

Movement, activity, and habitat use of white-tailed deer along the lower Yellowstone River
by James Daniel Herriges, Jr

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Fish and Wildlife Management
Montana State University
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Abstract:
A study was conducted using radio telemetry to evaluate distribution, movements, activity, and habitat use by white—tailed deer (Odocoileus virginianus) on two areas along the lower Yellowstone River in eastern Montana during summer 1982 and 1983 and winter 1984. Deer distribution centered on river bottomlands, though some deer made daily or seasonal movements to adjacent uplands on the Intake area. Deer movements were short and restricted to riparian cover during the day, but increased and extended to agricultural fields up to 2.5 km from cover at night. Movement to and use of fields increased through summer and from summer to winter and appeared greater on the Intake than Elk Island study area. Well defined peaks in deer activity and movement occurred at sunrise and sunset; lesser peaks occurred near midnight and noon. Peak use of agricultural fields occurred from 1-2 hours after sunset until midnight. Seasonal minimum convex polygon home range sizes for individual deer varied from 0.29 km2 to 10.0 km2. Adult females had the smallest home ranges, averaging 0.87 km2 in summer and 1.8 km2 in winter. Total (24-hour) home range size varied by sex and age of the deer, season, and study area. Home ranges based only on daytime relocations averaged half as large as total home ranges in summer and 28% of the total in winter and did not differ between seasons and study areas. Among riparian cover types, deer selected for mid-to-late serai communities (mature cottonwood, shrub, green ash, and mature willow) with tall dense cover; grasslands were avoided. Among croplands, deer preferred alfalfa in summer and ungrazed alfalfa, sugar beets, and winter wheat in winter. Differences in selection and use of crops between study areas and seasons were related to availability influenced by cropping, harvest, and postharvest grazing and field treatment practices. Overall, natural riparian cover and agricultural croplands were the two major components of deer habitat. These combined with topography and physiography of the river valley, and other land use and operational practices to influence deer distribution movements and home range size, activity, and use of specific cover types.

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A thesis submitted in partial fulfillment
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of

Master of Science

in

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MONTANA STATE UNIVERSITY
Bozeman, Montana

June, 1986

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ABSTRACT

A study was conducted using radio telemetry to evaluate distribution, movements, activity, and habitat use by white-tailed deer (Odocoileus virginianus) on two areas along the lower Yellowstone River in eastern Montana during summer 1982 and 1983 and winter 1984. Deer distribution centered on river bottomlands, though some deer made daily or seasonal movements to adjacent uplands on the Intake area. Deer movements were short and restricted to riparian cover during the day, but increased and extended to agricultural fields up to 2.5 km from cover at night. Movement to and use of fields increased through summer and from summer to winter and appeared greater on the Intake than Elk Island study area. Well defined peaks in deer activity and movement occurred at sunrise and sunset; lesser peaks occurred near midnight and noon. Peak use of agricultural fields occurred from 1-2 hours after sunset until midnight. Seasonal minimum convex polygon home range sizes for individual deer varied from 0.29 km^2 to 10.0 km^2. Adult females had the smallest home ranges, averaging 0.87 km^2 in summer and 1.8 km^2 in winter. Total (24-hour) home range size varied by sex and age of the deer, season, and study area. Home ranges based only on daytime relocations averaged half as large as total home ranges in summer and 28% of the total in winter and did not differ between seasons and study areas. Among riparian cover types, deer selected for mid-to-late seral communities (mature cottonwood, shrub, green ash, and mature willow) with tall dense cover; grasslands were avoided. Among croplands, deer preferred alfalfa in summer and ungrazed alfalfa, sugar beets, and winter wheat in winter. Differences in selection and use of crops between study areas and seasons were related to availability influenced by cropping, harvest, and post-harvest grazing and field treatment practices. Overall, natural riparian cover and agricultural croplands were the two major components of deer habitat. These combined with topography and physiography of the river valley, and other land use and operational practices to influence deer distribution movements and home range size, activity, and use of specific cover types.

INTRODUCTION

In 1980, the Montana Department of Fish, Wildlife and Parks initiated intensive studies of population ecology and habitat relationships of white-tailed deer on bottomlands of the lower Yellowstone River in eastern Montana. These bottomlands support dense populations of deer (Swenson et al. 1983, Dusek 1985) which provide important recreational hunting in the area, but may also depredate crops on and adjacent to the river bottom.

Detailed information on deer usage of bottomland habitats is required to assess agricultural relationships and develop effective methods to minimize depredations while sustaining deer populations for hunting and other benefits. There is also need for such information to assess the role of riparian vegetation, maintained by Yellowstone River flows (Boggs 1984), in the ecology of white-tails in bottomland habitat. Previous studies in the area (Swenson 1978) provided only general information. Allen's (1968) study of range use and food habits of white-tailed deer on bottomlands of the Missouri River in central Montana involved less agricultural cropland, and analysis of habitat use was limited primarily to open cover types.

My study was initiated in 1982 to obtain detailed information on habitat use over 24-hour periods during summer and winter. Specific objectives were: 1) to determine relative use of natural riparian communities and of agricultural lands and crops by white-tailed deer, 2) to determine distribution, movements, and activity patterns of deer, and 3) to determine how these parameters are affected by the distribution of riparian communities and agricultural lands and crops, environmental variables, and land use practices.

Field studies were conducted primarily during summer 1982 (July-September) and 1983 (June-September) and winter 1984 (January-March).

DESCRIPTION OF STUDY AREAS

Location

Field studies were conducted on two areas along the lower Yellowstone River (Fig. 1). The Intake study area was located in Dawson County about 24 kilometers (km) downstream from Glendive. The Elk Island study area was located in Richland County, near Savage, and about 32 km downriver from Intake. It included the Elk Island Wildlife Management and Recreation Area (EIWMA).

Climate

Winters are cold with average temperatures in January or February dropping below -18 C about once every 9 or 10 years (Pescador and Brockman 1980). Summers are warm and sunny with temperatures reaching 32 C or more on about half the afternoons in July and August. The average length of the growing season is 120-130 days. Annual precipitation is 30-36 centimeters (cm), 80% falling during April-September. Winter snowfall is moderate, averaging 71-81 cm.

Monthly temperatures and precipitation during the study are compared with long-term averages at Savage in Figures 2 and 3 (NOAA 1983-1984). The winter of 1983-1984

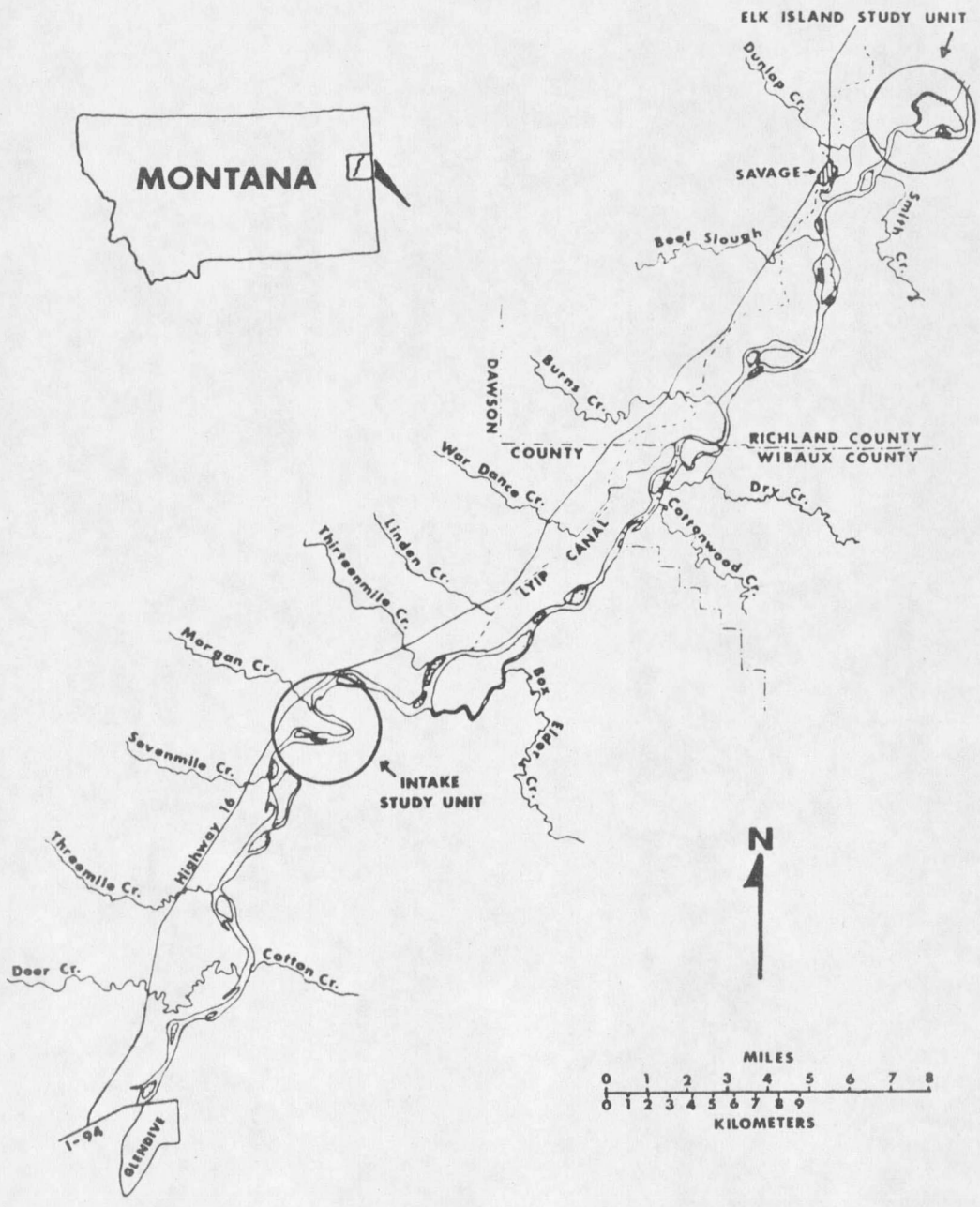


Figure 1. Map of the lower Yellowstone River showing location of the Intake and Elk Island study areas.

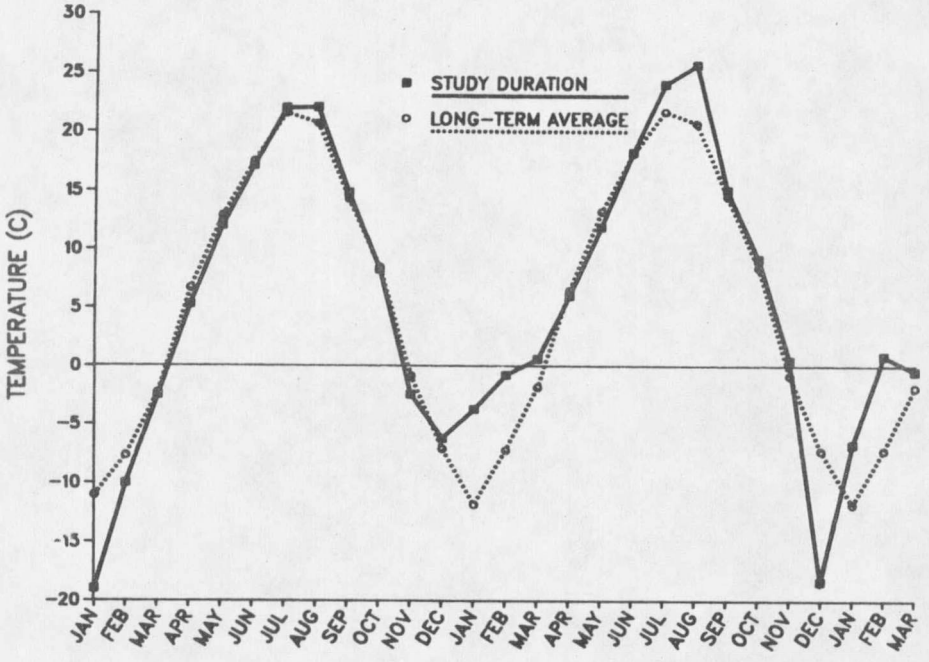


Figure 2. Average monthly temperatures during the study period compared to 75-year averages.

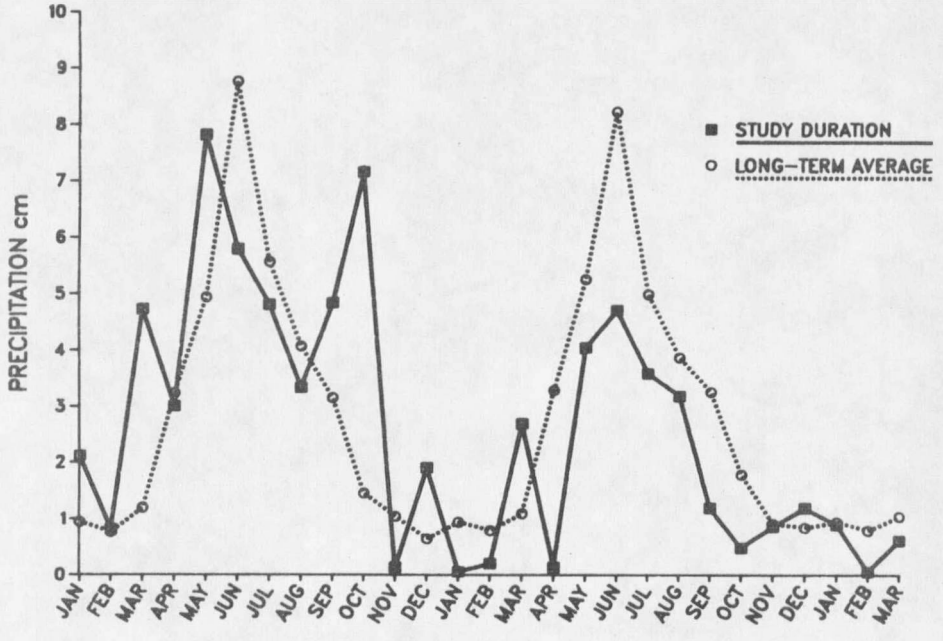


Figure 3. Monthly precipitation during the study period compared to 75-year averages.

was relatively mild, though severe weather conditions occurred in December and part of January. Overall, winter severity was much lower than the previous six winters - 4200 vs. 9400 using Picton and Knight's (1971) system - though December was the most severe since 1978 (Dusek 1984). The summer of 1983 was hot and dry, while the summer of 1982 was near normal in precipitation and temperature.

Physiography

The Yellowstone River flows through a broad floodplain (approximately 3 km wide at Intake and 5 km wide at Elk Island) bounded by terraces, rolling hill slopes, or steep "breaks". The Elk Island study area was located entirely on the floodplain, bounded on the west by the Lower Yellowstone Irrigation Project (LYIP) canal and on the east by steep bluffs rising from the rivers edge (Fig. 4). The Intake study area consisted primarily of floodplain but also included a cultivated terrace to the east and gradually rising upland grasslands and hardwood draws to the south (Fig. 5). Another terrace extended to the north and west. Morgan creek entered the study area from the northwest, with breaks or badland topography occurring to the northeast.

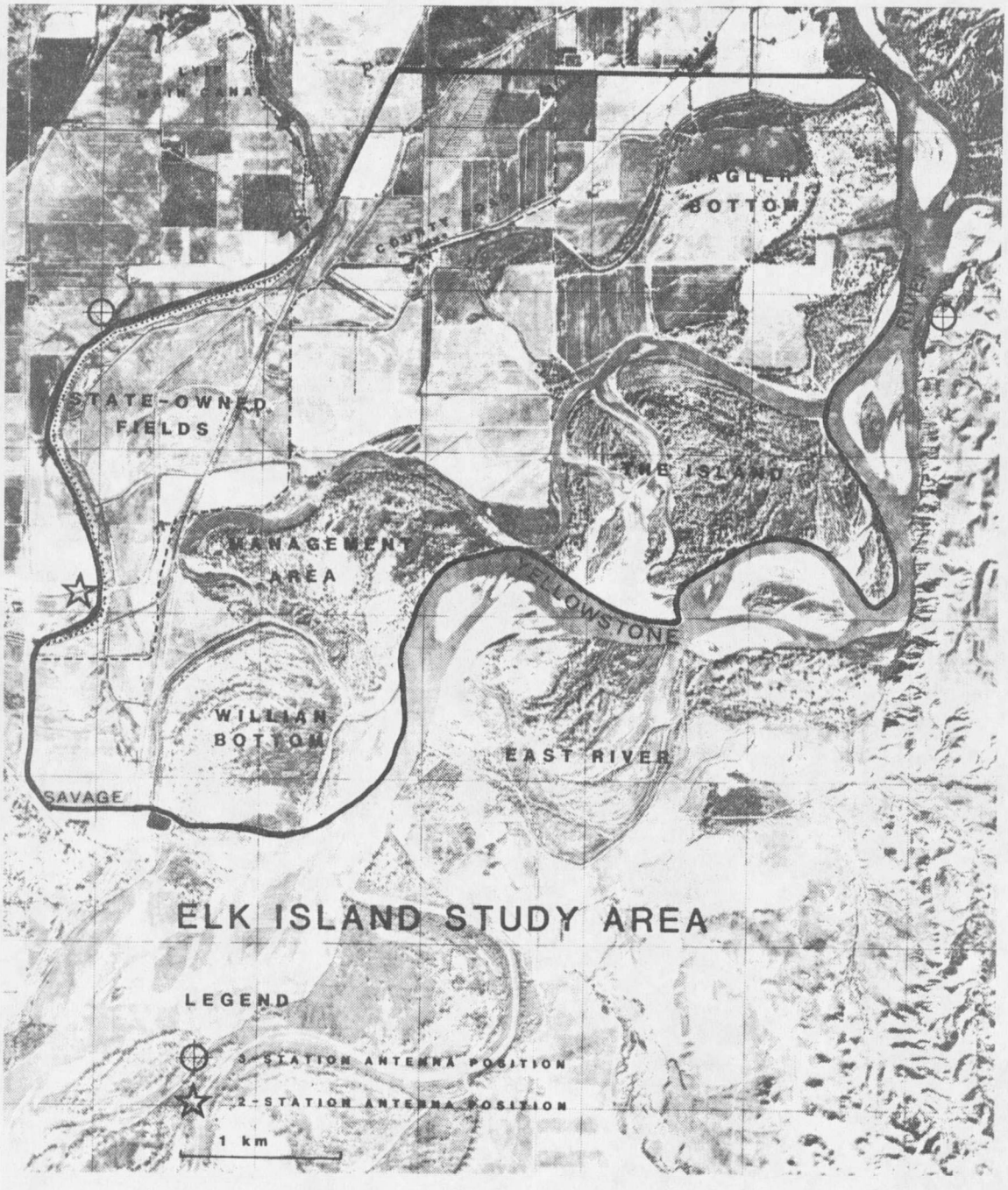


Figure 4. Aerial photograph of the Elk Island study area showing locations of antennas and other features.

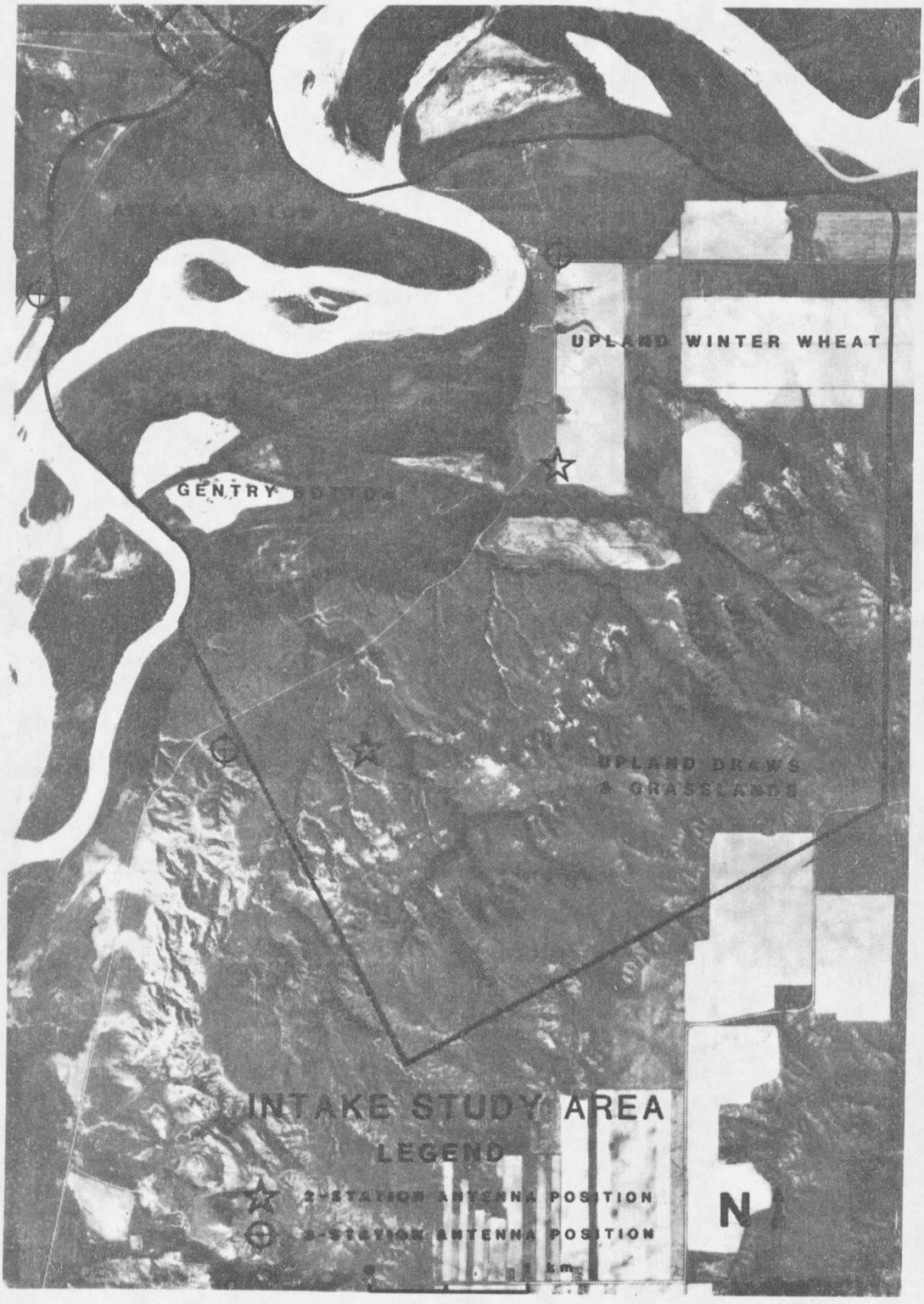


Figure 5. Aerial photograph of the Intake study area showing locations of antennas and other features.

Soils of the floodplain and low terraces are "level to gently sloping, deep fine sandy loams and silt loams underlain by sandy loam and silt loam" (Holder and Pescador 1976). Soils on terraces at Intake are deep, dominantly silty clay loam throughout.

Land Use

The Intake study area (Fig. 6) was not part of the Lower Yellowstone Irrigation Project, though some flood irrigation occurred through the use of private pumping systems. Wheat, barley, alfalfa, and grass hay were the primary crops on the floodplain. Alternate year winter wheat cropping predominated in cultivated fields on the benches or low terraces to the southeast and northwest, though some irrigated corn and alfalfa were also grown. Cattle were grazed on the floodplain during fall and winter and on upland pastures during spring and summer.

At Elk Island, the LYIP irrigation waters and a wider floodplain provided for a greater proportion of irrigated crops, primarily sugar beets, alfalfa, wheat, and some corn. Large blocks of ungrazed riparian vegetation occurred on Elk Island, Crittenden Island, and the EIWMA (Fig. 7). The latter included several fields which were cropped (alfalfa or barley) or had been abandoned to grass and weeds. Although livestock grazing is of lesser

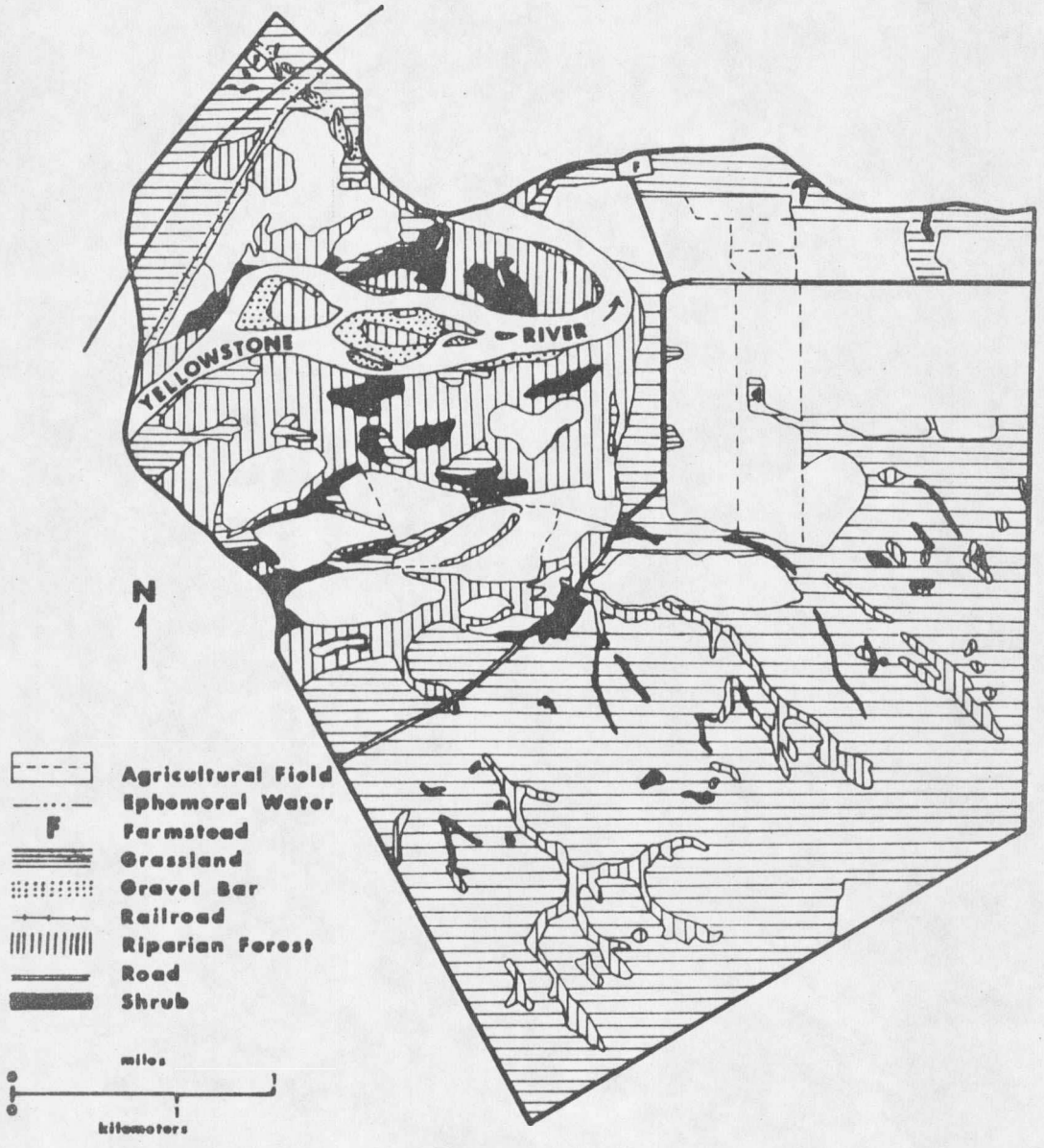


Figure 6. General cover-type map of the Intake study area.

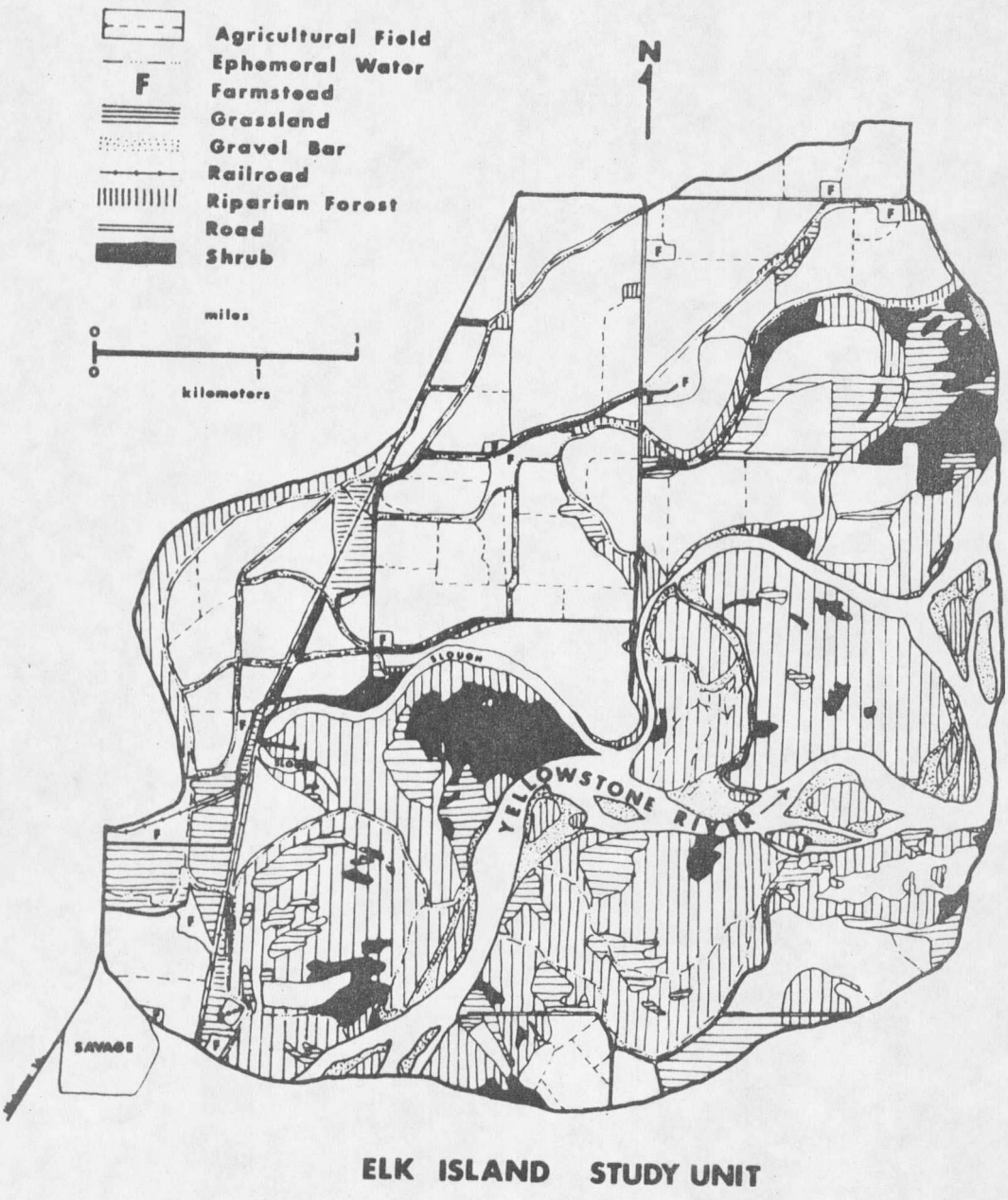


Figure 7. General cover-type map of the Elk Island study area.

importance on the Elk Island area, sheep were grazed on the Hagler and Willian bottoms.

Cover Types

Cover types and their relative occurrence on the two areas are listed in Table 1. Plant species names follow Booth (1972) and Booth and Wright (1966). Common names follow Scott and Wasser (1980), Booth (1972), or Booth and Wright (1966). Cover type designations and successional relationships (Fig. 8) for riparian vegetation generally follow Boggs (1984).

Sandbar Type

This cover type included gravelbars and sandbars along the river channel. Plant cover varied from none, to a few grasses and forbs, to seedling stands of eastern cottonwood (Populus deltoides) and willow (Salix spp.). Water levels determine the extent of this type exposed. My interpretation was made in the fall during low water.

Willow-Cottonwood Thicket Type

A dense overstory of cottonwood and willow saplings characterized this type. Understory vegetation was sparse, consisting primarily of grasses.

Table 1. Occurrence and approximate area (hectare) of cover types on the Intake and Elk Island study areas during summer 1983.[a]

Cover Type	Intake	Elk Island
Gravelbar	26	28
Thicket	21	37
Young Cottonwood	28	85
Mature Cottonwood	159	212
Shrub	54	110
Mature Willow	31	43
Green Ash	80	17
Slough	3	27
Canal Bank	-	36
Creekbottom	55	-
Fldp. Hay	72	80
Fldp. Uncut Grass	125	279
Upland Grassland	1772	-
Ash Draw	92	-
Shrub Draw	32	-
Wheat	77	342[b]
Barley	12	25
Oats	-	10
Corn	31	28
Winter Wheat	294	-
Fallow	274	-
Alfalfa	80	142
Beets	-	58
Farmsteads	4	6
Water	133	63

[a] Total area of the Intake Study area was approximately 35 km^2, 25% of which was bottomland; total area of Elk Island study area was 16 km^2.

[b] Much of the 342 ha of wheat was in sugar beets in 1982.

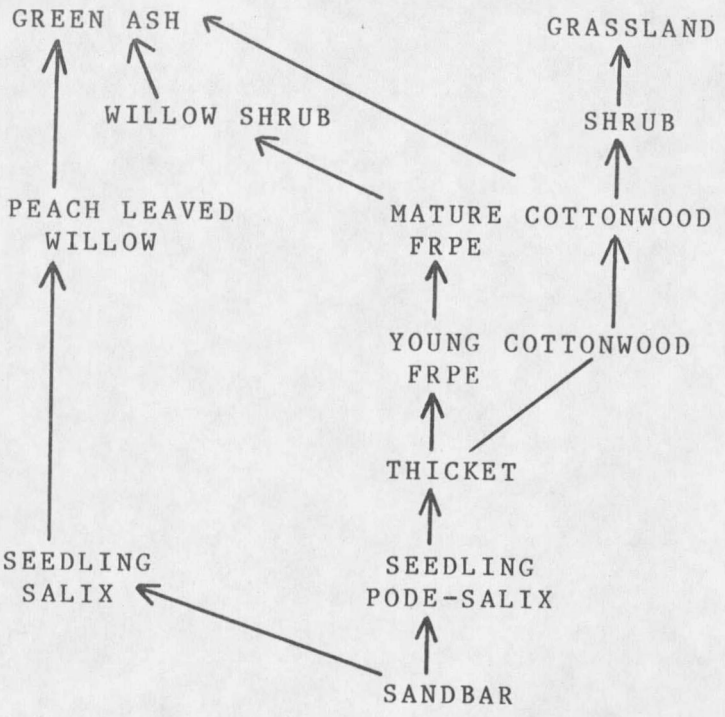


Figure 8. Flow chart summarizing successional changes on the lower Yellowstone River floodplain (after Boggs 1984).

Young Cottonwood Type

Young cottonwood trees in a dense canopy dominated; willows had largely disappeared. The understory consisted mainly of grasses, especially Canada wildrye (Elymus canadensis) and marsh muhly (Muhlenbergia racemosa). Shrub cover was poorly developed.

Mature Cottonwood Type

Cottonwood densities were much reduced as compared with the young cottonwood type, and a shrub understory was usually better developed, though a grass understory was sometimes present. Dominant shrubs were Woods rose (Rosa woodsii) and western snowberry (Symphoricarpos occidentalis). Other common shrubs included poison ivy (Toxicodendron rydbergii), silver buffaloberry (Sheperdia argentea), currants (Ribes spp.), Russian-olive (Eleagnus angustifolia), common chokecherry (Prunus virginiana), and red-osier dogwood (Cornus stolonifera). The vines, Virginia creeper (Parthenocissus quinquefolia), riverbank grape (Vitis riparia), and western white clematis (Clematis ligustifolia) were locally common. Common forbs included yellow sweetclover (Melilotus officinalis), American licorice (Glycyrrhiza lepidota), goldenrod (Solidago spp.), tumblemustard (Sisymbrium loeselli and S. altissumum) and prairie coneflower (Ratibida columnifera).

Some common grasses included Canada wildrye, marsh muhly, and smooth brome (Bromus inermis).

Shrub Type

Woods rose and western snowberry dominated this type, though decadent cottonwoods persisted in some stands. Many of the shrubs were dead-standing. Other shrubs occurring in this type included silver buffaloberry, poison ivy, golden currant (Ribes aureum), redshoot gooseberry (Ribes setosum), and Louisiana sagewort (Artemisia ludoviciana). Common grasses and forbs were Canada wildrye, smooth brome, prairie sandreed (Calamovilfa longifolia), marsh muhly, western wheatgrass (Agropyron smithii), yellow sweetclover, American licorice, and goldenrod. Green ash seedlings and saplings occurred in some stands.

Floodplain Grassland Type

This type included a variety of grasslands, distinguished as mowed for hay (floodplain hay meadow type) and not mowed (uncut floodplain grassland type). Several of the hay meadows at Intake had been planted to smooth brome or crested wheatgrass (Agropyron cristatum). Typically, however, there was little difference between cut and uncut grasslands. Common grasses included western wheatgrass, prairie sandreed, Canada wildrye, marsh muhly,

quackgrass (Agropyron repens), and needle-and-thread (Stipa comata). Shrubs occurred mainly as thin to moderately dense stands of Silver sagebrush (Artemisia cana), and islands of snowberry and Woods rose. Common forbs included yellow sweetclover, tumblemustard, curlycup gumweed (Grindelia squarrosa), American licorice, prairie coneflower, goldenrod, Aster spp., and common dandelion (Taraxicum laevigatum). Some grassland consisted of abandoned fields and disturbed areas with a wide variety of additional forbs and grasses.

Green Ash Type

This type typically occurred as dense-canopied stands of green ash trees with a primarily grass understory, though shrubs were abundant in some stands. Smooth brome was the most common grass, with some marsh muhly and Canada wildrye. Other trees were American elm (Ulmus americanus), boxelder maple (Acer negundo), and Rocky Mountain juniper (Juniperus scopulorum). Shrubs, when present commonly included Woods rose, western snowberry, and chokecherry.

Mature Willow Type

Thick stands of mature peach-leafed willow trees characterized this type. Smooth brome was the primary understory component. Mature willow sometimes occurred in

close association with shrubs, and stands often contained young ash trees. Western white clematis and riverbank grape vines often covered dead or dying willow trees.

Slough Type

This type occurred along old river channels and some drainage ditches. Dominant species included cat-tail (Typha spp.), common reed (Phragmites communis), and horsetail (Equisetum spp.).

Irrigation Canal Bank Type

This type occurred on the downhill slope of the LYIP main canal. A diversity of plant species and communities existed due to differential seepage and exposure and perhaps also to the relatively short time since the area had been disturbed in construction of the canal. The type in general was more mesic than the surrounding area. It included a a patchwork of trees (willow, young cottonwood, and green ash), shrublands (woods rose, snowberry and buffaloberry), grasslands, marshes (cat-tail and common reed), and disturbed areas dominated by forbs such as yellow sweet clover or tumblemustard.

Upland Grassland Type

A variety of grasslands characterized this type on sites that included dry hillsides, flat and rolling

uplands, and more mesic draws. Common grasses were blue grama (Bouteloua gracilis), needle-and-thread, and western wheatgrass. Silver sagebrush occurred in some draws.

Hardwood Draw Type

Stands of green ash dominated, although some cottonwoods, juniper, aspen, and a variety of shrubs occurred.

Shrub Draw Type

This type occupied narrow strips along the bottoms of draws and some north-facing slopes. Common shrubs were Woods rose, western snowberry, fragrant sumac (Rhus trilobata), and red-osier dogwood.

Creekbottom Type

This type occurred only along Morgan Creek at Intake. It consisted of grasslands with interspersed stands of shrub and woodland. Shrubs were woods rose and snowberry. Trees included mature cottonwood, juniper, young cottonwood, and ash.

Farmsteads

These areas usually included dwellings and outbuildings, shelterbelt, and often a small pasture or

corral. They were classified as inhabited or uninhabited.

Agricultural Fields

These were classified according to the crops grown during each year of the study. Grain fields at Elk Island were generally fall plowed; at Intake they were left in stubble.

METHODS

Movements and habitat use were determined primarily by telemetry relocations of deer captured and radio-collared in the course of on-going studies of white-tailed deer on the lower Yellowstone River (Dusek 1985). Collectively, fifty-one individual radio-collared deer were radio-tracked during the two summers (1982, 1983) and one winter (1984) of study at Elk Island and one summer (1983) and one winter (1984) at Intake.

Triangulation

Most radio-locations were obtained using triangulation methods (Heezen and Tester 1967, Pac 1978). Antenna systems were stationary null-peak antenna arrays (AVM Instr. Co., Champaign IL) or truck-mounted precision direction finding antenna arrays (Telonics Inc., Mesa, Arizona). Antennas were placed in areas of elevated topography at points surrounding, and within 2-3 km of the center of, the study areas (Figs. 4 & 5). During winter 1984, two truck-mounted antennas, located closer to the animals, were often used.

Antennas were zeroed on a beacon transmitter at the beginning of each triangulation session and periodically

checked. Azimuths were recorded at the null between two amplitude peaks. Signal quality was recorded as very good, normal, or poor. Deer were located at hourly intervals with observers on each of three antennas recording the azimuth within about 5 minutes of a predetermined time.

During summer 1982 six weekly sessions from 1700 to 0600 and two 24-hour triangulation sessions were conducted at Elk Island. During summer 1983, four monthly 24-hour sessions, 2 groups of three 8-hour sessions spanning the 24-hour period, and two night-long sessions with bihourly locations were conducted at Elk Island. Four biweekly groups of three 8-hour sessions were completed at Intake. In winter 1984, one 24-hour session was completed at each area and 3.3 twenty-four-hour periods were covered in 3-9-hour sessions.

Locations were plotted at the centroid of the polygon formed by intersection of bearing lines; ie., the error polygon described by Pac (1978). In cases of two azimuths intersecting at angles of less than 15 degrees (or more than 165 degrees) the location was plotted on the midpoint of the side of the triangle formed by the third azimuth line. If only two bearings were obtained the location was plotted at their intersection. Coordinates of locations were recorded to the nearest 25 meters (m) on a Universal Transverse Mercator (UTM) grid. An error code noted the

size of the error polygon or, in the case of only two bearings, the angle of intersection of the bearing lines, the mean distance from locations to antennas, and the signal quality. These were used as indices of location accuracy (Heezen and Tester 1967, Springer 1979). Locations were later used or deleted on the basis of the error code and specific analytical objectives (eg., more accurate locations were chosen for habitat use analysis than for home range delineation). Locations with error polygons greater than 350 m on a side were deleted from all analyses. A total of 5,648 acceptable deer locations were collected.

Accuracy of the system was verified during most sessions by taking bearings on "rabbit" or control transmitters placed in various known locations around the study area. If bias was indicated (i.e. readings were consistently off in one direction), all bearings for that antenna were corrected by the mean of the control bearing errors.

Average angular error of 229 accuracy test bearings was $\pm$ 0.95°. In 103 accuracy tests, the mean distance error from actual location to plotted location was 72 m. The mean error of control test locations that satisfied error code criteria for habitat use analysis was 59 m.

Other Deer Locations

All radio-collared deer on the study areas were relocated from the air at 1-2 week intervals using a Piper SuperCub in the course of overall studies of white-tailed deer on the lower Yellowstone River (Dusek 1985). These locations were plotted on aerial photographs, and cover type occupied was noted.

Radio-collared deer were also relocated periodically by walking in and flushing or close-range triangulation using a hand-held antenna such that location and habitat type occupied could be ascertained. In addition, locations and habitat type were recorded for all radio-collared and neckbanded deer observed during spotlight surveys and other activities on the study areas. Collectively, these techniques provided 227 observations of which 62% were walk-ins, 10% were by triangulation, 18% were by spotlight, and 10% by incidental direct observation. The walk-ins provided data on daytime locations and use of riparian habitat types, while other methods primarily recorded nighttime locations and use of agricultural fields and grasslands.

Activity Monitoring.

Indexes of animal activity were obtained by 1) measuring the average distances moved between successive

hourly locations of individual deer and 2) occasionally monitoring variations in radio signal strength which are produced when the animal is active by changes in orientation of the radio antenna (Cochran 1980, Lindzey and Meslow 1977, Happe 1982). Animals were considered active if more than three distinct changes in signal strength were recorded per 100 radio pulses within a 1.5-3 minute listening period. This was verified by observation.

Spotlight Survey

Spotlight surveys to record deer use of agricultural fields and crops and other open habitat types were conducted periodically on both study areas during summer 1983 and winter 1984. These surveys followed established vehicle routes along roads bordering fields. Counts were made by one person using a 300,000 candlepower spotlight while standing in the back of a pickup or, if a second person was not present, driving slowly until deer were seen. Group size, any collared animals present, and cover type were recorded for each observation.

Helicopter Survey

One complete-coverage aerial survey of the Elk Island study area and an adjacent bottomland was made during early morning February 21, 1984, using a Bell 47G

helicopter. Group size, location, and cover type were recorded for all deer observed.

Environmental Conditions

To examine their effect on deer behavior, environmental conditions were recorded during observational periods. Relative humidity and temperature were measured with a recording hygrothermograph placed in a weather station housing at Elk Island. Wind speeds were measured with a cup anemometer. Equivalent still air temperatures (wind-chill) were approximated for a 60 kg deer based on information provided by Dr. H. D. Picton (pers. comm.). In addition, cloud cover, phase of the moon, precipitation, and snow cover were recorded.

To examine shelter from the wind afforded by riparian vegetation, a second cup anemometer was placed at 1 m height in various riparian cover types at the Elk Island unit for periods of 1-9 days. Wind readings were compared with those of the control anemometer on the weather station which had been calibrated to wind speeds at 1 m height.

Cover Density

The vertical structure and density of vegetation within riparian cover types during summer was measured

using a "vegetation profile board" (Nudds 1977). The percentage of each of four, 0.5-m intervals obscured by vegetation was classified into one of five 20% classes. The board was placed in random orientation at randomly selected sites within selected stands. Readings were taken at a distance of 15 m, in four perpendicular directions, and averaged for each site.

Cover Type Mapping

Preliminary cover type maps developed by Boggs (1984) were ground-truthed, modified as necessary, and extended to unmapped areas used by deer. Cover type classifications (Table 1) were based on dominant overstory vegetation. Agricultural crops were determined and mapped for each season by field reconnaisance. Maps were digitized using GEOSCAN computer programs (Mont. Dept. Fish, Wildl., and Parks 1984).

Analytical Methods

Movements and Home Range

The TELDAY computer program (Mont. Dept. Fish, Wildl., and Parks 1985), was used to perform plotting and calculation functions. Seasonal home range sizes (daytime and total) were calculated by the convex polygon method (Mohr 1947) for all animals for which at least 30 locations, collected over at least one month were

available. All triangulation locations meeting minimum accuracy criteria were included in 24-hour home ranges together with aerial (Dusek, unpubl. data), walk-in, and other incidental locations. The average number of triangulation locations for each home range was 79. Only triangulation locations were used in calculating daytime home ranges.

In addition to polygon size, standard diameter (SD, Harrison 1958), geographic activity center (GAC), and average activity radius (AAR), were calculated for each home range, using only triangulation locations. The geographic activity center is the point whose coordinates are the arithmetic means of the x and y coordinates of each location for that animal, and the average activity radius is the average distance of each point from the GAC (Hayne 1949). AAR and SD were highly correlated ($r=0.995$, $p<0.001$). Therefore, SD was not included in the analysis. Although polygon and AAR measured different aspects of deer home range, they were also correlated ($r=0.867$, $p<0.001$). Despite the limitations of each technique (Dusek and Wood 1986), they showed the same relationships in most cases, indicating that most differences in home range characteristics between groups were greater than the biases inherent in each technique.

Multiple regression (Dixon et al. 1981) was used to

analyze the effects of study area, age, and season on home range. Because of small sample sizes in some categories for yearling males, differences between sexes were analyzed separately with t-tests. A separate variance estimate (Nie et al. 1975) rather than a pooled estimate was used when variances were significantly different.

Habitat Use

Animal location data were intersected with digitized habitat data files using GEOCALC (a computer program written) by Bill Hoskins for the Interagency Grizzly Bear Study, Bozeman, MT. This program measured the area and length of edge of each cover type within a scanning circle of 125 m radius drawn around each location. This radius was chosen because 91% of accuracy test locations were within 125 m of the true location.

To test the hypothesis that deer used the different cover types in proportion to their availability, random or grid points and scanning circles were generated within the area defined as the study area. The measured areas and edge lengths were used to define availabilities. In these analyses, availability (or limit of the study area) was determined by the extent of animal movement, geographic features limiting animal movement, and the limits of the area that could be covered accurately with telemetry reception.

Use relative to availability was analyzed within three time frames: DAYTIME, NIGHTTIME, and ALL HOURS. Because deer confined themselves to riparian cover during the day, DAYTIME deer locations were compared with random points generated within a boundary surrounding blocks of riparian habitat. NIGHTTIME and ALL HOURS deer locations were compared with random points generated over the entire study area. DAYTIME was defined as 0600-1800 in summer and 0800-1600 in winter. NIGHTTIME included periods between sunset and sunrise and, depending on the date, short periods before sunset and after sunrise.

If deer were selecting a certain cover type, the area of that cover type within deer scanning circles (use) should be greater than that within random scan circles (availability). This was tested using the Mann-Whitney U statistic (Nie et al. 1975). In addition, the frequency with which a preferred type occurred within deer scanning circles should be greater than that within random scanning circles. This was tested with the Z statistic, calculated using the normal approximation to the binomial (Z^2 of Eberhardt and Fligner 1977). Differences in both the areas and frequencies of occurrence of a type had to be shown at the 0.05 level for selection to be considered significant.

The term "selected" indicates that the proportional use of a cover type was greater than its proportional availability. "Avoided" indicates use less than availability.

RESULTS

Distribution

White-tailed deer were widely distributed, primarily on bottomlands of the Yellowstone River, on both study areas. The occurrence of small numbers of white-tails in adjacent uplands and tributary drainages may have reflected daily and seasonal movement of some deer between the river bottom and uplands. Such movement was evident in relocations of radio-collared deer and general observations at Intake. At Elk Island, no use of uplands or side drainages by radio-collared deer was recorded during this study.

Elk Island Study Area

Summer distribution of deer on the Elk Island study area was generally centered on large blocks of riparian tree and shrub cover. Small, isolated areas of tree and brush cover along drainage ditches, the LYIP main canal, and field borders were occupied by small numbers of deer. Nighttime relocations of radio-collared deer and spotlight observations were distinctly clustered in and around agricultural fields.

In winter, deer use of isolated areas of riparian

cover decreased and deer concentrated during the daytime in larger blocks of riparian cover and on Elk Island proper, when ice covered river channels provided easy access. Three radioed deer shifted their daytime activities to the Island in winter and general observations indicated that large numbers of deer moved on and off Elk Island throughout the winter. The February 1984 helicopter survey showed higher densities of deer on the Island (92/km^2) than the rest of the area (56/km^2); no deer were observed along the main canal. Coincident with these shifts, deer used agricultural fields farther from riparian cover at night.

Intake Study Area

Summer distribution of deer at Intake similarly centered on large blocks of riparian tree and shrub cover, though use of upland draws and small patches of cover on the bottom was more prevalent than at Elk Island.

Distribution of radio-collared deer in winter differed from summer and changed through the season. In January, four of five radioed deer on the Gentry area were located during the day in upland coulees south of the bottom. Three of the four moved back onto the bottom shortly after cattle were removed in mid-January. Of eighteen total radioed deer on the Intake area tracked in February and March, three used the uplands almost

exclusively, and one used the Morgan Creek bottom and adjacent upland wheat fields. However, all used the bottomlands at least once during or shortly after the study.

Sex and Age Differences

Few differences in distribution among age and sex classes of deer were apparent. At Intake during summer, all adult females were located on the bottoms, while two adult males and one yearling female without a fawn were distributed in peripheral upland draws. Among radioed deer at Elk Island, only yearlings used the northeastern portion of the Hagler area, which was regularly grazed by sheep.

Effect of Disturbance

There was little evidence that deer distribution was related to human activities and disturbance on either study area. At Intake, deer were often located in ash stands immediately adjacent to the river road along the Gentry bottom. One radio-collared deer on the Adams bottom often bedded within 50m of the heavily travelled Montana Highway 16 and within 150m of an occupied farmhouse with dogs. At Elk Island, deer appeared to use areas near frequently travelled roads and occupied farmhouses only at night, but these areas also had little riparian cover.

Movements

The most distinct feature of daily movements was travel to agricultural fields. Deer using the same general areas of riparian habitat during the day tended to move to the same agricultural fields at night (Figures 9-12). Radio-collared deer that changed the location of their home ranges within a season moved at night to the same agricultural fields as other deer in the new location.

Elk Island Study Area

Summer.--Deer moved little during midday in summer (Fig. 13). Evening movements were generally to the nearest alfalfa fields, usually within 0.5 km of riparian cover (Fig. 9).

Movement to and use of agricultural lands varied greatly among individual deer. Only one radioed deer was never known to move to agricultural fields during either of two summers. This adult female spent both summers in a small area on the Island. Another adult female occupied an adjacent home range and restricted her movements to the island during the entire summer of 1982. In contrast, adult female 1100 moved to and spent at least 1 hour and up to 11 hours in agricultural fields during every 12-hour nighttime tracking period. Overall, radio-collared deer



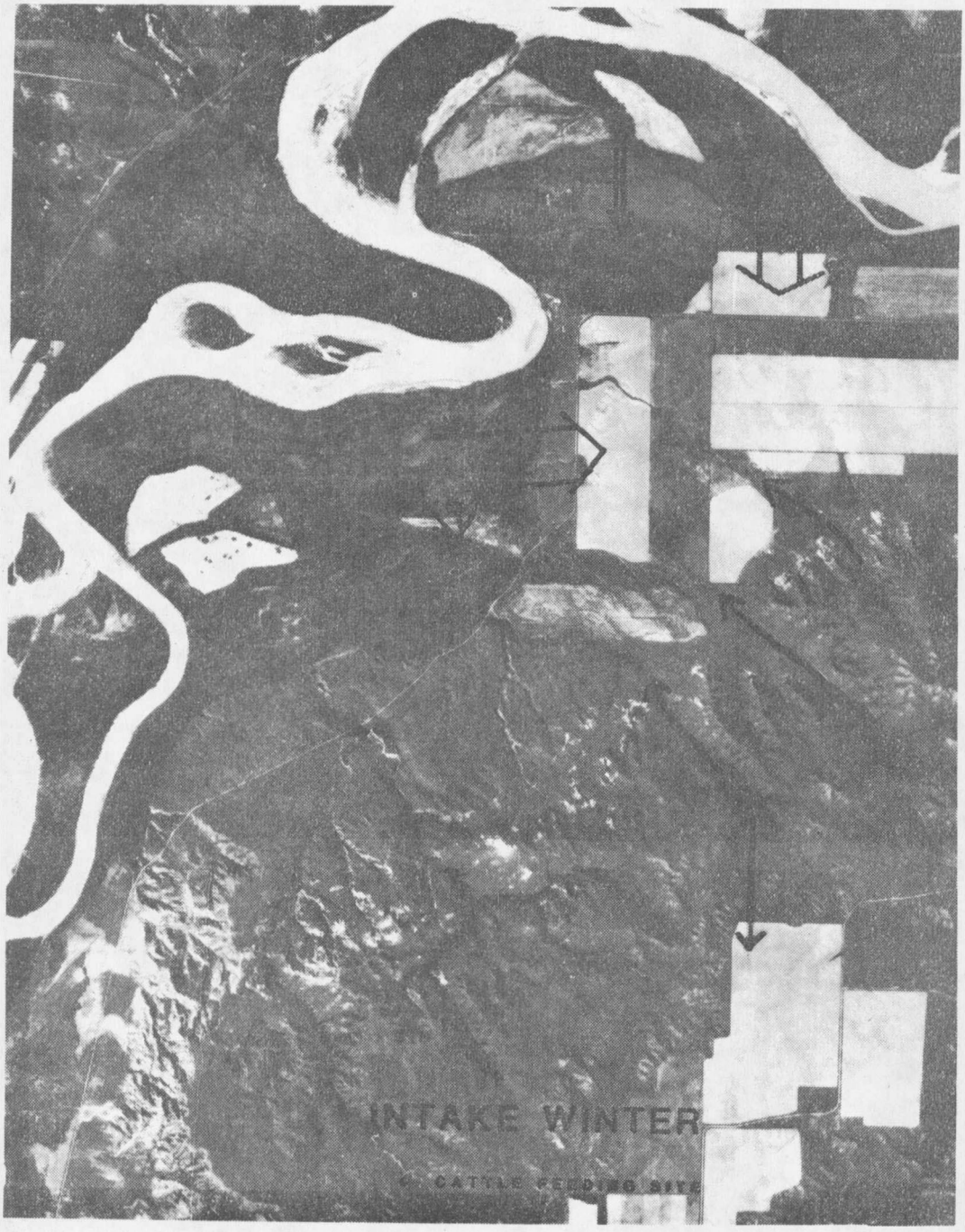
Figure 9. Evening movement patterns of deer on the Elk Island study area during summer.



Figure 10. Evening movement patterns of deer on the Elk Island study area during winter.



Figure 11. Evening movement patterns of deer on the Intake study area during summer.



Figuure 12. Evening movement patterns of deer on the Intake study area during winter.

traveled to agricultural fields on an average of 62% of all nighttime tracking periods.

A deer that travelled to agricultural fields on a given night spent an average of 4.5 hours there. Deer typically made only one trip to fields in a night. More than one trip between riparian cover and agricultural fields was common only among individuals with daytime bedding sites in close proximity to agriculture.

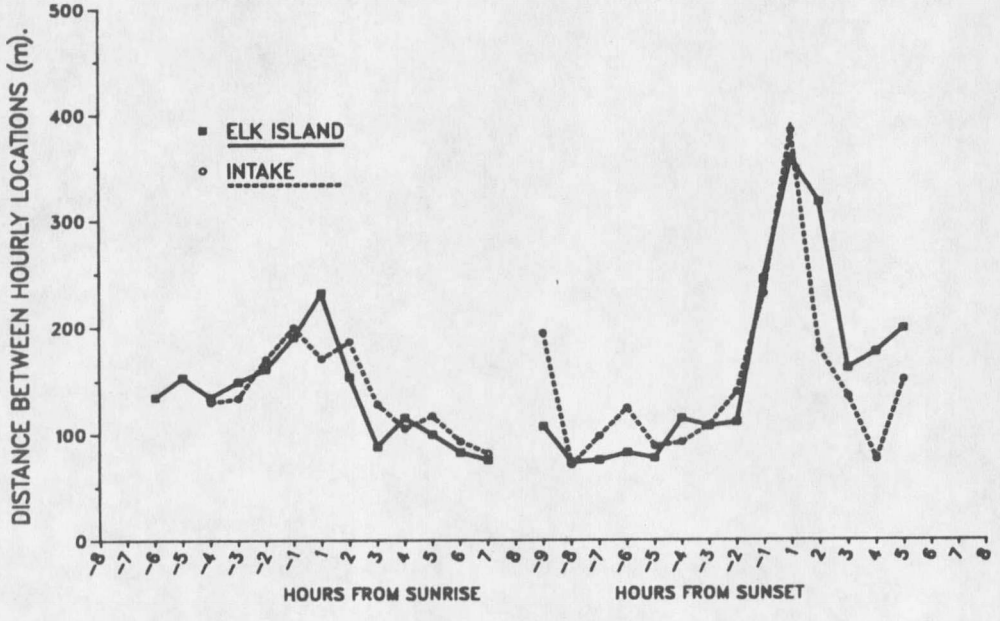


Figure 13. Mean distances moved between successive hourly locations of deer in summer on the Elk Island and Intake study areas.

The proportion of deer moving to agricultural fields and the average time in fields increased from early to late summer, especially for females with fawns (Fig. 14). The first doe/fawn pair was observed in fields during spotlight surveys at Elk Island on August 9. As summer progressed, does with fawns were more likely to travel to and stay longer in fields. Yearlings of both sexes and a non-producing adult female, visited agricultural fields more frequently and stayed longer per trip in early summer.

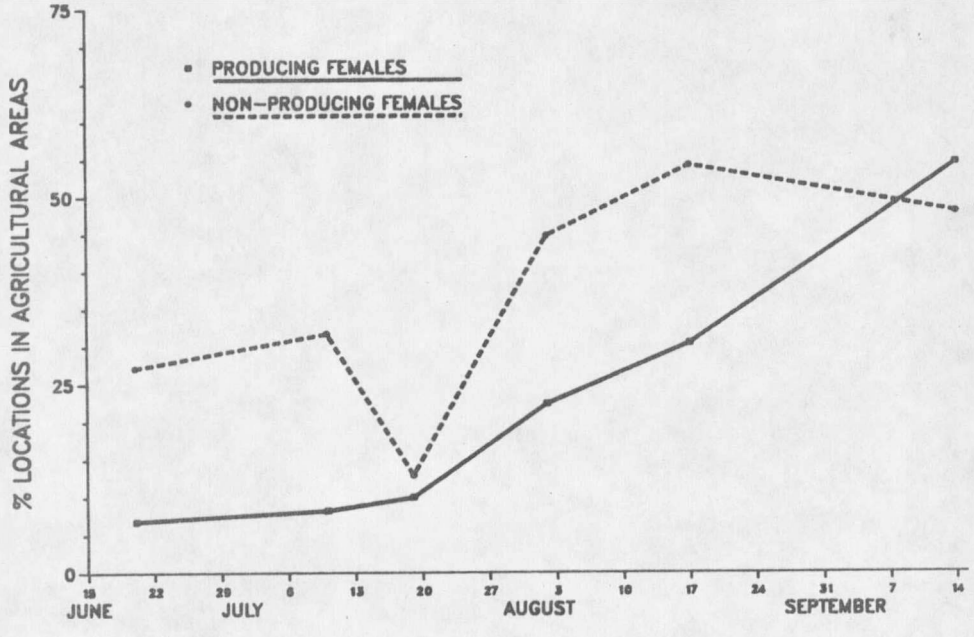


Figure 14. Percentage of nighttime radio locations of female deer with and without fawns in agricultural areas during triangulation sessions through summer.

Nighttime movements entirely within riparian habitats did not follow a distinct or consistent pattern. Some involved greater total distance than required to move to and from the nearest alfalfa field.

Deer were often observed in late summer swimming to and from the Island at dawn and dusk. Yet, radio-tracking data indicated that deer on the Island during the day did not make regular movements to agricultural fields on the mainland. Two adult females with fawns used the Island exclusively during one or both summers; another, a 2-year-old female with a fawn, shifted her home range off the Island between July 19 and August 2. One adult male apparently restricted his movements to the Island until 24 August, when he shifted his home range to the mainland. These data suggested that movements to and from the Island during summer may have been influenced by river flow which normally peaks in June (1,121 m^3/second) and drops rapidly from July (662 m^3/second) to August (233 m^3/second, Moore and Shields 1980). The river appeared to form a complete boundary to movements of females with fawns until approximately the first of August, and a partial one to movements of other deer.

Winter.--In general, winter movements were more extensive than those of summer. This primarily reflected greater distances between daytime bedding cover and agricultural

fields used in winter.

Figure 10 illustrates general nocturnal movement patterns for winter. Marked deer that spent the day in riparian cover just north of the Island typically traveled north across a drainage ditch into irrigated agricultural fields. Trails in the snow indicated that many deer from the northeast part of the Island crossed the river and used the same fields.

All radioed deer using the Island in winter 1984 regularly travelled northwest at night to a plowed sugar beet field and an adjacent alfalfa field, a distance of approximately 2.5 km. A segment of the deer on the north end of the Management Area also travelled to these fields, a distance of approximately 2 km.

Other deer that spent the day in cover on and just south of the Management Area followed several different movement patterns. One segment travelled to adjacent state-owned alfalfa fields and, to some extent, an adjoining beet field. Another segment, including one radio-collared deer, travelled southeast to fields just east of Savage. A well used trail suggested that a number of deer from the Management Area also travelled northwest across the state-owned fields, the main irrigation canal, and Highway 16 to alfalfa and beet fields off the main river bottom.

Movements observed in two tracking sessions in December 1982 and March 1983 as compared with winter 1984 indicated that movement patterns were similar between winters, though use of specific fields varied. Several deer travelled to fields north of the county road, though beet fields that were used during the October tracking session were nearer.

Individuals were located in agricultural areas during an average of 79% (range 40-100%) of all tracking sessions spanning 3 hours or more between 1800 and 0559. The time spent in fields ranged from less than 1 hour to the entire night. Most commonly, radioed deer moved into fields just before dark and stayed until morning twilight (Fig. 15). General observations of large numbers of deer moving to and from fields at dusk and dawn, respectively, indicated this was the general pattern of movement on the area. One adult female was located in the same beet field or in transit to or from that field every hour tracked between 1800 and 0600. Deer that did not remain in agricultural fields throughout the night typically travelled to the fields in early evening and returned to cover sometime in the middle of the night (Fig. 15).

Deer using fields close to riparian cover (within several hundred meters) were less likely to spend the entire night in fields than deer traveling greater distances (over 0.5 km). Also, deer using fields bordered

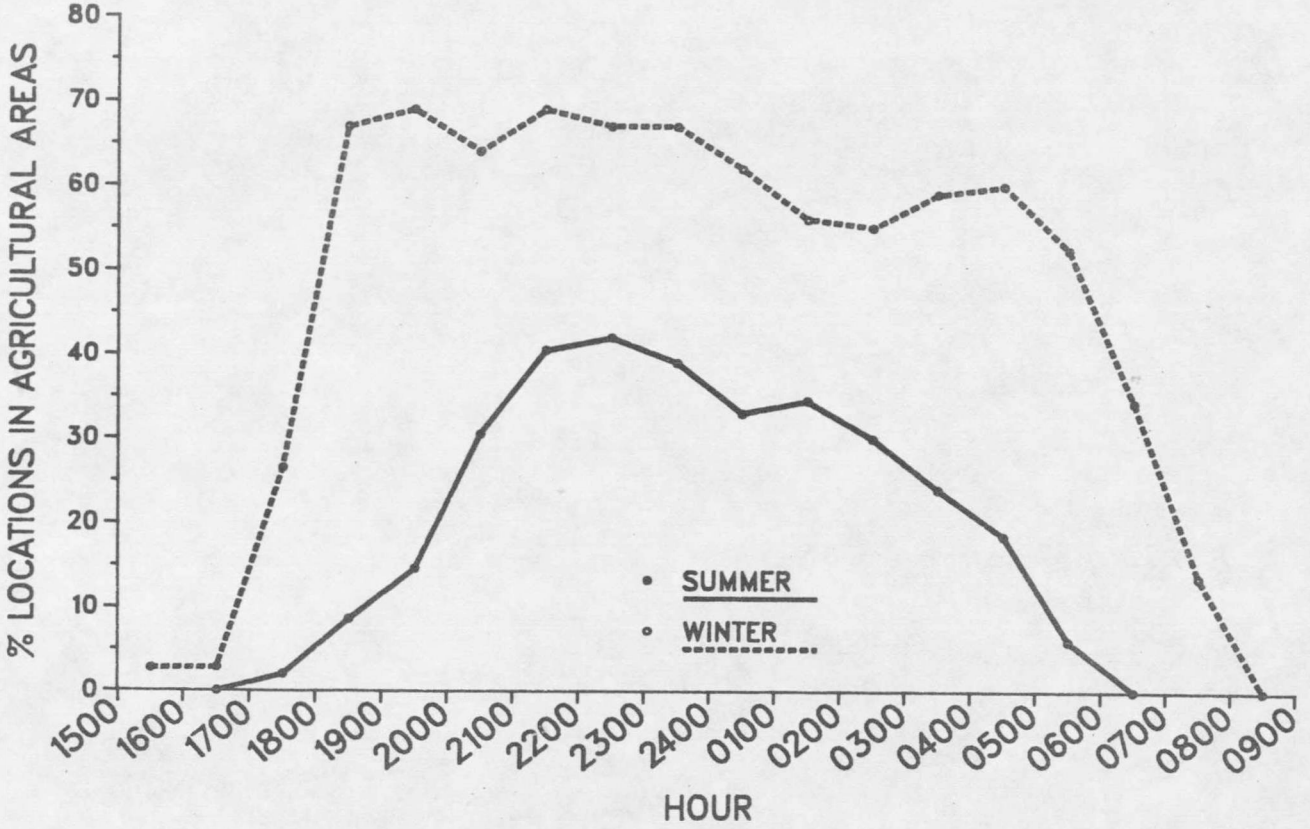


Figure 15. Percentage of triangulated radio locations of deer at Elk Island in agricultural areas by hourly periods during summer and winter.

by riparian cover sometimes made two or more trips a night to the fields.

Intake Study Area

Summer.--As at Elk Island, daytime movements were minimal, with animals apparently remaining bedded for most of the midday. Alfalfa fields were the focus of most evening movements in summer (Fig. 11). Deer that spent daylight hours in upland draws regularly travelled 2 km or more to the river bottom at dusk and returned to uplands sometime before sunrise, typically at dawn. Such movements usually followed drainage bottoms. Animals from ash thickets along the south side of the Gentry bottom travelled less than 500m north to alfalfa fields. Those using cover along the north side of the bottom moved south into alfalfa and wheat fields. One adult male exhibited all three patterns depending on where he bedded during the day. Although all fields on the Gentry bottom were readily accessible to all deer, individuals used only the one or two fields nearest their daytime bedding sites.

One small, non-irrigated alfalfa field occurred on the Adams bottom and was regularly used by two radioed deer. Another radioed deer in the area was never located in that field. Instead, it made short movements (< 0.5 km^2) back and forth under a bridge of Highway 16 to utilize an ash stand and both sides of the Morgan creek bottom.

There was no evidence of deer on the Adams bottom crossing the river to the more abundant fields on the Gentry bottom.

Deer on the Intake study area appeared to move to agricultural fields more consistently than deer at Elk Island. The proportion of 12-hour nighttime periods in which individuals travelled to fields during at least one of the two tracking sessions averaged 86% (100% on the Gentry bottom). The proportion moving to fields increased only slightly from early to late summer, even among females with fawns. No fawns were observed with does in fields until July 30. Because of the close proximity of woody cover to agricultural fields, the deer often bedded just off the edge of fields between feeding periods.

Winter.--In contrast to summer, when deer moved from uplands to the river bottom at night, one segment of the population on Gentry's (including 3 of 11 radio-collared deer) moved from the bottom to upland winter wheat fields, often well before dark (Fig. 12).

Another segment, including three other radioed deer, spent the day in upland coulees and either travelled down to the same winter wheat fields, upward to grain fields on the adjacent plateau, or both. Another deer ranged along the Morgan creek bottom north of the highway or moved to an abandoned grain field in the uplands.

Following removal of cattle in mid January, most radioed deer on the Gentry bottom regularly travelled to areas where, earlier in the winter, cattle had been fed straw and grain spread on the ground. All deer bedding in ash stands on the south side of the Gentry bottom traveled to nearby cattle feeding sites, as did some of the deer bedding in the cottonwood and other riparian types along the north side of the bottom. Deer that spent the day in ash stands near the feeding sites moved to those sites to feed during the day more often than other deer.

Radioed deer on the Adams bottom did not travel to the single alfalfa field during winter. Rather, they moved between mature willow and old cottonwood types where they spent the day and less dense young cottonwood, creek bottom and hay meadow types. Some unmarked deer were also known to travel northwest across Highway 16 to winter wheat fields. There was no evidence of deer travelling across the river from the Adams bottom to the Gentry bottom.

The frequency of movements to agricultural fields (including cattle feeding sites) was high. With one exception, all deer on the Gentry side of the river travelled to an agricultural field at some time during at least one of each pair of 8-hour nighttime tracking

sessions. However, deer generally stayed in agricultural areas for short periods. Deer travelling to upland wheat fields tended to stay there for much of the night, but periods of use of cattle feeding sites were generally short. Two radioed deer usually remained in bottom agricultural fields for 1 hour or less, and may have been simply travelling through or just along the edge.

Sex and Age Differences

Yearlings of both sexes and adult males exhibited more variable movements than adult females. They were more likely to move to two or more fields in one night, change fields between nights, and move in an unpredictable pattern. They were also less likely to return to the previous day's bedding area.

Home Range

Total Home Range Size

Total home range was defined by all locations of a deer over 24-hour periods within one season. Polygon total home range sizes for individual deer varied widely, from 0.29 km^2 for an adult female that spent the summer on Elk Island proper, to 10.05 km^2 for an adult male that used upland draws and agricultural fields at Intake during winter. Figure 16 and Table 2 demonstrate the variation in home range size by sex, age, season, and study area.

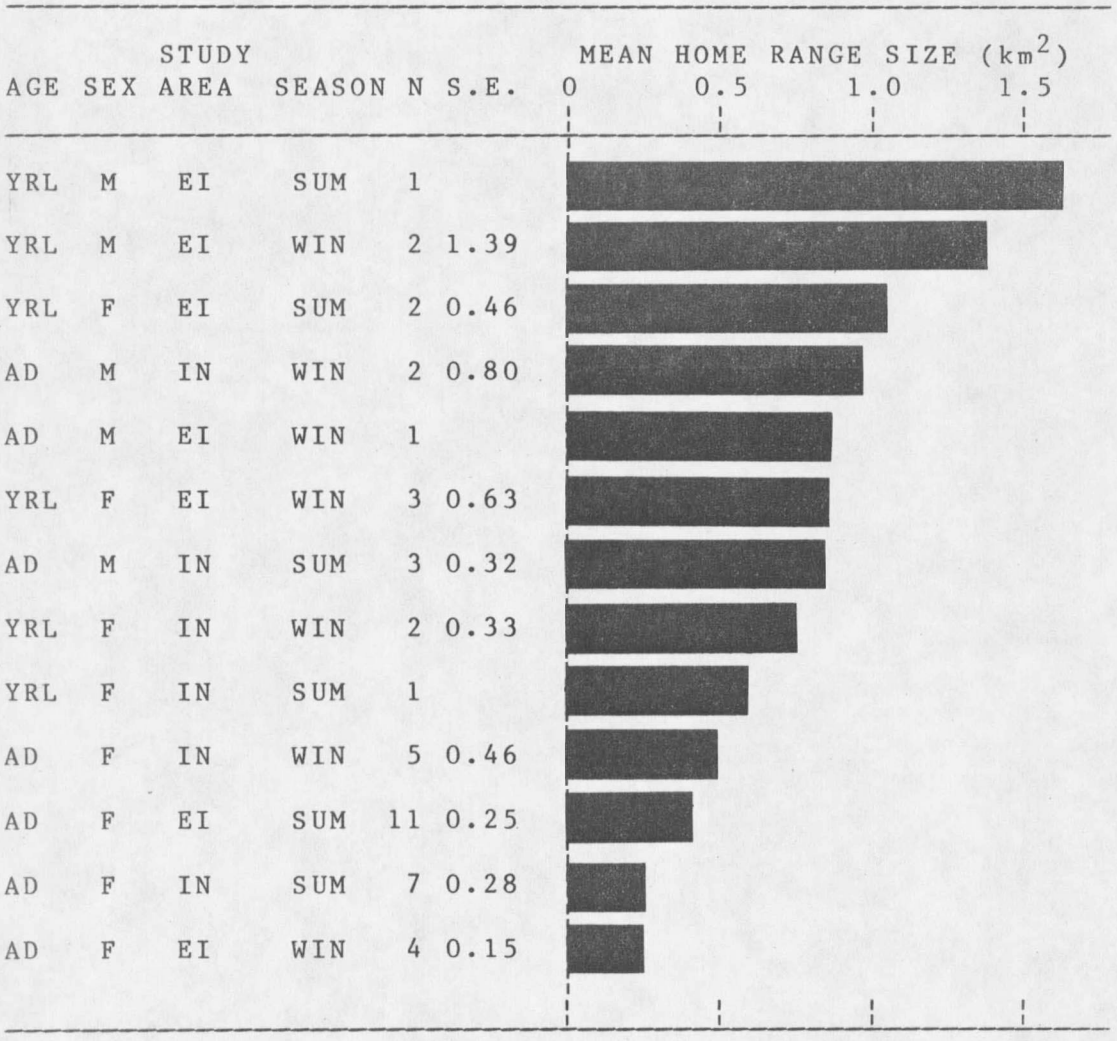


Figure 16. Mean seasonal polygon 24-hour home range sizes grouped by age, sex, study area, and season EI = Elk Island Study Area, IN = Intake Study Area.

Table 2. Summer and winter total (24-hour) and daytime home range sizes of radioed deer at both study areas by season, age, and sex.

Season	Sex	Age	N	Polygon (km^2) Mean	Polygon (km^2) SE	AAR (km) Mean	AAR (km) SE	SD (km) Mean	SD (km) SE
24-HOUR HOME RANGES									
Summer									
	Females								
		Adults	27	0.87	0.08	0.31	0.02	0.73	0.04
		Yrlgs.	4	1.74	0.22	0.55	0.03	1.25	0.09
	Males								
		Adults	7	2.75	0.40	0.63	0.03	1.42	0.08
		Yrlgs.	1	3.28		0.87		1.84	
Winter									
	Females								
		Adults	11	1.82	0.26	0.62	0.08	1.39	0.17
		Yrlgs.	7	2.76	0.79	0.69	0.11	1.56	0.25
		Fawns	4	2.16	0.90	0.53	0.24	1.25	
	Males								
		Adults	3	6.22	2.45	1.18	0.40	2.59	0.85
		Yrlgs.	2	6.72	1.49	0.97	0.14	2.24	0.22
DAYTIME HOME RANGES									
Summer									
	Females								
		Adults	18	0.37	0.05	0.24	0.02	0.55	0.04
		Yrlgs.	3	0.91	0.24	0.51	0.09	1.14	0.16
	Males								
		Adults	3	0.86	0.18	0.65	0.06	1.45	0.12
		Yrlgs.	1	1.63		0.66		1.57	
Winter									
	Females								
		Adults	9	0.40	0.12	0.32	0.05	0.75	0.11
		Yrlgs.	5	0.84	0.21	0.52	0.08	1.20	0.18
		Fawns	4	0.75	0.35	0.61	0.10	1.36	0.26
	Males								
		Adults	3	0.94	0.33	1.14	0.39	2.10	1.70
		Yrlgs.	2	1.38	0.98	0.58	0.29	1.30	0.52

Adult female home ranges, measured by both polygon and AAR, were significantly smaller than those of adult males ($0.01<p<0.02$). Yearling female home ranges also appeared smaller than those of yearling males (polygon, $p=0.023$; AAR, $p=0.066$).

Among yearling and older females, total seasonal home ranges differed in size by season, age, and study area (Table 3). Both AAR and polygon methods indicated that home ranges in winter were larger than in summer, that winter home ranges were larger at Elk Island than at Intake, and that yearling home ranges were larger than adult home ranges. The AAR analysis showed that the increase in yearling home range from summer to winter was small relative to that of adult females.

Among the small sample of adult males, mean winter home range sizes (AAR and polygon) were approximately twice those of summer. However, because of high variability, this difference was not significant ($p>0.2$). Differences between study areas and ages were not apparent.

There were no apparent differences in home range size between age classes of females 2 years and older. Of seven 2 year old females, only two had home ranges that might be considered larger than normal for older females, while one had the smallest home range recorded for any deer.

Table 3. Differences in home range size between seasons, study areas, and age classes for female deer as indicated by mean seasonal polygon areas and average activity radii.

Category	Difference[a]	p-value
POLYGON AREA (km^2)		
SEASON (Summer-Winter)		
Elk Island	+1.80	p<.001
Intake	+0.54	.1<p<.2
STUDY AREA (Elk Isl.-Intake)		
Summer	-0.27	.4<p<.5
Winter	-1.53	p<.001
AGE (Yearling-Adult)	-0.73	.01<p<.02
AAR (km)		
SEASON (Summer-Winter)		
Elk Island		
Yearlings	+0.31	p<.001
Adults	+0.57	p<.001
Intake		
Yearlings	-0.08	.3<p<.4
Adults	+0.18	.001<p<.01
STUDY AREA (Elk Isl.-Intake)		
Summer	-0.05	p>.5
Winter	-0.44	p<.001
AGE (Yearling-Adult)		
Summer	-0.24	p<.001
Winter	+0.02	p>.5

[a]Differences are based on Beta coefficients of the multiple regression equation and main affects are listed in order of stepwise entry.

Differences in summer home ranges of females with and without fawns were not apparent. Three radioed females without fawns had home range sizes that were essentially identical to those of producing females.

Home range sizes for four female fawns tracked during winter were highly variable, but the mean appeared to fall between the means of adult and yearling females (Table 2). Daytime home ranges for these fawns appeared more similar to those of yearlings.

The smallest home ranges generally were of adult females in summer, especially those at Intake (0.30-0.40 km^2) where riparian cover and agriculture lay in close proximity. Animals utilizing the uplands at Intake had some of the largest home ranges. In summer, 3 of 11 home ranges (2 adult males and 1 yearling female) included uplands, and averaged 2.82 km^2 in polygon area. In winter, three animals used primarily uplands (1 adult male, 1 adult female, and 1 yearling female). Together their average home range size was 5.9 km^2 (mean AAR=2.1km). All home ranges of animals in the uplands were underestimated due to the difficulty of obtaining regular locations there.

Locations of individual home range boundaries are shown in Appendix Figures 28-31. Overlap between individual ranges was considerable as would be expected at high deer densities. Ninety percent of all home ranges

included one or several agricultural fields, and overlap was greatest here.

Daytime Home Range Size

Daytime home ranges were also examined for the effects of sex, season, age, and study area (Table 2 and Figure 17). As with total home ranges, daytime polygon sizes and AAR's of adult males were larger than those of adult females (t-test, $0.02<p<0.05$). In daytime polygon and daytime AAR regressions, only age was a significant factor ($p<0.001$), with yearling female home ranges being larger than adult females (Table 3). Differences between seasons and study areas were insignificant ($p>0.1$). This indicated that differences in total home range size between seasons and study areas resulted largely from nighttime movements. that were not detected by observations only during daylight hours.

The ratio of daytime to total polygon size averaged 0.495 in summer but decreased to 0.280 in winter ($t=3.67, p<0.001$), indicating greater nighttime movement in winter. The same hold true for AAR's, although the difference was smaller ($t=1.86$, $0.05<p<0.1$).

Home Range Stability

Home ranges were fairly stable within a season. In some cases, total home range size was closely approximated in one 24-hour triangulation session. More commonly,

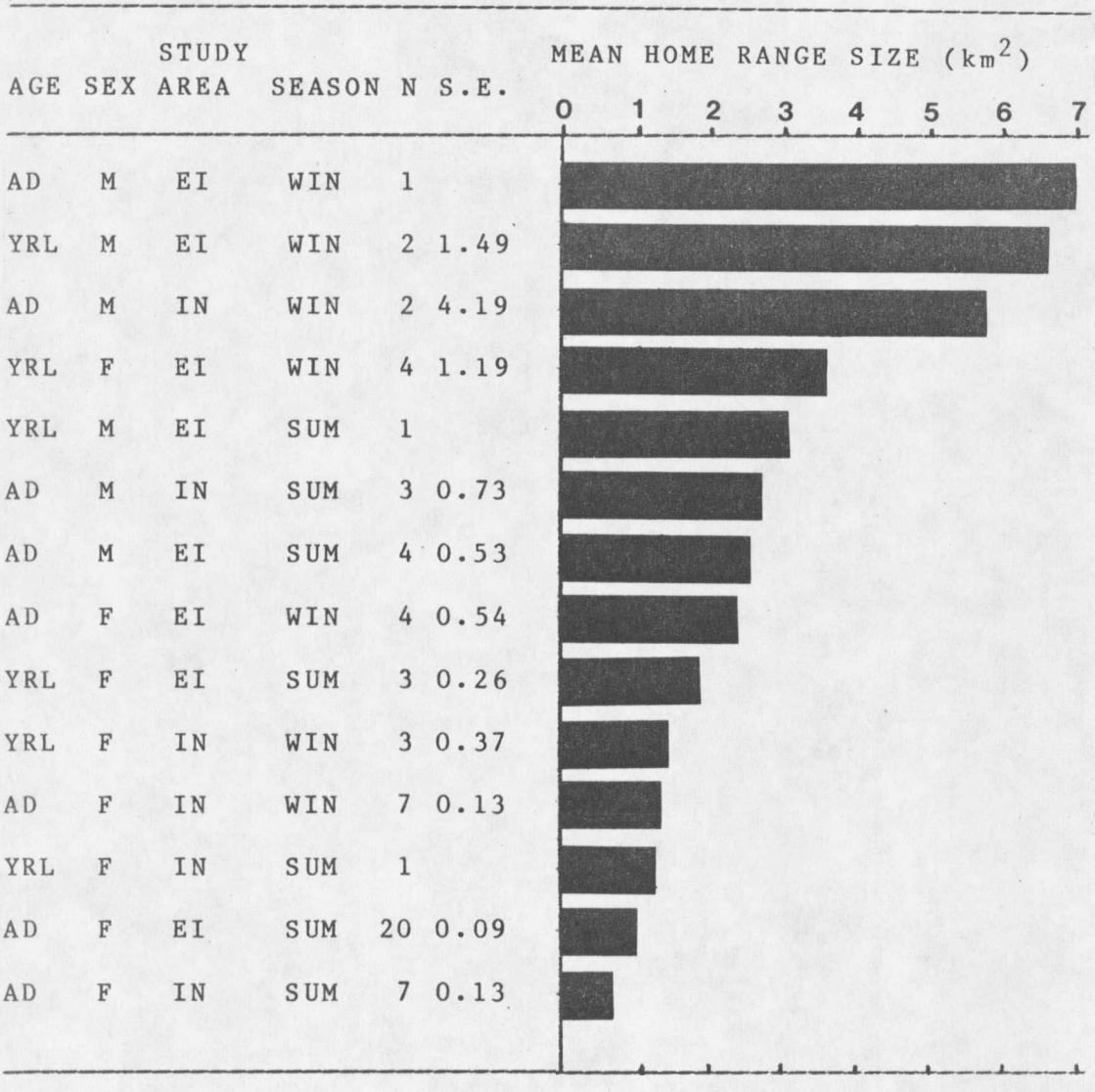


Figure 17. Mean daytime polygon home range sizes grouped by age, sex, study area, and season EI = Elk Island Study Area, IN = Intake Study Area.

however, home range sizes would be expanded at times through the season by trips somewhat outside of previously established home range boundaries, or by a change in daytime bedding sites. In three cases animals made a shift completely out of their established home ranges within a season. Two of these were shifts off of Elk Island in late summer.

Home ranges were also fairly stable from season to season. Of the seven animals tracked in summer and winter at Intake, all had overlapping summer and winter home ranges. Changes in home range size and shape from summer to winter reflected use of different agricultural fields, shifts in daytime home range to better access agricultural fields, and generally greater mobility, even among animals that did not use agricultural fields.

At Elk Island some amount of shifting occurred between the major segments or sub-areas of the river bottom. Most of these changes occurred in fall. Four of 13 animals had made complete (non-overlapping) shifts in home range between September and the October 29, 1982 triangulation session. These shifts may have been influenced by disturbance by archers or pheasant hunters. When tracked again in December, three of the four had made further shifts, one back to its summer home range. From September 1983 to January 1984 no complete home range shifts were observed in six animals, though in two

instances radioed deer had shifted daytime activity to the Island.

Most animals that did not change location from summer to winter expanded their home ranges through movement into new areas, including more distant agricultural fields. Three animals moved to the east side of the river one or more times.

Only 10 deer were radio-tracked during successive summers or winters. One of seven tracked in two summers had non-overlapping summer home ranges, while the others had similar home ranges in both years; one adult female had identical GAC's for both summers. All three animals tracked in both winters had quite similar home ranges.

Year to year changes in use of agricultural areas appeared to be slight in animals occupying approximately the same daytime home range. Of four such animals tracked in two summers, all used the same alfalfa fields. Of three animals tracked for two winters, two used the same agricultural areas, although not exactly the same fields, even though this area was several kilometers from their daytime bedding sites. Two of three animals tracked for one night in March 1983 used the same areas as they normally did in the winter of 1984.

Release in late summer of sheep onto agricultural fields and riparian cover of the Hagler farm at Elk Island

and cattle onto the Gentry bottomlands did not result in any noticeable changes in home range and movement of deer using either area. Some shifts in home range and movement of deer occurred after cattle were removed from the bottomlands at Intake in mid January, but these appeared related to the availability of cattle feed sites in the absence of cattle.

Activity

Patterns in activity of radio-collared deer determined by signal strength variation and observation were similar to those determined by mean distances between successive hourly locations (Figs. 18 and 19), indicating that periods of deer activity coincided closely with periods of deer movement. It also indicated that rate of movement could be used as an index to activity, though deer may occasionally be active without moving far enough for the movement to be detected by telemetry. Thus, a midday peak in activity based on signal strength was much more apparent than a midday peak in rate of movement.

Both data sets indicated that the deer were crepuscular, with pronounced peaks in activity at approximately sunrise and sunset. Less pronounced peaks appeared near midnight and noon (Figs. 18-20).

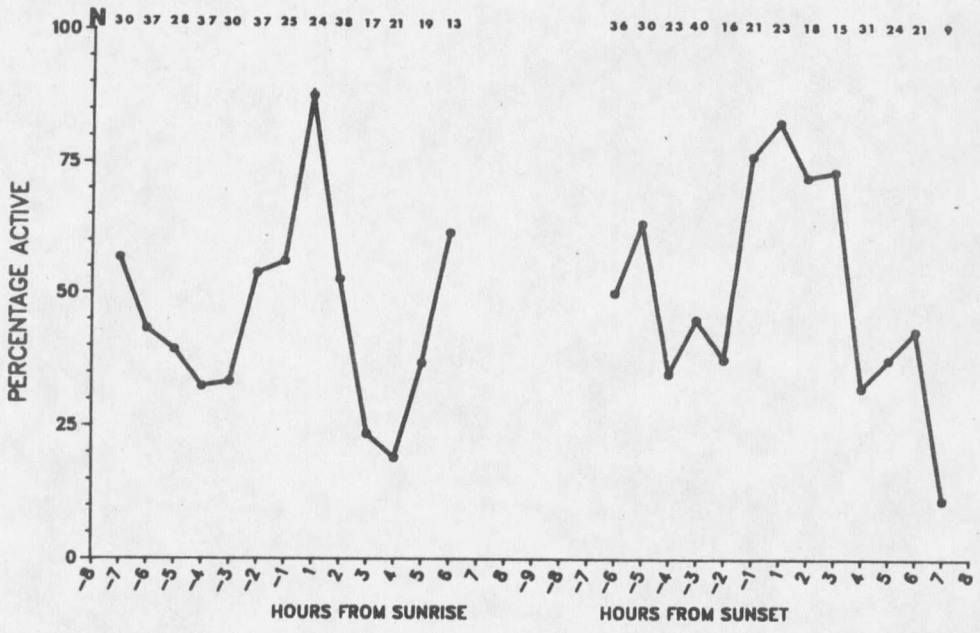


Figure 18. Percentage of deer on both study areas that were active, as measured by radio signal variation, during hour-long periods of the day in winter 1984.

Deer were more nocturnal during summer when activity was significantly ($p<0.05$) lower in midday and higher during other periods than in winter (Fig. 21). However, the daylong percentage of deer active in summer (52%) did not differ significantly ($p>0.3$) from that during winter (47%).

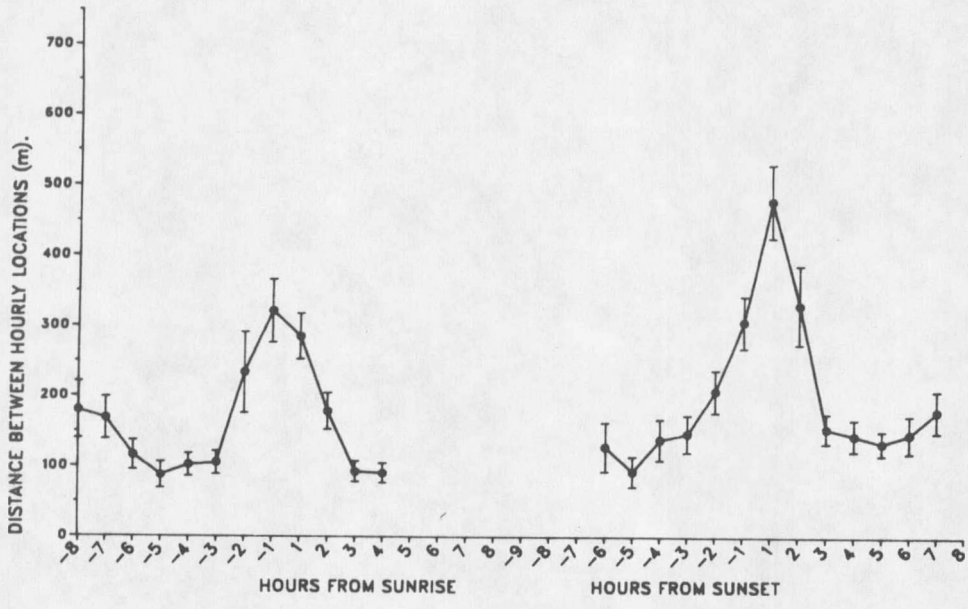


Figure 19. Mean distances moved between hourly locations of deer on both study areas in winter Vertical bars are ± 1 standard error.

Average hourly distances moved over 6-hr time periods compared within and between seasons also indicated that deer were more active nocturnally in summer. Midday movement rates in summer approached the mean distance error of triangulation, indicating little movement, and were lower than in winter (Table 4). Midday movement rates were significantly lower than during other periods in summer, but were similar to midnight movement rates in winter (Table 5).

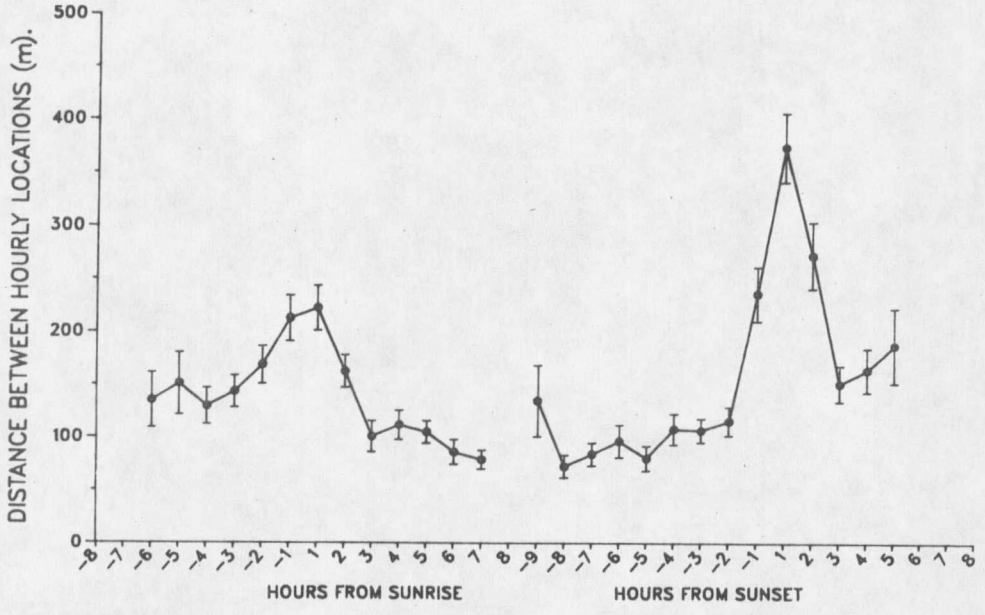


Figure 20. Mean distances moved between hourly locations of deer at both study areas in summer Vertical bars are ± 1 standard error.

Afternoon movement rates were higher than during other periods of the day in both seasons. Afternoon and morning movement rates were higher at Elk Island in winter than in summer, reflecting the greater distances moved to agricultural fields (Table 4).

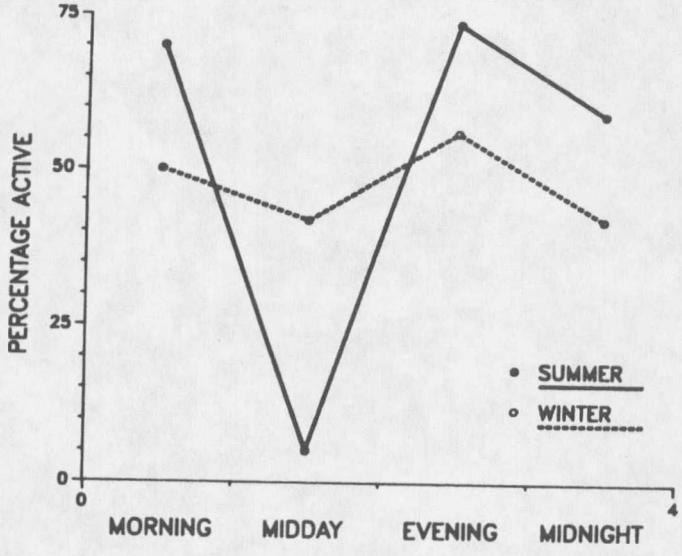


Figure 21. Percentage of deer at both study areas that were active, as measured by radio signal variation, during 6-hour periods of the day in winter and summer seasons.

Movement rates plotted by hour (Figs. 19 and 20) show that the timing of activity was similar in summer and winter. The evening peak in both seasons was higher than the morning peak, and occurred in the hour after sunset (i.e., the second in the pair of locations occurs in the hour following sunset, so the peak of movement centers around sunset). The peak in morning movement extended over the hour before and the hour after sunrise in both seasons, partly because of the averaging of different peak times on the two study areas. A possible peak in movement rate at midnight was also indicated in both seasons, but was more pronounced in winter. Both seasonal plots indicated a possible small peak in movement at noon.

Table 4. Multiple comparisons of mean deer movement rates (m/h) between 6-hour periods during summer and winter. Values joined by underlining are not significantly different at the 0.05 level using Scheffe's multiple comparison test.

SUMMER

Both Study Areas

Midday	Midnight	Morning	Afternoon
88	152	167	222

WINTER

Intake

Midnight	Midday	Morning	Afternoon
115	126	171	212

Elk Island

Midday	Midnight	Morning	Afternoon
106	159	288	329

Table 5. Seasonal comparisons of mean movement rates (m/h) of deer within 6-h time periods.

	Morning 0400-0959	Midday 1000-1559	Afternoon 1600-2159	Midnight 2200-0359
Intake Study Area				
Summer	174.9	97.5	218.4	137.0
Winter	170.9	125.8	211.6	115.0
p-value	0.850	0.097	0.800	0.221
Elk Island Study Area				
Summer	165.3	83.2	202.2	153.5
Winter	291.3	108.2	329.8	154.9
p-value	0.001	0.064	0.000	0.940

General observations suggested that deer on the Intake study area were active later in the morning and earlier in the evening than those on the Elk Island study area. Although this was supported by movement rates (Fig. 22) and signal monitoring (Fig. 23) in winter, only a slight difference in timing of movement rate peaks was apparent in summer (Fig. 13). The differences in timing may have been less than an hour and therefore too small to detect by hourly triangulation, or the apparently earlier afternoon activity at Intake may have been partially due to earlier use of open cover types such as agricultural fields. In late summer, five recorded observations of the time at which deer first appeared in alfalfa fields averaged 5 minutes before sunset at Elk Island and 37 minutes at Intake. A wider evening movement peak at Elk Island may indicate that deer there were active and moving for some time before venturing into open agricultural fields.

The relationship between habitat use and activity was examined for 124 radio locations. Deer were more active at night and in agricultural fields than during the day or in riparian cover. Over both study areas and both seasons, 27% of daytime locations in riparian habitat were classified as active, whereas 71% of nighttime riparian and 92% of nighttime agricultural locations were classified as active.

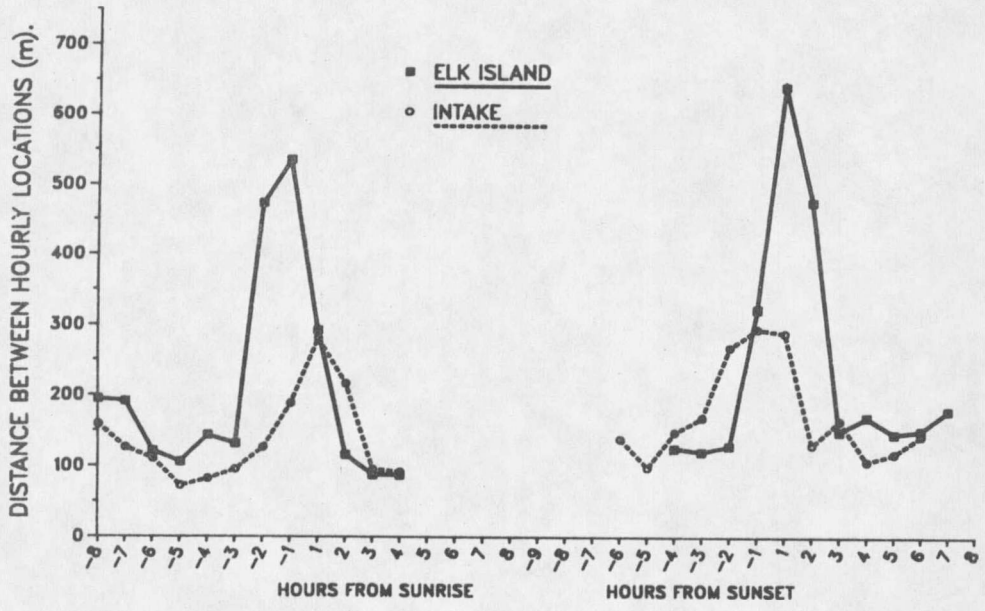


Figure 22. Mean distances moved between hourly locations of deer on the Elk Island and Intake study areas in winter.

In summer, females with fawns at Elk Island moved less during the 2 hours before and after sunrise and sunset in early summer than in late summer ($p<0.05$). This probably reflected their infrequent use of agricultural fields in early summer and increased use later. At other times of day there was little difference in movement rates between early and late summer.

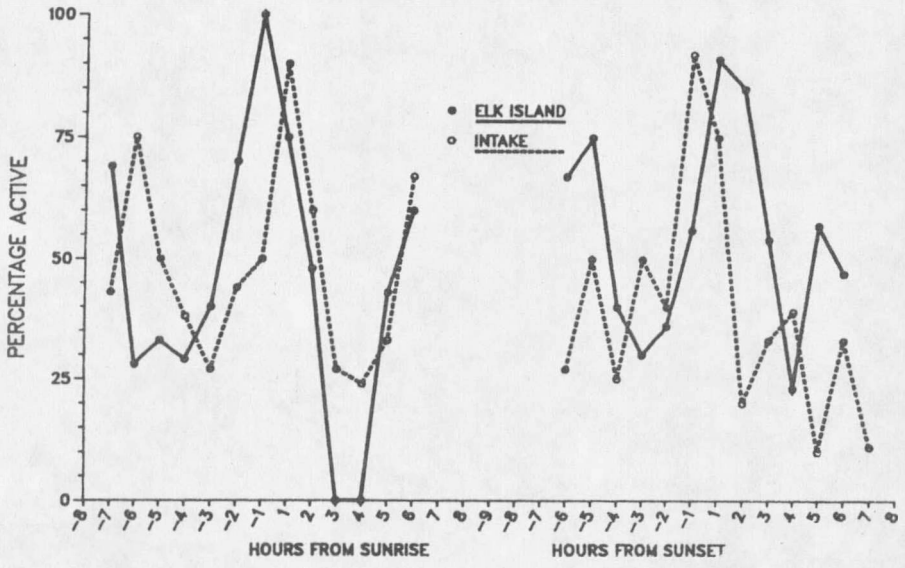


Figure 23. Percentage of deer that were active, as measured by signal strength variation, during hour-long periods of the day in winter 1984 at Elk Island and Intake study areas.

Ambient temperatures also affected deer activity, especially during summer when high temperatures apparently depressed activity (Fig. 24). Movement rates during the day (from the fifth hour after sunrise to the third hour before sunset) were significantly lower at temperatures over 32 C than below 32 C ($p<0.001$). At one hour after sunset this relationship was reversed, i.e.. movements at higher temperatures were larger than those at lower temperatures. This might indicate that more deer delayed movement/activity on hot days until about sunset, resulting in a more synchronous movement of deer and higher mean movement rates. Moreover, during the period from 2-4 hours after sunset, movement rates at 21-32 C were still somewhat higher than those at less than 21 C.

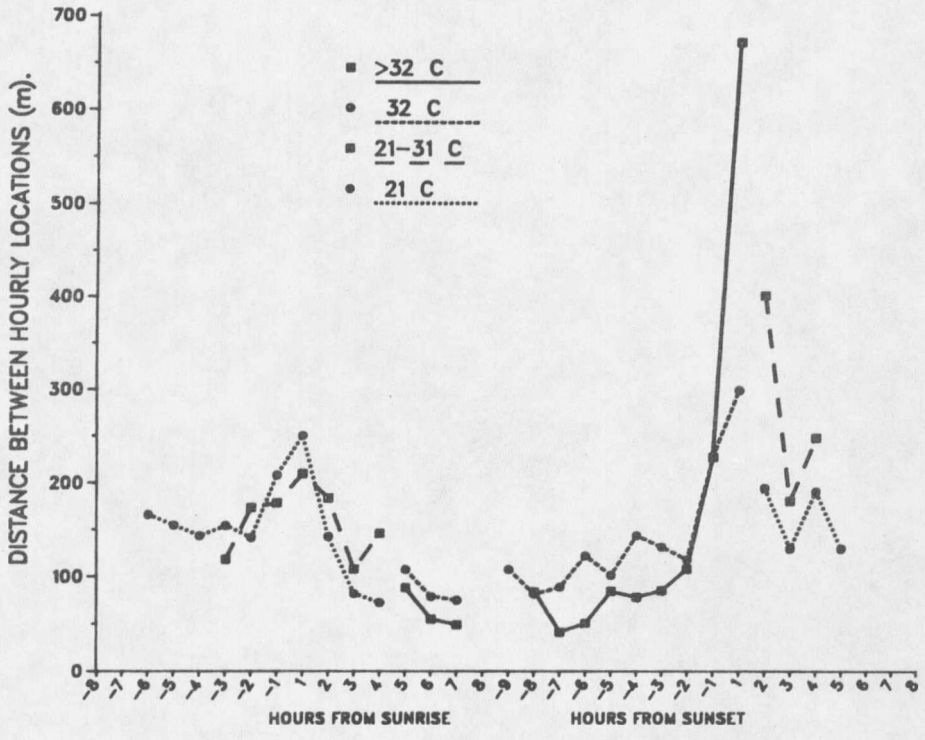


Figure 24. Mean distances moved between hourly locations by deer on the Elk Island study area in relation to ambient temperature during summer.

During winter, no relationship between temperature or wind-chill and movement rates was apparent. Movement rates within a temperature class were not consistently higher or lower than those in other temperature classes, and few differences were significant.

The phase of the moon did not appear to affect nighttime deer movement rates, or any effect was masked by other factors. Although analysis of variance showed some significant differences in mean movement rate among moon phases, there was no trend toward increasing or decreasing movement with increasing or decreasing lunar illumination.

Habitat Use

Patterns of habitat use and selection for specific cover types varied among study areas, seasons, daytime and nighttime periods, and, to some extent, methods of determination (Table 6).

Elk Island Study Area

Summer.--GEOCALC analysis of habitat types within scanning circles around locations of radio-collared deer as compared with random locations indicated highly significant selection for mature cottonwood (MCOTTONWOOD) and shrub (SHRUB) types at all times. Younger seral stages, including young cottonwood (YCOTTONWOOD), willow-cottonwood thicket (W-C THICKET) and sandbar-seedling (SANDBAR-SEED) were either used in proportion to availability or avoided. Use of mature willow (MWILLOW) was indicated to be proportionately greater than availability overall, but this apparent selection did not follow in separate analysis of data for nighttime and daytime periods. The slough type (SLOUGH) appeared to be selected for overall and at night while the canal bank (CANAL) was avoided. The apparent preference for sloughs, however, may have been an artifact of consistent deer use of adjacent mature cottonwood cover and alfalfa fields by two radioed deer; other observations indicated little use

Table 6. Cover-type selection by white-tailed deer on the Yellowstone River study areas as determined by GEOCALC, aerial radio relocations, spotlight surveys and other relocations.

	GEOCALC ANALYSIS												AERIAL LOCATIONS (YEARLONG)		SPOTLIGHTING				OTHER LOCATIONS (SUM&WIN)
	EI[a] SUMMER			EI WINTER			IN SUMMER			IN WINTER					EI		IN		
COVER TYPE	A[b]	N	D	A	N	D	A	N	D	A	N	D	EI	IN	SUM	WIN	SUM	WIN	EI & IN
GBAR-SEED & W-C THICKET	0[c]	-	-	0	0	-	--	--	0	-	-	0	-- --	-- -					2.20[d]
YCOTTONWOOD	0	0	-	0	0	-	-	-	-	0	0	0	--	+					3.08
MCOTTONWOOD	++	++	++	++	+	+	0	-	0	0	0	+	++	0					29.07
SHRUB	++	++	+	+	0	0	0	0	+	0	0	0	++	0					14.98
MWILLOW	+	0	0	+	+	0	-	-	-	-	-	0	++	0					3.08
ASH	0	0	0	0	0	+	++	++	++	++	++	+	++	++					11.45
SLOUGH	+	+	0	+	0	0							0						0
CANAL	-	-		-	-								--						0.44
CRBOTTOM							0	0		-	-								0.44
FLDPGRASS	0	-	0	0	0	0	0	0	0	+	+	0	--	--	-	-	--	++	5.73
UPLDGRASS														--					0.88
HWDRAW														--					0.44
GRAIN	--	-	0	0	0		0	+	0	0	0	0			--	0	--	--bott 0upl	2.64
PLOWED				0	0											--			
WWHEAT																		0	
BEETS	--	--		+	++	-									--	++			5.29
ALFALFA	0	+	0	-	0	0	++	++	+	+	+	0			++	++	++	+bott ++upl	17.62
CFSITE										++	++							++bott +upl	2.64
RICH			0			0			+			+							
TOTALE			-			0			0			0							

[a] EI=Elk Island, IN=Intake
[b] A=All (day and night locations, whole area), N=Night (night locations, whole area), D=Day (day locations, riparian areas).
[c] 0 indicates no selection ($p>.05$), - indicates avoidance ($p<.05$), + indicates positive selection ($p<.05$), and -- or ++ indicates highly significant avoidance or selection ($p<.0001$).
[d] values are percentages of all locations.

of this type by deer. No radio-collared deer used the canal bank in summer 1983 and, thus, avoidance was shown. Yet, one radioed adult female used this type exclusively during the day in summer 1982.

GEOCALC indicated floodplain grasslands (FLDPGRASS) were avoided at night and used in proportion to availability during the day. Other data indicated grasslands were little used during the day; e.g., less than 1% of aerial radio relocations at Elk Island and only 3.4% of summer daytime walk-in locations of radioed deer were in this type. The lack of avoidance of grasslands during the day in the GEOCALC analysis may have been influenced by the occurrence of grassland adjacent to riparian cover used by several radio-collared deer.

Agricultural types were used only during late afternoon, nighttime, and early morning periods. Telemetry data showed that diel use of agricultural areas peaked during 2100-2400, then decreased to none at 0500 (Fig. 13). Overall, 26.7% of all nighttime deer locations were in agricultural fields.

Of agricultural types, only alfalfa was significantly selected for in the GEOCALC analysis. Although the inclusion in the study area (availability) of some agricultural areas little used by radioed deer may have decreased the opportunity to detect selection of individual agricultural types, use did not approach

availability for any type but alfalfa. Thirty percent of all scanning circles around nighttime locations contained alfalfa as compared to 8.6 percent during the day. Spotlighting data also show that alfalfa was the only agricultural crop used more than expected based on availability ($p<0.0001$), accounting for 73% of all observations of deer in agricultural and grass fields (Table 7).

Table 7. Percentages of total deer observed using agricultural fields and grasslands during spotlighting counts in relation to the availability of each type on the Elk Island study area during summer.

Cover type	Percent Use	Percent Availability	Z[a]	p-value
Grassland	14.9	21.26	-3.836[b]	<0.0002
Cereal Grains	12.4	42.52	-15.035	<0.0001
Alfalfa	72.7	29.53	23.354	<0.0001
Beets	0	6.69	-6.608	<0.0001

[a] $Z=(U-A)/[A(1-A)/N]^{0.5}$, where U=use, proportion of all radio locations, A=availability, poportion of total area, N=number of radio locations.

[b] Negative Z-values indicate use of a type less than in proportion to its availability; positive indicates use greater than in proportion to its availability.

Numbers of deer seen in alfalfa fields and total numbers of deer observed in spotlight counts generally increased from early to late summer (Fig. 25). Telemetry data showed a similar increase in use of agricultural fields (Fig. 12).

Habitat use based on GEOCALC was similar during summer 1982 and 1983. A somewhat higher occurrence of grasslands in deer scanning circles during 1982 probably reflected slightly higher triangulation error plus use of riparian cover near grasslands by several radio-collared deer. Distribution and use of alfalfa fields was similar in both summers. Beet fields (BEET) were widespread in summer 1982, but the GEOCALC analysis showed them to be avoided at night ($p<0.05$). Few fields of beets were grown in 1983, most at some distance from riparian cover, and no use of beets was observed in spotlighting or general observations.

Winter.--GEOCALC analysis indicated significant selection for mature cottonwood during all times of the day. Shrub and mature willow types appeared to be selected overall, while mature willow was also selected at night. The green ash type (ASH) was selected during daylight hours, probably as a result of increased daytime deer use on the Island where most green ash stands occurred.

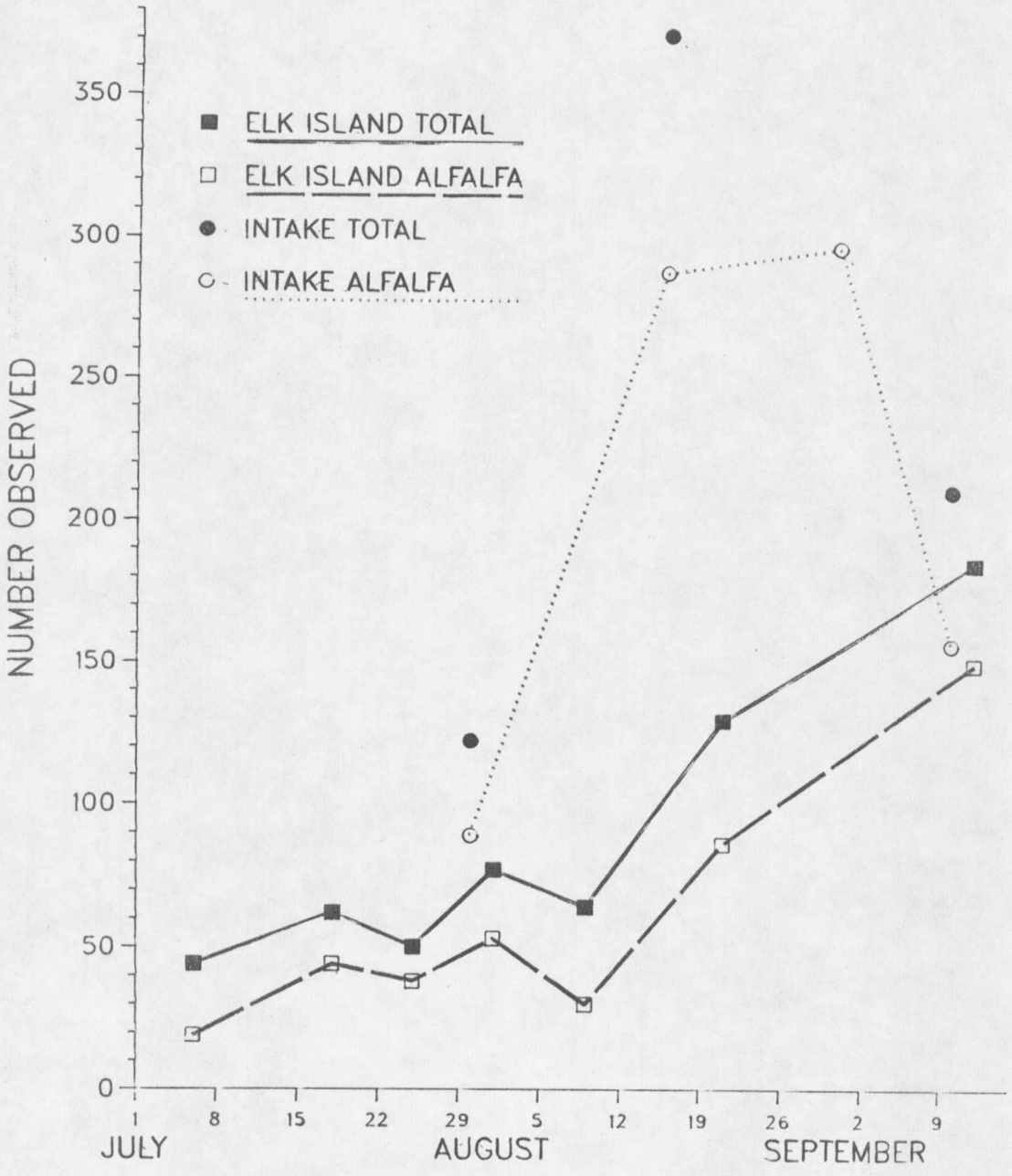


Figure 25. Numbers of deer observed in spotlight counts on the Elk Island and Intake study areas during summer 1983.

Grasslands occurred in deer scanning circles in approximate proportion to availability. Again, this may have been an artifact of deer use of riparian types adjacent to grasslands, at least during the day.

Alfalfa and sugar beets were the two most highly used agricultural crops in winter. GEOCALC analysis as well as spotlighting data (Table 8) showed sugar beets to be highly selected at night even though preferred beet fields were greater than 1 km from utilized riparian cover.

Table 8. Percentages of total deer observed using agricuultural fields and grasslands during spotlight couunts in relation to the availability of each type on the Elk Island study area during winter.

Cover type	Percent Use	Percent Availability	Z	p-value
Grassland	11.6	18.21	-2.799	0.0052
Grain Stubble	9.7	7.30	1.508	0.1310
Plowed Grain	2.2	43.33	-13.563	<0.0001
Alfalfa	42.3	23.47	7.260	<0.0001
Beets	33.7	7.69	15.952	<0.0001

Alfalfa was not selected in the GEOCALC analyses while spotlighting data showed it to be highly selected. This difference was due in part to the higher use by radioed deer of beet fields. Also, few alfalfa fields retained enough residual plant material to attract deer.

Most grain fields were fall-plowed and not used except for travel. The few small fields left in stubble were shown to be used about in proportion to their availability in GEOCALC and spotlighting analyses.

In winter, like summer, deer use of agricultural fields occurred primarily in late afternoon, at night, and during early morning. Fewer than 1% of daytime (0800-1600) locations occurred within agricultural areas, whereas, over half (64.3%) of all deer locations between 1800 and 0600 were in agricultural areas. Use of agricultural fields was highest before midnight (Fig. 15). The proportion of nighttime telemetry locations (1800-0600) occurring in agricultural areas decreased from January to March (Fig. 26). The trend in numbers of deer observed in spotlighting was also downward through the winter (Fig. 27). However, in winter 1982-83 agricultural use by radioed animals remained high in March (Fig. 26).

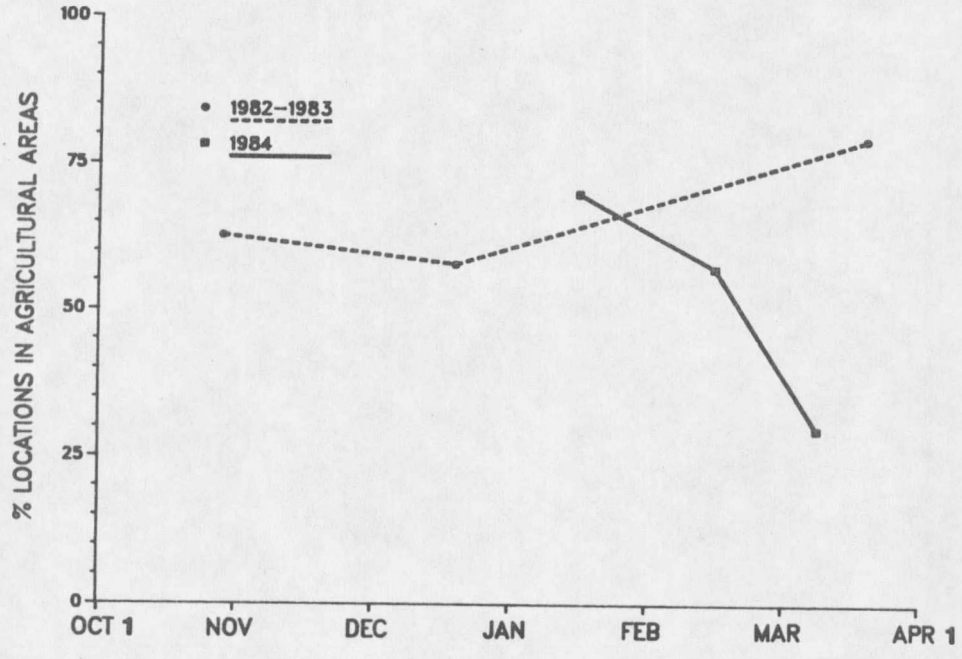


Figure 26. Percentage of total nighttime locations of radioed deer that were in agricultural areas on the Elk Island study area during winter (1984 data points were monthly means which included several sessions, while 1982-83 data points represent individual sessions).

Intake

Summer.--Analysis of habitat use at Intake was complicated by movement of 3 radio-collared deer from upland used during the day to fields on the river bottom at night. As the summer progressed, these deer spent more time on the bottom. Because deer could not be consistently and accurately relocated in the uplands, only bottomland locations were included in the GEOCALC analysis. Relative use of upland cover types was determined by aerial and ground radio locations and spotlighting.

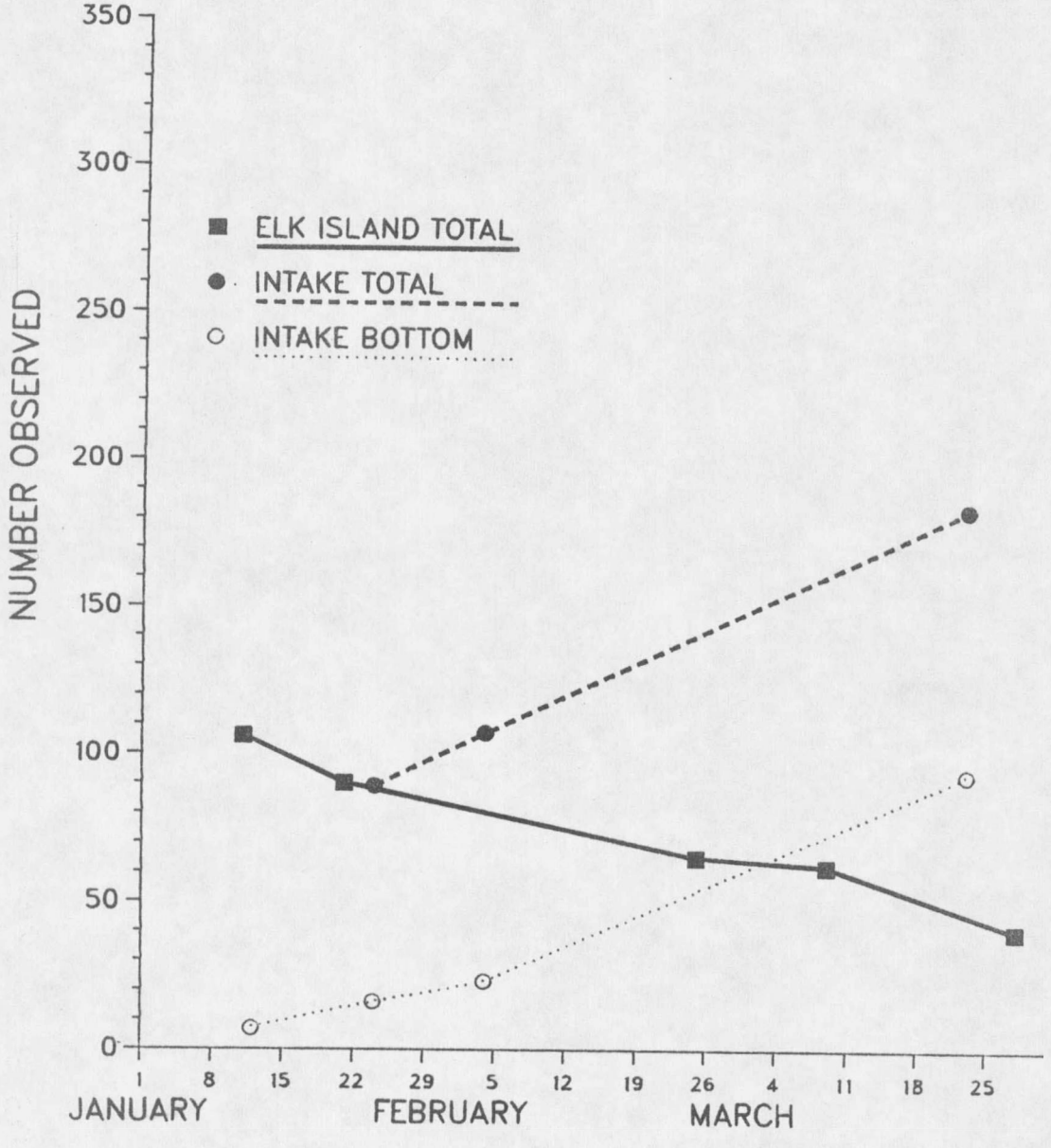


Figure 27. Trends in numbers of deer observed in spotlight counts of deer through winter 1984 on the Elk Island and Intake study areas.

Among bottomland riparian types, green ash was very highly selected at all times (Table 6). The extent of this use precluded measurable selection for any other riparian types, except shrublands during the day. Mature cottonwoods were not selected during the day and were avoided at night. Although mature willow appeared to be avoided, this may have been more a reflection of the distribution of radioed animals than preference. Most mature willow was located on the west end of the Gentry bottom, while radioed deer were more concentrated on the east.

Among bottomland agricultural types, alfalfa was highly selected ($p<0.0001$) in the GEOCALC analysis, and accounted for 80% of all spotlighting observations. Cereal grains appeared to be selected at night in the GEOCALC analysis, while spotlighting data showed these grain fields to be highly avoided ($p<0.0001$). The apparent selection of grain in the GEOCALC analysis was likely due to deer selection for alfalfa fields and riparian cover adjacent to wheat fields. Irrigated wheat fields, which were located adjacent to alfalfa fields, were selected, while non-irrigated wheat and barley fields, which were located further from alfalfa fields, were avoided in the GEOCALC analysis. In addition, meters of wheat edge per unit of wheat field area in deer scan

circles was almost twice that of random scan circles, indicating that most deer scan circles containing wheat were not centered in wheat fields.

Grasslands, which were shown to be used in approximate proportion to availability in the GEOCALC analysis, were avoided ($p<0.0001$) as measured by spotlighting counts. They accounted for only 6.8% of spotlight observations (Table 9). Aerial and direct observations of radioed deer indicated very little use of grasslands during the day (Table 6).

Table 9. Percentages of total deer observed using agricultural fields and grasslands during spotlighting counts in relation to availability of each type on the Gentry bottom at Intake during summer.

Cover Type	Percent Use	Percent Availability	Z[a]	P-value
Grassland	6.79	12.64	-4.533	<0.0001
Wheat	12.97	50.54	-19.349	<0.0001
Alfalfa	80.24	36.82	23.180	<0.0001
Irrigated	64.86	23.47	25.147	<0.0001
Non-irr.	15.38	13.36	1.529	0.1260

Only 13 deer were seen during two spotlighting surveys on the Adams bottom where, with little agriculture, deer apparently remained largely within riparian cover at night. Although only two deer were seen in the one low-quality alfalfa field during spotlighting, observations during triangulation indicated that 5-15 deer regularly used the field, at least at dusk and dawn.

In contrast, up to 371 deer were seen in individual spotlight counts on the Gentry bottom (Fig. 25), where several high-quality alfalfa fields were located. Average densities of deer in individual alfalfa fields were as high as 6.2/ha. Numbers observed in spotlight surveys increased sharply after July 30, when surveys were initiated.

Use of agricultural fields was highest before midnight. Where deer were located in fields during only one of each pair of nighttime sessions, it was almost twice as likely to be the pre-midnight rather than post-midnight session.

Among upland cover types, grasslands were avoided. Only 15 (1.6%) of 917 aerial locations at Intake during all seasons from 1980 to 1984 (Dusek, unpubl. data) were in upland grasslands (Appendix Table 12). Similarly, spotlighting along the base of the uplands resulted in only 5 (0.7%) observations of deer in grasslands, and all appeared to be travelling to or from bottomlands.

Although upland draws did not appear to be selected in the aerial location data, draws were the most highly used upland types. Very little use of upland agriculture was observed during summer, with the exception of one alfalfa field.

Winter.--In the GEOCALC analysis, ash was the predominant riparian cover type selected (Table 6). Use of the mature cottonwood type was higher than in summer, and selection was shown for the daytime period. Floodplain grassland appeared to be selected overall and at night, but this probably reflected the high use of cattle feed sites (CFSITE), two of which were located in grasslands. There also appeared to be an increased use of grasslands in March as greenup began. Deer were regularly observed feeding at dusk in crested wheatgrass fields on the Adams bottom, beginning in early March.

Deer made little use of bottomland agricultural fields at Intake during winter. Spotlight counts showed most deer in trees and shrubs near field edges (Table 11). Most agricultural use was concentrated on cattle feed sites (CFSITE), and much use of alfalfa appeared to be associated with use of these sites. Although GEOCALC indicated use of grain stubble in proportion to availability, spotlight surveys indicated avoidance. Again, much of this use probably was associated with use

of other types, especially cattle feeding sites.

Four of five radioed deer on the Gentry bottom used upland draws in early January when cattle were using and being fed on the bottom. Three of these returned to the bottom shortly after the cattle were removed in late January. Similarly, the number of deer observed in spotlighting counts on the bottom increased from only 7 in January to 93 on March 23, and the proportion of time radioed deer using both uplands and bottomlands spent on the bottom also increased to approximately 75% by late February and March. Meanwhile, numbers of deer seen in upland fields remained fairly constant through the winter (Fig. 27). This may have reflected increased use of the upland fields by deer from other areas. Some of the deer observed on upland fields were known to have travelled there from riparian areas outside the immediate study area.

Use of upland agricultural fields occurred from 1500 to 0800, with the peak just before midnight. Spotlighting showed that a harvested corn field and grasslands were avoided, while an ungrazed alfalfa field was highly selected (Table 10). Stubble and green winter wheat fields were used in approximate proportion to their availability, though they cumulatively accounted for more observations than alfalfa. Also, not all parts of winter

Table 10. Percentages of deer observed using various cover types during spotlight counts as compared with availability on the Intake area during winter.

Cover Type	Percent All Observ.	Percent Ag.Observ.	Percent Ag.Avail.	Z	P-value
		Bottomland			
Mature cott.	29.27				
Ash	10.36				
Shrub	4.27				
CFS	35.98				
Grassland	7.93	39.39	12.64	4.624	<0.0001
Stubble	1.22	6.06	50.54	-5.111	<0.0001
Alfalfa	10.98	54.55	36.82	2.112	0.0348
	N=164	N=33			
		Upland			
Draw	0.79				
Haystack	3.9				
CFS	4.3				
Corn[a]	0.0	0.0	3.98	-3.094	0.0020
Grassland	0.79	0.87	29.06	-9.436	<0.0001
Alfalfa	37.8	41.56	8.83	17.533	<0.0001
Stubble	31.9	35.06	32.40	0.864	0.3898
Winter Wheat	20.5	22.51	25.30	-0.975	0.3294
	N=254	N=231			

[a]The one corn field had been cut for silage.

wheat and stubble fields could be surveyed with a spotlight; such counts were lower than the February 2 count at dusk of 182 deer in upland winter and stubble fields. The recorded use of two haystacks on uplands near the bottom was 3.9% of all deer observed in upland spotlight counts.

Ground Observations

Ground observations of collared animals (representing approximately equal proportions of daytime riparian and nighttime agricultural locations) are listed in Table 6. Although the precise availabilities are not easily defined for these data, they generally support the previously stated patterns of habitat use, with mature cottonwood, shrub, and ash types being the most highly used riparian types and alfalfa and beets the most highly used agricultural crop types.

Heterogeneity

In addition to use of individual habitat types, the GEOCALC analysis examined the number of cover types (RICH) and the total of edge lengths of all types (TOTALE) within scanning circles as indices of diversity or heterogeneity (Table 6). In use of riparian habitat during the daytime deer did not generally select for areas with greater diversity or more total edge, at least not as measured in this study.

Effects Of Weather

During summer, selection of cover types was not obviously affected by ambient temperature. Thunderstorms appeared to decrease use of agricultural fields, as indicated by triangulation and spotlighting sessions conducted during nights of thunderstorm occurrence.

During winter, weather conditions severe enough to negatively affect deer use of agricultural areas were not encountered. January was the coldest month of the study (Fig. 2). Yet, this was the time of highest deer use of agricultural fields at Elk Island (Fig. 31). Similarly, the highest count of deer during spotlight surveys in winter occurred during the coldest conditions--temperature of -21 C, wind speed of 12.1 km/hr, and equivalent still air temperature of -48 C. During triangulation sessions, temperatures of -22 C with winds of 19 km/hr (equivalent still air temperature of -57 to -62 C) had no effect on deer use of agricultural fields. At low temperature and high wind conditions deer might be expected to select microsites within a field with lower wind speeds, such as along field edges or ditch banks, but this was not observed during any spotlight surveys.

Cover Density

Mature willow showed the highest overall density but only one stand was sampled; not all stands were this dense. Mature cottonwood and shrub types showed high densities at heights up to 1.5 m as a result of shrub understories. The green ash type had high values above 1.0 m due to trunks and limbs, while cover density above 0.5 m was low in young cottonwood and grass types. Willow-cottonwood thicket stands were not measured because, in most cases, the entire board would have been completely obscured.

Cover density scores at all heights were generally higher at Elk Island than at Intake, for those types sampled at both areas (young and mature cottonwood, shrub, and grassland). These differences were significant ($p<0.05$) for the 0.5-1.0 m and 1.0-1.5 m heights in mature cottonwood and shrub stands, reflecting lighter shrub understory at Intake. At Intake, density of mature cottonwood stands was similar to that of ash stands at the 0.5-1.0 m level.

Mature willow and willow-cottonwood thicket stands were most effective in decreasing wind speeds in winter (Table 11). Mature cottonwood and shrub cover types were also effective in slowing wind due to their shrub understories, while grass and grass-understoried types and

an open field were least effective. These comparisons should be considered only as rough estimates, since most types were only sampled at one site, but they serve to show the range of relative wind speeds to be expected in various cover types.

Table 11. Wind speed measured in representative stands of various cover types in winter expressed as a percentage of wind speed measured at the base weather station (grassland).

Willow-cottonwood thicket	0.3%
Mature Willow	2.9
Mature cottonwood	11.3
Shrub	26.3
Young Cottonwood	38.8
Ash	45.0
Sagebrush-Grassland	62.0
Alfalfa field	167.0

DISCUSSION AND CONCLUSIONS

Distribution, Movements, and Home Range

Deer distribution was centered on blocks of bottomland riparian habitat. Minor use of uplands at Intake reflected the proximity of upland woody draws and upland agricultural fields to bottomlands on that area. Allen (1968) along the Missouri River in northcentral Montana and Zwank (1979) along the Grand River in Missouri similarly reported white-tailed deer to occur primarily on bottomlands, with only occasional use of uplands.

Although nighttime deer distribution reflected the distribution of preferred agricultural fields, deer apparently did not concentrate near preferred agricultural fields during the day. The only direct measurement of daytime distribution, the winter helicopter survey at Elk Island, did not indicate any concentrations of deer near agricultural fields within riparian cover. Also, most radioed deer used the same daytime home range in winter as in summer, even when using different agricultural fields at night. In both seasons some deer regularly travelled distances of 2-2.5 km to agricultural fields when nearer riparian cover was available.

The most distinctive movements of deer in this study were between natural riparian cover and agricultural fields. These were similar to movements reported for

white-tailed deer in Iowa (Zagata and Haugen 1974), and may represent the general pattern in agricultural areas interspersed by blocks or patches of woodland or other cover.

Although deer from the same area of riparian cover generally travelled to and concentrated in the same agricultural fields, the pattern and extent of movement varied seasonally with the kind and location of selected fields. In summer, movements were most often simply to the nearest alfalfa field. In winter they were more varied and the closest fields were not always selected.

The variety in winter movements, plus the fact that several deer tracked in successive winters moved to and used fields in the same area (at some distance from riparian cover) both years, suggested that tradition and learning were important in determining field use and movements, in addition to proximity and forage quality.

It also appeared that deer were normally able to locate and travel to fields at considerable distance from riparian cover if more preferred fields were not located nearby. Most long distance movements on the study areas probably either fell within normal seasonal ranges or home range boundaries in agricultural areas were flexible enough to include nearby, higher-quality fields. Marchinton and Hirth (1984) stated that awareness of

distant food sources may determine the extent to which deer will move out of their normal ranges to meet their needs. Because crop types and cropping practices on individual fields changed annually, use of fields far from riparian cover probably began with their discovery by deer that have traditionally moved to their vicinity or by deer wandering sufficiently to locate them. Once several deer began using a field, knowledge of that field may have been conveyed to other deer by the movement towards these fields in the evening.

Bodies of water did not appear to limit deer movements and home ranges to the extent shown by Michael (1965) and Gavin et al. (1984) who reported that waters wider than a deer could jump across formed a barrier to deer movement. During this study deer regularly waded irrigation and drainage ditches and some commonly swam across the river from Elk Island to the mainland (75-100 m). Deer on the Adams bottom at Intake apparently did not cross the 200-300 m wide river in summer or on the ice in winter to use agricultural fields on the Gentry bottom, although they may readily swim across when harassed by hunters. Fawns were able to swim the river by August.

Fawns apparently did not begin making substantial movements and accompanying does into fields until August when they were approximately 6 weeks old. Jackson et al. (1972) found that fawns 30-70 days old were active only

12-16% of the time, mostly during the day, and Ozoga et al. (1982) indicated that does and their fawns did not readily associate with other deer until 4-6 weeks postpartum. Does with fawns used agricultural fields prior to the time fawns accompanied them, but less often and for shorter periods.

Differences in total home range sizes of deer in this study appeared to be related to differences in behavior between sex-age classes and changes in habitat between seasons and study areas. Yearlings and adult males exhibited more variation in movements from day to day than adult females. This was reflected in the larger home range sizes of adult males and yearlings of both sexes. Several studies have documented that males are generally more mobile than females (Carlsen and Farmes 1957, Thomas et al. 1964, Michael 1965, and Alexander 1968), while Tierson et al. (1985) reported similar home range size for both sexes.

Larger home ranges among yearlings than adult whitetails were also reported by Nelson and Mech (1984). There are several possible reasons for this. In summer, yearlings have become independent of maternal constraints (Nelson and Mech 1984) and may not have established a fixed home range or habitual movement and habitat use patterns. Secondly, the lower social status of yearlings

may result in greater movements due to encounters with dominant animals. Gavin et al. (1984) felt that agonistic behavior among females may act as a spacing mechanism. However, yearlings also appear to wander more than adult females at night, when deer are congregated in fields and such spacing mechanisms would presumably not be acting. Also, yearlings may simply have a greater innate behavioral tendency to wander than adults, just as males seem to have in comparison to females.

In winter, the difference between yearling and adult female home range sizes was smaller than in summer. This appeared due in part to a substantial increase in adult female home range size in winter, but may also indicate that yearling females had better established individual home ranges, that they reunited with their dams, or that social intolerance had decreased.

Deer in this study showed markedly different daytime and nighttime movements and habitat use. They were relatively sedentary during the day and limited movements to riparian cover such that daytime home ranges averaged only 1/2 to 1/3 the size of total home ranges. This may represent the general pattern in habitats where deer forage in open cover types subject to human activity or other disturbance.

Age and sex differences were reflected in daytime as well as total home ranges. However, because daytime home

ranges were not influenced by movements to agriculture, they did not differ by season or study area. Apparently, differences in distribution and kinds of riparian habitat between study areas were not great enough to produce significant differences in daytime home range size among females, although animals using uplands had large daytime as well as total home ranges.

Total home range size was related to habitat characteristics. Differences in home range size between study areas and seasons were largely a reflection of differences in distribution of agricultural fields relative to daytime bedding sites. This also appeared to account for a large part of the variation between individual deer within seasons and study areas. Many of the smallest home ranges in summer reflected the proximity of alfalfa to riparian cover. During winter many deer expanded their home ranges to include more distant fields, especially beets and upland wheat. However, even among deer that used the same fields in winter as in summer, home range size was often larger in winter.

Summer home ranges of white-tails in this study appeared to fit into the lower part of the range of home range sizes observed elsewhere (Appendix, Table 13), especially when the affect of number of locations on polygon size are considered (Jennrich and Turner 1969).

Only those reported by Marshall and Whittington (1968) and Kammermeyer and Marchinton (1976) were much smaller.

Mean winter home range sizes in this study were larger relative to other studies than in summer. Deer movements on the Yellowstone River were not restricted by snow in winter, and home ranges were expanded by use of agricultural fields more distant from daytime cover. Winter home ranges reported for other studies were often in areas where snow or yarding behavior restricted deer movement. Drolet (1976) reported larger home range sizes in a winter of low snow accumulation than in a winter of heavy snow.

Differences in habitat and distribution of important habitat components probably accounts for much of the variation in home range size between studies and areas. Home ranges of white-tailed in Texas appeared to be consistently small, while those reported by Wood (in prep.) for white-tails occupying open prairie habitat in Montana easily averaged the largest. Thomas et al. (1964) attributed the low mobility and small home ranges of deer in Texas to good dispersion of food, cover, and water, as well as high affinity of deer for their home range. The small, fairly stable home ranges seen in this study also appeared to reflect close interspersion of riparian cover types and the proximity of agriculture to riparian cover. In contrast, both the upland portion of the Intake area,

and Wood's study area, on which large home ranges occurred, were characterized by patchy cover consisting primarily of widely separated woody draws. Although home ranges of adult females reported by Sparrowe and Springer (1970) in a similarly patchy cover situation were not particularly large, the number of locations was low and other sex-age classes showed much larger home ranges--overall summer home ranges averaged 2.6 km^2, and winter 7.0 km^2.

Activity

The general diel pattern of deer activity observed in this study, with major peaks of activity near sunrise and sunset and sometimes minor peaks around noon and midnight, was similar to that seen in other studies of white-tailed deer (Michael 1970, Ozoga and Verme 1970, Jackson et al. 1972, Zagata and Haugen 1973, Kammermeyer and Marchinton 1977, Gladfelter 1978, Krausman and Ables 1981, and Gilbert and Bateman 1983) and mule deer (Eberhardt et al. 1984).

An activity pattern with two peaks is the most common in vertebrates (Aschoff 1966). The adaptive basis for this pattern in deer may relate to predator avoidance strategies (Jarman and Jarman 1973, cited in Leuthold 1977) and rumen fill requirements (Montgomery 1963, Leuthold 1977). However, deer are aparently capable of

showing considerable modification and adjustment to this basic pattern in adapting to local and seasonal environmental conditions.

Ambient temperatures appeared to have a decided effect on deer activity and probably accounted for much of the seasonal differences in diel activity patterns on my study area. Deer in summer were largely inactive during midday and highly active in evening, midnight, and morning periods, while in winter they were much more active during midday with little difference in activity during other periods of the day. Similar increases in daytime activity from summer to winter were reported by Michael (1970), Miller (1970), Hood (1971), and Vogel (1983). The decrease in movement and activity at high summer temperatures seen in this study, as well as others (Miller 1970, Drolet 1976, and Ockenfels and Bissonnette 1984) suggest that the low activity during the day in summer may be a response to high temperatures. However, Hood (1971) in Texas and Kammermeyer and Marchinton (1977) in Georgia, reported more activity during the day than at night in summer, indicating that deer were more tolerant of or acclimated to high summer temperatures in those areas than deer in this study, or that factors other than temperature are involved.

The shift towards daytime activity from summer to winter may have been a similar response to times of more

favorable temperatures. It might be expected that under more severe winter weather conditions, deer would become even less active (Gilbert and Bateman 1983), especially at night. Counteracting this tendency would be the attraction of high quality forage in the forms of agricultural crops and residues that were available under the cover of darkness. Weather conditions observed during this study were not severe enough to prevent use of agricultural fields. Moen (1966) also found deer using agricultural fields under severe winter weather conditions.

Activity patterns also appeared to have been affected by habitat characteristics and human disturbance. Deer did not remain bedded in fields during the day as reported by Moen (1966). Instead, most activity during midday was confined to riparian cover and most use of agricultural fields occurred during twilight and evening periods. Deer were more active while using agricultural fields than riparian cover. Hood (1971) also noticed a dichotomy in habitat use of open and dense cover types during daylight and nighttime periods.

Greater nocturnal relative to diurnal activity observed in this study in summer than that reported by Hood (1971) and Kammermeyer and Marchinton (1977) probably was related to deer dependence on agriculture, the

openness of the fields, and human activities. Diel activity and movement patterns similar to those in this study were reported in other agricultural areas by Gladfelter (1978) and Zagata and Haugen (1973). Kammermeyer and Marchinton (1977) found an increase in nocturnal relative to diurnal movement from summer to fall when deer began using agricultural fields. The dependence on agricultural crops seen in this study and their use only at night probably maintained a level of nocturnal activity in winter greater than what might have been expected in non-agricultural areas.

Disturbance may cause deer to become active more at night or to use open cover types only at night, or both. Vogel (1983) found lower diurnal and higher nocturnal activity in areas of high versus low housing density. Happe (1982), however, found that black-tailed deer in developed residential areas did not decrease their daytime activity relative to deer in undeveloped areas, but did use open cover types more under cover of darkness.

The apparent use of open cover types earlier in the afternoon and later in the morning at Intake than at Elk Island was probably related to distributions of riparian and agricultural habitat and levels of human disturbance. Many of the alfalfa fields at Intake were in proximity to or bordered by riparian cover, yet in winter deer often traveled well before sunset across the county road to

upland wheat fields in view of the road and also reacted less to spotlighting than those at Elk Island. This suggests that differences in overall human activity levels may be involved, rather than habitat distribution. The Elk Island study area has a higher housing density and is near the town of Savage. A large part of the area is open to public access and most of the area receives heavy hunting pressure, while the Intake area is more remote and comprised of private lands with restricted access and very restricted hunting pressure.

Seasonal differences in daylong activity levels of deer were not detected in this study. Although Behrend (1966), Silver et al. (1969) and Moen (1978) report decreased activity or lowered metabolic rate in mid-winter, deer in this study were active approximately the same proportion of the time and moved as much or more in summer as in winter.

Habitat Use

Selection of Riparian Types

Collectively, the habitat use data showed that mid- to late-seral riparian communities--mature cottonwood, green ash, shrub, and in some cases mature willow--were most highly preferred. Allen (1968) also found the mature cottonwood type used extensively by white-tailed deer on

Missouri River bottomlands. Younger seral stages were, for the most part, used less than or in proportion to availability. Grasslands were avoided, especially during the day.

Daytime habitat selection measured by aerial locations during 1980-1984 (Table 6, Appendix Table 12) was similar to that measured by GEOCALC. Aerial relocations better showed selection for ash and mature willow at Elk Island. These types were limited in distribution and generally occurred as small scattered stands such that the larger sample obtained as discrete locations over a greater length of time in aerial relocations might be more likely to show selection. At Intake, aerial locations showed selection for young cottonwood that was not observed in GEOCALC analyses. This may have reflected differences in cottonwood stand age classification applied to the two sets of data.

Little seasonal change in relative use of riparian cover types occurred, though daytime GEOCALC analysis and aerial radiolocations indicated a slight shift at Intake from heavy use of ash in summer to greater use of mature and young cottonwood in winter. Other seasonal differences that occurred in GEOCALC analyses involved changes in nighttime use of agricultural fields and changes in distribution of radioed deer. While total use of riparian types declined with increased use of

agricultural types at night, relative use of individual riparian types were similar to those during the day.

Habitat use and cover density data indicated that deer selected riparian cover types with dense, tall cover. Mature cottonwood and shrub cover types generally had abundant rose and snowberry cover. On the Gentry bottom at Intake, where mature cottonwood understories were sparse and area of shrub stands was limited, deer selected highly for the ash type. Ash stands provided cover in the form of dense canopy and numerous trunks, and some with a more open canopy had more of a shrub understory. Mature willow stands were generally quite dense and often included a shrub component. Deer also appeared to select the more dense sites within a given stand as bed sites, especially dense clumps of buffaloberry, rose, or snowberry.

Dense cover may serve several functions. It may provide thermal cover necessary to maintain heat balance in periods of high summer and low winter temperatures. Ockenfels and Bissonnette (1984) noted increased use of riparian areas and a decreased use of uplands by deer at temperatures above 30 C. The function of woody cover in reducing wind-chill and radiant heat loss in winter is well documented (Moen 1968, Ozoga and Gysel 1972). Cover may also be important for security, allowing deer to

inhabit areas subject to human disturbance and to withstand very heavy hunting pressure. Dense cover may also increase visual isolation, which may, if social intolerance exists (e.g., at fawning, Ozoga et al. 1982), permit a closer spacing and higher densities of deer than more open habitat.

Although riparian cover may serve thermal and security functions, patterns of habitat use seen in this study suggested that its role as security was the more important factor in selection. This was indicated by both the constancy, regardless of weather or season, in selection of riparian cover types and the diel use of agricultural and riparian types. Although the presence of human activity was probably an important factor in maintaining the diel pattern of habitat use in this study, Black et al. (1976) suggested that hiding cover was necessary even in the absence of predators or human disturbance, to achieve full use of an area by deer.

Forage availability may also have affected selection of riparian cover types. Suring and Vohs (1979) indicated that communities providing both cover and forage were more heavily used by white-tailed deer than those providing either alone, and Kohn and Mooty (1971) found that preferred forage abundance was the most important factor determining habitat selection.

Although I did not examine food habits, data obtained for the study area during 1980-1985 by Dusek (Appendix Table 14, unpubl. data) indicate that native riparian plant species provided a majority of the diet of deer on the river bottom throughout the year. Browse was the major forage class in rumens, with snowberry being the predominant species in summer, followed by rose and willow. In winter, cottonwood predominated followed by snowberry and rose.

These browse species were most abundant in cover types with high shrub densities. Vegetation transects within the Elk Island and Intake study areas (Boggs 1984) showed live shrub coverage of 38, 27, and 16% in mature cottonwood, shrub, and ash types, respectively. Mature willow transects in other sites also showed high shrub coverage (32%). Shrub coverage in willow-cottonwood thicket, young cottonwood, and grassland types were very low.

Some ash stands that were heavily used by deer at Intake contained little shrub understory. These may have been selected more for their cover value (dense canopy and high trunk density) and their close proximity to agricultural fields; mature cottonwood stands in the area generally had a sparse shrub understory. Ash stands also had high forb coverage (Boggs 1984).

The major winter food item, cottonwood browse, was probably obtained primarily in mature cottonwood stands from windfall branches, as evidenced by habitat use analysis and tracks of feeding deer in fresh snow, although leaf litter was probably used as well. At Intake, a shift in winter from high daytime use of ash to greater use of mature and young cottonwood may have been related to use of cottonwood browse, as well as a reduction in cover value of ash stands with leaf-fall.

Grasslands were avoided during daytime due to their lack of cover. Though use increased at night, it remained low relative to availability. Spotlight counts within the riparian cover at Elk Island revealed fewer deer in grasslands than in mature cottonwood or shrub stands despite very limited visibility in the latter. Low use of grasslands was probably related to low occurrence of grasses in the diet. Significant use was recorded only at Intake during early green-up in late winter 1984. Most grasslands on the study areas were dominated by introduced grasses and many were abandoned fields. Grasslands may also dry sooner than types with a shrub or tree overstory. The willow-cottonwood thicket type, which was also avoided, provided dense cover but lacked any shrub understory.

Factors Affecting Use of Agricultural Fields

The primary factors affecting agricultural field use were the amount and type of crop or crop residue available. Alfalfa was highly selected for wherever sufficient plant material remained. Beets were heavily used in winter. Grain fields were little used in summer. In winter, growing winter wheat and ungrazed stubble fields were used by large numbers of deer.

Grazing of livestock on agricultural fields, a common practice after fall harvest, had a major impact on forage availability and deer use of fields in fall and winter. Deer made little use of fields within an area on which sheep had been grazed at Elk Island. At Intake they made little use of alfalfa or wheat stubble fields which had been grazed by cattle; instead, they concentrated agricultural use on ungrazed upland winter wheat and stubble fields and one alfalfa field.

Harvest and post-cropping practices also affected the amount of crop residue left. Fall plowing precluded deer use of almost all wheat fields at Elk Island. Late-harvested barley fields with abundant waste grain were used, but at lower levels than adjacent alfalfa fields. The use of ungrazed alfalfa fields depended on the amount of residual material left as influenced by the number of cuttings, and also probably the time of last cutting.

Beet harvest and field treatment methods appeared to influence sugar beet residues and availability. Some harvesters left both shredded leaves and cut-off crowns on the ground, while others left crowns with leaves in windrows to be grazed by livestock or harvested for silage. Other beet parts that may be left are lower root sections, undersized beets, and whole beets spilled during loading. Some fields were then left until spring with waste materials on or near the surface, while others were plowed, probably burying some material but also exposing some roots, and allowing digging. Some fields were also treated further by disking, smoothing, and leveling, which also may bring some residual beets to the surface. Fields used in winter 1982-1983 were unplowed, with tops left, and largely ungrazed. The most heavily used field in winter 1984 had leaves and crowns removed but was also plowed. Food habits data (Dusek, unpubl. data) showed high use of beets in April, coincident with spring plowing of fields.

Extensive use by deer may gradually deplete forage in agricultural fields. This may have been the reason for the decline in use through winter 1984 of a beet field on which deer concentrated. A similar decline did not occur between December 1982 and March 1983, a winter when many more beet fields were available.

There was some evidence that forage conditions in riparian areas may have influenced deer use of agricultural fields. Decreased use of fields occurred during mild conditions in mid to late winter 1984 and early green-up. Desiccation of riparian vegetation may have been at least partly responsible for the increasing use of alfalfa through the summer, as has been reported by Kamps (1969) and Egan (1960). However, this increased use of alfalfa during summer was also related to increased use by does with fawns.

Proximity of fields to riparian vegetation also affected use by deer. Fields distant from riparian cover received relatively little use if high quality fields were located nearer to cover.

Location of fields relative to human disturbance seemed to have little affect on nighttime use. However, agricultural fields located away from disturbance and with one or more riparian cover borders probably received somewhat greater use by deer during the day.

Overall Habitat Use Relationships

Collectively, my findings indicate that habitat use by white-tailed deer reflected their response to varying physical and biotic characteristics along the lower Yellowstone River. Natural riparian cover and agricultural lands were the two major components of deer

habitat. Diel patterns of movement, habitat selection, and activity were closely tied to these components. Their relative distributions were reflected in distances deer moved and home range size. Food habits further documented the importance of both components--snowberry and alfalfa were the major items in summer diets, while cottonwood and beets at Elk Island or cottonwood and wheat at Intake comprised the bulk of the winter diets.

These relationships are consistent with the findings of Swenson et al. (1983), who reported that 71% of all white-tailed deer observed in eastern Montana during winter occurred in riparian habitats in association with agriculture.

In addition to and interacting with these two primary factors are the topography and physiography of the river valley, land use and operational practices, and, to a lesser extent, weather conditions. The combination of these features, as well as behavioral and social factors relating to sex and age, influenced deer distribution, movements and home range, activity, and selection and use of specific cover types.

MANAGEMENT IMPLICATIONS

1. Natural riparian communities in mid to late seral (tree and shrub) stages comprise the core habitat for white-tails on and adjacent to the Yellowstone River. Retention of existing stands is important to maintain current densities and distribution of deer in the area. Because of the seral nature of the major communities used by deer especially the cottonwood sere, which in most cases will succeed to open grasslands (Boggs 1984), management of the lower Yellowstone River ecosystem to maintain quality white-tailed deer habitat will require provisions to continually re-establish these stands. This is now occurring naturally through normal river high flows and the associated channel cutting and creation of new sand and gravel bars on which willow and cottonwood establish.

2. Although results of this study indicate a general pattern of habitat use behavior (distribution, movememt and home range, activity, and selection of specific cover types), differences between the Elk Island and Intake study units indicated that local patterns will differ in relation to specific topographical and vegetational features, and land use practices. These factors, as well

as local weather conditions, should be taken into account in applying specific details of this study to other situations. Also, studies to define habitat use patterns in other similar areas should include representative areas of the broadly different habitat situations which occur.

3. During the growing season, use by deer was concentrated upon alfalfa. Use of some alfalfa hay fields on the Intake study area was sufficiently high to be considered damaging by the landowner.

Although actual damage to alfalfa was not examined in this study, other studies (Boyd 1960, Egan 1960) reported no significant damage to alfalfa hay or seed production in study areas selected on the basis of frequent landowner complaints of high deer damage. Studies in an agricultural area in Wyoming with deer densities very similar to those seen in alfalfa fields during this study (Tebaldi 1982) found statistically significant damage ($p<0.1$), averaging 6.8 kg/ha, in 33% of 79 cases. The greatest damage measured was 13.19 kg/ha which occurred on a field which also had the highest mean deer densities in spotlight counts of 5.4 deer/ha. These data indicate that the maximum damage to be expected at these densities may be economically important but will normally be undetectable.

My study showed that deer density in alfalfa fields can vary widely (0.24-6.18/ha). Because local situations can occur where deer use is heavy, deer damage complaints should be evaluated on a local basis.

Deer use of other crops did not appear to be heavy enough to cause damage. Although landowners report that deer may damage growing sugar beet leaves and crowns, this probably depends on the availability of alternatives. Beet fields did not receive heavy use during summer in this study. Large numbers of deer used green winter wheat fields in winter, but large field areas probably reduced potential for overuse. The availability of stubble fields adjacent to winter wheat fields, which received as much use during spotlight counts, probably also reduced the use and impact on winter wheat. Tebaldi (1982) found no significant effect of deer on winter wheat in an area of frequent depredation complaints in Wyoming.

4. The tendency of deer from specific blocks of riparian cover to utilize certain fields near that area suggests that development of agricultural fields and crops for deer in or near riparian cover on state-owned or managed lands could reduce use on outlying private lands. Alfalfa may be the best crop in that it is highly preferred during the growing season as well as in winter if time for regrowth occurs after the last cutting. If fields are share-cropped, therefore, only two cuttings should be taken, and

stands maintained in vigorous condition. On private lands, grain stubble might be left standing after fall harvest. Although not highly preferred, the availability of stubble and waste grain could reduce use of other crops. If beet leaves and crowns are not left on the field after harvest, plowing may increase the availability of waste parts to deer.

5. Spotlight counts to determine numbers of deer using fields should be conducted in the period from 1-2 hours after sunset until midnight, when maximum numbers can be expected. Spotlight counts made in late summer will best represent numbers of deer using the field because deer tend to stay longer as the summer progresses. Spotlight counts may better represent deer-hours than numbers of deer, the former probably being more appropriate to crop damage estimation. Numbers of deer using fields adjacent to riparian cover will be underestimated by instantaneous spotlight counts because deer are more likely to alternate between use of riparian cover and agricultural fields if the two are near each other.

6. This study has demonstrated marked differences in nocturnal and diurnal distribution, movement and home range, activity, and use of specific cover types. Other studies should recognize the possibility of these differences, especially in areas with open habitat

components, and include monitoring during nighttime periods at least until such differences are shown not to exist.

REFERENCES CITED

REFERENCES CITED

Alexander, B. G. 1968. Movements of deer in northeast Texas. J. Wildl. Manage. 32:618-620.

Allen, E. O. 1968. Range use, foods, condition, and productivity of white-tailed deer in Montana. J. Wildl. Manage. 32: 130-141.

Aschoff, J. 1966. Circadian activity pattern with two peaks. Ecology 47: 657-662.

Behrend, D. F. 1966. Correlation of white-tailed deer activity, distribution, and behavior with climatic and other environmental factors. New York Fish and Game Job Compl. Rep. Proj. W-105-R-7, Job No. V-A. 123 pp.

Black, H., R. J. Scherzinger, and J. W. Thomas. 1976. Relationships of Rocky Mountain elk and Rocky Mountain mule deer habitat to timber management in the Blue Mountains of Oregon and Washington. Pages 11-31 in S. R. Hieb, ed. Proceedings of the Elk-Logging-Roads Symposium, University of Idaho Forest, Wildlife, and Range Exp. Sta., Moscow.

Boggs, K. W. 1984. Succession in riparian communities of the lower Yellowstone River. M.S. Thesis, Montana State Univ., Bozeman. 107 pp.

Booth, W. E. 1972. Grasses of Montana. Dept. of Botany and Microbiology, Montana State University, Bozeman. 305 pp.

Booth, W .E. and J. C. Wright. 1966. Flora of Montana, Part II. Montana State University. Bozeman. 305 pp.

Boyd, R. J. 1960. An evaluation of spring grazing on alfalfa by deer in western Colorado. Proc. Western Assoc. State Game and Fish Comm. 40:130-147.

Carlsen, J. C. and R. E. Farmes. 1957. Movements of white-tailed deer tagged in Minnesota. J. Wildl. Manage. 21:397-401.

Cochran, W. W. 1980. Wildlife telemetry. Pages 507-520 in S. D. Schenmitz, ed. Wildlife management techniques manual. 4th Ed. The Wildl. Soc., Washington, D. C.

Dixon, W. J., M. B. Brown, L. Engelman, J. W. Frane, M. A. Hill, R. I. Jennrich, J. D. Toporek. 1981. BMDP Statistical Software. University of California Press. Berkely. 725 pp.

Drolet, C. A. 1976. Distribution and movements of white-tailed deer in southern New Brunswick in relation to environmental factors. Can. Field-Nat. 90(2):123-136.

Dusek, G. L. 1980. An inventory of vegetation, wildlife, and recreational resources of the Long Pines, Montana. Montana Dept. Fish, Wildl., and Parks. Final Report. 158 pp.

_____. 1984. Population ecology of white-tailed deer in river bottom habitat in eastern Montana. Pages 75-100 in Montana deer studies. Job Prog. Rep., Montana Dept. Fish, Wildl., and Parks, Fed. Aid Proj. W-120-R-12.

_____. 1985. Population ecology of white-tailed deer in river bottom habitat in eastern Montana. Pages 101-123 in Montana deer studies. Job Prog. Rep., Montana Dept. Fish, Wildl., and Parks, Fed. Aid Proj. W-120-R-12.

_____, and A. K. Wood. 1986. An evaluation of the average activity radius as an estimator of monthly movements of deer. Proc. Mont. Acad. Sci. In Press.

Eberhardt, L. E., E. E. Hanson, and L. L. Cadwell. 1984. Movement and activity patterns of mule deer in the sagebrush-steppe region. J. Mammal. 65(3):404-409.

Eberhardt, K. R., and M. A. Fligner. 1977. A comparison of two tests for equality of proportions. Amer. Statist. 31:151-155.

Egan, J. L. 1960. Some relationships between mule deer and alfalfa production in Powder River County, Montana. Proc. Western Assoc. State Game and Fish Commissioners 40:232-240.

Gavin, T. A., L. H. Suring, P. A. Vohs, Jr., and E. C. Meslow. 1984. Population characteristics, spatial organization, and natural mortality in the Columbian white-tailed deer. Wildl. Monogr. No. 91. 41pp.

Gilbert, F. F. and M. C. Bateman. 1983. Some effects of winter shelter conditions on white-tailed deer, Odocoileus virginianus, fawns. Can. Field-Nat. 97:391-400.

Gladfelter, H. L. 1978. Movement and home range of deer as determined by radio telemetry. Iowa Conserv. Comm. Fed. Aid Project No. W-115-R. 27 pp.

Happe, P. J. 1982. The use of suburban habitats by Columbian black-tailed deer. M.S. Thesis. Oregon State University, Corvallis. 95 pp.

Harrison, J. L. 1958. Range of movement of some Malayan rats. J. Mammal. 39:190-206.

Hayne, D. W. 1949. Calculation of size of home range. J. Mammal. 30:1-17.

Heezen, K. L. and J. R. Tester. 1967. Evaluation of radio-tracking by triangulation with special reference to deer movements. J. Wildl. Manage. 31:125-141.

Holder, T. J. and P. Pescador, Jr. 1976. Soil survey of Dawson County, Montana. U.S. Dept. Agr., Soil Conserv. Serv., and Montana Agr. Exper. Sta. 72 pp.

Hood, R. E. 1971. Seasonal variations in home range, diel movement and activity patterns of white-tailed deer on the Rob and Bessie Welder Wildlife Refuge (San Patricio County, Texas). M.S. Thesis. Texas A & M University, College Station. 173 pp.

Hoskinson, R. L., and L. D. Mech. 1976. White-tailed deer migration and its role in wolf predation. J. Wildl. Manage. 40:429-441.

Inglis, J. M., R. E. Hood, B. A. Brown, C. A. DeYoung. 1979. Home range of white-tailed deer in Texas coastal prarie brushland. J. Mammal. 60:377-389.

Jackson, R. M., M. White, and F. F. Knowlton. 1972. Activity patterns of young white-tailed fawns in south Texas. Ecology 53:262-270.

Jarman, M. V., and P. J. Jarman. 1973. Daily activity of impala. E. Afr. Wildl. J. 11:75-92.

Jennrich, R. I., and F. B. Turner. 1969. Measurement of noncircular home range. J. Theoret. Biol. 22:227-237.

Kammermeyer, K. E., and R. L. Marchinton. 1976. Notes on dispersal of male white-tailed deer. J. Mammal. 57:776-778.

_____. 1977. Seasonal change in circadian activity of radio-monitored deer. J. Wildl. Manage. 41:315-317.

Kamps, G. F. 1969. White-tail and mule deer relationships in the Snowy Mountains of central Montana. M.S. Thesis. Montana State Univ., Bozeman. 59 pp.

Kohn, B. E., and J. J. Mooty. 1971. Summer habitat of white-tailed deer in north-central Minnesota. J. Wildl. Manage. 35:476-487.

Krausman, P. R., and E. D. Ables. 1981. Ecology of the Carmen Mountains white-tailed deer. Scientific Monograph Series No. 15. U.S. Dept. Interior, Nat. Park Service. Washington, D.C. 114 pp.

Larson, T. J., O. J. Rongstad, and F. W. Terbilox. 1978. Movement and habitat use of white-tailed deer in south central Wisconsin. J. Wildl. Manage. 42:113-117.

Leach, R. H. 1982. Summer range ecology of white-tailed deer in the coniferous forests of northwestern Montana. M. S. Thesis. Univ. of Montana, Missoula. 80 pp.

Leuthold, W. 1977. African ungulates. Vol. 8 in D. S. Farner, ed. Zoophysiology and ecology. Springer-Verlag, Heidelberg. 307 pp.

Lindzey, F. G., and E. C. Meslow. 1977. Home range and habitat use by black bears in southwestern Washington. J. Wildl. Manage. 41:413-425.

Marchinton, R. L., and D. H. Hirth. 1984. Behavior. Pages 129-168 in L. K. Halls, ed. White-tailed deer: ecology and management. Stackpole Books, Harrisburg, Pa.

Marchinton, R. L., and L. K. Jeter. 1966. Telemetric study of deer movement ecology in the southeast. Proc. Southeast. Assoc. Game and Fish Comm. 20:189-206.

Marshall, A. D., and R. W. Whittington. 1968. A telemetric study of deer home ranges and behavior of deer during managed hunts. Proc. Southeast. Assoc. Game and Fish Comm. 22:30-46.

Michael, E. D. 1965. Movements of white-tailed deer on the Welder Wildlife Refuge. J. Wildl. Manage. 29:44-52.

_____. 1970. Activity patterns of white-tailed deer in south Texas. Texas Jour. Sci. 21:417-428.

Miller, F. L. 1970. Distribution pattens of black-tailed deer (Odocoileus hemionus columbianus) in relation to environment. J. Mammal. 51:248-260.

Moen, A. N. 1966. Factors affecting the energy exchange and movements of white-tailed deer, western Minnesota. Ph.D. Thesis. Univ. Minnesota, 121 pp.

_____. 1968. Surface temperatures and radiant heat loss from white-tailed deer. J. Wildl. Manage. 32:338-344.

_____. 1978. Seasonal changes in heart rates, activity, metabolism, and forage intake of white-tailed deer. J. Wildl. Manage. 42:715-738.

Mohr, C. O. 1947. Table of equivalent populations of North American small mammals. Amer. Midl. Nat. 37:223-249.

Montana Department of Fish, Wildlife, and Parks. 1985. TELDAY--program to manage and analyze animal telemetry relocation data. 14 pp.

_____. 1984. GEOSCAN user's manual. Software designs, Bozeman, Montana. 22 pp.

Montgomery, G. G. 1963. Nocturnal movements and activity rhythms of white-tailed deer. J. Wildl. Manage. 27:422-427.

Moore, L. G., and R. R. Shields. 1980. Streamflow characteristics of the Yellowstone River Basin, Montana, through 1976. U.S. Geological Survey, Water-Resources Investigations 80-41. ??pp.

Mundinger, J. G. 1978. Population ecology and habitat relationships of white-tailed deer in coniferous forest habitat of northwestern Montana. Pages 5-73 in Montana deer studies. Job. Prog. Rept., Montana Dept. of Fish and Game, Fed. Aid Proj. W-120-R-7.

Nelson, M. E. 1979. Home range location of white-tailed deer. Res. Pap. NC-173. U.S. Dep. Agric. For. Serv., North Cent. For. Exp. Stn., St. Paul, MN. 10pp.

Nelson, M. E., and L. D. Mech. 1981. Deer social organization and wolf predation in northeastern Minnesota. Wildl. Monogr. No. 77. 53 pp.

_____. 1984. Home-range formation and dispersal of deer in northeastern Minnesota. J. Mammal. 65:567-575.

Nie, N. H., C. H. Hull, J. G. Jenkins, K. Seinbrenner, and D. H. Bent. 1975. SPSS: statistical package for the social sciences. McGraw-Hill Book Co., New York. 675 pp.

NOAA. 1983-1984. Climatological data for Montana. National Climatic Data Center, U.S. Dept. of Commer., Asheville, North Carolina.

Nudds, T. D. 1977. Quantifying the vegetative structure of wildlife cover. Wildl. Soc. Bull. 5:113-117.

Ockenfels, R. A., and J. A. Bissonnette. 1984. Temperature-related responses in north-central Oklahoma white-tailed deer. Pages 64-67 in Krausman, P. R., and N. S. Smith, eds. Deer in the southwest: a symposium. School of Renewable Resources, University of Arizona, Tuscon. 131 pp.

Ozoga, J. J., and L. W. Gysel. 1972. Response of white-tailed deer to winter weather. J. Wildl. Manage. 36:892-896.

Ozoga, J. J., and L. J. Verme. 1970. Winter feeding patterns of penned white-tailed deer. J. Wildl. Manage. 34:431-439.

Ozoga, J. J., L. J. Verme, and C. S. Bienz. 1982. Parturition behavior and territoriality in white-tailed deer: impact on neonatal mortality. J. Wildl. Manage. 46:1-11.

Pac, D. F. 1978. An evaluation of a fixed null-peak tracking system for monitoring big game movements in mountainous terrain. Pages 23-32 in Proc. Annu. Meeting Montana Chapter, The Wildlife Society.

Pescador, P., Jr., and L. C. Brockman. 1980. Soil survey of Richland County. Montana. U.S. Dept. Agr., Soil Conserv. Serv., and Montana Agr. Exper. Sta. 72 pp.

Picton, H. D., and R. R. Knight. 1971. A numerical index of winter conditions of use in big game management. Pages 29-38 in A. O. Haugen, ed. Proc. symp. on snow and ice in relation to wildlife and recreation. Iowa State Univ., Ames.

Rongstad, O. J., and J. R. Tester. 1969. Movements and habitat use of white-tailed deer in Minnesota. J. Wildl. Manage. 33:366-379.

Scott, T. G., and C. H. Wasser. 1980. Checklist of North American plants for wildlife biologists. The Wildlife Society, Washington, D.C. 58 pp.

Silver, H., N. F. Colovos, J. B. Holter, H. H. Hayes. 1969. Fasting metabolism of white-tailed deer. J. Wildl. Manage. 33:490-498.

Sparrowe, R. D., and P. F. Springer. 1970. Seasonal activity patterns of white-tailed deer in eastern South Dakota. J. Wildl. Manage. 34:420-431.

Springer, J. T. 1979. Some sources of bias and sampling error in radio triangulation. J. Wildl. Manage. 43:926-935.

Suring, L. H., and P. A. Vohs, Jr. 1979. Habitat use by Columbian white-tailed deer. J. Wildl. Manage. 43:610-619.

Swenson, J. 1978. Intake terrestrial wildlife study, final report. Montana Dept. of Fish and Game. 72 pp.

_____, S. J. Knapp, and H. J. Wentland. 1983. Winter distribution and habitat use by mule deer and white-tailed deer in southeastern Montana. Prairie Nat. 15(3):97-112.

Tebaldi, A. 1982. Effects of deer use on winter wheat and alfalfa production. Wyoming Game and Fish Dept. Fed. Aid Job Final Rep. FW-3-R-26, Job No. 3-17W. 78 pp.

Thomas, J. W., J. G. Teer, and E. A. Walker. 1964. Mobility and home range of white-tailed deer on the Edwards Plateau in Texas. J. Wildl. Manage. 28:463-472.

Tierson, W. C., G. F. Mattfield, R. W. Sage, Jr., and D. F. Behrend. 1985. Seasonal movements and home ranges of white-tailed deer in the Adirondacks. J. Wildl. Manage. 49:760-769.

Vogel, W. O. 1983. The effects of housing developments and agriculture on the ecology of white-tailed deer and mule deer in the Gallatin Valley, Montana. M.S. Thesis. Montana State Univ., Bozeman. 86 pp.

Wood, A. K. In. prep. Ph.D. Thesis. Montana State Univ., Bozeman.

Zagata, M. D., and A. O. Haugen. 1973. Pilot Knob State Park: a winter deer haven. Iowa State J. Res. 47(3):199-217.

_____. 1974. White-tailed deer movement at Pilot Knob State Park, Iowa. Proc. Iowa Acad. Sci. 81(2):76-82.

Zwank, P. J., R. D. Sparrowe, W. R. Porath, and O. Torgerson. 1979. Utilization of threatened bottomland habitats by white-tailed deer. Wildl. Soc. Bull. 7:226-232.

APPENDICES

APPENDIX A - Tables

Table 12. Habitat selection and use based on aerial relocations of radio-collared deer on Elk Island and Intake study areas, 1980-1984 (Dusek, unpubl. data).

COVER TYPE	PERCENT USE	PERCENT AVAIL	Z[a]
ELK ISLAND STUDY AREA (N=1245)			
SANDBAR-SEED	0.24	5.83	-8.418
W-C THICKET	2.65	6.78	-5.796
YCOTTONWOOD	5.22	12.19	-7.517
MCOTTONWOOD	50.36	29.48	16.158
SHRUB	19.92	14.43	5.513
MWILLOW	7.39	1.83	14.637
ASH	10.20	1.92	21.290
SLOUGH	1.20	1.85	-1.702
CANAL	1.85	4.69	-4.740
FLDPGRASS	0.96	17.53	-15.377
INTAKE STUDY AREA (N=782)			
SANDBAR-SEED	0.24	3.48	-4.944
W-C THICKET	1.42	2.83	-2.378
YCOTTONWOOD	5.80	3.81	2.907
MCOTTONWOOD	21.30	23.27	-1.304
SHRUB	6.27	7.53	-1.335
MWILLOW	4.62	4.25	0.513
ASH	46.63	10.88	32.105
FLDPHAY	6.27	9.78	-3.304
FLDPUNCUT	1.18	16.97	-11.763
ASHDRAW	4.85	12.52	-6.481
SHRUBDRAW	1.18	4.31	-4.310

[a] $Z=(U-A)/[A(1-A)/N]^{0.5}$, where U=use, proportion of all radio-locations; A=availability, proportion of total area; N=number of radio-locations.
[b] Selection significant ($p<0.05$) at $|Z|>1.96$.

Table 13. Home range sizes of adult female white-tailed deer reported from studies in various areas and habitats.

MEAN HOME RANGE SIZE(ha) (range or SE)	N[a]	MEAN NO. LOCATIONS (range)	LENGTH OF PERIOD	METHOD[b]	LOCALITY	SOURCE	NOTES
				SUMMER			
MIXED FOREST							
211 (48-210)	14-16	(>5)	--	Min. Area	NE Minnesota	Hoskinson and Mech (1976)	Mostly adult females, some fawns.
16	1	--	5/18-7/8	Mod. Min.	Georgia	Marshall and Whittington (1968)	Female with fawn.
83 (17-114)	5	8	7 weeks	Min. Area	NE Minnesota	Nelson and Mech (1981)	Early Summer
150 (100-199)	2	(74-80)	May-Aug.	Min. Area	NE Minnesota	Nelson (1979)	
76 (68,85)	2	(64,30)	6/11-8/26, 6/23-7/72	Mod. Min.	NC Minnesota	Kohn and Mooty (1971)	
45	<9	--	--	Mod. Min.	Georgia	Kammermeyer and Marchinton (1976)	915 total locations, No. home ranges not known.
221 (SE=19)	64	(>4)	--	Hand drawn	Adirondacks, New York	Tierson et al. (1985)	Summer Min. Area(all deer) =325, hand drawn=219 ha.
84 (65-97)	4	--	29 days (16-55)	Mod. Min.	C & NE Florida	Marchinton and Jeter (1966)	Every 1-3 hrs. over 24 hr. period, 1-2 periods/wk.
AGRICULTURAL-HARDWOOD							
233	1	124	3/22-11/17	Min. Area	Iowa	Gladfelter (1978)	Riverbottom
149 (52-337)	4	6 (4-13)	1-4 mos.	Min. Area	E South Dakota	Sparrowe and Springer (1970)	
326 (42-881)	19	15 (10-19)	--	Min. Area	E Montana	Wood (in prep.)	Prairie-Agricultural
87 (29-165)	27	101 (71-143)	2-3 mos. June-Sep.	Min. Area	E Montana	This Study	Riverbottom
CONIFER FOREST							
311 (<13-829)	8	(>4)	June-Aug.	Min. Area	SE Montana	Dusek (1980)	H.R. of two deer expanded by winter range pts.
71 (10-289)	12	(9-36)	--	Min. Area	NW Montana	Leach (1983)	

Table 13. Continued.

MEAN HOME RANGE SIZE(ha) (range or SE)	N[a]	MEAN NO. LOCATIONS (range)	LENGTH OF PERIOD	METHOD[b]	LOCALITY	SOURCE	NOTES
				WINTER			
MIXED FORESTS							
26	10	(5-30)	--	Min. Area	NE Minnesota	Hoskinson and Mech (1976)	Mostly adult females. 8 of 10 < 34 ha.
132 (SE=18)	45	(>4)	--	Hand-drawn	Adirondack Mtns., NY	Tierson et al. (1985)	
345 (202-484)	5	1160	Dec-Apr 10, Jan-Apr	Grid	NC Minnesota	Rongstad and Tester (1969)	Cedar Swamp
44 (37-50)	2	30	7-8 weeks	Min. Area	NE Minnesota	Nelson and Mech (1981)	
182 (28-546)	5	55 (21-129)	<1-4 mos.	Min. Area	New Brunswick	Drolet (1976)	3 of 5 tracked for one month or less.
AGRICULTURAL-HARDWOOD							
70 (59-81)	2	20 (8-33)	2/5-4/1 12/13-3/19	Mod. Min.	Iowa	Zagata and Haugen (1974)	Riverbottom
634 (112-1370)	17	15 (10-24)	--	Min. Area	E Montana	Wood (In Prep.)	Prairie-Agricultural
182 (84-387)	11	68 (36-90)	Jan-Mar 1-2.5 mos.	Min. Area	E Montana	This study	Riverbottom
93 (26-155)	5	6 (3-14)	20 days to whole season	Min. Area	E South Dakota	Sparrowe and Springer (1970)	Riverbottom
CONIFEROUS FOREST							
78 (<13-181)	6	(>4)	--	Min. Area	SE Montana	Dusek (1980)	Ponderosa Pine Forest
40 (19-83)	17	--	--	Hand Drawn	NW Montana	Mundinger (1978)	
				ANNUAL OR ANY SEASON			
62 (SE=6)	12	--	2.2 mos. avg.	Grid	Texas	Inglis et al. (1979)	7,350 fixes on 25 radioed females. Prairie brushland.
84 (SE=8)	27	--	"	95% Ellipse	"	"	
59 (24-138)	9	31 (5-101)	7.3 mos. avg.	Mod. Min.	Texas	Michael (1965)	Those w/ >20 locations mean =83 ha. Prairie Brushland.
178 (SE=26)	15	(51-249)	>5 months	Min. Area	SC Wisconsin	Larson et al. (1978)	Adult and fawn females trapped. Tamarack swamp and bordering ag. land.
104 (36-317)	18	112 (35-339)	19 months (6-38)	95% Ellipse	Columbia R., Washington	Gavin et al. (1984)	Riverbottom. Conifer woods-grassland.

[a]Number of home ranges or deer.
[b]Min. Area=Minimum convex polygon of Mohr(1947); Mod. Min.=some method of connecting perimeter pts. resulting in a smaller area. All studies but Michael (1965) utilized telemetry, although some also included visual locations.

Table 14. Food habits of white-tailed deer on the lower Yellowstone River during the period March 1980 through Sept. 1985 as determined by rumen content analysis (Dusek, unpubl. data). Only those taxa comprising more than 1% of total volume are listed.

WINTER (Nov.-Mar.)	INTAKE(N=16)	ELK ISLAND(N=23)
BROWSE		
Populus deltoides	88/31.0[a]	78/19.5
Rosa spp.	44/ 2.5	52/ 2.5
Salix spp.	31/ 2.5	26/ 3.0
Symphoricarpos spp.	38/ 3.0	74/11.5
Acer negundo	6/ 2.5	0/0
Total Browse	100/48.0	100/44.5
FORBS (total)	44/ 2.0	57/ 5.5
GRASSES (total)	69/ 4.0	78/ 9.5
AGRICULTURAL CROPS		
Alfalfa	0/0	47/ 3.5
Barley	6/tr	22/ 1.0
Wheat	81/44.0	13/ 3.5
Corn	6/tr	13/ 3.0
Sugar Beets	0/0	61/27.5
Total Ag. Crops	88/45.0	78/39.5

SUMMER (May-Sept.)	All Rumen Samples (N=22)
BROWSE	
Populus deltoides	45/ 1.0
Rosa spp.	91/ 9.5
Salix spp.	55/ 8.0
Symphoricarpos spp.	86/21.5
Shepherdia argentea	23/ 2.5
Prunus virginiana	41/ 1.5
Total Browse	100/49.5
FORBS (total)	100/17.0
GRASSES (total)	50/ 3.0
AGRICULTURAL CROPS	
Alfalfa	73/22.5
Corn	5/ 2.0
Barley	9/ 5.0
Total Ag. Crops	73/29.5

[a] Percent Occurrence/Percent Volume
[b] Primarily August and September.

APPENDIX B - Figures

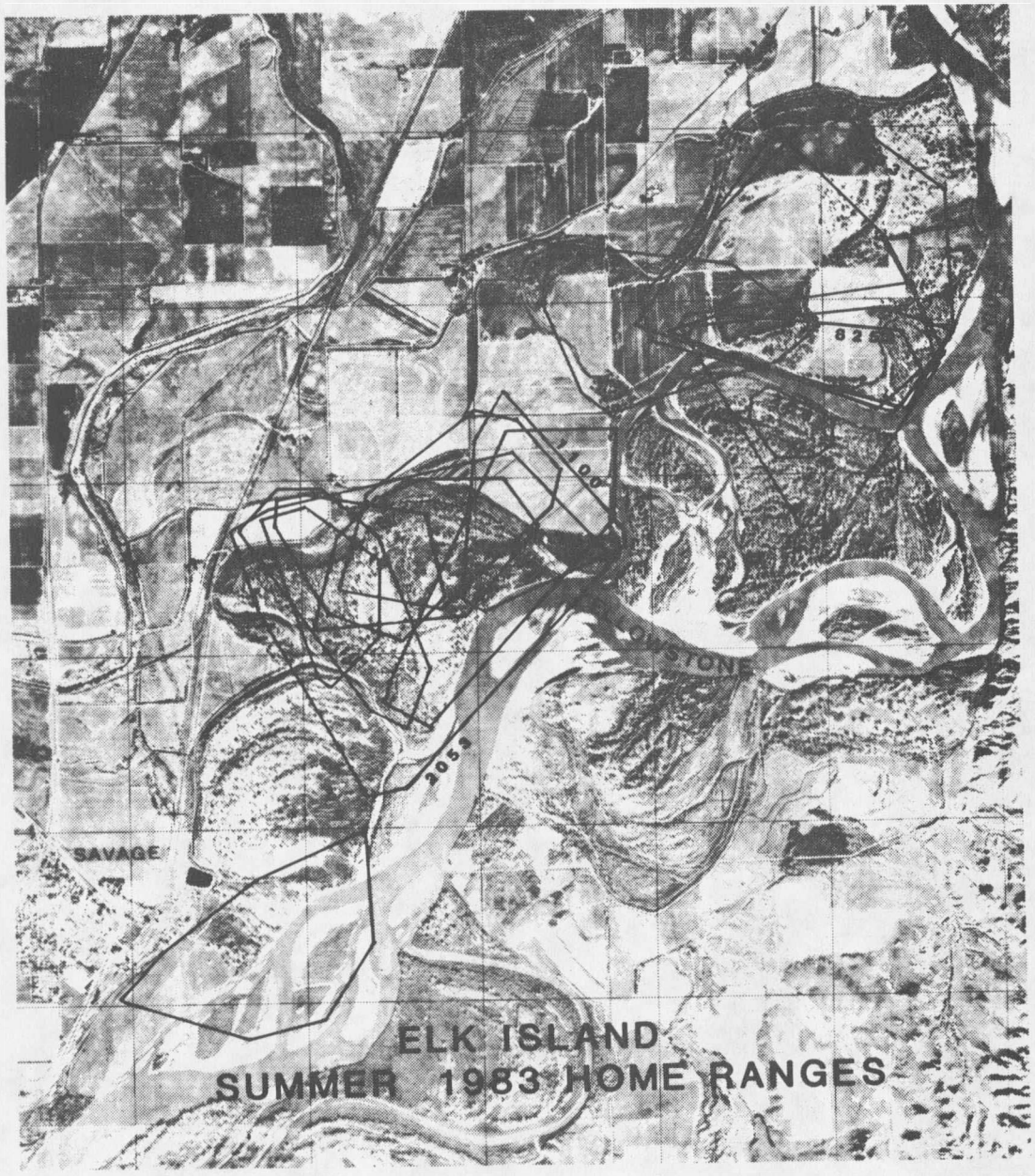


Figure 28. Minimum convex polygon home range boundaries of radio-collared deer at Elk Island during summer 1983.



Figure 29. Minimum convex polygon home range boundaries of radio-collared deer at Elk Island during winter 1984.

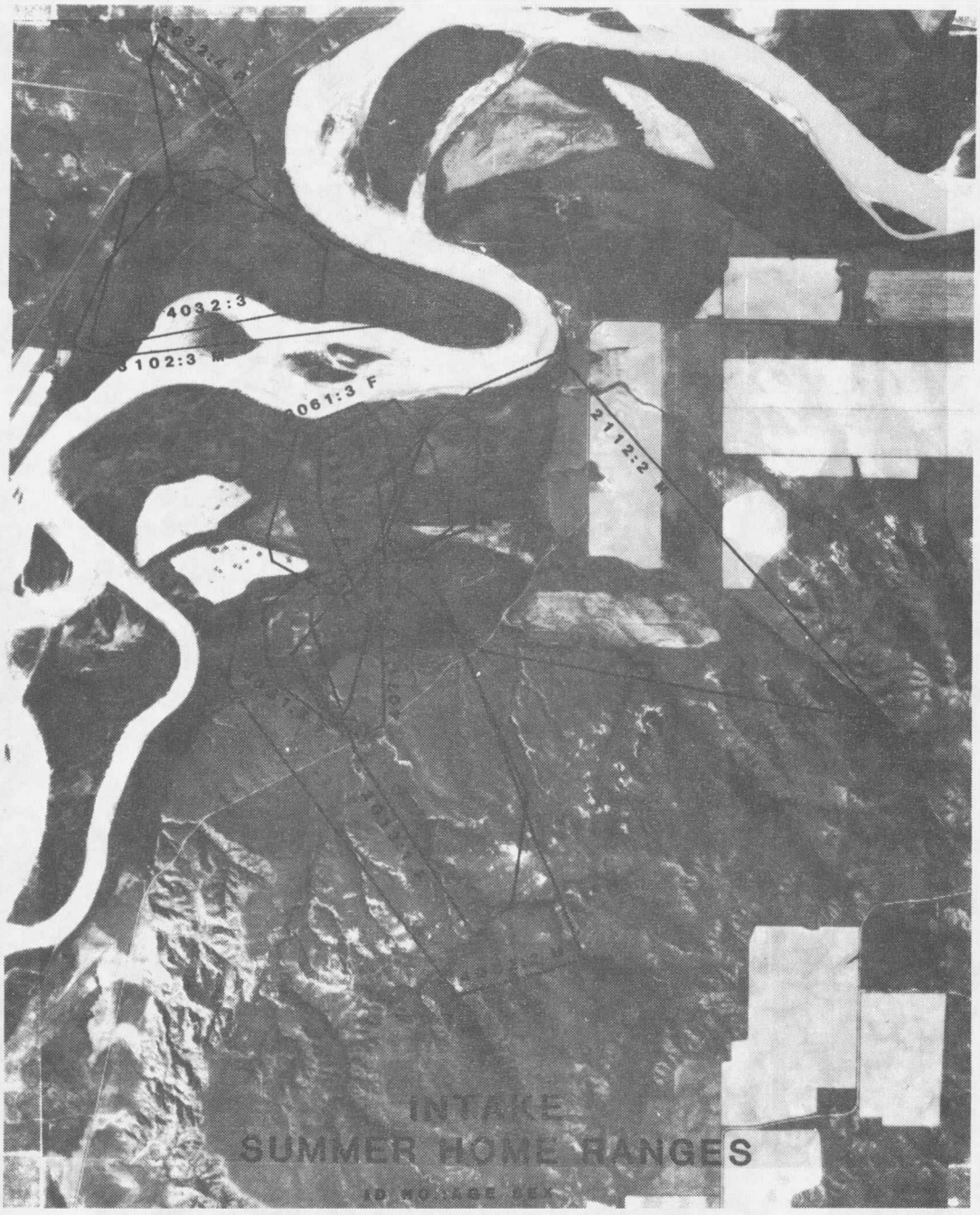


Figure 30. Minimum convex polygon home range boundaries of radio-collared deer at Intake during summer 1983.



Figure 31. Minimum convex polygon home range boundaries of radio-collared deer at Intake during winter 1984.

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