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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ON PRONGHORN ANTELOPE

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF TABLES (CONTINUED)

LIST OF TABLES (CONTINUED)

LIST OF TABLES (CONTINUED)

LIST OF TABLES (CONTINUED)

LIST OF FIGURES

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

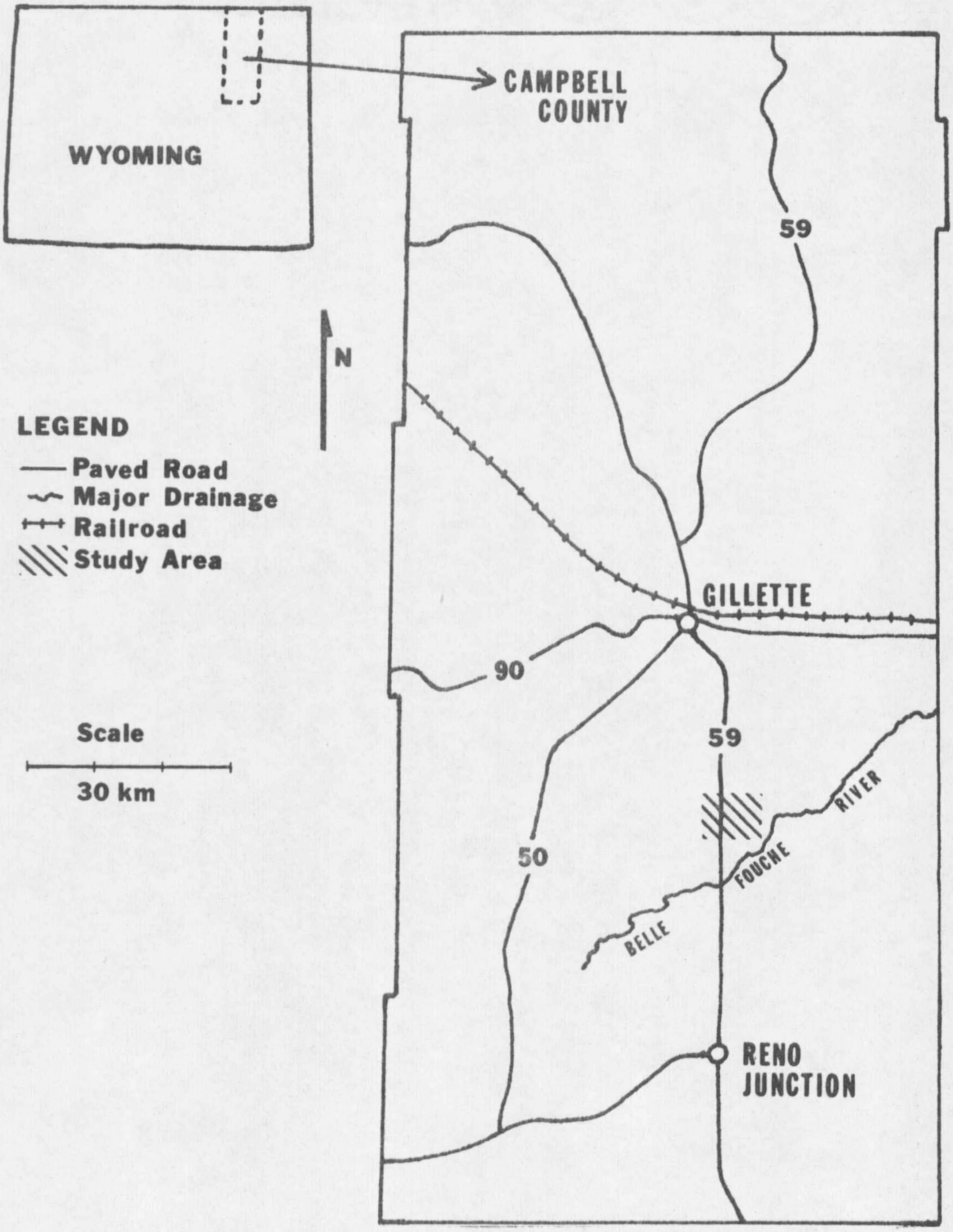

Figure 1. Location of the Belle Ayr study site in Campbell county, Wyoming.

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 the nearest human activity were tested against the mean distance to a disturbance (MDTD) for all random points using Student's t-tests.

Behavioral Observations

A behavioral observation technique (Amstrup pers. comm.) was used to assess impacts of disturbances on pronghorns. At 5-minute intervals, activity, vegetation type use, and terrain type use by all pronghorns under observation were recorded. The number and types of human activities occurring and the reactions of the observed antelope were also recorded.

Antelope reactions were rated by intensity (Appendix Table 41) based on the energy requirements of the behavioral response (e.g. rapid flight would demand greater energy expenditures than a vigilant stare). Data from mine and control sites were analyzed separately.

RESULTS

Population Characteristics

Antelope densities determined from aerial censuses (Figure 2) were high in 1978, decreased dramatically during winter 1978-1979, and increased again in summer 1979. Densities were significantly influenced ($P<0.05$) by both site and season (Table 4), but densities were not consistently lower on the mine than the control site (Table 5). The buffer zone had higher densities than either the mine or control, but this difference was significant ($P<0.05$) only during spring and early summer and November 1979.

The ratios of fawns per 100 does determined from ground observations (Table 6) for the mine and control were not significantly different ($P>0.05$) in 1978 but were in 1979. The proportion of control site fawns observed in summer 1979 was significantly less ($P<0.05$) than the number observed on the mine (Table 7). Fawn:doe ratios observed from aerial censuses in 1979 were not significantly different ($P>0.05$), 2x2 contingency test) on the mine site than either the buffer or control site (Table 8). Male:female ratios (Table 9) on the mine site were not significantly different from those on the control site in 1978 or 1979 ($P>0.05$).

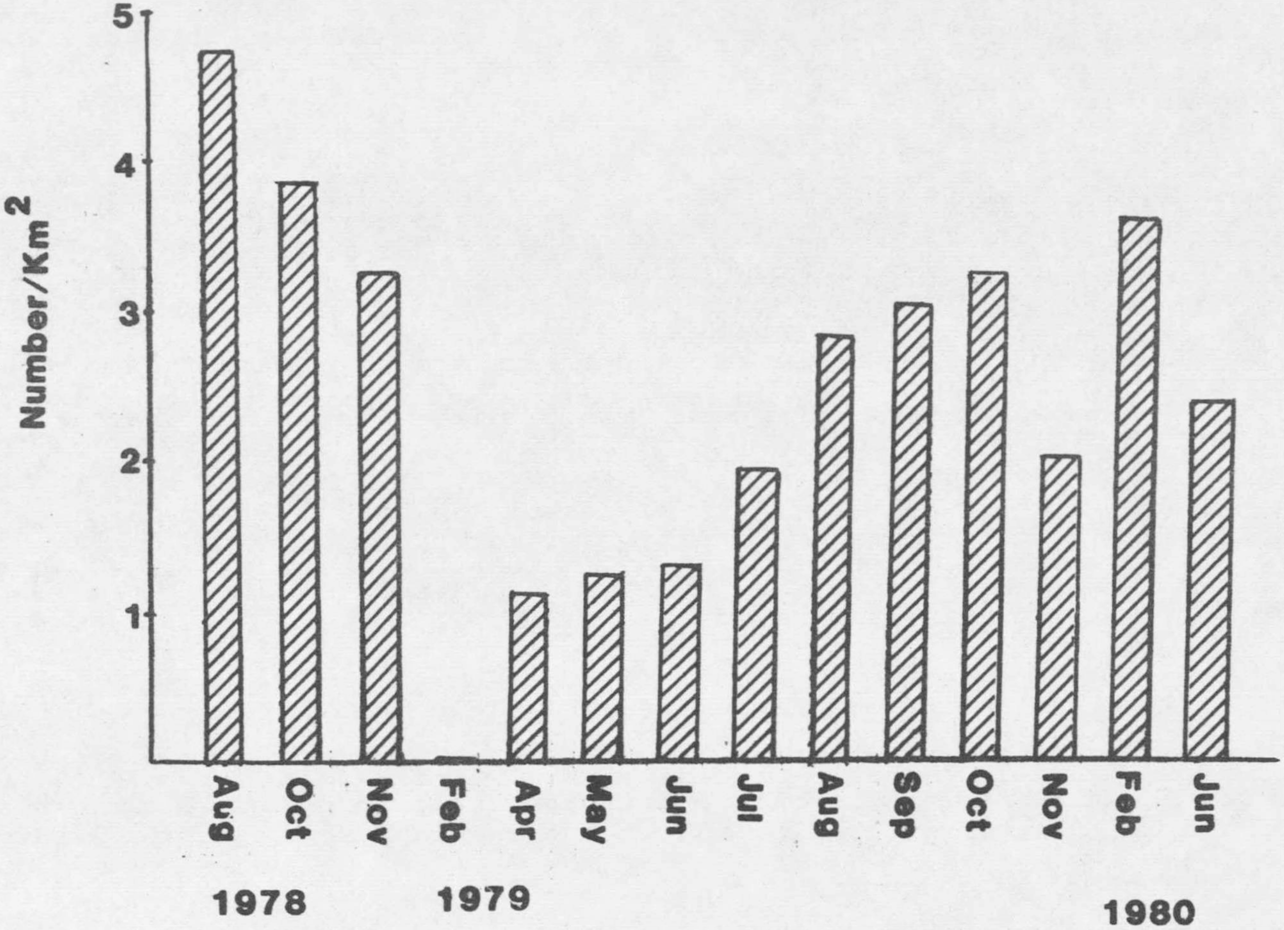

Figure 2. Antelope densities (number per km^2) determined from aerial censuses at the Belle Ayr study site, Gillette, Wyoming, 1978-1980.

Table 4. The relationship between season and site and antelope (number per km^2) observed on aerial censuses at the Belle Ayr study site, Gillette, Wyoming, 1978-1979.

Source	D.F.	S.S.	M.S.	F-Value	P-Value
Site	2	901.7	450.9	10.230	0.0017
Season	4	1285.0	321.2	7.286	0.0010
Interaction	8	532.5	66.6	1.510	0.2127
Error	21	925.8	44.1		

Table 5. Antelope densities (number per km^2) by season and site on the mine, buffer, and control sites and the results of a 2-factor analysis of variance, Gillette, Wyoming, 1978-1980.

	Apr-May	Jun-Jul	Aug-Sep	Oct†	Nov†	$\bar{X}$
Mine	0.5^{a*}	4.3^{a}	4.3	3.2	2.4	2.3
Buffer	1.9^{b}	3.1^{b}	4.6	4.5	4.7^{a}	3.7
Control	1.2	2.2	1.9	3.2	1.3^{b}	2.0
$\bar{X}$	1.2	2.1	3.6	3.7	2.8	

*a and b are significantly different at $P<0.05$.

†October = Fall during hunting season; November = Fall after the hunting season.

Movements

Seasonal home ranges indicated that animals which were associated with the mine were yearlong residents (Table 10). Excluding the unusual winter exodus in 1978-79, seasonal shifts of home ranges

Table 6. Number of fawns per 100 females observed from ground censuses at the Belle Ayr study site, Gillette, Wyoming, 1978 and 1979.

	1978				1979			
Month	Mine	(N)*	Control	(N)*	Mine	(N)*	Control	(N)*
Jun	46	(131)	32	(151)	22	(79)	12	(38)
Jul	74	(151)	80	(133)	113	(202)	73	(85)
Aug	88	(241)	116	(69)	140	(204)	108	(81)
Sep	100	(70)	86	(26)	152	(159)	111	(19)
Oct	121	(177)	55	(31)	128	(198)	100	(24)
Nov	55	(183)	56	(89)	121	(168)	109	(69)

*Total number of fawns and females observed.

Table 7. Number of fawns and females by season observed from ground census data from the Belle Ayr study site and results of a contingency analysis, 1979.

	Mine		Control		Total	
	Su[a]	Fa[b]	Su	Fa	Su	Fa
Fawns	240[c]	299	82[c]	58	322	357
Females	245	226	122	54	367	280
Totals	485	525	204	112	689	637

[a]Su consists of the months June through August.

[b]Fa consists of the months September through November.

[c]Value is significantly different from expected ($P<0.05$).

Table 8. Number of fawns and does counted on the mine, buffer, and control sites during aerial censuses at the Belle Ayr study site, Gillette, Wyoming, July and August, 1979.

	Mine		Buffer		Control		Totals	
	July	Aug	July	Aug	July	Aug	July	Aug
Fawns	11	45	51	26	37	33	99	104
Females	12	46	26	18	33	32	71	96
Fawns per 100 females	91.7	97.8	196.2	144.4	112.1	103.1	139.4	108.3

Table 9. Number of males per 100 females observed from ground censuses at the Belle Ayr study site, Gillette, Wyoming, 1978 and 1979.

	Mine				Control			
Month	1978	(N)[a]	1979	(N)[a]	1978	(N)[a]	1979	(N)[a]
Jun	90.0	(171)	30.8	(85)	40.3	(160)	20.6	(41)
Jul	81.6	(158)	13.7	(108)	68.9	(125)	16.3	(57)
Aug	80.5	(231)	17.7	(100)	125.0	(72)	10.3	(43)
Sep	54.3	(54)	20.6	(76)	50.0	(21)	44.4	(13)
Oct	31.3	(105)	16.1	(101)	40.0	(28)	33.3	(16)
Nov	62.7	(192)	13.2	(86)	29.8	(74)	12.1	(37)

[a]Total number of adult males and females observed.

appeared to be opportunistic. These movements ranged from 2 to 4 km. No specific wintering, summering, or fawning areas could be determined. Movements around the mine may have been hindered but were not

Table 10. Seasonal home ranges (km^2) of pronghorns by season at the Belle Ayr study site, Gillette, Wyoming, 1978 and 1979.

	May	Jun-Aug	Sept-Oct
Adult female #45+	0.5	1.1	0.9
Adult female #0−		0.8	1.5
Adult female #1−		1.2	0.8
Adult female #2−		1.2	0.5
Yearling male #3−		1.2	-
Adult male #50*		2.5	-

+Animal was instrumented during both 1978 and 1979.

*Animal was instrumented during 1978 only.

−Animal was instrumented during 1979 only.

prohibited. Daily home range sizes for telemetered animals are shown in Appendix Table 42.

Habitat Use

Vegetation Type Use

The sagebrush/grassland vegetation type received nearly half of the total recorded use by pronghorns telemetered in 1979 (Table 11). Antelope telemetered on the mine site which had access to reclaimed land made more use of reclaimed areas than expected ($P<0.05$) when compared to availability (Table 12). Reclaimed lands were used largely for foraging by telemetered antelope (Table 13).

Table 11. Summer and fall use of vegetation types by 10 pronghorns telemetered at the Belle Ayr study site, Gillette, Wyoming, 1979.

Vegetation Type*	Number of relocations	Percent
Producing hayfield	44	21.4
Idle hayfield	6	2.9
Reclaimed land	27	13.2
Grassland	27	13.2
Sagebrush/grassland	101	49.3

*Composition of vegetation types is shown in Appendix Tables 34-40.

Table 12. Use of vegetation types by instrumented pronghorns on the mine site compared with availability of vegetation types on the mine site at the Belle Ayr study site, Gillette, Wyoming, 1979.

	Number of relocations July-Nov N=87	Availability of mine site vegetation types %
Hayfield	2	15.8
Idle hayfield	5	2.4
Reclaimed lands	27 (+)*	11.3
Grassland	23	20.6
Sagebrush/grassland	30	49.5
Improved range	0	0.4

*(+) denotes greater than expected use when compared with availability at P<0.05.

Table 13. Activities of instrumented pronghorns observed on mine site reclaimed land at the Belle Ayr study site, Gillette, Wyoming, 1979.

	Number of relocations N=27
Bedded	6
Foraging	17
Standing alert	4

Pronghorns observed from ground routes in 1978 on the mine site made use of hayfields more than expected in summer and fall (Table 14) and reclaimed spoil and topsoil storage areas more than expected during fall ($P<0.05$). Pronghorns made use of grassland types less than expected in both seasons and made use of the sagebrush/grassland type less than expected in fall. Antelope on the control site made greater than expected use of the improved range type in summer and greater than expected use of the sagebrush/grassland type in the fall ($P<0.05$).

The lower density antelope population on the mine site in 1979 used reclaimed spoil more and reclaimed topsoil storage areas less than expected during summer ($P<0.05$). During fall 1979, mine site antelope made use of the hayfield and idle hayfield vegetation types more than expected ($P<0.05$). Antelope made less than expected use of reclaimed spoil during fall. On the control site, pronghorns made

Table 14. Antelope use of vegetation types on the mine and control sites on the Belle Ayr study site, Gillette, Wyoming, 1978 and 1979.

	Mine Site						Control Site					
	1978			1979			1978			1979		
Vegetation type	% of total area	Su[a]	Fall[b]	% of total area	Su	Fall	% of total area	Su	Fall	% of total area	Su	Fall
Producing hayfield	8.5	122[c](+)	184(+)	15.8	77	165(+)						
Idle hayfield	7.3	75	27	2.4	21	47(+)						
Improved range	0.3	0	0	0.4	2	0	11.8	39(+)	4	11.8	41	0
Reclaimed spoil	6.2	41	49(+)	7.0	72(+)	0(-)						
Reclaimed topsoil	0.5	2	30(+)	3.3	0(-)	29						
Reclaimed seeded	0.4	4	0	1.0	0	0						
Grassland	28.5	187(-)	26(-)	20.6	100	97	20.2	54(-)	32(-)	20.2	14(-)	0
Sagebrush/grassland	48.3	522	123(-)	49.5	245	274	49.0	766(-)	202(+)	49.0	176(+)	53(-)
Greasewood							19.0	37(-)	11(-)	19.0	4(-)	47(+)

[a]Su consists of the months June–August.

[b]Fa consists of the months September–November.

[c]Number of antelope observed.

(+)Greater than expected use at $P<0.05$.

(-)Less than expected use at $P<0.05$.

use of the sagebrush/grassland type more than expected during the summer months and less than expected during the fall ($P<0.05$). The reverse occurred on the greasewood type.

Terrain Use

In 1978 antelope observed from ground routes on the mine site showed a seasonal shift in use of terrain from greater than expected use of steep sites in summer to a preference for flat benches in fall ($P<0.05$, Table 15). Antelope on the control site shifted from greater than expected summer use of steep terrain to greater than expected use of rolling terrain ($P<0.05$). In 1979 the steep terrain type again received greater than expected use in summer on both mine and control sites ($P<0.05$). During fall, however, only flat plateau terrain type on the control site received antelope use that was significantly different (less) than expected ($P<0.05$).

Aspect Use

Thirty-two percent of all the relocations of telemetered antelope in 1979 were on south aspects (Table 16). Antelope on the mine site observed from ground routes used west (27.5%) and east (19.8%) aspects most heavily during summer 1978 (Table 17). East (24.1%) and northeast (16.4%) aspects were most frequently used during summer 1979. In fall 1978, flat areas (47.9%) and north (19.3%), west (15.3%), and east aspects (10.4%) were most frequently used. Antelope made use of

Table 15. Antelope use of terrain types on the mine and control sites at the Belle Ayr study site, Gillette, Wyoming, 1978 and 1979.

	Mine Site						Control Site					
	1978			1979			1978			1979		
Terrain type	% of total area	Su[a]	Fall[b]	% of total area	Su	Fall	% of total area	Su	Fall	% of total area	Su	Fall
Flat bench	25.8	278[c]	238(+)	25.6	87(-)	154	37.2	100(-)	54(-)	37.2	13(-)	50
Flat plateau	21.3	75(-)	14(-)	18.3	67	127	22.4	65(-)	23(-)	22.4	56(+)	0(-)
Rolling	30.3	202(-)	119	35.2	177	218	29.2	217(+)	152(+)	29.2	100(+)	45
Steep	18.9	372(+)	48(-)	17.4	158(+)	80	6.7	91(+)	20	6.7	44(+)	0
Ridgetop	3.7	26	20	3.6	28	33	4.5	23	0(-)	4.5	22(+)	5

[a]Su consists of the months June-August.

[b]Fa consists of the months September-November.

[c]Number of antelope observed.

+Greater than expected use at P<0.05.

−Less than expected use at P<0.05.

Table 16. Summer and fall use of aspects by telemetered pronghorns at the Belle Ayr study site, Gillette, Wyoming, 1979.

Aspect	Number of relocations	Percent
None	20	10.3
North	32	16.5
Northeast	17	8.8
East	15	7.7
Southeast	8	4.1
South	62	32.0
Southwest	20	10.3
West	15	7.7
Northwest	5	2.6

southeast aspects (39.5%) most often followed by east aspects, level areas, and northeast aspects.

Observed use of aspects by antelope on the control site was similar in both years. During the summer, east aspects were used most frequently (18.6% in 1978 and 28.8% in 1979), followed by south and west aspects. During the fall flat areas were used most frequently (34.5% in 1978 and 50% in 1979), followed by east aspects (22.5% in 1978 and 38% in 1979).

Slope Use

Sixty-four percent of all relocations of telemetered antelope were on sites with a 1-5% slope (Table 18). Antelope observed from ground routes made use of slopes on the mine and control sites during summer

Table 17. Number (%) of antelope observed by aspect on the mine and control sites at the Belle Ayr study site, Gillette, Wyoming, 1978 and 1979.

	Mine Site				Control Site			
	1978		1979		1978		1979	
Aspect	Su*	Fa¯	Su	Fa	Su	Fa	Su	Fa
None	92 (12.7)	243 (47.7)	39 (8.1)	101 (17.6)	62 (12.5)	86 (34.5)	8 (3.9)	50 (50.0)
North	85 (11.8)	98 (19.3)	71 (14.7)	27 (4.7)	51 (10.3)	32 (12.9)	14 (6.8)	5 (5.0)
Northeast	38 (5.3)	4 (0.8)	79 (16.4)	32 (5.6)	53 (10.7)	12 (4.8)	14 (6.8)	0 (0.0)
East	143 (19.8)	53 (10.4)	116 (24.1)	134 (23.3)	92 (18.6)	56 (22.5)	59 (28.8)	38 (38.0)
Southeast	25 (3.5)	0 (0.0)	22 (4.6)	227 (39.5)	39 (7.9)	4 (1.6)	15 (7.3)	4 (4.0)
South	41 (5.7)	20 (3.9)	27 (5.6)	20 (3.5)	89 (18.0)	6 (2.4)	47 (22.9)	1 (1.0)
Southwest	52 (7.2)	3 (0.6)	56 (11.6)	9 (1.6)	23 (4.7)	47 (18.9)	19 (9.3)	0 (0.0)
West	199 (27.5)	78 (15.3)	64 (13.3)	24 (4.2)	66 (13.3)	6 (2.4)	22 (10.7)	2 (2.0)
Northwest	48 (6.6)	10 (2.0)	8 (1.7)	0 (0.0)	20 (4.0)	0 (0.0)	7 (3.4)	0 (0.0)

*Su consists of the months of June–August.

¯Fa consists of the months of September–November.

Table 18. Summer and fall use of slope classes by telemetered pronghorns at the Belle Ayr study site, Gillette, Wyoming, 1979.

Slope class in percent	Number of relocations	Percent
0 (flat)	20	9.7
1-5	132	64.1
5-10	36	17.5
10-15	18	8.7

similarly for both years (Table 19). Slopes of 1-5% were used most frequently followed by 5-10% slopes. In the fall of 1978, pronghorns on the mine site were observed most frequently on flat areas (47.0%) and slopes 1-5% were used 33.0% of the time. During that same period the reverse trend was evident on the control sites with 39.8% of the antelope observed were on 1-5% slopes, and 34.5% of the antelope observed were on flat areas. In fall 1979, 50.5% of the antelope observed were on 1-5% slopes, 26.7% of the antelope observed were on 5-10% slopes. On the control site during fall 1979, 50% of the pronghorns observed were on flat areas and 34% were on 1-5% slopes.

Habitat Losses

Physical habitat losses for each year were not additive. In 1978 1.7 km^2 were physically unsuitable to antelope (Figure 3), and

Table 19. Number and percent of antelope observed by slope classes on the mine and control sites at the Belle Ayr study site, Gillette, Wyoming, 1978 and 1979.

	Mine Site				Control Site			
	1978		1979		1978		1979	
Slope class	Su*	Fa-	Su	Fa	Su	Fa	Su	Fa
None (flat)	107 (14.8)	239 (47.0)	39 (8.1)	101 (17.6)	62 (12.5)	86 (34.5)	8 (3.9)	50 (50.0)
1-5 percent	363 (50.2)	168 (33.0)	202 (42.0)	290 (50.5)	301 (60.8)	99 (39.8)	133 (64.9)	34 (34.0)
5-10 percent	152 (21.0)	65 (12.8)	166 (34.5)	153 (26.7)	119 (24.0)	59 (23.7)	49 (23.9)	13 (13.0)
10-15 percent	101 (14.0)	37 (7.2)	74 (15.4)	30 (5.2)	13 (2.7)	5 (2.0)	15 (7.3)	3 (3.0)

*Su consists of the months of June-August.

-Fa consists of the months of September-November.

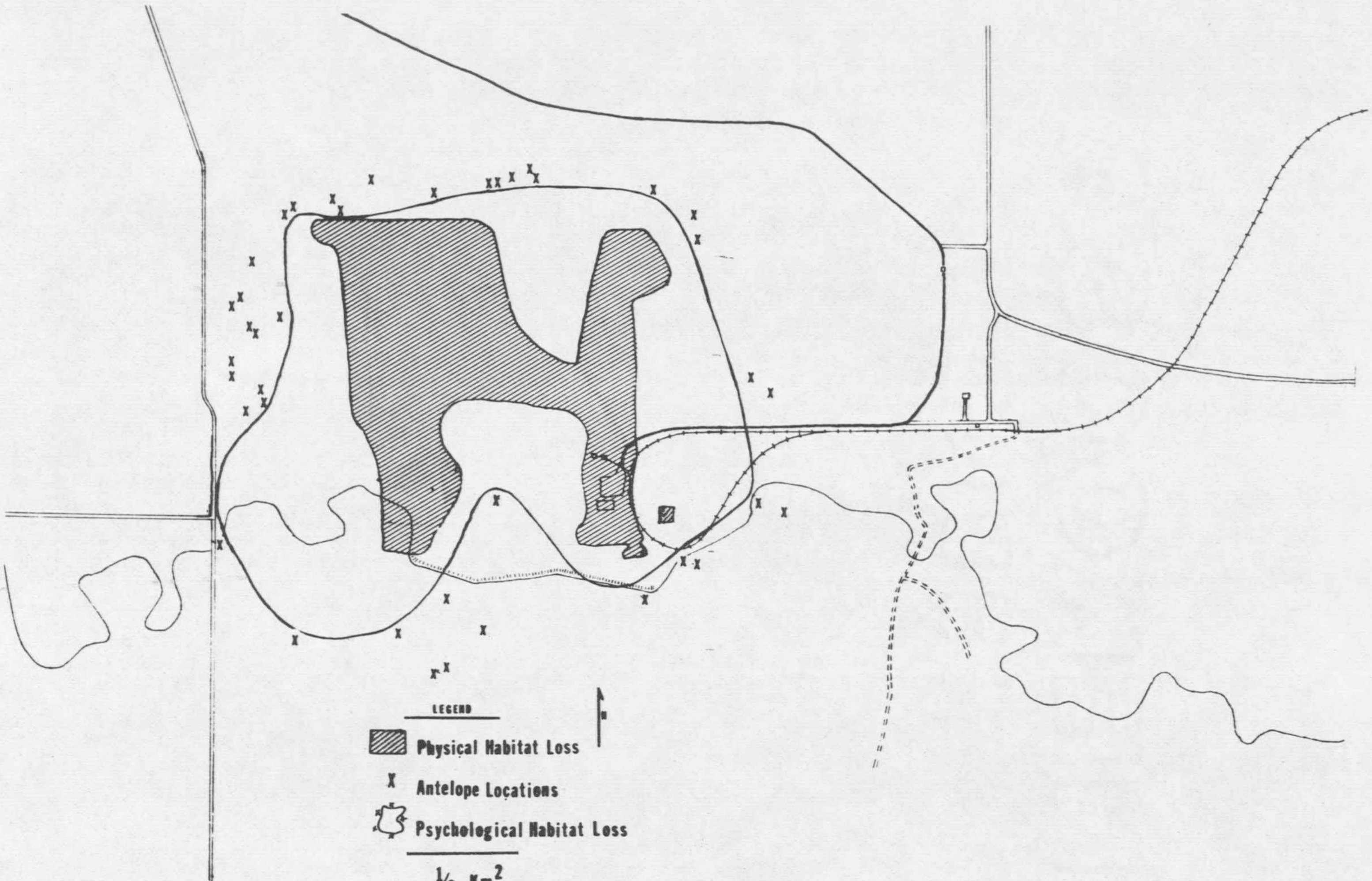

Figure 3. Psychological and physical habitat losses on the mine site at the Belle Ayr study site, Gillette, Wyoming, 1978.

psychological habitat loss was 2.4 km^2 giving a total habitat loss of 4.1 km^2. In 1979 1.6 km^2 were physically unsuitable and psychological habitat loss was 3.9 km^2 making total habitat loss 5.5 km^2 (Figure 4).

Interrelations between Human-Associated Habitat Factors with Natural Habitat Factors and Observed Antelope Hunters

The 1978 antelope observations generated multiple coefficients of determination (R^2) of about 0.05 for the "varying" parameters (Table 20) and 0.13 for the permanent factors (Table 21). This indicates that the "varying" factors could explain roughly 5% of the observed variation in antelope numbers and the "permanent" factors explained about 13% of the variation. The regression analysis of 1979 observations for "varying" and "permanent" parameters yielded multiple R^2 values of less than 0.14 and 0.01, respectively (Tables 22 and 23).

To examine the effect of the naturally occurring "permanent" habitat parameters of vegetation, terrain, and season adjusted for the area in each sample unit, in relation to the human-associated "permanent" habitat factors which were first to enter in the stepwise regression analysis, multiway analysis of variance (MAOV) tests were utilized. The parameters used for the control site were the same for both 1978 and 1979. These parameters accounted for 39% of the variation in observed antelope numbers for 1978 (Table 24) and 44% of that in 1979 (Table 25). The human-associated factors selected from the

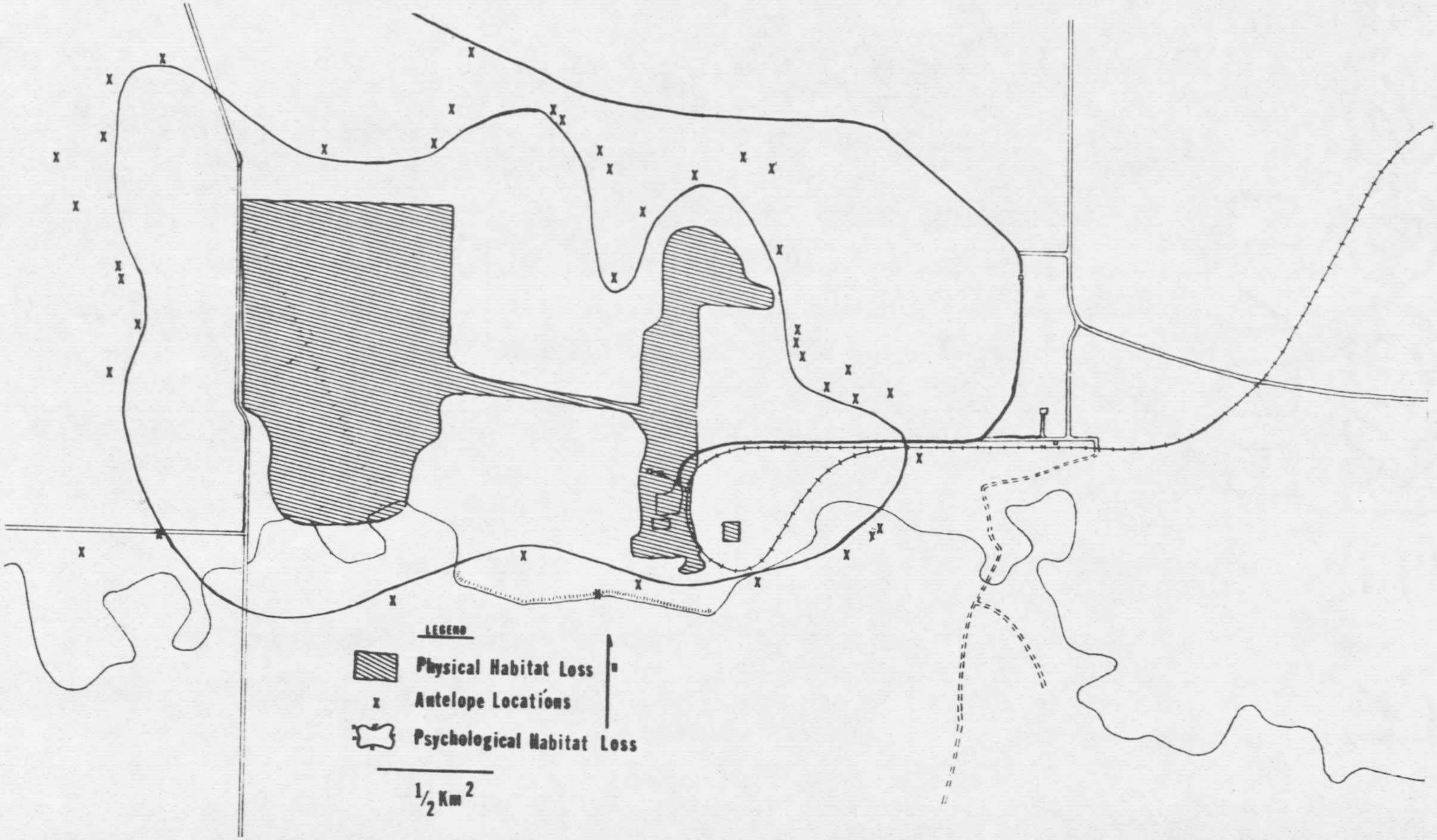

Figure 4. Psychological and physical habitat losses on the mine site at the Belle Ayr study site, Gillette, Wyoming, 1979.

Table 20. The relationship between "varying" habitat factors and variation of observed antelope numbers on the mine and control sites at the Belle Ayr study site, Gillette, Wyoming, 1978.

Habitat factors	F Value	R^{2*}
Train	4.811	0.01419
Scrapers	3.631	0.02280
Slope	0.108	0.02793
Northwest aspects	0.651	0.02926
North aspects	0.295	0.03168
Northeast aspects	0.680	0.03302
East aspects	1.126	0.03302
Southeast aspects	2.288	0.03613
South aspects	0.404	0.03630
Southwest aspects	2.539	0.04723
West aspects	0.002	0.04728
Drilling rigs	1.148	0.05009
Ecotone	0.329	0.05087
Car traffic	0.139	0.05121
Human on foot	0.011	0.05124

* The R^2 value indicates the amount of variance explained by the features at and above the value.

stepwise regressions for the mine site were different for 1978 and 1979. Using the parameters selected for 1978, less than 3% of the variation in antelope numbers observed in 1978 was explained (Table 26). The parameters selected from the 1979 regressions utilized with the antelope observations for 1979 accounted for 31% of the observed variation in pronghorn numbers (Table 27).

Table 21. The relationship between "permanent" habitat factors and variation of observed antelope numbers on the mine and control sites at the Belle Ayr study site, Gillette, Wyoming, 1978.

Habitat factors	F Value	R^2*
Area	809.659	0.11333
Railroad tracks	22.601	0.11749
Paved road (mine access)	6.379	0.11997
Dirt road (country road)	5.833	0.12044
Mine office complex	5.663	0.12077
Pit	3.915	0.12135
Paved road (highway)	3.150	0.12177
Explosives trailer	0.862	0.12186
Oil well	0.153	0.12191
Security shack/dwelling complex	0.429	0.12194
Transformer	0.292	0.12199
Season	0.127	0.12201

*The R^2 value indicates the amount of variance explained by the features at or above the value.

Table 22. The relationship between "varying" habitat factors and variation of observed antelope numbers on the mine and control sites at the Belle Ayr study site, Gillette, Wyoming, 1979.

Habitat factors	F Value	R^{2*}
Livestock	8.336	0.02072
Human on foot	2.473	0.02832
Ecotones	2.225	0.03447
Heavy trucks	1.516	0.04134
Car traffic	0.974	0.04541
Northwest aspects	0.196	0.04837
North aspects	0.986	0.04886
Northeast aspects	0.207	0.05486
East aspects	0.505	0.05685
Southeast aspects	1.026	0.05720
South aspects	7.742	0.13295
Southwest aspects	0.219	0.13349
West aspects	0.053	0.13390
Scrapers	0.406	0.13612
Train	0.612	0.13788
Security/mine trucks	0.219	0.13852
Drilling rigs	0.073	0.13877
Slope	0.027	0.13886

*The R^2 value indicates the amount of variance explained by the features at or above the value.

Table 23. The relationship between "permanent" habitat factors and variation of observed antelope numbers on the mine and control sites at the Belle Ayr study site, Gillette, Wyoming, 1979.

Habitat factors	F Value	R^{2*}
Paved road (mine access)	15.818	0.00124
Mine office complex	5.205	0.00468
Pit	5.328	0.00375
Season	6.784	0.00426
Dwelling	2.281	0.00452
Area	1.039	0.00460
Transformer	0.700	0.00467
Explosives trailer	0.931	0.00471
Oil well	0.241	0.00475
Paved road (highway)	0.552	0.00478
Dirt road (county)	0.565	0.00480
Railroad tracks	0.509	0.00484
Security shacks	0.044	0.00484

*The R^2 value indicates the amount of variance explained by the features at or above the value.

Table 24. The relationship between observed antelope numbers on the control site, and selected "permanent" disturbance factors with vegetation type, terrain type, and season, Belle Ayr study site, Gillette, Wyoming, 1978.

Habitat Factors	F Value	Signif. of F	Multiple R^2
Area	114.712	0.00001	0.389
Season	0.411	0.52172	
Vegetation type	2.483	0.05940	
Terrain type	200.247	0.00001	
Highway-paved	7.844	0.00517	
County road-dirt	1.084	0.29794	

Table 25. The relationship between observed antelope numbers on the control site, and selected "permanent" disturbance factors with vegetation type, terrain type, and season, Belle Ayr study site, Gillette, Wyoming, 1979.

Habitat Factors	F Value	Signif. of F	Multipe R^2
Area	0.004	0.947	0.44
Season	0.002	0.967	
Vegetation type	18.225	0.000	
Terrain type	36.285	0.000	
Highway-paved	740.003	0.000	
County road-dirt	6.666	0.010	

Table 26. The relationship between observed antelope numbers at the mine site, and selected "permanent" disturbance factors with vegetation type, terrain type, and season at the Belle Ayr study site, Gillette, Wyoming, 1978.

Habitat factors	F Value	Signif. of F	Multiple R^2
Area	73.461	0.00001	0.026
Season	0.001	0.97365	
Vegetation type	1.624	0.10229	
Terrain type	0.236	0.96482	
Mine access road-paved	2.183	0.13962	
County road-dirt	1.729	0.18854	
Railroad tracks	8.313	0.00395	
Mine office complex	0.365	0.54584	

Table 27. The relationship between observed antelope numbers on the mine site, and selected "permanent" disturbance factors with vegetation type, terrain type, and season at the Belle Ayr study site, Gillette, Wyoming, 1979.

Habitat factors	F value	Signif. of F	Multiple R^2
Area	31.645	0.000	0.31
Season	1.072	0.301	
Vegetation type	395.033	0.000	
Terrain type	162.589	0.000	
Mine access road-paved	714.372	0.000	
Mine office complex	104.875	0.000	
Pit	41.518	0.000	
Dwelling	34.234	0.000	

Antelope Responses to Human Activity

Spatial Relationships Between Antelope and Human Activity

The mean distance to disturbance (MDTD) for all random points was significantly smaller than the MDTD for all antelope locations ($P<0.05$, Table 28). This indicated that antelope were located further from disturbances at the mine site than would be expected if they had been randomly distributed relative to human activity.

I examined the role of the visibility of a disturbance in determining the distance maintained from the activity by pronghorns (Tables 28 and 29). The proportion of the antelope observed for which disturbances were out of sight was significantly larger than that for random points ($P<0.05$).

The MDTD's for random points associated with visible disturbances and nonvisible disturbances were not significantly different ($P>0.05$) from each other or from the MDTD for all of the random points thus allowing comparisons to be made with similar subsets of antelope locations (Table 28). The mean distances that antelope maintained from visible and nonvisible disturbances were significantly larger ($P<0.05$) than the mean distance from random points to visible and nonvisible disturbances, respectively (Table 28). In other words, antelope stayed further from human activity than if they had been randomly distributed relative to disturbances, regardless of the visibility of the disturbance. However, the mean distance that

Table 28. Comparisons between distances (km) from random points to human activity and distances from antelope locations to human activity at the Belle Ayr study site, Gillette, Wyoming, 1979.

	$\overline{X}$	Range	St.Dev.	N
Random points (all)	0.6[a*]	0.05-2.0	4.4	63
Antelope (all)	0.9[b]	0.20-2.5	4.9	63
Random points (visible)	0.5	0.05-1.4	5.6	50
Random points (nonvisible)	0.7	0.05-1.0	1.0	13
Random points (visible)	0.5[a]	0.05-1.4	5.6	50
Antelope (visible)	0.8[b]	0.05-2.0	3.9	38
Random points (nonvisible)	0.7[a]	0.05-1.0	1.0	13
Antelope (nonvisible)	1.1[b]	0.20-2.5	2.8	25
Antelope (visible)	0.8[a]	0.05-2.0	3.9	38
Antelope (nonvisible)	1.1[b]	0.20-2.5	2.8	25

*a and b are significantly different at $P<0.05$.

Table 29. Visibility of disturbances from random points and antelope locations and results of a contingency analysis at the Belle Ayr study site, Gillette, Wyoming, 1979.

	Antelope locations	Random points	Totals
Number of disturbances visible	38(44)*	50(44)	88
Number of disturbances not visible	25(19)	13(19)	38
Totals	63	63	126
Percent not visible	39.7	20.6	

*Values in parenthesis are the expected values for the cell.

antelope maintained from nonvisible disturbances was significantly greater ($P<0.05$) than the mean distance that antelope maintained from visible disturbances. This suggested that antelope stayed further away from human activity when it was not directly visible.

To determine if random points were suitable for testing the effects of the type of human activity on the observed distances maintained by pronghorns, the random points associated with the 4 most common types of human activity were compared (Table 30). The MDTD for sets of random points associated with given types of disturbance were not significantly different from each other or from the MDTD for all of the random points ($P>0.05$). This allowed comparisons of random points associated with the same disturbance types as antelope locations to be made (Table 31).

The mean distances from antelope to light vehicles and humans on foot were significantly greater than the MDTD for random points associated with those disturbances ($P<0.05$). When compared to the mean distance maintained by antelope from all types of human activity, the mean distance maintained from light vehicles was significantly larger, and the mean distance maintained from heavy machinery was significantly smaller ($P<0.05$, Table 32).

Table 30. Comparisons of the distances (km) from random points to associated disturbance types at the Belle Ayr study site, Gillette, Wyoming, 1979.

	$\overline{X}$	Range	St.Dev.	N
Random points to all types	0.59*	0.05-2.0	4.4	63
Random points to light vehicle	0.72*	0.05-2.0	2.4	24
Random points to heavy machinery	0.39*	0.10-1.0	1.1	11
Random points to humans	0.60*	0.10-1.0	0.9	12
Random points to trains	0.39*	0.05-0.9	0.7	6

*Values were not significantly different at P>0.05.

Table 31. Comparisons of the distances (km) from random points and antelope locations to disturbance types at the Belle Ayr study site, Gillette, Wyoming, 1979.

	$\overline{X}$	Range	St.Dev.	N
Random points to light vehicles	0.7[a*]	0.05-2.0	2.4	24
Antelope to light vehicles	1.4[b]	0.20-2.5	3.2	32
Random points to heavy machinery	0.4	0.10-1.0	1.1	11
Antelope to heavy machinery	0.2	0.05-0.7	0.7	14
Random points to humans	0.6[a]	0.10-1.0	0.9	12
Antelope to humans	1.3[b]	0.55-1.7	1.0	5
Random points to trains	0.4	0.05-0.9	0.7	6
Antelope to trains	0.9	0.17-1.9	1.7	9

*a and b are significantly different at P<0.05.

Table 32. Comparisons of the distances (km) that antelope maintained from different types of human activity at the Belle Ayr study site, Gillette, Wyoming, 1979.

	$\bar{X}$	Range	St.Dev.	N
Antelope to all disturbances	0.91[a*]	0.20-2.5	4.9	63
Antelope to light vehicles	1.41[b]	0.20-2.5	3.2	32
Antelope to heavy machinery	0.25[b]	0.05-0.7	0.7	14
Antelope to humans	1.28	0.55-1.7	1.0	5
Antelope to trains	0.86	0.17-1.9	1.7	9

*a and b are significantly different at $P<0.05$.

Antelope Behavioral Reactions to Human Activity

The mean intensity of antelope reactions (1 = no reaction, 10 = rapid immediate flight, Appendix Table 44) to human activity on the mine site was significantly smaller ($P<0.05$) than the intensity of reactions on the control site (Table 33). This trend held for most disturbance types. The major exceptions were reactions to heavy machinery. Antelope on the mine site reacted at a significantly higher intensity to heavy machinery ($P<0.05$) than did antelope on the control site. Humans on motorcycles yielded the highest mean reaction intensity of any type on both sites.

Table 33. Mean intensity of behavioral reactions by pronghorns to disturbance types at the Belle Ayr study site, Gillette, Wyoming, 1979.

Type of Disturbance	Mine	Control	All
All disturbances	1.30[a*]	1.54[b]	1.35
Light vehicles	1.41	1.62	1.50
Heavy machines	1.73[a]	1.19[b]	1.48
Humans on foot	1.28	1.50	1.31
Trains	1.25		1.25
Aircraft	1.82	1.00	1.64
Motorcycles	2.00	2.00	2.00
Tractors	1.03[a]	1.50[b]	1.05
Drilling rigs	1.00		1.00

*a and b are significantly different at $P<0.05$.

DISCUSSION

There were no important differences in antelope densities or reproduction between the mine and control sites that would indicate an adverse effect of the mining operation. The significantly higher densities noted in the buffer zone during spring 1979 were primarily a function of the pattern in which antelope returned from their unusual exodus from the area in winter 1978-1979.

I failed to identify any abnormal movement patterns that could be attributed to the intense human activity in the mine area. Antelope home range sizes were similar to those found by Roberts (1970) in central Montana but smaller than home range sizes noted by Bayless (1967) and Wentland (1968) in central Montana, Campbell (1970) in southeastern Montana, or Amstrup (1978) in northeastern Wyoming. Home range shifts which occurred during my study were similar to shifts noted by Campbell (1970), Pyrah (1970) and Amstrup (1978). Movement by pronghorns around the mine was not precluded by structures or human activities although certainly not enhanced. Fences did not constitute barriers to movement, and the railroad spur and loop were crossed by antelope. Analyses of habitat use data demonstrated that the presence of intense human activity did affect the relationship between antelope and habitat parameters. The effects, however, were complex, involving the disruption of antelope use of naturally occurring habitat parameters.

Naturally occurring habitat parameters and selected human-associated factors explained 39 to 40% of the variation in observed antelope numbers on the control site in 1978 and 1979. Naturally occurring habitat parameters with selected human-associated factors explained less of the variation in antelope numbers on the mine site in 1978 and 1979. The model did show a better association between antelope and habitat features on the mine site in 1979, but this could have been due to differences in densities of antelope between the 2 years. Antelope density was 40% lower in 1979, and antelope may have made less use of suboptimal habitat units.

The habitat feature-antelope number relationship indicated that human-associated perturbances present in the study area did not rigidly control antelope land use patterns. Instead, the increased intensity of human disturbance on the mine disrupted the tight association between pronghorns and naturally occurring habitat features. This breakdown in the relationship between natural habitat features and antelope numbers was in part due to the high frequency of human activities (an antelope attempting to avoid one disturbance would have to move closer to another disturbance) and in part due to the breaking of a large homogeneous habitat unit into several smaller units by road construction, topsoil stripping, reclamation efforts, or the building of structures.

Ground route data on aspect use by pronghorns on the mine site versus the control site also indicated a possible disruption of normal habitat use due to human activity. Pronghorns on the control site exhibited virtually the same pattern of aspect use in both years, whereas, pronghorns on the mine site exhibited entirely different aspect selection between years.

Observations of the spatial relationships between antelope and human activity revealed the means by which habitat use could be influenced. Pronghorns avoided human activity whether it was visible to them or not. Antelope did not actively attempt to remain out of sight from human activity. This was expected as pronghorns are heavily dependent on their eyesight to avoid predation (Vaughn 1972). Keeping a potential danger in sight evidently reduces the possibility of the danger approaching by stealth and has also been observed in desert bighorn sheep (*Ovis canadensis*) (Leslie and Douglas 1980) as well as African ungulates (Schaller 1972). Distances maintained from human activities which were not visible to pronghorns averaged 300 m greater than to visible disturbances. This may indicate that pronghorns felt insecure when a potential danger, in this case a human activity, was not visible and moved away from it.

Distances that pronghorns maintained from disturbances were influenced by the type of disturbance. Light vehicles and humans on foot elicited the greatest avoidance distances. These disturbance types were unpredictable in timing, speed, and pathway. Distances to heavy machinery and trains at the mine site were lowest presumably because they tended to follow predictable, repetitious movement patterns.

Detriment to the antelope population by loss of habitat was not evident. The amount of area physically unsuitable for pronghorns did not change as the mine progressed, although the amount of habitat loss because of human activity while the mine was operating coupled with physical habitat losses was 2-3 times larger than physical losses alone. The amount of habitat lost because of human activity was not constant from year to year nor did it increase in proportion to the total area disturbed by mining during the study. The increase in total habitat loss in 1979 may have been due to the decrease in pronghorn density between 1978 and 1979. If areas adjacent to the mine were suboptimal habitat relative to areas further from the mine, lower densities may have allowed animals to avoid those suboptimal habitats. Topsoil and vegetation removal or revegetation of areas adjacent to the mine did not appear to influence losses or gains in habitat.

Revegetated areas did receive extensive use in spring and summer by pronghorns, and most antelope activities were observed on revegetated lands, but I could not determine if reclaimed land alone provided adequate habitat for antelope. Reclaimed lands utilized during this study were noncontiguous, not larger than 2 km^2 in size and were accessible from native range. It is possible that use of other vegetation types by pronghorns facilitated the high use of reclaimed lands observed.

Upon completion of mining by a number of coal companies in the Gillette, Wyoming area, reclaimed areas may be 150 km^2 in size. Thus, access to native vegetation types by antelope will be more difficult. The maintenance of present pronghorn densities may also depend on creating reclaimed land that is adequate winter habitat. Widespread establishment of sagebrush, a major component of antelope winter diets in the northern Great Plains (Couey 1946, Cole 1956, Cole and Wilkins 1958, Severson and May 1967, Bayless 1967, Bernt 1976, Hoskinson and Tester 1980), on reclaimed lands may be necessary to support present densities of wintering antelope.

Antelope behavioral reactions to human activity indicated that pronghorns on the mine site had habituated to many types of human activity and simply moved slowly away from disturbing situations. The exceptions to this trend were motorcycles which elicited a high intensity response on both sites, and the high intensity of reactions to heavy machinery on the mine site. Pronghorns on the mine site allowed themselves to get very close to heavy machines that behaved predictably. In doing so, the pronghorns set themselves up for intense reactions when heavy machines occasionally altered their patterns.

Pronghorns on the control site never allowed machinery to get close to them and consequently exhibited low intensity reactions.

MANAGEMENT IMPLICATIONS

Mining at present levels did not preclude the use of large proportions of the land around the mine by antelope. Future demands on land for housing and recreation as the human population grows in response to increases in mining probably will have greater impacts.

To optimize pronghorn use of the mine site while the mine is operating, movements of light vehicles and humans on foot outside the area of physical habitat loss should be restricted when possible. Most of this type of activity comes from security guards patrolling, surveying teams, environmental staff visiting water and air quality stations, and foremen and administrative personnel. Laborers generally work within the areas that are already unsuitable for pronghorn use.

If increased use of revegetated areas by pronghorns during mining is desirable, access to native range from reclaimed areas should be provided. Access can be improved by limiting structures, such as fences, roads, and buildings, and human activity near the reclaimed areas.

To provide adequate yearlong pronghorn habitat on reclaimed land, availability of native vegetation types to antelope cannot be disregarded. Sagebrush should be established on reclaimed areas to provide winter forage. Failure to establish sagebrush or provide access to a variety of vegetation types may not cause any decreases in pronghorn densities until reclaimed lands from contiguous coal mines are joined to form large blocks of land without native range.

APPENDIX

Table 34. Mean canopy coverage (%) and frequency of occurrence (%) of plant taxa in the grassland vegetation type at the Belle Ayr study site, Gillette, Wyoming, 1978.

Taxa	Mine cv/fr	Control cv/fr	Total cv/fr
GRAMINOIDS			
Agropyron smithii	T[+]/37	1.2/35	0.9/36
Agropyron trachycaulum	-/-	T/2	T/1
Aristida longiseta	T/3	-/-	T/1
Bouteloua gracilis	3.2/63	2.6/48	2.9/56
Bromus tectorum	T/27	T/15	T/21
Calamovilfa longifolia	-/-	2.2/37	1.1/18
Carex filifolia	2.4/32	3.1/67	2.7/49
Festuca octoflora	T/2	0.9/42	T/22
Koleria cristata	T/12	T/13	T/13
Oryzopsis hymenoides	T/2	T/2	T/2
Poa spp.	T/3	-/-	T/2
Stipa comata	6.8/90	2.4/58	4.6/74
Stipa viridula	T/3	-/-	T/2
FORBS AND HALF SHRUBS			
Allium spp.	-/-	T/2	T/1
Atriplex canescens	T/2	-/-	T/1
Artemisia frigida	T/2	T/15	T/8
Cruciferae	T/4	T/13	T/24
Erigeron spp.	T/5	T/3	T/4
Helianthus spp.	-/-	T/5	T/3
Lichen	T/33	-/-	T/17
Lupinus spp.	T/3	T/17	T/10
Opuntia polycantha	1.3/22	1.4/32	1.34/27
Phlox hoodii	-/-	T/2	T/1
Plantago purshii	T/17	T/22	T/19
Psorosa spp.	-/-	T/8	T/4
Sphaeralea coccinia	T/17	T/17	T/17
Taraxacum officinale	T/12	-/-	T/6
Yucca glauca	T/2	T/2	T/2
Xanthocephalum sarothrae	T/2	-/-	T/1
Total canopy coverage	17.6%	16.3%	17.0%

[+]T indicates less than 0.05% of the total canopy coverage.

Table 35. Mean canopy coverage (%) and frequency of occurrence (%) of plant taxa in the scattered sagebrush vegetation type at the Belle Ayr study site, Gillette, Wyoming, 1978.

Taxa	Mine cv/fr	Control cv/fr	Total cv/fr
SHRUBS			
Artemisia cana	T+/7	-/-	T/6
Artemisia patatifida	-/-	0.9/18	T/9
Artemisia tridentata	T/18	1.4/15	0.9/17
Chrysothamnus nauseosus	T/7	T/3	T/5
GRAMINOIDS			
Agropyron smithii	1.4/57	2.5/68	1.9/63
Bouteloua gracilis	2.6/63	3.5/53	3.0/58
Bromus tectorum	T/17	T/18	T/18
Carex filifolia	3.6/82	1.6/35	2.6/58
Festuca octoflora	T/47	T/25	T/36
Koleria cristata	1.6/43	2.2/73	1.9/58
Oryzopsis hymenoides	T/2	-/-	T/1
Poa spp.	T/20	-/-	T/10
Stipa commata	2.5/62	T/12	1.5/37
Stipa viridula	-/-	T/10	T/5
FORBS AND HALF-SHRUBS			
Allium spp.	T/7	T/8	T/8
Artemisia frigida	T/13	-/-	T/6
Atriplex cancescens	-/-	T/8	T/4
Ceratoides lanata	T/2	T/7	T/4
Cruciferae	T/30	T/10	T/20
Erigeron spp.	T/3	T/2	T/3
Eriogonum spp.	T/2	-/-	T/1
Grindelia squarosa	T/3	-/-	T/2
Lichen	T/30	-/-	T/15
Lipinus spp.	T/10	T/2	T/6
Melilotus officinalis	T/7	-/-	T/3
Opuntia polycanthus	T/15	1.2/28	0.9/22
Phlox hoodii	T/30	T/2	T/16
Plantago purshii	T/2	T/52	T/27
Psoralea spp.	T/18	T/25	T/22
Sphaeralea coccinea	T/5	T/18	T/12

Table 35. Continued.

	Mine cv/fr	Control cv/fr	Total cv/fr
FORBS AND HALF-SHRUBS (Continued)			
Taraxicum officinalis	T/2	-/-	T/1
Unknown forb	T/32	-/-	T/16
Total canopy coverage	16.5%	16.4%	18.2%

+T indicates less than 0.05% of the total.

Table 36. Mean canopy coverage (%) and frequency of occurrence (%) of plant taxa in the common sagebrush vegetation type at the Belle Ayr study site, Gillette, Wyoming, 1978.

Taxa	Mine cv/fr	Control cv/fr	Total cv/fr
SHRUBS			
Artemisia cana	-/-	T[+]/13	T/7
Artemisia tridentata	3.1/68	3.4/28	3.2/48
Chrysothamnus nauseosus	T/7	T/2	T/4
GRAMINOIDS			
Aristida longiseta	-/-	T/5	T/3
Agropyron smithii	0.7/47	0.8/55	0.8/51
Agropyron spicatum	-/-	T/2	T/1
Bouteloua gracilis	-/-	0.7/53	T/27
Bromus tectorum	-/-	T/1	T/0.5
Carex filifolia	T/10	0.8/57	T/33
Calamovilfa longifolia	-/-	1.1/22	T/11
Festuca octoflora	T/5	T/42	T/23
Koleria cristata	4.0/83	1.7/58	2.9/71
Poa spp.	T/30	-/-	T/15
Stipa comata	1.1/40	0.8/32	0.9/36
Stipa viridula	T/12	0.9/32	T/22
FORBS AND HALF-SHRUBS			
Allium spp.	-/-	T/5	T/3
Artemisia frigida	T/5	T/17	T/11
Cruciferae	T/7	T/10	T/8
Erigeron spp.	T/17	T/5	T/11
Helianthus spp.	-/-	T/2	T/1
Lupinus spp.	1.1/38	T/15	T/27
Opuntia polycantha	T/2	0.9/25	T/13
Phlox hoodii	T/17	-/-	T/8
Plantago purshii	-/-	T/42	T/21
Psoralea spp.	1.7/72	T/13	1.3/43
Sphaeralea coccinea	-/-	T/23	T/12
Unknown forb	T/5	T/8	T/7
Xanthocephalum sarothrae	T/2	T/7	T/4
Total canopy coverage	13.5%	14.3%	14.3%

[+]T indicates less than 0.05% of the total canopy coverage.

Table 37. Mean canopy coverage (%) and frequency of occurrence (%) of plant taxa in the dense sagebrush vegetation type at the Belle Ayr study site, Gillette, Wyoming, 1978.

Taxa	Mine cv/fr	Control cv/fr	Total cv/fr
SHRUBS			
Artemisia cana	-/-	T+/2	T/1
Artemisia tridentata	5.1/63	13.9/82	9.5/73
Chrysothamnus nauseosus	T/2	-/-	T/1
GRAMINOIDS			
Agropyron smithii	2.0/68	T/68	1.6/68
Aristida longiseta	-/-	T/2	T/1
Bouteloua gracilis	1.3/27	1.2/45	1.2/36
Bromus tectorum	T/12	T/2	T/7
Carex filifolia	T/3	T/27	T/15
Festuca octoflora	T/2	T/10	T/6
Hordeum juratum	-/-	T/8	T/4
Koleria cristata	1.4/30	1.8/43	1.6/37
Poa spp.	T/8	-/-	T/4
Stipa comata	1.4/27	1.4/48	1.4/38
Stipa viridula	1.9/37	T/2	T/20
FORBS AND HALF-SHRUBS			
Achillio millifolia	T/2	-/-	T/1
Allium spp.	T/2	-/-	T/1
Artemisia frigida	T/8	T/20	T/14
Cruciferae	T/20	T/7	T/14
Erigeron spp.	T/2	T/7	T/5
Ceratoides lanata	T/12	-/-	T/6
Grindillia squarosa	-/-	T/2	T/1
Heterotheica villosa	T/7	-/-	T/4
Lichen	T/7	-/-	T/4
Opuntia polycantha	T/20	T/27	T/24
Phlox hoodii	T/17	-/-	T/9
Plantago purshii	T/5	T/23	T/14
Psoralea spp.	T/13	T/2	T/9
Sphaeralea coccinea	T/18	T/20	T/19
Salsoa kali	-/-	T/2	T/1
Taraxacum officinale	T/3	-/-	T/2

Table 37. Continued.

Taxa	Mine cv/fr	Control cv/fr	Total cv/fr
FORBS AND HALF-SHRUBS (Continued)			
Tragopogon dubious	T/2	-/-	T/1
Unknown forb	T/3	-/-	T/2
Total canopy coverage	15.6%	22.3%	18.9%

+T indicates less than 0.05% of the total canopy coverage.

Table 38. Mean canopy coverage (%) and frequency of occurrence (%) of plant taxa in the greasewood vegetation type of the Belle Ayr study site, Gillette, Wyoming, 1978.

Taxa	Control cv/fr
SHRUBS	
Artemisia cana	T[+]/2
Artemisia patatifita	T/2
Artemisia tridentata	0.8/20
Chrysothamnus nauseosus	T/1
Sarcobatus vermiculatus	0.7/13
GRAMINOIDS	
Agropyron smithii	1.3/88
Bouteloua gracilis	T/3
Bromus tectorum	1.0/53
Carex filifolia	0.9/5
Festuca octoflora	T/2
Hordeum jurbatum	T/2
Koleria cristata	1.9/50
Poa spp.	T/13
Stipa comata	T/2
Stipa viridula	T/7
FORBS AND HALF-SHRUBS	
Achilla millifolia	T/5
Allium spp.	T/8
Atriplex canescens	1.7/27
Cruciferae	T/12
Erigeron spp.	T/2
Opuntia polycantha	T/8
Phlox hoodii	T/2
Plantago purshii	0.7/47
Psoralea spp.	T/17
Sphaeralea coccinea	T/8
Taraxacum officinalis	T/5
Unknown forb	T/13
Total canopy coverage	11.5%

[+]T indicates a value less than 0.05% of the total canopy coverage.

Table 39. Mean canopy coverage (%) and frequency of occurrence (%) of plant taxa in the improved range vegetation type at the Belle Ayr study site, Gillette, Wyoming, 1978.

Taxa	Mine cv/fr	Control cv/fr	Total cv/fr
SHRUBS			
Artemisia tridentata	T[+]/10	-/-	T/5
Chrysothamnus nauseosus	-/-	T/5	T/3
GRAMINOIDS			
Agropyron cristata	14.5/100	9.1/100	11.3/100
Agropyron smithii	-/-	T/10	T/5
Bouteloua gracilis	T/10	1.1/3	0.7/7
Koleria cristata	-/-	T/15	T/8
Stipa comata	-/-	T/10	T/5
FORBS AND HALF-SHRUBS			
Artemisia frigida	T/5	-/-	T/3
Lupinus spp.	T/5	-/-	T/3
Opuntia polycantha	T/5	T/5	T/5
Plantago purshii	T/15	-/-	T/8
Psoralea spp.	-/-	1.1/55	T/28
Sphaeralea coccinea	T/5	T/90	T/50
Xanthocephalum sarothrae	-/-	T/10	T/5
Total canopy coverage	16.3%	12.7%	14.7%

[+]T indicates a value less than 0.05% of the total canopy coverage.

Table 40. Shrub canopy coverage (%) and densities (plants per ha) on four shrub dominated vegetation types at the Belle Ayr study site, Gillette, Wyoming, 1978.

Vegetation type	Taxa	Mine cv/d	Control cv/d	Total cv/d
Scatter sagebrush	*Artemisia tridentata*	4.40/1866	3.80/1327	4.06/1563
	Chrysothamnus nauseosus	-/-	0.10/27	T^{+}/16
	Shrub totals	4.40/1866	3.90/1354	4.10/1579
Common sagebrush	*Artemisia cana*	-/-	7.02/6301	7.74/4890
	Artemisia tridentata	8.56/4033	3.46/3104	1.58/1001
	Shrub totals	8.56/4033	10.48/9405	9.32/5891
Dense sagebrush	*Artemisia cana*	54.96/634	1.26/1112	1.18/790
	Artemisia tridentata	1.12/31065	23.42/20686	37.69/25292
	Chrysothamnus nauseosus	-/-	0.50/445	0.39/264
	Shrub totals	56.08/31699	25.18/22243	39.26/26346
Greasewood	*Artemisia cana*	-/-	0.50/182	-/-
	Artemisia tridentata	-/-	5.90/2083	-/-
	Sarcobatus vermiculatus	-/-	7.20/2589	-/-
	Shrub totals	-/-	13.60/4854	-/-

[+]T indicates a value less than 0.1% canopy cover.

Table 41. "Varying" habitat parameters deleted from stepwise forward regression analyses because of high multicolinearity with other parameters or small sample size of antelope sightings, Belle Ayr study site, Gillette, Wyoming, 1978 and 1979. Number of observations in each distance class are given in the table.

Parameters	0.0-0.4 km	0.4-0.8 km	0.8-1.2 km	> 1.2 km	No Disturbance
1978					
Cars	52	1	0	0	1,931
Security/mine trucks	63	21	2	0	1,899
Heavy machinery	43	0	0	0	1,942
Aircraft	37	3	0	0	1,945
1979					
Ranch truck	8	3	0	0	1,350
Tractors	0	2	1	0	1,358
Human on horseback	0	0	0	1	1,360
Human on motorcycle	0	0	0	0	1,361
Dog	0	0	0	1	1,360
Aircraft	21	12	0	0	1,328
Unknown disturbance	0	0	0	0	1,361

Table 42. Home ranges (ha) of 2 pronghorns telemetered for 24-hour periods during summer and fall at the Belle Ayr study site, Gillette, Wyoming, 1978.

	July	Aug	Sept	Oct	Nov
Yearling female	16.4*	19.9*	21.7*	93.2	90.0
Adult male	95.4	49.3	43.9		

*Mean from two 24-hour trackings.

Table 43. Intensity rating for behavioral reactions to human activities by antelope at the Belle Ayr study site, Gillette, Wyoming, 1979.

Reaction	Intensity rating
No reaction	1
Head lift	2
Vigilant stare	3
Stand up	4
Walk and resume	5
Run and resume	6
Group up	7
Run/walk	8
Group and flee	9
Rapid, immediate flight	10

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