:151-153.

Gosling, S.D. 1998. Personality dimensions in spotted hyenas (*Crocuta crocuta*). Journal of Comparative Psychology 112:107-108.

Green, J. S., and R. A. Woodruff. 1983. The use of three dog breads to protect rangeland sheep from predators. Applied Animal Ethology 11:141-161.

Huygens, O.C. and H. Hayashi. 1999. Using electric fences to reduce Asiatic black bear depredation in Nagano Prefecture, central Japan. Wildlife Society Bulletin 27:959-964.

Knowlton, C. E., Gese, E. M. and Jaeger, M. M. 1999. Coyote depredation control: an interface between biology and management. Journal or Range Management 52:398-412.

Linhart, S.B., J.D. Roberts, and G.J. Dasch. 1982. Electric fencing reduces coyote predation on pastured sheep. Journal of Range Management 35:276-281.

Linhart, S. B., R. T. Sterner, T. C. Carrigan, and D. R. Henne. 1979. Komondor guard dogs reduce sheep losses to coyotes: a preliminary evaluation. Journal of Range Management 32:238-241.

Meadows, L. E., and F. F. Knowlton. 2000. Efficacy of guard llamas to reduce canine predation on domestic sheep. Wildlife Society Bulletin 28:614-622.

Mech, L.D. 1970. The wolf: the ecology and behavior of an endangered species. Doubleday/Natural History Press, Garden City, New York, USA.

Mech, L.D. 1996. A new era for carnivore conservation. Wildlife Society Bulletin 24:397-401.

Mettler, A.E. 2005. Investigations into behavioral responses of predators to novel visual stimuli. M. S. Thesis, Utah State University, Logan, Utah.

Musiani, M., and E. Visalberghi. 2001. Effectiveness of fladry on wolves in captivity. Wildlife Society Bulletin 29:91-98.

Musiani, M., C. Mamo, L. Boitani, C. Callaghan, C. C. Gates, L. Mattei, E. Visalberghi, S. Breck, and G. Volpi. 2003. Wolf depredation and the use of fladry barriers to protect livestock in western North America. Conservation Biology 17:1538-1547.

Nass, R. D., and J. Theade. 1988. Electric fences for reducing sheep losses to predators. Journal of Range Management 41:251-252.

Okarma, H. 1993. Status and management of the wolf in Poland. Biological Conservation 66:153-158.

Okarma, H., and W. Jędrzejewski. 1997. Livetrapping wolves with nets. Wildlife Society Bulletin 25:78-82.

Poole, D. W., and I. G. McKillop. 2002. Effectiveness of two types of electric fencing for excluding the Red Fox (*Vulpes vulpes*). Mammal Review 32:51-57.

Reiter, D. K., A. D. Dayton, F. R. Henderson, R. L. Meduna, and C. W. Spaeth. 1999. Public attitudes towards wildlife damage management and policy. Wildlife Society Bulletin 27:746-758.

Robel, R.J., A.D. Dayton, F.R. Henderson, R.L. Meduna, and C.W. Spaeth. 1981. Relationships between husbandry methods and sheep losses to cine predators. Journal of Wildlife Management 45:894-911.

Shivik, J.A. 2004. Non-lethal alternatives for predation management. Sheep and Goat Research Journal 19:64-71.

Shivik, J. A. 2006. Tools for the edge: what's new for conserving carnivores. Bioscience 53:253-259.

Shivik, J.A., and D.J. Martin. 2000. Aversive and disruptive stimulus applications for managing predation. Wildlife Damage Management Conference 9:111-119.

Shivik, J. A., A. Treves, and P. Callahan. 2003. Non-lethal techniques: primary and secondary repellents for managing predation. Conservation Biology 17:1531-1537.

Sime, C.A., V. Asher, L. Bradley, K. Laudon, M. Ross, J. Trapp, M. Atkinson, and J. Steuber. 2008. Montana gray wolf conservation and management 2007 annual report. Montana Fish, Wildlife & Parks. Helena, Montana.

Wilson, D.S., K.Coleman, A.B. Clark, and L. Biederman. 1993. Shy-bold continuum in pumpkinseed sunfish (*Lepomis gibbosus*): an ecological study of a psychological trait. Journal of Comparative Psychology 107:250-260.

Wilson, D.S., A.B. Clark, K. Coleman, and T. Dearstyne. 1994. Shyness and boldness in humans and other animals. Trends in Ecology and Evolution 9:442-446.

Table 2.1. Age, sex, species, and pen number of of captive animals at Wildlife Science Center, MN.

Pen	Age	Sex	Species
1	6	Male	*Canis lupus baileyii*
1	14	Female	*Canis lupus baileyii*
2	5	Male	*Canis lupus*
2	4	Female	*Canis lupus*
3	5	Male	*Canis rufus*
3	4	Female	*Canis rufus*
4	8	Female	*Canis lupus*
4	8	Male	*Canis lupus*
4	8	Male	*Canis lupus*
4	1	Male	*Canis lupus*
4	1	Female	*Canis lupus*
5	3	Male	*Canis lupus*
5	3	Male	*Canis lupus*
5	3	Female	*Canis lupus*
5	3	Female	*Canis lupus*
5	3	Female	*Canis lupus*
6	8	Female	*Canis lupus*
6	11	Male	*Canis lupus*
7	14	Female	*Canis rufus*
7	1	Male	*Canis rufus*
7	1	Male	*Canis rufus*
9	7	Male	*Canis lupus*
9	6	Female	*Canis lupus*
9	3	Female	*Canis lupus*
9	3	Male	*Canis lupus*
9	3	Male	*Canis lupus*
11	11	Female	*Canis lupus*
11	11	Male	*Canis lupus*
11	5	Male	*Canis lupus*
11	5	Male	*Canis lupus*
11	3	Male	*Canis lupus*
11	2	Male	*Canis lupus*
11	3	Male	*Canis lupus*
12	3	Male	*Canis lupus*
12	3	Female	*Canis lupus*
12	3	Female	*Canis lupus*
12	3	Female	*Canis lupus*
13	5	Male	*Canis rufus*
14	14	Male	*Canis lupus*
14	12	Female	*Canis lupus*
15	11	Male	*Canis lupus*
15	10	Female	*Canis lupus*
16	10	Female	*Canis lupus*
16	11	Male	*Canis lupus*
17	11	Female	*Canis lupus baileyii*

Table 2.2. Latency to crossing by a single animal during Phase I with fladry (F) and electrified fladry (EF) treatments.

Pen	Number of Wolves	Treatment	Days to Crossing
2	2	F	< 1
4	5	F	< 1
5	5	F	< 1
14	2	F	< 1
15	2	F	< 1
6	2	EF	Did Not Cross
9	5	EF	5
11	7	EF	Did Not Cross
12	4	EF	Did Not Cross
16	2	EF	3

Table 2.3. Latency to crossing by a single animal during Phase II with fladry (F) and electrified fladry (EF) treatments.

[a] Treatment received in Phase I as listed in Table 2.2.

Pen	Number of Wolves	Treatment	Days to Crossing
2	2	EF (F[a])	Did Not Cross
4	5	EF (F[a])	Did Not Cross
5	5	EF (F[a])	Did Not Cross
14	2	EF (F[a])	Did Not Cross
15	2	EF (F[a])	Did Not Cross
6	2	F (EF[a])	Did Not Cross
9	5	F (EF[a])	2
11	7	F (EF[a])	9
12	4	F (EF[a])	Did Not Cross
16	2	F (EF[a])	2

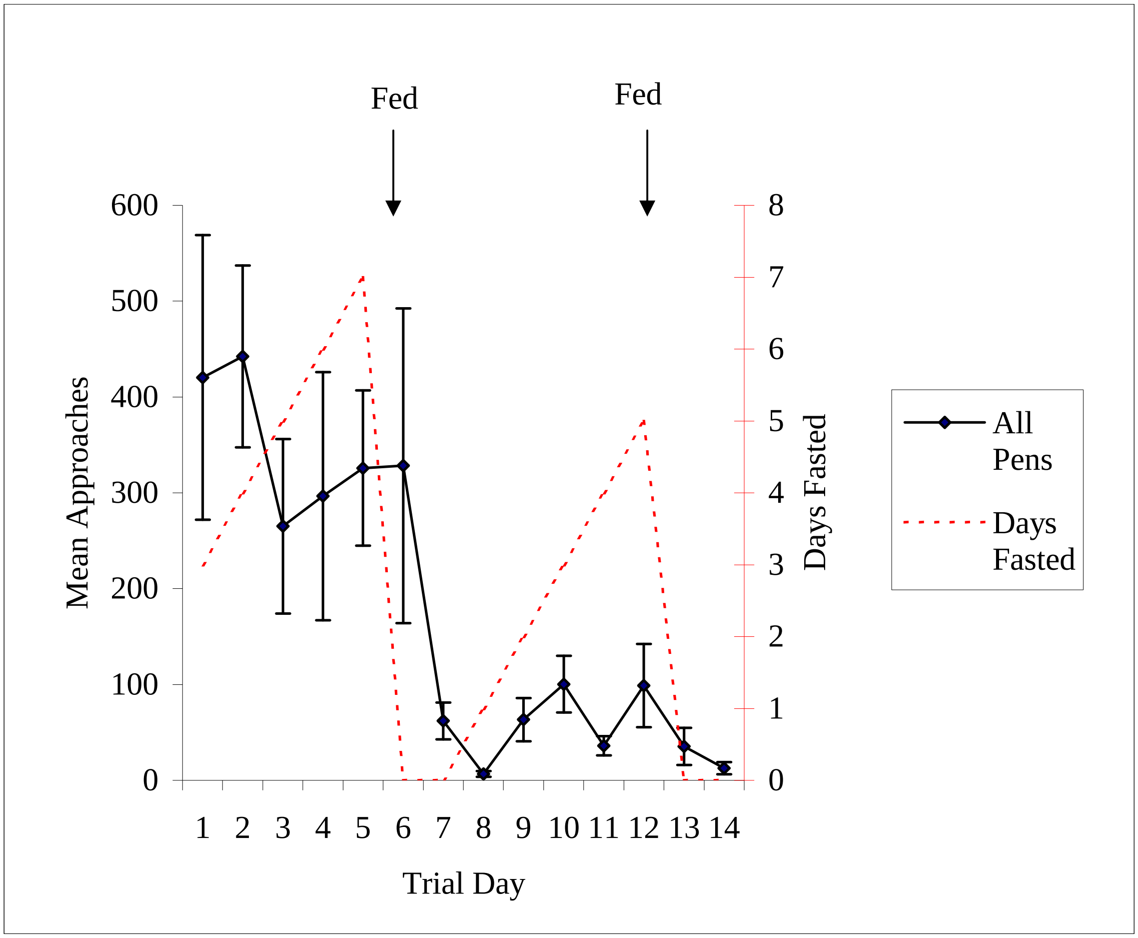

Figure 2.1. Mean approaches (± SE) by wolf groups (n=5) and days fasted for electrified fladry treatment pens during Phase I at Wildlife Science Center, MN, 2006.

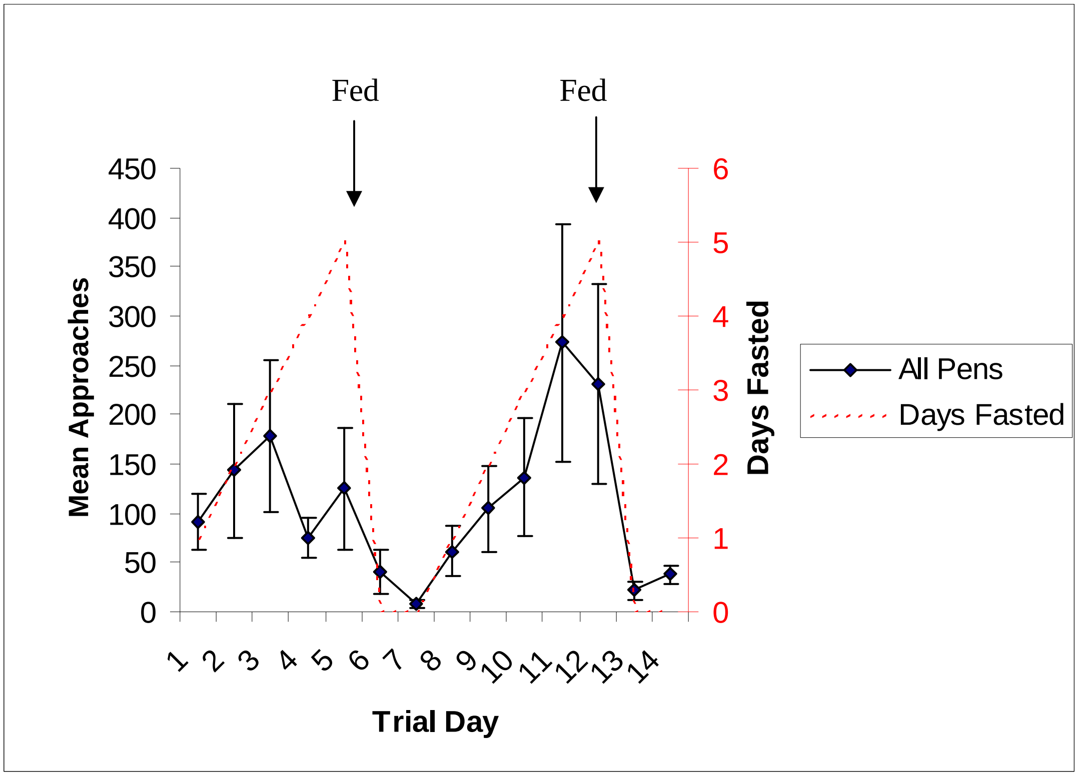

Figure 2.2. Mean approaches (±SE) by wolf groups (n=5) and days fasted for fladry (Phase I- electrified fladry) treatment pens during Phase II at Wildlife Science Center, MN, 2006

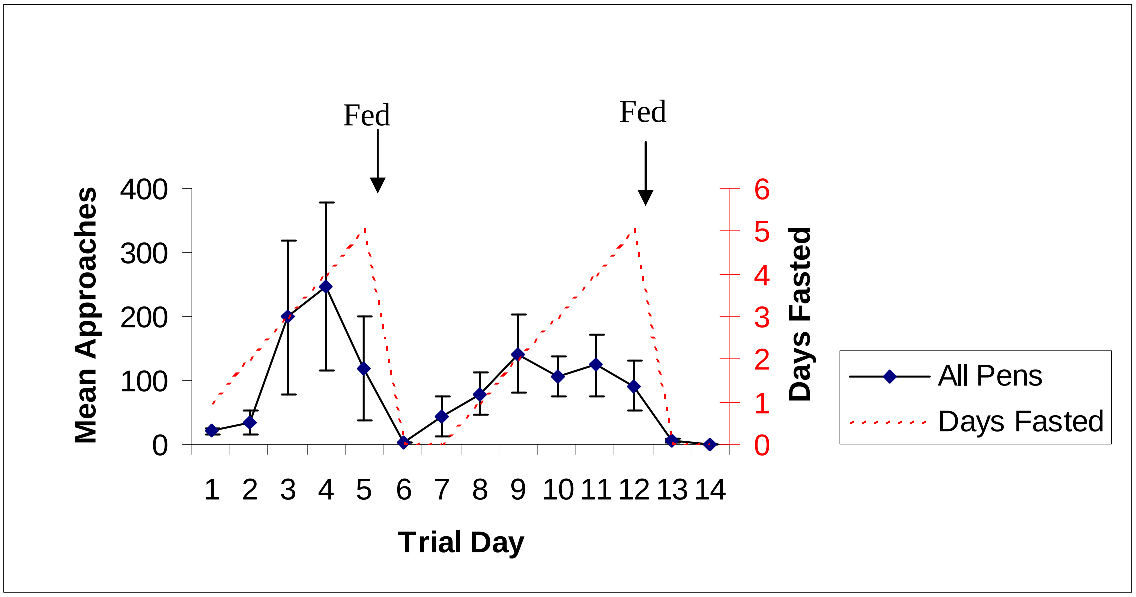

Figure 2.3. Mean approaches (±SE) by wolf groups (n=5) and days fasted for electrified fladry (Phase I- fladry) treatment pens during Phase II at Wildlife Science

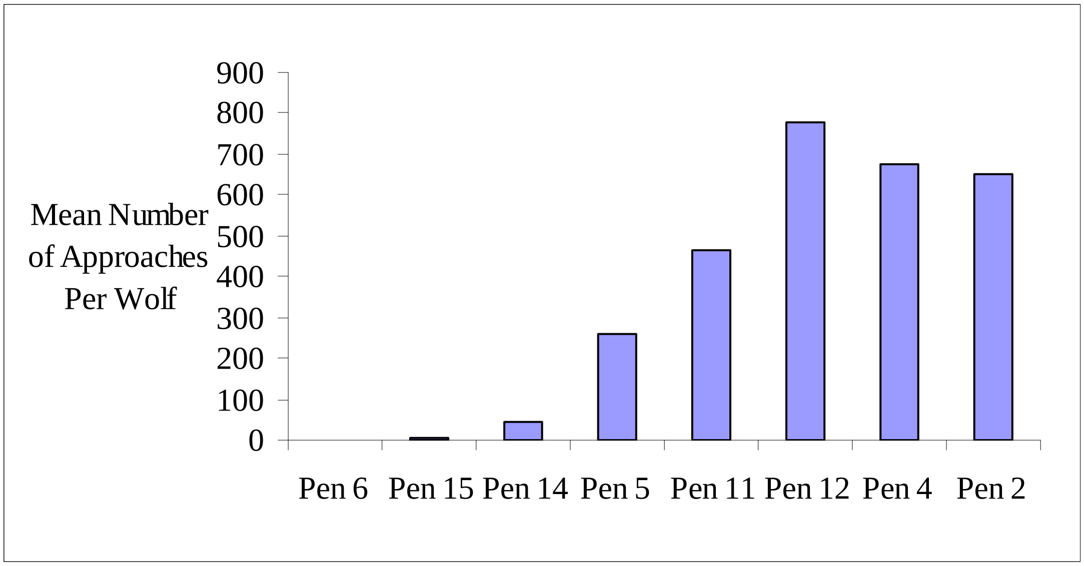

Figure 2.4. Mean number of approaches to electrified fladry per wolf without crossing at Wildlife Science Center, MN, 2006

CHAPTER 3

BIOLOGICAL AND SOCIOLOGICAL EFFICACY AND APPLICABILITY OF ELECTRIFIED FLADRY FOR PROTECTING FREE-RANGING CATTLE FROM GRAY WOLVES, *CANIS LUPUS*, IN MONTANA

Abstract

Wolves living near livestock increase risks of depredations, which increase economic losses, animosity, and conflict among stakeholders. Although wolves may not have drastic economic effects on the livestock industry as a whole, they can substantially affect individual ranchers when depredations become chronic. Lethal control is often controversial because some stakeholders want wolves removed and others do not, but both lethal and non-lethal methods require evaluation for their effectiveness in mitigating predator-livestock conflicts. Thus, I examined the use of electrified fladry for managing wolf conflicts on 9 ranches in Montana. Wolf activity at the ranches was insufficient during the period of study, however, and I was not able to determine if electrified fladry was successful or unsuccessful for preventing livestock depredations. I found, however, that electrified fladry may be limited by costs associated with purchasing and that the application of electrified fladry may limit it's usefulness for addressing wolf-livestock conflict. Biological, economical, and sociological goals of management can be met through lethal and non-lethal methods, but no one method is without limitations. The understanding of human perceptions of management tools is critical for successfully implementing management techniques and fostering participation and cooperation among

stakeholders. With this understanding, education and training can change human perceptions and may render non-lethal tools more effective.

Introduction

Because gray wolves (*Canis lupus*) have been given special federal and state protection, regulations limit the ability of livestock owners and wildlife managers to address wolf depredation on livestock. Wolves that kill livestock can be a significant problem for livestock operators and require wildlife professionals to decrease conflict via management of wolves. Management intervention can involve both lethal and non-lethal tools to decrease chronic livestock depredation (Sime et al. 2007). The best information on non-lethal management techniques is usually anecdotal and often interpreted to support one opinion or another about wolves or lethal control, rather than efficacy of various tools under different management situations. More emphasis has been placed on developing various non-lethal methods to prevent wolves from killing livestock, but evaluating their long-term effectiveness and applicability in field conditions has not been completed (Shivik 2006).

Even with compensation programs and lethal removal, people's attitudes towards wolves remains negative (Bath 1987). The ecological and political drawbacks of lethal control warrants further testing in regards to the applicability and efficacy of non-lethal tools in proactive and reactive management situations. Two non-lethal methods, fladry (rope barriers with suspend flagging) (Musiani & Visalberghi 2001; Musiani et al. 2003) and electrified fladry (electrified rope barriers with suspended flagging) (see Chapter 2), show promise as effective tools. Studies of captive wolves demonstrates electrified fladry is several times better compared to fladry in preventing motivated wolves from accessing protected food resources (see Chapter 2). While testing in captivity allows for initial development while restricting costs, assessing the efficacy and applicability in real management situations is vital for a complete evaluation.

Understanding both biological and sociological factors in human-wildlife conflict is essential to conservation and developing management programs. A recognized but often ignored criteria for non-lethal tools is the overall acceptance by producers who might use them over the long-term. Often the sociological attitudes of wolf recovery and wolf livestock conflict far surpass the biological issues in management. Several studies have examined the diverse viewpoints on wolves (Kellert 1985; Bath and Buchanan 1989; Tucker and Pletscher 1989; Pate et al. 1996), and lethal and non-lethal management (Arthur 1981; Messmer et al. 1999; Reiter et al. 1999; Decker et al. 2006), yet none have addressed the human attitudes in regards to the applicability and success of non-lethal tools in management situations. The objective of this research was to evaluate the biological and sociological efficacy and applicability of electrified fladry for protecting cattle from free-ranging wolves on ranches with previous wolf activity and depredations.

Study Area

I selected two study areas, one in southwest Montana and one in western Montana (Figure 3.1 and Figure 3.2). The study areas consist of private and public lands intermixed with rural human settlements. Natural prey items such as white-tailed deer (*Odocoileus virginianus*), mule deer (*Odocoileus hemionus*), elk (*Cervus canadensis*), and moose (*Alces alces*) are found throughout the study areas. Study areas were multi-predator systems with grizzly bears (*Ursus arctos*), black bears (*Ursus americanus*), mountain lions (*Felis concolor*), coyotes (*Canis latrans*), and wolves, all increasing in numbers due to of natural recolonization and a successful federal reintroduction in 1995 to parts of Yellowstone National Park and parts of Idaho (Sime et al. 2008).

The southwest Montana study area ("Boulder River") was located in the Boulder River valley near McLeod (45° 39' N, 110° 06' W), 27 km south of Big Timber. Vegetation consisted of mixed native and non-native grass pastures. The lower elevation foothills were a mix of public and private lands and were used by ungulates as winter range. Livestock in the area included cattle, sheep, and horses.

The Boulder River area had three different wolf packs at the end of 2006 (Moccasin Lake, Mission Creek, and Baker Mountain). Historically, it has been difficult to attribute wolf activity and wolf-related livestock damage to a specific pack due to dispersal and exchange among them. In addition, the Boulder River Valley and the East and West Forks in particular seem to be where all three territories come together (Carolyn Sime, personal communication).

Sime et al. (2008) reported that the Moccasin Lake pack, which first formed in 2004, historically denned on Gallatin National Forest lands in close proximity to private land and consisted of 4 wolves at the end of 2006. The Moccasin Lake pack territory contained about 3% private land, 96% U.S. Forest Service land, and 1% Bureau of Land Management lands in 2006 (Sime et al. 2008).

The Mission Creek pack, which first formed in 2002, historically denned on private land (Sime et al. 2008) and had 3 wolves at the end of 2006. The Mission Creek territory was comprised of about 90% private land, 4% state land, and 6% U.S. Forest Service land in 2006 (Sime et al. 2008).

The Baker Mountain pack, which was first documented in fall 2005 (Sime et al. 2008), contained 7 wolves at the end of 2006. The Baker Mountain territory is comprised of 83% private land, 2% state land, and 15% U.S. Forest Service lands (Sime et al. 2008).

The second study area ("Arlee") was in western Montana on the Flathead Indian Reservation near Arlee (47° 10' N, 114° 05' W), 42 km north or Missoula. This study area had a mixture of private and tribal lands, grazed mainly by cattle and horses during the summer and early fall period. Study pastures consisted of mixed native and non-native grass vegetation. As with the Boulder River study area, the lower elevation foothills along the tribal-private land interface provide ungulate winter range.

The Arlee area had one known wolf pack in the end of 2007 (Hewolf Mountain). Livestock depredations have been historically attributed to the Hewolf pack territory and activity. Pack activity and confirmed depredations have historically warranted close monitoring and at times lethal removal of individuals from the pack.

The Hewolf Mountain pack, which was first identified in 2005 (Sime et al. 2008), had 6 wolves at the end of 2006. The Hewolf Mountain territory is composed of 15% private land, 4% state land, and 81% tribal land (Sime et al. 2008). The Hewolf pack has historically denned on tribal land near private land where livestock calving occurs.

Methods

Ranches and Pastures

I conducted field-testing of electrified fladry between February and May 2007 in Montana as approved by the National Wildlife Research Center's Institutional Animal Care and Use Committee QA-1332. Using Montana Fish, Wildlife and Parks and United States Department of Agriculture Wildlife Services maps and data, I identified 12 pastures within the study areas where there had been consistent wolf activity in close proximity to livestock and depredations had occurred. Pastures were identified on 5 ranches in the Arlee area and 4 ranches in the McLeod area. I randomly assigned twelve pastures approximately 16 – 122 ha in size as control (no electrified fladry) or treatment (electrified fladry installed around pastures) (Figure 3.1 and Figure 3.2). Pastures at the start of calving contained approximately 40 – 200 cows.

Electrified Fladry

The electrified fladry system (Carol's Creations, Arco, ID and Jonco Industries Inc., Milwaukee, WI) construction followed the methods of Musiani and Visalberghi (2001). The system consisted of red plastic flags (50 x10 cm) sewn at 50 cm intervals on a 0.2 cm diameter mixed metal stranded wire (Gallagher Turbo Wire, North Kansas, MO). When possible flags were set 1 m outside existing barbed-wire fence away from cattle to minimize destruction and ingestion of flags. I suspended the electrified wire 50 cm above the ground and attached it to 61 cm fiberglass posts with adjustable metal clips; fiberglass posts placed at 7.6 meter intervals between t-posts set at 30.5 meters and on corners. Attachment of the electrified fladry to t-post consisted of plastic insulators (Gallagher t-post insulator). I suspended a second 0.2 cm electric ground wire (Gallagher Turbo Wire) 13 cm above the ground and attached it to the fiberglass posts and t-posts. A 12-volt solar powered battery fence energizer (Gallagher B260) electrified the wire and produced a pulsed energy output of $\geq$ 2000 volts with 2.6J of stored energy and a resistance of 500 ohms. Three 1m copper rods grounded the circuit.

To determine wolf activity in or near the 12 pastures, I monitored pasture perimeters for wolf spoor, used radio telemetry to document presence of wolves, and checked all pastures for dead or injured livestock. I rode (with ATV) the perimeter fence line of control and treatment pastures and monitored approximately 20 m on both sides of the electrified fladry barrier for wolf activity and maintenance during bi-weekly checks, but I also checked perimeters when weather and snow conditions facilitated detection of wolf visitation. I also monitored wolf presence and absence in the vicinity of ranches by scanning the valley for signals from the ground utilizing handheld antennas and VHF radiocollars. All packs had at least one radiocollar (VHF collars, Telonics, Meza, AZ) that a wolf wore (having been previously collared by Montana Fish, Wildlife and Parks or Wildlife Services). Lastly, I checked for dead or injured cattle by riding the entire pasture and conversing with ranch personnel monitoring spring calving. I recorded when wolves were present or absent in area, presence and absence of spoor inside and outside of pastures, and the number of confirmed depredations or injuries on control versus treatment ranches. I also quantified the number of days wolves were present at control and treatment areas, cost per km to install and maintain electrified fladry, and mean time to install electrified fladry per km.

Participant Surveys

I used a survey to measure attitudes of ranchers towards the application and effectiveness of electrified fladry for protecting calving pastures. I mailed each of 9 participating ranchers a packet in December 2007 that included a cover letter that explained the study and participating organizations, survey, and a postage paid envelope (Appendix A, B, C). Respondents were assured anonymity in the presentation of results. Non-respondents were called and reminded to fill in the survey after two weeks, and those who had not responded on the third and fourth week were called again.

The survey packet for protected pastures consisted of twelve questions on electrified fladry covering applicability, effectiveness, affordability, wolf sign, outcomes of the project, and willingness to participate in the future (Appendix B). The unprotected pastures survey consisted of three questions covering applicability, effectiveness, affordability, and willingness to participate in the future (Appendix C). Questions followed 3 formats to assess attitudes toward electrified fladry. A traditional scaled format was used: the respondents could strongly disagree or strongly agree on a scale of 1 to 5. A second scale of 1 (none) to 9 (a lot) was used for presence of wolf sign. A third scale involved scenario questions providing information on approximate cost and person hours to install an electrified fladry system. Questions with short answer responses were given to assess positive and negative outcomes in addition to further comments and suggestions not addressed in the survey.

Analysis

Data are presented as days wolves were present at control and treatment areas, cost per km to install and maintain fladry, and mean time to install fladry per km. I made descriptive comparisons for survey responses for ranchers of protected and unprotected pastures.

Results

Wolf Activity

I detected wolves, with telemetry, on 11 of the 20 monitoring days near the Arlee ranches and on 19 of the 29 days in the McLeod area.

No scat was found inside or outside of any protected or unprotected pasture. I detected wolves via track surveys at one ranch in the McLeod area where wolf track were observed outside one protected and one unprotected pasture on 2 consecutive days. On the first day I detected wolf tracks, the control pasture had cattle break out of the pasture during the previous night; wolf tracks were found inside the control pasture. On the second consecutive day I detected wolf tracks outside the protected and unprotected pastures and one wolf was seen in the unprotected pasture. Therefore, tracks were seen outside of control pastures on 2 days and inside of control pastures on 2 days; tracks were observed outside of treatment pastures on 2 occasions and never observed within treatment pastures.

Livestock Depredations

During the study no livestock mortalities or injuries occurred in protected or unprotected study pastures. The same night the ranch had cattle break out of the control pasture; they confirmed a calf kill in a non-study pasture (adjacent to the control and treatment pastures).

Installation and Maintenance Costs

Protected and unprotected study pastures ranged in size from approximately 16-122ha. The cost of a complete electrified fladry system (posts, energizer, electrified fladry, clips, gates, battery, etc, many of which have to be purchased from different suppliers) to protect a 16 ha square pasture was $3,685. Electrified fladry fencing supplies cost $3,252 per additional 1.6 km. I installed 14 km of electrified fladry systems between the two study areas, and used 3-8 people per ranch pasture to install fencing.

The mean time spent installing the fencing was 32 man-hours per km. I performed maintenance on electrified fladry systems only when a system became inoperable. Various factors caused the system to fail including branches on fence, deer, elk and cattle crossings, and heavy snows. Restoring a failed system involved locating and fixing specific problems as well as a check of the entire system. I observed 18 total failures on the 6 treatment pastures during 81 total days of use ($\bar{x}$ = 3 visits (SE= 0.3) per ranch). Mean time to locate and fix problems was 49 minutes (SE= 11.3) per visit.

Participant Survey

All 9 project participants responded to the questionnaire. For participants with a protected pasture (n=6), 83.3% were willing to participate in another electrified fladry project in the future. During the study, 83.3 % of ranches with electrified fladry saw no wolf sign in protected pastures. Respondents with protected pastures felt that there was little wolf sign before, during, and after the electrified fladry were removed (Table 3.1). No apparent trends appeared and responses varied on agreement to the perceived ease of implementation and maintenance, efficacy, and timing of application of electrified fladry (Table 3.2). However, 100% of the producers disagreed with the statement that electrified fladry is affordable and not too expensive. In addition, there was 100% agreement that it would be unlikely that electrified fladry would be implemented if a producer incurred the total cost to apply it to any pasture size ranging from 8- 65 ha. Respondents were more agreeable with using electrified fladry when there was cost sharing or no support required from producers (Table 3.3).

For ranchers surveyed with unprotected pastures, 66.6% were interested in participating in electrified fladry projects in the future. Similar to protected pasture respondents, no trends emerged and respondents varied on agreement to the applicability and potential efficacy of electrified fladry (Table 3.4). When questioned if electrified fladry is affordable and not to expensive, 100% disagreed. Like ranchers that had protected pastures, 100% of respondents from unprotected pastures agreed that it was unlikely that they would use electrified fladry if they had to bear the total cost and labor to implement the tool. However, opinions to the use of electrified fladry in the future shifted towards likely when there would be cost sharing (Table 3.5).

Discussion

Changing a wolf's behavior with a non-lethal tool such as electrified fladry can be performed at two levels: preventing actual depredations (by precluding the behavior) or injuries and decreasing the level of depredation risk (by exclusion from an area that livestock occupy). The easiest to measure and the most economically devastating is the actual loss or injury of livestock. A loss or injury of an animal is easy to rule as a failure at some level of a deterrent system. However, success in regards to decreasing the risk of depredation by preventing access to pastures is difficult to link with behavior altering variables without an accurate assessment of wolf activity in and around pastures. My data indicated that there were no losses or injuries to livestock in any of the pastures during the study. With inadequate detection of wolf activity in or outside of protected and unprotected pastures, I could not determine if lack of wolf presence or deterring variables may have prevented wolf depredations. Telemetry data indicated that wolf packs were present and in close proximity to protected and unprotected pastures during the study indicating a level of depredation risk.

Although no losses were observed on study pastures, non-study pastures adjacent to protected pastures on two study ranches had confirmed wolf depredations. One loss occurred in the McLeod area on a pasture between a control and treatment pasture on an individual ranch. In the Arlee study area, the day after moving cattle and llamas from a protected pasture to an adjacent pasture, there was a confirmed kill of one llama and confirmed injuries to a second llama on the non-study pasture. Wolf depredation is a rare event and consequently it is hard to quantify how effective a tool is based on this small-scale study with a short duration. There was some, albeit not experimental, evidence that electrified fladry could have had some effect, thus warranting further field testing or data collection to further support the success of electrified fladry in captivity (see Chapter 2).

I detected tracks inside an unprotected pasture on 2 days and outside protected and unprotected pastures on 3 days. The lack of sign was due, at least in part, to inadequate environmental conditions. From track and scat surveys I could not detect a difference in regards to the success of electrified fladry at impeding wolves from entering protected pastures compared to unprotected pastures. Telemetry and datalogging systems or GPS collars would significantly improve the ability to detect behavioral responses when testing non-lethal deterrents on free-ranging animals in large-scale situations, but would be costly (Breck et al. 2006, 2007).

Maintenance and installation has the potential to be a limiting factor in the applicability of electrified fladry depending on timing and environmental conditions. Installation was challenging, especially when snow depths increased and terrain features made accessibility difficult. A change in the design of electrified fladry to an integrated approach with existing fencing would decrease the number of people, supplies, installation time, and difficulties with transportation and handling. Maintenance only occurred when there was a complete failure in the system, meaning no shock could be discharged when fencing is touched. Fence damage and maintenance may have increased when electric systems were malfunctioning and livestock utilized heavy vegetation growth on the other side of the electrified fladry system.

Modifying the design of electrified fladry can substantially decrease the direct and indirect costs associated and increase the effective applicability, thus likely encouraging stakeholder's willingness to use this tool. Shortening the flagging to < 30 cm would enable electrified fladry to be placed on an existing barbed-wire fence with industry standard hardware therefore cutting material cost and reducing labor time and effort. In addition, it is not necessary to utilize the braided turbo wire as a ground wire; it is more cost effective to utilize an industry standard high tensile strength electric wire. Additional changes may increase the easy of applicability and increase social tolerance of this method. Musiani and Visalberghi (2001) imply that red flagging is not critical to the success of fladry; thus, changing from red to a more neutral color may make the system more palatable and less offensively garish. My assumption is that these modifications will not change the natural neophobic response by wolves subsequently changing the effectives of this non-lethal tool.

Wolf-livestock conflict can cause economic hardships for livestock producers and can be costly to successfully ameliorate while satisfying conservation and constituent needs. Non-lethal tools are considered costly compared to lethal methods (Shivik 2004, 2006). Yet, lethal removal programs have associated costs too, and may not be the most cost effective for satisfying many of the stakeholders (Phillips et al. 2004; Berger 2006).

Many non-lethal tools have short-term success and are relatively expensive, but they may be essential for fostering and increasing tolerance of predators. Electrified fladry has proven successful and may provide a longer-term solution in predator management (see Chapter 2). Balancing demands from stakeholders can be difficult in predator-livestock conflicts, but caution should be taken when making cost-benefit decisions relative to the biological, economical, and sociological contexts of the situation. Public stakeholders involved in human-wildlife conflict are challenged by the demand of personal benefit (i.e. economic gains, aesthetic) and a low tolerance for cost (i.e. actual or perceived) (Shivik 2004).

While electrified fladry has proven biologically successful at changing wolf behavior in confinement (see Chapter 2), due to logistic and economic considerations, its use may be limited to smaller applications. Economic cost-benefit analyses are easily performed on simple scales when evaluating the loss of an animal compared to protecting a 16-122 ha pasture for a relatively short period of time. Examining my data economically, electrified fladry costs $3,685 for a 16 ha treatment pasture. No costs were incurred on the similar control pasture, yet neither control nor treatment pastures sustained wolf kills. Thus, fladry had a cost of $3,685, but no measurable benefit. However, 83.3% of ranchers that used fladry would continue to use it under certain conditions, which strongly indicates that its use provides some psychological benefit. How do managers calculate the costs and benefits of a social tolerance of wolves that could be fostered by using new management techniques? It is possible that limiting the evaluation of a tool to its economic cost-benefit ratio may erroneously discount the biological and sociological importance of these tools.

Successful management can appease people's concerns, lower depredation risks, and build tolerance of predators or management. Proactively applying a non-lethal tool can lower the level of concern when a rancher cannot actively be with the herd. Human dimension surveys can assess perceptions of success and tool applicability and foster cooperative relationships between stakeholders. While research in predator behavior and behavior manipulation is common, the addition of the human dimensions arena is becoming more frequent in carnivore conflict management. Human-carnivore conflict management and predator conservation is based as much on sociological and political factors as it is on biological factors. The evaluations and use of management tools depend on the biological, economic and sociological context in which the methods are applied (Primm and Clark 1996; Shivik 2006).

While lethal removal may be considered ineffective in some contexts, it can be administered to simply satisfy stakeholders and balance political goals (Mech 1995). Non-lethal tools may be applied to change animal behavior, but ultimately they too are applied to satisfy social factors. Predation management has evolved from total eradication to approaches that minimize damage by predators (Shivik 2004), potentially indicating an increase in tolerance for some level of damage.

Yet, viewpoints still vary in regard to effective management approaches. Just as lethal removal is potentially used to increase wolf tolerance for some members of the public, non-lethal management techniques may increase tolerance for wolf management by others. While understanding public attitudes toward predators and management is becoming more common in predator management and conservation, managers may need to apply more effort into understanding the perceptions, attitudes, and resistance toward applying less favored management methods leading to success in political and social arenas.

Effectiveness of innovative and cost effective management tools is difficult to assess in political environments. For some, a 100% success rate is required or the method is dismissed. For others, any potential benefit is considered success. Also, practical applicability of a method is often disjointed or ignored in regards to efficacy. Applicability of lethal or non-lethal tools can be limited by biological, economic or social factors. Even when proven successful at some level, management tools may be impractical in actual management programs. Non-lethal deterrents and lethal removals all have failed and worked in some degree, and each has limitations (Sime et al. 2007). The success of predator management and the mitigation of predator-livestock conflict are based on the biological modifications of predator or human behaviors to limit or prevent depredations (Treves and Karanth 2003; Shivik 2004). Success should not be solely limited to changing the predatory behaviors of an animal.

Improving carnivore conservation and management will require rigorous scientific testing of lethal and non-lethal management tools for efficacy and applicability. It is important to also acknowledge, however, that lethal control is not a proxy for non-lethal techniques and non-lethal tools are not a replacement for lethal control. Ultimately, there is a need for a combination of tools that promotes livestock protection, fosters human tolerance of predators, and maintains a viable population of carnivores. A multi-faceted approach to management is the key to successful state and federal management programs. Solutions to predator-livestock conflict need to evolve from an understanding and balance of the biological, economical, and sociological contexts in which these problems exist.

Management Implications

The actual effectiveness of electrified fladry for preventing wolf depredation is still unknown. However, data indicate that there are potential social and biological benefits of its use. Managers will need to weigh the costs of electrified fladry and its maintenance against the risk of damage in a particular pasture.

Literature Cited

Arthur, L.M. 1981. Coyote control: the public response. Journal of Range Management 34:14-15.

Bath, A.J. 1987. Attitudes of various interest groups in Wyoming toward wolf reintroduction in Yellowstone National Park. M.A. Thesis, University of Wyoming. Laramie, Wyoming, USA.

Bath, A.J., and T. Buchanan. 1989. Attitudes of interest groups in Wyoming toward wolf restoration in Yellowstone National Park. Wildlife Society Bulletin 17:519-525.

Berger, K.M. 2006. Carnivore-livestock conflicts: effects of subsidized predator control and economic correlates on the sheep industry. Conservation Biology 20:751-761.

Breck, S.W., N. Lance, and J. Bourassa. 2006. Limitations of Receiver/Data Loggers for Monitoring Radiocollared Animals. Wildlife Society Bulletin 34:111-114.

Breck, S.W., N. Lance, J. Bourassa, S. Matthews, and V. Seher. 2007. An automated system for detecting and reporting trespassing bears in Yosemite National Park. Ursus 18:230-235.

Decker, D.J., C.A. Jacobson, and T.L. Brown. 2006. Situation-specific “impact dependency” as a determinant of management acceptability: Insights from wolf and grizzly bear management in Alaska. Wildlife Society Bulletin 34:426-432.

Kellert, S.R. 1985. Public perceptions of predators, particularly the wolf and coyote. Biological Conservation 31:167-189.

Mech, L.D. 1995. The challenge and opportunity of recovering wolf populations. Conservation Biology 9:270-278.

Messmer, T.A., M.W. Brunson, D. Reiter, and D.G. Hewitt. 1999. United States public attitudes regarding predators their management to enhance avian recruitment. Wildlife Society Bulletin 27:75-85.

Musiani, M., C. Mamo, L. Boitani, C. Callaghan, C. C. Gates, L. Mattei, E. Visalberghi, S. Breck, and G. Volpi. 2003. Wolf depredation and the use of fladry barriers to protect livestock in western North America. Conservation Biology 17:1538-1547.

Musiani, M., and E. Visalberghi. 2001. Effectiveness of fladry on wolves in captivity. Wildlife Society Bulletin 29:91-98.

Pate, J., M.J. Manfredo, A.D. Bright, and G. Tischbein. 1996. Coloradans' attitudes toward reintroducing the gray wolf into Colorado. Wildlife Society Bulletin 24:421-428.

Phillips M.K., E.E. Bangs, L.D. Mech, B.T. Kelly, and B.B. Fazio. 2004. Extermination and recovery of the red wolf and grey wolf in the contiguous United States. Pages 297–309 in D.W. MacDonald and C. Sillero-Zubiri, editors. Biology and conservation of wild canids. Oxford University Press, New York, New York, USA.

Primm, S.A., and T.W. Clark. 1996. Making sense of the policy process for carnivore conservation. Conservation Biology 10:1036-1045.

Reiter, D. K., A. D. Dayton, F. R. Henderson, R. L. Meduna, and C. W. Spaeth. 1999. Public attitudes towards wildlife damage management and policy. Wildlife Society Bulletin 27:746-758.

Shivik, J.A. 2004. Non-lethal alternatives for predation management. Sheep and Goat Research Journal 19:64-71.

Shivik, J. A. 2006. Tools for the Edge: What's New for Conserving Carnivores. Bioscience 53:253-259.

Sime, C.A., E. Bangs, E. Bradley, J.E. Steuber, K. Glazier, P.J. Hoover, V. Asher, K. Lauden, M. Ross, and J. Trapp. 2007. Gray wolves and livestock in Montana: a Recent history of damage management. Proceedings of the Wildlife Society Wildlife Damage Management Working Group Conference, Corpus Christi, TX, USA. April 2007.

Sime, C.A., V. Asher, L. Bradley, K. Laudon, M. Ross, J. Trapp, M. Atkinson, and J. Steuber. 2008. Montana gray wolf conservation and management 2007 annual report. Montana Fish, Wildlife & Parks. Helena, Montana, USA.

Treves, A., and K.U. Karanth. 2003. Human-carnivore conflict and perspectives on carnivore management worldwide. Conservation Biology 17:1491-1499.

Tucker, P., and D.H. Pletscher. 1989. Attitudes of hunters and residents toward wolves in northwestern Montana. Wildlife Society Bulletin 17:509-514.

Table 3.1. Protected pasture survey respondents' attitudes about wolf sign during field trails in Montana, 2007.
[a] Columns indicate percentage of respondents expressing the following levels of agreement with each statement.

	Response %[a]								
	none								**a lot**
Statement	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
How much wolf sign did you see **in** protected parcels during the time EF was in use on your property	83.3	16.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
How much wolf sign did you see **near or around** protected parcels during the time EF was in use on your property	16.6	16.6	50.0	0.0	0.0	0.0	16.6	0.0	0.0
How much wolf sign did you see **in the two-month period before EF was installed** on your property	16.6	0.0	50.0	16.6	0.0	0.0	0.0	0.0	16.6
How much wolf sign did you see **in the two-month period after EF was removed** from your prorerty	16.6	33.3	33.3	0.0	0.0	0.0	0.0	0.0	16.6

Table 3.2. Protected pasture survey respondents' attitudes about applicability and efficacy of electrified fladry use in Montana, 2007.
[a] Columns indicate percentage of respondents expressing the following levels of agreement with each statement: SD= strongly disagree; SA =strongly agree.
[b] One survey respondent did not reply to question.

	Response %[a]				
Statement	**SD 1**	**2**	**3**	**4**	**SA 5**
EF **appears** to be easy to install	0	50	50	0	0
EF **appears** to be easy to maintain	0	33	33	17	17
EF is affordable (e.g., not too expensive)	33	67	0	0	0
EF itself did NOT stress my livestock	0	0	17	50	33
EF helped keep wolves away from protected parcels on my property	0	17	67	0	17
EF helped reduce livestock losses to wolves on my property	0	17	67	0	17
EF helps decreases the risk of depredation by wolves	17	33	33	0	17
The use of EF helped reduce the stress of my livestock	0	33	50	0	17
Because of EF, I was less concerned about my livestock during times when they were not being watch by myself or others	0	33	17	17	33
I would recommend the use of EF to neighboring private landowners who are concerned about livestock depredation by wolves	0	17	50	17	17
EF is effective if used before depredation has occurred prior to its use as a wolf deterrent [b]	17	33	17	0	17

Table 3.3. Protected pasture survey respondents' attitudes towards the use of electrified fladry given an approximate cost of $3,450 and 50 person hours per mile (approx. 40 acres) to install and a use a system in Montana, 2007.
[a] Columns indicate percentage of respondents expressing the following levels of agreement with each statement: VU= very unlikely; VL= very unlikely.

	Response %[a]				
	VU				**VL**
Scenario	**1**	**2**	**3**	**4**	**5**
If you need to protect a 20 acre parcel and…					
...you had to obtain the material and provide the labor to install	67	33	0	0	0
...the materials were provided to you and you only had to provide the labor to install it	17	17	33	17	17
...the materials and labor to install it were all provided to you	17	17	0	17	50
If you need to protect a 40 acre parcel and…					
...you had to obtain the material and provide the labor to install	67	33	0	0	0
...the materials were provided to you and you only had to provide the labor to install it	17	17	33	17	17
...the materials and labor to install it were all provided to you	17	17	17	0	50
If you need to protect a 80 acre parcel and…					
...you had to obtain the material and provide the labor to install	100	0	0	0	0
…the materials were provided to you and you only had to provide the labor to install it	17	50	17	0	17
...the materials and labor to install it were all provided to you	17	17	17	0	50
If you need to protect a 160 acre parcel and…					
...you had to obtain the material and provide the labor to install	100	0	0	0	0
...the materials were provided to you and you only had to provide the labor to install it	17	67	0	0	17
...the materials and labor to install it were all provided to you	17	17	17	17	33

Table 3.4. Unprotected pasture survey respondents' attitudes about the applicability and efficacy of electrified fladry in Montana, 2007.
[a] Columns indicate percentage of respondents expressing the following levels of agreement with each statement: SD strongly disagree; SA= strongly agree.

	Response %[a]				
	SD				SA
Statement	**1**	**2**	**3**	**4**	**5**
I think it would be relatively easy to install EF	0	67	0	0	33
I think it would be relatively easy to maintain EF once installe	0	33	67	0	0
I think EF is affordable (e.g., not too expensive)	0	100	0	0	0
I think EF has the potential to help reduce the risk of livestock depredation by wolves on my property	33	0	33	33	0
I would be interested in trying EF in the future	0	33	0	33	33

Table 3.5. Unprotected pasture survey respondents' attitudes towards the use of electrified fladry given an approximate cost of $3,450 and 50 person hours per mile (approx. 40 acres) to install and use a system in Montana, 2007.
[a] Columns indicate percentage of respondents expressing the following levels of agreement with each statement: VU= very unlikely; VL= very unlikely.

	Response %[a]				
	VU				**VL**
Scenario	**1**	**2**	**3**	**4**	**5**
If you need to protect a 20 acre parcel and…					
...you had to obtain the material and provide the labor to install	67	33	0	0	0
...the materials were provided to you and you only had to provide the labor to install it	0	33	33	0	33
...the materials and labor to install it were all provided to you	0	0	33	33	33
If you need to protect a 40 acre parcel and…					
...you had to obtain the material and provide the labor to install	67	33	0	0	0
...the materials were provided to you and you only had to provide the labor to install it	0	33	33	33	0
...the materials and labor to install it were all provided to you	0	0	33	33	33
If you need to protect a 80 acre parcel and…					
...you had to obtain the material and provide the labor to install	100	0	0	0	0
...the materials were provided to you and you only had to provide the labor to install it	0	100	0	0	0
...the materials and labor to install it were all provided to you	0	0	100	0	0
If you need to protect a 160 acre parcel and…					
...you had to obtain the material and provide the labor to install	100	0	0	0	0
...the materials were provided to you and you only had to provide the labor to install it	33	67	0	0	0
...the materials and labor to install it were all provided to you	0	0	100	0	0

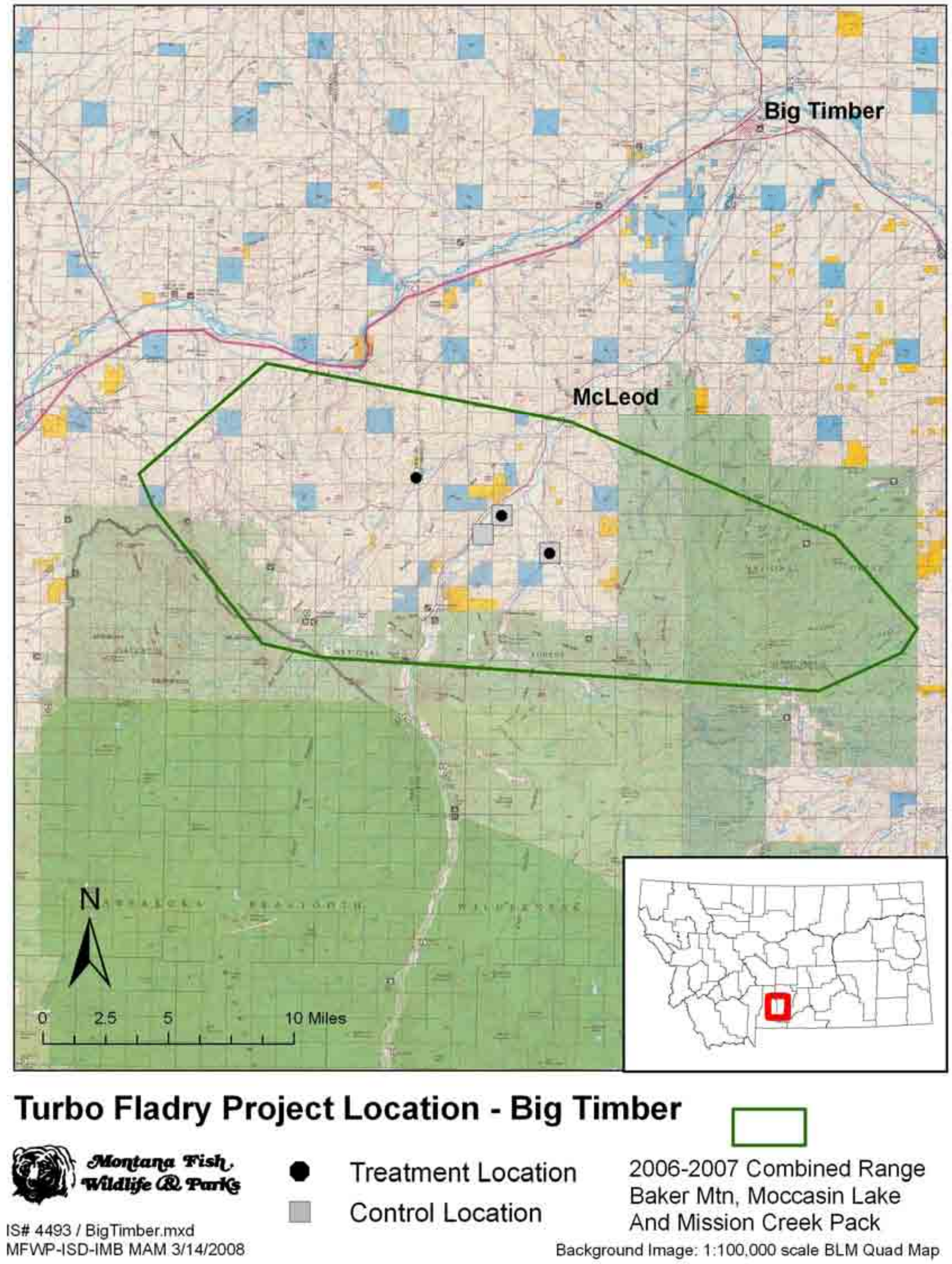

Figure 3.1. Map of study area in southwestern Montana, including 6 treatment pastures on 4 ranches and combined wolf pack ranges.

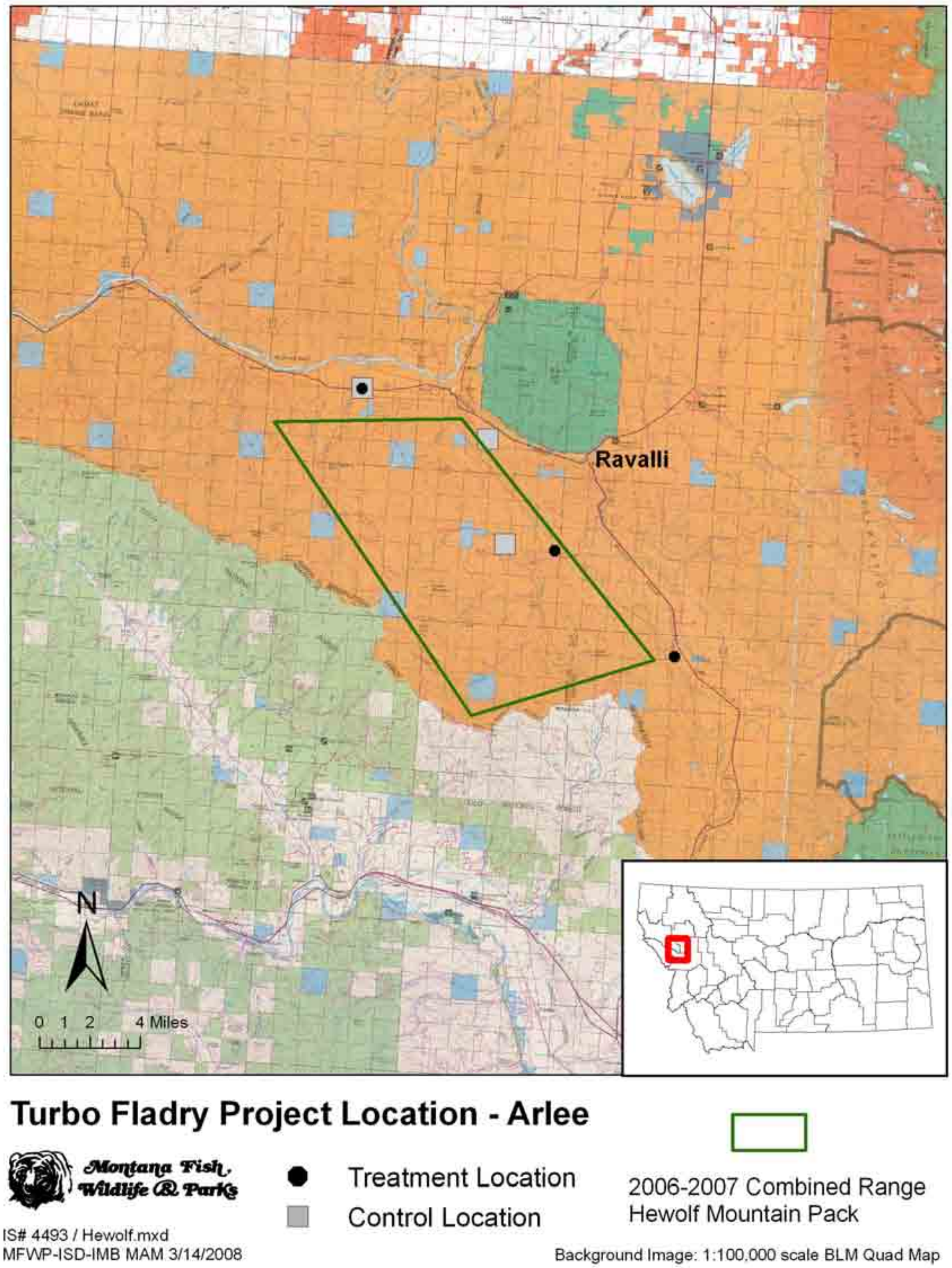

Figure 3.2. Map of study area in western Montana, including 6 treatment pastures on 5 ranches and wolf pack range.

CHAPTER 4

CONCLUSIONS

Wolf (*Canis lupus*) conflict arises from public concerns for human safety, livestock depredation, changes in natural prey abundance, and folklore increasing animosity towards wolves and conservation. Despite advances in management techniques, wolf-livestock conflicts are still a problem on a human-dominated landscape. The level of risk and effects predators pose on livestock may be debated, but the social tolerance of predators and management techniques is a problem that managers will continue face. Historically, lethal removal of wolves proved adequate for mitigating conflict (Knowlton et al. 1999), however, public support and tolerance for lethal predator management is decreasing (Mech 1996; Reiter et al. 1999). Public, private, and governmental stakeholders continually develop non-lethal devices to satisfy controversial management methods and continue an attempt to foster tolerance for wolves on private lands.

Of concern for managers is that lethal and non-lethal techniques are often supported by insufficient or anecdotal evidence of success and applicability that often supports stakeholders' agendas. In the absence of structured field trials in a management context, anecdotal information will prolong and continue to be the basis for frenzied public debate and hinder management goals. Limited knowledge to make controversial predator management decisions is insufficient for managing agencies. Too often success or failures of management techniques are limited to solely the biological evaluation, which often ignores sociological and political goals.

Developing and testing of tools is often difficult in management situations. A captive setting is an ideal starting point in the initial development, but the testing of new tools in the field is vital for a complete evaluation of their success and potential. Regularly, research tends to highlight success in changing animal behavior, and ignore the monetary costs, applicability, or social willingness to apply such tools.

My research explored the efficacy and applicability of the newly developed electrified fladry technique for protecting a food resource. The testing of tools in free ranging management situations is often difficult and tends to yield insufficient evidence. By using a controlled captive environment, I was able to compare the success of electrified fladry to fladry for protecting a food resource. My findings were similar to previous studies highlighting the abilities of fladry to restrict movements and protect a food source from captive wolves and coyotes (Musiani & Visalberghi 2001; Mettler 2005). Fladry's success is based on an animal's innate neophobic response to novel objects. Neophobia can be simply described as the fear of new (Mettler 2005). Whereas, electrified fladry relies on both neophobia and an animal's ability to learn through aversive conditioning. Elliot and Covington (2001) describe aversive conditioning as an avoidance motivation initiated by discomfort, pain, or a general negative experience. However, if choosing between the two systems for an actual management scenario, it should be noted that electrified fladry proved substantially better at protecting a food resource from motivated captive wolves. While my research indicated that electrified fladry has the potential to reduce wolf depredations, animal learning, motivation, and personality play significant parts in the efficacy of fladry systems. In addition, caution should be used when extrapolating the success and failures of these tools in captivity to management situations. Of note, is that captive animals are highly habituated to human activities and thus may be less susceptible to fladry than free-ranging wolves.

A successful non-lethal management tool has the ability to deter an animal for the longest time period. Previous work with fish indicates that animals take greater risks when food motivated (Wilson et al. 1993, 1994), which may increase the rate of habituation. My research shows that wolves can habituate to fladry quicker when food motivated than shown in previous studies (Musiani & Visalberghi 2001). Although the limitations of repellants are generalized to the method of habituation, my research indicates that the duration of success and rate of habituation is partially dependent on behavioral variations. Gosling (1998) and Darrow (2006) described personality traits for behavioral variations in spotted hyenas and coyotes. My first study (Chapter 2) revealed similar variations in pack behaviors towards electrified fladry potentially influencing behavioral risk taking and ultimately affecting the latency to crossing. An individual's ability to take risks, especially when motivated, limits the success of non-lethal tools. Thus, motivation and behavioral variability between wolves may be critical when using non-lethal management techniques.

Assessing the biological efficacy and applicability in real management situations is vital for a comprehensive assessment. Understanding both biological and sociological dynamics in wolf-livestock conflicts is fundamental to conservation and developing management strategies. Often the sociological attitudes of wolf recovery and wolf-livestock conflict surpass the biological issues in management. With the success of electrified fladry in captivity, my research (Chapter 3) focused on the efficacy and applicability of electrified fladry for protecting cattle from free-ranging wolves on private ranches with historic wolf-livestock conflict and found no losses or injuries to livestock in any of the pastures during the study. From this I could not adequately determine if electrified fladry was successful. Telemetry data indicated that wolf packs were present and in close proximity to protected and unprotected pastures during the study indicating a level of depredation risk. There was some anecdotal evidence that electrified fladry could have had some effect, thus warranting additional testing.

While electrified fladry has proven biologically successful at changing wolf behavior in captive scenarios, it may be limited economically to smaller management applications. Some modifications can be used and are suggested to decrease the direct and indirect cost associated with design and applicability of electrified fladry. Non-lethal tools are usually considered costly (Shivik 2004, 2006), yet lethal removal programs have associated costs too, and may not be the most cost effective approach for satisfying the majority of stakeholders (Phillips et al. 2004; Berger 2006). Electrified fladry may have short-term success and is relatively expensive, but it may be essential for fostering and increasing tolerance of predators and management techniques for conservation and management and require a different cost-benefit analysis.

Success in predator management is not solely changing predatory behaviors; it can also include pacifying people’s distress or building acceptance of predators or management. Wolf-livestock conflict and wolf conservation are based as much on sociological and political factors as it is on biological factors for successful conservation and livestock protection. The evolution from total eradication to incremental implementation may indicate a change in social tolerance and highlight political success of current management techniques, lethal and non-lethal (Shivik 2004).

Political and sociological settings make it difficult to assess management tools; even when proven successful at some level, tools may be impractical in actual management scenarios. Using the combination of lethal and non-lethal tools while having flexibility is key to successful predator-livestock conflict management. Predator-livestock conflicts can be mitigated with insight and stability of biological, economical, and sociological contexts from which these problems evolve.

The effectiveness of electrified fladry for preventing wolf depredation in actual proactive or reactive management scenarios is still unknown. However, captive success, anecdotal field evidence and sociologic data indicate that there are potential benefits of its use in wolf-livestock conflict management. Managers will need to weigh the costs of electrified fladry and its maintenance against management goals and the risk of damage.

Literature Cited

Berger, K.M. 2006. Carnivore-livestock conflicts: effects of subsidized predator control and economic correlates on the sheep industry. Conservation Biology 20:751-761.

Darrow, P.A. 2006. Habituation and variable captive coyote response to behavior contingent stimuli. M. S. Thesis, Utah State University, Logan, Utah, USA.

Elliot, A. J., and M. V. Covington. 2001. Approach and avoidance motivation. Educational Psychology Review 13:73-92.

Gosling, S.D. 1998. Personality dimensions in spotted hyenas (*Crocuta crocuta*). Journal of Comparative Psychology 112:107-108.

Knowlton, C. E., Gese, E. M. and Jaeger, M. M. 1999. Coyote depredation control: an interface between biology and management. Journal of Range Management 52:398-412.

Mech, L.D. 1996. A new era for carnivore conservation. Wildlife Society Bulletin 24:397-401.

Mettler, A.E. 2005. Investigations into behavioral responses of predators to novel visual stimuli. M. S. Thesis, Utah State University, Logan, Utah, USA.

Musiani, M., and E. Visalberghi. 2001. Effectiveness of fladry on wolves in captivity. Wildlife Society Bulletin 29:91-98.

Phillips, M.K., E.E. Bangs, L.D. Mech, B.T. Kelly, B.B. Fazio. 2004. Extermination and recovery of the red wolf and grey wolf in the contiguous United States. Pages 297–309 in D.W. MacDonald and C. Sillero-Zubiri, editors. Biology and conservation of wild canids. Oxford University Press, New York, New York, USA.

Reiter, D. K., A. D. Dayton, F. R. Henderson, R. L. Meduna, and W. Spaeth. 1999. Public attitudes towards wildlife damage management and policy. Wildlife Society Bulletin 27:746-758.

Shivik, J.A. 2004. Non-lethal alternatives for predation management. Sheep and Goat Research Journal 19:64-71.

Shivik, J. A. 2006. Tools for the Edge: what's new for conserving carnivores. Bioscience 53:253-259.

Wilson, D.S., K.Coleman, A.B. Clark, and L. Biederman. 1993. Shy-bold continuum in pumpkinseed sunfish (*Lepomis gibbosus*): an ecological study of a psychological trait. Journal of Comparative Psychology 107:250-260.

Wilson, D.S., A.B. Clark, K. Coleman, and T. Dearstyne. 1994. Shyness and boldness in humans and other animals. Trends in Ecology and Evolution 9:442-446.

APPENDIXES

APPENDIX A. COVER LETTER

Dear (*Producers Name*)-

I would like to start off by thanking you for your participation in the electrified fladry study this year. This questionnaire survey is part of the collaborative study with Utah State University, Montana Fish, Wildlife & Parks, and Wildlife Services and should only take **approximately 20 minutes** of your time. The results of this study will help wolf managers as they evaluate the future of wolf management.

I know you are busy trying to get cattle back from the summer range and your schedule is as tight as ever. I would appreciate it if you could take a few minutes and complete this survey and send it back to me as quick as possible. I assure you that your responses will be kept **COMPLETELY CONFIDENTIAL.** When completed the survey, please place it in the postage paid envelope provided, and return it to me.

I do appreciate all of your effort, as you have been a critical component to the success of the research. Please feel free to contact me in you have any question during the completion of the survey.

Sincerely,

Nathan

Nathan J. Lance
Graduate Research Assistant
Utah State University
Department of Wildland Resources
5230 Old Main Hill
Logan, Utah 84322
(435) 760-4078

APPENDIX B. PROTECTED PASTURE SURVEY

2007 Survey of
Livestock Producers
Who Agreed to Test the Use of Electrified Fladry (EF) as a Tool to Reduce the Risk of Wolf Depredation

Montana Fish, Wildlife & Parks

Utah State University

Wildlife Services
NWRC
National Wildlife Research Center

Wildlife Services
Animal and Plant Health Inspection Service
United States Department of Agriculture

The Confederated Salish and Kootenai Tribes of the Flathead Reservation

Questions 1-9 focus on the electrified fladry (EF) project that was recently conducted on your property.

1. On a scale from (1) strongly agree to (5) strongly disagree, to what extent do you agree or disagree with the following statements concerning the EF project on your property? **Circle only one number for each statement below**.

2. On a scale from (1) none to 9 (a lot), how much wolf sign (e.g., scat, tracks, actual wolves, etc.) did you see in protected parcels during the time EF was in use on your

Statement:	**Strongly Agree**				**Strongly Disagree**
EF appears to be easy to install	1	2	3	4	5
EF appears to be easy to maintain	1	2	3	4	5
EF itself did NOT stress my livestock	1	2	3	4	5
EF helped keep wolves away from protected parcels on my property	1	2	3	4	5
EF helped reduce livestock losses to wolves on my property	1	2	3	4	5
The use of EF helped reduce the stress of my livestock	1	2	3	4	5
Because of EF, I was less concerned about my livestock during times when they were not being watched by myself or others	1	2	3	4	5
I would recommend the use of EF to neighboring private landowners who are concerned about livestock depredation by wolves	1	2	3	4	5

property? (circle only one number)

(none) 1 2 3 4 5 6 7 8 9 (a lot)

3. Overall, on a scale from (1) none to 9 (a lot), how much wolf sign (e.g., scat, tracks, actual wolves, etc.) did you see near or around protected parcels during the time EF was in use on your property? (circle only one number)

(none) 1 2 3 4 5 6 7 8 9 (a lot)

4. On a scale from (1) none to 9 (a lot), how much wolf sign (e.g., scat, tracks, actual wolves, etc.) did you see in the two-month time period before EF was installed on your property? (circle only one number)

(none) 1 2 3 4 5 6 7 8 9 (a lot)

5. On a scale from (1) none to 9 (a lot), how much wolf sign (e.g., scat, tracks, actual wolves, etc.) did you see in the two month time period after EF was removed from your property? (circle only one number)

(none) 1 2 3 4 5 6 7 8 9 (a lot)

6. What were the positive outcomes of the EF project on your property? How did this project positively affect operations on your property? (please print legibly)

____
____
____
____
____
____

7. What were the negative outcomes of the EF project on your property? How did this project negatively affect operations on your property? (please print legibly)

____
____
____
____
____
____

8. Would you be willing to participate in another EF project in the future? (check only one)

[ ] NO……...If no, why not?

____

[ ] YES

____

____

9. On a scale from (1) very unsuccessful to (9) very successful, how would you rate the overall success of the EF project on your property? (**circle only one number**)

(Very unsuccessful) 1 2 3 4 5 6 7 8 9 (Very successful)

The remaining questions in this survey focus on your opinions concerning EF in general.

10. **PER MILE OF FENCE (approximately a 40 acre parcel),** EF materials cost approximately $ 3100 plus $350 for energizer and battery …and, take approximately 50 person hours to install. On a scale from (1) very unlikely to (5) very likely, how likely are you to use EF in the future? **Circle only one number for <u>each scenario</u> below.**

<u>Scenario:</u>	**Very <u>Unlikely</u>**				**Very <u>Likely</u>**
If you needed to protect a 20 acre parcel and…					
…you had to obtain the materials and provide the labor to install it?	1	2	3	4	5
…the materials were provided to you and you only had to provide the labor to install it?	1	2	3	4	5
…the materials and labor to install it were all provided to you?	1	2	3	4	5
If you needed to protect a <u>40 acre parcel</u> and…					
…you had to obtain the materials and provide the labor to install it?	1	2	3	4	5
…the materials were provided to you and you only had to provide the labor to install it?	1	2	3	4	5
…the materials and labor to install it were all provided to you?	1	2	3	4	5
If you needed to protect a <u>80 acre parcel</u> and…					
…you had to obtain the materials and provide the labor to install it?	1	2	3	4	5
…the materials were provided to you and you only had to provide the labor to install it?	1	2	3	4	5
…the materials and labor to install it were all provided to you?	1	2	3	4	5

If you needed to protect a 160 acre parcel and…

…you had to obtain the materials and provide the labor to install it?	1	2	3	4	5
…the materials were provided to you and you only had to provide the labor to install it?	1	2	3	4	5
…the materials and labor to install it were all provided to you?	1	2	3	4	5

11. On a scale from (1) strongly disagree to (5) strongly agree, to what extent do you agree or disagree with the following statements concerning EF. **Circle only one number for each statement below**.

Statement:	**Strongly Disagree**				**Strongly Agree**
EF is affordable (e.g., not too expensive)	1	2	3	4	5
EF helps decreases the risk of depredation by wolves	1	2	3	4	5
EF is effective if used before depredation has occurred	1	2	3	4	5
EF can be effectively used even if depredation has occurred prior to its use as a wolf deterrent	1	2	3	4	5

12. Please offer any additional comments or suggestions you have regarding EF and its use as a wolf deterrent. (**please print legibly**)

____

____

____

____

THANK YOU FOR YOUR HELP!

APPENDIX C. UNPROTECTED PASTURE SURVEY

2007 Survey of Livestock Producers Who Agreed to be the Control Group in Study of Electrified Fladry (EF) as a Tool to Reduce the Risk of Wolf Depredation

Montana Fish, Wildlife & Parks

Utah State University

Wildlife Services NWRC National Wildlife Research Center

Wildlife Services

Electrified Fladry (EF) may be an effective tool that private landowners can use to help reduce the risk of livestock depredation by wolves. EF consists of flagging interspersed on electrified wire. An EF system is typically hung approximately 1-meter outside of an existing fence and constructed of red plastic flags (50 x 10 cm) sewn at 50 cm intervals on a 0.2 cm diameter mixed metal stranded wire. The wire is suspended 50 cm above the ground, and attached to 24 inch fiberglass posts with adjustable metal clips (the posts are placed at 5 meter intervals). Metal t-posts are placed every 25 meters and on corners. The electric wire is driven by a solar powered battery operated fence energizer (Gallagher B260) that produces a pulsed energy output of 1.5J and a maximum output of 6kV. In controlled test environments, EF has been shown to effectively keep captive wolves away from potential food sources. EF is currently being tested in the field on several ranches in Montana.

1. On a scale from (1) strongly disagree to (5) strongly agree, to what extent do you agree or disagree with the following statements? Circle only one number for each statement below.

Statement:	**Strongly Disagree**				**Strongly Agree**
I think it would be relatively easy to install EF	1	2	3	4	5
I think it would be relatively easy to maintain EF once installed	1	2	3	4	5
I think EF is affordable (e.g., not too expensive)	1	2	3	4	5
I think EF has the potential to help reduce the risk of livestock depredation by wolves on my property	1	2	3	4	5
I would be interested in trying EF in the future	1	2	3	4	5

2. **PER MILE OF FENCE (approximately a 40 acre parcel),** EF materials cost approximately $ 3100 plus $350 for energizer and battery …and, take approximately 50 person hours to install. On a scale from (1) very unlikely to (5) very likely, how likely are you to use EF in the future? **Circle only one number for <u>each scenario</u> below.**

Scenario:	**Very Unlikely**				**Very Likely**
If you needed to protect a 20 acre parcel and…					
…you had to obtain the materials and provide the labor to install it?	1	2	3	4	5
…the materials were provided to you and you only had to provide the labor to install it?	1	2	3	4	5
…the materials and labor to install it were all provided to you?	1	2	3	4	5
If you needed to protect a <u>40 acre parcel</u> and…					
…you had to obtain the materials and provide the labor to install it?	1	2	3	4	5

…the materials were provided to you and you only had to provide the labor to install it?	1	2	3	4	5
…the materials and labor to install it were all provided to you?	1	2	3	4	5

If you needed to protect a 80 acre parcel and…

…you had to obtain the materials and provide the labor to install it?	1	2	3	4	5
…the materials were provided to you and you only had to provide the labor to install it?	1	2	3	4	5
…the materials and labor to install it were all provided to you?	1	2	3	4	5

If you needed to protect a 160 acre parcel and…

…you had to obtain the materials and provide the labor to install it?	1	2	3	4	5
…the materials were provided to you and you only had to provide the labor to install it?	1	2	3	4	5
…the materials and labor to install it were all provided to you?	1	2	3	4	5

3. Please offer any additional comments or suggestions you have regarding EF and its potential use as a wolf deterrent. (**please print legibly**)

THANK YOU FOR YOUR HELP!