Wildlife Society Bulletin 37(4):893–900; 2013; DOI: 10.1002/wsb.348

Tools and Technology

Efficacy of Electronet Fencing for Excluding Coyotes: A Case Study for Enhancing Production of Black-Footed Ferrets

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ABSTRACT Reducing coyote (*Canis latrans*) predation can be an important management objective. Here, we evaluated the efficacy of electronet fencing for excluding coyotes from focal areas on black tailed prairie dog (*Cynomys ludovicianus*) colonies, measured the effect of fencing on wild-born black-footed ferret (*Mustela nigripes*) kit survival, and modeled costs and benefits of fencing. From 27 July to 2 October 2010 in north-central Montana, USA, we erected and maintained 7.7 km of electronet that enclosed 108 ha on portions of 2 prairie dog colonies. We monitored 2 female ferrets and 6 kits inside exclosures and 3 females and 12 kits outside of exclosures. Percent of coyote sightings in the protected areas was 6 times less than expected during the exclosure period (42% pre-exclosure, 7% exclosure, 47% post-exclosure). We conclude that the electronet fencing was effective for dramatically decreasing coyote activity in focal areas where black-footed ferret litters were being raised. We found evidence that survival of kits living primarily in protected areas was 22% higher, but we qualify this finding because of low sample sizes and because our monitoring activity on the study site may have influenced coyote activity. We estimated one-time costs for fencing to be US$4,464/km and operation and/or maintenance costs for the 68 days of fence operation to be US$641/km. If fencing increased survival by 20–30%, then total cost per ferret kit not lost to coyote predation would range between US$5,400 and $3,600, or US$2,550 and $1,700 if fence set-up–take-down labor and use of an all-terrain vehicle were donated. Published 2013. This article is a U.S. Government work and is in the public domain in the USA.

KEY WORDS black-footed ferret, coyote, electric fence, endangered species, Montana, *Mustela nigripes*, predation, reintroduction, translocation.

The coyote (*Canis latrans*) is an important species to manage ∈ 2006*b*, Breck et al. 2006, Thompson and Gese 2007), in urban areas (Timm et al. 2004, Lukasik and Alexander 2011, Poessel et al. 2013), in agricultural settings (Knowlton et al. 1999), and for native game-species management (Hurley et al. 2011). Managing coyote predation in these different contexts requires a suite of tools to match management objectives to management context. A variety of tools exist for managing coyotes (Knowlton et al. 1999), including use of electric fencing to protect sheep from coyotes (Thompson 1979, Dorrance and Bourne 1980, Linhart et al. 1982, Nass and Theade 1988, Acorn and Dorrance 1994). Here, we report on the use of ElectroNet^{TM} electric fencing (Premier1 Supplies, Washington, IA; Fig. 1, hereafter referred to as electronet) used in the context of endangered species management to enhance wild-born black-footed ferret (*Mustela nigripes*; hereafter, ferret) production.

Ferrets are one of the most endangered mammals in the world (Hillman et al. 1979, Miller et al. 1996, Biggins 2012) and are currently being recovered via an intensive captive-breeding and reintroduction program (Miller et al. 1996, Lockhart et al. 2006) that will likely continue for many years. From 1991 to 2010, >3,000 captive-reared ferrets were reintroduced at 19 sites. The captive-breeding program has been successful in saving ferrets from extinction, but maintaining the captive population and producing kits for reintroduction is expensive. Furthermore, survival rates of captive-reared ferrets are lower than those of wild-born kits that are translocated to new sites (Biggins et al. 2011*a*).

Received: 4 September 2012; Accepted: 28 March 2013
Published: 4 October 2013

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Author Discloser and Disclaimer Statements: No competing financial interests exist for any of the authors. The findings and conclusions in this article are those of the authors and do not necessarily represent the views of the U.S. Fish and Wildlife Service. The findings and conclusions in this article are those of the authors and do not necessarily represent the views of the U.S. Department of Agriculture, Animal Plant and Health Inspection Service. Any use of trade, product, or firm names is for descriptive purposes only and does not imply endorsement by the U.S. Government.

Figure 1. Electric fencing (ElectroNet™ Premier1 Supplies, Washington, IA) used to exclude coyotes from portions of black-tailed prairie dog colonies in an attempt to increase survival of black-footed ferret kits during 2010 on the UL Bend National Wildlife Refuge in Montana, USA.

Thus, another recovery strategy to rearing ferrets in captivity is to "harvest" wild-born kits from sites with large and stable ferret populations for translocation elsewhere.

In this study, we tested the use of electronet fencing for protecting juvenile black-footed ferrets from coyote predation. The idea of using electronet fencing to enhance ferret production was partly based on data from 1994 to 2001 (M. R. Matchett, unpublished data), in which coyotes were documented as important predators and fencing was used to protect reintroduced ferrets at release sites in Montana, USA (Biggins et al. 2006*a*, Breck et al. 2006). Telemetry helped confirm that nearly half of 40 ferrets released on the UL Bend National Wildlife Refuge were killed by coyotes within 2 weeks of release in 1994. Electronet fencing was used at the site during releases of 37 captive-reared ferrets in 1995 to exclude coyotes (and other potential ferret predators) from portions of black-tailed prairie dog (*Cynomys ludovicianus*) colonies. Telemetry monitoring showed approximately 90% of the ferret locations were within the exclosures during the 2 weeks post-release. Five ferrets were confirmed killed by coyotes—3 outside exclosures and 2 after exclosures were removed. Despite intensive spotlighting and snow-tracking search efforts, coyotes were never detected inside exclosures; but coyotes were observed many times outside of exclosures, indicating that fencing was effective. However, a systematic evaluation of the effects of fencing on coyotes was not conducted.

In this study, we built on earlier work at this site and evaluated electronet fencing as a means to increase wild-born ferret kit survival. The motivation for this study included observations at UL Bend National Wildlife Refuge, where 46% of the 242 wild-born kits observed during summers and early autumn from 1996 to 2009 were unaccounted for in follow-up surveys during October or November (M. R. Matchett, unpublished data). The cause of kits not being found later during the autumn and after the family breakup and dispersal period is unknown, but coyote predation is a plausible factor given the commonality of coyote predation on ferrets in studies of radiocollared ferrets (Biggins et al. 2006*a*) and Siberian polecats (*M. eversmannii*; a closely related mustelid used in past studies as an investigational surrogate species [Biggins et al. 2011*a*]). In a wild population of ferrets studied in the early 1980s, 60–80% of all juveniles either emigrated or died each year, and it was believed that predation was the cause of most mortality (Forrest et al. 1988).

At sites with small ferret populations, electric fencing might increase kit recruitment that could contribute to establishing a self-sustaining population. At sites where self-sustaining ferret populations exist, electric fencing could lead to an increase in the 'harvestable' surplus of kits for translocation to other sites. The primary disadvantage of harvesting wild-born ferrets is that doing so may jeopardize the persistence of the donor population (Biggins et al. 2011*b*). However, if it was possible to increase the availability of donor animals by boosting survival of resident ferrets, then removing surplus animals would be less of a threat to the donor population, and could offer a cost savings compared with rearing ferrets in captivity for release in the wild.

Our goal was to determine whether management of coyote predation on ferrets was biologically feasible and monetarily justified. The specific project objectives were to 1) determine whether electric fencing excluded coyotes; 2) determine whether coyote exclusion resulted in increased juvenile ferret survival during late rearing and dispersal time periods (Aug through Sep); and 3) determine the costs of managing coyote predation relative to the benefits of producing additional juvenile ferrets.

STUDY AREA

We conducted our study on the UL Bend National Wildlife Refuge in north-central Montana from July through October, 2010 (see Matchett et al. 2010 for a detailed description of the study area). Ferret reintroductions, research, and management at UL Bend were started in 1994 and the site has been occupied by ferrets since then. Since reintroduction, the number of detected ferrets has varied annually with a high of >80 in the autumn of 1999 to a low of 3 in 2003 because of a variety of factors, including disease (e.g., plague; Matchett et al. 2010), weather, and predation. Spotlight surveys conducted by the U.S. Fish and Wildlife Service in April, 2010, indicated that there was a minimum of 5–6 female ferrets and 11–12 total ferrets in the prairie dog complex at UL Bend. Based on these results, we selected 4 prairie dog colonies (total of 463 ha) that were believed to have resident adult female ferrets for this study. All prairie dog colonies in the study area were last treated with Deltamethrin in 2008 to control fleas in efforts to reduce the effects of sylvatic plague (Seery 2006). Attempts are also made every year to vaccinate all ferrets against plague (Rocke et al. 2004, 2006, 2008; Matchett et al. 2010).

METHODS

On 27 July 2010, we erected electronet to exclude coyotes from portions of 2 prairie dog colonies in order to protect the primary areas where 2 adult female ferrets and their litters resided (Fig. 2) and removed the fences on 2 October 2010. Female ferrets and their litters residing elsewhere in the complex were not protected from coyotes with fencing and served as an experimental control. Predicting litter locations, and where to erect fences, was based largely on ferret observations during the April breeding season survey and from previous experience.

Public roads and avoiding the need for gates were considerations in the fencing design. Each fence had 9 horizontal poly-conductors spaced 10 cm apart that alternated between grounded and charged. This type of "pos–neg" netting delivers the full shocking power of the energizer (generally around 7,000 V) when any 2 opposite conductors are contacted (e.g., as a coyote pushes its face or nose through the fence). Fence energizers were powered by two 12-V deep-cycle batteries wired in parallel and recharged by two 40-watt solar panels. Two-centimeter-wide conductive poly-tape was strung along the top of each post at 107 cm and the netting was supported with built-in vertical plastic stays every 30 cm (Fig. 1). The fence allowed ferrets and prairie dogs to pass through the netting, while larger terrestrial animals (e.g., coyotes, and badgers [*Taxidea taxus*]) were shocked when an individual encountered the fence. We quantified the person-hours required to set up, maintain, and take down the fence.

We evaluated the effectiveness of fencing for excluding coyotes by recording the locations of all coyotes seen while spotlighting at night in search of ferrets (Biggins et al. 2006*b*) and determining whether each observation was inside or outside designated protected areas during 3 time periods: pre-exclosure (28 Jun to 26 Jul 2010), exclosure (27 Jul to 2 Oct 2010), and post-exclosure (3 Oct to 24 Oct 2010). We performed a chi-square test of independence to determine whether the number of coyote observations differed between protected and non-protected areas for the 3 time periods.

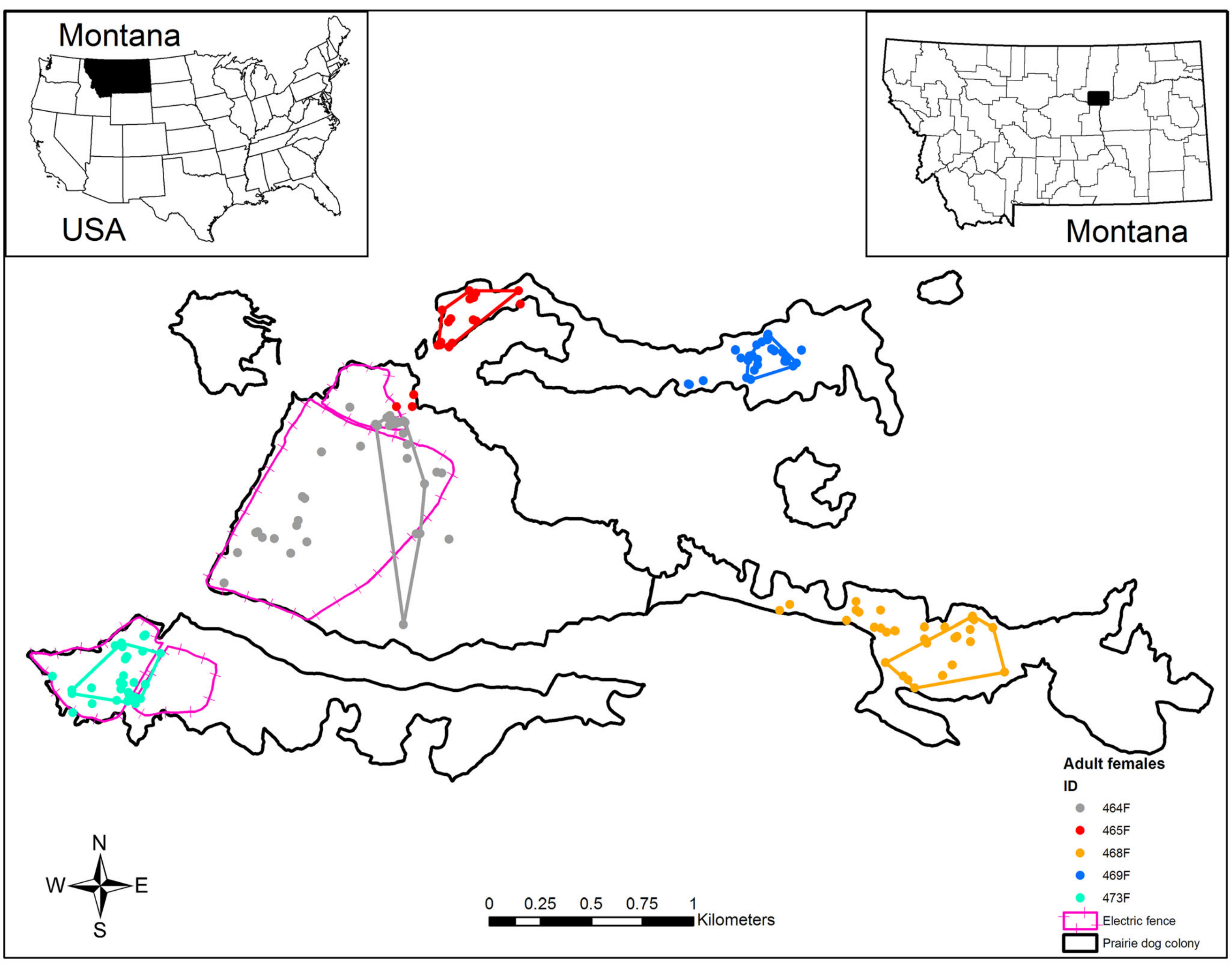

Figure 2. Schematic map of all observations of adult female black-footed ferrets in during 2010, electric fence exclosures, black-tailed prairie dog colonies, and 100% minimum convex polygons for ferret observations during the time electric fences were operational on the UL Bend National Wildlife Refuge, Montana, USA.

Coyotes found inside an exclosure were removed by first taking down a short section of the fence, often near a corner, then hazing animals out by either walking or riding an all-terrain vehicle (ATV) inside the exclosure.

We measured the effect of protecting ferrets by estimating apparent survival through mark–recapture efforts. Surveys consisted of driving trucks and ATVs with mounted spotlights through each prairie dog colony looking for ferret eye-shine and then capturing and tagging animals that had not been previously tagged, or obtaining a passive integrated transponder tag reading from animals that had been tagged (Biggins et al. 2006*b*). We surveyed for 33 nights from 28 June to 20 August and observed 5 litters with a minimum of 13 kits. We then surveyed intensively and tagged ferrets from 21 August to 16 September (19 out of 27 nights), beginning 25 days after the fencing was erected. Our marking effort occurred after the fence was erected because it is difficult to catch wild-born ferret kits until late August or September when they begin to express their independence and progress through family breakup and dispersal (M. R. Matchett, personal observation). We then surveyed one night when we removed exclosures (2 Oct), and then surveyed intensively again for 9 nights from 15 to 23 October.

We used the Live Recapture model in Program MARK (White and Burnham 1999) to test for differences in apparent survival for the 64-day period (21 Aug to 24 Oct) between ferret kits residing in protected and unprotected areas. Sample sizes for this analysis were very small; thus, we focused on very simple models and only looked at differences in survival between the 2 groups. Questions regarding differences in recapture rates and issues regarding model fit (e.g., over-dispersion) were not addressed because the small sample sizes and issues resulting from small sample sizes (i.e., over-fitting) precluded this effort. We emphasize that our effort to measure survival should be considered a pilot effort only. We treated every night spotlighting as a separate encounter occasion and adjusted time intervals between survey efforts accordingly. We used Akaike's Information Criterion corrected for small sample size (AIC_c) to rank 2 competing models, one with apparent survival differing and one with apparent survival not differing between ferrets residing in protected and unprotected areas. In both models, we kept the recapture parameter (p) constant (i.e., did not test for differences in recapture between groups). To account for model selection uncertainty, we model-averaged results from both models to develop estimates of apparent survival for the 64-day monitoring period. We used the delta method for calculating the standard error (SE) for our estimates of apparent survival (Powell 2007). We did not include adults in survival analysis and only analyzed 2 simple models because of the small sample sizes associated with this study.

We tested for potential differences in search effort between the time periods (i.e., pre-exclosure, exclosure, and post-exclosure) by quantifying the number of nights spent spotlighting, where one person spotlighting for the entire night counted as one night of spotlighting. We performed a chi-square test of independence to determine whether search effort differed between periods by using the length of the period (i.e., no. of days) as expected values and number of nights spotlighting as observed values.

We developed a cost-benefit model to evaluate a monetary argument of using fencing for protecting ferrets. First, we estimated the amount of electric fence required to surround a female and her litter by calculating 100% minimum convex polygons (MCP; Rodgers et al. 2007) using locations for all observations of each adult female during 2010. Given the range of observed perimeter values, we selected 3 km as the amount of fencing needed to protect one family group to use in our cost-benefit model. We selected 3 km, a value approximately 50% larger than the average perimeter of the MCPs of our 5 study female ferrets, because even with known areas of use in April, females may move and it can be difficult to predict in what area a female may choose to rear her litter. We tried fencing areas sufficiently large (within reason) to accommodate this uncertainty and tried factoring that into our cost-benefit model.

We measured 2 types of costs: one-time costs (i.e., fencing, energizers, batteries, solar panels, and an ATV), and ongoing costs (i.e., labor for fence construction, maintenance and removal, and fuel). Fencing and equipment used for this project was purchased in 1995, but to estimate costs we used current advertised prices from the following web page accessed in May 2011: (http://www.premier1supplies.com/detail.php?prod_id=401&cat_id=53). Cost of a new ATV was priced at $5,000 (all dollar figures in U.S. currency). We calculated ongoing costs by recording the number of person-hours required to set up, maintain, and take down the fencing and the gallons of gas used per km driven by the ATV and a truck. We multiplied the number of person-hours by a pay rate of $12/hr and the amount of gas by $4/gallon. We also calculated cost-benefits assuming equipment (ATV) and labor could be supplied by local agencies. Benefits were modeled in terms of differences in survival of kits between fenced and non-fenced areas, where we used 3 hypothetical increases in survival (10%, 20%, and 30%) for protected ferret kits. We projected our model over a 10-year time period. One-time costs were applied once in year 1 and ongoing costs remained constant and were added each year.

This study was approved by the NWRC IACUC under study protocol QA-1777.

RESULTS

We erected and maintained 7.7 km of fencing that enclosed 108 ha (23% of the total study area) for 68 days. During the exclosure period, sightings of coyotes in the protected areas were >6 times lower than expected ($\chi^2 = 20.72$, df = 2, $P < 0.01$) compared with pre-exclosure and post-exclosure periods (Table 1). On 3 occasions, we found coyotes (4 animals) had entered exclosures. We found one badger inside the fence and digging evidence next to the fence indicated that this animal was repeatedly deterred from getting out of the exclosure. We suspect the exclosure was built around the badger's den and that it was therefore unable to exit the exclosure.

Table 1. Coyote observations outside and inside the designated protected areas relative to the time frames before, during, and after electric fence exclosure operation on the UL Bend National Wildlife Refuge, Montana, USA.

Period	Timing in 2010; no. of days	No. of search nights	No. of coyote sightings outside of protected area	Percent of coyote sightings outside protected area	No. of coyote sightings within the protected area	Percent of coyote sightings within protected areas
Pre-exclosure	28 Jun to 26 Jul; 29 days	24	11	58	8	42
Exclosure	27 Jul to 2 Oct; 68 days	84	50	93	4	7
Post-exclosure	3 Oct to 24 Oct; 22 days	34	23	53	20	47

We regularly observed 5 adult female ferrets, all with litters, and we tagged 18 kits during the study (Fig. 2). Two families with 3 kits each were generally located within the protected areas and were observed 49 times while fences were operational. Seven of those observations (14%) were located outside of an exclosure, 6 of which were within 20 m of the fence. Three families with 11 kits resided outside exclosures. Another kit, which was likely from a sixth litter, was first detected on 6 September, and the associated dam was never observed.

All 6 kits observed within exclosures at the time they were erected were known present when exclosures were removed, compared with 9 of the 12 kits located outside of exclosures. Two of the missing kits outside of exclosures were last observed on 8 September 2010, 25 days before exclosures were removed; and the third missing kit was last observed 18 days before exclosures were removed. None of these 3 ferrets were ever observed in subsequent surveys through 2011.

The survival analysis showed some support for the model indicating survival differed between ferrets residing in protected or unprotected areas (i.e., AIC_c wt = 0.59 for the model indicating a difference in survival between the groups; Table 2). The model-average estimates of survival (S ± SE) for ferrets residing in protected versus unprotected areas were 0.88 ± 0.23 and 0.66 ± 0.17, respectively, for the 64-day period. The detection rate for the capture–recapture effort was estimated at 0.48 (95% CI ± 0.06). We found no statistical difference in search effort between exclosure time periods ($\chi^2 = 2.72$, df = 2, $P = 0.26$).

It took 184 person-hours (23.9 person-hour/km) to construct the fence. Eighty person-hours were required to erect the fence on the first day and 104 were required to set up the charging stations, eliminate all electrical shorts and troubleshoot aging solar panels and regulators (originally purchased in 1995) the first and second days. Fence maintenance took an average of 2 person-hours/day and primarily involved fixing sections that were leaning or fallen down from wind pressure, finding new electrical shorts, and making sure solar panels were keeping batteries charged. Fencing was maintained daily when possible, but at times the fence went unchecked for up to 6 days. Ninety-one person-hours were required to take down and store the fencing (11.8 person-hr/km).

Table 2. Results of survival analysis to test whether juvenile black-footed ferret survival differed between those residing in protected and unprotected areas in UL Bend National Wildlife Refuge, Montana, USA, during 2010. In the two models, "p" is recapture probability, "phi" is apparent survival, (g) indicates a group effect (i.e., difference in survival between ferrets residing in protected vs. and unprotected areas), and (.) indicates no group effect.

Model	AIC_c	AIC_c wt	No. of parameters	Deviance
p (.); phi (g)	420.8	0.59	3	414.6
p (.); phi (.)	421.7	0.41	2	417.5

The average 100% MCP home-range area for all 2010 observations for the 5 adult females was 26.6 ha (range = 6.6–73.2 ha) and home ranges averaged 8 ha during the time that fences were operational (Table 3). The average polygon perimeter was 2.1 km (range = 1.3–3.4 km; Table 3). For our cost-benefit model we used a value of 3 km (i.e., near the max. perimeter value) of electric fence needed to protect a single family ferret. We calculated our one-time costs to be $34,376 ($4,464/km), which included fencing $29,376 ($3,815/km) and an ATV ($5,000). We calculated on-going costs to be $4,939/year ($641/km), which included labor for fence set-up, maintenance, and take-down, and fuel for vehicles during the ≥2 months that exclosures were operational. Our cost-benefit model demonstrated that over time, the benefits of fencing increased, with the highest rate of benefit gain occurring after the first 3–4 years (Fig. 3). Presuming fencing increased juvenile ferret survival by 20–30%, then at the end of 10 years, cost of protecting wild kits would range from $5,400–$3,600/ferret, respectively. The cost decreases to $2,550–$1,700, respectively, if we presume utilizing an existing ATV and local agency labor for fence set-up and take-down.

DISCUSSION

Electronet was an effective tool for dramatically reducing coyote activity in our focal areas for >2 months. Similarly, coyote baiting trials, coyote monitoring, and ferret movement and survival assessments during 1995 and 1996 (when electronet fencing was first used at UL Bend in an attempt to protect ferrets from coyotes) indicated electronet was highly effective (M. R. Matchett, unpublished data). Collectively, these results corroborate other studies that have generally found electric fencing effective for protecting domestic sheep from coyotes (Thompson 1979, Dorrance and Bourne 1980, Linhart et al. 1982, Nass and Theade 1988, Acorn and Dorrance 1994).

However, electronet fencing was not perfect. On 3 occasions during this study, we found coyotes inside the exclosure, and we are unsure how these individuals were able to get in. Acorn and Dorrance (1994) and Thompson (1979) suggested that a fence 168 cm high was needed to preclude

Table 3. Number of female black-footed ferret observations made during 2010 and during the time electric fences, designed to exclude coyotes from ferret use areas and thereby reduce coyote predation on ferrets, were operational on the UL Bend National Wildlife Refuge, Montana, USA, and the sizes and perimeters of associated 100% minimum convex polygons (MCP).

Black-footed ferret ID	No. of observations during all of 2010	100% MCP area (ha) during 2010	100% MCP perimeter (km) during 2010	No. of observations during fence operation	100% MCP area (ha) during fence operation	100% MCP perimeter (km) during fence operation
464F[a]	49	73.2	3.4	29	12.8	2.2
465F	35	13.2	1.8	30	5.2	1.1
468F	42	27.6	2.5	22	11.9	1.5
469F	33	6.6	1.3	21	3.0	0.7
473F[a]	36	12.2	1.4	24	7.5	1.1
Mean	39	26.6	2.1	25	8.1	1.3

[a] Ferrets that resided primarily within electric fence exclosures.

coyotes from jumping over it (ours was 107 cm high). We have no information to support or refute this, but it did appear that once coyotes were inside the exclosure, they would not leave on their own volition and avoided the electric fence when chased, suggesting they had been shocked and did not want to be shocked again. M. R. Matchett (unpublished data) observed similar avoidance of electronet fence by coyotes on the few occasions that they were found inside exclosures that were operated during the mid- to late 1990s as part of ferret recovery activities.

Searching for predators (primarily coyotes and badgers) has always been a component of operating electric exclosures, so they can be removed as soon as possible by providing them an escape opening in the fence or by shooting them. This is especially important during the first few days of fence operation in case predators were inadvertently enclosed. On-going monitoring for predators during fence operations was also important to be able to remove any that somehow got into the exclosure. Given the generally low vegetation cover and flat ground found on prairie dog colonies, we found coyotes to be easily seen, especially during nightly spotlight searches. Badgers are often seen during spotlight searches and fresh evidence of digging, as we observed, can also be used to indicate their presence and assist with their removal. Without such efforts, it is possible a predator may be prevented from leaving the area where ferret litter(s) are being raised. Even if this occurs for a period of time before predator removal can be accomplished, the risk of predation to ferrets is still likely less than with no protection, given the frequency with which predators (especially coyotes) were observed to travel through ferret home ranges when no fences were present. During the 1990s, and during this study, predators were removed from inside exclosures from within minutes of detection to, at most, a few days after detection.

We report in the results that 3 kits were last observed in early September outside exclosures. Virtually no monitoring was done from 17 September to 14 October 2010; hence, we cannot establish when those 3 kits were likely no longer present relative to when exclosures were removed. The other kits marked during this study (15) were all observed during the 15–23 October survey period.

If our evaluation of the fence was based solely on kit survival, our results indicate fencing increased survival by 22%. However, caution is appropriate when interpreting the limited data from this study as sample sizes were low (6 kits inside exclosures and 12 kits outside), which provided low power to evaluate treatment effects and a great deal of model uncertainty. Second, it is possible our spotlighting activity influenced coyote behavior throughout the study area. Generally, any time we spotted a coyote, it would run away from our position. Because our efforts were focused on prairie dog colonies where we expected to find ferrets, and because we spotlighted during much of the period when exclosures were erected, it is possible that our activity deterred coyotes and reduced the potential for predation on ferrets throughout the study area.

Assuming equal detection, search effort, and proportional use of prairie dog colonies by coyotes, we expected 23% of coyote sightings to be in protected areas because we built exclosures on 23% of the study area. Interestingly, coyote sightings on the protected areas were twice as high as

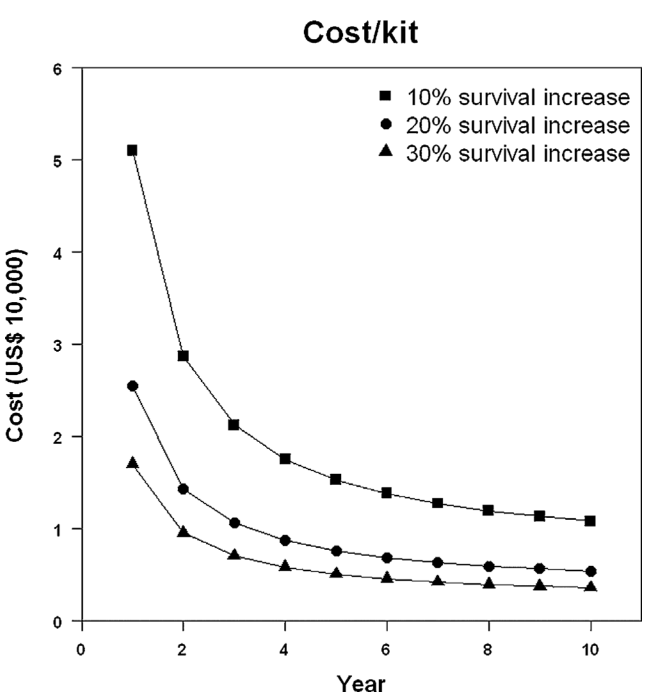

Figure 3. Hypothetical total costs per black-footed ferret kit resulting from 10%, 20%, and 30% increases in survival from prevention of predation by coyotes using electric fencing.

expected during pre- and post-exclosure periods. Search effort may have been biased, with the protected areas receiving disproportionately more search effort relative to its area because they were centered in the study area and immediately adjacent to the field-camp living quarters, naturally leading to increased searching of this area. If there was a bias, it makes the low 7% observation rate of coyotes in the protected areas during operation of exclosures even more compelling that fences were effective (Table 1).

On multiple occasions we viewed smaller animals such as ferrets, prairie dogs, and desert cottontails (*Sylvilagus audubonii*) easily moving through the electronet fence with no indication they were, or had been, shocked. Although there were no wildlife entanglements with the fence during this study, there have been some wildlife deaths documented during the many months in which electric fencing was used to protect ferrets in Montana over a 6-year time frame. They included one desert cottontail, one sharp-tailed grouse (*Tympanuchus phasianellus*), one great horned owl (*Bubo virginianus*), and one golden eagle (*Aquila chrysaetos*) that were found entangled and dead. We are also aware of one pronghorn (*Antilocapra americana*) that was entangled and killed when this style of electric fence was used at a ferret reintroduction site in South Dakota, USA.

To ensure electronet fencing is as effective as possible, we recommend the following. First, it is important that the initial interaction a coyote (or other terrestrial predator) has with the fence is negative (i.e., it receives a shock). To ensure this, the fence should be erected and fully energized as quickly as possible. We have always been successful in having exclosures operational during the first night after construction, and we believe this is an important aspect of effectively managing the psychology and motivation of coyotes attempting to enter exclosures. Another consideration is that thunderstorm and wind events, as well as factors such as movement of native ungulates (i.e., elk [*Cervus elaphus*] being chased by hunters), can knock down sections of fence that require repair. Electrical wiring of fence into distinct, independent sections (approx. 1 km each with the energizer located in the center of each section) is also advantageous so that if problems develop in one section, all the other sections remain fully functional. Placing energizers, batteries, and solar panel apparatus inside the exclosures eliminates potential issues with livestock interference. We also suggest that fence maintenance and surveillance for predators inside exclosures be accomplished from within the exclosure; ATV tracks or trails therefore will likely be developed along the inside perimeter of the fence and thus will not be accessible to coyotes (as compared with developing a potentially attractive travel path along the outside perimeter of the exclosure). Our observations suggest that these electric fences are highly effective in repelling domestic livestock. Elk and deer (*Odocoileus* spp.) have been observed to generally jump over and navigate them well with no issues unless under pursuit from humans. We found that checking fencing at least every other day was adequate for the long-term after an initial 1–2-week daily check to maximize effectiveness and assure no predators were inadvertently fenced in.

Our total cost-benefit model suggested that a 20–30% increase in the number of wild-born kits surviving (a figure supported by our limited data) would cost around $4,500/kit over 10 years. That costs drops, to around $2,100/kit, if an ATV can be borrowed and local agency staff or volunteers can be assembled for focused work days. Our survival analysis indicated that ferret kits outside of fences had lower survival; thus, we offer this cost assessment for consideration when evaluating comparative costs of breeding ferrets in captivity for release in the wild. Furthermore, the results of this study support the notion that coyotes impact juvenile ferret survival and that further research is warranted.

MANAGEMENT IMPLICATIONS

Although substantial progress has been made, recovery of highly endangered black-footed ferrets remains challenging. Our study was limited in estimating fencing effects on survival of juvenile ferrets, but it did demonstrate greatly reduced coyote activity in areas occupied by ferrets. Coyotes have been documented as a predator on ferrets; therefore, it is plausible that reduction of coyote activity in areas occupied by ferrets likely reduces predation by coyotes and could potentially lead to viable population establishment and/or additional 'harvestable' ferret kits from self-sustaining populations for translocation elsewhere.

ACKNOWLEDGMENTS

We thank the numerous Charles M. Russell National Wildlife Refuge (CMR) staff and Rocky Mountain College volunteer students that assisted with construction and take-down of the electric fence in addition to the numerous volunteers that assisted with spotlighting efforts to monitor ferrets. P. Darrow, U.S. Department of Agriculture-Wildlife Service-National Wildlife Research Center (NWRC) deserves special mention for his assistance in the field. We thank P. Doherty for advice with the survival analysis. Field technician support was provided by funding from NWRC and we are indebted to CMR for providing funding and logistical support, without which this study could not have been conducted.

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Associate Editor: Applegate.