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Utility of livestock-protection dogs for deterring wildlife from cattle farms

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Abstract

Context. Livestock producers worldwide are negatively affected by livestock losses because of predators and wildlife-transmitted diseases. In the western Great Lakes Region of the United States, this conflict has increased as grey wolf (*Canis lupus*) populations have recovered and white-tailed deer (*Odocoileus virginianus*) have served as a wildlife reservoir for bovine tuberculosis (*Myobacterium bovis*).

Aims. We conducted field experiments on cattle farms to evaluate the effectiveness of livestock-protection dogs (LPDs) for excluding wolves, coyotes (*C. latrans*), white-tailed deer and mesopredators from livestock pastures.

Methods. We integrated LPDs on six cattle farms (treatment) and monitored wildlife use with tracking swaths on these farms, concurrent with three control cattle farms during 2005–2008. The amount of time deer spent in livestock pastures was recorded using direct observation.

Key results. Livestock pastures protected by LPDs had reduced use by these wildlife compared with control pastures not protected by LPDs. White-tailed deer spent less time in livestock pastures protected by LPDs compared with control pastures not protected by LPDs.

Conclusions. Our research supports the theory that LPDs can be an effective management tool for reducing predation and disease transmission. We also demonstrate that LPDs are not limited to being used only with sheep and goats; they can also be used to protect cattle.

Implications. On the basis of our findings, we support the use of LPDs as a proactive management tool that producers can implement to minimise the threat of livestock depredations and transmission of disease from wildlife to livestock. LPDs should be investigated further as a more general conservation tool for protecting valuable wildlife, such as ground-nesting birds, that use livestock pastures and are affected by predators that use these pastures.

Additional keywords: bovine tuberculosis, coyote, grey wolf, livestock protection dog, mesopredators, white-tailed deer, wildlife damage management.

Introduction

Agricultural producers are important stakeholders in wildlife conservation (Kellert 1981; Conover 1998). For example, in the USA there are ~2 million farmers and ranchers, who make up <2% of the country's population but control ~40% of the land (Berg 1986; US Census Bureau 2010). Producers appreciate wildlife (Brown *et al*. 1978) and their support has long been recognised as essential if wildlife conservation is going to occur on private land in concert with farming and ranching (Leopold 1933). However, livestock producers worldwide, particularly smaller-scale operations, are often confronted with the challenge of reducing livestock losses to predators and wildlife-transmitted diseases. In the western Great Lakes Region of the USA, most producers are small- and medium-sized operations, with 45–59% having cattle/calf commodity sales of <US$10 000 per year, 72–85% having cattle/calf commodity sales of <US$100 000 per year, and 71–86% having <100 head of cattle (www.nass.usda.gov, accessed 1 June 2009). This region exemplifies challenges of maintaining agricultural production while conserving valued wildlife. Livestock depredations will likely increase as the grey wolf (*Canis lupus*) population increases and expands its geographic range (Mech 1995; Gehring and Potter 2005; Harper *et al*. 2005). The region has a large population of coyotes (*C. latrans*). Livestock producers in this region have also been affected negatively by livestock losses associated with infectious disease transmitted by wildlife. In Michigan, and more recently Minnesota, free-ranging white-tailed deer (*Odocoileus virginianus*, deer) continually infect cattle with bovine tuberculosis (*Mycobacterium bovis*, TB; Schmitt *et al*. 1997; Palmer *et al*. 2001; O'Brien *et al*. 2002).

Effective, producer-based management tools are needed to assist producers in reducing risk of livestock depredation and transmission of diseases such as TB to livestock (Gehring *et al*. 2006; VerCauteren *et al*. 2008). Efficacious tools that producers can adapt into their normal husbandry practices are needed to

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reduce economic losses. Lethal control, as a management tool, can be effective (Conover 2002). However, livestock depredations commonly recur annually after wolves are removed lethally following a depredation (Fritts *et al*. 1992; Gehring *et al*. 2003), and does not appear to reduce depredations at a regional scale (Musiani *et al*. 2005). Non-lethal management tools are regarded by society as more humane than lethal control (Reynolds and Tapper 1996; Reiter *et al*. 1999). Numerous non-lethal management options exist; however, few have been the subject of a controlled experiment involving free-roaming wildlife (Shivik 2006). Partly, this has been due to the difficulty in conducting large-scale experiments while controlling for confounding variables (Breck 2004; VerCauteren *et al*. 2008; Gehring *et al*. 2010*a*).

Livestock protection (guarding) dogs (LPDs) were developed centuries ago to protect goats and sheep from predators (Coppinger and Coppinger 2001). LPDs are generally regarded as effective in reducing livestock depredations caused by coyotes (Green *et al*. 1984; Andelt 1992; Andelt and Hopper 2000; Smith *et al*. 2000), but their effectiveness against wolves is more tenuous (Gehring *et al*. 2010*a*). VerCauteren *et al*. (2008) and Gingold *et al*. (2009) provided experimental evidence of the ability of LPDs to deter deer from livestock pastures and modify ungulate behaviour, respectively. LPDs may also have value related to the conservation of species of wildlife that are predated by species that LPDs repel. For example, Hansen and Smith (1999) documented that medium-sized mammals were excluded and/or killed by LPDs in livestock pastures, which we propose could allow species such as grassland birds to be more successful. In general, though, there is a dearth of experimental work that has evaluated the effectiveness of LPDs for reducing the use of farms by wildlife (Gehring *et al*. 2010*a*).

Our objective was to determine whether LPDs that were socialised and bonded to cattle could reduce the use of livestock pastures by wildlife, a measure of reduced risk of livestock depredation and transmission of disease to livestock. We predicted that LPDs would reduce the number of wolf, coyote, white-tailed deer and mesopredator visits into livestock pastures, and amount of time deer spent within livestock pastures.

Materials and methods

Study sites

During 2005–2008, we studied LPDs within a study area located in the western Upper Peninsula (UP) of Michigan, including Houghton, Iron, Marquette and Ontonagon counties. The study area consisted of a mixture of northern hardwoods, upland conifers, lowland conifers, agricultural areas, streams and rivers. Agriculture included cattle operations and forage crops. During the study, the UP contained 425–520 wolves within an estimated total of ≥87 wolf packs (D. E. Beyer, Michigan Department of Natural Resources & Environment, pers. comm.), as well as coyotes, deer and mesopredators interspersed within the landscape.

We selected nine beef-cattle farms on the basis of their location within the study area, habitat, livestock on pasture and their willingness to participate in the study. Farms contained 19–50 head of cattle on 10–40-ha fenced pastures. During June–September, cattle were located on pasture and confined near or in buildings for the remainder of the year. All farms were surrounded by forest and six farms included wooded areas within a portion of the pasture. All farms had existing electrified livestock fencing (≥three electric wires and a total height of 110 cm) which was used to maintain cattle within pastures. We added one electrified strand of wire ~0.25 m from the ground and additional wires to maintain gaps ≤0.33 m at each farm (Gehring *et al*. 2010*b*). The lowest strand of wire served to improve the training of LPDs to remain within pastures on treatment farms (Gehring *et al*. 2010*b*), and control pastures also had this lower strand of wire to reduce variability among the farms as a result of fencing. Fencing on study farms was not designed to serve as predator- or deer-proof fencing and would not effectively prevent access by wolves, coyotes or deer. Dorrance and Bourne (1980) reported that coyotes still penetrated a 7-strand electric fence they used, even though the bottom wire (15-cm above ground level) was electrified. Gates *et al*. (1978) found that 111-cm-high fencing was not effective at preventing coyotes from entering pastures. Only coyote-proof fencing (150–168-cm high with 12 strands) reduced coyote access to pastures (Gates *et al*. 1978; Linhart *et al*. 1982). VerCauteren *et al*. (2006) reported that common livestock-fencing designs (e.g. multi-strand electric wire fence) were not effective for excluding white-tailed deer, even with a lower electrified wire 25 cm from the ground.

We initially used Michigan Department of Natural Resources & Environment (MDNRE) winter track and radio-telemetry data to identify likely study sites where wolves and farms overlapped. These areas were locations where MDNRE had monitored radio-collared wolf packs within 1–2 years of the present study. Annually, we also conducted track and scat surveys along dirt roads and on farms within these areas during late winter to early summer, to confirm the presence of wolves within 5 km of potential study farms. Track surveys were conducted a minimum of three times so as to confirm the presence of wolves (Wydeven *et al*. 1995).

We randomly assigned farms as treatment (LPDs present, $n = 6$) or control (no LPDs present, $n = 3$) farms. In 2007, one treatment farm was dropped from the study after the farmer ceased raising livestock. Treatment and control farms were located within 10 km of each other, to ensure that the wildlife within the area had equal access to both farm types. We assumed that both farm types were equally accessible to wildlife. Further, all farm pastures were confirmed to be used by wolves, coyotes, deer and mesopredators (raccoons (*Procyon lotor*), opossums (*Didelphis virginiana*), red fox (*Vulpes vulpes*) and striped skunks (*Mephitis mephitis*)), on the basis of our track surveys conducted before the experiment began.

Dog training and integration with cattle

In March 2005, we purchased 7–8-week-old Great Pyrenees pups (6 females, 6 males) from a reputable breeder that had an established record of producing working LPDs. Subsequently, we placed a male–female pair of pups at each treatment farm. We provided producers with a document of training guidelines and, with our assistance, they were responsible for the care and training of their pups. Within a livestock barn, pups were housed in a 2 × 4-m pen (LPD pen) located within a livestock pen (8 × 8 m) that contained two ≤1-week-old calves. We provided food and water in the LPD pen that only the dogs had access to. Pups could move in and out of the LPD pen to interact and bond with calves (Gehring *et al*. 2010*b*). We limited human contact with pups for a strong bond to develop with cattle and not humans (VerCauteren *et al*. 2008). However, pup interactions with calves were monitored to detect inappropriate behaviours (e.g. biting calves, pulling tails or playing aggressively), and these behaviours were corrected immediately. At 4 months, pups were allowed to interact with adult cattle in barns under direct supervision by producers. If taken outside, pups were on leashes and allowed only in the area they would be guarding as adults. At 6 months, pups were neutered or spayed to reduce the likelihood of hormonal changes from influencing their effectiveness as LPDs, including roaming behaviour (VerCauteren *et al*. 2008).

At 7 months, we began a slow-release program for integrating pups with adult cattle in pastures. During the day, pups were housed with their calves in outdoor pens (5 × 5 m) within pastures and then returned to their livestock barn by dusk. Pups were walked daily on leashes around the inside of pastures to familiarise them with the pasture and to establish the fence as a boundary. Pups were encouraged to interact with the adult cattle while exploring pastures. This slow-release program allowed the pups to become accustomed to living in a new area, while furthering the bonding between the adult cattle and the pups (Gehring *et al*. 2010*b*).

Before pups were released into pastures, we added a strand of 12-gauge electric fence wire to the existing fence at treatment and control farms to maintain a bottom wire 0.25 m from the ground at each farm (Gehring *et al*. 2010*b*). We monitored fencing regularly and maintained it at 7000 V. Throughout the study, if a dog escaped and began roaming, we installed an invisible fencing system (PetSafe Stubborn Dog System, Radio Systems Corporation, Auburn, IN, USA) and put a shock collar on the LPD to ensure it stayed in the pasture (Gehring *et al*. 2010*b*).

Wildlife visitation on farms

We recorded visits by wolves, coyotes, deer and mesopredators at treatment and control farms by using track swaths. We created track swaths by clearing a 1.5 × 4-m area of debris and vegetation and sifting soil over the area. Track swaths were placed at 200-m intervals around the entire perimeter of each pasture, with equal proportions inside and outside the pasture (i.e. straddling the livestock fencing). No attractant was used at track swaths. Surveys of track swaths were conducted biweekly during May to August, with treatment and control farms being monitored concurrently during the 6-day sampling periods. This resulted in a total of 24 sample days each year. During each check of track swaths, tracks were identified and recorded as a single visitation if the track proceeded into the pasture. We identified tracks using shape characteristics and track dimensions (Halfpenny and Bruchac 2001). We used a cut-off point in track size of 9.0 cm in length and 7.0 cm in width to differentiate coyote and wolf tracks. Domestic-dog and wild-canid tracks were differentiated on the basis of size and shape (e.g. length : width ratio) characteristics (Halfpenny and Bruchac 2001). Track swaths were raked smooth after each check to prevent double counting. Annual visitation data were standardised by summing the number of tracks entering the pasture for each farm and dividing by the number of sampling days. This provided an index of species-specific visitation by wildlife to farms, a measure of intensity of use and potential risk.

During 22–25 June 2006, we conducted ground-nesting bird and nest surveys on two treatment and two control farms. We used a drag line to flush birds and walked 20-m-wide transects throughout the herbaceous portions of pastures. Locations of flushed birds were marked with a wire flag and the area was searched to find a nest. The number of flushed birds and nests was recorded and summed for each pasture. Because of a small sample size (i.e. two treatment and two control farms), we did not conduct statistical analyses to compare treatment and control farms for the number of birds flushed or the number of nests.

During June–August 2007 and 2008, we also used direct observation to measure the amount of time deer spent in livestock pastures on four treatment and three control farms. We observed pastures for 2 h at each farm once per week for 7 weeks, from 1 h 40 min before to 20 min after the sunset. We used binoculars and a stop-watch to record observations from a parked vehicle outside the pasture, at positions that allowed the pasture area to be viewed without obstruction. We recorded the time when a deer or group of deers entered the pasture until the time they left the pasture. The total number of minutes deers spent in pastures at each farm was standardised as the number of minutes per 2-h sample period for each farm. Our research was approved by the Institutional Animal Care and Use Committee at Central Michigan University (IACUC #13-04).

Statistical analysis

We used a two-way Friedman's test and repeated-measures ANOVA (Conover and Iman 1981) for wolf, coyote and deer visits to livestock pastures. We blocked by farm type (treatment or control) and time (year). We excluded data from 2005 in our analyses because no LPDs were yet present on farms. We used a Wilcoxon rank-sum test to compare mesopredator visits on treatment and control farms during 2006, the first year LPDs were present. We used a Wilcoxon rank-sum test to compare treatment and control farms relative to deer use (time spent in pastures) during 2007 and 2008. We conducted statistical analyses with SAS statistical software (SAS Institute, Cary, NC, USA). We used a significance level of $\alpha = 0.05$.

Results

We found a group effect (i.e. between-subject effect) for wolf, coyote and deer visitation. Treatment farms had fewer visits by wolves ($F = 28.57$, $P < 0.001$), coyotes ($F = 5.69$, $P = 0.027$), and deer ($F = 4.34$, $P = 0.047$) than did the control farms. We did not find a time effect for wolves ($F = 1.43$, $P = 0.263$), coyotes ($F = 0.87$, $P = 0.435$), or deer ($F = 0.21$, $P = 0.888$). We recorded wolves only ever on treatment farms in 2005, the year before LPDs were present. During 2005, coyote ($S = 15$, $P = 0.560$, Fig. 1), deer ($S = 15.5$, $P = 0.488$, Fig. 2) and mesopredator ($S = 14.5$, $P = 0.548$, Fig. 3) visitation was similar on treatment and control farms. Once LPDs were present, wolf and coyote visitation declined to zero on treatment farms, and increased slightly on control farms (Fig. 1). Further, no

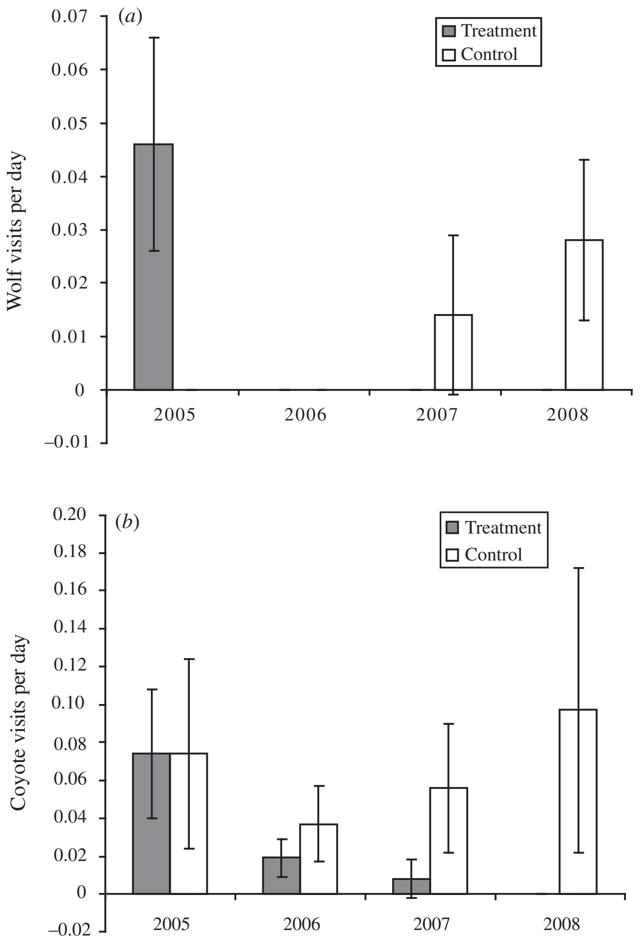

Fig. 1. Mean (± 1 s.e.) number of (*a*) wolf and (*b*) coyote visits per day into livestock pastures on study farms in the western Upper Peninsula of Michigan, May–August 2005–2008. No livestock-protection dogs (LPDs) were present in pastures during 2005. LPDs were present on treatment farms during 2006–2008.

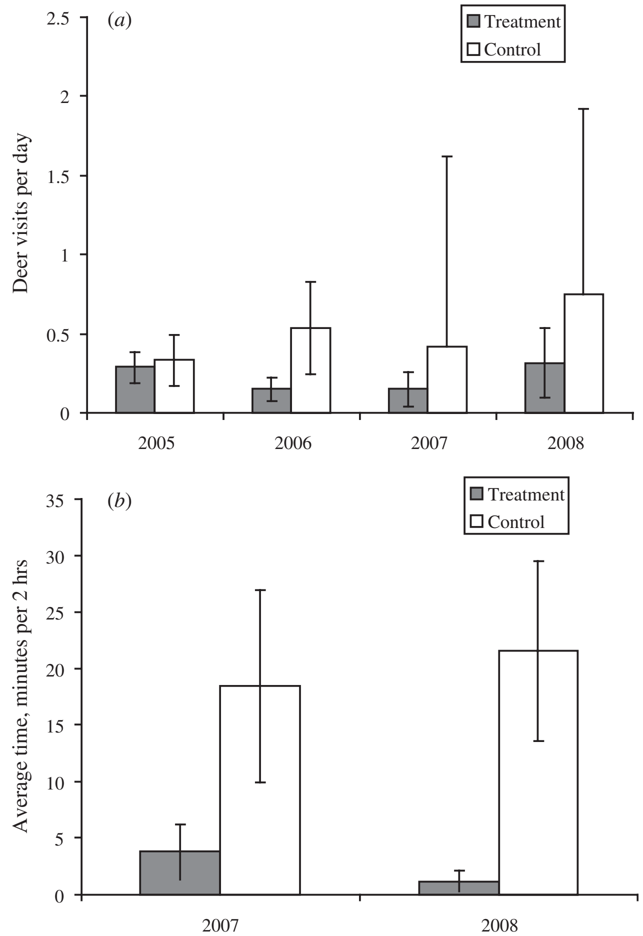

Fig. 2. Mean (± 1 s.e.) number of (*a*) deer visits per day into livestock pastures and (*b*) amount of time deer spent in pastures on study farms in the western Upper Peninsula of Michigan, May–August 2005–2008. No livestock-protection dogs (LPDs) were present in pastures during 2005. LPDs were present on treatment farms during 2006–2008.

livestock depredations occurred on our treatment farms, whereas neighbouring farms experienced depredations. Deer visitation was lower on treatment than on control farms, and remained relatively stable throughout time (Fig. 2). We noted a slight decrease in mesopredator visits to treatment farms during the first year that LPDs were present, compared with control farms ($S = 21$, $P = 0.083$, Fig. 3). Our personal observations and farmer accounts noted cases of LPD-killed mesopredators (raccoons, opossums, foxes and skunks) on protected pastures. We recorded 14 birds and four nests on treatment farms, whereas we recorded 14 birds and zero nests on control farms.

The amount of time deer spent on treatment pastures was not different from the time spent on control pastures during 2007 ($S = 16$, $P = 0.114$), whereas they spent less time in treatment than on control pastures during 2008 ($S = 6$, $P = 0.050$). During 2007 and 2008, deer spent an average of 3.8 min and 1.2 min on treatment pastures compared with 18.4 min and 21.6 min, respectively, on control pastures (Fig. 2). During 2007, one treatment farm accounted for 67% of total time deer spent on treatment farm pastures. In one case, deer were visually

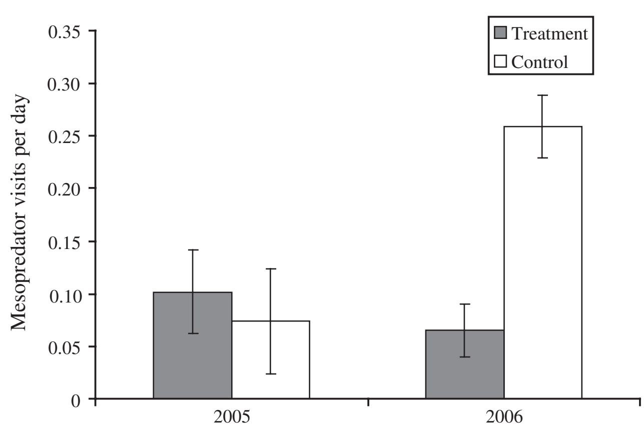

Fig. 3. Mean (± 1 s.e.) number of mesopredator visits per day into livestock pastures on study farms in the western Upper Peninsula of Michigan, May–August 2005–2006. No livestock-protection dogs (LPDs) were present in pastures during 2005. LPDs were present on treatment farms during 2006.

obstructed from the LPDs by forest cover and went undetected for 1 h.

Discussion

The effectiveness of LPDs has primarily been evaluated for predators, and more recently it has been assessed for ungulates. Among predator-based studies, most have relied on producer-based reporting and surveys, rather than field experimentation (Gehring *et al*. 2010*a*). We found only one field trial evaluating LPD efficacy with wolves (cited in Coppinger *et al*. 1988; Coppinger and Coppinger 1996). This study suggested that LPDs displayed protective behaviour against free-ranging wolves and defended experimenter-created bait stations. However, sample size was small and the researchers did not make direct observations on LPD behaviour while defending the bait stations. Linhart *et al*. (1979) provided the only field-trial evidence of the effectiveness of LPDs against coyotes. They found that LPDs reduced sheep depredations by coyotes on three ranches over a 20-day period, and coyotes appeared to be displaced from ranches for an additional 20 days after the LPDs were removed. Our study demonstrated reduced use of livestock pastures by wolves and coyotes, with visitation indices declining to zero. As such, we suggest that LPDs can be effective for reducing the risk of livestock depredations by wolves and coyotes on pastures associated with small- and medium-sized cattle farms.

VerCauteren *et al*. (2008) were the first to use an experimental design to examine LPDs in a novel application for deterring potentially infectious deer. They found that LPDs were effective at reducing the use of livestock pastures and consumption of livestock feed by deer. Shared use of concentrated livestock feed (Palmer *et al*. 2004) is a primary route of transmission of TB from deer to cattle (O'Brien *et al*. 2006). Gingold *et al*. (2009) found that LPDs modified the behaviour, movements and reproductive success of mountain gazelles (*Gazella gazella*) present in their study area. Our study demonstrated reduced use of livestock pastures by deer. We also demonstrated reduced time deer spent on pastures during one year. Our results support the assertion of VerCauteren *et al*. (2008) that LPDs may reduce the potential for disease transmission between deer and cattle by reducing the use of and time spent on pastures by deer. Our study also expands this assertion to moderately sized livestock operations.

Medium-sized mammals also have been excluded and/or killed by LPDs on livestock pastures (Hansen and Smith 1999). Our study noted a slight decrease in mesopredator visitation to livestock pastures during the first year when LPDs were present. We failed to continue monitoring mesopredator activity for subsequent years. Thus, we are not certain whether LPD effectiveness for deterring mesopredators would have increased as the dogs matured and became better protectors. We obtained preliminary field data that suggested that control pastures had fewer ground-nesting bird nests, possibly because of greater rates of nest predation from mesopredators, than did LPD-protected pastures (Gehring *et al*. 2010*a*). Thus, LPDs might also serve as a more general tool for wildlife-conservation objectives, such as reducing mortality of ground-nesting birds by limiting pasture use by mammalian species of wildlife. However, more research is needed on this topic.

The soil track swaths we used were a passive method for monitoring wildlife visitation. Visitation rates for predators were low, yet we showed a difference between treatment and control farms. We were unable to determine whether higher levels of predator visitation would be deterred by LPDs. We suggest that some wildlife visits into pastures should not be construed as a measure of LPD ineffectiveness. Our track swaths did not measure the outcome of wildlife trespasses into pastures. LPDs would still be effective if they chase out wildlife and limit interactions between wildlife and livestock. Also, imperfect detection of wildlife by LPDs may allow wildlife to temporarily use pastures, which likely explains the equal amounts of time deer spent on treatment and control pastures during 2007.

VerCauteren *et al*. (2008) estimated that the cost of LPDs was US$850 per year, assuming a 10-year effective working life of dogs (Green *et al*. 1994; Green and Woodruff 1999). Our purchase price for LPDs was US$400 per dog, monthly maintenance costs (food and veterinary care) were US$50 per dog, and farmer-assisted training costs during the first year (paid graduate-student assistant) was US$4000. Thus, our estimated cost of each LPD applied in our study was US$1040 per year. In addition to cost considerations, the application of LPDs to farms requires livestock producers that are genuinely interested in using LPDs and fully committed to proper training and maintenance of the dogs (Gehring *et al*. 2010*b*). We deem the assistance provided to farmers during the first year as important in successfully integrating LPDs.

Our results have provided evidence that LPDs are an effective non-lethal management tool for deterring wolves, coyotes and deer from livestock pastures. LPDs may have a more general application of protecting livestock and pastures from a range of wildlife species, and appear to be a very versatile and general conservation tool for managing wildlife–human conflict issues. LPDs could serve as a valuable, pro-active management tool producers could implement into their normal livestock husbandry to help reduce livestock losses from predators and wildlife diseases. LPDs also may be a more general conservation tool for excluding mesopredators from pastures, thereby reducing rates of nest predation on ground-nesting birds, although more research is needed on this issue. Although the utility of LPDs is clear and we advocate their application, additional research is required to better determine how to maximise their efficacy. Questions to explore include evaluating the number of LPDs needed relative to pasture size, wildlife species present and the level of motivation of wildlife to enter pastures.

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