Ecology and behavior of mule deer on the Rosebud Coal Mine, Montana
by Duane E Fritzen

A thesis submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Biological Sciences
Montana State University

Abstract:
Mule deer (Odocoileus hemionus) inhabiting the Rosebud Coal Mine near Colstrip, Montana were studied 1992-1995. Aerial surveys were used to assess distribution and abundance of deer. Radiotelemetry provided information regarding deer movement, activity, use of vegetation-cover types, and survivorship. Biological materials obtained from collected deer provided information regarding food habits, physical condition, and productivity.

Based on aerial surveys, male and nonproductive female groups exhibited similar distributions different from that of productive female groups. Deer population density, approximately 7.5 deer / km2 during this study, increased 1974-1994, while deer distribution shifted from outlying portions of the study area to core reclamation sites.

Fifty of 55 radiocollared deer monitored during this study were yearlong residents of the study area. Mean home range size of males exceeded that of females annually and during all seasons. Diel mobility and activity of females during summer, fall, and spring exceeded that during winter. Mobility and activity were greatest during nocturnal, afternoon, and diurnal hours during summer, winter / fall, and spring, respectively. Deer preferred pine savannah, riparian, and reclamation vegetation-cover types and avoided mixed shrub and disturbance types. Annual survivorship of radiocollared fawns, adult females, and adult males averaged 43.1, 90.0, and 57.7%, respectively. Leading causes of death for fawns and adult females were coyote predation (58.6%) and vehicle collision (17.2%). Hunter harvest accounted for 87.5% of all adult male deaths.

Examination of collected deer indicated forbs comprised 88.2; 50.5, and 55.9% of diets during summer, fall, and spring, respectively. Browse predominated during winter, forming 79.4% of diets. Physical condition of deer was greatest during fall and least during spring. Female ovulation and fertilization rates were high, averaging 1.68 ova / female and 100.0%, respectively.

Although deer abundance increased since 1974, population characteristics during this study suggested a relatively high-density but stable population. Deer movements suggested the study area provided high-quality habitats capable of supporting deer on yearlong home ranges. Post-mining reclamation was used extensively and consistently by deer. Collectively, these findings suggest that surface mining on the study area benefited deer, at least in the short term, providing increased diversity of habitats resulting in increased abundance of deer.

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Duane E Fritzen

This thesis has been read by each member of the thesis committee and has been found to be satisfactory regarding content, English usage, format, citations, bibliographic style, and consistency, and is ready for submission to the College of Graduate Studies.

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Chairperson, Graduate Committee

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Head, Major Department

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Graduate Dean

STATEMENT OF PERMISSION TO USE

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ABSTRACT

Mule deer (Odocoileus hemionus) inhabiting the Rosebud Coal Mine near Colstrip, Montana were studied 1992-1995. Aerial surveys were used to assess distribution and abundance of deer. Radiotelemetry provided information regarding deer movement, activity, use of vegetation-cover types, and survivorship. Biological materials obtained from collected deer provided information regarding food habits, physical condition, and productivity.

Based on aerial surveys, male and nonproductive female groups exhibited similar distributions different from that of productive female groups. Deer population density, approximately 7.5 deer / km^2 during this study, increased 1974-1994, while deer distribution shifted from outlying portions of the study area to core reclamation sites.

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Although deer abundance increased since 1974, population characteristics during this study suggested a relatively high-density but stable population. Deer movements suggested the study area provided high-quality habitats capable of supporting deer on yearlong home ranges. Post-mining reclamation was used extensively and consistently by deer. Collectively, these findings suggest that surface mining on the study area benefitted deer, at least in the short term, providing increased diversity of habitats resulting in increased abundance of deer.

INTRODUCTION

Mule deer (Odocoileus hemionus) are widely distributed and extensively studied in western North America. Investigations have been conducted in a wide variety of natural environments including mountain-foothill (Robinette 1966, Ihsle Pac et al. 1988, Pac et al. 1991), prairie (Dusek 1975, Severson and Carter 1978, Swenson et al. 1983, Wood 1986, Jackson 1990), breaks and badlands (Mackie 1970, Komberec 1976, Dood 1978, Riley 1982, Kraft 1987, Hamlin and Mackie 1989, Jensen 1992), and chaparral and desert (Linsdale and Tomich 1953, Kucera 1978, Bowyer 1984, Ordway and Krausman 1986) environments. Studies also have been conducted in human-disturbed environments including agricultural (Egan 1957, Ball 1987, O'Connor 1987), industrial (Eberhardt et al. 1984, Clark and Medcraft 1986, Medcraft and Clark 1986) and urban (Mackie and Pac 1980, Happe 1983, Vogel 1983, de Vos et al. 1984, Bellantoni et al. 1993) environments. However, studies of mule deer occupying a complex of undisturbed and highly disturbed environments generally are lacking.

The human population is expected to increase by 19.4% (3,709,000 individuals) in the Intermountain West region of the United States between 1995 and 2010 (Bureau of the Census 1994). As human population increases, development and alteration of natural habitats will continue such that mule deer may be increasingly impacted (Reed 1981). Mule deer populations already have decreased or been eliminated over portions of the species original distribution, due primarily to recent human influences (Geist 1990). Accordingly, understanding the ecology of mule deer inhabiting human-disturbed environments is necessary if populations are to be maintained in the future.

The Rosebud Mine and town of Colstrip in southeastern Montana collectively comprise an environment in which undisturbed native vegetation and intensively disturbed agricultural, industrial, urban, and postmining reclamation sites are intermixed. Further, undisturbed and disturbed sites are highly fragmented. The area is inhabited by a sizable population of Rocky Mountain mule deer (O. h. hemionus), many members of which have access to the entire range of sites along the disturbance continuum. Thus, the area represents a unique environment in which to examine mule deer population-habitat relationships in the presence of variable human disturbance.

This study was initiated in July 1991 by Western Energy Company (WECO), the owner and operator of the Rosebud Mine, in response to concerns about mule deer encroachment upon industrial and residential sites on the Rosebud Mine and in the town of Colstrip, respectively. The increased presence of mule deer in these areas resulted in a greater incidence of deer-human interactions, many of which, including deer-vehicle collisions, deer damage to gardens and ornamental shrubbery, and direct physical contact between deer and humans, were detrimental to either humans or their property. The goal of the study was to define habitat / mule deer population relationships in this variable environment. Specific objectives were to (1) evaluate characteristics of disturbed and undisturbed habitats available to mule deer on the area, (2) define physical, reproductive, survival, and behavioral characteristics of mule deer occupying the area, and (3) assess mule deer distribution among and use of disturbed and undisturbed vegetation-cover types on the area. Understanding population-habitat relationships is necessary if WECO is to achieve its long-term management goals of (1) maintaining the mule deer population on the Rosebud Mine, while (2) minimizing the occurrence of negative deer-human interactions in Colstrip.

STUDY AREA

Location

The study was conducted primarily in the vicinity of the Rosebud Mine and nearby town of Colstrip, in southeastern Montana. Observations, however, extended south to the Big Sky Mine and west to the Sarpy Creek Mine in Bighorn County, yielding an overall study area of approximately 300 km^2 (Figure 1). The study area as defined specifically for analytical purposes was that area (130.2 km^2) containing all relocations of radiocollared deer residing yearlong on or about the Rosebud Mine. The Rosebud Mine lies at 45° 51' north latitude and 106° 37' west longitude and surrounds the town of Colstrip. The East Fork of Armell's Creek is the major drainage within the study area. It courses through the study area along a predominantly east-west axis before turning north and eventually emptying into the Yellowstone River, roughly 50 km north of Colstrip. Major topographic features of the area include the Little Wolf Mountains and the Green-leaf Ridge which separate the Rosebud Mine from the Sarpy Creek and Big Sky Mines, respectively.

Regional and Local Geology

The study area was located in the northern portion of the Powder River Basin in the Northern Great Plains physiographic province (Plantenberg 1983). Geologic history of the region since the Precambrian includes periods of deposition, deformation, and erosion. Deposition occurred during the Paleozoic

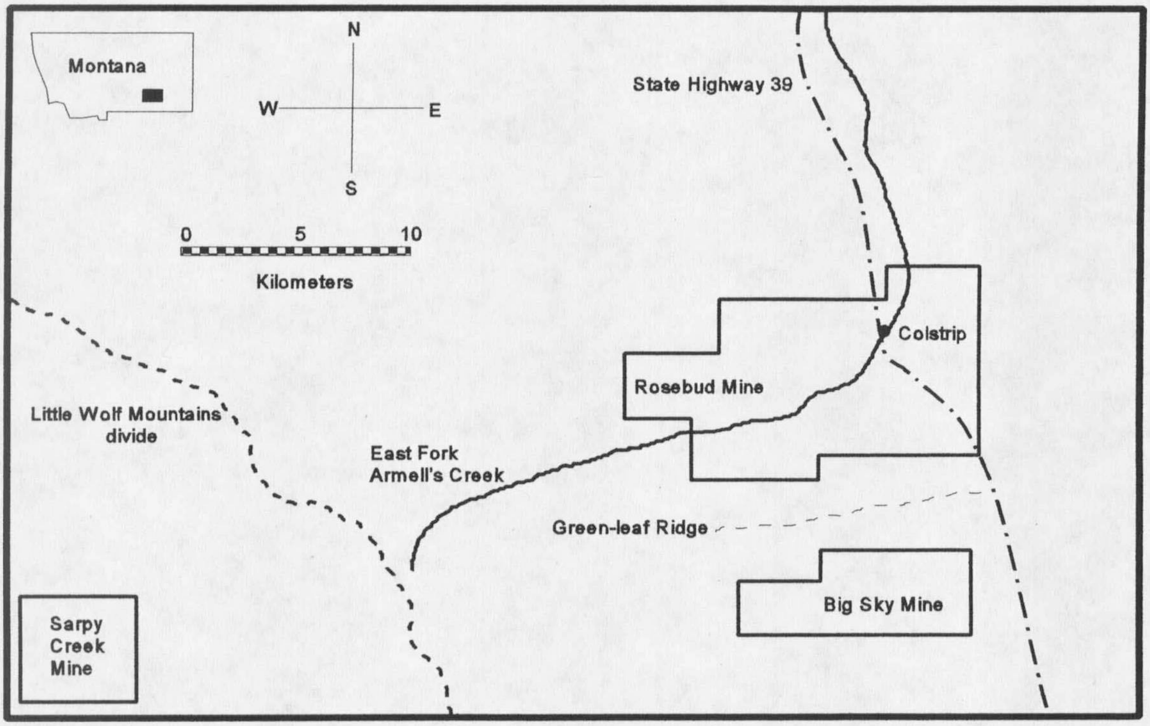

Figure 1. The general region of study including mining areas, major drainages and topographic features, and the city of Colstrip.

and Mesozoic when an epicontinental sea covered the area (Schafer et al. 1979). The late Cretaceous marked the beginning of the Laramide orogeny, when the Black Hills and Big Horn Mountains were uplifted and intermediate ground subsided forming the Powder River Basin. Extensive deposition of sediments on flood plains of the newly formed Powder River Basin during the Paleocene resulted in development of the Fort Union Formation, a succession of rock strata rich in coal deposits (Lewis and Roberts 1977). The Eocene was a period of folding and faulting that produced many of the present structural features of southeastern Montana (Glaze and Keller 1965). The region was buried by debris from volcanic activity to the west during the Oligocene and Miocene. However, uplift of areas bordering the Powder River Basin occurred again during the Pliocene, rejuvenating streams throughout the basin and resulting in erosion that continued through the Pleistocene, forming the present landscape. The northern portion of the Powder River Basin was not glaciated during the Pleistocene, but climate changes associated with glaciation doubtless contributed to increased rates of erosion and greater relief of the landscape (Schafer et al. 1979).

The landscape in the vicinity of Colstrip (approximately 980 m elevation) is characterized by rolling prairies with alternating ridges, drainages, and sandstone bluffs (Meyn et al. 1976). Twenty to 50 percent of the land surface slopes less than 8%, and relief ranges from 150-300 m (Schafer et al. 1979). Local geology is dominated by the Tongue River member of the Fort Union Formation. The Tongue River member is composed of lenticular sandstones, carbonaceous shales, and porcelainite (scoria) beds overlying subbituminous coal seams (Veseth and Montagne 1980). The coal seam underlying the Rosebud Mine is 5-8 m thick and lies under 5-65 m of sandy shale overburden (Dollhopf et al. 1977a).

Soils

The study area lies in a transition zone where Aridisols (desert soils) of the southern Powder River Basin, Mollisols (prairie soils) of the eastern Great Plains, and Alfisols (forest soils) of the Black Hills and Big Horn Mountains overlap. Entisols (young, undeveloped soils) are common locally where steep slopes are subject to erosion. In general, coarse-loamy and fine-loamy soil textural classes predominate (Packer 1974).

Potential evapotranspiration far exceeds annual precipitation on the study area, and run-off during snow melt and high-intensity thunderstorms prevents some precipitation from ever entering the soil profile (Schafer et al. 1979). Accordingly, soils are dry in the root zone during the majority of the growing season. This lack of water penetration into the soil results in the accumulation of lime and other soluble salts near the base of the root zone (Schafer et al. 1979). Because of these and other soil profile characteristics, Hertzog (1983) assigned the study area to Land Capability Class IV, lands suitable for improved pasture and rangeland but not suitable for row crops.

Climate and Weather

The study area has a semi-arid, continental climate characterized by extreme temperatures and precipitation. January and July typically are the coldest and warmest months with long-term means of -6.8 and 21.7 C, respectively (N.O.A.A. 1961-1990). Annual temperature extremes may range between -40 and 40 C. February and June are the driest and wettest months with long-term means of 1.3 and 14.5 cm, respectively. Annual precipitation may range between 22 and 63 cm, but the long-term mean was 46 cm. Approximately ¾ of the annual precipitation total falls during April-October and results mainly from showers and high-intensity thunderstorms (Schafer et al. 1979). The average frost-free season in southeastern Montana is approximately 110 days (Wood et al. 1989), although most growth of native herbaceous plants occurs during April-June (Smoliak 1956).

Seasonal weather during the 1992-1995 study period was characterized by (1) warm, dry springs, (2) cool, dry summers, and (3) normal falls and winters relative to long-term temperature and precipitation means (N.O.A.A. 1992-1995) (Figure 2). Exceptions were (1) summer 1993, which was wetter than normal, (2) fall 1993 and 1994, which were drier and wetter than normal, respectively, and (3) winter 1992-1993, which was cooler than normal.

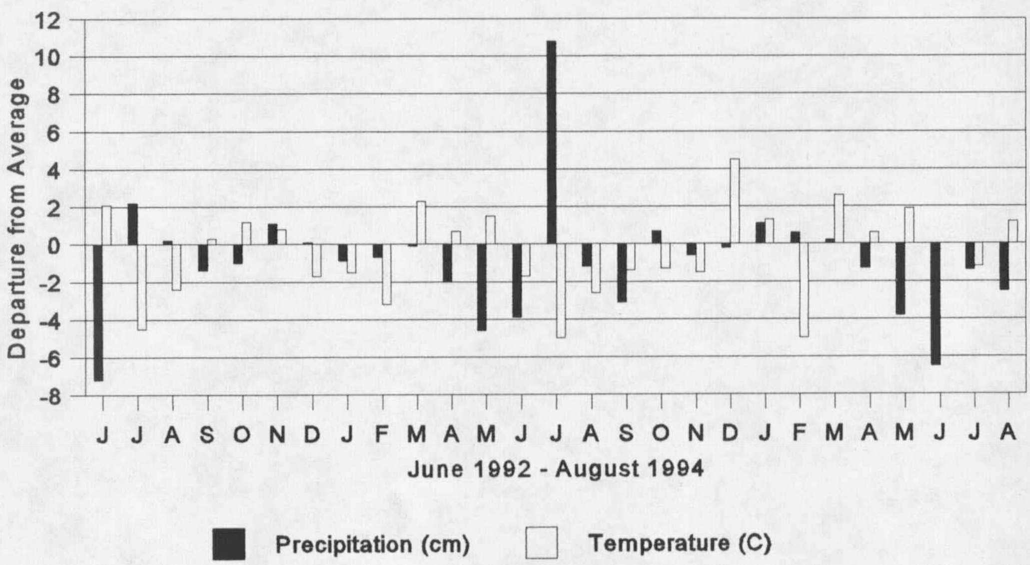

Figure 2. Monthly departures from the 30-year mean (1961-1990) with respect to precipitation (cm) and temperature (C) patterns for the period, June 1992-August 1994, Rosebud Mine (Colstrip weather reporting station), Montana. The 30-year mean monthly values, June-May, were: precipitation---June=14.5, July=3.0, August=3.1, September=3.7, October=2.9, November=1.5, December=1.5, January=1.7, February=1.3, March=2.0, April=4.1, and May=6.7; and temperature---June=17.8, July=21.7, August=20.6, September=14.1, October=8.4, November=0.6, December=-5.4, January=-6.8, February=-3.3, March=1.2, April=7.0, and May=12.4.

Vegetation

Native plant communities in southeastern Montana have been characterized broadly as either mixed prairie or coniferous woodland, with scattered intrusions of riparian vegetation on more mesic sites (Payne 1973, Dollhopf et al. 1977b). Because large-scale manipulation of native vegetation commonly occurs on surface mines, however, the Rosebud Mine / Colstrip study area was a highly interspersed mosaic of native and introduced / human-created vegetation types.

Wildlife

Mule deer were by far the most abundant of all big game species on the study area, 1992-1995. White-tailed deer (Odocoileus virginianus) and elk (Cervus elaphus) were rare, and a lone moose briefly visited the area during summer 1994. In addition to wild ungulates, WECO maintained a captive population of approximately 20 bison (Bison bison) on the Rosebud Mine. Upland game birds were abundant and included sharp-tailed grouse (Tympanuchus phasianellus), pheasant (Phasianus colchicus), and wild turkey (Meleagris gallopavo). Sage grouse (Centrocercus urophasianus) and Hungarian partridge (Perdix perdix) were observed occasionally. Coyotes (Canis latrans) were abundant while bobcats (Felis rufus) and red fox (Vulpes vulpes) were sighted infrequently. Large predators apparently were absent, although mountain lions (Felis concolor) and black bears (Ursus americanus) were harvested in heavilywooded regions south and west of the study area.

Recreational hunting was a popular activity on public and private lands in the Colstrip area. However, federal and state regulations and concern for the safety of employees and equipment precluded hunting on the Rosebud Mine except under limited, highly controlled conditions. Similar concerns generally precluded recreational hunting in and around Colstrip, although limited bow harvest of deer occurred within the townsite.

Land Use

Cattle grazing constitutes the primary historic land use of native vegetation in the Colstrip area. Although surface coal mining was the major land use on the Rosebud Mine, reclaimed lands also were subject to limited grazing. A small amount of land adjacent to the mine was used by the town of Colstrip for family dwellings, schools, commercial developments, parks, recreational developments, and roads. Power-generating facilities, associated settling and cooling ponds, pipelines, and service roads were located in and around Colstrip. Only a small amount of native mixed prairie, both on and off the Rosebud Mine, was converted to agricultural cropland, predominantly alfalfa (Medicago sativa).

Commercial development of coal on the study area began in 1917 when Northern Pacific Railway Company (NPRC) developed a coal field to obtain high-quality, low-cost coal to power its steam locomotives. To facilitate development, a branch rail line was constructed to the coal field from the main line at Forsyth, Montana in 1923. At that time, the coal field site became known as Colstrip.

Coal was first mined at Colstrip in 1924 by the Northwestern Improvement Co., a subsidiary of NPRC. Production continued until 1958 when NPRC switched from coal to diesel-powered locomotives. Mining resumed in 1968 when WECO, a subsidiary of Montana Power Co., purchased the operation, including the town of Colstrip, and began producing coal for electrical utilities in Montana and several midwestern states (Schafer et al. 1979, Plantenberg 1983).

In 1971, Montana Power Co. and Puget Sound Power and Light Co. constructed 2 350-megawatt coal-fired power-generating facilities in Colstrip (Aasheim 1981). Two 700-megawatt facilities were added in the early 1980s (Knudson and Peterman 1980). As a result of industrial development, residential and commercial sections of Colstrip were developed, and the human population increased to its present level of approximately 3,035 (U.S. Bureau of the Census 1992). Production of coal from the Rosebud Mine also increased, peaking during the early 1990s at roughly 12 million tons of coal extracted per year; 30% was exported to Minnesota and Wisconsin and 70% was burned in Montana, principally in Colstrip.

METHODS

The Biological Year

Seasonal designations were derived from changes in climatic conditions and deer behavior. The biological year, 01 June-31 May, was divided into 4 seasons: (1) summer, 01 June-31 August; (2) fall, 01 September-30 November; (3) winter, 01 December-28 February; and (4) spring, 01 March-31 May. All data and analyses relating to seasonal patterns reflected these designations.

Classification of Vegetation-Cover Types

Eight vegetation-cover types were defined based on conspicuous vegetation, topography, and dominant land-use characteristics. The amount of the study area covered by each type was determined via the map-weight method (White and Garrott 1990) following ground-truthing of aerial orthophoto maps.

Plant species composition was estimated for vegetation-cover types to elucidate the unique vegetative characteristics of each. Frequency occurrence of species was determined based on plots (n=100 / type) positioned randomly throughout the study area (Gysel and Lyon 1980, Bonham 1989, Higgins et al. 1994). One- and 100-m^2 circular plots were used to measure presence of grasses and forbs and shrubs / trees, respectively. Circular plots were used to reduce circumference:area ratios, thereby reducing edge and the potential bias introduced by researcher decisions to include or exclude individual plants from plots (Bonham 1989). Determination of plot size was based on recommendations of Bonham (1989) for grasses and forbs and Oosting (1956) and Irwin and Peek (1979) for shrubs / trees. Plots were examined during mid-summer (July 1994) to maximize the probability of including both cool- and warm-season plant species. Common and scientific names of plants followed Booth (1950) and Booth and Wright (1962) except where otherwise noted.

Deer Capture

Sixty-seven yearlings, adults and fawns ≥6 months of age (48 females and 19 males) were captured using cannon nets (Hawkins et al. 1968), drive nets (Beasom et al. 1980), a dart gun (Pond and O'Gara 1994), and a hand-held net gun (Barrett et al. 1982), March 1992-January 1993 (Appendix, Table 1). Captured deer were sexed, aged according to tooth replacement and wear criteria (Robinette et al. 1957, Rees et al. 1966), marked with metal ear tags, and fitted with uniquely colored neck bands equipped with radiotransmitters (Telonics, Inc., Mesa, Ariz.) (n=58) or neck bands / plastic ear flags without radiotransmitters (n=9) (Nietfeld et al. 1994).

Forty-one neonate fawns (11 females and 30 males) were captured using either random ground searches and behavioral cues of adult females (Downing and McGinnes 1969, White et al. 1972, Huegel et al. 1985) or aerial location techniques (Riley and Dood 1984), June 1993 and 1994 (Appendix, Table 1). Captured fawns were sexed, weighed, marked with metal ear tags, and fitted with either expandable, break-away neck bands equipped with radiotransmitters (n=34) or uniquely marked plastic ear flags without radiotransmitters (n=7)

(Nietfeld et al. 1994).

Radiotelemetry

Use of vegetation-cover types and patterns of home range establishment, mobility, activity, and survival were determined through analysis of radiotelemetry data. Ninety-two radiocollared deer were located 9,821 times through aerial telemetry (n=151 locations, 1.5%) and ground triangulation (n=9,670 locations, 98.5%). Aerial locations were obtained using a Piper Supercub fixed-wing aircraft equipped with 2-element H-antennas mounted on each wing strut. Deer location was determined by homing in on the transmitter signal and obtaining visual verification of the position of the radiocollared deer (Gilmer et al. 1981, Mech 1983, Kenward 1987, Samuel and Fuller 1994). The error polygon method (Heezen and Tester 1967, Nams and Boutin 1991) was used to estimate deer location from the ground using a single hand-held, 2-element H-antenna. A Telonics TR-2 receiver was used for both aerial and ground telemetry (Telonics, Inc., Mesa, Ariz.). All locations were recorded to the nearest 10 m as Universal Transverse Mercator (UTM) grid coordinates.

Deer activity status (active or inactive), recorded at the time of location, was determined via visual verification or estimated based on variability of radiosignal strength (Kjos and Cochran 1970, Gilmer et al. 1971, Cochran 1980). Fluctuating radiosignal strength indicated deer activity whereas constant signal strength indicated inactivity.

Telemetry error was evaluated throughout the study by visually verifying the location and activity status of randomly selected radiocollared deer subsequent to remote telemetry contact and estimation of location and activity (Samuel and Fuller 1994). Error trials were conducted during both diurnal and nocturnal hours and during each season. Mean error of telemetry bearings was 2.2±2.6 (SE) degrees based on 76 error trials conducted at a mean receiver-transmitter distance of 376.8 m. This error resulted in misclassification of vegetation-cover type occupied by deer 2.6% of the time. In contrast to the findings of Gillingham and Bunnell (1985) and Beier and McCullough (1988), activity status of deer based on fluctuating radiosignal strength was reliably estimated (94.5% correct estimation based on 127 error trials).

Radiocollared deer were located 4 times monthly to assess seasonal patterns of survival and home range use. One location per deer per month was obtained during each of 4 different diel periods: (period 1) sunrise to mid day; (period 2) mid day to sunset; (period 3) sunset to mid night; and (period 4) mid night to sunrise. Successive locations obtained for each radiocollared deer were separated by a minimum of 24 hours to ensure independence of observations.

A subset of radiocollared deer (n=16 yearling and adult females) was monitored during diel periods to assess diel home range, mobility, and activity characteristics among seasons. Diel monitoring involved location of deer at hourly intervals spanning a 24-hour period. Attempts were made to monitor each deer during at least 1 diel period per month. Deer monitored over diel periods generally occupied home ranges on the periphery of Colstrip, centered near active mining and reclamation sites. Accordingly, they had access to a wide