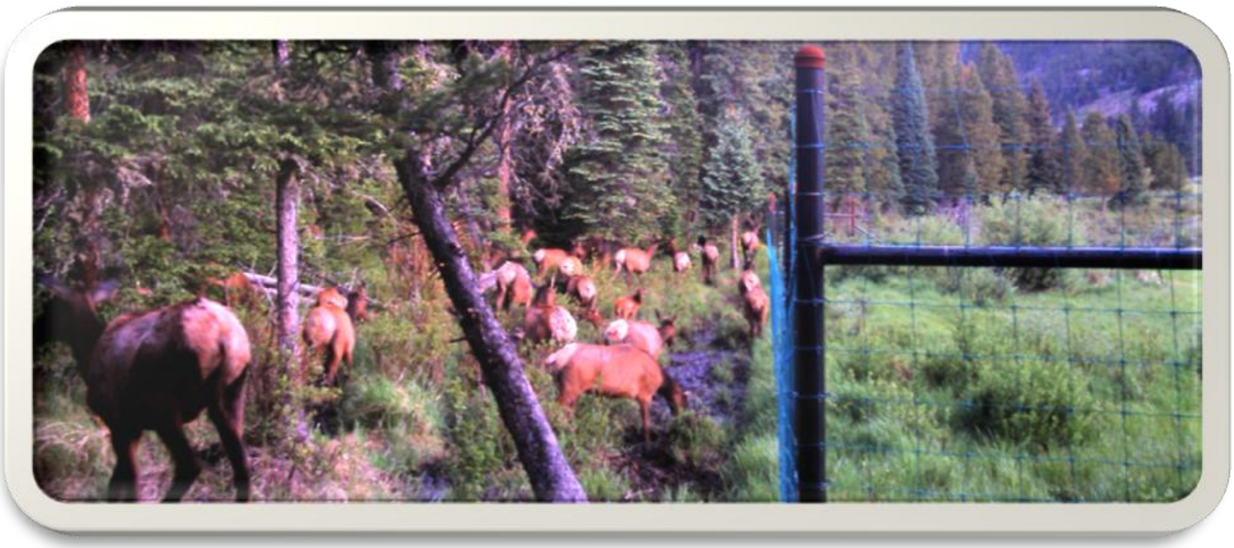
A Study of the Effectiveness of a Fence Design in Excluding Elk and Moose but Allowing the Movement of Other Wildlife



Final Research Report

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Summary

Although a natural part of Rocky Mountain National Park ecosystems, increases in elk populations beyond the historical range of variability have led to degradation of native willow and aspen communities in portions of the park. Fencing is one approach being used to help protect existing resources and facilitate rehabilitation and restoration of new areas. However, traditional woven wire fence, while a proven deterrent for large ungulates like elk and moose, can limit the passage of other animals. This study evaluates the efficacy of a fence design installed at the Fan Lake riparian restoration site in ROMO in excluding elk and moose but allowing the passage of other species such as deer. We employed the use of paired track lots located around the perimeter of the fence and motion-detecting scouting cameras to document animal occurrence inside and outside the fence. During the study, we documented elk (*Cervus canadensis*), moose (*Alces alces*), American badger (*Taxidea taxus*), coyote (*Canis latrans*), deer (*Odocoileus spp*.), mountain lion (*Puma concolo*r), lagomorphs (Leporidae), and red fox (*Vulpes vulpes*). With a few exceptions, the fence design was effective in its main functions of excluding elk and moose, but allowing the passage of other species.

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Introduction

Elk (*Cervus canadensis*) are a natural component of Rocky Mountain National Park (ROMO) ecosystems. However, since the adoption of a natural regulation policy by the National Park Service in the late 1960's, elk populations have increased outside their historical range of variability, negatively affecting native vegetation in portions of the park. The most significant impacts have occurred in willow and aspen communities on the elk winter range and in alpine tundra on their summer range (Baker et al. 1997, Peinetti et al. 2002, Weisberg and Coughenour 2003). Excessive elk browsing is inhibiting riparian willow and aspen reproduction and recruitment (Dickens 2003, Gage and Cooper 2005, Binkley 2008), and has altered the basic morphology of riparian willows (Peinetti 2000, Peinetti et al. 2001), reducing the suitability of riparian habitats for beaver, a keystone species historically important for the geomorphic and ecological functioning of many riparian areas (Baker et al. 2005).

To address the negative impacts from excessive elk browsing, ROMO has developed an elk and vegetation management plan (EVMP), the purpose of which is to guide elk management in the park for the next several decades (NPS 2007). Among the proposed actions is the construction of elk exclosures to protect existing willow and aspen stands, and to allow restoration of willow and aspen in areas where they no longer exist. Fences will be installed adaptively, based on vegetation response indicators assessed through long-term monitoring. The main function of fencing is to restrict access of elk and moose; however, fences are not intended to restrict the movement of other species.

Given the potentially widespread use of fencing in the park, ROMO wants to be sure the particular fence design used is one that is effective at excluding target species, but allows the passage of other wildlife. Our objective in this study was to evaluate a fence design used to enclose a recently restored riparian area on the east side of ROMO. The primary purpose of fencing at this site is to protect new wetland plantings installed as part of restoration activities and to promote natural establishment and recruitment of willows. However, this project also provides an opportunity to evaluate the efficacy of the particular fence design used at this site. This information should help improve future implementation of fencing elsewhere in the park, as prescribed by the EVMP.

Methods

Study area

The study was conducted in Horseshoe Park, part of the core elk winter range on the east side of ROMO (Figure 1). In 1982, the failure of the Lawn Lake dam above the site created a torrent of water flowing down the Roaring River, transporting vast quantities of sediment and creating a large alluvial fan in Horseshoe Park. The fan impeded the flow of the Fall River, resulting in the formation of Fan Lake and the flooding of nearly 18 acres of riparian willow habitat. To help restore communities and ecological functions lost or impaired by the formation of the Lake, ROMO and collaborators from Colorado State University and the NPS Water Resources Division developed a restoration plan for the site involving stream realignment, extensive planting of native wetland species such as willows and sedges (*Carex* spp.), and creation of a fence to protect the site and facilitate long-term recovery. Earthwork was completed in the fall of 2006, and a woven-wire fence approximately 30 acres in size completed during 2007 (Figure 1). Planting occurred during the summer of 2008.

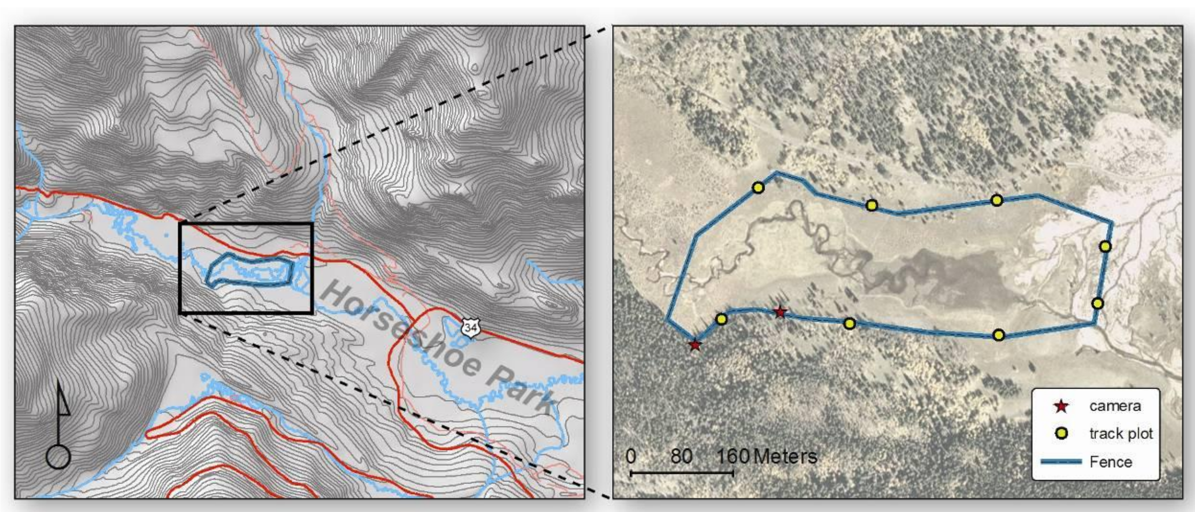

Figure 1. Location of study area in Horseshoe Park (left panel) and locations of track plots and motion-detecting cameras (right panel).

The fence installed at the Fan Lake site consists of woven wire mesh attached to a framework of welded steel posts. The fence is 76 inches high, with a 16 inch gap between the ground surface and the start of the woven wire fencing to allow passage of small to medium sized animals (VerCauteren et al. 2007). The fence is designed so that additional wire can be added to the top or bottom if monitoring determines that too many elk are gaining access.

Track plots

To evaluate animal use inside and outside of the fence, we established paired 2m x 3m track plots in 8 locations along the fence perimeter, with one plot located inside the fence and one outside (Figure 1). Track plots were created by removing vegetation down to mineral soil, then raking soil to create a tracking medium. Approximately every 2-3 weeks during the spring, summer, and fall we raked track plots clear and returned approximately 24 hours later to document the occurrence of any new tracks. Sampling during the winter was more infrequent due to accumulated snow over the track plots. However, we opportunistically visited the site and walked the fence perimeter following fresh snowfall and recorded observations of tracks inside and outside the fence. Track identifications were made using characteristics in Halfpenny (Halfpenny 1986). For each sampling date, species, and relative location (i.e. inside/outside of fence), we recorded a binary outcome based on the presence (1) or absence (0) of tracks in one or more track plots. We used Fischer's exact test of proportions to compare the proportion of positive counts inside versus outside the fence using the Minitab statistical package (version 15, Lead Technologies, Inc.), evaluating differences at $\alpha=0.05$.

Scouting cameras

We installed two Cuddeback Expert 3.0 megapixel digital scouting cameras, set up oriented along the fence line, in order to capture animals inside and outside the fence. Cameras were set to collect photos both day and night, with a minimum separation between shots of one minute. In practice, this often yielded multiple photos of the same animal. Thus, in addition to tallying all photographs for each camera, we reviewed and consolidated obvious instances of multiple shots of the same animal(s), to provide a more representative estimate of photo events.

Photos were stored internally within the camera on a CompactFlash card and periodically downloaded to a PDA for transfer to a PC. Photographs were organized using Picasa (Google, Inc.), free photo management software that allows for the tagging of pictures using attribute information, in our case, the species present in the photo and their location (inside versus outside). The flash included with the Cuddeback camera is relatively weak, and in many nighttime shots, it was impossible to identify the animal present in raw images. Therefore, we employed post-processing in Adobe Photoshop to improve our ability to detect and accurately document species (Figure 2).

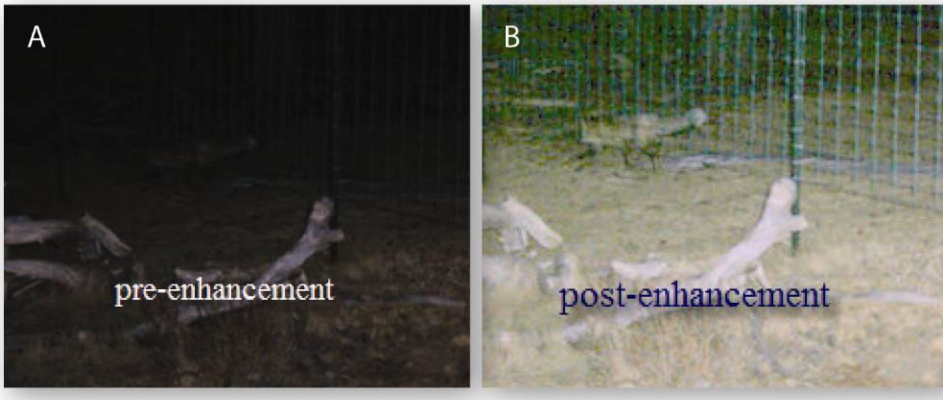

Figure 2. Example of nighttime shot before (A) and after (B) processing in Adobe Photoshop.

Results

During the study period, we documented the occurrence of elk (*Cervus canadensis*), moose (*Alces alces*), American badger (*Taxidea taxus*), coyote (*Canis latrans*), deer (*Odocoileus spp*.), mountain lion (*Puma concolo*r), lagomorphs (Leporidae), and red fox (*Vulpes vulpes*) (Figure 3). Instances of all species were more numerous outside the fence versus inside, but there were large differences among species.

Elk tracks were the most frequently recorded outside of the fence, recorded in 21 of 27 (78%) of sampling visits (Table 1). However, we recorded only a single instance of elk tracks inside the fence (4% of sampling visits). Compared with elk, deer tracks were less frequent in track plots outside of the fence, but far more frequent inside, observed in 30% of visits. Humans and lagomorphs were less common overall, compared to elk or deer, but showed similar frequencies inside versus outside of the exclosure.

Table 1. Results from track plots (n=27). P values are from Fischer's exact test (Ho: proportion inside = proportion outside)

	inside		*outside*		
Species	***count***	***proportion***	***count***	***proportion***	***p***
elk	1	4%	21	78%	<.000
deer	8	30%	16	59%	0.054
human	6	22%	8	30%	0.757
lagomorph	2	7%	3	11%	1.00
fox	0	0%	1	4%	1.00

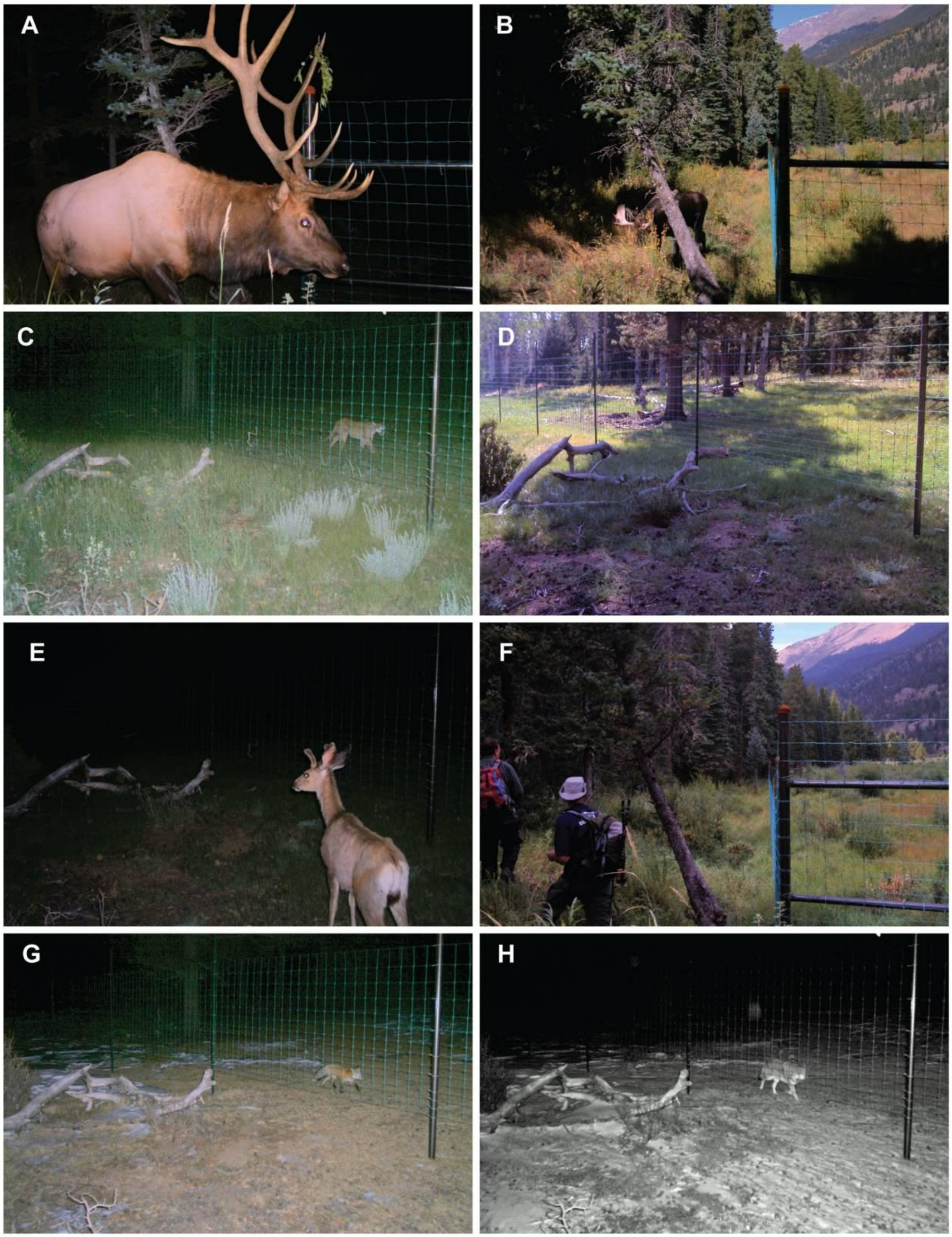

Figure 3. Examples of animals captured using motion-activated cameras: (A) elk, (B) moose (C) mountain lion, (D) badger, (E) mule deer, (F) humans, (G) red fox, (H) coyote.

In terms of raw and adjusted event counts, elk were by far the most frequent species recorded in photographs (Table 2). As with the track plot data, the majority of events were recorded outside of the fence (99.6%). All of the 16 photographs featuring an elk inside the disclosure were of a single animal passing back and forth in front of the camera over a two hour period (Figure 4). Mule deer were the next most frequent species, followed by red fox, and humans. The relative frequency of species photographed inside the fence was generally lower compared to proportions from track plots.

Table 2. Summary of camera data. Raw counts are unadjusted for repeat shots taken in short succession, while numbers represented in adjusted columns have had obvious duplicate shots removed. Note that all tallies represent total numbers of pictures, not counts of animals; some photos (those of elk, in particular) often featured >1 animal.

	Outside		*Inside*		*Total events*		*Proportion inside*	
Species	**raw**	**adjusted**	**raw**	**adjusted**	**raw**	**adjusted**	**raw**	**adjusted**
elk	1045	369	16	1	1061	370	1.5%	0.3%
deer	30	22	7	6	37	28	18.9%	21.4%
red fox	23	22	1	1	24	23	4.2%	4.3%
human	10	9	3	2	13	11	23.1%	18.2%
coyote	3	3	0	0	3	3	0.0%	0.0%
moose	2	2	0	0	2	2	0.0%	0.0%
lion	1	1	0	0	1	1	0.0%	0.0%
badger	1	1	0	0	1	1	0.0%	0.0%

Anecdotal accounts of animal use of the exclosure were reported. For example, there was a single reported instance of a mature bull elk inside the exclosure, and resource management staff observed deer jumping the fence (Jeff Connor, personal communication). An additional observation of note was the passage of a badger underneath the fence.

Figure 4. Collage of 16 photos taken over a 2-hour period on 10/12/07 showing a single elk inside the fence. No other photos of elk inside the fence were recorded, although there was one anecdotal account of a bull elk inside the exclosure.

Discussion

Overall, our results suggest that the fence design used at the Fan Lake site is effective in its primary purpose of excluding elk and moose, but allowing the passage of other animals such as deer. The fence was not 100% effective at excluding elk; however, there were only a couple of documented instances of elk inside the exclosure during the study period, despite very high elk densities in the area.

We were unable to directly observe how elk were able to gain access, but there are several possible scenarios. There are two gates to allow public access. Although these are designed to automatically close, it is possible that a gate became stuck, providing access. Alternatively, elk may have gained access by jumping the fence. Although the fence was constructed to a fixed height, in areas with steeper slopes, such as the south side of the exclosure, the higher relief may reduce the effective height, allowing easier access to a motivated animal.

An additional concern observed during the winter is the drifting of snow along portions of the fence (Figure 5). If sufficiently hardpacked, these snowdrifts may effectively reduce the fence height and allow easier access. This appears to have been how one bull elk entered and exited the exclosure (Jeff Connor, personal communication).

Figure 5. Drifted snow along a portion of the fence.

One of our goals was to document the ability of other species to get across the fence. Instances of deer tracks were relatively common inside the fence, particularly when compared to elk. Likewise, motion detecting cameras documented several instances of deer inside the fence. In addition, deer were observed on several occasions by park staff jumping the fence (Jeff Connor, personal communication). Gaps >15 cm have been shown to provide adequate passage for deer (Vercauteren et al. 2006), a conclusion supported by this study.

With a few exceptions, track plots and cameras failed to document the passage of smaller mammals. However, we do not interpret this to mean that smaller animals are unable to cross; previous research into the matter and common sense suggest that most smaller animals should have little problem passing through the gap below the start of the wire. We did document the passage of red fox under the gap in the fence (Figure 6) and resource management staff directly observed the passage of a badger (Jeff Connor, personal communication). For animals such as fox, we expected that the frequency of photos captured inside versus outside the fence would have been similar, since the animals are small enough to pass under gap below the wire (Figure 6). However, frequencies were skewed towards the outside, suggesting that camera placement may have been a factor influencing photo counts.

Figure 6. Photograph of red fox passing under the fence.

A variety of factors should be considered when evaluating different fence designs. These include the desired level and duration of protection, the ability of different species to penetrate various designs, focal species' behavioral characteristics and motivation to penetrate, and cost (Vercauteren et al. 2006). It is also important to consider any possible negative effects, such as effects on landscape aesthetics.

Animal size, intelligence, and physical ability are important variables affecting the efficacy of any particular design (Vercauteren et al. 2006). Motivation is also a key factor. Under current conditions, elk may not have been that motivated to breach the fence. However, as willows inside the exclosure rebound, elk may have greater motivation to penetrate the fence. The ability of managers to add additional woven-wire should provide a mechanism to address increases in incursion rates.

Other factors such as slope may decrease the overall effective height of a fence, and should be incorporated into fence designs. Where slopes fall towards the area to be protected, fence height should be increased. Likewise, where topography favors accumulation of deep snow packs, fence height may need to be increased to ensure efficacy (Figure 5).

Economic considerations are also important when evaluating competing fence designs. Initial construction costs are obviously important, but must also be viewed in the context of long-term maintenance. Fence designs that cost more initially may provide greater value when long-term maintenance requirements are considered. Careful consideration of fence layout is also important. For a given area, widely varying perimeter values are possible depending on the shape and configuration of the enclosed area. For example, the perimeter length of a square plot is shorter than a rectangular plot enclosing the same area. Since cost is primarily determined by perimeter, irregular or narrow shapes will be more expensive than more simple ones.

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