Chapter 15
The Influence of Land Use and Fences on Habitat Effectiveness, Movements and Distribution of Pronghorn in the Grasslands of North America

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Introduction

The pronghorn *Antilocapra americana* is an open-country grassland and shrub-steppe obligate and the sole surviving member of a taxonomic family unique to North America. Adapted to outrun American cheetahs, *Miracinonyx trumani*, an extinct predator that once roamed the North American plains (Byers 1997), the pronghorn can reach a top speed of nearly 100 km/h, making it the fastest land mammal on the continent. With its exceptionally large eyes set far back on the skull it can detect movements up to 5 km away, and with a burst of speed it can quickly deter any modern predator from giving chase. Despite these and other adaptations to the prairie landscape, the pronghorn is ill equipped to deal with the agro-industrial and social transformation of the mixed-grasslands of the Northern Great Plains, which began at the turn of the nineteenth century (O'Gara and McCabe 2004).

Today, the landscape mosaic of native prairie and cultivated fields comprising the northern mixed-grasslands largely reflects the early agricultural history of the region. More broadly, the prairies continue to be dramatically altered by the cumulative effects of cultivation, irrigation, roads, petroleum and natural gas development,

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mining, water development, urban expansion and exurban development, electrical transmission lines, fences and other developments (Barrett and Vriend 1980; Czech et al. 2000; Forrest et al. 2004). In Saskatchewan and Alberta, only ~20 and ~40%, respectively, of native mixed-grasslands remain untilled (Gauthier and Wiken 2003). As development progressed following settlement for farming and the human population grew, roads associated with industry and rural access improvement increased. By the mid-1990s more than 90,000 km of highways, roads and natural gas well-site access trails existed in the Grassland Natural Region of Alberta (Alberta Environmental Protection 1997).

Although pronghorn can persist in low numbers in cultivated areas, they are most common in large open native rangelands where they are able to satisfy life history requirements, including migrating in response to landscape and regional-scale variations of forage availability in winter. Human activities from the period of agricultural settlement during the early years of the twentieth century to contemporary infrastructure and industrial uses of the landscape have had a profound effect on the distribution and abundance of pronghorn. Here, we review the historical depletion and partial recovery of pronghorn and the contemporary influence of fences, roads and other infrastructure and human activities on the spatial ecology of pronghorn. We comment on the importance of land-use planning and measures that can mitigate the negative impacts of land use, fences and roads on ecological cohesion of landscapes to sustain the pronghorn as a common species.

Pronghorn Ecology and Habitat Requirements

Remaining mixed-grasslands of south-western Saskatchewan, north-eastern Montana and south-eastern Alberta provide habitat for pronghorn and other native prairie obligates (Forrest et al. 2004). The landscape between the Missouri River in Montana and the Parklands in Alberta and Saskatchewan contains several large, relatively intact grassland landscapes (Forrest et al. 2004). The dominant sagebrush species in this area, particularly north of the Milk River in Montana, is silver sagebrush *Artemisia cana* (Jones et al. 2005). This palatable shrub becomes critical winter forage for pronghorn, particularly during harsh winters (Martinka 1967). Winter ranges have been identified for pronghorn in Alberta and Montana. These areas provide shrub cover and other winter forage (evergreen forbs) important for pronghorn in winter (Dirschl 1963; Martinka 1967; Mitchell and Smoliak 1971; Barrett 1980, 1982).

Pronghorn aggregate in restricted areas during severe winter conditions more than in normal winters (Barrett 1982). They have a low chest height and a small hoof with the heaviest foot loading of any North American ungulate (Guthrie 1990). Hence, they are poorly adapted to cope with moving through or foraging in snow (Telfer and Kelsall 1984). Severe winter storms and prolonged heavy snowfall with reduced access to browse sporadically causes heavy mortality in pronghorn

(Compton 1970; McKenzie 1970; West 1970; Wishart 1970; Oakley 1973). When snow is present, pronghorn seek areas that have blown free or areas with low snow cover through which forage protrudes (Dirschl 1963; Martinka 1967; Mitchell and Smoliak 1971; Bruns 1977). After heavy snowfall, pronghorn have been observed to undertake long-distance movements in search of areas with better forage availability (Creek 1967; Yoakum 1978; Guenzel 1986; Raper et al. 1989; Sawyer and Lindzey 2000). Such movements may be a facultative response (Baker 1978; a response to unpredictable spatial resource availability) to a severe storm (Martinka 1967) or an annually repeated calculated movement through an invariant corridor from an area where snow accumulates predictably every year (e.g. the Jackson Hole/Green River herd in Wyoming; Berger 2004; Berger et al. 2006). In a study in Oregon, Dalton (2009) concurred with White et al. (2007; Yellowstone ecosystem) that pronghorn do not return to the same winter range consistently because they only migrate as far as necessary to find suitable environmental conditions. Regardless of where they overwinter, in large landscapes female pronghorn exhibit high fidelity to fawning areas within their summer range, returning each spring to the general area where they successfully fawned in previous years (Autenrieth and Fichter 1975; Mitchell 1980; Byers 1997). In an example from Idaho, all 22 collared female pronghorn followed for 2 years returned to the same areas they had occupied the previous summer (Hoskinson and Tester 1980).

Maintaining large tracts of native prairie, traditional and critical seasonal ranges and corridors to sustain long-distance movements of this species are important targets for conserving the ecological cohesion of landscapes (*sensu* Opdam et al. 2003). Pronghorn select large, open landscapes (O’Gara and Yoakum 2004). The largest populations of pronghorn in the mixed-grasslands are associated with expansive tracts of native prairie (Martinka 1967; Mitchell 1980; Sheriff 2006). Based on 23 years of survey records from Alberta, Sheriff (2006) found a significant log-linear relationship between the density of pronghorn in provincial management units and proportion of the landscape in native cover (Fig. 15.1). This landscape cover variable alone explained ~56% of variation in pronghorn densities. The lowest densities were in management units in south central Alberta that have been extensively converted (>75%) for dryland crop production. Although pronghorn exhibited lower densities in cultivated landscapes, they produced more offspring (fawns at heel in July) than in native landscapes (Sheriff 2006). Under the regulated management system of the province (Alberta Fish and Wildlife 1990), doe hunting is either not allowed or is set proportionately very low in croplands, and does not explain the low density of pronghorn in these areas. In Alberta, cropland-dominated landscapes appear to be population sinks that may provide surplus forage for the few animals residing there, supporting high productivity, but compensated by high mortality.

During a 3-year period between 2003 and 2007, the Alberta Conservation Association recovered GPS receivers from 65 pronghorn collared in Alberta with the objective of tracking movements and studying habitat selection. Results of the study confirmed a strong association of pronghorn with native prairie and provided insights into movement patterns. Among pronghorn residing in mixed or predominantly

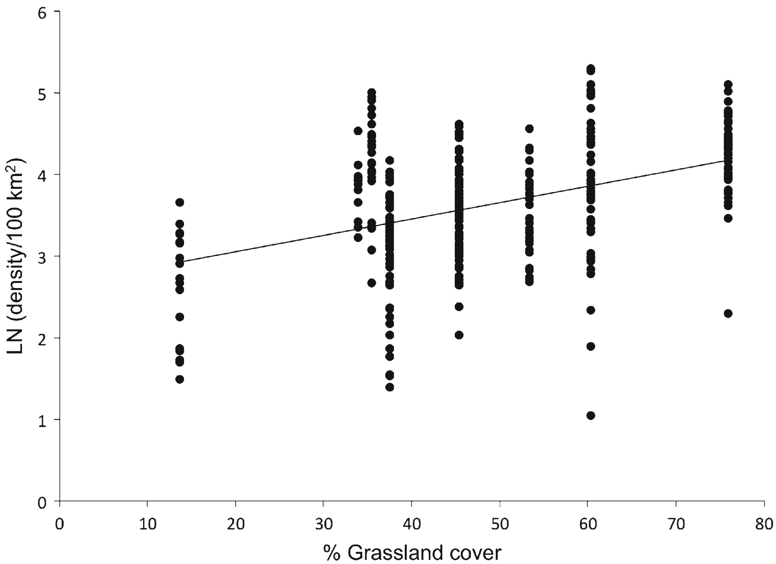

Fig. 15.1 Relationship between pronghorn density and percent native grassland cover in pronghorn management units in Alberta for the period 1985–2003. Source: Sheriff (2006)

native landscapes, about one-third undertook long-distance movements between winter ranges and fawning locations in summer range. They moved an average of 204 ± 112 km (n = 17). Pathways followed during spring migration were strongly directional (mainly south to north) and linear, deviating only where a major highway and railway corridor, fences, urban areas or steep terrain deflected them (Fig. 15.2). One exceptional movement originated from a winter-range capture location near the Montana border and followed a 445-km pathway northwards into west-central Saskatchewan. This is a record movement for the species; previously Sawyer et al. (2005) recorded a seasonal movement of 258 km between winter and summer range in Wyoming.

Terrain can have an important influence on pronghorn movements. In south-eastern Oregon, a river and associated road profoundly influenced pronghorn movements (Dalton 2009). Pathways followed by migrating pronghorn in Alberta were influenced by terrain features, particularly by steep banks of the deeply incised V-shaped valleys of the Saskatchewan and Red Deer Rivers. River crossing sites are limited in number and are characterized by shallow grades or flats on either side of the river, and were connected to native grassland habitat in the adjacent uplands. Pathways of 4-h point locations of radio-collared pronghorn that crossed the river appeared to be aligned with these likely crossing sites. Among anecdotal information obtained by Alberta researchers were several reports of pronghorn using small low-traffic bridges to move across rivers, indicating pronghorn can learn to use some human structures. Sawyer and Rudd (2005) reviewed anecdotal published accounts to formulate recommendations for designing road-crossing structures for pronghorn.

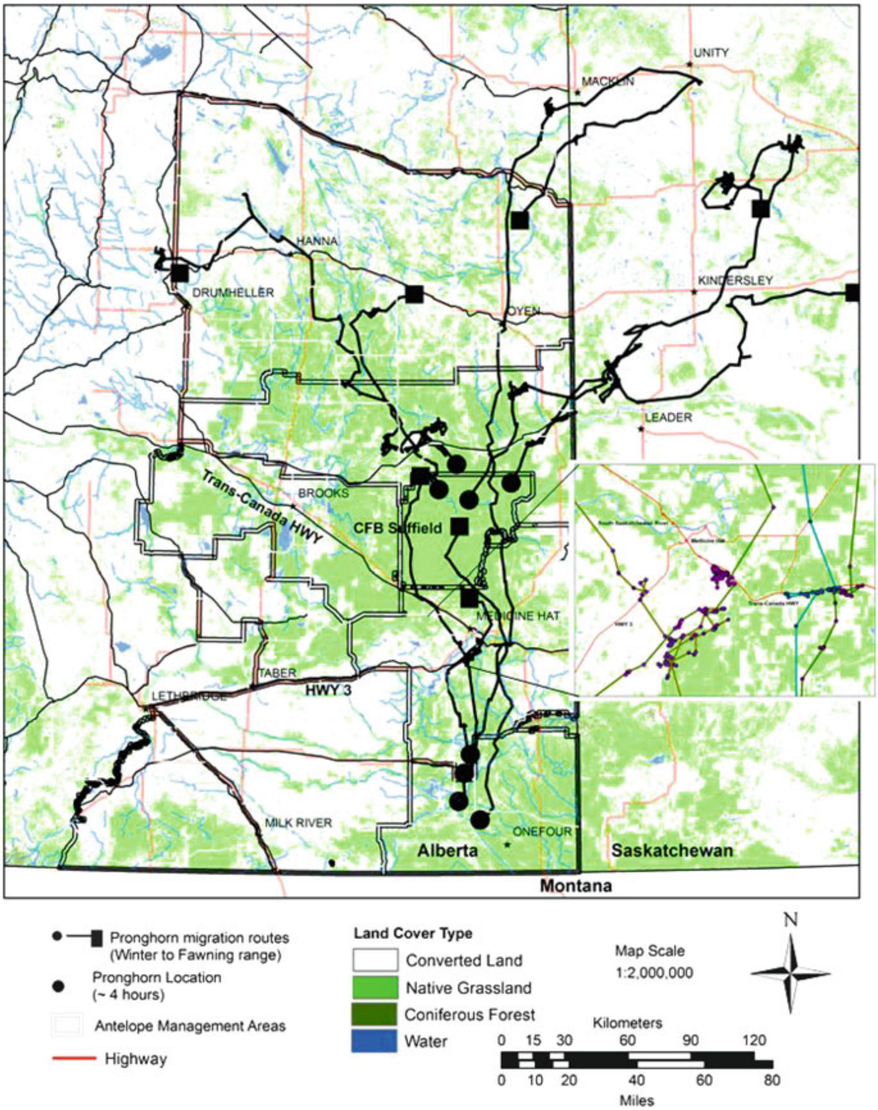

Fig. 15.2 Examples of long-distance movement pathways of pronghorn in spring in Alberta based on 4-h GPS collar location fixes. Note the strong northward directionality of movements, the funnelling effect of land use and the impeding effect of the Trans-Canada transportation corridor near Medicine Hat. Data source: Alberta Conservation Association

Land Use and Infrastructure Effects on Pronghorn Abundance

In rural western North America, effective land-use planning is one of the most important needs for wildlife conservation (Brown et al. 2005). Human activities and infrastructure can have a profound influence on wildlife distribution and movements. Urban sprawl and exurban settlement are expanding urban edges and leap-frogging of residential development and commercial zones into surrounding rural landscapes. Together, they are leading causes of biodiversity loss in North America (Hansen and Brown 2005; Baldwin et al. 2007). In Alberta, expansion of the City of Medicine Hat is incrementally infringing on the primary north-south migration pathway of pronghorn identified in our current research. The City is situated at an L-shaped bend of the Saskatchewan River that acts as a funnel for pronghorn moving south in the fall and winter from Canadian Forces Base (CFB) Suffield, a 2,600-km^2 area of mostly unfenced native prairie located north of Medicine Hat (Fig. 15.3). Mass movements of pronghorn into the City are common during harsh winter weather events as the animals strive to navigate southwards to more favourable ranges (Fig. 15.4). The area surrounding the City is becoming less porous to pronghorn movements owing to increasing commercial, residential and agricultural development combined with the main cross-Canada transportation corridor (Highway 1 and the Canadian-Pacific Railway).

Even in extensive grassland landscapes, infrastructure and human activities can affect the distribution and movements of pronghorn. The township grid of surveyed lands, a legacy of federal western settlement Acts in Canada and the United States, provides the framework for land development, land tenure, the transportation network and fence lines. As their density increases, roads and fences have had a negative effect on populations of several species and various ecological processes (Trombulak and Frissell 2000). Roadways are a major concern for pronghorn populations, acting as a filter or barrier to movements (van Riper and Ockenfels 1998; Ticer et al. 1999; Yoakum 2004). Unlike other ungulate species, the primary concern for pronghorn with roadways is not vehicle collisions; rather, roadways restrict pronghorn movements and can impede movements within or between seasonal ranges. Pronghorn reduce their use of habitats adjacent to roads, depending on traffic volume (Gavin 2006; Kolar 2009), and alter activity budgets near roads by increasing vigilance at the expense of foraging (Gavin and Komers 2006). In North Dakota, pronghorn selected open areas in non-rugged landscapes during winter and summer, and avoided primary roads during summer and secondary roads during both seasons (Kolar 2009). Similarly, in Wyoming pronghorn consistently selected home ranges with lower density of highway rights-of-way (ROW) than available (Sheldon 2005). Depending on traffic volume and width of an ROW, roads may be barriers to movements or deflect or deter passage across them (Forman and Alexander 1998). Ockenfels et al. (1997) radio-tracked 37 pronghorn females and found that fenced roads and railways were barriers to movement and influenced the shapes of home ranges. In Alberta, we observed that the transportation corridor near Medicine Hat (Fig. 15.2) presents a significant impediment to migrating pronghorn; radio-tracked

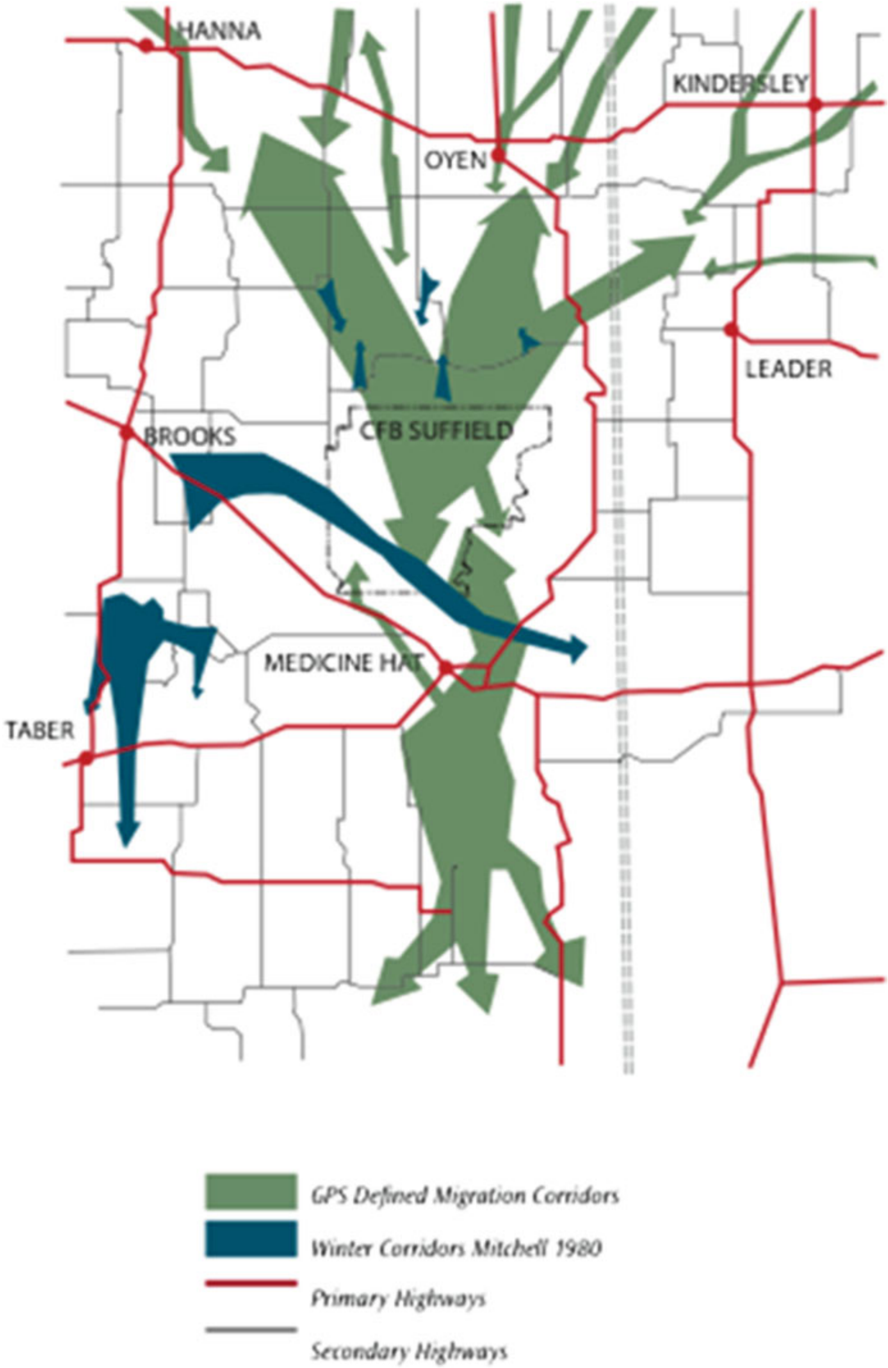

Fig. 15.3 Generalized movement corridors of GPS radio-collared pronghorn captured on winter range and winter movement pathways previously identified by Mitchell (1980) in Alberta, Canada. CFB Suffield is the Canadian Forces Base Suffield, a military training facility. Source: Alberta Conservation Association

Fig. 15.4 Pronghorn attempting to move through a suburban area on the outskirts of Medicine Hat, Alberta following a severe winter storm in November 2003. Photo: D. Eslinger

individuals (4-h GPS locations) were recorded moving back and forth along the transportation corridor for up to 10 days before finally crossing it. In southern Alberta, herds of pronghorn have been killed by trains during periods of deep snow cover. Pronghorn appear to be attracted to snow free railway tracks from which they cannot readily escape owing to fences and high snow banks.

Manufacturing of barbed-wire fences to contain domestic livestock on western rangelands was an emerging industry in 1870. In 1874, 4.5 tonnes of barbed wire was manufactured in the United States (MacCallum 1957; cited by Leftwich and Simpson 1978). By 1880, 36,000 tonnes were produced, increasing to 210,600 tonnes in 1945. Initially most fences were "drift fences", used to guide movements of livestock on extensive rangelands. Within a decade of barbed-wire fences first being erected on western rangelands, Canton (1877:48) reported that four-foot (1.2 m) high fences restricted pronghorn movements. Cross-fencing and fencing of smaller pastures became increasingly commonplace, further restricting the movement of pronghorn (Martinka 1967; Spillett et al. 1967; Hailey 1979). Although most fences are installed to control livestock, they also are constructed to control animal access to roads, highways and railroads, to protect agricultural crops, or to limit access of wildlife to private property or special land-use areas (e.g. mining operations, military installations).

Several studies have found that some fence designs, their location and density can affect pronghorn movements and distribution (Hailey and DeArment 1972; O'Gara and Yoakum 1992; Scott 1992; Sheldon 2005). Fences designed to confine

Fig. 15.5 Pronghorn struggling to move through wire fences (buck on *left*, doe on *right*). Photographed using automated cameras at Canadian Forces Base Suffield, Alberta. Source: M. Suitor, Alberta Sustainable Resource Development

traditional livestock (cattle, sheep or horses) or novel livestock (bison [*Bison bison*], elk [*Cervus elaphus*] or deer [*Odocoileus* spp.]) without regard for the ecological needs of free-ranging wild large mammals can act as partial or impermeable barriers to wildlife movements (Kie et al. 1994; Demarais et al. 2002; Yoakum 2004; Autenrieth et al. 2006; Gadd 2012). Fences also can be purposefully constructed to impede wildlife movements to protect crops (Palmer et al. 1985; Fritzell 1998) or reduce wildlife-vehicle collisions (Clevenger et al. 2001).

The effects of fences on the ecology of wildlife are expressed at different scales and levels of ecological organization, including partial to complete obstruction of daily movements, reduced access to seasonal habitat, food, cover and water, blockage or diversion of seasonal migration, increased energy demands, separation of juveniles from does, entanglement or impact injuries. Increased mortality from obstructive fences also can occur if traditional travel corridors are blocked and animals are forced into situations where vulnerability is high, such as along highways or railroad beds (Reed et al. 1974; Harrington and Conover 2006). Predators may push prey into fences to increase their chances of making a kill (Holzenbein and Marchinton 1992).

Although pronghorn have the physical ability to jump fences up to 2.5 m high (Spillett et al. 1967), they do so infrequently (Rouse 1954; Harrington and Conover 2006). Typically they crawl through or under barbed-wire fences. They have been observed to experience difficulty in crossing fences (Fig. 15.5), and may suffer injuries or become entangled in strand wire and die (Spillett 1965; Bear 1969; Oakley 1973; Kie et al. 1994; Sheldon 2005; Harrington and Conover 2006). Pronghorn are unable to pass under woven-wire fences and barbed-wire fences with low bottom wires (Yoakum 2004). On western rangelands, three or four strand barbed-wire fences with ~25 cm high bottom wires are common and represent a significant barrier to pronghorn movements. In a current study, we observed a large herd of pronghorn driven by adverse snow conditions temporarily stopped by such a fence as they

Fig. 15.6 Pronghorn exhibiting a mid-line dorsal wound likely caused by a low-strung barbed wire. Photo: Paul Jones, Alberta Conservation Association

attempted to move south of the Bodoin Wildlife Refuge in north-eastern Montana. In all seasons, we have observed pronghorns searching fence lines for feasible crossing opportunities. A well-documented catastrophe occurred in Wyoming in 1983 when several 100 migrating pronghorn died during harsh snow conditions as a result of being unable to cross a newly erected fence (Johnson 1988, cited by Cherney and Clark 2009). Injuries from barbed wire are common. Pronghorn captured in Alberta and photographed with automated cameras commonly had linear tissue injuries down the mid-line of their backs, which we inferred were caused by crawling under barb wire (Fig. 15.6).

In an analysis of minor highways and fences in northern Arizona, Bright and van Riper (2000) found fenced ROWs were greater barriers to movement than highways alone. Pronghorn will travel long distances parallel to fenced roads then cross the road where no fence is present (Bear 1969; Riddle and Oakley 1973; Sheldon 2005). In Wyoming, pronghorn selected habitats with the lowest fence densities (Sheldon 2005). Home ranges were bounded by fences in Arizona (Ockenfels et al. 1997; Ticer et al. 1999) and Wyoming (Sheldon 2005). In Alberta, we observed a distinct boundary effect on the distribution of pronghorn using CFB Suffield along the western and southern borders of the military base. This fence-line effect may have reflected the combined influence of boundary roads, fences and land use that reduced habitat quality adjacent to the military base. In Wyoming, pronghorn selected migration routes where they encountered fewer fences than random (Sheldon 2005). Similarly, in a current study in northern Montana and adjacent Saskatchewan, led by one of the authors of this chapter, movement data for radio-tracked animals indicates migrating pronghorn elect to move through areas with either no fences or highly permeable fences.

A combination of heavy traffic volume and fences can make fenced roads effective barriers or severe filters to pronghorn movements (Büechner 1950; Ockenfels et al. 1994). Fences have been shown to limit daily movements of pronghorn in winter in south-eastern Alberta and northern Montana, and accumulated snow can interfere with the ability of pronghorn to crawl under fences (Bruns 1977). Riddle and Oakley (1973) found the combined impacts of severe winter conditions and fences obstructed movements and led to increased mortality. Fences can reduce or prevent the use of previously used movement routes across highways (Büechner 1950; Ward et al. 1976; Guenzel 1986). Under adverse winter conditions in the absence of such obstructions we observed large herds of prairie pronghorn rapidly moving long distances, nose-to-tail, pushing towards distant ranges where conditions may be more favourable.

Land-Use Planning and Mitigation

As human populations continue to grow and economic activity shifts from east to west in North America, transportation infrastructure will inevitably become more elaborate. Road upgrading will include wider ROWs and top-widths, multiple-lanes, divided-lanes and fences. Consequently, the ability of pronghorn to move across transportation corridors is expected to decrease or perhaps be eliminated in some areas. To maintain connectivity within and between seasonal ranges it is increasingly important to design crossing structures that feasibly allow pronghorn to safely cross roadways (Sawyer and Rudd 2005). Placement of such structures in key linkage zones like the Trans-Canada transportation corridor near Medicine Hat and Montana Highway two area near Malta, Montana will require improving the awareness and cooperation of transportation, land management and wildlife agencies.

On a broad scale, conserving large tracts of native prairie by preventing conversion to croplands (intensive farming; e.g. Fargione et al. 2009) or large intensive industrial development (sub-surface minerals and wind energy; e.g. Sawyer et al. 2005; Pruett et al. 2009) and changing conventional livestock fences to wildlife-friendly fences (Autenrieth et al. 2006) represent important opportunities for advancing pronghorn habitat conservation and enhancement. For example, Gross et al. (1983) and Mapston (1970) tested gate structures that restrict domestic sheep but allow passage by pronghorn. They found specifically designed horizontal grills placed in fence corners effectively restricted sheep but pronghorn would leap over the grill (Fig. 15.7). An obvious solution to making impassable fences permeable to pronghorn is to leave gates open during periods when livestock are not in a pasture.

Pronghorn will readily cross under well-designed fences where there is sufficient space between the bottom wire and the ground (Gregg 1955: 57 cm; Cole 1956: 43 cm; Autenrieth et al. 2006: 41–46 cm). Most western wildlife agencies have published guidelines for wildlife-friendly fences (Arizona, Alberta, Colorado, Montana,

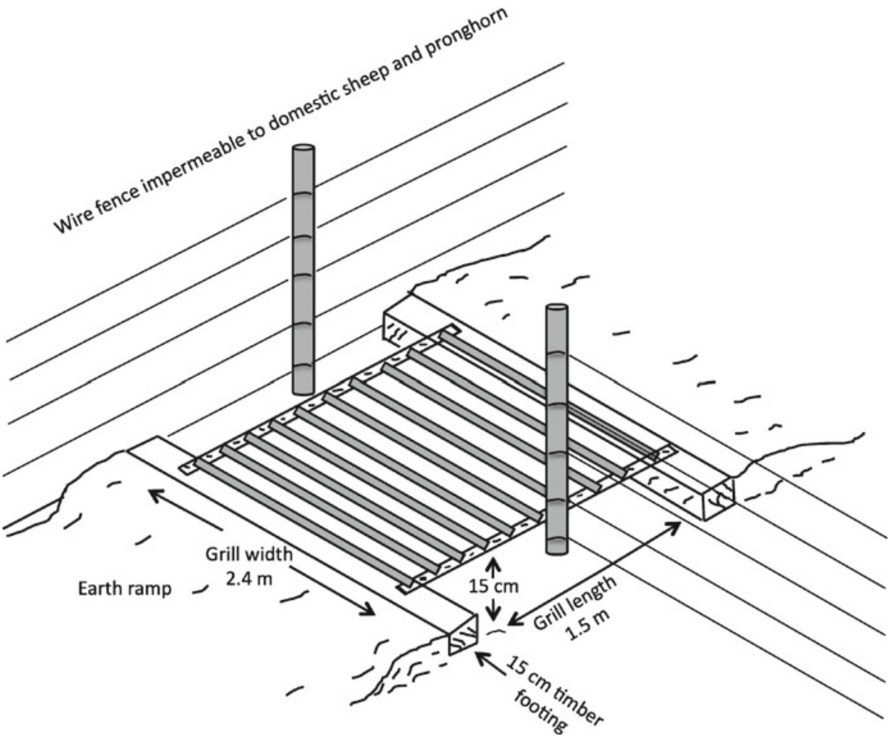

Fig. 15.7 Design and placement of a welded tubular metal grill that allows passage of pronghorn in an otherwise impermeable fence line. Adapted from Gross et al. (1983) and Mapston (1970)

North Dakota, Washington, Wyoming). As an example, the MultiSAR Program in Alberta (http://www.multisar.ca/documents/fencingBMP.pdf) provided a design for a wildlife-friendly fence that considered passage by pronghorn and deer species (Fig. 15.8).

Cooperative actions by agencies and NGOs can play an important role in improving landscape permeability for pronghorn. In Wyoming, backed by a court decision, the Wyoming Wildlife Federation successfully forced the removal of a woven-wire fence from a rancher's property after pronghorn were blocked from their winter habitat on public land and hundreds died during the tough winter of 1983–1984. Citizen groups may volunteer to modify fence lines to accommodate pronghorn movements in local areas. In the late 1980s, the California Department of Fish & Game reintroduced pronghorn into the Carrizo Plain. A joint effort between the Sierra Club, ForestWatch, Desert Survivors and the California Department of Fish & Game was organized to remove or modify fences, with the goal of restoring free pronghorn movements. Together the non-profit organizations and state and federal agencies worked to remove or modify more than 240 km of fencing. In Charles M. Russell National Wildlife Refuge in Montana fences are being removed from areas where containment of livestock is no longer necessary. In eastern Montana, the US

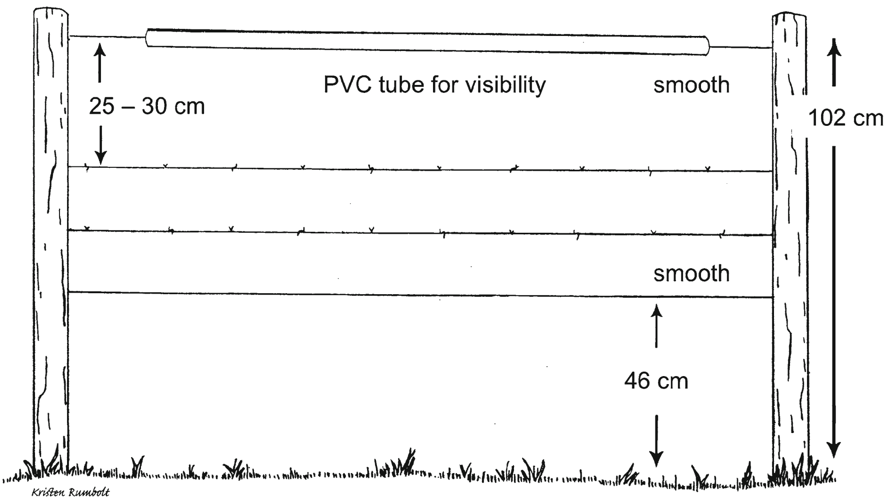

Fig. 15.8 Design of a wire fence for containing cattle yet allowing free passage of pronghorn under the bottom wire. Note use of smooth top and bottom wires to prevent injuries. Split PVC tubing can be used to increase visibility of the top wire in high frequency crossing areas used by wild ungulates. Source: Alberta Conservation Association

Bureau of Land Management is converting fences on land it manages to make them friendlier to wildlife movements.

In 2009, the Alberta Fish and Game Association, with assistance from the Alberta Conservation Association and the Alberta Fish and Wildlife Division, undertook a project to replace the bottom barbed wire with raised double-strand barbless wire along the 37 km northern boundary fence line of CFB Suffield. Officials at CFB Suffield were encouraged by the pilot project and continued the effort. To date 153 km of boundary fence has been modified. Sparked by success of the CFB Suffield projects, other initiatives have moved forward in Alberta. For example, fences are being retrofitted at Antelope Creek Ranch, a model ranch in the mixed-grasslands of Alberta.

Conclusions

Grasslands of the Northern Great Plains were substantially altered for crop production early in the twentieth century. Remaining native range is used predominantly for livestock grazing, although the energy sector has increased its footprint incrementally during the past 2 decades. Fences were first used to guide livestock movements but as pasture size decreased and the road network was elaborated, the density of fences has increased. Conventional fencing designed to contain cattle (three or four strands of barbed wire) with the bottom wire set at about 25 cm above grade is relatively impermeable to pronghorn. Woven-wire fencing is impermeable. Recent research has shown that pronghorn select large contiguous areas of native habitat. Roads and fences diminish habitat effectiveness and effective patch size.

Pronghorn may undertake long-distance movements to escape deep snow, then return to traditional fawning and summer ranges in the spring. Such movements may occur at a regional scale. Migration corridors in Alberta, Saskatchewan and Montana are largely located within large tracts of native grassland. Local bottlenecks associated with natural terrain features, urban expansion and major transportation corridors have been identified as key linkage areas threatened by incremental development. Mitigation of transportation impediments in key linkage zones may be possible with the construction of appropriate crossing structures. Mitigation of the effects of fences on movements and distribution is possible and is indeed encouraged by most jurisdictions with published guidelines for wildlife-friendly fences. Non-profit organizations can play an important role by undertaking cooperative projects to modify fences in strategic locations to facilitate passage by pronghorn.

The connection between migration and population dynamics of partially migratory ungulates remains poorly understood (Bolger et al. 2007), but obstruction of migratory pathways can be expected to result in negative impacts. Although the pronghorn remains a relatively common species in many areas of western North America, without appropriate land-use planning and management, cumulative anthropogenic changes will continue to erode habitat, and alter the suitability of movement corridors and key linkage zones supporting movements within and between seasonal ranges.

In the context of eco-regional planning, the pronghorn requires conservation of large areas of native habitat connected by corridors that allow long-distance movements to various winter ranges during harsh conditions. Plans that focus on maintaining the ecological coherence of landscapes (Opdam et al. 2003) for common species like the pronghorn should also benefit conservation of other native grassland species.

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