Effects of an operational coal mine on pronghorn antelope
by Thomas Bruce Segerstrom

A thesis submitted in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE in Fish and Wildlife Management
Montana State University

Abstract:
Pronghorn antelope (Antilocapra americana) habitat use, movements, and reactions to human activity at a coal strip mine south of Gillette, Wyoming, were examined from 1978 to 1980. No detrimental effects of mining were evident in population density, reproduction or sex ratios. Antelope movements were nonmigratory and opportunistic. Telemetry and ground route observations indicated that revegetated mine lands were primarily used by antelope for foraging, although all types of activities were observed. Physical habitat losses from mining were about 1.6 square kilometers and constant between years, Psychological habitat losses in proximity to the mine varied from 4.1 to 5,5 kilometers between years. During 1978 and 1979 naturally occurring habitat parameters and selected human associated habitat factors explained a large degree (39 and 44 percent, respectively) of the variation in the number of antelope observed on the control site.

Less of the observed variation (3 and 31 percent, respectively) could be explained on the mine site. Spatial relationships between antelope and human activity indicated avoidance of human activity regardless of the visibility of the activity to antelope. Pronghorns tended to keep human activity in view when in close proximity to it. Distances from antelope to light vehicles and humans on foot, disturbances which were erratic in occurrence and movements were significantly greater ($P<0.05$) than the average distance to a disturbance. Distances from antelope to human activities that were predictable and repetitious in their movements were significantly lower ($P<0.05$) than the average. Antelope behavioral reactions to human activity were generally of low intensity, and habituation to human activity on the mine site was evident.

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Date March 5, 1982

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ABSTRACT

Pronghorn antelope (*Antilocapra americana*) habitat use, movements, and reactions to human activity at a coal strip mine south of Gillette, Wyoming, were examined from 1978 to 1980. No detrimental effects of mining were evident in population density, reproduction or sex ratios. Antelope movements were nonmigratory and opportunistic. Telemetry and ground route observations indicated that revegetated mine lands were primarily used by antelope for foraging, although all types of activities were observed. Physical habitat losses from mining were about 1.6 square kilometers and constant between years. Psychological habitat losses in proximity to the mine varied from 4.1 to 5.5 kilometers between years. During 1978 and 1979 naturally occurring habitat parameters and selected human associated habitat factors explained a large degree (39 and 44 percent, respectively) of the variation in the number of antelope observed on the control site. Less of the observed variation (3 and 31 percent, respectively) could be explained on the mine site. Spatial relationships between antelope and human activity indicated avoidance of human activity regardless of the visibility of the activity to antelope. Pronghorns tended to keep human activity in view when in close proximity to it. Distances from antelope to light vehicles and humans on foot, disturbances which were erratic in occurrence and movements were significantly greater ($P<0.05$) than the average distance to a disturbance. Distances from antelope to human activities that were predictable and repetitious in their movements were significantly lower ($P<0.05$) than the average. Antelope behavioral reactions to human activity were generally of low intensity, and habituation to human activity on the mine site was evident.

INTRODUCTION

The world's largest and most productive pronghorn antelope (*Antilocapra americana*) populations occur on the prairies of Wyoming and Montana (Buechner 1960, Hockley 1968, Pyrah 1976, Vriend and Barrett 1978). These populations exist on lands which hold the nation's largest stripable coal reserves (U. S. Department of Interior. 1974).

More than 203.5 square kilometers (km^2) of rangeland may be mined in the Eastern Powder River Basin by 1995 (BLM, unpublished data). In southwestern and southcentral Wyoming mining western coal reserves will physically disturb or impact an estimated 213 km^2 and 1,830 km^2 of critical and general pronghorn habitat, respectively (Strickland 1977). Temporary impacts resulting from the physical presence of operational mines on surrounding areas will occur during the decades that each mine operates and produces coal. Upon completion of mining, large blocks of pronghorn habitat will be left with drastically altered vegetation, topography, and soil structure.

This study was initiated to determine the effects of an operational coal strip mine on pronghorn habitat use and to gain insight into the effectiveness of reclamation by documenting antelope use of revegetated areas.

Field research was conducted at the AMAX Belle Ayr Mine in Campbell county, in northeastern Wyoming, during spring and summer, 1978, 1979, and 1980. Research was also conducted on selected weekends in the fall and winter of those years.

DESCRIPTION OF STUDY AREAS

Three areas were studied at the Belle Ayr site. The experimental site was a 2,500 hectare (ha) area within 1 kilometer (km) of the AMAX Belle Ayr mine located 29 km south of Gillette, in Campbell county, Wyoming (Figure 1). Mining activity within this area had been intensive since 1970 when mine construction was begun. The mine was a truck-and-shovel operation that, during maximum production, operated on a 3-shift schedule, 7 days per week with the exception of Saturday evening and Sunday mining closures. During closures only management, maintenance and security personnel were present.

The control site was located 8 km west of the Belle Ayr mine. The area was approximately 1,800 ha in size, consisting of rangeland owned by the AMAX Coal Company and private ranchers. The private lands, with restricted access, received less human activity than the experimental site. Human activity levels on the control site were typical of levels occurring on private land throughout Campbell county. A third area, the buffer, was located between the experimental and control sites. The buffer was about 2,900 ha in size and was used with aerial census data analysis.

The areas were traversed by Caballo Creek and had rolling topography with draws and ridges generally oriented in a northwest-southeast direction. The annual precipitation averaged 37.8 centimeters (cm), with an April-June peak (U.S. Department of Interior 1974). Spring 1978

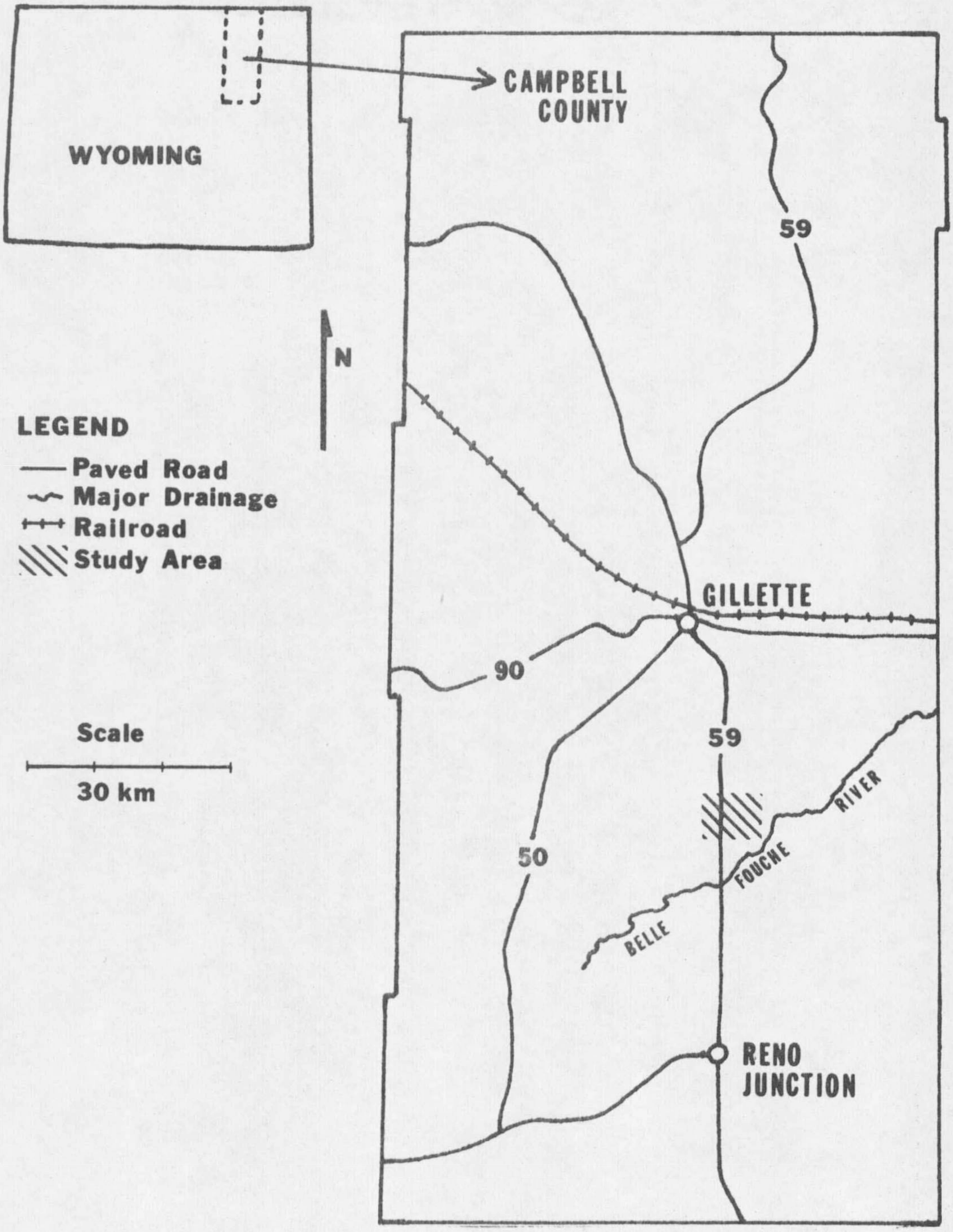

Figure 1. Location of the Belle Ayr study site in Campbell county, Wyoming.

was very wet and winter 1979 was very severe (Table 1). Elevations on the study areas ranged from 1,372 to 1,433 meters (m).

Table 1. Mean monthly precipitations and temperatures during 1978 and 1979 at the Belle Ayr study site and deviations from 30-year averages for Gillette, Wyoming.

Year	Month	Precip. total (cm)	Dev. from mean (cm)	Mean temp. (c^o)	Dev. from mean (c^o)
1978	Jan	2.0	+0.4	-9.4	-3.8
	Feb	2.9	+1.7	-7.3	-3.2
	Mar	1.3	-1.4	1.0	+1.5
	Apr	3.6	-0.6	6.3	+0.3
	May	19.1	+13.4	9.9	-1.8
	Jun	3.5	-3.1	15.9	-0.5
	Jul	5.0	+3.2	19.6	-2.6
	Aug	0.6	-1.8	18.8	-2.4
	Sep	1.0	-1.7	15.4	+0.1
	Oct	0.7	-1.1	6.7	-2.4
	Nov	3.3	+1.4	-3.6	-4.2
	Dec	3.0	+1.4	-10.3	-7.3
1979	Jan	1.6	0.0	-15.6	-10.0
	Feb	1.8	+0.6	-8.3	-4.2
	Mar	0.6	-2.1	0.6	+1.1
	Apr	0.7	-3.5	5.0	-1.0
	May	2.6	-3.0	9.4	-2.2
	Jun	5.4	-1.2	16.7	+0.2
	Jul	6.0	+2.8	21.1	-1.1
	Aug	5.3	+2.9	18.9	-2.3
	Sep	0.3	-2.5	16.7	+1.3
	Oct	1.1	-0.7	8.3	-0.8
	Nov	1.5	-0.5	-2.2	-2.8
	Dec	0.6	-1.0	-0.9	+2.2

The vegetation of the study areas was a mixed prairie association of tall grasses with an understory of shorter grasses (Weaver and

Albertson 1956). Dominant tall grasses included needle and thread grass (*Stipa comata*), bluebunch wheatgrass (*Agropyron spicatum*), prairie junegrass (*Kolera cristata*), western wheatgrass (*Agropyron smithii*), and cheatgrass (*Bromus tectorum*). Shorter graminoids, which dominated some sites, included blue grama (*Bouteloua gracilis*), canby bluegrass (*Poa canbii*), and threadleaf sedge (*Carex filifolia*).

Common forbs and half-shrubs were scarlet globemallow (*Sphaeralea coccinia*), scurf pea (*Psoralea* spp), prickly pear (*Opuntia polycantha*), and fringed sagewort (*Artemisia frigida*). Sagebrush communities (*Artemisia tridentata* and *A. cana*) were common in uplands on both the mine and control sites. Greasewood (*Eurotia lanulata*) communities dominated the stream bed areas on the control site. More detailed vegetative, meteorological and pedological descriptions are available in an Environmental Impact Statement on the Belle Ayr coal mine prepared by Thorne Ecological Institute (1974).

METHODS

Aerial Censuses

In 1978, aerial counts of antelope were made once each month during August, October, and November. Flights in 1979 were made once in February and once each month from April through November. Additional flights were made once in February and once again in June of 1980.

The flights covered a 58 km^2 area that included the mine, buffer, and control sites. A Cessna 172 was used to fly north-south lines approximately 7 km long and 0.8 km apart. Lines were flown at approximately 60 m elevation at as slow a speed as possible. Flights were made only on calm, clear mornings.

Antelope were counted on both sides of the aircraft and their locations mapped. Age (fawn:doe) and sex ratios were determined from animals classified during the July and August 1979 flights.

Radio Telemetry

Seven pronghorns, 3 in 1978 and 4 in 1979, were immobilized with powdered succinylcholine chloride using pneu-dart[R] projectiles powered with powder charges (Amstrup and Segerstrom 1981). All animals were instrumented with radio collars from Davtron Inc. and AVM Instrument Co., and monitored 3 times per week at varying times of day. Collared animals were relocated once every 2 hours for 24 hour periods on 8 occasions in summer and fall, 1978.

Animals were relocated by triangulation and verified visually when possible. Relocations were utilized to determine seasonal and daily movements and home range sizes using the least pentagon method (Hayne 1949). The vegetation types, aspect, slope, and terrain being used by the antelope at the time of relocation were also recorded.

Habitat Losses

Physical habitat losses were areas made physically unsuitable for antelope use and were measured using a planimeter on 1/1,000 scale aerial photographs provided by AMAX. Psychological habitat losses (areas not used by pronghorns even though the area appeared, to the investigator, to provide usable habitat) were delineated using pronghorn sightings on replicated surveys of the mine margins and relocations of radio-collared animals to determine the area around the mine where antelope were not observed.

Ground Route Observations

Systematic observations were made from 3 selected routes on the mine site and 2 routes on the control site. Routes were covered by foot or vehicle. Each consisted of a series of observation stations from which the surrounding area could be searched. A minimum of 10 minutes were spent at each station. The area observed from the stations was restricted to an ocularly estimated 0.8 km to allow accurate aging and sexing of antelope. When moving between stations speed was restricted to no more than 24 km per hour, and the area scanned was reduced to 0.4 km. Routes were replicated 3 times per month during June through November, 1978 and 1979. Routes covered an area of 939 ha on the control site in both years, and mine routes covered 2,000 ha in 1978 and 2,473 ha in 1979 as the area disturbed by mining increased.

Observations of antelope were plotted on 1:24,000 topographic maps. Information recorded for each sighting included age, sex, and activity of the antelope, vegetation type, terrain type, slope, aspect, and distance to human activity. Temperature, wind speed, and precipitation data were obtained from weather monitoring stations at the mine site and from the Agricultural Experimental Station in Gillette, Wyoming.

Vegetation and Terrain Classification

Vegetation types (Table 2) were delineated on the basis of the presence or absence of woody shrubs, cultivation, and/or stage of revegetation, or past coal extraction. Species frequency and canopy coverage for species in each type were determined using 2X5 dm frames (Daubenmire 1959) (Appendix Tables 34-39). Shrub densities and canopy coverage were determined by the point-centered-quarter method (Cottam and Curtis 1956) (Appendix Table 40). Terrain was classified into 5 types based on topographic diversity in elevation and slope (Table 2).

Table 2. "Permanent" habitat factors used for analysis of ground route information on the mine and control sites at the Belle Ayr study site, Gillette, Wyoming, 1978 and 1979.

Vegetation types	Disturbances
1) Producing hayfield	1) Oil well
2) Idle hayfield	2) Paved road (mine access)
3) Improved range	3) Paved road (highway)
4) Reclaimed spoil	4) Dirt road (ranch road)
5) Reclaimed topsoil	5) Dirt road (county road)
6) Reclaimed land-seeded	6) Security road
7) Grassland	7) Railroad tracks
8) Sagebrush/grassland	8) Transformer
9) Bareground/scraped	9) Mine office, shop complex
10) Greasewood	10) Pit
	11) Dwelling
Terrain types	12) Security shack
	13) Explosives trailer
1) Flat bench	14) Reclamation trailer/shop
2) Flat plateau	15) Haul road
3) Rolling slopes	
4) Steep slopes	**Distance to Disturbance Classes**
5) Ridgetop	
	1) Contact to 0.4 km
	2) 0.4 - 0.8 km
	3) 0.8 - 1.2 km
	4) 1.2 - 1.6 km
	5) Greater than 1.6 km

Computer Analysis of Route Data

Habitat units were developed, each being characterized by a single vegetation, terrain, and distance relationship to disturbance factors within 1 km. To adjust for differences in sizes of the units a variable "Area" was introduced. Seasonal adjustments were also included in the analysis (Summer = Jun.-Aug.; Fall = Sept.-Oct.).

The difficulties encountered in determining the availability of some of the habitat parameters recorded on routes necessitated analysis of these data in 2 parts. The parameters were divided into "varying" and "permanent" (Tables 2 and 3). "Varying" included 2 classes: (1) irregularly occurring disturbances, such as vehicles and humans on foot, which could not be systematically sampled, and (2) terrain characteristics, such as slope and aspect, that could not be measured by techniques used in the study. "Permanent" habitat parameters included natural and man-made features which could be mapped accurately and systematically sampled.

The analysis of the "varying" factors began with the derivation of frequency distribution tables and a simple correlation matrix (Nie et al. 1975). From these, factors that were to be included in further analysis were determined. Factors that were highly correlated ($r>0.6$) were combined or deleted based on the investigators knowledge of the site and pronghorn behavior (Appendix Table 41). Parameters retained after this selection process were subjected to a forward stepwise regression analysis (Nie et al. 1975) to determine the relationship of each factor to observed antelope numbers.

"Permanent" habitat factors were also screened using a simple correlation matrix to determine factor multicolinearity. Highly correlated factors ($r>0.6$) were combined or deleted. A forward stepwise

Table 3. "Varying" habitat factors used for analysis of ground route information on the mine and control sites at the Belle Ayr study site, Gillette, Wyoming, 1978 and 1979.

Disturbances	Aspects
1) Trains (engines and cars)	1) None (flat)
2) Car traffic	2) North
3) Heavy truck traffic	3) Northeast
4) Security or mine truck	4) East
5) Ranch truck	5) Southeast
6) Tractors	6) South
7) Scrapers (heavy machinery)	7) Southwest
8) Human on foot	8) West
9) Human on horseback	9) Northwest
10) Human on motorcycle	
11) Dog	
12) Cattle	
13) Sheep	
14) Horses	
15) Drilling rig	
16) Aircraft	
17) Parked vehicle	
Distance to Disturbance Classes	
1) Contact to 0.4 km	
2) 0.4 - 0.8 km	
3) 0.8 - 1.2 km	
4) 1.2 - 1.6 km	
5) Greater than 1.6 km	
Slope Classes	
1) Zero percent	
2) 1-5 percent	
3) 5-10 percent	
4) 10-15 percent	

regression was then utilized to determine the relation of each factor to observed antelope numbers.

The most significant factors from the forward stepwise regression analysis of "permanent" factors were utilized in an analysis of covariance (Nie et al. 1975). The mine and control sites were analyzed separately because of differences in the abundance of roads and structures on the 2 areas. Route data for 1978 and 1979 were also analyzed separately because the severe winter of 1978-1979 affected pronghorn densities on the study area.

Random Point Comparisons

A random point comparison technique (Steve Amstrup pers. comm.) was used to determine spatial relationships between antelope and potential disturbance factors. Random point locations were generated by computer using the transverse mercator system. The random locations were visited, and vegetation type, terrain type, nearest human activity, and distance to the activity (estimated from 1:24,000 topographic maps using a 0.1 km grid) at each point were noted. Parameters recorded at random locations were compared to similar parameters recorded for antelope locations randomly selected from the ground route observations on the mine site.

To determine if sets of computer-generated random points were appropriate for testing spatial relationships between antelope and disturbances, the mean distances from subsets of the random points to