Summer habitat use of white-tailed deer on the Tally Lake Ranger District, Flathead National Forest
by John Thomas Morgan

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

Abstract:
Summer habitat relationships of white-tailed deer (Odocoileus virginianus) were studied on the Tally Lake Ranger District of the Flathead National Forest in northwestern Montana during 1989-1991. Macro-habitat selection patterns were analyzed using 2,009 relocations of radio-collared deer obtained through aerial surveys while deer occupied summer ranges. An additional 463 relocations provided information on migration routes and accessory areas. Micro-habitat selection was investigated in the Star Meadows and Corduroy Creek complexes through 18 diel telemetry sessions and a remote camera survey in Corduroy Creek. The geographic information system programs ERDAS and EPPL7 were used to create 8 habitat component data layers including: slope, aspect, elevation, vegetation, riparian areas, and roads (all, open, and closed).

Deer habitat selection at the macro-level appeared to be influenced by locations of second and third order streams and associated riparian meadow complexes. Deer initially selected sites close to riparian habitat, between 1,159 and 1,524 m, containing naturally occurring grass/forb and shrub/hardwood vegetation. Later in the season deer preferences shifted to slightly higher elevations containing more open and closed pole/immature timber. In general, early serai and mature vegetation were avoided. Roads appeared to play little role in whitetail habitat selection except for an avoidance of sites within 100 m of a road. Aspect and slope also had little impact on habitat selection. Deer habitat selection at the micro-level was less specific. Once deer selected their summer home range, use of individual habitat variables within this area apparently was less important.

Forest management on the Tally Lake District should aim to preserve riparian complexes, including mesic bottomlands and associated upland pole/immature timber within 750 m of riparian sites. Cutting units occurring above 1,646 m or below 1,159 m and/or on westerly to northerly aspects would have less impact on deer. Stands should be allowed to return to the pole/immature stage before adjacent cuts are made.

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A thesis submitted in partial fulfillment
of the requirements for the degree

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Doctor of Philosophy

in

Biological Sciences

MONTANA STATE UNIVERSITY
Bozeman, Montana

April 1993

APPROVAL

of a thesis submitted by

John Thomas Morgan

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

April 12, 1993 — Date

[signature] — Chairperson, Graduate Committee

Approved for the Major Department

12 April 1993 — Date

Robert E. Moore — Head, Major Department

Approved for the College of Graduate Studies

4/14/93 — Date

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Date 4-9-93

ACKNOWLEDGEMENTS

Accomplishing a study of this magnitude does not occur without the assistance of many groups and individuals. I would like to acknowledge the Montana Department of Fish, Wildlife, and Parks (MDFWP); the U.S. Forest Service (USFS); and the Department of Biology, Fish and Wildlife Management Program at Montana State University for logistical and financial support.

Specifically at the university I would like to thank my graduate committee Drs. Richard Mackie, Robert Eng, Harold Picton, Robert White, Carl Wambolt, and Jim Johnson for reviewing the manuscript and many thought provoking questions. Dr. Mackie's involvement throughout the project from initial inception, to assistance with data collection and final write-up was invaluable.

Gary Dusek (MDFWP) was an integral part of every aspect of this project. His assistance with study design, data collection, and manuscript review, as well as his friendship were greatly appreciated. Also with Fish, Wildlife, and Parks I would like to acknowledge Shawn Riley, Dave Pac, Ken Hamlin, Terry Lonner, Harvey Nyberg, and Jim Cross for assistance in collection of 24-hr data.

I would like to acknowledge Reed Kuennen's (USFS) efforts in initiation of the project, data collection, and manuscript review. Also with the Forest Service I would like to thank Amy Jacobs and many others for collection of 24-hr data, as well as, Don Long, and Don Krogstat for GIS assistance.

I also would like to thank the many other individuals who assisted in various ways with this project. This list includes Eagle Aviation pilots: Dave Bright, Dick Brady, and David Hoerner; landowners and residents within and around the study area, particularly Larry Rabadoo, manager of the Star Meadows Ranch; fellow students from MSU: Bret Stansberry, Matt Reid, and Jim Williams; and the many volunteers who assisted with collection of 24-hr data.

A particular note of thanks needs to go out to Leonard Howke, a gentleman who volunteered hundreds of hours toward this project. His assistance in collection of 24-hr data, trapping, camera surveys, vegetation work, and countless other tasks were invaluble to the project. His friendship to myself and my family was greatly appreciated.

Last, I would like to thank my wife Cathleen and son Christopher. Cathleen has endured many lean years while I pursued my degrees, her love and devotion are greatly appreciated. Christopher came into this world at the very end of the study but he made me realize that this career I have chosen is not only for me but for him.

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ABSTRACT

Summer habitat relationships of white-tailed deer (Odocoileus virginianus) were studied on the Tally Lake Ranger District of the Flathead National Forest in northwestern Montana during 1989-1991. Macro-habitat selection patterns were analyzed using 2,009 relocations of radio-collared deer obtained through aerial surveys while deer occupied summer ranges. An additional 463 relocations provided information on migration routes and accessory areas. Micro-habitat selection was investigated in the Star Meadows and Corduroy Creek complexes through 18 diel telemetry sessions and a remote camera survey in Corduroy Creek. The geographic information system programs ERDAS and EPPL7 were used to create 8 habitat component data layers including: slope, aspect, elevation, vegetation, riparian areas, and roads (all, open, and closed).

Deer habitat selection at the macro-level appeared to be influenced by locations of second and third order streams and associated riparian meadow complexes. Deer initially selected sites close to riparian habitat, between 1,159 and 1,524 m, containing naturally occurring grass/forb and shrub/hardwood vegetation. Later in the season deer preferences shifted to slightly higher elevations containing more open and closed pole/immature timber. In general, early seral and mature vegetation were avoided. Roads appeared to play little role in whitetail habitat selection except for an avoidance of sites within 100 m of a road. Aspect and slope also had little impact on habitat selection. Deer habitat selection at the micro-level was less specific. Once deer selected their summer home range, use of individual habitat variables within this area apparently was less important.

Forest management on the Tally Lake District should aim to preserve riparian complexes, including mesic bottomlands and associated upland pole/immature timber within 750 m of riparian sites. Cutting units occurring above 1,646 m or below 1,159 m and/or on westerly to northerly aspects would have less impact on deer. Stands should be allowed to return to the pole/immature stage before adjacent cuts are made.

INTRODUCTION

White-tailed deer (Odocoileus virginianus) are the most widely distributed and abundant of North American big game mammals (Smith and Coggin 1984). Their ability to exist in a diversity of habitats, under a variety of conditions, and in the presence of humans has allowed whitetail populations to expand and occupy much of North America. Whitetails also are one of the most studied wildlife species in the country as indicated by the numerous texts, monographs, and journal articles on the species (Halls 1984).

Despite this abundance of information, knowledge of whitetail ecology and requirements in specific habitats is often lacking. A widely applicable and generally acceptable framework of knowledge and understanding of habitat relationships has yet to be developed. Thus, Caughley (1980), claimed white-tailed deer were one of the most studied and least understood of all animals.

In Montana, whitetail populations are distributed throughout the mountains and plains in a variety of habitats (Allen 1971). The Dakota subspecies (Odocoileus virginianus dacotensis), found east of the Continental Divide, primarily inhabits river bottoms (Dusek et al. 1989), a few isolated mountainous areas (Martinka 1968, Kamps 1969), and to a limited extent prairie habitats (Swenson et al. 1983, Wood et al. 1989). However, whitetails reach their greatest concentrations west of the divide, particularly in the heavily timbered northwest counties (Allen 1971) where the Northwest subspecies (O. v. ochrourus) has been studied in the Swan River Valley (Hildebrand 1971, Leach 1982, Mundinger 1984), the Clearwater River Valley (Janke 1977, Slott 1979), the Thompson River Valley (Hicks 1990), along the North Fork of the Flathead River (Jenkins 1985, Krahmer 1989, Tucker 1991, Rachael 1992), and in the Fisher River/Wolf Creek drainages (Zajanc 1948, Schmautz 1949, Schmautz and Zajanc 1949 and 1951, Blair 1954-55, Neils et al. 1955, Firebaugh et al. 1975). These northwest white-tailed deer populations are somewhat unique in their close yearlong association with relatively dense, often mature coniferous forest habitats.

Many whitetail studies in northwestern Montana have concentrated on winter habitat relationships. Generally, these have emphasized deer use of southerly aspects which are often clear of snow (Firebaugh et al. 1975, Janke 1977, Slott 1979), mature timber in riparian and/or upland areas which intercepts snow (Hildebrand 1971, Mundinger 1984, Hicks 1990), and timbered areas interspersed with small openings providing edge (Krahmer 1989).

However, whitetails in northwestern Montana are generally migratory and often spend up to 9 months of the year on summer ranges and/or transitional and accessory areas between summer and winter range. Summer habitat must not only meet the general food, water, and cover requirements for adult deer throughout the season but must also provide for specific seasonal needs. For instance, adult females require quality forage throughout this season for gestation, lactation, and recovery. Fawns need hiding cover early, and quality forage later in the summer to meet their growth and survival needs. Also important is security cover from predators and during hunting season, which is ongoing while deer occupy summer ranges. And last, high quality forage in abundance is needed for maintaining physical condition and building fat reserves prior to fall migration and the onset of winter.

Summer use of coniferous forest by white-tailed deer in northwestern Montana was previously reported by Leach (1982) in the Swan River Valley, Slott (1979) along the Clearwater River, and Krahmer (1989) and Rachael (1992) along the North Fork of the Flathead River. All studies showed an apparent preference by whitetails for riparian areas and moist habitats. In managed forests small cutting units providing a diverse vegetative structure also were noted as important to deer (Leach 1982, Krahmer 1989).

The Salish Mountains, which include the Tally Lake Ranger District of the Flathead National Forest northwest of Kalispell, also provide important whitetail summer range (Mundinger and Riley 1982, 1983). Extensive timber harvesting and road building on the district could potentially disrupt traditional patterns of whitetail activity and habitat use on summer ranges and during migration to wintering areas.

This study was initiated to investigate habitat use and selection patterns at the macro- and micro-habitat levels by whitetails on summer and transitional ranges on the Tally Lake District. Research was conducted from spring through fall 1989-1991. Specific objectives were (1) to determine use and importance of various seral stages of coniferous forest and riparian communities, (2) to determine how spatial distribution and organization of these communities to form habitat complexes influences distribution and abundance of deer, and (3) to determine the importance of other habitat features including topographic, climatic, and land use components.

STUDY AREA

The Tally Lake Ranger District (TLRD) of the Flathead National Forest (FNF) lies in the northern portion of the Salish Mountains in northwestern Montana at 48° 30′ north latitude 114° 30′ west longitude (Fig. 1). The study area, as used for macro-habitat analysis, was defined as the area within the district containing all summer and transitional relocations of radio-marked deer from January 1989 through December 1991. This included approximately that portion of the district north of Ashley Mountain, east of the Flathead/Lincoln County line, south of Martin Falls, and west of Tally Lake. The district is approximately 926 km^2 (USDA For. Serv. 1985). The study area consisted of approximately 445 km^2 of Forest Service land and 35 km^2 of private land within and adjacent to the district boundary.

Geologically, parent material throughout much of northwestern Montana consists of fine-grained metamorphic rocks from the Belt Super Group of the late Precambrian age (Johns 1970, Montagne et al. 1982). The northern Salish Mountains were created by faulting and folding during the late Cretaceous to early Tertiary ages and are characterized by north-northwest trending folds in the Belt sediments. The Cordilleran ice sheet covered much of northwestern Montana moving into the northern and western portions of the Tally Lake District. Also, 30-45 cm of volcanic ash covered northwestern Montana. The metamorphic parent material,

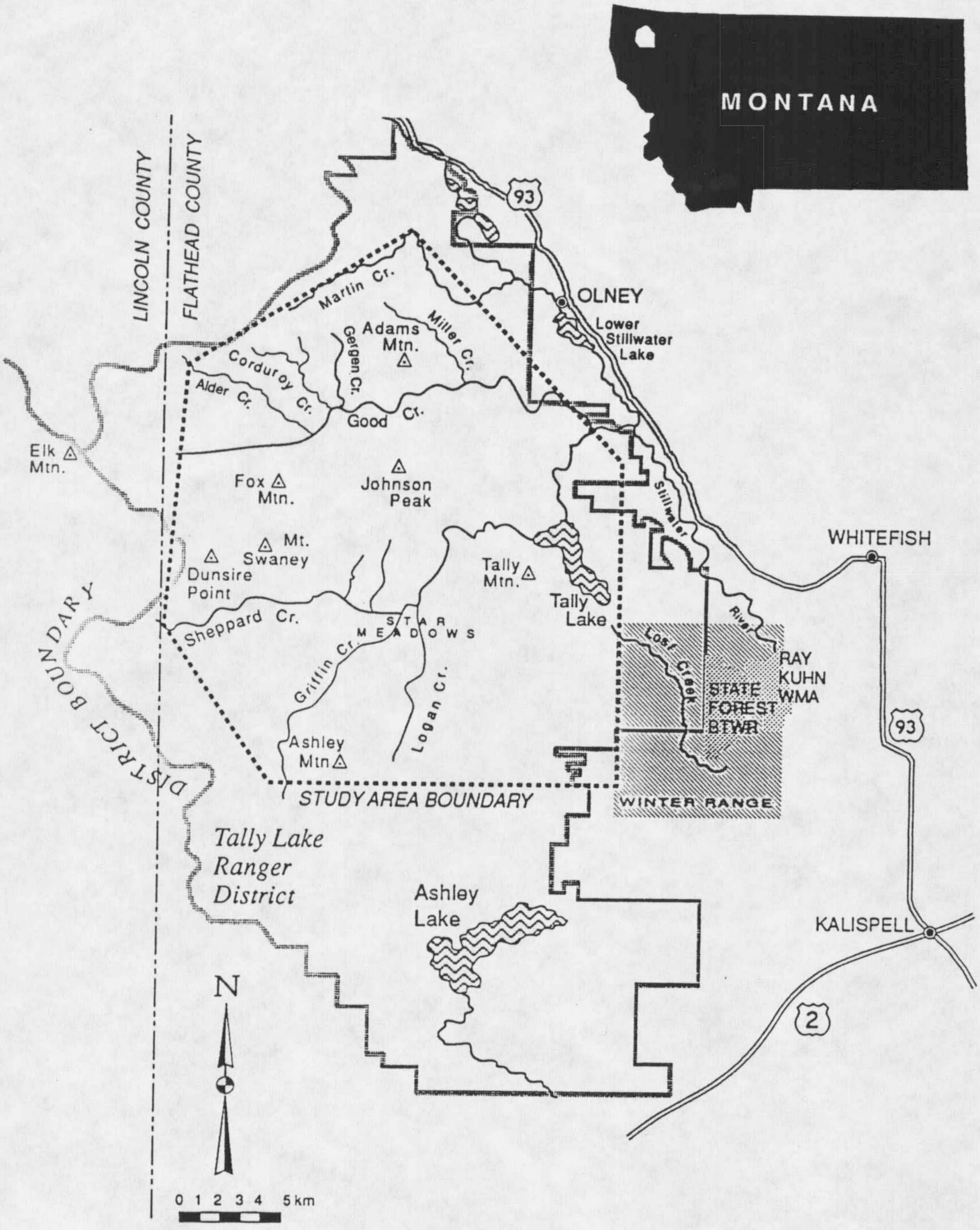

Figure 1. White-tailed deer study area within the Tally Lake Ranger District, Flathead National Forest.

glacial till, volcanic ash, cool temperatures, and relatively high precipitation have resulted in deep fertile soils from the Alfisol and Inceptisol orders which are typically found under coniferous canopies (Montagne et al. 1982).

Topographically, the study area lies between 915 m at the confluence of Good and Logan Creeks in the northeast and 1,935 m at the summit of Mount Swaney (Fig 2). The majority of the study area (60%) lies between 1,281 and 1,646 m. Because the northwestern edge of the district terminates at the highest elevations, easterly and southerly aspects prevail slightly over northern and western aspects. Slope is fairly moderate throughout the study area with the majority (53.5%) falling between 6 and 25%.

The study area drains to the northeast into the Stillwater River via Martin, Good, and Logan Creeks (Fig. 1). The northern portion is characterized by relatively low ridges (1,500 m) of moderate slope (< 25%) separated by numerous first and second order drainages flowing into Martin and Good Creeks.

The central portion of the district is separated from the north by the 1,585-1,935 m Dunsire Point/Johnson Peak ridge line (Fig. 1). Star Meadows, at 1,219 m, is the primary feature in the central portion and is formed by the confluence of Sheppard, Griffin, and Logan Creeks,

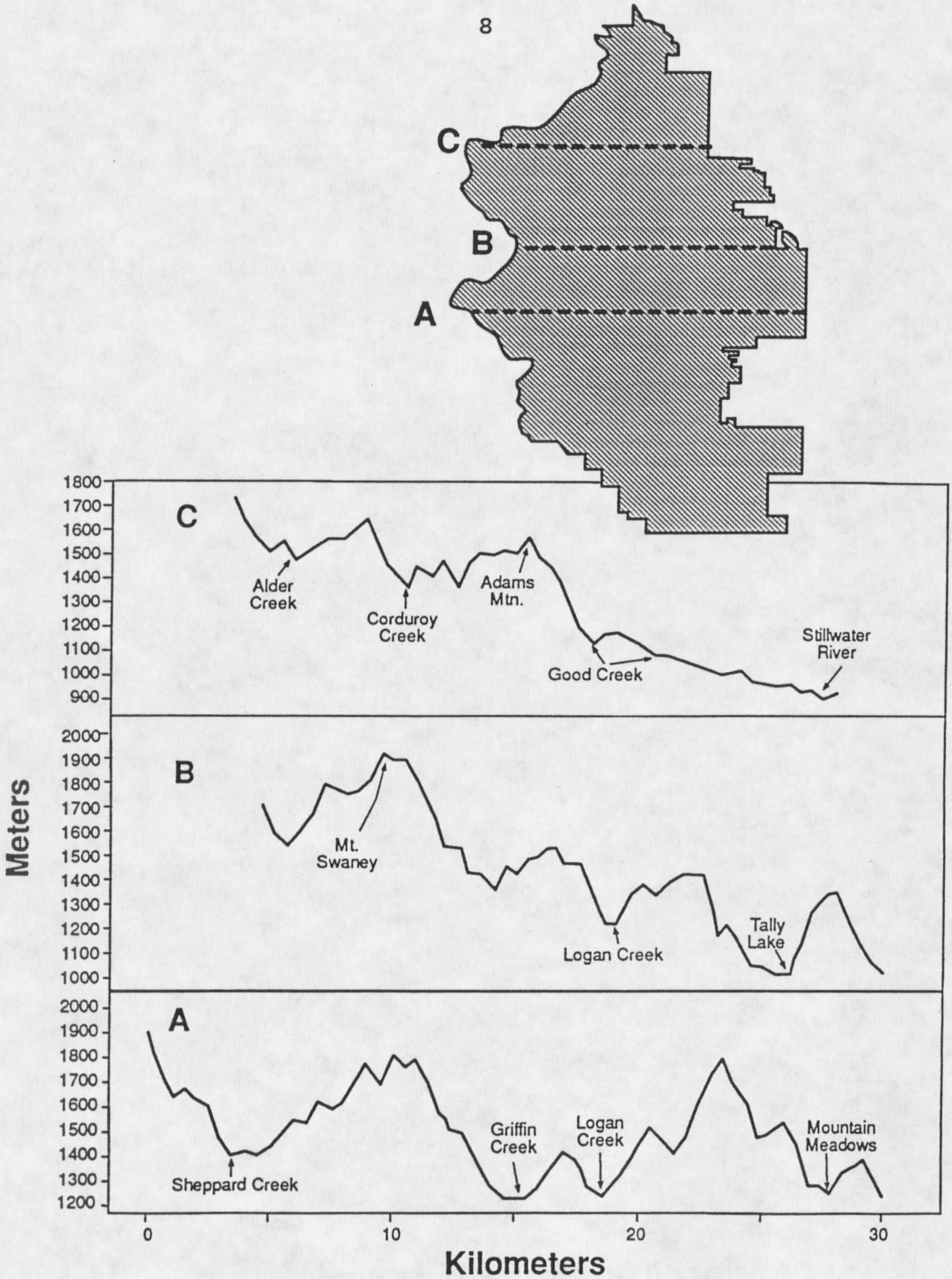

Figure 2. Cross-section of northern, central, and southern portions of the study area showing elevational change.

with Logan Creek emptying the meadow to the northeast into Tally Lake.

Climate in northwestern Montana is strongly influenced by moisture-ladened air from the Pacific northwest. The area is characterized by cool winters and warm summers with frequent cloudy days much of the year except mid-summer.

Longterm and daily climatic data were available from the weather station at Olney, Montana on the northern edge of the study area (Appendix Table 28). Annual precipitation averages 59.4 cm of which approximately half falls as snow averaging 323.5 cm. Maximum and minimum temperatures average 27.2 C during July and August and -11.1 C during January. During the 3 years of the study, annual and summer mean daily maximum and minimum temperatures, as well as mean monthly precipitation were not significantly different from longterm averages (t-tests, $P < 0.05$).

The area is 94% forestland with only a few natural grass and shrub openings. The Abies lasiocarpa/Clintonia uniflora habitat type predominates (Pfister et al. 1977). However, habitat alteration through logging, cattle grazing, and natural fires has produced a forest which is now a mosaic of mature mixed conifer, large stands of lodgepole pine (Pinus contorta), clearcuts in various stages of regrowth, riparian areas, and natural willow/grass meadows.

Major overstory species include lodgepole pine, Douglas-fir (Pseudotsuga menziesii), subalpine fir (Abies lasiocarpa), and western larch (Larix occidentalis). Common grass, forb, and shrub species include pine grass (Calamagrostis rubescens), timothy (Phleum pratense), strawberry (Fragaria virginiana), yarrow (Achillea millefolium), arnica (Arnica spp.), fireweed (Epilobium angustifolium), beargrass (Xerophyllum tenax), pachistima (Pachistima myrsinites), prince's pine (Chimaphila umbellata), spiraea (Spiraea densiflora), rose (Rosa gymnocarpa), Oregon grape (Berberis repens), twinflower (Linnaea borealis), buffaloberry (Shepherdia canadensis), alder (Alnus spp.), willow (Salix spp.), snowberry (Symphoricarpus albus), and huckleberry (Vaccinium spp.).

The study area included 2 specific areas, or microhabitat complexes, that supported large numbers of deer throughout summer; the Star Meadows complex and the Alder-Corduroy-Gergen-Good Creek complex located in the central and northern portions of the district, respectively. Star Meadows is approximately 65 km^2, of which one-third was riparian bottomland consisting of a mixture of large open meadowlands, willows, and scattered timber. Slopes within the complex comprised a mosaic of timber and cutover areas.

The Alder-Corduroy-Gergen-Good Creek complex was approximately 32 km^2. In contrast to Star Meadows this area consisted primarily of large stands of 60-70 year old lodgepole pine, a remnant of large fires which occurred during the early part of this century. This complex lacks large meadows but small wet meadows were associated with each drainage.

Timber production was the primary land use on the study area. Road development, in association with timber production, occurred throughout the area such that over 40% of available habitat was within 100 m of a road.

Cattle grazing occurred on private land around Star Meadows during snow free periods and on Forest Service land just north of Star Meadows during July-September. Private residences primarily occurred around Star Meadows and along Good Creek as well as on the northern and eastern periphery of the study area.

Tally Lake was the primary recreation point on the district attracting campers, boaters, and anglers. Sylvia Lake and some of the larger streams provided additional fishing opportunities. Hiking trails were present on the district but received limited use. Firewood cutting occurred yearlong but increased during fall.

The study area lies within hunting district 102. The proximity to Kalispell and other communities, as well as abundant game, make the area popular for hunting. While white-tailed deer were the most abundant big game species, mule deer (<u>Odocoileus</u> <u>hemionus</u>), elk (<u>Cervus</u> <u>elaphus</u>), moose, (<u>Alces</u> <u>alces</u>), and black bear (<u>Ursus</u> <u>americanus</u>) also occurred on the area. In addition to black bear, mountain lions (<u>Felis</u> <u>concolor</u>) and coyotes (<u>Canis</u> <u>latrans</u>) are predators common to the area. Wolves (Canus lupus) are extending their range in northwest Montana and have been sighted on the Tally Lake District. There also have been a few sightings of grizzly bears (Ursus arctos); however, like wolves, this species is a rare visitor.

METHODS

Data Collection

Animal Component

Collection of data on white-tailed deer essentially involved monitoring individually radio-collared animals which summered on the Tally Lake District. Three hundred eighty-nine deer were captured by Montana Department of Fish, Wildlife, and Parks personnel and myself using Clover traps (Clover 1954) during both winter (1988-1991) and spring-summer (1989-1991) periods. Female deer trapped included 139 adults, 38 yearlings, and 75 fawns. Male deer trapped included 22 adults, 33 yearlings, and 82 fawns.

Ninety-one percent (356) of all deer captured were on winter range. While summer trapping contributed only a fraction of the total trapping effort, trap efficiency (number of deer captured/trap night) was similar to winter trapping. Also, summer trapping greatly added to samples of radio-collared deer available for micro-habitat analysis in the Star Meadows and Corduroy Creek complexes. Specific details on trapping techniques and the relationship between winter and summer trapping have been reported previously (Morgan and Dusek 1992).

For each deer captured, sex and age, assigned through mandibular tooth wear and replacement (Severinghaus 1949), were recorded. Every deer was marked with an individually numbered metal ear tag and a uniquely colored neckband. One hundred deer (26% of total) were equipped with radio transmitters (approximately half with mortality sensors) in the 150-152 MHz range (Telonics Inc., Mesa, Ariz.).

Fifty eight (79%) of 73 deer radio-collared on winter range migrated north and northwest to summer on the Tally Lake District. Relocations of these deer were used to assess macro-habitat use patterns. In addition, 27 deer were radio-equipped on summer range and 1 deer was trapped on a neighboring Forest Service district (part of another study) but summered on the Tally Lake District. Relocations of these deer were added to the winter-trapped sample to assess micro-habitat use patterns in the Star Meadows and Corduroy Creek areas. Hence, 86 radio-collared deer were present on the district during all or part of the 3 field seasons and provided data for this study (Appendix Table 29).

The 86 radio-equipped deer were relocated 3,299 times through aerial telemetry surveys conducted with a Cessna 180 or 182 equipped with 2 element H-antennas mounted on the wing struts. Visual confirmation of specific deer was rarely attempted due to the timbered habitat of the study area and difficulty in identifying collar colors and patterns from the air. Each deer was located 2-3 times per month between 0500 and 1900 hrs mountain standard time (MST) with the majority being between 0700 and 1000 hrs.

Locations were marked on topographic maps or air photos and assigned a coordinate via the Universal Transverse Mercator System (UTM).

Locations were recorded as summer, winter, transitional, or accessory. Winter and summer range locations were easy to determine as a deer would generally remain in the same area for several months. Eight hundred twenty seven and 2,009 winter and summer relocations were recorded, respectively. Fifteen hundred and ninety nine of 2,009 summer relocations were of winter-trapped deer and were used to assess macro-habitat use. Five hundred and fifty one and 560 of 2,009 summer relocations were from deer in the Corduroy Creek and Star Meadows complexes, respectively, and were used to assess micro-habitat use.

Transitional locations were those occurring during spring or fall migration wherein a deer usually remained in an area for only 1 relocation. Accessory areas were those in which a deer was found at least 2-3 times but were neither summer or winter areas. Two hundred twenty and 243 transitional and accessory relocations were recorded, respectively.

Accuracy of aerial telemetry was checked through test transmitters placed at known locations by another individual familiar with the study area and through locations of dead animals or dropped transmitters. Relocations of test transmitters (N=13) averaged 104 m from the actual location.

An additional 31 and 15 relocations were obtained through direct observations and remote camera surveys, respectively, and were used along with aerial data in calculating home ranges. Composite and individual summer home ranges and activity centers were calculated using program TELEM (Coleman and Jones 1988).

Diel monitoring by triangulation from 3 ground-based stations was conducted in the Star Meadows and Corduroy Creek areas to assess micro-habitat use patterns. Truck-mounted null antennae arrays were used to locate deer over a 24-hr period. A beacon transmitter was set in a known location. Each station recorded the azimuth of each deer in the area hourly as degrees from the beacon. After the session each relocation was adjusted to indicate degrees from true north. The program TELEM (Coleman and Jones 1988) was used to triangulate the angles and indicate the location of the deer. Accuracy of the system was checked by placing 1 to 3 test transmitters at known locations during each session (White and Garrott 1990).

Diel monitoring was conducted monthly in each area during July and August 1989, June-September 1990, and July 1991. Monitoring was conducted only in Star Meadows during April 1990 and only in Corduroy Creek during May 1990 and August and September 1991.

Remote camera units developed to detect and monitor grizzly bears (Mace et al. 1990) also were applied to this study. Design and use of the camera system has been described previously (Mace et al. 1990, Dusek and Mace 1991). Cameras can be used to assess whitetail population size, age and sex structure, and habitat use. However, only summer habitat use results are discussed. Cameras were placed randomly at the macro-level, i.e., drainage or quadrat. At the micro-level, cameras were placed along active deer trails. All cameras were placed in operation within 1-3 days of each other and removed within 1-3 days. Hence, all cameras collected data for approximately the same time period. Sites were visited after 1 week to check film. After 2-3 weeks cameras were removed from the sites and all film was developed. Photographs were examined for animal species present, number of individuals, and sex and age class when possible. Surveys were conducted in the Star Meadows area during May 1990, in Griffin Creek alone during August and September 1990, and in the Corduroy Creek drainage during July-August 1991.

The 1990 sessions were experimental to determine if sufficient numbers of deer, dispersed on summer range, could be recorded by cameras to obtain useful data. During these sessions photographs of radio-collared deer were assigned a UTM coordinate and included in the relocation database for use in home range calculations and micro-habitat use.

The experimental design of the 1991 session at Corduroy Creek was described previously (Dusek and Morgan In press).

For this session cameras were deployed to maximize the number of radio-collared deer photographed for population estimation. It was known from aerial relocations that approximately half of the radio-collared deer in the drainage were below 1400 m, 35% were between 1400 and 1525 m, and 15% above 1525 m. Hence, the drainage was divided into 25 ha quadrats and 20 cameras were distributed randomly in similar proportions to deer distribution.

A secondary objective was to use the camera system to compliment habitat use data obtained through radiotelemetry. The deployment of cameras described above was not necessarily ideal to meet this objective. A sampling scheme distributing cameras based on area of available habitat would have been better. However, it would be difficult to distribute 20 cameras equally among the 6 habitat components described.

Food habits were investigated during 1990 and 1991. Deer collections were made twice monthly from April-October as authorized by the MDFW&P Commission. A 1-quart sample of rumen material was taken from each animal and fixed with 1% formalin. Samples were rinsed and sorted macroscopically at the MDFW&P Wildlife Research Lab in Bozeman. Identification was made by comparing large fragments with known plant specimens. Percent occurrence was noted for browse and forbs to the species level when possible. Grass-like plants were simply noted as such. Percent volume was measured by water displacement in a graduated cylinder.

Habitat Component

Eight individual geographic information system (GIS) layers were developed for the study area, each containing 7-9 specific classes (Table 1). Data layers were originally created at the Flathead National Forest GIS lab (Kalispell, Mt.) with the aid of Landsat imagery, digitized maps, and the computer program ERDAS version 7.5 (ERDAS, Atlanta, Ga. 1990). Layers were modified using program EPPL7 (EPPL7, Minnesota DNR). All layers were created using a pixel size of 50 m.

Table 1. Geographic information system data layers and classes.

Layer	Classes
Elevation (m)	915-1158, 1159-1280, 1281-1402, 1403-1524, 1525-1646, 1647-1768, 1769+
Slope (%)	0-5, 6-10, 11-15, 16-20, 21-25, 26-35, 36-50, 51+
Aspect	N, NE, E, SE, S, SW, W, NW, No aspect
Vegetation	Grass/forb natural, Grass/forb artificial, Shrub/hardwood, Seedling/sapling, Sapling/pole, Pole/immature open, Pole/immature/closed, Mature open, Mature closed
Riparian features, All roads, Open roads, and Closed roads (distance from in meters)	0-100, 100-200, 200-300, 300-400, 400-500, 500-750,750-1000, 1000+

The vegetation layer was developed using the Landsat TM image #041-026 from 28 August 1988 (EOSAT Inc., Lanham, Md.). The image recorded the district in 7 bands (3 visual, 3 near infrared, and 1 thermal infrared) with a spectral resolution of 256 classes. Combining spectral classes was required because many of the original 256 classes were vegetatively similar.

Initially, an unsupervised spectral classification system using spectral bands 3, 4, and 7 was employed to reduce the 256 spectral classes to 60. These 60 classes were then grouped into 10 based on crown closure, topographic position, reflectance, and general vegetative condition. However, because there was overlap among the 10 groups, further analysis was needed. The district landtype layer was used to group terrain features based on slope, aspect, and general substrate into 9 landtype associations. The 10 spectral groups were then sorted by the 9 landtypes yielding 90 classes. These 90 classes were then regrouped using information from aerial photographs, previously conducted ground surveys, or surveys which were carried out for the sole purpose of verifying GIS information.

Vegetation classes were defined by the U. S. Forest Service (Hodgeboon and Long, Flathead National Forest, unpublished memo) with some modifications. Basically, grass/forb and shrub/hardwood layers were lands containing less than 10% coniferous trees. Timbered areas were defined by DBH class and age: seedling=0-2.3 cm and/or 0-15 yrs, sapling=2.4-12.6 cm and/or 16-30 yrs, pole/immature=12.7-22.8 cm and/or 31-70 yrs, and mature 22.8+ cm and/or 71+ yrs.

Modifications to the vegetation layer for this study included combining and dividing types. Grass/forb areas were divided as either artificial or natural. Artificial grass/forb areas were those created through logging or road building. Natural grass/forb areas included riparian meadows and naturally burned sites. Because a 1988 satellite image was used, it was anticipated that some regrowth may have occurred, moving stands into later seral classes. Hence, seedling/sapling and sapling/pole classes were created. Vegetation in these 2 classes was generally of the smaller type, i.e., seedling and sapling, respectively. However, it was acknowledged that some larger plants also may be present. Pole/immature and mature classes were split as open or closed canopy based on 70% canopy closure. Corrections were made for areas logged since 1988 by combining the GIS layer for forest activity with the completed vegetation layer. Areas on the vegetation layer within sites of recent logging activity were changed to artificial grass/forb if not already in that class.

Topographic layers were developed from the digital elevation model (DEM) created by the Geometronics Service Center, a branch of the USFS at Salt Lake City, Utah. Topographic maps were scanned into the computer and each pixel was assigned a value for slope (percent), aspect (degree), and elevation (feet converted to meters).

Riparian and road layers were developed in the Flathead National Forest computer lab by digitizing from USGS 7.5′ topographic maps using a Numonics digitizing pad and the computer program JELLY (USFS Region 1, Missoula, MT). Additional roads created since the last update were included by changing the GIS layer.

Habitat information also was obtained through ground truthing 50 randomly selected aerial relocations of radio-collared deer during both 1990 and 1991. Each site was identified using aerial photos and topographic maps. Topography, plant species present, an estimate of relative abundance, as well as vegetational cover were recorded for descriptive purposes and to verify GIS data layers.

Verification of GIS layers was conducted by locating the UTM coordinate of the ground plot on each GIS layer and determining if the description from the ground agreed with the GIS layer. Because walking into a particular quarter hectare area (50m pixel) was difficult, and aerial telemetry was not accurate to 50 m, an error radius of 100 m or 2 pixels was allowed. Also, for topographic layers, a margin of error of 2% for slope, 3° for aspect, and 61 m for elevation was allowed.

All GIS and onsite descriptions of a location were in agreement more than 80% of the time. Specifically, elevation, slope, and aspect were in agreement 99, 88, and 88% of the time, respectively. The vegetation layer agreed with ground data 90% of the time in general, however, open and closed canopy areas were in agreement only 82% of the time. Distances from roads and riparian areas were not measured in the field and could not be checked. However, because locations of roads and riparian areas have been checked by the Forest Service, it was believed that these layers were accurately distinguished to a reasonable degree.

Photoplots were set up at seven sites throughout the study area during 1991 to record general phenological change. Photographs were taken monthly from May to September.

Data Analysis

The general analytical procedure used in this study follows that described by Neu et al. (1974) and Byers et al. (1984). Chi-square goodness-of-fit tests were used to determine if classes within a habitat component were used in proportion to availability. Then, 95% Bonferoni confidence intervals were calculated for each class in each component to determine if the class was used greater than, less than, or equal to availability. If deer use was statistically greater than availability the class presumably had some positive aspects for deer and could be considered a preferred class within that habitat component. Use less than availability would connotate a negative relationship or avoidance.

Habitat availability was determined by the number of pixels within each class of each GIS habitat layer. Use was determined by the number of deer relocations in each class of each layer.

Generally, 1 deer relocation would equal 1 pixel. However, because radiotelemetry was not accurate to 50 m (the size of a pixel) an attempt was made to improve confidence in estimates of deer locations and hence, habitat use. To do this, I used the BUFFER routine in EPPL7 to create a "scanning circle" (Pac et al. 1991) around each deer relocation. Each location was buffered by 2 pixels on each side and 1 on the diagonals forming a 13 pixel star-shaped complex. Used habitat was calculated by determining the proportion of each habitat class within these complexes.

Following analysis, the technique of buffering relocations to gain greater confidence in deer locations made negligible difference in the results. Hence, used habitat was calculated solely on the original deer relocations with no buffering. In studies with smaller sample sizes buffering, or the use or scanning circles, may give a truer picture of habitat use.

For this study, habitat analysis was conducted at 2 scales. Macro-habitat use involved determining general habitat preferences of deer throughout the entire study area. This involved using summer relocations of only those deer captured and radio-equipped on winter range. Because deer were captured on winter range in an essentially random pattern their migration routes, summer range areas, and habitat selection patterns were unknown prior to their first use of an area. Hence, they potentially had the opportunity to migrate off the Bowser Lake wintering area and select any part of the study area for summer range. Using relocations of deer captured on summer range would bias results.

Micro-habitat use involved determining habitat preferences within areas of high deer use; ie., Star Meadows and the Corduroy Creek complexes. Reasons for deer selection of these areas were determined through analysis of macro-habitat use. However, once in 1 of these preferred areas, analysis of micro-habitat use patterns evaluated seasonal and daily habitat use. This analysis also included all relocations of summer trapped deer, 24-hr monitoring, and cameras surveys.

Macro-Habitat Use

Use versus availability analysis was conducted first at the macro-scale based on pooled data, i.e., all summer range relocations of winter trapped deer. This allowed determination of general habitat selection patterns for deer throughout the entire period on summer range. Next, because most deer were actually using summer range through 3 seasons, data were segregated for spring (first location on summer range-30 June), summer (1 July-31 August), and fall (1 September-last location on summer range). This categorization roughly coincided with changes in plant phenology on the study area, changes in deer annual cycle (pre-fawning and fawning, early post-fawning, and hunting season), and changes in road status on the district (many roads gated all year were open during July and August).

An attempt was made to assess habitat use differences based on sex and age classes. In this study, deer were grouped in subadult and adult age classes. Because deer changed age halfway through a study season, early 2-year-olds were included as subadults.

After habitat preference was determined for each habitat layer individually, all layers were combined to create a deer habitat preference map of the study area (Manley and Mace In press). Chi-square values were used to weight each layer, determining the relative importance of each habitat component in deer selection. For example, if chi-square values for slope and aspect were 100 and 10, respectively, the slope layer would apparently be of greater importance to determining deer preference of an area.

Classes in each layer were then revalued using the results of the Bonferoni confidence intervals. Classes used more than available were assigned a value of 10, those used equal to availability a value of 5, and those used less than available a value of 1. The EVALUATE routine in EPPL7 was then used to combine all layers and provide a new GIS layer with values from 1-10, 10 being the most preferred areas. From these data a preference map was created.

Because vegetation is the habitat variable most influenced by humans, this component was analyzed in detail. Managed timber stands were present on the study area at various densities (e.g. 20% of a given area was cutover). Use was related to availability of various densities (occurrence/unit area) of managed timber to determine whether some degree of disturbance affected use by deer. In addition, use was related to degree of diversity, where diversity was defined as the number of different vegetative classes/unit area.

Micro-Habitat Use

Analysis of micro-habitat use patterns was conducted for deer inhabiting the Star Meadows and Corduroy Creek complexes in fashion similar to macro-habitat analysis for deer use within the entire study area. Composite home ranges of deer determined boundaries of the 2 complexes. Habitat availability was determined by the number of pixels/class/habitat component within each area. Deer use was determined by the number of relocations/class/component.

Diel telemetry sessions were used to determine possible differences in use of vegetation between day and night within randomly selected 24-hr periods each season. Because diel telemetry sessions involved ground-based equipment from 3 stations, telemetry error needed to be calculated differently than aerial relocations. Error angles (degrees from true location) from 1-3 test transmitters put out during each session were used to calculate error arcs (distance from true location) for each deer from each station. The largest arc for each deer was used to determine the distance a deer had to move between subsequent relocations to be considered a true move. When subsequent relocations were less than 2 times the error arc, the latter relocation was eliminated from analysis. No relocations from a deer with a calculated error arc greater than 250 m were used. This generally eliminated deer which were far from a particular station because deer farther away tended to have larger error arcs. It also eliminated all data from three 24-hr sessions which were conducted under adverse weather conditions.

The use versus availability analysis also was applied to data from the 1991 camera survey at Corduroy Creek. Here, habitat availability was determined by the number of camera locations/class/component, i.e., if 4 of 20 cameras were in mature timber, this class had a 20% availability. Use was determined by the number of deer photographs recorded/class/component, not including fawns or multiple photos of the same deer taken in succession. Because deer could not be individually identified photos of the same deer recorded on different days or different times of the same day were counted.

RESULTS

Movements, Distribution, and Home Range

As noted earlier 79% of deer radio-collared on winter range migrated to the Tally Lake District to summer. Other deer radio-collared on winter range migrated shorter distances typically moving north along the Stillwater River but not onto the district. A few deer spent the entire year around the Bowser Lake winter range.

Spring migration generally commenced between the last week of March and early April, though a few deer remained on winter range until late May. Departure dates were difficult to ascertain because of relatively infrequent aerial monitoring. Transitional locations were not obtained for all deer, though most were located sufficiently to assume general migration routes. There was no definitive relationship between location of deer on winter range and subsequent summer locations. Hence, it was assumed that winter trapping was generally random with respect to migration routes as well as summer distribution.

Deer followed 2 general routes between winter range and summer ranges on the Tally Lake District (Fig. 3). Those summering in the northern portion of the study area moved from winter range northwest along the northeast side of Tally Lake toward the confluence of Good and Logan Creeks.

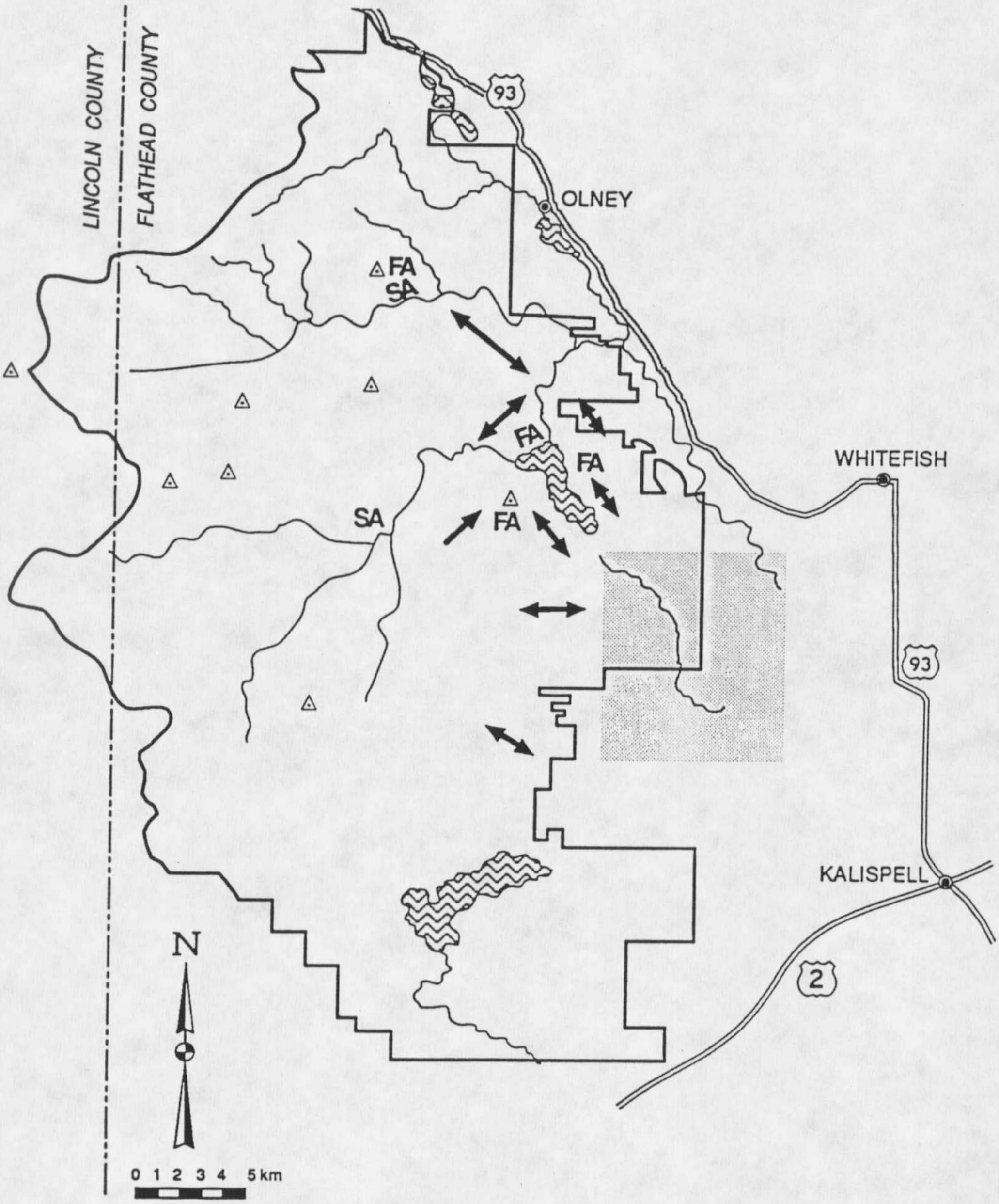

Figure 3. General migration routes and spring (SA) and fall (FA) accessory areas of deer moving to and from the Bowser Lake winter range (labels removed for clarity, see Fig. 1).

Transitional areas included Stovepipe Canyon, Bootjack Lake, and Round Meadows. From there, deer moved up Good Creek toward its confluence with Miller Creek, where this large riparian area, and lower slopes of Adams Mountain, were used by some deer as a spring accessory area. These initial movements of approximately 22 km occurred relatively quickly, typically between relocation flights (7-10 days).

Deer summering further west moved from the base of Adams Mountain up Good Creek using the creek bottom and south facing slopes as transitional areas. This movement of up to 13 km often spanned several weeks depending on snow melt and the distance to specific summering areas. According to 1991 photoplots from the Corduroy Creek drainage, snow was still present in higher elevations during mid-May and vegetation was sparse throughout the drainage until mid-June; thus influencing deer arrival on summer range in this area.

Deer moving from winter range to Star Meadows followed 3 different routes. Some traveled along the northeast side of Tally Lake then southwest across Hill Meadow toward Logan Creek. Others moved along the southwest side of the lake continuing up Logan Creek toward Star Meadows. Still a third path took deer over Reid Creek or Lost Creek Divides. Transitional areas used varied depending on the exact route. They included Stovepipe Canyon, Lost Creek, and Logan Creek above Tally Lake. The only true accessory area along these routes was Star Meadows as used by deer moving further up Griffin and Sheppard Creeks. These movements of approximately 22 km from winter range to Star Meadows occurred quickly, again typically between aerial relocations.

Once in Star Meadows deer tended to use southerly slopes waiting for snow melt and the meadow to dry out. Photoplots from around Star Meadows showed the meadow completely flooded in May and partially flooded in June.

Vegetation in the Corduroy Creek drainage was most succulent during July and August. While vegetation in September was still green, riparian bottoms especially meadows, began to dry out. Fall migration from the northern portion of the study area began for some deer as early as September. However, the majority of deer didn't leave summer range until November.

Migration routes from the northern portion of the study area were similar to spring. During fall, Stovepipe Canyon and Hill Meadow were used as accessory areas. Deer often spent several weeks in these locations before moving onto winter range. This apparently depended on snow conditions with an occasional deer remaining in the area the entire winter.

Plant phenology around Star Meadows tended to be slightly ahead of Corduroy Creek. Vegetation was most succulent during June and July and deer used the meadow bottom at this time. By August the meadow began to dry out and deer moved up slope. While 1 or 2 deer moved completely back to winter range in August, more typically deer moved to Tally Mountain, which was used as a late summer/fall accessory area for up to 3 months by deer prior to a final move to winter range.

Among all deer monitored in 1991, approximately 35% moved off summer range prior to hunting season (last week of October) while approximately 15% moved completely to winter range by this time. By the end of the hunting season (last week of November) all deer had left summer areas, though a few remained in transitional locations. Movements off summer ranges during 1991 were slightly earlier than in 1989 or 1990 because of earlier than usual snowfall and cold weather.

The 58 deer migrating to the Tally Lake District were distributed throughout the study area during summer (Fig. 4). However, there appeared to be greater use of some areas than others. Summer activity centers of individual deer were tested for random distribution throughout the study area. Results indicated that in each year deer were not distributed randomly, but were clumped (1989 X^2=3.56 $\underline{P}$=0.059, 1990 X^2=5.93 $\underline{P}$=0.015, 1991 X^2=7.92 $\underline{P}$=0.005) in 3 primary areas. Thirty-one deer summered in the southern portion of the study area, including 21 in and around Star Meadows. Twenty-seven summered in the northern portion of

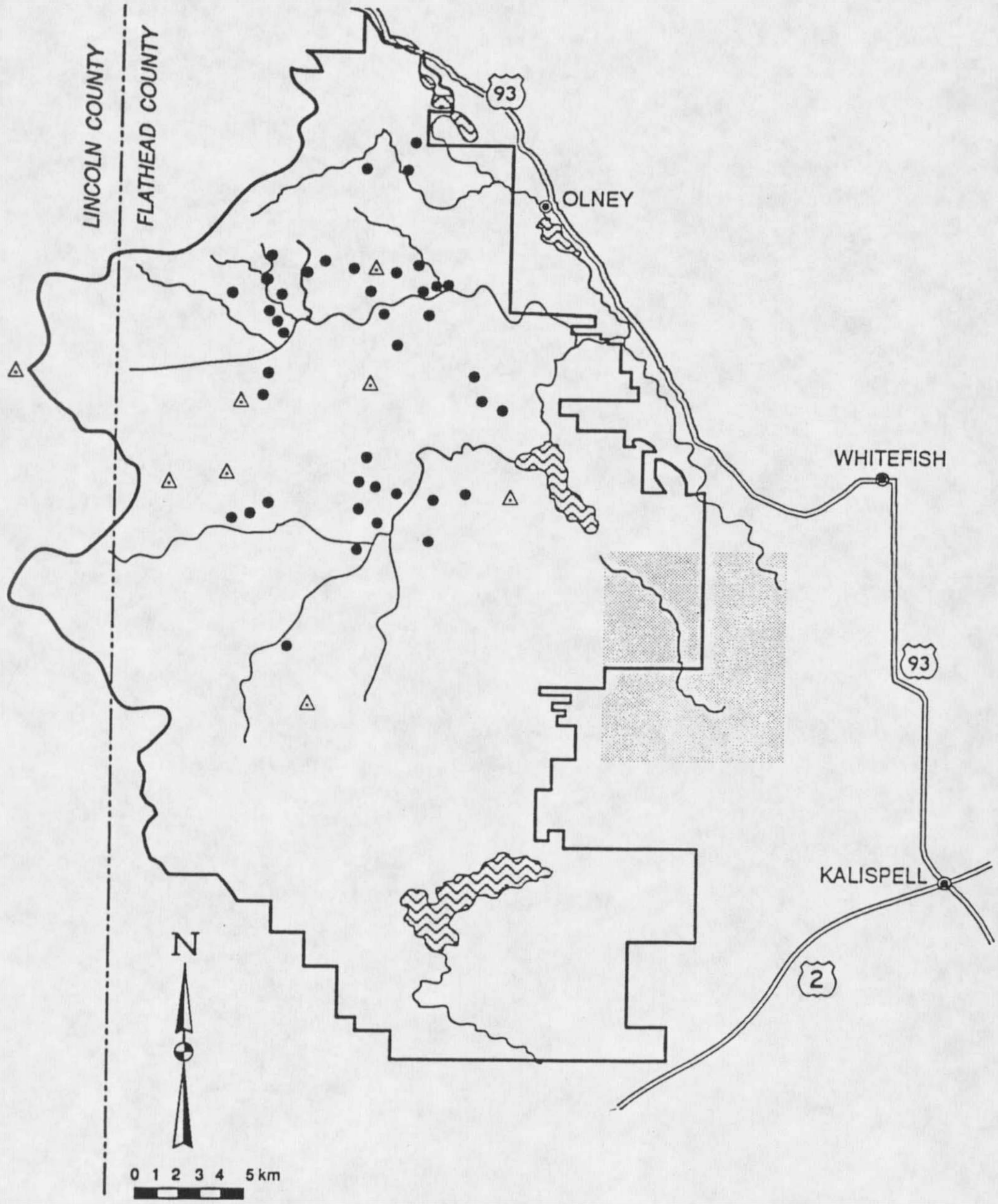

Figure 4. Deer distribution on the Tally Lake District as indicated by summer activity centers (•), 1991 (labels removed for clarity, see Fig. 1).

the study area, of these, 12 and 10 used the Corduroy Creek and Adams Mountain complexes, respectively.

Summer home ranges averaged 88.5 ha with male home ranges being larger than females and subadult home ranges larger than adults (Table 2).

Table 2. Average home range (convex polygon using 90% of locations) in hectares of white-tailed deer (N) on the Tally Lake study area, all years combined.

	Adult	Subadult	Total
Female	61.6 (86)	90.8 (19)	66.6 (105)
Male	235.3 (12)	268.2 (3)	241.9 (15)
Total	82.5 (98)	115.0 (22)	88.5 (120)

Macro-Habitat Use

Pooled and Seasonal Data

Summer habitat selection by deer migrating off winter range was independent of availability (X^2 tests, P<0.05) for 5 of 6 habitat components considered (Table 3). This indicated deer selected particular habitat classes over others within a given habitat component.

Elevation was the most important habitat component (highest X^2) with respect to deer selection of summer range for both pooled and seasonal data. Although its importance diminished throughout the summer range period its relative weight remained well above the other components except all roads.

Table 3. Values for chi-square goodness-of-fit tests (relative weights[1]) for individual habitat components, pooled and seasonal data.

	Pooled	Spring	Summer	Fall
Slope	13.1 (1)[NS]	15.1 (2)	7.5 (1)[NS]	16.4 (1)
Aspect	72.3 (6)	58.2 (8)	19.1 (3)	19.3 (1)
Elevation	459.3 (35)	274.7 (37)	138.7 (18)	114.6 (7)
Vegetation	155.5 (12)	72.4 (10)	64.3 (9)	62.6 (4)
Riparian areas	89.1 (7)	52.8 (7)	32.4 (4)	20.8 (1)
All roads	161.6 (12)	40.4 (5)	56.3 (7)	104.5 (6)
Open roads		7.4 (1)[NS]	12.9 (1)[NS]	37.9 (2)
Closed roads		16.9 (2)	61.1 (8)	24.1 (1)

[1]Weight of chi-square value relative to lowest
[NS]not significant, α=0.05

The vegetation and road components were about equal in importance when data were pooled, although much less than elevation. When separated seasonally, vegetation remained an important factor particularly during spring and summer. When the road layer was separated seasonally it also remained an important factor. However, when it was split between open and closed its importance to deer habitat selection lessened except for the relatively high value for closed roads during summer.

Aspect and riparian areas also were about equal in importance to deer habitat selection when data were pooled, but even of less importance than vegetation and roads. Like the other layers the importance of aspect and riparian areas to habitat selection diminished during summer and fall. Slope appeared to have had very little influence on deer habitat selection relative to other components regardless of season.

Elevationally, deer as a group used the 1,159-1,524 m zone more than available, 1,525-1,646 equal to available, and areas above 1,646 m and below 1,159 m less than available (Table 4). Forty-eight percent of the study area was in the preferred elevation zone. In the southern portion of the study area this preferred zone included Star Meadows and the Logan, Griffin, and Sheppard creek bottomlands, as well as the slopes adjacent to these areas except the highest ridges which were used equal or less than available. In the northern portion of the study area the preferred elevation zone included the Good Creek bottom above Miller Creek and the adjacent drainages and slopes, except for the higher ridges.

Table 4. Use versus availability for elevation (m) habitat component, pooled and seasonal data.

		Pooled	Spring	Summer	Fall
915-1,158	(9.8)[1]	-[2] (27)[3]	- (9)	- (9)	- (9)
1,159-1,280	(10.9)	+ (213)	+ (78)	+ (77)	= (58)
1,281-1,402	(15.2)	+ (406)	+ (182)	+ (122)	= (102)
1,403-1,524	(21.6)	+ (518)	+ (178)	+ (148)	+ (192)
1,525-1,646	(22.9)	= (333)	- (83)	= (108)	= (142)
1,647-1,768	(14.0)	- (81)	- (16)	- (25)	- (40)
1,769+	(5.6)	- (21)	- (4)	- (3)	- (14)

[1]percent available
[2]- used less than available, = used equal to available, + used greater than available
[3]number of relocations

Seasonally, preferred elevation shifted higher from spring to fall. During spring the 1,159-1,524 m elevational zones were preferred; other zones were avoided. During summer, use of the next higher elevational zone, 1,525-1,646 m, increased from less than available to equal. During fall, use of the 1,159-1,402 m zones decreased from greater than available to equal leaving 1,403-1,524 m as the only preferred elevational zone.

Vegetatively, deer as a group used natural grass/forb, shrub/hardwood, and both open and closed pole/immature stands more than available (Table 5). Artificial grass/forb, seedling/sapling, and closed mature timber were used less than available. Sapling/pole and closed mature timber were used equal to availability.

Table 5. Use versus availability for vegetation habitat component, pooled and seasonal data.

		Pooled	Spring	Summer	Fall
Nat. grass/forb	(1.1)[1]	+[2] (38)[3]	= (14)	= (16)	= (8)
Art. grass/forb	(9.5)	- (104)	= (48)	- (29)	- (27)
Shrub/hardwood	(4.7)	+ (123)	+ (49)	+ (45)	= (29)
Seedling/sapling	(9.7)	- (122)	= (39)	= (35)	= (48)
Sapling/pole	(14.5)	= (219)	= (86)	= (73)	- (60)
Pole/imm. open	(16.8)	+ (355)	+ (126)	= (98)	+ (131)
Pole/imm. closed	(12.2)	+ (245)	= (72)	= (70)	+ (103)
Mature open	(11.1)	= (175)	= (54)	= (52)	= (69)
Mature closed	(20.5)	- (218)	- (62)	- (74)	= (82)

[1]percent available
[2]- used less than available, = used equal to available, + used greater than available
[3]number of relocations

Only 35% of the study area contained preferred vegetation and unlike the distinct elevational zones preferred vegetation was interspersed with avoided and areas of equal use. There were, however, some large sections of preferred vegetation. One of these was the Star Meadows bottom where natural grass/forb and shrub/hardwood types occurred together. Another large area of preferred vegetation was the north side Good Creek where both open and closed pole/immature timber was abundant.

Approximately one-half of the 40% of avoided vegetation included early seral coniferous stands composed of artificial grass/forb and seedling/sapling. Hence, portions of the district most affected by timber harvesting generally were avoided. The other half of the avoided vegetation included the relatively large, closed mature timber type. These areas often occurred on the south side of Good Creek and in higher portions of the district.

Seasonally, the trend was toward greater use of timbered areas and less use of open, shrubby areas from spring to fall. While use of natural grass/forb and seedling/sapling types remained the same, deer made less use of artificial grass/forb and shrub/hardwood as the summer range season progressed. At the same time use of both open and closed pole/immature timber increased during fall.

When roads were grouped regardless of being open or closed deer generally avoided areas closest to a road and preferred sites more than 500 m away (Table 6). While only the 0-100 m zone was avoided, this accounted for 41% of the study area. The preferred areas 500+ m from a road accounted for only 11% of the study area. The primary roadless portions of the study area were found on top of Tally Mountain, on the north side of Good Creek in the Corduroy/Gergen/Grouse Creek area, and on the south side of Good Creek along the north side of Johnson Peak.

Seasonally, there was little variation in use of roads. The area closest to a road was always avoided while the furthest areas generally were preferred regardless of season.

Table 6. Use versus availability for road (distance from in meters) habitat component, regardless of whether open or closed, pooled and seasonal data.

		Pooled		Spring		Summer		Fall	
0-100	(41.1)[1]	-[2]	(497)[3]	-	(181)	-	(149)	-	(167)
100-200	(21.4)	=	(320)	=	(114)	=	(103)	=	(103)
200-300	(13.1)	=	(231)	=	(80)	=	(71)	=	(80)
300-400	(7.8)	=	(151)	=	(50)	=	(44)	=	(57)
400-500	(5.4)	=	(100)	=	(44)	=	(28)	=	(28)
500-750	(6.3)	+	(132)	=	(31)	=	(43)	+	(58)
750-1000	(2.6)	+	(83)	+	(31)	+	(29)	=	(23)
1000+	(2.3)	+	(85)	=	(19)	+	(25)	+	(41)

[1]percent available
[2]- used less than available, = used equal to available, + used greater than available
[3]number of relocations

When open and closed roads were considered separately deer generally used areas similar to availability (Tables 7 and 8). However, deer still avoided areas adjacent to closed roads; open roads were only avoided during fall.

Deer as a group used sites within 100 m of riparian habitats more than available and avoided sites between 300-400 m and over 750 m (Table 9). Deer preferred the 0-100 m zone regardless of season. However, preferences appeared to shift slightly away from riparian habitat through summer and fall as indicated by the change in the further zones from use less than available to equal to available.

Table 7. Use versus availability for open road (distance from in meters) habitat component, pooled and seasonal data.

		Spring	Summer	Fall
0-100	(20.5/30.9)[1]	=[2] (101)[3]	= (127)	- (87)
100-200	(14.2/18.9)	= (87)	= (100)	= (64)
200-300	(12.0/13.3)	= (74)	= (56)	= (61)
300-400	(9.4/9.1)	= (57)	= (56)	= (60)
400-500	(8.4/7.2)	= (55)	= (36)	= (43)
500-750	(14.5/10.1)	= (74)	= (52)	= (92)
750-1000	(9.3/5.4)	= (42)	= (36)	= (44)
1000+	(11.9/5.0)	= (60)	= (29)	+ (106)

[1]percent available, non-summer/summer
[2]- used less than available, = used equal to available, + used greater than available
[3]number of relocations

Table 8. Use versus availability for closed road (distance from in meters) habitat component, pooled and seasonal data.

		Spring	Summer	Fall
0-100	(24.1/14.0)[1]	-[2] (97)[3]	- (36)	- (96)
100-200	(16.3/11.2)	= (84)	= (42)	= (88)
200-300	(13.7/11.1)	= (86)	= (62)	= (82)
300-400	(10.4/9.7)	= (58)	= (41)	= (69)
400-500	(9.0/9.7)	= (58)	= (55)	= (48)
500-750	(13.5/18.0)	= (88)	= (77)	= (92)
750-1000	(6.9/12.2)	= (38)	= (59)	= (33)
1000+	(6.2/14.0)	= (41)	+ (120)	= (49)

[1]percent available, non-summer/summer
[2]- used less than available, = used equal to available, + used greater than available
[3]number of relocations

Preferred sites made up only 21% of the study area and were found along all drainages containing water at least long enough for riparian vegetation to exist. Avoided areas accounted for 24% of the study area. Large sites lacking riparian habitat were found on Reid and Lost Creek Divides, northwest of the head of Martin Creek, and on Fox Mountain.

Table 9. Use versus availability for riparian (distance from in meters) habitat component, pooled and seasonal data.

		Pooled		Spring		Summer		Fall	
0-100	(21.5)[1]	+[2]	(468)[3]	+	(167)	+	(150)	+	(151)
100-200	(16.2)	=	(247)	=	(100)	=	(73)	=	(74)
200-300	(15.2)	=	(219)	=	(70)	=	(69)	=	(80)
300-400	(11.9)	-	(150)	=	(51)	=	(49)	=	(50)
400-500	(10.0)	=	(160)	=	(60)	=	(46)	=	(54)
500-750	(13.7)	=	(215)	=	(79)	=	(72)	=	(94)
750-1000	(6.1)	-	(66)	-	(14)	=	(22)	=	(30)
1000+	(5.4)	-	(44)	-	(9)	-	(11)	=	(24)

[1]percent available
[2]- used less than available, = used equal to available, + used greater than available
[3]number of relocations

Easterly and southerly aspects were selected greater than available by deer as a group while northerly and northwesterly aspects were avoided (Table 10). Preferred aspects accounted for 24% of the study area. Because major drainages tended to flow to the northeast many preferred aspects occurred on the north side of Good Creek and Star Meadows and their tributaries. Aspect became less important as summer progressed; during summer and fall most aspects were used in proportions to availability.

Last, as previously stated slope was not an important factor in habitat selection. No slopes were preferred and only the 36-50% slope was avoided (Table 11). There was little seasonal change with respect to use of slope.

Table 10. Use versus availability for aspect habitat component, pooled and seasonal data.

		Pooled	Spring	Summer	Fall
East	(14.1)[1]	+[2] (268)[3]	= (101)	= (73)	= (94)
Northeast	(14.7)	= (203)	- (56)	= (69)	= (78)
North	(11.2)	- (125)	- (31)	= (39)	= (55)
Northwest	(9.7)	- (104)	- (33)	- (31)	= (40)
West	(9.1)	= (123)	= (40)	= (41)	= (42)
Southwest	(11.2)	= (216)	= (74)	= (71)	= (71)
South	(10.2)	+ (201)	= (68)	= (59)	= (71)
Southeast	(11.9)	= (222)	+ (90)	= (62)	= (70)
No Aspect	(8.0)	= (137)	= (57)	= (47)	- (33)

[1]percent available
[2]- used less than available, = used equal to available, + used greater than available
[3]number of relocations

Table 11. Use versus availability for slope (%) habitat component, pooled and seasonal data.

		Pooled	Spring	Summer	Fall
0-5	(8.1)[1]	=[2] (123)[3]	= (48)	= (45)	= (30)
6-10	(11.3)	= (188)	= (72)	= (58)	= (58)
11-15	(13.0)	= (240)	= (81)	= (80)	= (79)
16-20	(14.3)	= (237)	= (97)	= (64)	= (76)
21-25	(14.9)	= (246)	= (80)	= (73)	= (93)
26-35	(23.6)	= (362)	- (104)	= (110)	= (148)
36-50	(12.6)	- (166)	= (59)	= (53)	= (54)
50+	(2.2)	= (37)	= (9)	= (9)	= (19)

[1]percent available
[2]- used less than available, = used equal to available, + used greater than available
[3]number of relocations

Sex and Age Differences

An attempt was made to assess differences in habitat use between sexes and 2 female age classes. The majority of radio-collared deer were adult females. Hence, 1,143 (71%) of 1,599 relocations were adult females while only 197 (12%)

were subadult females and 259 (16%) were males. Similar use versus availability analysis was conducted on the 3 groups individually. Selection by adult females was similar to the overall data presented above while subadult females and males generally used each habitat class equal to availability.

Composite Habitat Preference

The habitat preference map developed by meshing the various layers together emphasized the importance of the elevation component in macro-site selection (Fig. 5). Because elevation had such a high weighting factor preferred and avoided areas on the composite preference map were similar to those for elevation with the exception of areas where use was equal to availability. Preferred habitat under this scenario was located along major drainages and up the adjacent slopes because these areas were located within the 1,159 and 1,524 m zone. Areas where use was equal to availability occurred along the next high elevation zone and where other components such as roads and vegetation played an important role.

When elevation was removed from the equation, preferred habitat was much more interspersed (Fig. 6). Under this scenario vegetation and roads had the highest weighting factors and were most dominant with riparian areas and aspect secondary. Major preferred areas occurred in the

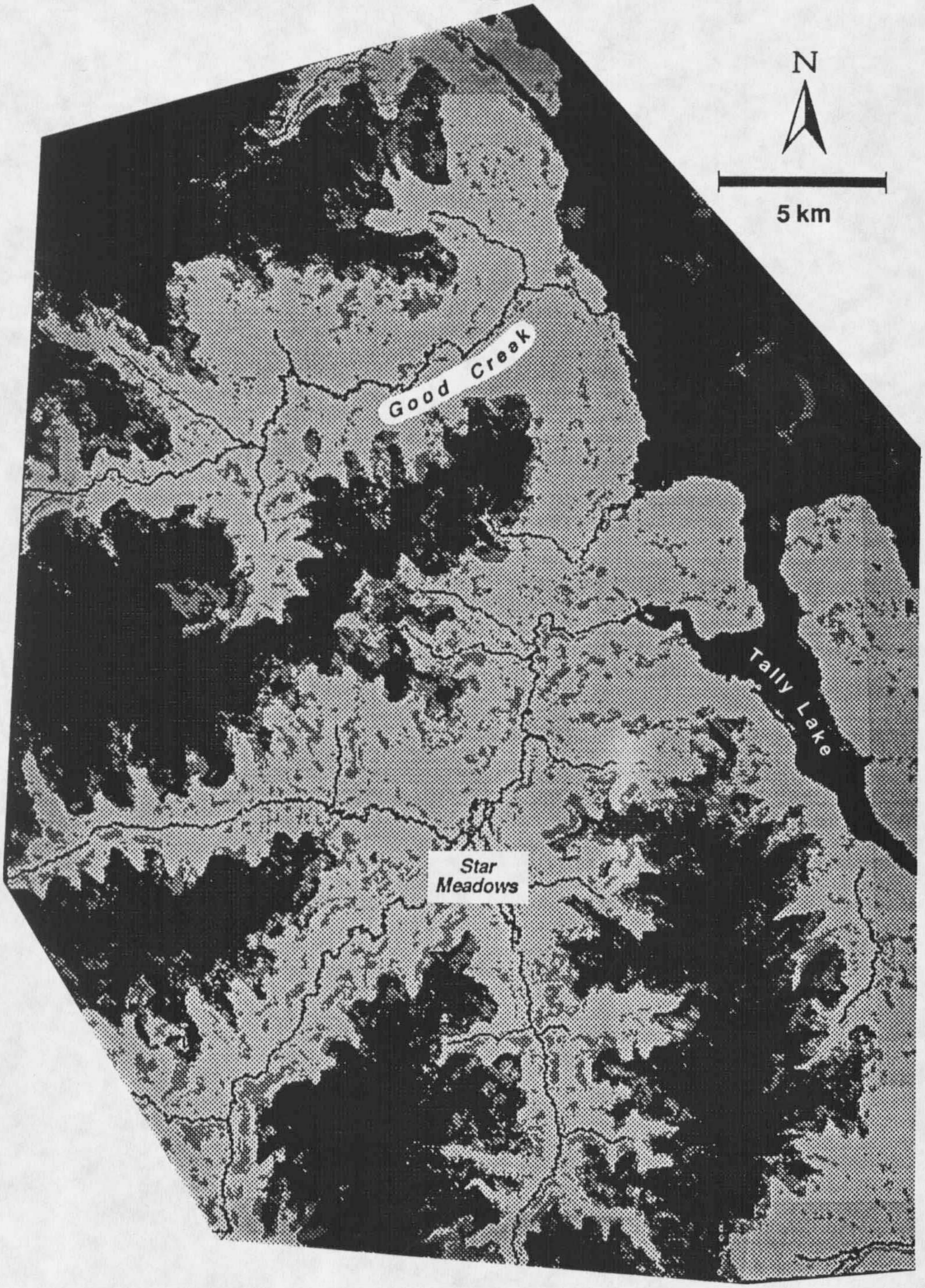

Figure 5. White-tailed deer study area habitat preference map encompassing all 6 habitat components (dark tone indicates use < available, light tone indicates use > available, and middle tone indicates use = available).

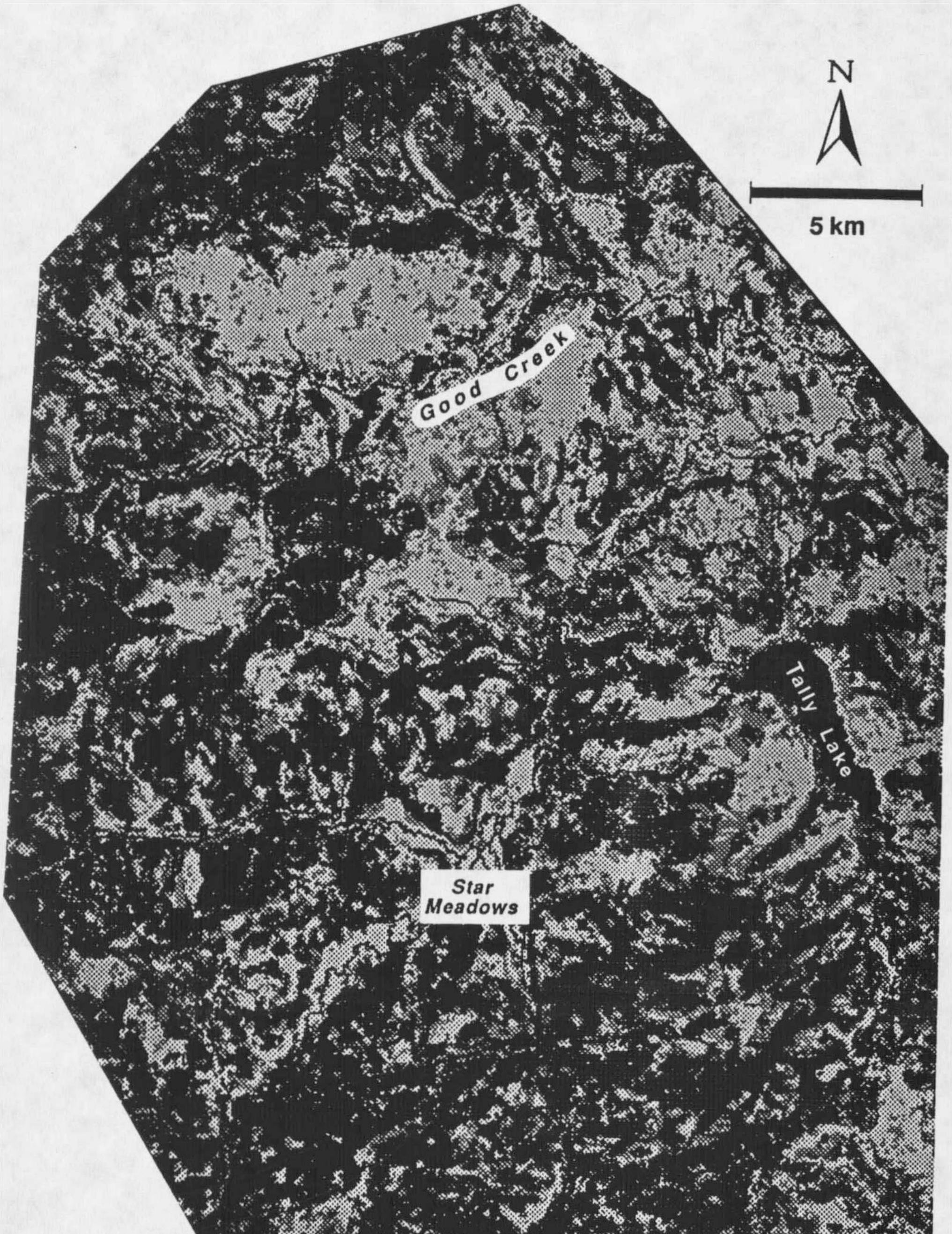

Figure 6. Modified habitat preference map with elevation removed from the equation (dark tone indicates use < available, light tone indicates use > available, and middle tone indicates use = available).

Star Meadows bottom and along the north side of Good Creek in the Corduroy/Gergen/Grouse Creek areas.

Deer Habitat Use of Managed Timber

Managed timber areas are those altered by humans either through cutting or prescribed burns. In this study, artificial grass/forb and seedling/sapling types were managed timber areas. Deer generally used artificial grass/forb areas equal to availability only avoiding areas containing 28%/0.9 km^2 (Table 12). There was greater selection within the seedling/sapling type. Deer preferred areas with no seedling/sapling and avoided areas with 11-17 and 39%/0.9 km^2. When the 2 types were combined 0-5% and 50+% were preferred while 17 and 33% were avoided.

Table 12. Use versus availability for managed timber areas.

% cut/ 90 ha	Grass/forb artificial	Seedling/sapling	Sapling/pole	Columns 1 and 2	Columns 1, 2, and 3
0	=[1] (33.5/564)[2]	+ (34.1/675)	+ (28.8/576)	+ (20.3/443)	+ (8.7/252)
5	= (18.1/264)	= (21.5/338)	+ (19.6/378)	= (14.9/225)	= (7.6/147)
11	= (14.0/189)	- (13.9/183)	= (15.2/219)	= (11.9/172)	= (8.3/140)
17	= (10.2/190)	- (9.3/118)	- (11.1/128)	- (10.2/131)	= (9.1/143)
22	= (6.9/108)	= (7.0/101)	- (7.9/72)	= (9.6/133)	- (9.5/114)
28	- (4.8/52)	= (4.4/69)	- (5.5/26)	= (8.3/105)	- (8.9/96)
33	= (3.2/50)	= (2.8/37)	- (3.8/26)	- (6.6/75)	- (8.3/98)
39	= (2.4/46)	- (2.0/16)	- (2.4/23)	= (5.0/67)	- (7.7/88)
44	= (1.8/39)	= (1.5/15)	= (1.5/40)	= (3.8/52)	= (6.9/98)
50+	= (4.9/97)	= (3.5/47)	+ (4.3/111)	+ (9.4/196)	= (25.2/423)

[1]- used less than to available = used equal to available, + used greater than available
[2]percent available/number of relocations

Sapling/pole could be considered managed timber in certain instances. In the northern portion of the study area sapling/pole stands often occurred as remnants of fires in the early part of the century. However, the type also exists as a result of logging. In either case, deer again showed a preference for areas with little or no (0-5%), and relatively high (50+%), amounts of sapling/pole (Table 12); they avoided areas with sapling/pole present on 17 and 39% of the units. When all 3 types were combined, deer preferred only habitat with no managed timber.

Vegetation Diversity

An area was considered more vegetatively diverse as the number of different vegetative classes/unit area approached the maximum of 9. Three different size areas (blocks) were considered: 90, 20, and 7 ha. In general, the more immediate the surroundings, the less diversity was important (Table 13). At the large scale (90 ha), deer preferred a moderate amount of diversity (5 types) as well as the maximum amount of diversity (8-9 types). They avoided areas of intermediate diversity (7 types). At the middle level (20 ha), deer again preferred the maximum amount of diversity; however, they avoided habitats just less than maximum diversity. At the smallest scale (7 ha), diversity appeared to play a minor role in habitat selection.

Table 13. Use versus availability for vegetation layer by diversity.

Number of different vegetation types/ unit area	Unit area		
	90 ha	20 ha	7 ha
1	na	*	= (2.5/45)
2	na	= (1.2/24)	= (11.4/165)
3	*	= (4.1/79)	= (22.8/397)
4	=[1] (1.0/13)[2]	= (13.5/233)	= (29.4/512)
5	+ (4.4/108)	= (22.1/376)	= (22.2/313)
6	= (10.9/156)	- (31.1/419)	= (9.8/127)
7	- (48.2/510)	- (23.8/331)	= (1.9/40)
8	+ (28.0/526)	+ (4.3/137)	**
9	+ (7.5/286)	**	na

[1]- used less than available, = used equal to available, + used greater than available
[2]percent available/number of relocations
*combined with class below
**combined with class above

Micro-Habitat Use

Pooled and Seasonal Data

Macro-habitat analyses indicated that deer migrating off winter range selected summer areas based on elevation, vegetation, roads in general, presence of riparian areas, aspect, and slope generally in that order depending on season. The 2 areas that supported the greatest number of radio-collared deer, Star Meadows and the Corduroy Creek complexes, occurred almost entirely within the preferred elevational zone. Thus, detailed analyses of habitat structure and use of these areas by deer should provide closer insight to the importance of various habitat components and habitat relationships in general.

Micro-habitat use for pooled data in both the Corduroy Creek and Star Meadows Complexes was independent of availability (X^2 tests, $\underline{P}<0.05$) for each of the 6 habitat components considered except for vegetation at Star Meadows (Tables 14 and 15). However, unlike macro-analysis, here individual layers were closer (X^2 values less extreme) with regard to importance in determining habitat selection. Also, when separated seasonally, habitat classes in most layers were not used differently from occurrence on the study area. The major exceptions were that elevation at both Corduroy Creek and Star Meadows and open roads at Star Meadows were important in all seasons.

Table 14. Values for chi-square goodness-of-fit tests (relative weights[1]) for individual habitat components for the Corduroy Creek complex, pooled and seasonal data.

	Pooled	Spring	Summer	Fall
Slope	16.6 (1)	6.9 (2)^{NS}	12.2 (3)^{NS}	10.5 (2)^{NS}
Aspect	25.5 (1)	7.7 (3)^{NS}	9.4 (2)^{NS}	22.2 (4)
Elevation	79.0 (5)	43.4 (15)	25.5 (6)	29.3 (5)
Vegetation	20.6 (1)	13.2 (3)^{NS}	10.6 (3)^{NS}	14.8 (3)^{NS}
Riparian areas	21.3 (1)	7.8 (3)^{NS}	6.2 (1)^{NS}	7.0 (1)^{NS}
All roads	22.3 (1)	11.1 (4)^{NS}	7.9 (2)^{NS}	13.6 (2)^{NS}
Open roads		2.9 (1)^{NS}	4.2 (1)^{NS}	16.7 (3)
Closed roads		9.7 (3)^{NS}	16.2 (4)	5.7 (1)^{NS}

[1]Weight of chi-square value relative to lowest
^{NS}not significant, α=0.05

Table 15. Values for chi-square goodness-of-fit tests (relative weights[1]) for individual habitat components for Star Meadows complex, pooled and seasonal data.

	Pooled	Spring	Summer	Fall
Slope	19.9 (1)	20.8 (3)	11.5 (2)[NS]	6.6 (1)[NS]
Aspect	32.7 (2)	27.4 (4)	10.4 (2)[NS]	11.4 (2)[NS]
Elevation	18.0 (1)	22.5 (3)	16.7 (3)	27.8 (4)
Vegetation	13.6 (1)[NS]	12.2 (2)[NS]	10.0 (2)[NS]	16.2 (2)
Riparian areas	27.8 (2)	9.3 (1)[NS]	9.3 (2)[NS]	36.1 (5)
All roads	24.0 (3)	7.4 (1)[NS]	6.3 (1)[NS]	27.1 (4)
Open roads		21.3 (3)	24.9 (5)	14.2 (2)
Closed roads		12.9 (2)	5.2 (1)[NS]	10.3 (2)[NS]

[1]Weight of chi-square value relative to lowest
[NS]not significant, $\alpha=0.05$

In general, classes within individual habitat components were used equal to availability; as would be expected when X^2 values are not significant. Elevation showed some differential use among classes (Table 16). Even though both complexes were generally within the overall preferred elevational zone, middle elevations were preferred within each complex. At Corduroy Creek, use of elevation was similar between spring and summer but preferences shifted to higher zones during fall. At Star Meadows, deer shifted to slightly lower elevations from spring to summer but moved higher from summer to fall.

Vegetation types generally were used equal to availability in both complexes during all seasons (Table 17). No types were used more than expected during any season or when pooled across seasons. The only type avoided in the pooled sample was sapling/pole in Corduroy Creek.

Natural and artificial grass/forb types in Corduroy Creek were used less than expected in some seasons; however these types occurred only in small quantities.

Table 16. Use versus availability for elevation (m) habitat component for Corduroy Creek (CC) and Star Meadows (SM) complexes, pooled and season data.

		Pooled		Spring		Summer		Fall	
		CC	SM	CC	SM	CC	SM	CC	SM
1219-1280	(na/13.4)[1]	na	=[2] (66)[3]	na	= (24)	na	= (32)	na	= (10)
1281-1340	(3.7/22.8)	= (16)	= (122)	= (3)	= (61)	= (10)	= (46)	- (3)	- (15)
1341-1402	(11.0/18.7)	= (77)	= (122)	= (18)	+ (63)	= (22)	= (43)	= (37)	- (16)
1403-1462	(17.4/18.4)	+ (150)	+ (131)	+ (46)	= (46)	+ (48)	= (50)	= (56)	= (35)
1463-1524	(15.0/18.4)	+ (113)	= (60)	= (24)	= (21)	= (32)	- (15)	+ (57)	= (24)
1525+	(52.9/13.4)	- (195)	= (59)	- (36)	- (16)	- (60)	- (15)	- (99)	= (28)

[1]percent available (Corduroy Creek/Star Meadows)
[2]- used less than available, = used equal to available, + used greater than available
[3]number of relocations

Table 17. Use versus availability for vegetation habitat component for Corduroy Creek (CC) and Star Meadows (SM), pooled and seasonal data.

		Pooled		Spring		Summer		Fall	
		CC	SM	CC	SM	CC	SM	CC	SM
Nat. grass/forb	(0.9/6.2)[1]	=[2] (2)[3]	= (40)	- (0)	= (16)	= (2)	= (17)	- (0)	= (7)
Art. grass/forb	(1.1/14.7)	= (4)	= (67)	- (0)	= (36)	- (0)	- (18)	= (4)	= (13)
Shrub/hardwood	(2.7/8.5)	= (18)	= (45)	= (4)	= (22)	= (10)	= (22)	= (4)	- (1)
Seedling/sapling	(4.9/17.5)	= (27)	= (102)	= (5)	= (43)	= (7)	= (34)	= (15)	= (25)
Sapling/pole	(10.5/8.9)	- (37)	= (51)	= (9)	= (16)	= (13)	= (18)	- (15)	= (17)
Pole/imm. open	(27.6/13.7)	= (178)	= (89)	= (45)	= (38)	= (50)	= (31)	= (83)	= (20)
Pole/imm. closed	(25.2/13.7)	= (140)	= (49)	= (35)	= (22)	= (40)	= (15)	= (65)	= (12)
Mature open	(10.9/14.2)	= (72)	= (65)	= (18)	= (23)	= (21)	= (23)	= (33)	= (19)
Mature closed	(16.3/9.9)	= (73)	= (52)	- (11)	= (15)	= (29)	= (23)	= (33)	= (14)

[1]percent available (Corduroy Creek/Star Meadows)
[2]- used less than available, = used equal to available, + used greater than available
[3]number of relocations

Among the remaining habitat components, few types were used significantly more or less than expected and there was little evidence for seasonal shifts in habitat use (Tables 18-23). Those habitat classes used more or less than expected generally followed macro-analysis results. For instance at Corduroy Creek, areas furthest from riparian habitats were avoided in spring (Table 18). Northerly and westerly aspects and steeper slopes were avoided during some seasons (Tables 19 and 20). Few significant relationships existed for the road components.

Diel Habitat Use

Changes in habitat use between day and night periods generally revolved around movement by deer to and from cover and open areas. At Corduroy Creek, deer apparently moved out into more open areas at night as use of open timber decreased and both natural and artificial grass/forb areas increased (Table 24). However, as with aerial data the sample of relocations in the latter types was extremely low, as was the amount of habitat available. Also at Corduroy Creek, deer used both seedling/sapling and sapling/pole less than available during both day and night.

At Star Meadows, deer used all types equal to availability except for an increased use of sapling/pole at night.

Table 18. Use versus availability for riparian (distance from in meters) habitat component for Corduroy Creek (CC) and Star Meadows (SM), pooled and seasonal data.

		Pooled		Spring		Summer		Fall	
		CC	SM	CC	SM	CC	SM	CC	SM
0-100	(21.1/29.3)[1]	= (132)[2]	= (183)[3]	= (27)	= (76)	= (45)	= (74)	= (60)	= (33)
100-200	(15.8/16.7)	= (82)	= (74)	= (22)	= (37)	= (26)	= (26)	= (34)	- (11)
200-300	(15.5/15.7)	= (102)	- (62)	= (26)	- (21)	= (29)	= (23)	= (47)	= (18)
300-400	(12.5/12.1)	= (75)	= (65)	= (16)	= (28)	= (25)	= (25)	= (34)	= (12)
400-500	(10.2/9.6)	= (50)	= (62)	= (13)	= (28)	= (16)	= (19)	= (21)	= (15)
500-750	(13.9/12.6)	= (73)	+ (98)	= (18)	= (32)	= (18)	= (29)	= (37)	+ (37)
750+	(10.8/4.0)	- (37)	= (16)	- (5)	= (9)	= (5)	= (13)	= (19)	= (2)

[1]percent available (Corduroy Creek/ Star Meadows)
[2]- used less than available, = used equal to available, + used greater than available
[3]number of relocations

Table 19. Use versus availability for aspect habitat component for Corduroy Creek (CC) and Star Meadows (SM), pooled and seasonal data.

		Pooled		Spring		Summer		Fall	
		CC	SM	CC	SM	CC	SM	CC	SM
East	(14.0/11.5)[1]	=[2] (98)[3]	= (67)	= (21)	= (25)	= (32)	= (23)	= (45)	= (19)
Northeast	(14.5/9.7)	= (75)	= (50)	= (11)	= (18)	= (27)	= (19)	= (37)	= (13)
North	(3.1/10.4)	= (21)	= (44)	= (2)	- (12)	= (6)	= (18)	= (13)	= (14)
Northwest	(2.9/11.5)	= (8)	- (46)	= (3)	= (17)	= (2)	- (12)	= (3)	= (17)
West	(7.9/10.8)	- (20)	= (44)	= (8)	= (17)	= (6)	= (21)	= (6)	- (6)
Southwest	(24.0/11.0)	= (127)	= (60)	= (33)	= (29)	= (42)	= (22)	= (52)	= (9)
South	(17.2/10.0)	= (106)	= (66)	= (25)	= (28)	= (27)	= (23)	= (54)	= (15)
Southeast	(12.8/14.1)	= (76)	+ (113)	= (21)	= (48)	= (22)	= (39)	= (33)	= (26)
No Aspect	(3.7/10.9)	= (20)	= (74)	= (3)	= (37)	= (8)	= (24)	= (9)	= (13)

[1]percent available (Corduroy Creek/ Star Meadows)
[2]- used less than available, = used equal to available, + used greater than available
[3]number of relocations