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Ecology of mule deer in the upper Missouri River breaks Montana

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ECOLOGY OF MULE DEER IN THE UPPER

MISSOURI RIVER BREAKS, MONTANA

by

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Movement patterns and daytime habitat selection by mule deer (Odocoileus hemionus) were investigated using radio telemetry and sign transects. Home range sizes were intermediate between those in mountain-foothill and in rolling prairie habitats, indicating moderate habitat complexity. Home range size was negatively correlated with doe age and with the roughness of the area occupied. A positive relationship existed between age of does and roughness of core areas, suggesting that mortality rates may be lowest in roughest terrain. More than 90% of all deer sign and locations of marked deer were in rough breaks habitat. Deer avoided most plateau and river bench habitats, and selected mesic sites including steep north slopes and shrubby draws.

Mule deer in the upper Missouri River breaks fed in grainfields from September to April. Deer used grainfields primarily at night, fed more often in stubble strips than in new winter wheat, preferred field areas <200 m from escape terrain, and avoided areas >400 m from it. High reproductive and fawn survival rates of this population indicated the individuals were in excellent nutritional condition. The nutritional benefits and potential effects of agricultural crop use by mule deer on their population dynamics should be considered in management decisions.

Habitat use and movement patterns of mule deer were also investigated to determine potential impacts of a proposed hydroelectric dam. Floodplain riparian zones and islands made up 1% of the primary deer habitat but were used by approximately 3% of the fawns in July. Because elevations below the proposed inundation level were generally avoided by mule deer, potential losses of the resident herd were estimated at 4-8% rather than the 10% predicted by the overall loss of primary deer habitat. Major impacts could result from loss of rough terrain and woody riparian sites, and secondary impacts could result from increased harassment and hunting pressure if recreational access is developed. Mitigation should be directed at restoring and enhancing woody riparian and shrub cover, and discouraging recreational access into rough terrain if necessary.

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Financial support, flight services, and field housing for the project was provided by the Montana Power Company (MPC). I thank MPC liaison, T. O'Neil, for his aid during all phases of the study. We greatly appreciated the special housing provided at Ryan Dam and the hospitality extended to us by the residents of that community. The Montana Cooperative Wildlife Research Unit also provided financial and logistical support. Montana Department of Fish, Wildlife and Parks personnel, including J. Cada, F. Feist, J. Mitchell, G. Olson, and many others, provided logistical support and information that helped make this project successful.

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THESIS INTRODUCTION

The Great Plains, comprised of short- and mixed-grass prairies, constitute the largest grassland ecosystem in North America. Many soils of the Plains are extremely erodible, and erosion within drainage basins has created the highly dissected, rough terrain commonly called "breaks". Mule deer (Odocoileus hemionus) of the Plains are usually dependent on the habitat types associated with breaks or with the rough topography of scattered buttes and escarpments.

Mule deer were common on the Great Plains until the 1870's, then declined to near extinction by the early 1900's (Cutright 1969, Mackie 1970, Richardson and Peterson 1974). Deer populations declined during the mass settlement of the Plains that was promoted by the homestead acts of 1862, 1909, and 1919. Thousands of homesteaders journeyed to the Plains and vainly attempted to eke livings from small tracts of land that were inadequate to sustain most families. Devastation of prairie habitat resulted from the plowing of non-arable lands, intensive livestock grazing on small acreages, and extensive harvest of limited timber resources. In addition to habitat destruction, drought and blizzards during 1885-1887, subsistence hunting by homesteaders, and market hunting for the steamboat companies along the upper Missouri River all contributed to a major decline in the deer population (Severson 1981). Deer populations remained low until after the drought of the 1930's, then increased to relatively high densities by the 1960's. Mackie (1970) suggested that human depopulation of the Plains during the 1930's allowed deer populations to recover. In addition, farming and stocking rates have been adjusted to the semi-arid environment of the Plains, and range conditions have generally improved. Predator control that was initiated during World War II, and the enactment and improved enforcement of game laws also helped deer populations to increase (Severson 1981).

Mule deer of the Plains have become an important economic and wildlife management consideration. Several major existing and potential environmental problems affecting this resource are livestock overgrazing, brush and weed control, and hydroelectric development (Constan and Hook 1981). The Missouri River within Montana is currently impounded along approximately 45% of its 1,175 km length, and several agencies have shown interest in the development potential of remaining sites. The Montana Power Company proposed building a run-of-the-river dam at Carter Ferry, approximately 42 km northeast of Great Falls, Montana, and licensing of the project was required in accordance with regulations of the Federal Energy Regulatory Commission. Under these regulations, the developer must determine impacts of the project on wildlife in the area and develop an effective mitigation plan. Because the proposed dam was to inundate approximately 1,250 ha of river-bottom and breaks habitat, impacts on resident mule deer populations were expected. This study was designed to document movement patterns and habitat use by mule deer, evaluate quantity and quality of the habitat that would be lost, and contribute to the development of a comprehensive mitigation plan.

The following chapters have been written in manuscript format to facilitate publication of thesis material. The first manuscript is targeted for The Prairie Naturalist and deals with home range and daytime habitat selection of radio-marked female mule deer. The second manuscript is targeted for the Wildlife Society Bulletin and addresses deer use of agricultural lands adjacent to breaks habitat. The third manuscript, evaluating the potential impacts of hydroelectric development and possible mitigation measures, was submitted to the 3rd biennial symposium Issues and Technology in the Management of Impacted Wildlife, hosted by the Thorne Ecological Society in Colorado during November 1987 (Ball 1988).

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CHAPTER II

HOME RANGE AND HABITAT SELECTION BY MULE DEER IN NONTIMBERED BREAKS HABITAT

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ABSTRACT

Movement patterns and daytime habitat selection by mule deer (*Odocoileus hemionus*) were investigated using radio telemetry and sign transects. Home range sizes were intermediate between those in mountain-foothill and in rolling prairie habitats, indicating moderate habitat complexity. Home range size was negatively correlated with doe age and with the roughness of the area occupied. A positive relationship existed between age of does and roughness of core areas, suggesting that mortality rates may be lowest in roughest terrain. More than 90% of all deer sign and locations of marked deer were in rough breaks habitat. Deer avoided gentle upland and river bench habitats, and selected mesic sites including steep north slopes and shrubby draws.

INTRODUCTION

Mule deer residing in prairie habitats are subject to increasing pressures from intensive livestock grazing, conversion of native rangelands to croplands, development of coal and hydroelectric energy resources, and intensive hunting pressure. Knowledge of mule deer habitat selection and spatial requirements is necessary for making needed management decisions to cope with increasing resource development.

STUDY AREA

The study area encompassed 237 km^2 of nontimbered breaks and agricultural lands along a 26 km segment of the Missouri River, 16 km northeast of Great Falls, Montana. The area was located in the western portion of the Northern Great Plains. The climate was semi-arid and typically continental except for frequent chinook winds that moderated winter temperatures. Average annual temperature was 7 C, and precipitation averaged 35 cm, 75% of which occurred from April through September.

Erosion of the gently rolling Missouri Plateau created rough irregular topography commonly referred to as river "breaks". Elevation varied from 810 to 1,029 m, with an average rise of 100 m between the River and Plateau. More than 95% of the land was privately owned, with only a few scattered parcels of federal and state land that were leased for grazing. Dryland farming was the primary land use on plateau and river-bench areas. Winter wheat and barley were the most common crops, and were usually planted in strips with alternate strips summer fallowed. Most coulee systems and smaller river benches unsuitable for cropland were grazed by cattle or horses.

Native vegetation communities were highly interspersed because of the rough terrain. Habitats were categorized according to range sites with similar vegetation, topography, and microclimate (Severson 1981). Most common and scientific names of plants were from Booth and Wright (1959):

Plateau.--Plateau Agriculture and Range Sites occurred on level and gently-rolling plateau areas. Agriculture Sites were dominated by small grain production. Range Sites were represented by small, isolated remnants of short-grass prairie.

Breaks.--Breaks habitats were categorized as Xeric Run-off, Mesic Run-off, or Run-in Sites. Xeric Run-off Sites occurred on slopes and ridges with southerly aspects. They were sparsely vegetated with grasses, and little soapweed (Yucca glauca), rubber rabbitbrush (Chrysothamnus nauseosus), and broom snakeweed (Xanthocephalum sarothrae) or isolated stands of greasewood (Sarcobatus vermiculatus). Mesic Run-off Sites occurred on slopes and ridges with northerly aspects. They were covered with grasses, and shrubs including silver sage (Artemisia cana), skunkbush sumac (Rhus trilobata), and common and creeping juniper (Juniperus communis and J. horizontalis). Run-in Sites occurred at the base of side slopes, in swales, side draws, and major coulee bottoms. These sites had vegetation similar to Mesic Run-off Sites plus large patches of western snowberry (Symphoricarpos occidentalis) and Wood's rose (Rosa woodsii), and scattered thickets of common chokecherry (Prunus virginiana) or silver buffaloberry (Shepherdia argentea).

Floodplain.--Floodplain habitats were categorized as Agriculture, Range, or Riparian Sites. Agriculture Sites were used primarily for small-grain production. Range Sites were dominated by grasses and silver sage. Riparian Sites consisted of narrow (<30 m) strips of woody riparian vegetation confined to the river's edge. These sites supported boxelder (Acer negundo), plains cottonwood (Populus deltoides), and willow (Salix spp.), in addition to the wide variety of shrubs common to other mesic sites. They also contained mesic grasses and forbs including blue grass (Poa spp.) and hemp dogbane (Apocynum cannabinum).

Island.--Nine islands in the Missouri River ranged in size from 0.1 to 8.3 ha. The 3 largest islands averaged 7.4 ha; the largest was xeric and sparsely vegetated with little soapweed and peachleaf willow (Salix amygdaloides), and the other 2 were dominated by shrubs, grasses, and forbs common to other mesic and riparian sites.

METHODS

Habitat use and movement patterns of resident mule deer were studied from January 1983 through July 1984. Helicopter drive netting and net-gunning were used to capture mule deer for radio-collaring. Captured deer were marked with numbered metal ear-tags, and their ages estimated from tooth wear and replacement (Robinette et al. 1957). Radio collars were attached to 20 does >18 months of age. Radio-equipped deer were located during regular tracking flights and ground reconnaissance, and their locations recorded by Universal Transverse Mercator grid coordinates. Date, time, elevation, slope, range site, herd composition, and activity also were recorded. Most daytime ground tracking consisted of careful "track and stalk" efforts, allowing us to locate and observe most deer without disturbing them. Deer behavior was coded according to the activity of the majority of deer within a group (1+ animals). Hourly triangulation from 2 precision-null tracking systems (Telonics Inc., Mesa, AZ) was used to monitor nocturnal movements of instrumented deer.

Daytime and total home range sizes were determined by the minimum area technique (Dalke 1942, Mohr 1947) for each radio-marked doe. Harmonic home ranges and core areas (Samuel et al. 1985) were calculated from the pooled daytime locations of 1 group of 4, and 8 groups of 2 marked deer that generally occupied different coulee systems (Fig. 1). Habitat availability was determined from a minimum of 200 systematic grid points within the 100% utilization volume contours of the 9 harmonic home ranges. Elevation, slope, range site, and a modified version of the Land Surface Roughness Index (LSRI) developed by Beasom et al. (1983) were recorded for each point within core and peripheral (outside of core areas but within the 100% utilization contour) areas from 7.5 minute USGS topographic maps and 1:12,000 aerial photos. The LSRI estimates the total length of topographic lines within a 40 ha sampling unit. Roughness Index values for this study were calculated using 21 systematic points within a 4 ha circle, and expanded by a factor of 10 to standardize them with the technique described by Beasom et al. (1983). Point estimates of habitat availability were pooled within core, peripheral, and total areas (core + peripheral areas) for analyzing habitat selection. Availability of habitats along the Missouri River corridor was determined from plots along 32 sign transects established at 0.8 km intervals along the corridor. Each transect began at the edge of the agricultural plateau (or 1.6 km from the River, whichever distance was least) and ran approximately

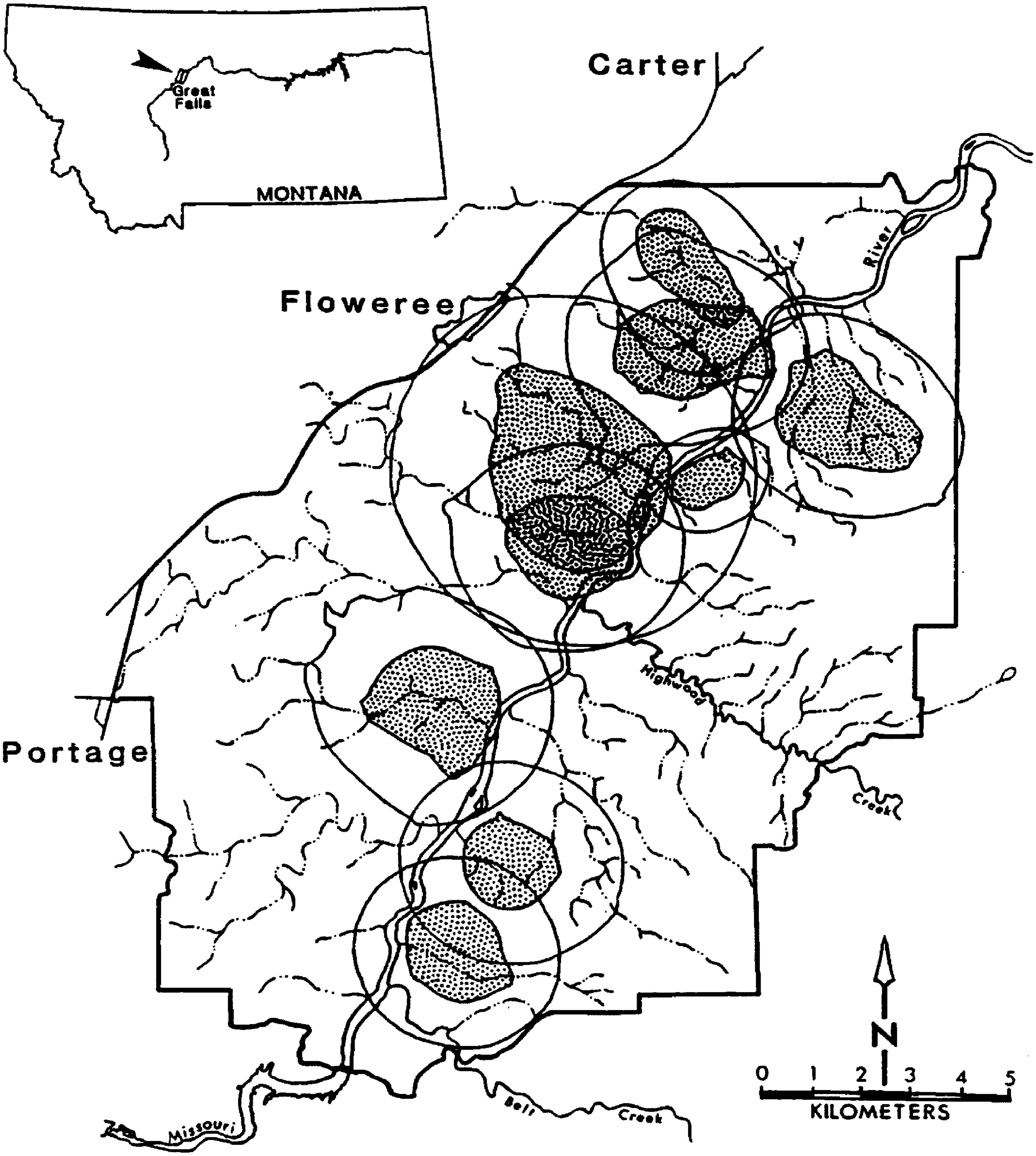

Fig. 1. Daytime harmonic home ranges and core areas of 9 groups of radio-marked does residing in different coulee systems on the Carter Ferry study site.

perpendicular to the River to the plateau on the other side. Circular plots of 9.3 m^2 were sampled at 6.1 m contour intervals along each transect. To minimize sampling size bias caused by major differences in topographic relief, additional plots were sampled at 50 m intervals along added transects established perpendicular to the River at 200 m intervals on 2 noncultivated benches. No plots were sampled on islands, cliffs (slopes > 55°), or in cultivated areas. Slope, elevation, range site, the number of pellet groups (≥10 pellets), and the presence or absence of deer tracks or beds were recorded at each plot.

Observation and sign transect data were used independently to assess habitat selection as determined from the comparison of habitat use to availability (Neu et al. 1974, Marcum and Loftsgarden 1980). Only daytime visual observations of undisturbed (bedded, feeding, traveling undisturbed, or standing alert) radioed does were used to determine habitat use within each group's harmonic home range area. The total number of pellet groups, plus other deer sign (presence = 1, absence = 0), was used to assess habitat use along the River corridor.

RESULTS

During 4 days of trapping in January and February of 1983, 42 deer were captured; 3 yearling and 17 mature does were fitted with radio-collars. Between 16 January 1983 and 16 July 1984, the 20 instrumented does were located 1,322 times. Most (80%) of the 1,062 daytime locations were visual observations of undisturbed deer (57% bedded, 18% feeding, 3% traveling undisturbed, 22% standing alert).

Sign transects were sampled during August of 1983, and 2,418 plots were sampled along approximately 67 km of transects.

Nine harmonic home ranges were constructed from 1,007 independent daytime locations ($\bar{x}$ = 112, range 77-211). The average area enclosed within the 100% utilization contour was 1,680 ha (range 409-4,363). Average core areas were 451 ha (range 102-1,186), enclosed approximately 27% of the total area, averaged of 66% of the utilization volume, and contained an average of 91% of the points. Habitat availability was recorded for 2,080 systematic points within 100% contours, and 572 points within core areas.

Home Range

Instrumented deer were nonmigratory and exhibited a high degree of home range fidelity (Ball 1988). The average daytime home range size was 478 ha (n = 20, range 87-1,069). Total home range areas were calculated for does with more than 4 ($\bar{x}$ = 18, range 9-35) nocturnal locations, and averaged 583 ha (n = 14, range 225-1,138). Nocturnal movements to grainfields and river bench areas accounted for an average 40% (range 0-162) increase between day and total home range areas.

Daytime home range size was negatively correlated with the does' estimated age and the roughness of core areas (Fig. 2 and 3). A stepwise multiple regression of the roughness of core areas (LSRI) and the estimated age of marked does on the natural log of minimum area home range sizes (ha) indicated that core roughness accounted for a greater proportion of the variability in the size of home ranges than age (partial

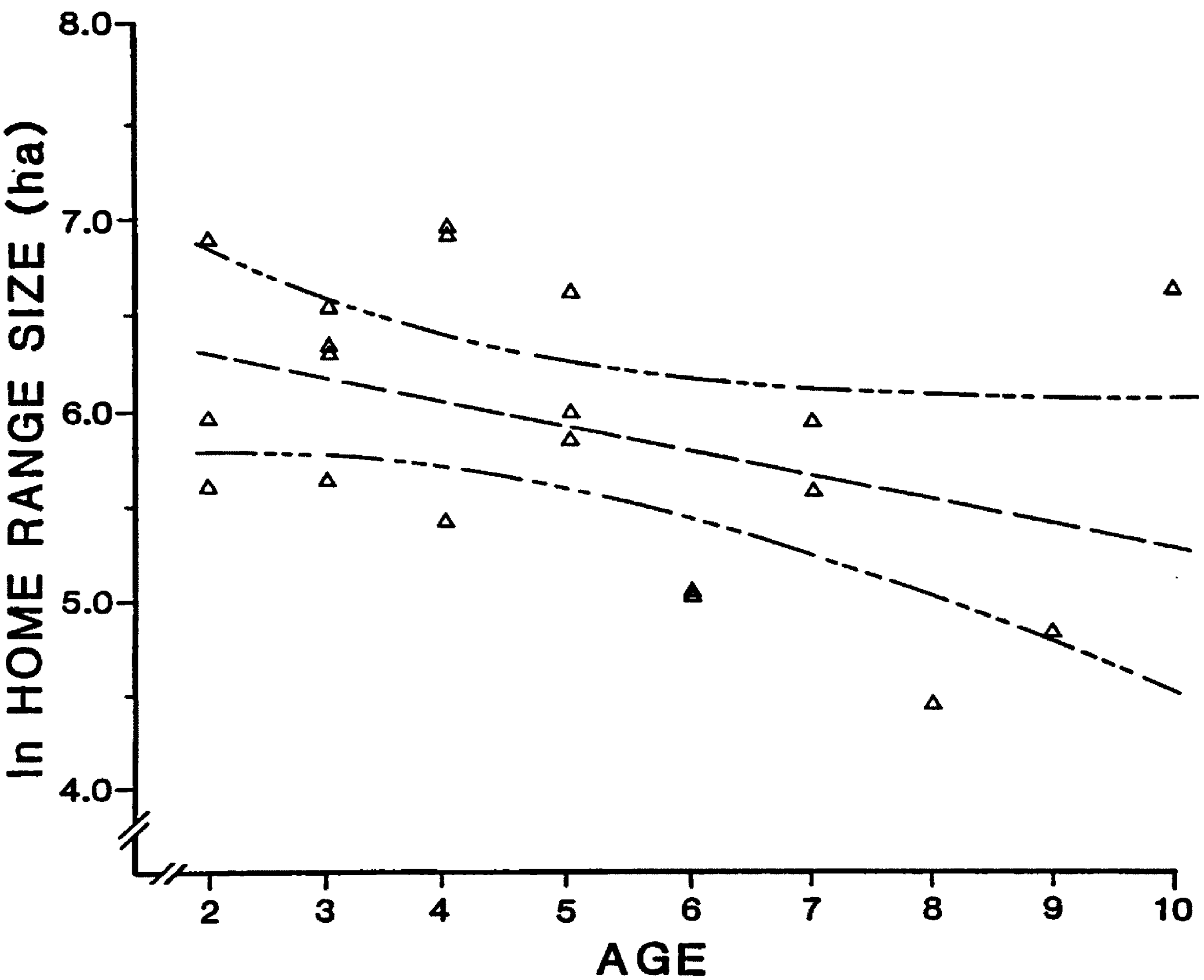

Fig. 2. Regression of the natural log of minimum area home range size on estimated age of radio-marked does ($y = -0.13x + 6.56$, $r^2 = 0.17$, $P = 0.04$). Delineated band marks the 95% CI.

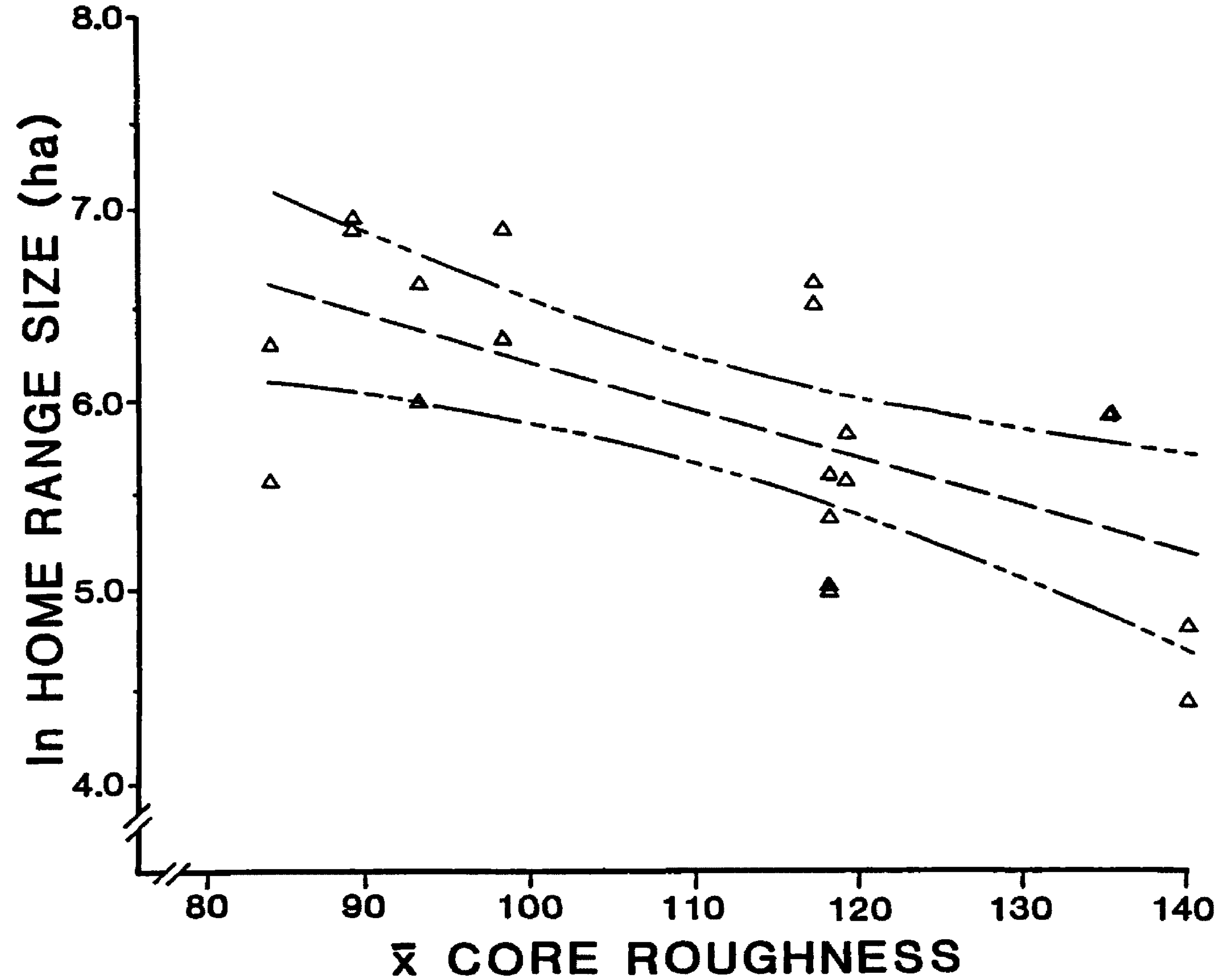

Fig. 3. Regression of the natural log of minimum area home range size on mean roughness (LSRI) of core areas of radio-marked does ($y = -0.25x + 8.67$, $r^2 = 0.39$, $P = 0.002$). Delineated band marks the 95% CI.

$R^2 = 0.39$ vs $R^2 = 0.05$). A positive and marginally significant correlation ($P = 0.06$) existed between roughness of core areas and estimated age of does (Fig. 4).

Habitat Selection

Total habitat availability was strongly influenced by the habitat components within peripheral areas of the harmonic home ranges. Habitat availability within peripheral and core areas were significantly different in 10 of the 17 habitat categories tested (Table 1). Breaks habitat (all range sites minus Island, Plateau, and Flood Plain Sites) within core areas was significantly rougher than breaks within peripheral areas (Sign Test, $P \leq 0.05$). Core areas were located almost exclusively within breaks habitat. They therefore contained proportionately less upper elevation agricultural areas, lower elevation river bench areas, and gentler transition slopes than peripheral areas. Despite these differences, patterns of habitat selection by mule deer does were consistent at both the core and total area levels in 14 of the 17 categories tested (Table 2). Differences in selection occurred in lower elevation areas represented by Flood Plain Sites. Flood Plain Agriculture and Range Sites were selected against at the total area level and used equal to their availability at the core level. Overall, radio-marked does exhibited a strong selection for Mesic Run-off and Run-in Sites, middle elevation zones, and $<26^{\circ}$ side slopes. Plateau and Flood Plain Agricultural and Range Sites were selected against, as were steep side slopes ($>35^{\circ}$).

Selection for Mesic Run-off and Run-in Sites determined from sign

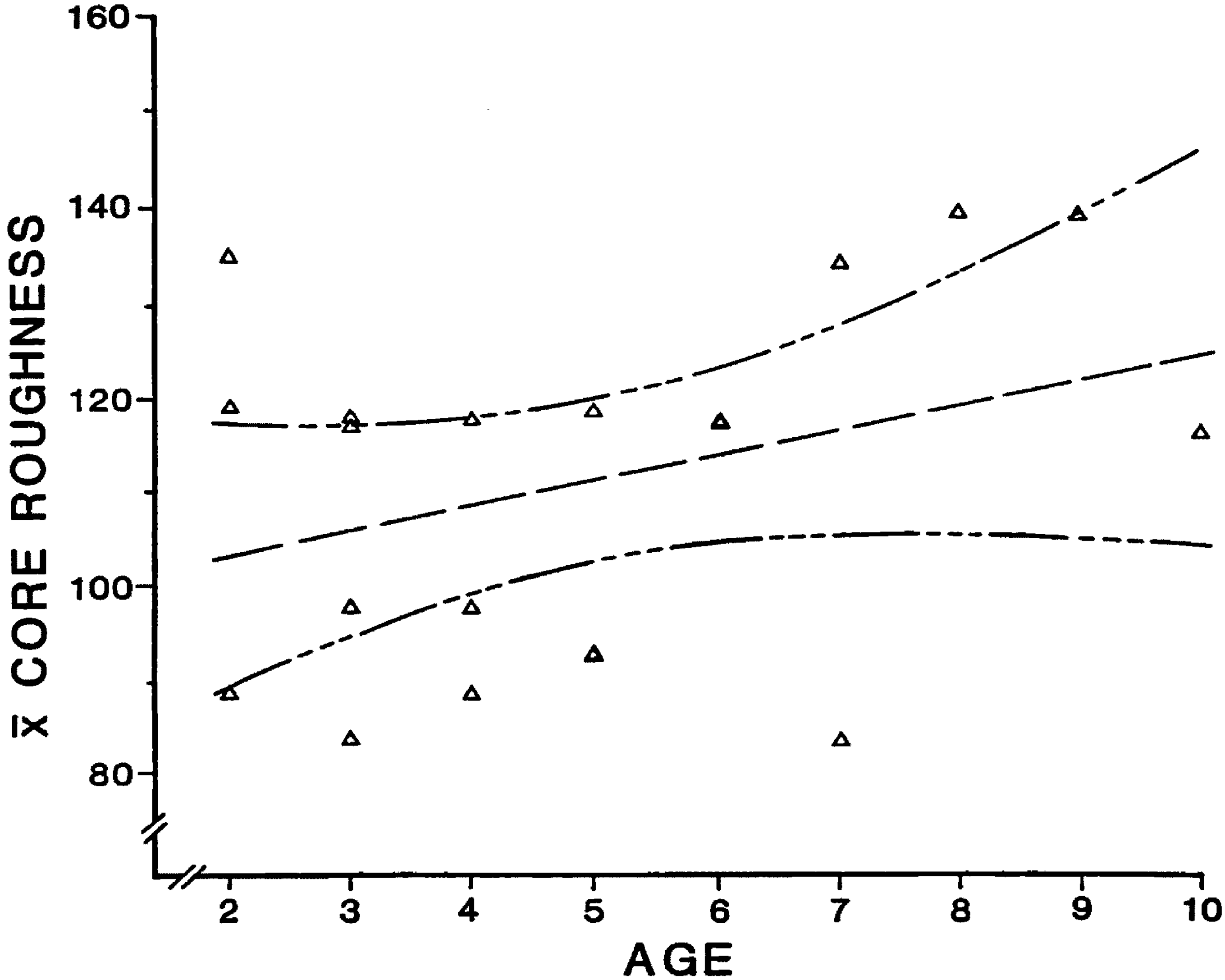

Fig. 4. Regression of the mean roughness (LSRI) of core areas on estimated age of radio-marked does ($y = 0.28x + 9.75$, $r^2 = 0.12$, $P = 0.06$). Delineated band marks the 95% CI.

Table 1. Comparison of percent habitat availability within core and peripheral harmonic home range areas.

HABITAT CATEGORY	CORE AREAS N	CORE AREAS Avl	PERIPHERAL AREAS N	PERIPHERAL AREAS Avl	Z[a]
RANGE SITE	572		1508		
Plateau					
Agriculture		27.3		40.4	5.83^{----}
Range		10.8		05.3	3.89^{++++}
Breaks					
Xeric Run-off		14.0		13.3	0.39
Mesic Run-off		21.0		14.7	3.24^{++}
Run-in		24.3		18.4	2.86^{++}
Flood Plain					
Agriculture		0.9		2.3	2.63^{-}
Range		1.6		3.2	2.34
Riparian		0.2		1.9	4.43^{----}
Island		0.0		0.2	2.45
ELEVATION ZONE	572		1508		
Upper		25.0		41.0	7.23^{----}
Upper-middle		39.2		24.4	6.36^{++++}
Lower-middle		27.3		18.3	4.25^{++++}
Lower		8.6		16.3	5.14^{----}
SIDE SLOPE	187		395		
<26°		14.4		24.3	2.94^{--}
26-35°		41.7		37.7	0.94
36-45°		36.4		31.4	1.18
>45°		7.5		6.6	0.39

[a] Significance levels were determined from X^2 and Bonferroni Z tests. Probabilities designated as * = $P \leq 0.10$, ** = $P \leq 0.05$, *** = $P \leq 0.01$, or **** = $P \leq 0.001$ where * = + (core avail. > peripheral avail.) or * = - (core avail. < peripheral avail.).

Table 2. Habitat selection by mule deer in the upper Missouri River breaks, determined from observations of radio-marked does and habitat available within the total and core harmonic home range areas.

HABITAT CATEGORY	TOTAL AREA					CORE AREA				
	Use		Available			Use		Available		
	N	%	N	%	Z*	N	%	N	%	Z
RANGE SITE	851		2080			788		572		
Plateau										
Agriculture		5.4		36.8	23.93----		5.1		27.3	10.99----
Range		2.4		6.8	5.90----		2.2		10.8	6.21----
Breaks										
Xeric Run-off		15.9		13.5	1.54		16.5		14.0	1.28
Mesic Run-off		34.1		16.4	9.71++++		34.5		21.0	5.64++++
Run-in		40.1		20.0	10.56++++		40.4		24.3	6.41++++
Flood Plain										
Agriculture		0.0		1.9	6.39----		0.0		0.9	2.25
Range		0.6		2.7	4.85----		0.4		1.6	2.11
Riparian		1.6		1.4	0.40		1.0		0.2	2.11
Island		0.0		0.3	2.45		0.0		0.0	0.00
ELEVATION ZONE	851		2080			788		572		
Upper		8.2		36.6	20.04----		6.5		25.0	8.90----
Upper-middle		49.5		28.5	10.62++++		36.4		39.2	3.61+++
Lower-middle		35.3		20.7	7.77++++		50.1		27.3	4.05++++
Lower		7.1		14.2	6.13----		7.0		8.6	1.43
SIDE SLOPE	481		582			459		187		
<26°		47.8		21.1	9.40++++		47.5		14.4	9.53++++
26-35°		37.6		39.0	0.46		37.7		41.7	0.94
36-45°		12.5		33.0	8.33----		12.8		36.4	6.11----
>45°		1.9		6.9	4.34----		2.0		7.5	2.72--

* Significance levels were determined from X^2 and Bonferroni Z tests. Probabilities designated as * = $P \leq 0.10$, ** = $P \leq 0.05$, *** = $P \leq 0.01$, or **** = $P \leq 0.001$ where * = + (selection for) or * = - (selection against)

transects (Table 3) was similar to that determined from deer locations. Distribution of deer sign indicated a high degree of avoidance of Xeric Run-off Sites that was different from the "no selection" by marked does. Many of the differences in the proportionate availability of habitat categories measured by point estimates within harmonic home ranges compared to plots along sign transects may be the result of the exclusion of Plateau and Flood Plain Agricultural Sites as available habitat along sign transects. However, proportionate availability of side slope categories should have been unaffected by the exclusion of agricultural habitats and were probably the result of biases produced by the exclusion of cliff areas from sign transects, and the less accurate measurement of gentler slopes from topographic maps for point estimates. Patterns of side slope use were similar for deer location and sign data. The less biased sign transect data indicated that deer used most side slopes (<55°) in proportion to their availability except for the steep (36-45°) slopes, which were avoided.

DISCUSSION AND CONCLUSIONS

Different daytime and nighttime movements and habitat use associated with open terrain have been reported for mule deer using open prairie adjacent to badlands (Steigers 1981), and for whitetails and mule deer adjacent to croplands (Montgomery 1963, Herriges 1986, Wood 1986). The 40% increase between daytime and total home range area observed during this study was consistent with a 33-50% increase related to the nocturnal use of agricultural fields by white-tailed deer along the Yellowstone

Table 3. Habitat selection by mule deer in the upper Missouri River breaks, determined from sign transect data.

HABITAT CATEGORY	DEER USE[a] N	DEER USE[a] %	HABITAT AVAIL.[b] N	HABITAT AVAIL.[b] %	Z[c]
RANGE SITE	1533		2418		
Plateau					
Agriculture		-		-	-
Range		1.4		5.1	6.93^{----}
Breaks					
Xeric Run-off		30.4		37.8	4.99^{----}
Mesic Run-off		40.3		35.9	2.77^{++}
Run-in		21.6		14.8	5.31^{++++}
Flood Plain					
Agriculture		-		-	-
Range		2.4		3.9	2.66^{-}
Riparian		3.7		2.4	2.20
Island		-		-	-
ELEVATION ZONE	1533		2418		
Upper		17.5		17.6	0.08
Upper-middle		41.4		35.2	3.94^{++++}
Lower-middle		27.9		28.0	0.07
Lower		16.8		19.3	2.04
SIDE SLOPE	1003		1574		
<25°		53.7		54.1	0.19
25-35°		35.1		32.9	1.14
36-45°		8.7		11.8	2.56^{--}
>46°		2.5		1.2	2.28^{+}

[a] Use indicated as total N pellet groups, plus beds or tracks (presence = 1, absence = 0)

[b] Habitat characterized within each sign plot.

[c] Significance levels were determined from X^2 and Bonferroni Z tests. Probabilities designated as * = P ≤ 0.10, ** = P ≤ 0.05, *** = P ≤ 0.01, or **** = P ≤ 0.001 where * = + (selection for) or * = - (selection against).

River in eastern Montana (Herriges 1986). The general behavioral pattern of limited movements within areas of topographic or vegetative cover during the day and foraging in open habitats at night apparently evolved as an antipredator strategy (Geist 1981); it is currently reinforced by hunting pressure and other forms of human disturbance.

Daytime home ranges of mule deer does in this study ($\bar{x}$ = 478 ha) were larger than the average 40-100 ha home ranges reported for mule deer in mountainous habitats (Leopold et al. 1951, White 1960, Steerey 1979), and smaller than the 700-1,000 ha average in semi-desert, open prairie, and timbered breaks habitats (Rogers et al. 1978, Hamlin 1978a,b). Wood (1986) also reported intermediate sized home ranges ($\bar{x}$ = 440 ha) for resident mule deer in badlands and prairie habitat in eastern Montana. Home range size has been related to the distribution of food, cover, and water: increased diversity of habitat generally corresponds with decreased size of home ranges (Thomas et al. 1964, Robinette 1966).

The intermediate home range sizes observed during this study suggest that nontimbered breaks associated with agriculture provide an environment that is more diverse than the dryer, more rolling plains habitats but is less diverse than foothill and mountain habitats. The Roughness Index provided an objective index of roughness or topographic complexity (Beasom et al. 1983). Topographic complexity can directly influence habitat diversity by providing a wide variety of range sites with different temperature and/or moisture gradients and plant potential. Therefore, mule deer in rougher terrain should have smaller home ranges. Home ranges of deer occupying the gentlest terrain on my study area (LSRI < 90, $\bar{x}$ = 723 ha, n = 4) were approximately 3 times larger than home ranges of deer in the roughest areas (LSRI > 120, $\bar{x}$ = 220 ha, n = 4). Wood (1986) also reported that prairie mule deer had relatively small home ranges in rougher terrain. Severson and Carter (1978) reported the average activity radii of does and fawns in gentle terrain were 5 times larger than those in rougher badlands habitats.

Age has been another factor commonly linked with home range size (Robinette 1966, Nelson and Mech 1984). Larger home range size of younger does has been attributed to increased movements of yearling does after they were forced to become independent from their dams, and to the lack of established home range or habitat use patterns in younger deer. As expected, home range size was negatively correlated with the estimated age of the marked does in this study.

A positive relationship existed between the age of radio-marked does and the roughness of the core areas they occupied. The relationship between age and roughness may indicate that mule deer in rougher habitats have higher survival rates, that older does selectively occupy rougher terrain while forcing younger does to occupy gentler sites, or both. Swenson (1982) reported that mule deer in prairie habitats appeared to be more vulnerable to hunting than mule deer in forested habitats because of the limited value of topography as security cover. The roughest breaks habitats on my study area were less accessible to vehicles, and hence experienced less hunting pressure, than gentler terrain. Rougher terrain should also allow mule deer to more effectively escape natural predators (Geist 1981). Swenson et al. (1983) found that mule deer densities in prairie habitats of eastern Montana were highest in rough habitats including badlands, juniper breaks, scattered pine, and dense pine habitats. Working in northern Texas, Wiggers and Beasom (1986) reported the highest mule deer densities in areas with high LSRIs ($\bar{x}$ = 81) compared to low deer densities in areas with low LSRIs ($\bar{x}$ = 40).

The relationship between habitat roughness and mule deer home range size, age structure, and population density has several potentially important implications for management. If the quality of prairie mule deer habitat (as evidenced by relatively high survival rates, high population density, and small home range sizes) proves to be consistently highest in rough terrain, then the rough areas probably serve as refugia. I predict that population trends and impacts of harvest rates will need to be monitored across a wide range of habitat roughness, and that imminent declines will be noticed first in the gentlest terrain. Because the roughest terrain will be the last places where population declines will be noticeable, crop depredation problems in these high density areas may persist even when the population as a whole is declining rapidly. The level of hunting kill applied district-wide necessary to eliminate crop depredation problems in the roughest areas may very well be high enough to accelerate declines or retard recovery. Furthermore, the level of hunting kill necessary to affect stabilization or a moderate decline in rough terrain may well cause precipitous declines in populations inhabiting gentler terrain. Roughness can be easily measured from topographic maps and mapped over a large area and a diversity of habitat types. Deer locations and numbers, corrected for observability bias (Mackie et al. 1981), obtained during repeated population surveys, could be grouped according to roughness categories in order to track population trends. Additional refinement could be accomplished by adding information about the age structure of deer harvested from areas with different roughness indices.

The selection of specific habitat types by mule deer was activity specific. Habitat selection measured in this study from deer observations corresponded to the daytime security or thermal requirements of bedded deer, plus some limited foraging areas. The distribution of pellet groups was also more indicative of bed sites because deer tend to defecate most when just leaving their beds and while traveling (Collins and Urness 1981). Because of a distinct temporal segregation of habitat use related to the use of open terrain, the preference or avoidance of habitats during the day cannot be applied to all times or activities.

Avoidance of level terrain and preference for mesic sites in or adjacent to rough terrain during the day has been documented in most studies of prairie mule deer (Mackie 1970, Dusek 1975, Severson and Carter 1978, Steigers 1981, Riley and Dood 1984, Wood 1986). Mesic sites provided the maximum vegetative cover and forage availability in these semi-arid environments. Shrubs on steep (11-35°) north slopes provided hiding cover for fawns in the Missouri Breaks (Riley and Dood 1984) and badlands of South Dakota (Steigers 1981). Swenson (1982) noted that mule deer on mixed-grass prairie in eastern Montana significantly increased their use of more mesic upland timbered cover types during the hunting season. The combination of steep slopes and shrub cover on north slopes provided ideal escape "cover" for deer pursued by coyotes or dogs (Geist 1981). Ockenfels and Bissonette (1984) reported on the importance of riparian cover during periods of heat stress (>30 C) and recommended reduced disturbance of riparian areas during temperature extremes. The shade provided by steep north slopes, thickets in shrubby side draws, and the bases of cut banks were commonly used by deer on my study area. Mule deer and antelope (Antilocapra americana) in prairie habitats seek out microhabitats that provide cover from persistent winds (Bruns 1977, Wood 1986). Temperature extremes of -30 to 40 C, and average wind speeds of 25 km/hr from the south and southwest on the study area suggest that the observed selection of north slopes and other mesic sites may be partially thermal related.

Many of the important forage species of prairie mule deer (Mackie 1970, Dusek 1975), such as snowberry, sumac, and creeping juniper were found on most mesic sites. Other important food items, such as little soapweed and rubber rabbitbrush, were commonly found on xeric south slopes. Mackie (1970) and Severson (1981) noted the importance of south slopes as feeding sites during late winter and early spring green-up. Marked does in this study used south slopes approximately equal to their availability. The small proportion of deer observations made during spring, plus an overall lack of observations of feeding deer may have caused me to underestimate the value of xeric, south slope habitats. The apparent avoidance of xeric south slopes, as measured by sign transects, was possibly due to biases caused by lower defecation rates of feeding deer (Collins and Urness 1981), and accelerated weathering of pellet groups on exposed sites (Wallmo et al. 1962, Neff 1968).

The location of approximately 90% of all deer sign and daytime locations in breaks habitat, and the selective importance of mesic sites within or adjacent to rough terrain suggests that any resource development that would decrease the availability of these habitats would adversely impact prairie mule deer populations. Development of coal strip-mined areas has the potential to positively influence mule deer habitat availability if topographic relief and vegetative diversity is enhanced during the reclamation process (Tessmann 1982). Negative impacts could be expected from conversion of riparian habitat to cropland through burning or plowing (Hoar and Erwin 1985), reduced mesic shrub cover due to agricultural herbicides, intensive summer grazing of livestock (Severson 1981), and hydroelectric developments that would inundate areas of rough terrain and riparian zones along narrow river benches. Livestock grazing probably impacts mule deer habitat more than any other current land use on the study area. Cattle rarely use steep side slopes (Dusek 1975) but are attracted to mesic sites in relatively flat coulee bottoms and riparian areas that provide shade, succulent vegetation, and water. Even with low stocking rates, damage to mesic sites can be extensive because of disproportionate use that leads to local overgrazing, rubbing, and soil compaction. Overgrazing and soil compaction creates microclimatic drought and reduces vegetative cover. The areas on my study area that received heaviest livestock grazing had little or no woody riparian areas, no shrub cover in coulee bottoms or on gentler north slopes, and were dominated by blue grama (Bouteloua gracilis) and cheatgrass (Bromus tectorum). Careful regulation of livestock distribution, season of use, and stocking rates is necessary in prairie habitat to protect mesic shrub and tree cover. Better distribution of artificial shade and water sources, effective fencing schemes, and grazing systems that consider impacts to mesic shrubs should be implemented to decrease impacts of livestock on prairie mule deer habitat.

ACKNOWLEDGMENTS

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CHAPTER III

MULE DEER USE OF AGRICULTURAL LANDS ADJACENT TO BREAKS HABITAT

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Populations of mule deer (Odocoileus hemionus) on the Great Plains have recovered from near extinction during the early 1900's and have increased to relatively high densities in many areas. Mule deer use of Plains habitats is poorly understood compared to use of mountainous habitats. Movement patterns, social organization, mortality factors, and habitat use by Plains mule deer have been studied in timbered breaks (Mackie 1970, Hamlin et al. 1984, Riley and Dood 1984), in prairie (Krämer 1971, Dusek 1975, Swenson 1982, Swenson et al. 1983), and in badland habitats (Severson and Carter 1978, Steigers 1981). Most of those studies were conducted on public land where livestock grazing was the dominant land use.

Many biologists assume that white-tailed deer (O. virginianus) are inherently more productive than mule deer. However, Beasom and Wiggers (1984) concluded that intra- and interspecific variability results primarily from differences in diet quality and that the 2 species have similar reproductive potentials. Relatively high productivity and fawn survival rates of whitetails in the Midwest have been attributed to their use of agricultural crops (Verme 1969), but agricultural lands are unavailable to mule deer throughout much of their range. A large portion of the Plains is used for dryland farming, and each year more private rangeland is converted to small-grain production. Most of Chouteau County, Montana, is privately owned, and changing land use patterns in this County are typical of current trends. Approximately 18% of the County was cultivated by 1927, 47% by 1967, and the trend has continued until almost all of the tillable land has been converted to agricultural use (Constan and Hook 1981).

Because mule deer are usually associated with rough breaks and escarpments unsuitable for cropland, their primary habitat has remained intact. This study was conducted where river breaks were interspersed with fields of cereal grains readily accessible to resident mule deer. I examined the use of grainfields by mule deer and the potential effects of that use on their population dynamics.

STUDY AREA

This study was conducted on 10,740 ha of agricultural lands dissected by 12,560 ha of nontimbered breaks along a 26 km segment of the Missouri River, 16 km northeast of Great Falls, Montana (Fig. 1). Climate was typically continental except for the frequent chinook winds that moderated winter temperatures. The average annual temperature was 7 C, and precipitation averaged 35 cm, 75% of which occurred from April to September.

Erosion of the gently rolling Missouri Plateau created the rough topography of deep coulees and river "breaks". Average rise between the

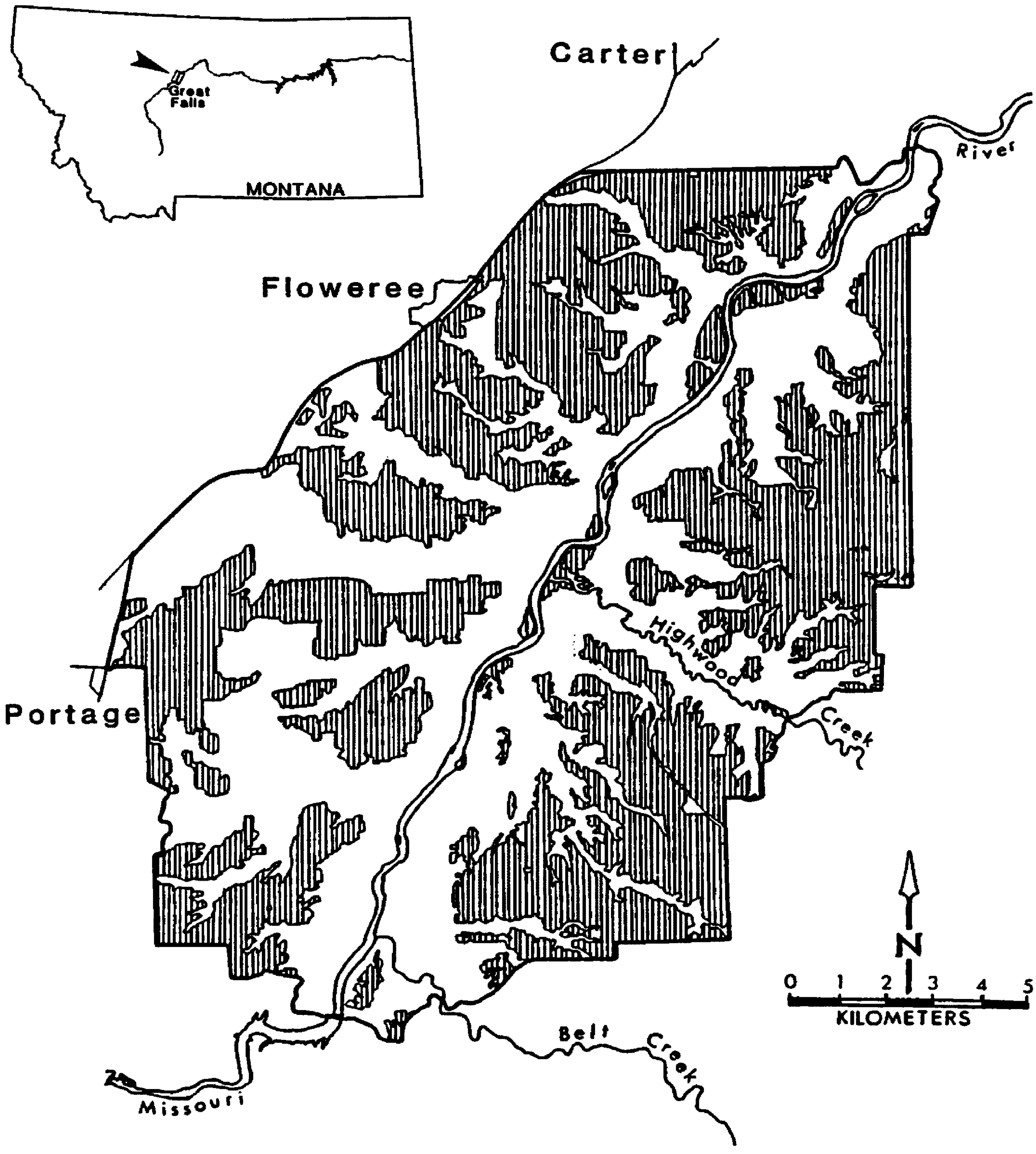

Fig. 1. Interspersion of croplands (shaded - primarily small grains) with rough break habitat on the Carter Ferry study area.

River and Plateau was about 100 m. The majority of land was privately owned, with only a few scattered parcels of federal and state land. Dryland farming was the primary land use on plateau and river-bench areas. Winter wheat and barley were the most common crops cultivated, and were usually planted in strips with alternate strips summer fallowed. Most coulee systems and smaller river benches unsuitable for cropland were grazed by cattle or horses.

Native vegetation communities were highly interspersed because of the rough terrain. Habitats were categorized according to range sites with similar vegetation, topography, and microclimate (Severson 1981). Most common and scientific names of plants were from Booth and Wright (1959):

Plateau.--Plateau Agriculture and Range Sites occurred on level and gently-rolling plateau areas. Agriculture Sites were dominated by small grain production. Range Sites were represented by small, isolated remnants of short-grass prairie.

Breaks.--Breaks habitats were categorized as Xeric Run-off, Mesic Run-off, or Run-in Sites. Xeric Run-off Sites occurred on slopes and ridges with southerly aspects, and were sparsely vegetated with grasses, little soapweed (*Yucca glauca*), and rubber rabbitbrush (*Chrysothamnus nauseosus*). Mesic Run-off Sites occurred on slopes and ridges with northerly aspects, and were covered with grasses and shrubs including silver sage (*Artemisia cana*), skunkbush sumac (*Rhus trilobata*), and common and creeping juniper (*Juniperus communis* and *J. horizontalis*). Run-in Sites occurred at the base of side slopes, in swales, side draws, and major coulee bottoms. These sites had vegetation similar to Mesic Run-off Sites plus large patches of western snowberry (Symphoricarpos occidentalis) and Wood's rose (Rosa woodsii), and scattered thickets of common chokecherry (Prunus virginiana) or silver buffaloberry (Shepherdia argentea).

Floodplain.--Floodplain habitats were categorized as Agriculture, Range, or Riparian Sites. Agriculture Sites were used primarily for small-grain production. Range Sites were dominated by grasses and silver sage. Riparian Sites consisted of narrow (<30 m) strips of woody riparian vegetation confined to the River's edge. These sites supported boxelder (Acer negundo), plains cottonwood (Populus deltoides), and willow (Salix spp.), in addition to the wide variety of shrubs common to other mesic sites.

Island.--Nine islands in the Missouri River ranged in size from 0.1 to 8.3 ha. The 3 largest islands averaged 7.4 ha; the largest was xeric and sparsely vegetated, and the other 2 were dominated by mesic shrubs, grasses, and forbs common to other mesic and riparian sites.

METHODS

Habitat use and movement patterns of resident mule deer were studied from January 1983 through July 1984. Helicopter drive netting and net-gunning were used to capture mule deer for marking. Captured deer were marked with numbered metal ear tags, and their ages estimated from tooth wear and replacement (Robinette et al. 1957). Radio collars were attached to 20 adult does (18+ months); 20 other deer were marked with numbered white neck bands. Radio-equipped deer were located during regular tracking flights and ground reconnaissance. Most daytime ground tracking consisted of careful "track and stalk" efforts, allowing us to locate and observe most deer without disturbing them. Deer behavior was coded according to the activity of the majority of deer within a group (1+ animals), and all references to observations or sightings were based on number of groups, not number of individual deer. Habitat use and activity data were recorded for radio-collared deer during tracking flights, and on all deer observed during ground reconnaissance. Hourly triangulation from 2 precision null tracking systems (Telonics Inc., Mesa, AZ) was used to monitor nocturnal movements of instrumented deer.

Spatial use of grainfields was studied by establishing 66 track transects in planted strips of 2 winter wheat fields (226 ha and 317 ha) each located on separate plateau areas surrounded on 3 sides by coulees and river breaks. Transects were established parallel to the length of each strip and 1 m in from the adjoining stubble strips. Transects were divided into segments that corresponded to 100 m contours (lateral distance) from plateau edges to the center of the fields. Tracks (and pellet groups) were counted along the transect segments during late March and early April 1984.

Deer were censused during late winter 1982-83, and early and late winter 1983-84 from a Cessna Super Cub. Observed deer were classified by age (fawn or adult) and sex when feasible. A population estimate was calculated from the average number of deer observed during winter census flights corrected for observability bias based on the average proportion of marked animals observed (Mackie et al. 1981).

RESULTS

Mule deer were trapped during 3 days in January and February of 1983. Forty deer were captured; 3 yearling and 17 mature does were fitted with radio-collars, and 14 fawns (5♂,9♀), 3 yearlings (1♂,2♀), and 3 mature does were marked with numbered neck collars. Between 16 January 1983 and 16 July 1984, the 20 instrumented does and associated unmarked deer were located 1,322 times, and 670 other groups of deer were observed.

Observations of feeding deer accounted for 22% (n = 382) of all sightings, and groups feeding in grainfields accounted for 42% of these locations. The average herd size of deer feeding in fields ($\bar{x}$ = 7.8, range 1-45, SD = 7.1), was nearly twice the size of herds feeding in the breaks ($\bar{x}$ = 4.2, range 1-17, SD = 3.9). Herds were observed more often in stubble strips (n = 93) than in green winter wheat (n = 67) (X^2 = 4.23, d.f. = 1, $P < 0.05$) although the 2 field conditions occurred with equal frequency. Deer were frequently observed feeding in a small field of unharvested wheat during the winter of 1983, where they appeared to consume seed heads as well as green regrowth.

Temporal and Seasonal Patterns of Use

Most of the sightings in grainfields occurred during the hour before sunset (53%) and during twilight (32%). Of the locations determined by triangulation, 45% (116/258) were in grainfields, and 97% of the field use occurred at night (sunset to sunrise). Collared deer were active throughout most tracking nights, and remained in the grainfields all night during winter (22 Dec. - 19 March), at least until 2200 during fall (23 Sept. - 21 Dec.), and only for brief periods during summer nights (21 June - 22 Sept.). Seasonal use of the grainfields, measured as the percent of all evening sightings per season occurring in fields, was most intense during fall at 66% (54/82) and winter at 59% (95/162), but very light during summer at 8% (5/65) (Fig. 2). I did not attempt to obtain nocturnal locations during spring (20 March - 20 June) but the presence of numerous tracks in wheatfields indicated heavy nocturnal use of grainfields at least through 6 April. Farmers began plowing stubble strips to prepare them for spring planting or summer fallow at the end of April.

Spatial Patterns of Use

The track transects gave a consistent and clear picture of grainfield use by deer: track densities were highest near rough terrain and decreased linearly with distance away from it (Fig. 3). An unexpected exception to this pattern occurred on a portion of 1 field where horses and cattle were grazing. In the heavily grazed area the density of deer tracks was drastically reduced with no clear relationship between track density and distance to rough terrain. Use of grainfield habitat within 200 m of rough terrain significantly exceeded proportionate availability ($P \leq 0.01$), and the opposite occurred on areas >400 m from rough terrain. Intermediate field areas (200-400 m) were used in a less consistent and significant manner (Fig. 4).

Surprisingly few pellet groups were observed in the fields; only 26

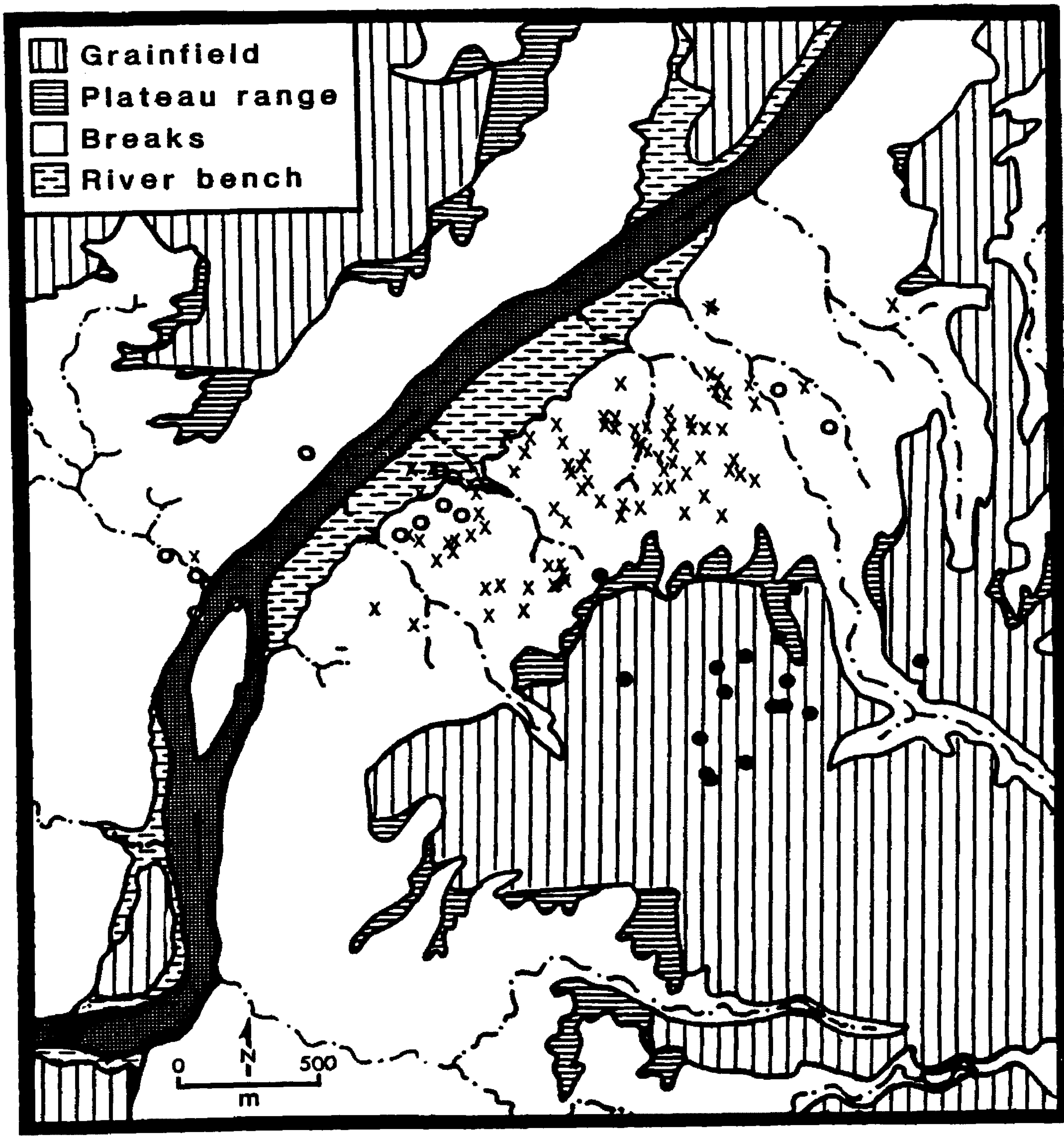

Fig. 2. Distribution of day and night locations of 2 resident mule deer does residing in breaks along the upper Missouri River. (X = day, ● = winter and fall nights, O = summer nights).

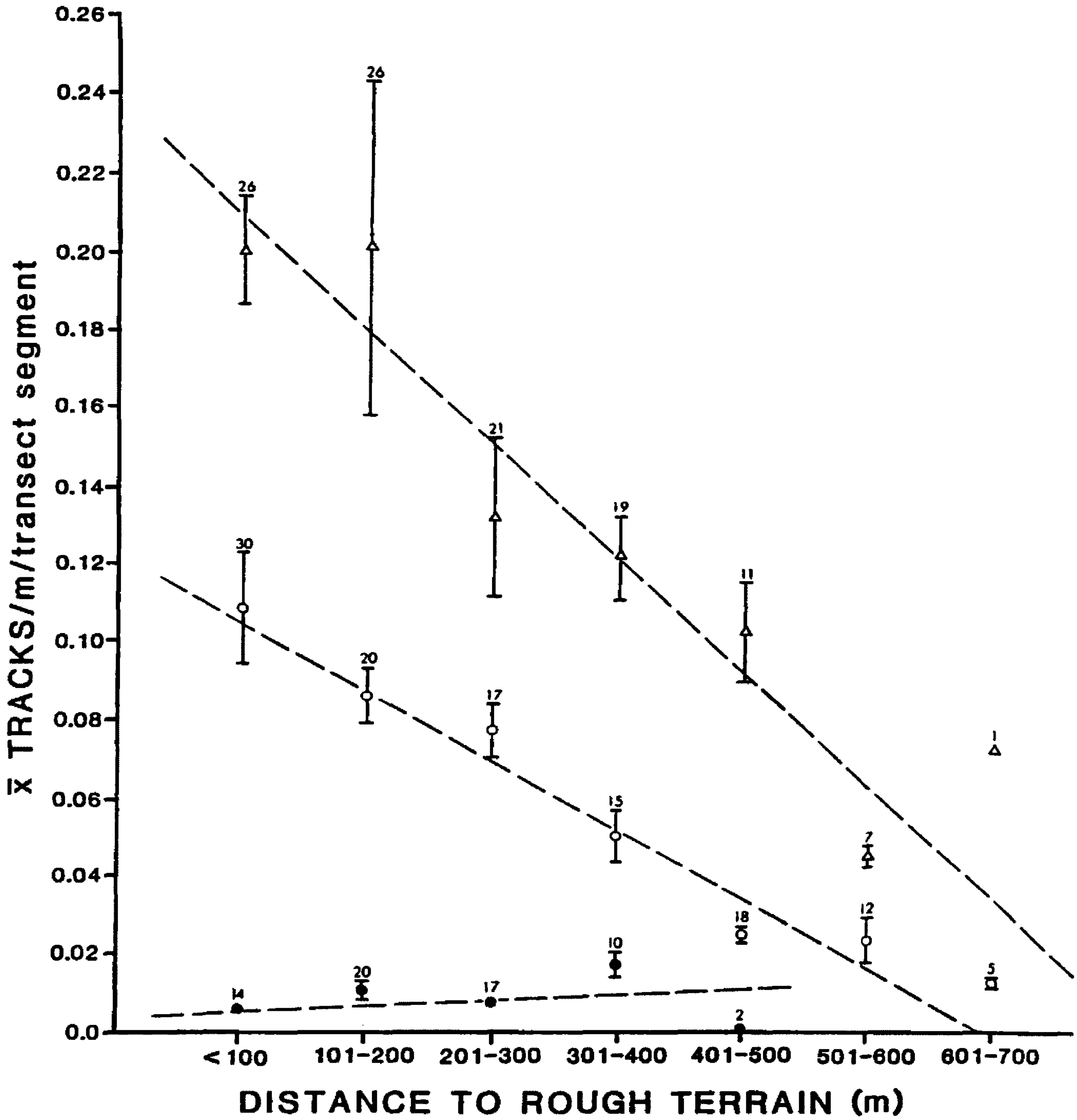

Fig. 3. Distribution of tracks in 2 winter wheat fields bordered by breaks habitat along the upper Missouri River. (△ = field A without livestock use, o = field B without livestock use, and ● = field B with heavy livestock use). Vertical bars represent 95% CL and n = number of track transect segments sampled.

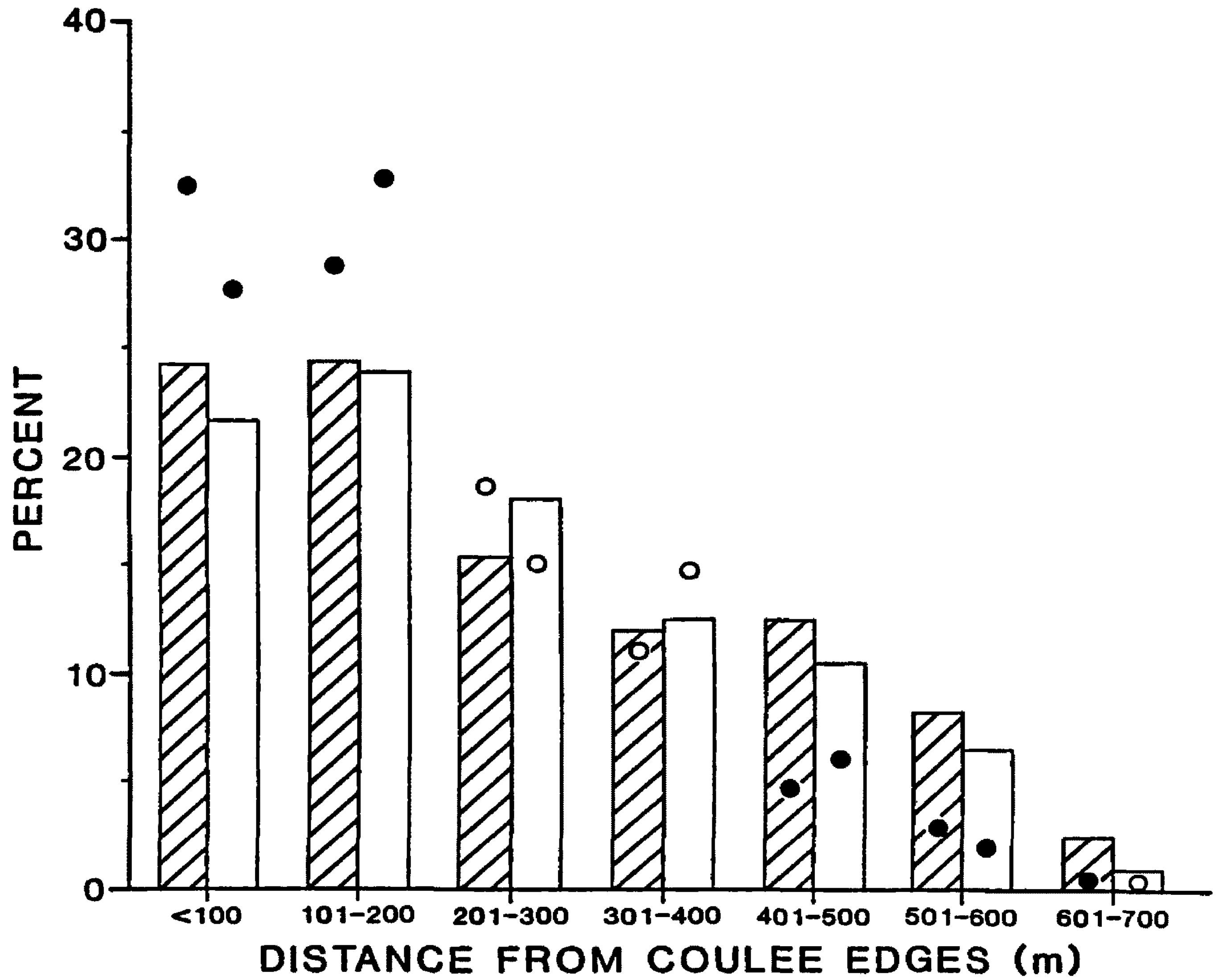

Fig. 4. Patterns of selection by mule deer of 2 grainfield areas adjacent to breaks habitat along the upper Missouri River. Significant differences ($P \leq 0.01$) between use (o) and availability (bars: field A striped, and field B open) were determined from X^2 and Bonferroni Z analyses and are indicated by solid circles.

pellet groups were encountered along 29.7 km of track transects.

A comparison of the data gathered through deer sightings, night-tracking, and track transects showed similar patterns of grainfield use (Fig. 5). Night-tracking and track transect data showed the greatest similarity. Night-tracking was the most expensive and time-consuming method but provided the only tool for evaluating individual nocturnal movements. Under most circumstances, triangulation locations were not accurate enough to assign them to specific field conditions because strips were relatively narrow. Track transects were most efficient for determining spatial use, but were only effective if established in newly-planted strips or if snow cover was complete. Data from deer sightings tended to overestimate the use of field areas within 100 m of rough terrain and to underestimate the relative use of more distant areas because deer could only be observed during daylight hours when they were just entering or leaving the fields. Sightings were the best indicator of seasonal changes in use patterns and of field condition preferences.

Casual observations and comments by landowners suggested that deer preferred feeding in barley stubble when it was available. Four of the radio-collared deer traveled across green winter wheat and wheat stubble to feed at night in an isolated strip of barley stubble that was more than 500 m from the breaks and within 100-200 m of a farm house. Otherwise, <10% of all deer use of fields was >400 m from rough terrain and I never located deer more than 800 m from it.

Population Dynamics

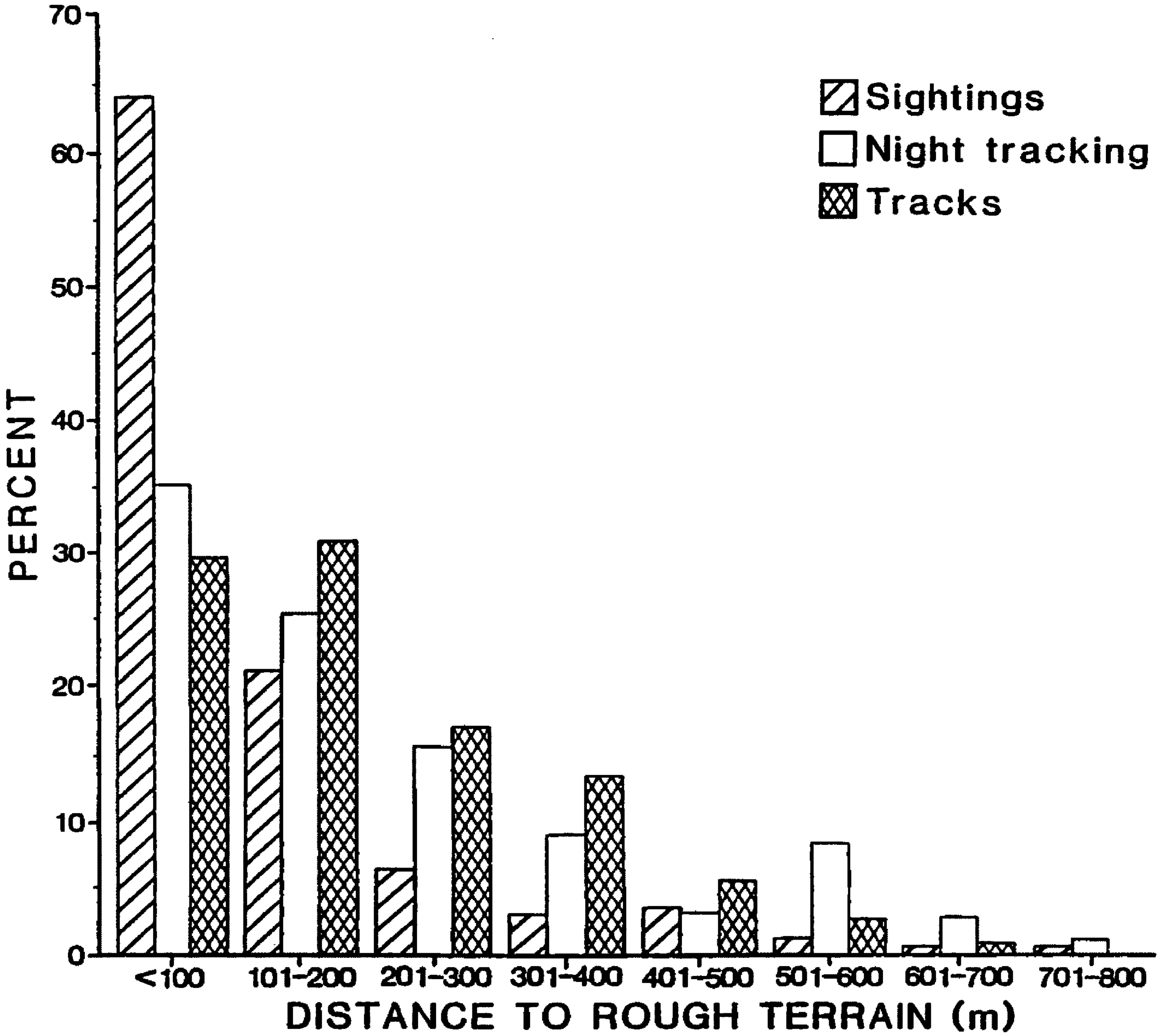

Fig. 5. Comparison of patterns of use of grainfields determined from deer sightings (n = 176), locations of radioed deer at night (n = 122), and tracks along field transects (n = 3,166).

Aerial censuses were conducted on 20 March 1983, 17-18 January 1984, and 15 March 1984: 737, 840, and 603 ($\bar{x}$ = 727) deer were observed on the study area. The proportion of marked deer observed per flight was 36, 33, and 43% and an average observability index of 38% (range ± 5%) was used to estimate population size, which was consistent with the average observability of 37.5 (range ± 2.5%) for deer in breaks habitats reported by Mackie et al. (1981). Based on an estimated deer population of 1,913 ± 290, relative deer densities for the total area were 7.0-9.5 per km^2 or 12.9-17.5 per km^2 of breaks habitat.

One of the 3 does radio-collared as a yearling was seen with fawns on several occasions, indicating possible breeding as a fawn, and all 3 had twins the spring following capture. Radioed does produced at least 1.75 fawns per doe, as determined from the number of fawns observed with them in August 1983. Fawn:doe ratios of 123:100 and 125:100 observed during the March 1983 and January 1984 censuses were very similar to the fawn:doe ratios of 120:100 and 129:100 calculated for instrumented does in February of each year. The fawn:doe ratio of 85:100 observed during the March 1984 census was considerably lower than expected, and the apparent decrease was believed to have resulted from poor sighting conditions making age determination difficult, rather than from fawn mortality. At least 79% of 33 fawns belonging to 18 radio-marked does survived from August 1983 through February of 1984. Also, I found only 2 fawn carcasses during the 2 winters of the study.

DISCUSSION

In areas where cultivated cereal grains are unavailable, grasses are an important component of mule deer diets only during spring (Mackie 1970, Dusek 1975). In the Texas Panhandle when grainfields were accessible, cereal grains comprised 27% of the winter diet of mule deer (Sowell 1981). In a study of mule deer use of 5 cultivated cereal grains, Wiggers et al. (1984) found that foliage use was greatest during November and December and declined through March. They concluded that the amount of new growth per month was a major factor governing the use and selection of the grain species tested. Foliage production and deer preference varied monthly, but overall preference was rated as: triticale > rye > barley > winter wheat > annual ryegrass. Archibald et al. (1943) and Thomas et al. (1964) concluded that succulence was the major factor governing the selection of grasses. The observed seasonal use of grainfields and apparent preference for barley by deer during this study were similar to those reported by Wiggers et al. (1984), but deer use of planted and stubble strips began in September or as soon as fall greenup occurred and continued into April. Allen (1968) reported that seed heads of barley accounted for nearly all of the grass use by white-tailed deer during winter along the Missouri River bottomlands. Consumption of waste grain in addition to green regrowth may explain the greater use of stubble over planted strips.

Deer used rough coulee habitats during the day, moved into grainfields shortly before sunset, spent the night in the fields, and then usually returned to the breaks by dawn. The behavior of deer using fields included antipredator strategies associated with the use of open terrain: forming large herds, moving and feeding at night, and using areas close to escape terrain (Sweeney et al. 1971, Wilson 1975, Geist 1981).

Montgomery (1963) and Herriges (1986) described similar movement patterns for white-tailed deer occupying woodlands adjacent to small-grain and hay fields in Pennsylvania and Montana. Steigers (1981) found that fawns in South Dakota badlands bedded in shrub cover in rough terrain during the day and in open prairie habitat at night. In other studies of habitat use by Plains mule deer, researchers may have underestimated the use of open prairie or agricultural areas by relying on observations or radiolocations recorded during daylight hours. Temporal segregation of habitat use makes some form of nocturnal monitoring important when assessing overall habitat selection where open habitats are present.

The majority (90%) of the deer use of grainfields occurred within 400 m of rough terrain. Although mule deer are physically capable of traveling long distances and exploiting large home ranges (Robinette 1966), their movements into croplands appear behaviorally restricted. This restriction implies that not all portions of a particular area are necessarily "available" for use, and that availability of open habitats is probably related to the amount of interspersion of escape cover or terrain. Deer appear to avoid use of fields being grazed by livestock. Martinka (1968) and Dusek (1975) likewise noted that deer tended to avoid areas where livestock were concentrated.

Cultivation of cereal grains was proposed as a potentially cost effective management practice for improving mule deer winter range in the Texas Panhandle (Wiggers et al. 1984). The patterns of spatial use that I observed suggest that such cultivation would be most effective within 200 m of escape terrain and that cultivation >400 m from escape terrain would have little benefit for the purpose of supplemental feeding. A maximum amount of supplemental feed may also be available when fields contain growing grain, stubble with regrowth, and some standing mature grain. Concurrent grazing by livestock is likely to minimize use by deer and should be avoided.

Use of the pellet-group count technique as an index to habitat use is based on the assumption that pellet group density is directly related to the amount of time animals spend in each habitat. The validity of the assumed relationship between deer defecation rates and habitat use has been questioned previously (Neff 1968, Anderson 1969, Collins and Urness 1981). Collins and Urness (1981) documented that defecation rates were highest while deer were traveling and immediately after they left their beds. They noted that deer moved little while feeding in areas where availability of preferred forages was high, and that defecation rates were correspondingly low. High forage availability in grainfields may explain the lack of pellet groups compared to tracks and sightings. The use of pellet surveys in the fields I studied would have grossly underestimated actual deer use.

Numerous investigators have reported the apparent relationship between nutrition and the survival and reproductive rates of deer (Cheatum and Severinghaus 1950, Julander et al. 1961, Dietz 1965, Murphy and Coates 1966, Verme 1969, Robinette et al. 1973). The crude protein content of wheat and barley foliage (14-16%, Wiggers et al. 1984) far exceeds the minimum 7% necessary for maintenance (Dietz 1965, Murphy and Coates 1966), and approach the 16-17% level that Verme and Ullrey (1972) concluded would meet the maximum needs of deer, including growing fawns and lactating does. Because fawns do not accumulate large fat reserves, the amount of digestible energy in their winter diet can be critical to their survival (Dietz 1965). The digestible energy levels for wheat and barley (2,710 and 2,449 kcal/kg, Wiggers et al. 1984) would be adequate for meeting the winter energy requirements of deer (48 kcal/kg body wt/day, Wallmo et al. 1977) even considering average forage intake limitations (21.9 g/kg body wt/day, Alldredge et al. 1974).

Exceptionally high rates of productivity in white-tailed deer in the Midwest have been attributed to the use of agricultural crops (Ransom 1967, Roseberry and Klimstra 1970, Haugen 1975). The summer ratio of 1.75 fawns per instrumented doe in my study was higher than the average natality rate of 1.73 fawns per doe reported by Verme (1969) for captive whitetails on a high nutrition diet and close to the fetal rate of 1.85 for mule deer on good range (Julander et al. 1961). The reproductive performances of fawn and yearling does were considered the most sensitive indicator of diet quality by Cheatum and Severinghaus (1950), Julander et al. (1961), Verme (1969), and Robinette et al. (1973). Possible fawn breeding, high reproductive performance of yearling and adult does, and high winter fawn survival rates were all indications that deer on my study area were in excellent nutritional condition.

Population characteristics of mule deer on my study area essentially correspond to the Class I herd dynamics described by Verme (1969) for white-tailed deer in the Midwest: the range appears to provide optimum nutrition year-round, winters are relatively mild, adult does are very productive, a portion of the doe fawns may breed, fawn mortality is low, and the population has the capacity to increase rapidly. Management strategies, as related to both harvest and habitat concerns, should take into consideration the benefits of agricultural crops as nutritional supplements. Managers throughout much of western North America are rightfully concerned about the potential negative impacts on wildlife of the current trend toward "sodbusting", the broadscale conversion of native prairie with erodible soils to grain production. These concerns, however, should not deny recognition of the important benefits to mule deer where agricultural lands are interspersed with adequate cover or escape terrain.

SUMMARY

Mule deer in the upper Missouri River breaks fed in grainfields from September to April. Deer used grainfields primarily at night, fed more often in stubble strips than in new winter wheat, preferred field areas <200 m from escape terrain, and avoided areas >400 m from it. High reproductive and fawn survival rates of this population suggested that the individuals were in excellent nutritional condition. The nutritional benefits and potential effects of agricultural crop use by mule deer on their population dynamics should be considered in management decisions.

Acknowledgments.--This study was part of a project designed to determine the potential impacts of a proposed hydroelectric dam on mule deer movements and habitat use in the upper Missouri River breaks of Montana (Kraft 1989). Financial support for the project was provided by the Mont. Power Co. and the Mont. Coop. Wildl. Res. Unit. I gratefully acknowledge assistance by Univ. of Mont. volunteers and by personnel of the Mont. Power Co. and Mont. Dep. Fish, Wildl. and Parks. B. W. O'Gara and I. J. Ball aided in project planning and provided editorial assistance. I thank C. L. Marcum and L. H. Metzgar for reviewing this manuscript. Special thanks are due the many landowners who allowed me access to their property and extended their warm hospitality.

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CHAPTER IV

POTENTIAL IMPACTS OF HYDROELECTRIC DEVELOPMENT ON A MULE DEER POPULATION

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Abstract: Habitat use and movement patterns of mule deer (*Odocoileus hemionus*) were investigated along the upper Missouri River near Carter, Montana, to determine potential impacts of a proposed hydroelectric dam. More than 90% of all pellet groups and daytime locations of instrumented deer were located in breaks habitat. Deer avoided most gentle upland and river bench habitats and selected mesic sites, including steep north slopes and shrubby coulee bottoms. Floodplain riparian zones and islands made up 1% of the primary deer habitat but were used by approximately 3% of the fawns in July. Because elevations below the proposed inundation level were generally avoided by mule deer, potential losses of the resident herd were estimated at 4-8% rather than the 10% predicted by the overall loss of primary deer habitat. Major impacts could result from loss of rough terrain and woody riparian sites, and secondary impacts could result from increased harassment and hunting pressure if recreational access is developed. Mitigation should be directed at restoring and enhancing riparian and shrub cover, and discouraging recreational access into rough terrain if necessary.

INTRODUCTION

Soils of the Northern Great Plains are extremely erodible, and erosion along drainages has created the highly dissected, rough terrain commonly called "breaks". Prairie mule deer are usually dependent on the habitat types associated with breaks or with the rough topography of scattered buttes and escarpments. Several major existing and potential environmental problems affecting this resource are livestock overgrazing, brush and weed control, and hydroelectric development (Constan and Hook 1981). The Missouri River within Montana is currently impounded along 45% of its 1,175 km length, and several entities have shown interest in the development potential of remaining sites. The Montana Power Company proposed building a run-of-the-river dam at Carter Ferry, 42 km northeast of Great Falls, Montana; licensing of the project was required in accordance with regulations of the Federal Energy Regulatory Commission. Because the proposed dam was to inundate approximately 1,250 ha of river-bottom and breaks habitat at maximum pool (858.6 m), impacts on a resident herd of approximately 2,000 mule deer were expected. This study was designed to document movement patterns and habitat use by mule deer, evaluate the quantity and quality of the habitat that would be lost, identify potential impacts, and contribute to the development of a comprehensive mitigation plan.

STUDY AREA

The study area encompassed 237 km^2 of nontimbered breaks and agricultural lands along a 26 km stretch of the Missouri River, 16 km northeast of Great Falls, Montana (Fig. 1). The climate was semi-arid and typically continental except for frequent chinook winds that moderated winter temperatures. Average annual temperature was 7 C (range -30 to 40 C), and precipitation averaged 35 cm, 75% of which occurred from April through September. Elevation varied from 810 to 1,029 m, with an average rise of 100 m between the River and plateau. More than 95% of the land was privately owned, with only a few scattered parcels of federal and state land that were leased for grazing. Dryland farming was the primary land use on plateau and river-bench areas, and winter wheat and barley were the most common crops. Most coulee systems and smaller river benches unsuitable for cropland were grazed by cattle or horses.

Native vegetation communities were highly interspersed because of the rough terrain. Habitats were categorized according to range sites with similar vegetation, topography, and microclimate (Severson 1981):

Plateau.--Plateau Agriculture and Range Sites occurred on level and gently-rolling plateau areas. These sites were dominated by small grain production, or represented by isolated remnants of short-grass prairie.

Breaks.--Breaks habitats were categorized into Xeric Run-off, Mesic Run-off, and Run-in Sites. Xeric Run-off Sites occurred on slopes and ridges with southerly aspects, and were sparsely vegetated with grasses, little soapweed (*Yucca glauca*), and rubber rabbitbrush (*Chrysothamnus nauseosus*). Mesic Run-off Sites occurred on slopes and ridges with northerly aspects, and were covered with grasses and shrubs including silver sage (*Artemisia cana*), skunkbush sumac (*Rhus trilobata*), and common and creeping juniper (*Juniperus communis* and *J. horizontalis*). Run-in

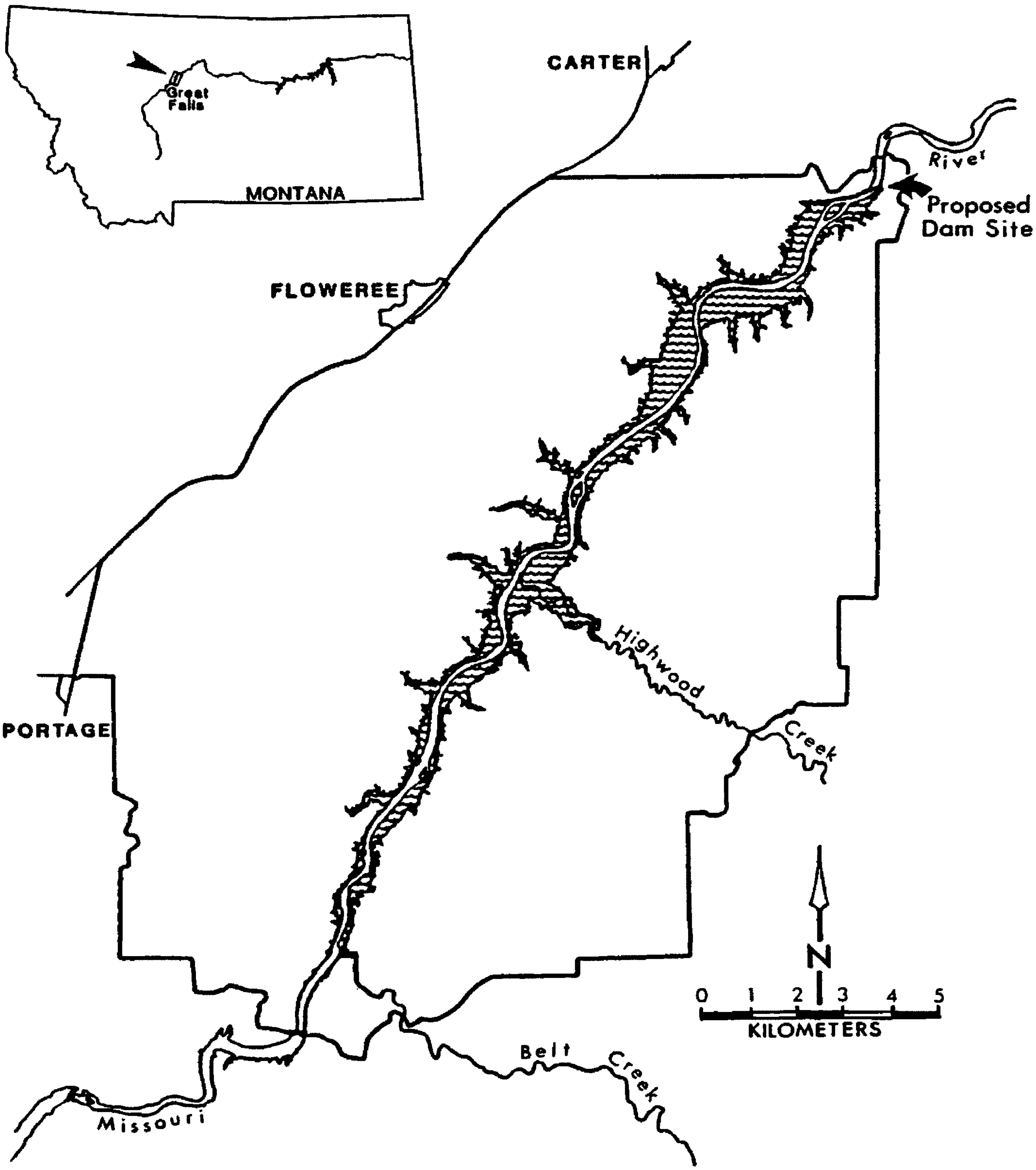

Fig. 1. Location of the study area and inundation zone (shaded area) of the proposed Carter Ferry Hydroelectric Project.

Sites occurred at the base of side slopes, in swales, side draws, and major coulee bottoms. These sites had vegetation similar to Mesic Run-off Sites plus large patches of western snowberry (Symphoricarpos occidentalis) and Wood's rose (Rosa woodsii), and scattered thickets of common chokecherry (Prunus virginiana) or silver buffaloberry (Shepherdia argentea).

Floodplain.--Floodplain habitats were categorized into Agriculture, Range, and Riparian Sites. Agriculture Sites were used primarily for small-grain production. Range Sites were dominated by grasses and silver sage. Riparian Sites consisted of narrow (<30 m) strips of woody riparian vegetation confined to the River's edge. These sites supported boxelder (Acer negundo), plains cottonwood (Populus deltoides), and willow (Salix spp.), in addition to the wide variety of shrubs common to other mesic sites.

Island.--Nine islands in the Missouri River ranged in size from 0.1 to 8.3 ha. The 3 largest islands averaged 7.4 ha; the largest was xeric and sparsely vegetated, and the other 2 were dominated by mesic shrubs, grasses, and forbs.

METHODS

Habitat use and movement patterns of resident mule deer were studied from January 1983 through July 1984. Helicopter drive netting and net-gunning were used to capture and radio collar 20 does >18 months of age. Radio-equipped deer were located during regular tracking flights and ground reconnaissance. Date, time, elevation, slope, range site, herd composition, activity, and Universal Transverse Mercator coordinates were recorded for each location. Most daytime ground tracking consisted of careful "track and stalk" efforts, allowing us to locate and observe most deer without disturbing them. Deer behavior was coded according to the activity of the majority of deer within a group.

Movement patterns were determined by plotting seasonal home ranges. Home range sizes were calculated by the minimum area technique (Dalke 1942, Mohr 1947) using daytime locations of each radio-marked doe. Harmonic home ranges and core areas (Samuel et al. 1985) were calculated from the pooled daytime locations of 8 groups of 2, and 1 group of 4, marked deer that generally occupied different coulee systems. The 100% utilization volume contour was used to identify the area available to each group of deer. Habitat availability was determined from a minimum of 200 grid points within the 100% contours of the 9 harmonic home ranges. Elevation and range sites were recorded for each point from 7.5 minute USGS topographic maps and 1:12,000 aerial photos. Point estimates of habitat availability within the 9 harmonic home ranges were pooled for analysis of habitat selection.

Habitat use and availability along the River corridor was also determined from 64 pellet transects established on both sides of, and approximately perpendicular to, the Missouri River at 0.8 km intervals. Circular plots along transects were sampled once during August of 1983. Plots (9.3 m^2) were sampled at 6.1 m contour intervals from the River's edge to the agricultural plateau (or for 1.6 km, whichever occurred first). No plots were sampled on islands, cliffs (slope > 55°), or in cultivated areas. Elevation, range site, number of pellet groups (≥10 pellets), and presence or absence of deer tracks or beds were recorded at each plot.

Observation and pellet data were used independently to assess habitat selection (Neu et al. 1974, Marcum and Loftsgarden 1980) and preference indices (Van Dyne and Heady 1965, Robel et al. 1970). Only daytime visual observations of undisturbed (bedded, feeding, traveling undisturbed, or standing alert) radioed does were used to determine habitat use within combined harmonic home range areas. The total number of pellet groups plus other sign (presence = 1, absence = 0) was used to assess habitat use along the River corridor.

A complete search of all islands and riparian zones for fawns was conducted during late July and early August 1983. Searches were scheduled to overlap the time during which fawns were old enough to flush when disturbed but too young to swim from islands.

Estimates of potential habitat loss within the proposed inundation area were made from range site classifications at 417 grid points from 7.5 minute USGS topographic maps and 1:12,000 aerial photos. Total habitat loss was calculated as the area of land inundated divided by the amount of primary habitat available on the study area. Primary habitat was considered to include all breaks, floodplain, and island habitats, but excluded all agricultural plateau areas.

RESULTS

During 4 days of trapping in January and February of 1983, 42 deer were captured; 3 yearling and 17 mature does were fitted with radio-collars. Between January 1983 and July 1984, the 20 instrumented does were located 1,322 times. Daytime locations (n = 1,062) occurred almost exclusively (90%) in breaks habitat. Most (80%) of the daytime locations were observations of undisturbed deer (57% bedded, 18% feeding, 3% traveling undisturbed, 22% standing alert). Only 4% of these observations occurred within the proposed inundation zone.

Eleven of thirteen fawns observed on islands were located on the 2 large shrub covered ones. Another 28 fawns were flushed from riparian zones along the River and Highwood Creek. Based on population estimates, fawn:adult ratios in winter censuses, and estimated fawn mortality rates between August and February (Kraft 1989), an estimated 1,246 fawns were present at the time of the searches. Therefore, about 3% of the fawns on the study area were located on islands and in riparian zones. The movement patterns of 2 radioed does indicated they may have fawned in riparian areas.

A total of 1,530 pellet groups and additional sign was observed in 2,418 plots sampled along 67 km of pellet transects. Most deer sign (92%) occurred in breaks habitat. A total of 11.7% of all deer sign occurred within the proposed inundation zone.

Home Range

Instrumented deer were non-migratory and exhibited a high degree of home range fidelity (Fig. 2). The average daytime home range size was 478 ha (range 87-1,069 ha).

Nine harmonic home ranges were constructed from 1,007 independent

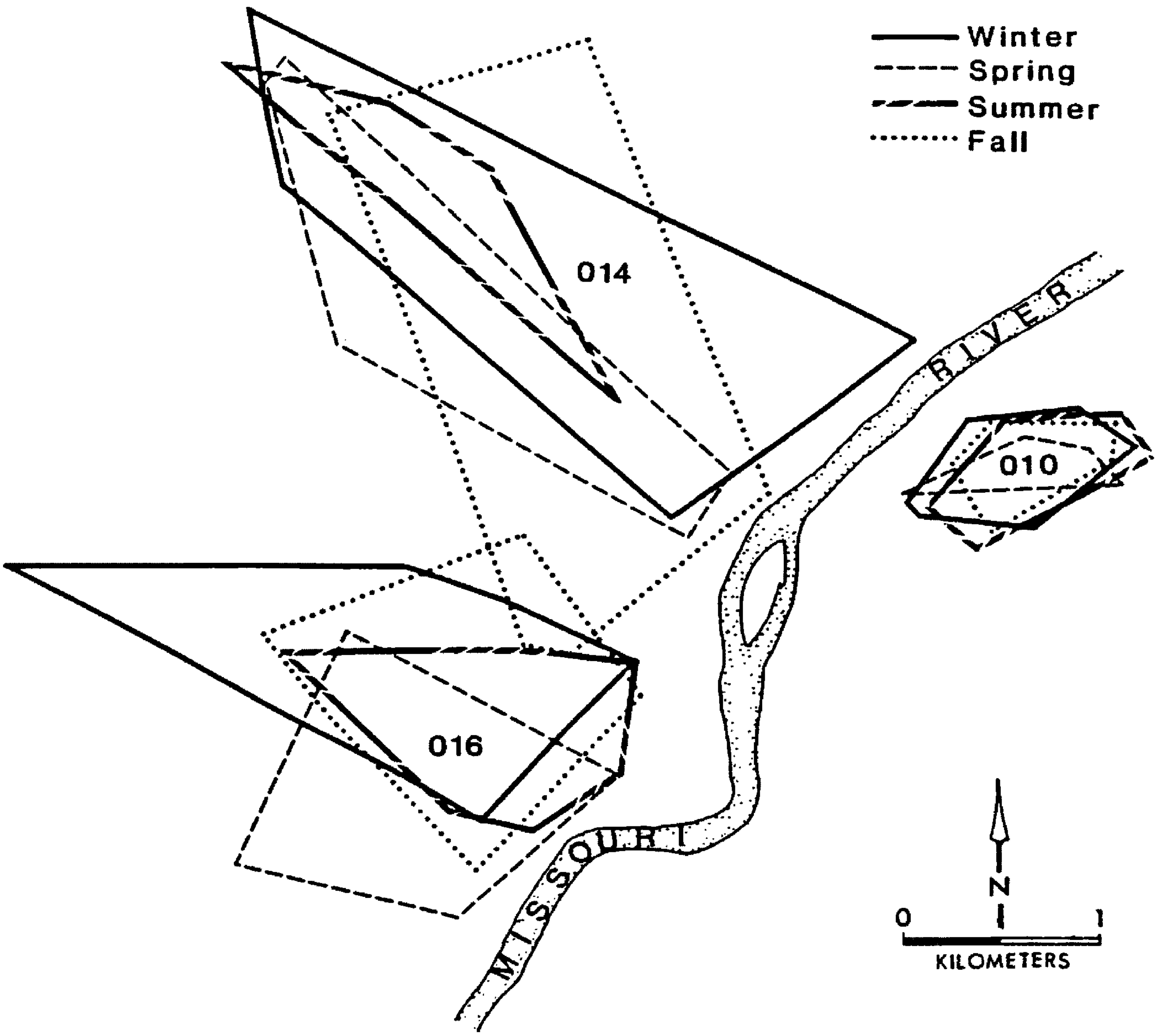

Fig. 2. Examples of seasonal home ranges and home range fidelity typical of adult mule deer does on the study area.

daytime locations ($\bar{x}$ = 112, range 77-211). The average area enclosed within the 100% utilization volume contour was 1,680 ha (range 409-4,363 ha). Core areas averaged 451 ha (range 120-1,186 ha). They enclosed approximately 27% of the total home range area, 66% of the utilization volume, and 91% of the deer location points. An average of 10.4% (range 6.0-15.8%) of the total harmonic home range area, and 1.6% (range 0.0-3.8%) of the core areas would lie below inundation.

Habitat Selection

Deer selected Mesic Run-off and Run-in Sites and Middle Elevation Zones. Plateau and Floodplain Agriculture and Range Sites were selected against, as were areas within the inundation zone. (Table 1). Distribution of pellet groups indicated a high degree of avoidance of Xeric Run-off Sites that was different from the "no selection" by marked does. Pellet transect data also indicated a lack of significant avoidance of Upper and Lower Elevation Zones, and a larger proportionate use of elevations below inundation.

Potential Losses

The Reservoir would inundate approximately 1,250 ha of breaks, floodplain, and island habitats, plus 350 ha currently occupied by the Missouri River. The inundation zone would cover nearly equal amounts of breaks and floodplain habitats (Table 2) and 9.7% of the primary mule deer habitat on the study area (N = 12,904 ha).

Table 1. Habitat selection by mule deer in the upper Missouri River breaks, determined from observations of instrumented does (n = 850) compared to habitat availability within harmonic home ranges (n = 2,080), and distribution of deer sign (n = 1,530) within plots (n = 2,418) along pellet transects.

HABITAT CATEGORY	INSTRUMENTED DEER			PELLET TRANSECTS		
	Use[a]	Avl	PI[b]	Use	Avl	PI
RANGE SITE						
Plateau						
Agriculture	05.4	36.8	0.15***	-	-	-
Range	02.4	06.8	0.35***	01.4	05.1	0.27***
Breaks						
Xeric Run-off	15.9	13.5	1.18	30.4	37.8	0.80***
Mesic Run-off	34.1	16.4	2.08***	40.3	35.9	1.12*
Run-in	40.1	20.0	2.00***	21.6	14.8	1.46***
Flood Plain						
Agriculture	00.0	01.9	0.00***	-	-	-
Range	00.6	02.7	0.22***	02.4	03.9	0.62*
Riparian	01.6	01.4	1.14	03.7	02.4	1.54
Island	00.0	00.3	0.00	-	-	-
ELEVATION ZONE						
Upper	08.2	36.6	0.22***	17.5	17.6	0.99
Upper-middle	49.5	28.5	1.74***	41.4	35.2	1.18***
Lower-middle	35.3	20.7	1.70***	27.9	28.0	1.00
Lower	07.1	14.2	0.50***	16.8	19.3	0.87
Below 858 m	04.0	10.4	0.38***	11.7	14.5	0.81**

[a] Percent.

[b] Preference Indices (PI) reflect relative selection, for > 1.0, against < 1.0. Significance levels were determined from X^2 and Bonferroni Z tests, * = $P \leq 0.05$, ** = $P \leq 0.01$, *** = $P \leq 0.001$.

Table 2. Percent habitat composition of the inundation zone, proportion of the primary mule deer habitat impacted, and the area of each habitat component inundated.

HABITAT CATEGORY	INUNDATION ZONE	PRIMARY HABITAT	AREA (ha)
Plateau			
Agriculture	0.0	0.0	0
Range	0.0	0.0	0
Breaks			
Xeric Run-off	16.0	1.6	200
Mesic Run-off	12.8	1.2	160
Run-in	28.1	2.7	351
Floodplain			
Agriculture	20.0	1.9	250
Range	13.1	1.3	164
Riparian	8.1	0.8	101
Island	1.9	0.2	24
TOTAL	100.0	9.7	1,250

Decreased carrying capacity could result from direct losses from the population if the habitat is saturated, a decrease in the growth potential of the population, or a decrease in the vigor of the herd (Dasmann 1964). If the deer used all of the habitats in proportion to their availability,the amount of habitat lost would result in a proportionate decrease in the carrying capacity of the area. If the impacted habitat was preferred or avoided, however, a more accurate estimate of the overall impact to carrying capacity would be the percent habitat loss times the preference index for the area of impact. The area within the impact zone of Carter Ferry Reservoir was generally avoided, and had preference indices of 0.38 and 0.81 from marked deer and pellet transect estimates. The percent habitat loss (9.7%) times the preference indices for that area result in an estimated 4-8% loss in the carrying capacity of the study area without mitigation.

DISCUSSION AND CONCLUSIONS

The high degree of home range fidelity and the concentrated use of breaks habitat indicate that most seasonal requirements of food, water, and cover are met within this primary habitat type. Mule deer are behaviorally adapted to the use of rough terrain to escape predators (Geist 1981), and they often seek shelter from strong winds in the lee of irregular terrain (Lindsdale and Tomich 1953, Loveless 1964, Wood 1986). Winds on the study area were generally from the southwest, averaged 23 km per hour, and probably played a significant role in the selection of steep north slopes by deer. North slopes, shrub thickets, and steep, eroded side draws also provided shade during hot summer months. Thermal and security cover may be provided by wooded draws in areas lacking river breaks (Severson and Carter 1978, Wood 1986). These functions may be provided by woody Riparian Sites when they occurred within mule deer home ranges on my study area. Mesic sites provided most of the forage species described as important to prairie mule deer (Mackie 1970, Dusek 1975). Other studies described fawning and fawn-rearing habitat as sites with well-developed lateral and overhead vegetative cover, usually associated with tall shrub communities (Dood 1978, Steigers 1981). Although the Riparian and Island Sites provided some fawn habitat, approximately 97% of the fawning and fawn-rearing sites probably also occurred in shrub communities located within the breaks habitat on my study area.

This study used direct measurement of habitat selection by resident mule deer rather than more common capability rating methods (e.g. HEP, U.S. Fish and Wildl. Serv. 1976) to assess habitat values and potential impacts. This approach was used because it was less subjective than other rating or ranking methods, especially in light of the general lack of information on how mule deer use nontimbered breaks. This approach also could be repeated to compare and monitor deer responses to project development and mitigation.

The methods used to measure habitat selection provided relatively precise data on how deer used the project site, but were not without limitations. Radio telemetry studies are time- and labor-intensive, and hence expensive. Because deer on the study area showed a high degree of home range fidelity, habitat use and availability were dependent in part on where the deer were trapped. Pellet transects were independent of this bias but were unusable in cultivated areas because pellet groups were regularly "cleared" by cultivation. Many of the differences between habitat values determined from pellet transects versus deer locations, including the higher estimated value of the inundation area, were probably caused by the exclusion of Agriculture Sites from pellet transects. Accumulation of pellet groups is also affected by differential exposure to weathering in different habitats (Wallmo et al. 1962, Van Etten and Bennett 1965, Neff 1968), which may have led to underestimating the value of Xeric Run-off Sites. Mackie (1970) described this type as providing important foraging sites during spring green-up.

Distribution of pellet groups tends to be activity-specific: defecation rates are highest as deer leave bedding sites and when they are traveling (Collins and Urness 1981). Thus, feeding areas are probably under-represented in the pellet transect data. I suspect a similar bias exists in the daytime deer-location data because 82% of the observations were of deer traveling, or at or near bed sites. Mule deer, like white-tailed deer (O. virginianus), exhibit temporal habitat segregation by feeding in open prairie or agricultural habitats mostly at night (Montgomery 1963, Steigers 1981, Herriges 1986). On my study area these diurnal shifts occurred mostly between breaks habitat and upper-elevation agricultural fields (Kraft 1989). I could not obtain precise locations in all habitats at night because of signal interference caused by rough terrain and the inability to visually verify locations at night. Implicit in my general approach is the assumption that habitats used by mule deer during the day reflect critical habitat requirements. The distribution of mule deer in the Great Plains appears limited by the availability of rough terrain (Swenson et al. 1983), so this assumption seems reasonable.

Initial disturbances from dam construction would displace mule deer from the immediate construction site, but would have minimal impacts on other deer. Secondary impacts from increased human activity could be minimized by restricting activity to the construction site and initiating programs to reduce deer/vehicle collisions and poaching.

The major impact of the project would result from habitat lost to inundation. Approximately 57% of the flooded land would be breaks habitat; mostly along the lower third of the reservoir. Narrow floodplain areas would remain along the upper third of the reservoir, but all riparian zones and islands would be totally inundated. Rejuvenation and development of deciduous shrub cover within the remaining breaks habitat may provide additional thermal, security, and fawning cover to help mitigate impacts from the loss of rough terrain and riparian zones. Woody riparian communities should be reestablished prior to project initiation to insure adequate structural development prior to the clearing or inundation of the current riparian zone. Development of temporary irrigation systems on bench areas that will remain above full pool, or small impoundments in coulee systems that will eventually be inundated, will probably be necessary to provide suitable soil moisture conditions for the successful establishment of new riparian habitat. Plantings may also require the same seedbed preparation and care that is used for shelterbelt establishment, but cultivation could eventually be abandoned if native species are used (Severson 1981). Cooperative management of livestock distribution, grazing systems, and stocking rates should be initiated with local ranchers to allow establishment and development of woody riparian habitat.

The level of secondary impacts after inundation will be dependent on the type, level, and distribution of recreational activities. If recreational activity is limited to an occasional fisherman, hiker, or hunter, or light boat traffic on the main stem of the reservoir, impacts would be minimal and limited to the temporary displacement of deer at the site of the disturbance. Higher levels of disturbance will have proportionately higher impacts by displacing more deer and functionally removing larger areas of available habitat. High levels of recreational activity may necessitate preventing public access to flooded side channels. Prairie mule deer may be especially susceptible to hunting pressure because vegetative cover is sparse, and rough terrain offers only limited security (Swenson 1982). Consequently, problems of overharvest could develop if unlimited public hunting access occurred from the reservoir. Most landowners on the study area currently allow public access for deer hunting by permission, but serious public relation problems probably would develop if trespassing accompanied boat access during the hunting season. Because the majority of land surrounding the reservoir will remain in private ownership, I recommend that boat access for hunting be discouraged, and prohibited if necessary.

ACKNOWLEDGMENTS

Financial support for this project was provided by the Mont. Power Co. and the Mont. Coop. Wildl. Res. Unit. I gratefully acknowledge assistance by Univ. of Mont. volunteers and by personnel of the Mont.

Power Co. and Mont. Dep. Fish, Wildl. and Parks. B. W. O'Gara and I. J. Ball aided in project planning and provided editorial assistance. Special thanks are due the many landowners who allowed me access to their property and extended their warm hospitality.

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APPENDIX A

TRAPPING SITES AND DATA RECORED FOR MULE DEER TRAPPED DURING WINTER OF 1982-83 ON THE CARTER FERRY STUDY AREA.

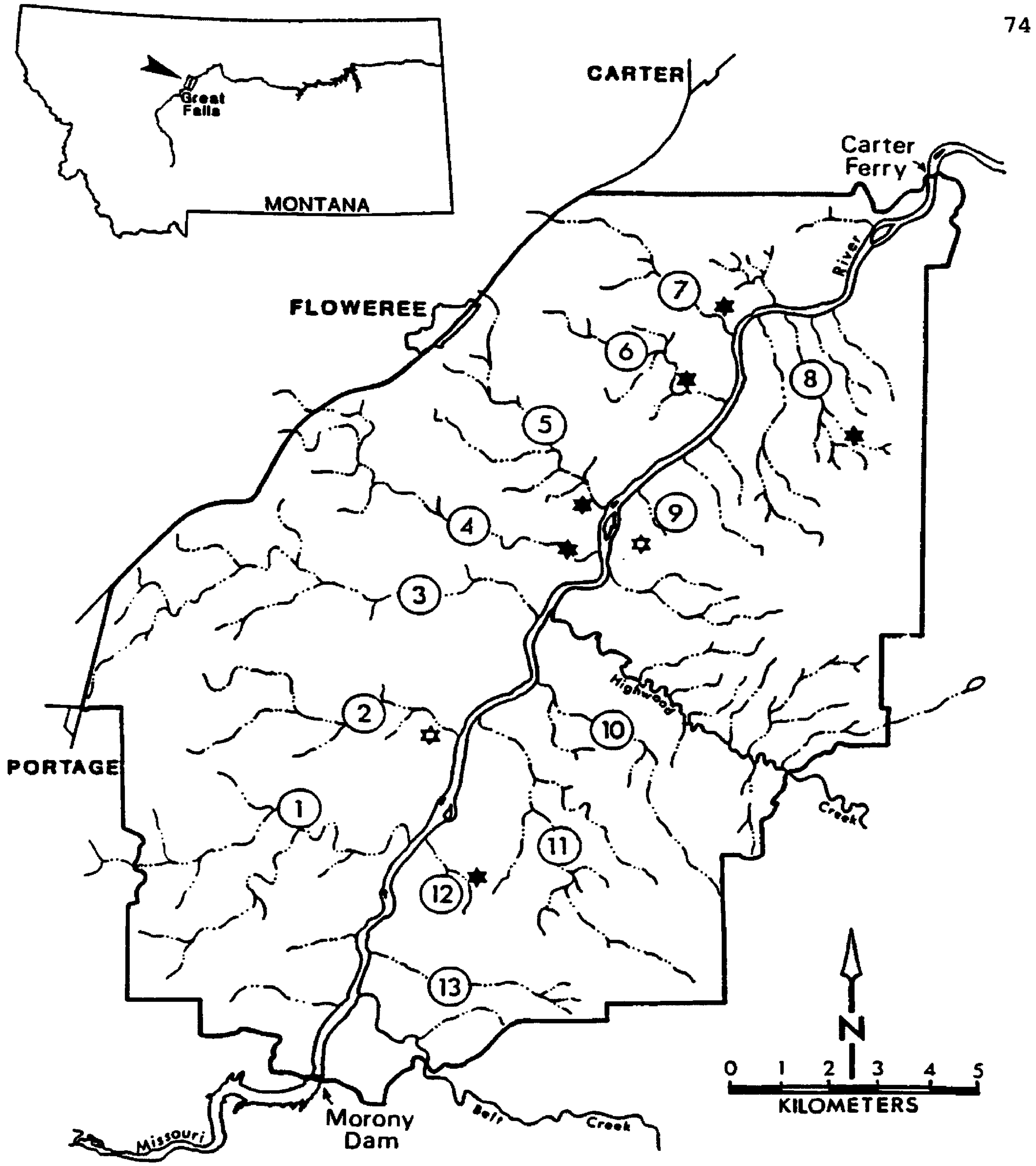


Fig. 1. Trapping sites for mule deer on the Carter Ferry study area (✸ = drive net, ✡ = net gun). (N) = names of coulee systems: 1 = Portage, 2 = Dry(Horn), 3 = Ryan, 4 = Huntley, 5 = North Huntley, 6 = Middle, 7 = Black, 8 = North Trails End, 9 = West Trails End, 10 = Stackhouse, 11 = Widow, 12 = South Widow, and 13 = Hower.

Table 1. Trapping data and history of deer marked on the Carter Ferry study area, 1983-84.

TRAP INFORMATION			SEX	CODE #	EST.	COLLARS		EAR TAGS		COMMENTS
Site	Date	Type			AGE	Type (freq.)	Symbol*	R	L	(incl. markings, fate, last loc., & date)
NW side of the Missouri River										
Dry(Horn) Coulee	1/5/83	Net gun	F	012	2.5	Radio (151.321)	- - - -	14446	14445	Hunter kill - Portage C. 11/11/84
|	|	|	|	015	10+	Radio (151.391)	0 0 0 0	14447	14448	Missing toe bk. rt. Found dead (old age) - Dry C. 6/13/84
Huntley Coulee	1/6/83	Drive net	|	020	3.5	Radio (151.541)	X 0 X 0	A5908	A5909	Last seen in N. Huntly C. 7/17/84
|	|	|	|	202	0.5	Visual	A2 A2 A2	A6426	A6427	Hunter kill - Huntley C. 11/5/87
|	|	|	M	206	0.5	Visual	V2 V2 V2	A5911	A5910	Last seen in Teton River breaks N. of Carter 7/??/83
|	1/10/83	|	F	016	6.5	Radio (151.412)	≡	A6478	A6473	Last seen in Huntley C. 7/17/84
|	|	|	|	003	1.5	Radio (150.831)	T⊥ T⊥	A6483	A6498	Last seen in Ryan C. 7/17/84
|	|	|	|	014	2.5	Radio (151.360)	∿ ∿ ∿	A5907	A5906	Last seen in N. Huntley C. 7/17/84
|	|	|	|	204	0.5	Visual	A4 A4 A4	A6430	A6429	Last seen in Huntley C. 6/12/84
|	|	|	M	205	1.5	Visual	Y4 Y4 Y4	A6424	A6428	Hunter kill - Ryan C. 11/??/83
Middle Coulee	2/12/83	|	F	008	6.5	Radio (151.610)	■□■□	A6444	A6445	Found dead (hunter kill) - Middle C. 11/20?/83
|	|	|	|	001	2.5	Radio (150.721)	V A V A	A6442	A6443	Last seen in Black C. 6/28/84
|	|	|	|	011	3.5	Radio (151.271)	ǀ ǀ ǀ ǀ	A6447	A6446	Last seen in Middle C. 7/17/84
|	|	|	|	017	1.5	Radio (151.440)	∝ ∝ ∝	A6481	A6480	Last seen on River bench E. Middle C. 7/17/84
|	|	|	|	203	1.5	Visual	H3 H3 H3	A5902	A5903	Last seen in Black C. 9/6/83
|	|	|	|	207	2.5	Visual	H4 H4 H4	A6441	A6440	Last seen in Middle C. 8/1/83
Black Coulee	|	|	|	208	0.5	Visual	H8 H8 H8	A6432	A6431	Last seen at Benton Lake NWR 6/3/83
|	|	|	M	201	0.5	Visual	M1 M1 M1	A6436	A6437	Hunter kill - W. of Collins 11/??/84
SE side of the Missouri River										
S. Widow Coulee	1/5/83	Drive net	F	006	1.5	Radio (151.001)	● ● ● ●	A6488	A6489	Last seen in Hower C. 7/16/84
|	|	|	|	013	2.5	Radio (151.340)	-ǀ--ǀ--ǀ-	A5921	A5920	Hunter kill - S. Widow C. 10/27/84
|	|	|	|	004	4.5	Radio (150.881)	▫ ▫ ▫ ▫	A5919	A5918	Rt. ear notched (∩). Last seen in Hower C. 7/16/84

Table 1. continued.

TRAP INFORMATION			SEX	CODE #	EST.	COLLARS		EAR TAGS		COMMENTS
Site	Date	Type			AGE	Type (freq.)	Symbol[a]	R	L	(incl. markings, fate, last loc., & date)
S. Widow Coulee	1/5/83	Drive net	F	005	5.5	Radio (151.970)	• • • •	A6419	A6420	Last seen in S. Widow C. 7/16/84
|	|	|	|	018	5.5	Radio (151.481)	△ △ △	A6417	A6418	Hunter kill - S. Widow C. 11/10/84
|	|	|	|	019	3.5	Radio (151.520)	X X X X	A6500	A6499	Last seen in S. Widow C. 7/16/84
|	|	|	|	101	1.5	Visual	01 01	A6495	A6494	Last seen in Hower C. 3/13/83
|	|	|	|	104	3.5	Visual	04 04	A6492	A6493	Hunter kill - S. Widow C. 10/30/83
|	|	|	|	114	3.5	Visual	14 14	A6491	A6490	Last seen in S. Widow C. 5/23/84
|	|	|	|	171	0.5	Visual	71 71	A5917	A5916	- fate unknown[b] -
|	|	|	|	172	0.5	Visual	72 72	A6484	A6485	- fate unknown -
|	|	|	|	173	0.5	Visual	73 73	A6496	A6497	Last seen in S. Widow C. 1/28/84
|	|	|	|	174	0.5	Visual	74 74	A6476	A6477	- fate unknown -
|	|	|	M	140	0.5	Visual	40 40	A5923	A5922	Hunter kill 6 mi W. of Highwood on Highwood Ck. 11/??/84
|	|	|	|	144	0.5	Visual	44 44	A6487	A6486	- fate unknown -
W. Trails End Coulee	2/13/83	Net gun	F	010	7.5	Radio (151.210)	≈≈≈≈	A5905	A5904	Hunter kill - 3 mi S. of Carter 11/3/84; Arthritic feet.
|	|	|	|	002	8.5	Radio (150.810)	▲ ▲ ▲	A6482	-	Arthritic feet. Last seen in W. Trails End C. 6/14/84
N. Trails End C.	1/5/83	Drive net	|	007	4.5	Radio (151.090)	Z Z Z Z	A5912	A5913	Hunter kill - N. Trails End C. 11/??/83
|	|	|	|	009	4.5	Radio (151.190)	■ ■ ■ ■	A6450	A6449	Last seen in N. Trails End C. 7/16/84
|	|	|	|	102	0.5	Visual	02 02	A6474	A6475	- fate unknown -
|	|	|	|	170	0.5	Visual	70 70	A6470	A6423	- fate unknown -
|	|	|	|	-	0.5	No collar	-	A6472	A6471	- fate unknown -
|	|	|	M	141	0.5	Visual	41 41	A6421	A6422	Hunter kill - Portage C. 10/28/83
|	|	|	|	-	0.5	No collar	-	A5914	A5915	- fate unknown -

[a] Symbols on radio collars were red on white, symbols of visual collars were black on white.

[b] Visual collars were often seen during ground or aerial tracking but some symbols were never identified after initial banding.

APPENDIX B

CENSUS DATA COLLECTED DURING AERIAL SURVEYS OF MULE DEER POPULATIONS ALONG THE UPPER MISSOURI RIVER BREAKS FROM MORONY DAM TO CARTER FERRY, MONTANA, 1978-1984.

Table 2. Summary of census data collected on mule deer on the Carter Ferry study area, 1978-1984. Aerial surveys were conducted from a Cessna Super Cub.

	10 Jan 78[a]	16 Feb 80[a]	8 Feb 82[a]	20 Mar 83	13 Aug 83	17 Jan 84	15 Mar 84
No. Deer Obs.							
N.W. Side	139	214	255	331	350	420	384
S.E. Side	192	311	435	406	236	420	219
Total	**331**	**525**	**690**	**737**[b]	**586**	**840**	**603**
% Markers Obs.	-	-	-	36.4	32.4	33.3	46.6
Fawns/100 Adults[c]	94	111	112	118	-	121	81

[a] Mont. Dep. Fish, Wildl. and Parks data, courtesy of F. Feist.

[b] An additional 233 deer were observed outside of the study area along the Missouri River, between Ryan Dam and Morony Dam (N = 65), and along Belt Creek from the study area boundary to the 1st railroad bridge (N = 168).

[c] Winter censuses only.

APPENDIX C

QUESTIONNAIRES, FOLLOW-UP LETTER, AND SUMMARY OF RESPONSES TO QUESTIONNAIRES SENT TO B-DEER TAG HOLDERS IN MONTANA HUNTING DISTRICT 405 FOLLOWING THE 1982 AND 1983 GENERAL HUNTING SEASONS.

1982

Dear Hunter,

I am conducting a study for The Montana Power Company, on deer populations along the Missouri River between Great Falls and Fort Benton. Major purposes of the study are to assess potential impacts of a proposed hydro-electric dam at Carter Ferry on deer numbers, distribution and habitat use, and hunter use of the area. Your answers to the following questions may help assure current and future hunting opportunities in this area. Please fill out and return this questionnaire even if you did not hunt or were unsuccessful. All information provided will be considered confidential.

1. How many days did you spend hunting in HD 405 (mapped below)? ________

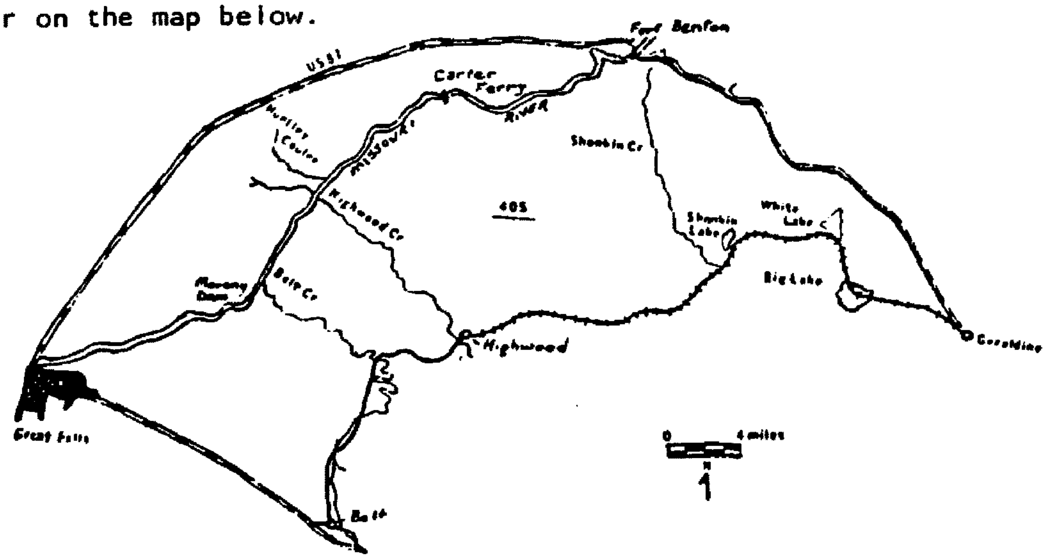
2. Please mark the number of deer killed from each of the following categories:

	Mule deer	White-tailed deer
Buck fawn	☐	☐
Doe fawn	☐	☐
Adult buck	☐	☐
Adult doe	☐	☐

3. Circle the time period(s) of your kill(s):

   Oct. 24-30   Oct. 31 - Nov. 6   Nov. 7-13   Nov. 14-28

4. Please indicate the approximate location(s) where you killed your deer on the map below.



Thank you for your cooperation!

Sincerely,

Susan Kraft

Susan Kraft
Graduate Student
Montana Cooperative Wildlife Research Unit
HS 107, University of Montana
Missoula, MT 59812

1983

Dear Hunter,

I am conducting a study for the Montana Power Company, on deer populations along the Missouri River between Great Falls and Fort Benton. Major purposes of the study are to assess potential impacts of a proposed hydroelectric dam at Carter Ferry on deer numbers, distribution and habitat use, and hunter use of the area. Your answers to the following questions may help assure current and future hunting opportunities in this area. Please fill out and return this questionnaire even if you did not hunt or were unsuccessful. All information provided will be considered confidential.

1. How many days did you spend hunting in HD 405 (mapped below)? ____________

2. Were you successful in filling your B tag ☐, A tag ☐, both A&B tag ☐, or neither ☐

3. Please mark the number of deer killed from each of the following categories:

	Mule deer	White-tailed deer
Doe fawn	☐	☐
Buck fawn	☐	☐
Adult doe	☐	☐
Adult buck	☐	☐

4. Circle the time period(s) of your kill(s): Before Oct. 25

Oct. 25–30 Oct. 31 – Nov. 6 Nov. 7 – 13 Nov. 14 – 20 Nov. 21 - 27

5. Did you hunt from a boat? ☐ yes ☐ no

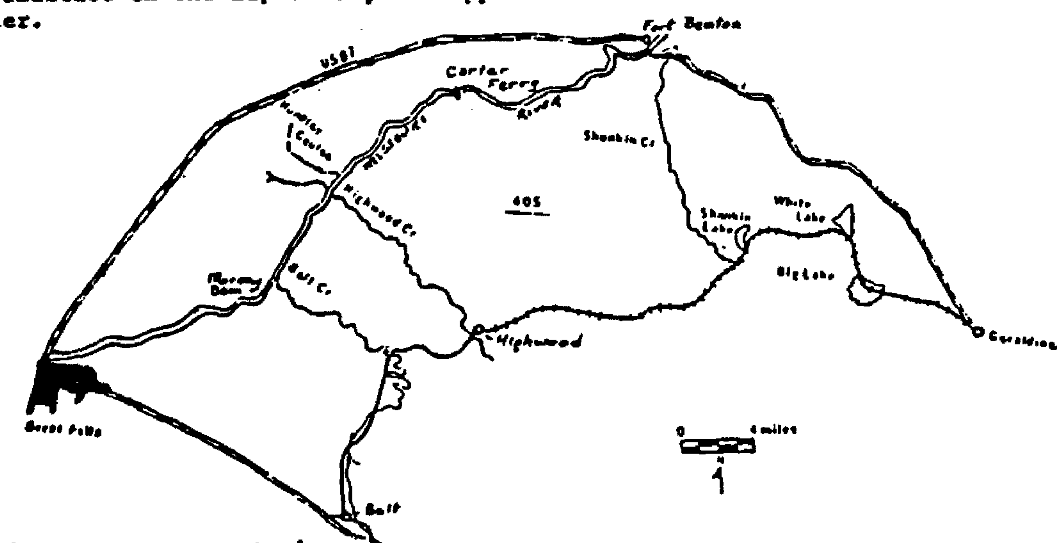
If so did you utilize one of the following access sites:

Public access at Morony Dam ☐ Private access above Carter Ferry ☐

Public access at Carter Ferry ☐ Private access below Carter Ferry ☐

Other Public access below Carter Ferry ☐

6. Please indicate on the map below, the approximate location(s) where you killed your deer.



Thank you for your cooperation!

Sincerely,

Susan Kraft

Susan Kraft
Graduate Student
Montana Cooperative Wildlife Research Unit
HS 107, University of Montana
Missoula, MT 59812

27 February 1984

Deer Hunter,

I have enclosed a copy of the hunter questionnaire I sent out in December. My study is designed to use the information from this questionnaire to improve deer management and hunting opportunities in HD 405. So, if you have not already returned one, please take a minute to fill this one out and return it in the enclosed envelope. Your answers are important even if you did not hunt or were unsuccessful, and additional comments are welcome. Thank you for your help and consideration.

Sincerely,

Susan Kraft

Susan Kraft
Graduate Student
Montana Cooperative Wildlife Research Unit
HS 107, University of Montana
Missoula, MT 59812

Table 3. Summary of responses to questionnaires sent to 1982 and 1983 B-deer tag holders in Montana Hunting District 405.

	CF Study Area		All HD 405	
	1982	1983	1982	1983
No. B tags Issued	-	-	300	600
No. Questionnaires Delivered	-	-	295	298
No. Respondents	-	-	196	186
No. that Hunted	61	45	179	171
No. Hunter Days	140	117	427	432
x Days/hunter	2.3	2.6	2.4	2.5
Tags Filled				
Unsuccessful	0	1	17	19
A tag only[a]	7	0	20	10
B tag only	22	24	71	77
Both A & B tag	32	18	71	65
% B tag Success	88	93	79	83
No. Mule Deer Killed				
Antlerless	54	43	146	142
Antlered	35	16	77	67
Subtotal	89	59	223	209
No. Whitetails Killed				
Antlerless	3	0	6	4
Antlered	1	2	4	3
Subtotal	4	2	10	7
Total Reported Kill	93	61	233	216
No. Hunting From Boat	-	1	-	3

[a] All B tag holders must also possess a valid A tag.