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The Effect of FIRE on MERRIAM'S TURKEY BROOD HABITAT in Southeastern Montana

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THE EFFECT OF FIRE ON MERRIAM'S TURKEY BROOD HABITAT IN SOUTHEASTERN MONTANA

by

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ABSTRACT

Radio telemetry was used to analyze brood habitat of Merriam's turkey (*Meleagris gallopavo merriami*) in southeastern Montana after a major forest fire had occurred. Eighteen broods were monitored from hatching until September 30 in 1989 and 1990 with a total of 416 relocations. Average home range sizes of broods in burned and unburned areas were similar. Daily movements were greater in burned areas. Broods in unburned areas preferred ponderosa pine/chokecherry cover types early in the brood-rearing period and later moved to hardwood draws when poults became more mobile. Broods in burned areas used habitat types in proportion to availability, however broods during the early rearing period showed a preference for severely burned areas. No broods were found in logged areas. A woody understory interspersed with openings of herbaceous cover was important for young and older poults. Feeding areas were mainly within the hardwood draw-grassland ecotone and the pine/cherry-open meadow ecotone. Roost trees were large mature ponderosa pine and green ash trees (average DBH = 59.2 cm).

INTRODUCTION

Merriam's turkeys (*Meleagris gallopavo merriami*) originally occupied the southwestern ponderosa pine and oak forests of Arizona, New Mexico, west Texas, and southern Colorado. The bird was first described by Nelson (1900) as a subspecies of the eastern wild turkey (*Meleagris gallopavo sylvestris*). Unlike its eastern counterpart, Merriam's turkey is notable for its affinity for more open and rugged terrain and its close relationship with ponderosa pine (*Pinus ponderosa*) forests.

Based on the success of turkey introductions in other western states, Merriam's turkeys were introduced into Montana by the Montana Fish and Game Department in the Judith Mountains near Lewistown, and in the Long Pines near Ekalaka, in 1954 and 1955, respectively. Populations were soon established and became the sources for subsequent introductions throughout the state. An initial investigation by Rose (1956) detailed the success of the Long Pines population. Jonas (1966) studied the movements , general habitat use, population characteristics, and life history of Merriam's turkeys in the Long Pines.

The Long Pines turkey population grew rapidly and turkeys were introduced into the nearby Ekalaka Hills in

1958, although some birds from the Long Pines may also have emigrated to the Ekalaka Hills via connecting woody draws. Merriam's turkeys have since spread into the adjacent Little Missouri River and Box Elder Creek drainages, the Chalk Buttes to the southwest of the Ekalaka Hills, and the Sheep Mountains to the south of the Long Pines. Hunting seasons, both in the spring and fall, have been established in the Long Pines and Ekalaka Hills since the early 1960's and attract sportsmen from all over the United States.

Several aspects of turkey ecology in southeastern Montana, such as brood habitat, the influence of fire, and land use impacts from logging and grazing, have not been adequately investigated. On June 20, 1988 two lightning-induced wildfires quickly spread and joined together to form the Brewer Fire. When this fire was finally brought under control on June 29, 74 % of the Long Pines unit had been affected. The fire burned 20,923 hectares (ha) of public land and 2639 ha of private land. The Ekalaka Hills were not affected. The Brewer Fire situation established a unique opportunity to study the effects of a natural wildfire on turkey ecology in a fire-adapted forest-grassland ecosystem such as that found in southeastern Montana.

This study was undertaken to investigate brood habitat requirements of Merriam's turkeys and the influence of fire in the Long Pines and Ekalaka Hills. Field work was performed during February-August in 1989, and from April-

August in 1990. This is part of a larger study on the ecology and biology of Merriam's turkeys and the influence of logging and fire. The study was conducted through the Fish and Wildlife Program at Montana State University and was funded by Montana Department of Fish, Wildlife, and Parks, the U.S. Forest Service, and the National Wild Turkey Federation.

DESCRIPTION OF STUDY AREA

The Long Pines and the Ekalaka Hills are located in Carter County in extreme southeastern Montana (Figs. 1 and 2). They make up two units of the Sioux Ranger District on the Custer National Forest. Surrounding lands consist primarily of private rangelands and Bureau of Land Management lands. The predominant land use is livestock grazing but some small-grain farming also occurs. Logging operations are small and limited. Two mills, one in Ekalaka and one in nearby Camp Crook, S.D., have small and sporadic timber operations in the area.

The Ekalaka Hills and the Long Pines rise approximately 366 meters (m) from the surrounding prairie and are often described as "islands of forest in a sea of prairie". Although ponderosa pine is the predominant woody vegetation, there exists a mosaic of open park-like forests, various-sized grassland meadows, aspen (*Populus tremuloides*) groves, shrub communities, deciduous woody draws, canyons, and badlands scattered throughout both units. Parent rocks are tertiary clays and sandstone deposits which form soils with high alkali contents and low water penetration. Shallow, rocky soils are commonly found in steeper areas. Both units are highly dissected by drainageways but none contain

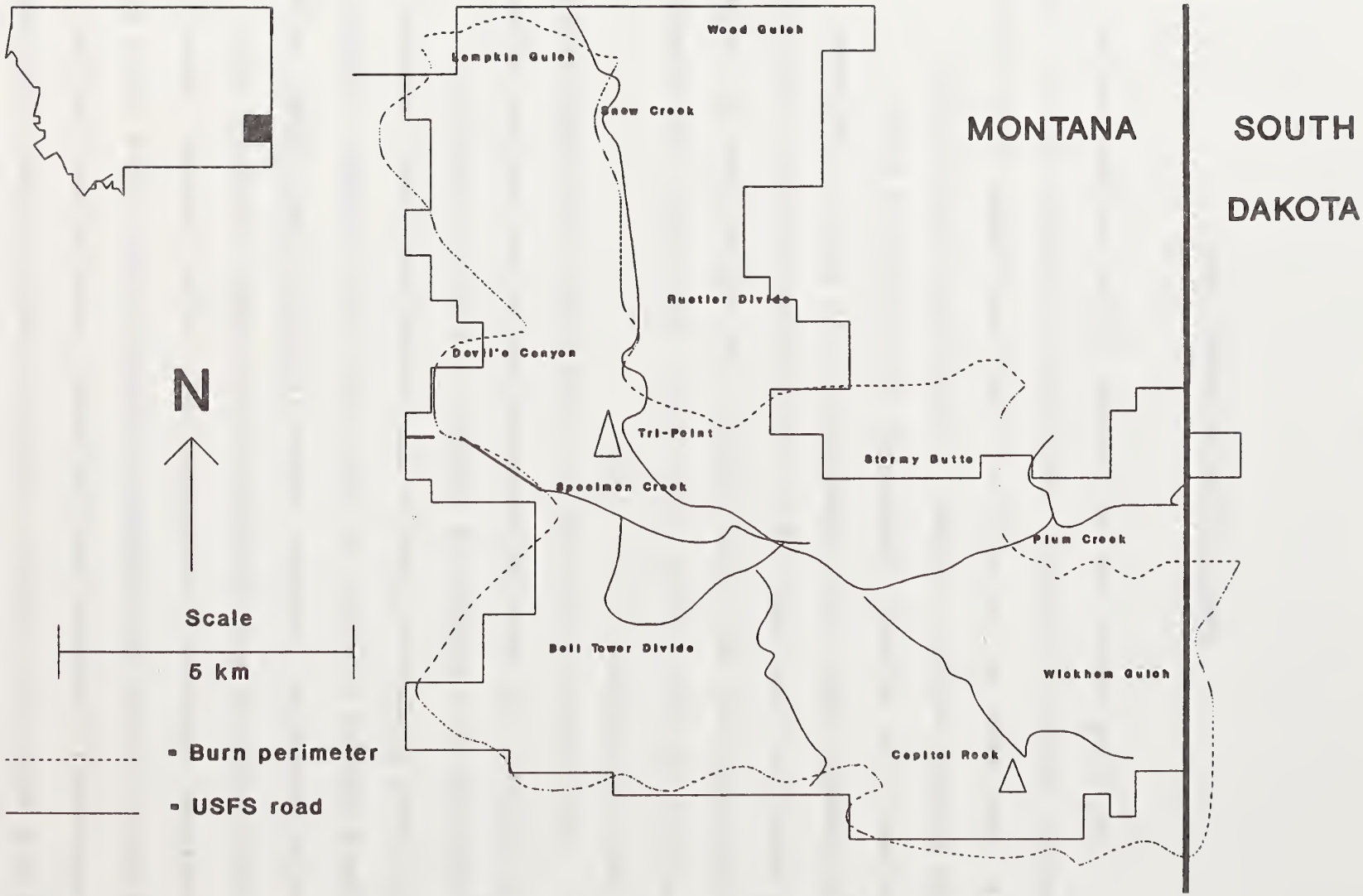

Figure 1. Long Pines unit of the Sioux District, Custer National Forest.

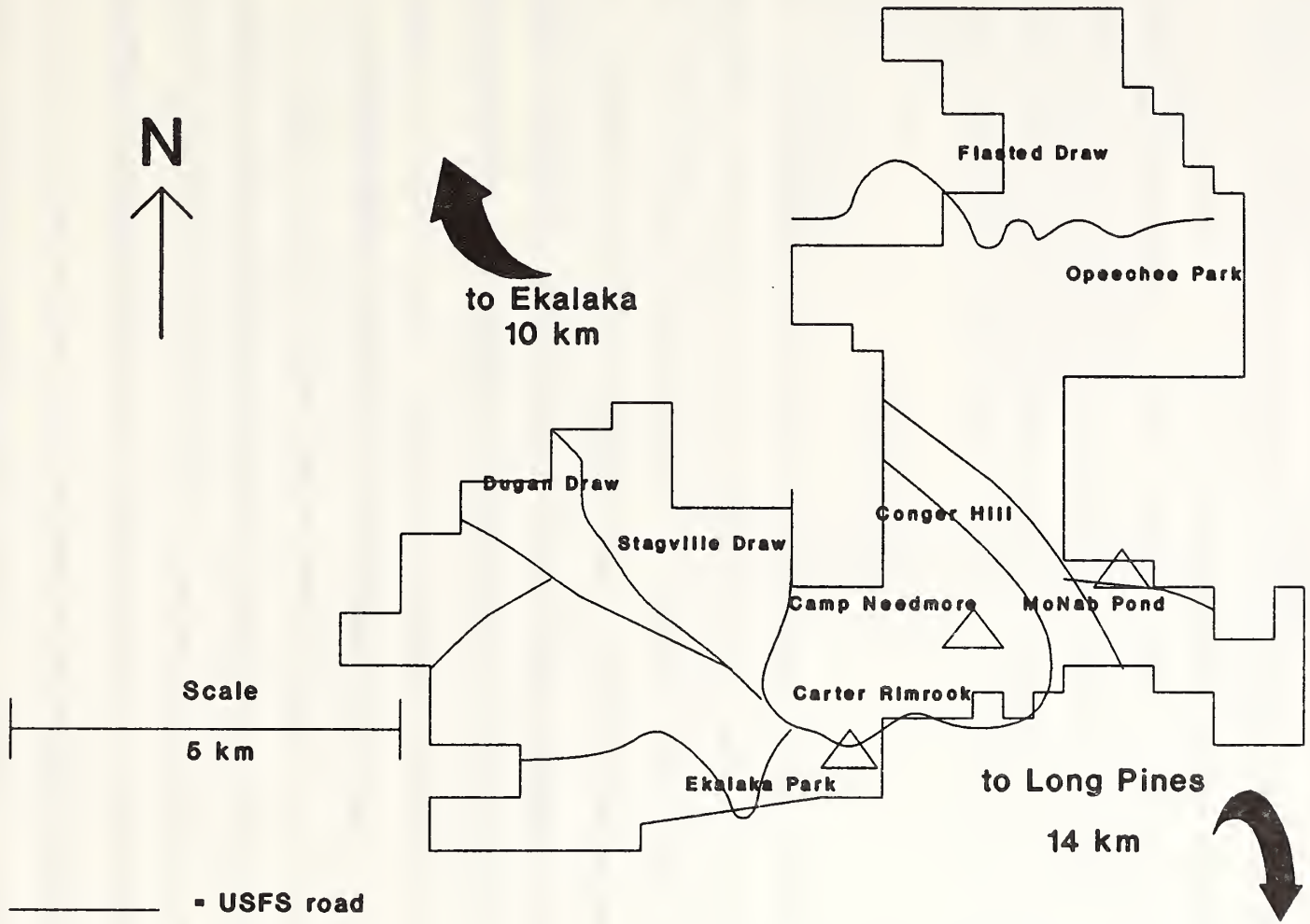

Figure 2. Ekalaka Hills unit of the Sioux District, Custer National Forest.

running water, on an average year, for their entire length. The area contains many springs, however, and the U.S. Forest Service and local landowners have cooperated to construct many small water impoundments and stock tanks for livestock.

The climate of the area is semi-arid. The mean annual temperature is 6.7 degrees centigrade (C.) with extremes of -41 C and 42 C. The average annual precipitation is 33.7 cm, one-half of which falls during the months of May, June, and July. During this study the annual precipitation was 40.8 cm in 1989 and 31.6 cm in 1990 (U.S. Forest Sevice).

Habitat Types

The following describes the existing vegetative conditions in the Ekalaka Hills and the pre-fire conditions in the Long Pines (Table 1). Forest and shrub habitat types are adapted from Hansen and Hoffman (1988). Grassland habitat types are adapted from Weaver and Albertson (1956). Scientific names of plant species follow the terminology by Scott and Wasser (1980).

The *Pinus ponderosa/Prunus virginiana* (PIPO/PRVI) habitat type (h.t.) is the major forest type in the Long Pines and Ekalaka Hills. It occurs on moist sites (north slopes, drainages, canyons) and typically consists of mature ponderosa pine forests with at least 40% canopy closure and a chokecherry dominated understory.

Table 1. Vegetation conditions for Long Pines prior to Brewer Fire, June 20,1988. (From Timber Stand Management System, Sioux Ranger District, Custer National Forest).

Vegetation/Strata	Hectares	% of Area
Seedling-Sapling	153	0.6
Poletimber	271	1.0
Sawtimber-Low Stocking	3,050	11.5
Sawtimber-Mod Stocking	7,260	27.3
Sawtimber-High Stocking	2,447	9.2
Two-storied-Low Stocking	631	2.4
Two-storied- Mod Stocking	766	2.9
Two-storied-High Stocking	218	0.8
Aspen	115	0.4
Juniper	21	0.1
Mixed/Other	306	1.2
Water	2	0.01
Scoria/Sandstone	1,040	3.9
Dry Grasslands	9,947	37.3
Wet Grasslands	360	1.4
Total	26,587	100

Associated understory species include green needlegrass (*Stipa viridula*), needle-and-thread (*Stipa comata*), Kentucky bluegrass (*Poa pratensis*), northern bedstraw (*Galium boreale*), Oregon grape (*Berberis repens*), Louisiana sagewort (*Artemesia ludoviciana*), and rose (*Rosa* spp).

A second major forest type is the *Pinus ponderosa*/*Agropyron spicatum* (PIPO/AGSP) h.t. which occurs on dry sites (south and west slopes, exposed ridges). This type has canopy closures of less than 40 %. Associated understory species include fragrant sumac (*Rhus aromatica*), common snowberry (*Symphoricarpos albus*), western coneflower (*Rudbeckia occidentalis*), milkvetch (*Astragalus* spp.), and

prairie thermopsis (Thermopsis rhombifolia). This type is especially common in the north half of the Long Pines where pine forests are very open and occur as small scattered patches.

The Fraxinus pennsylvanica/Prunus virginiana (FRPE/PRVI) h.t. occurs as wooded draws within the upland pine forest and extending into the adjacent prairie. Quaking aspen appears as a codominant in upland areas while boxelder (Acer negundo) is a codominant in prairie draws. Large ponderosa pine may occur sporadically within this type. Plains cottonwood (Populus sargentii) appears in larger drainages or as solitary trees further out on the prairie. Understory species may be relatively diverse and appear in several strata beneath the overstory. The diverse flora include various grasses and forbs, and most conspicuously, woody shrubs such as chokecherry, silver buffaloberry (Shepherdia argentea), hawthorns (Crataegus spp.), serviceberry (Amelanchier alnifolia), and American plum (Prunus americana). Most of these riparian areas do not reach climax condition due to persistent livestock damage and human disturbances.

The main shrub habitat type is Symphoricarpus albus/Monarda fistulosa (SYAL/MOFI) and appears as pure stands in many areas. This type is commonly found as large clumps (15-60 m) in wide, shallow drainages within grassland meadows. Pure stands of buffaloberry and of wild plum are

very rare. Pure hawthorn stands, however, are locally common along springs.

The dominant grassland habitat type in the study area is the Agropyron smithii/Stipa viridula (AGSM/STVI) habitat type. During my study, needle-and-thread (Stipa comata) replaced green needlegrass in importance within this type. Jonas (1966) recognized threadleaf sedge (Carex filifolia) and blue grama (Bouteloua gracilis) as being more important components of this h.t. than green needlegrass during his study. Several vegetation strata are associated with the AGSM/STVI h.t. In the duff layer (0-5 cm.) is found phlox (Phlox spp.), field pussytoes (Antennaria neglecta), clubmosses (Selaginella spp.), and lichens. The middle stratum (5-10 cm.) consists of blue grama, sedges, field pennycress (Thlaspi arvense), and yarrow (Achillea millifolium). The upper layer (> 10 cm.) consisted of white prairie aster (Aster falcatus), yarrow, penstemon (Penstemon spp.), lambstongue groundsel (Senecio integerrimus), and silvery lupine (Lupinus argenteus).

Other important grassland habitat types include (Andropogon scoparius/Carex filifolia) (ANSC/CAFI) and (Juniperus scopulorum/Agropyron spicatum) (JUSC/AGSP). The former occurs in small pockets, the latter on the foothills of the Ekalaka Hills and Long Pines.

Disturbed areas such as roadsides and overgrazed areas consist of a multitude of invading species such as bindweed

(Convolvulus arvensis), cheatgrass (Bromus tectorum), wild licorice (Glycyrrhiza lepidota), Rocky mountain beeplant (Cleome serrulata), curlycup gumweed (Grindelia squarrosa), yellow sweetclover (Melilotus officinalis), annual sunflower (Helianthus annuus), mullein (Verbascum thapsus), skeletonplant (Lygodesmia juncea), thistle (Cirsium spp.), Russian thistle (Salsola kali), houndstongue (Cynoglossum officinale), and pricklypear (Opuntia polyacantha). Pricklypear was especially prevalent in severely overgrazed areas.

Post-Fire Conditions in the Long Pines

The Brewer Fire significantly changed stand distribution and plant communities over much of the Long Pines. A mosaic of burn intensities occurred. Severely burned areas totaled 34% of the burn, moderately burned areas covered 28%, and lightly burned areas accounted for 38%. The latter did not include severely burned pockets within the low intensity burns. Stands with moderate to high stocking levels and fertile forest soils experienced high fire mortality while those stands with low stocking on poorer soils escaped severe damage (Resource Opportunity Analysis 1988). In stands where understories of chokecherry and aspen existed, and where woody draws were burned, sprouting of these species was evident in 1989 and 1990.

In many severely burned areas several plants have invaded including dock (*Rumex* spp.), spreading dogbane (*Apocynum androsaemifolium*), horseweed (*Conyza canadensis*), and woolly plantain (*Plantago patagonica*). In many areas, these species and a few others provided the only plant cover.

Grassland communities in the Long Pines are well adapted to fire and sustained little permanent damage, although the ecological status of some communities may have been altered. Lush re-growth was evident in many areas in the spring of 1989 due to an increase in nutrients from ash. In open grasslands (less than 10% tree cover), 950 ha (7.5%) experienced a high intensity burn, 1940 ha (15%) were burned at moderate intensity, 4170 ha (33%) were burned at a low intensity, and 5545 ha (44%) acres were unburned.

METHODS AND MATERIALS

Capture and Monitoring

Seven turkey hens were captured during December 1988 through March 1989 and 11 hens were captured from December 1989 through March 1990. The trap used was a walk-in drop gate trap. A commercial poultry feed was spread inside and around the trap near known feeding areas. Once conditioned to the trap the birds would move inside to feed and the drop gate could be tripped by the observer from a vehicle a short distance away.

After capture, turkey hens were placed in burlap sacks and weighed to the nearest 0.1 kg. Age determination was based on 2 criteria: examination of the outer 2 primaries (Amman 1944) and by using weight as an indication between juveniles and adults (Larson and Taber 1980). All hens were marked with a Montana Department of Fish, Wildlife, and Parks leg band for identification.

All 18 hens were equipped with 94 gram radio-transmitters (AVM Instrument Co., Livermore, CA.) with a backpack harness that extended around the base of each wing; the radio was positioned on the bird's back. Radio-tagged

turkeys were relocated using a Telonics (Mesa, AZ.) TR-2 portable receiver and a 2-element hand-held Yagi antennae.

Brood relocations were determined by triangulation. This consisted of a minimum of 3 bearings, each separated by at least 20 degrees. Relocations were plotted on 1:24,000 U.S. Geological Survey topographical maps of the study area. Most broods were relocated at least 3 times per week or every alternate day. Each telemetry fix was categorized by brood activity based upon time period: sunrise to 1000 hours = feeding, 1001 hours to 1400 hours = loafing, 1401 to dusk = feeding, dusk to sunrise = roosting. An effort was made to rotate each relocation to incorporate each brood activity at least once a week.

Hens with broods were observed from a safe distance by walking in to the brood vicinity and remaining concealed so as not to haze the birds. Visual sightings such as these were limited by constraints of time, weather, topography, and restricted access to private property. Visual sightings from roads provided additional relocations.

Relocation error was determined by placing radios at known locations and relocating them several times a week (Springer 1979). Relocation error was influenced by topography, distance of the radio from the observer, vegetation density, and bird movement. Relocations suspected of containing an unacceptable amount of error (> 5 ha.) were discarded.

Home Range Analysis

Home range analysis included overall home range size and stratified home range areas based on the age of the poults. I chose ≤ 15 days (young broods), and > 15 days (older broods) as a criterion in analyzing home range and habitat use. This is based on the age at which most gallinaceous birds are capable of minimal flight, prior to which they are most vulnerable to harsh weather and predation (Williams 1981). Relocations were analyzed using the TELDAY home range system (Lonner and Burkhalter 1988) which calculated home range size based upon the convex polygon method (Mohr 1947). TELDAY also calculated rate of movement (km/day), distance (km) travelled between successive relocations, and the average daily movement (km).

Shifts in home range were determined by measuring the distance between geographical activity centers (GAC). TELDAY calculates the GAC as the center of a circle which encompasses 68% of the relocations. Mann-Whitney U tests were used to determine differences in home range sizes between age classes, broods inhabiting burned areas vs. non-burned areas, and brood home range sizes in the Ekalaka Hills vs. those in the Long Pines.

Habitat Sampling

Feeding Sites

All vegetation sampling of feeding habitat used by broods was based on visual observations. Sampling employed a 50 m transect, and was based on the method by Daubenmire (1959). Transects were placed with the axis in the direction of travel by the brood. Plots (0.1 m^2) were placed every 2 m along the transect. Plant species and percent coverage by each species within all plots was recorded. Frequency was determined by the percentage of plots along the transect in which the species occurred. Horizontal coverage within plots and frequency of occurrence were summed for each species to give species importance values. Species were then grouped by class such as grass, shrub, forb, litter, or bare ground and averaged to give mean percent coverage values.

Vegetation density was recorded after Robel et al. (1970). A pole marked off in decimeters (dm) was placed at the center of each Daubenmire frame and observed from a distance of 1 meter away and 1 meter above ground in each of the 4 cardinal directions. The lowest visible dm mark on the pole was then recorded and the 4 readings averaged to give 1 reading. These readings from each of the 25 plots were averaged to give an average site density value.

Random sites were chosen and measured using the same methodology for statistical comparison.

Roosting Sites

A 10 x 10 m quadrat was used to analyze vegetation at roost sites for young broods. A 25 x 25 m quadrat was used for older broods in order to account for the larger area used when broods joined together.

All tree species with a diameter at breast height (dbh) > 1 cm were measured at sites used by young broods, and all tree species > 4.5 cm (dbh) were measured at roost sites for older broods. Height of trees (m) and the height of the first live limb (m) were measured with an Abney level. Aspect and slope were determined by compass. Distance to the nearest opening and to the nearest water source was recorded from topographic maps or by pacing in the field (Boeker and Scott 1968). Canopy closure was determined using an ocular tube with readings taken from plot center and corners for young broods. These were averaged to give a site value. For older broods, ocular tube readings were taken at the base of each roost tree. Robel pole readings were taken at each plot center and corner and averaged to give one reading. These readings were compared with similar data recorded for random sites using the same methodology.

Data Analysis

Data were analyzed using the MSUSTAT program (Lund 1991). Home ranges were overlayed on the most recent U.S. Forest Service forest stand inventory maps and typed

according to the 5 major habitat types on the study area: PIPO/PRVI, PIPO/AGSP, FRPE/PRVI, AGSM/STVI, and SYAL/MOFI. A planimeter was used to measure the areas of the habitat types within each brood home range.

Stand inventory maps were also used to analyze variables such as timber class (seedling-sapling, pole, or mature), timber stocking (low, medium, or high) as a measure of relative stand density, understory (herbaceous or woody), and burn severity (low, moderate, severe, or unburned).

Use-availability analyses were performed with chi-square goodness of fit tests (Neu et al. 1974). Habitat use in proportion to availability was determined by using the Bonferroni z-statistic and the methods of Byers et al. (1984). Habitat availability was determined by the average amount (ha) of each habitat type within the home range (Bidwell et al.1989).

The natural logarithm of the Shannon index (Hill 1973, Peet 1974, Pielou 1977) was used to test for differences in species diversity between observed and random sites. Mann-Whitney tests were used to analyze differences between canopy coverage, height and diameter of roost trees, distance to cover, distance to water, and distance to nearest opening. All tests were computed as two-tailed and with a significance level of $P < 0.05$ with +/- one standard deviation unless otherwise specified.

RESULTS

Relocations

A total of 416 relocations was obtained from May-September 1989 and May-September 1990. Several brood hens were lost during the study (appendix Table 17). In 1989, 1 hen was killed by an avian predator and 1 was taken by a hunter in the early fall. In 1990, 3 brood hens were lost to mammalian predators, 2 during mid-season and 1 in September.

Precipitation data indicated a slightly wetter spring in 1989 with a + 2.06 cm departure from normal, while in 1990 a - 4.7 cm departure was noted (Table 2).

Table 2. Monthly precipitation totals (cm) and departures from the normal mean during April-August 1989 and 1990 for Ekalaka, Montana. *

Month	Normal Mean	1989		1990	
		Pcpt.	Dep.	Pcpt.	Dep.
April	2.28	7.14	+4.85	5.13	+2.84
May	5.82	4.67	-1.14	3.02	-2.79
June	6.27	5.79	-0.48	6.81	+0.53
July	4.42	5.13	+0.71	1.37	-3.05
August	4.19	2.31	-1.88	1.95	-2.23

* Data from U.S. Forest Service weather records.

Home Ranges

Home range sizes varied with age of the poults and among different brood flocks (Appendix Table 18). For young broods, the average home range size was 16.3 ha (n=5, SD=16.3) in burned areas and 14.5 ha (n=9, SD=14.5) in unburned areas. For older broods, the average home range size was 139.5 ha (n=6, SD=99.1) in burned areas and 123 ha (n=12, SD=127.6) in unburned areas. There was no significant difference between home range sizes of broods in burned areas and those in unburned areas (Table 3).

Table 3. Comparison of home range sizes (ha) of young broods and older broods between burned and unburned areas in the Long Pines and Ekalaka Hills, May-September 1989 and 1990.

Age Category	Burned areas	Unburned areas	p*
≤ 15 days old	16.3 (n=5) (SD=16.3)	14.5 (n=9) (SD=14.5)	.689
> 15 days old	139.5 (n=6) (SD=99.1)	123.8 (n=12) (SD=127.6)	.607

* Computed with Mann-Whitney U-tests.

Home range sizes were typically small for young broods (range = 2.0 - 26.6 ha.). It was obvious that some broods were much more nomadic than others due to the wide range in home ranges once the poults reached 15 days in age (range = 21.9 - 444.2 ha). This difference between nomadic and sedentary brood flocks was not related to age of the hen.

Only 3 radioed hens raised broods in both 1989 and 1990. All 3 set up home ranges in the same areas both years (Figs. 3, 4, 5). All 3 moved from their wintering grounds to these areas to nest and raise their broods on both years. Home range sizes were smaller in 1989 for all 3 hens. Although based on a small sample size, there appears to be a rather high degree of fidelity to brood-rearing areas by turkeys in the Long Pines and Ekalaka Hills.

Daily Movement

Broods in burned areas had larger daily movements than broods in unburned areas (Table 4). The average daily movement by broods in burned areas was 0.72 km/day compared to 0.44 km/day for broods in unburned areas. This should be regarded as an index of relative activity in burned versus unburned areas and not as an indicator of the amount of area covered in a 24 hour period.

Home Range Shifts

Sixty-nine percent of hens with known nest locations established initial brood home ranges at least 295 meters from the nest site. On average, adult hens established the brood home range closer (average = 820 m, SD=500) to the

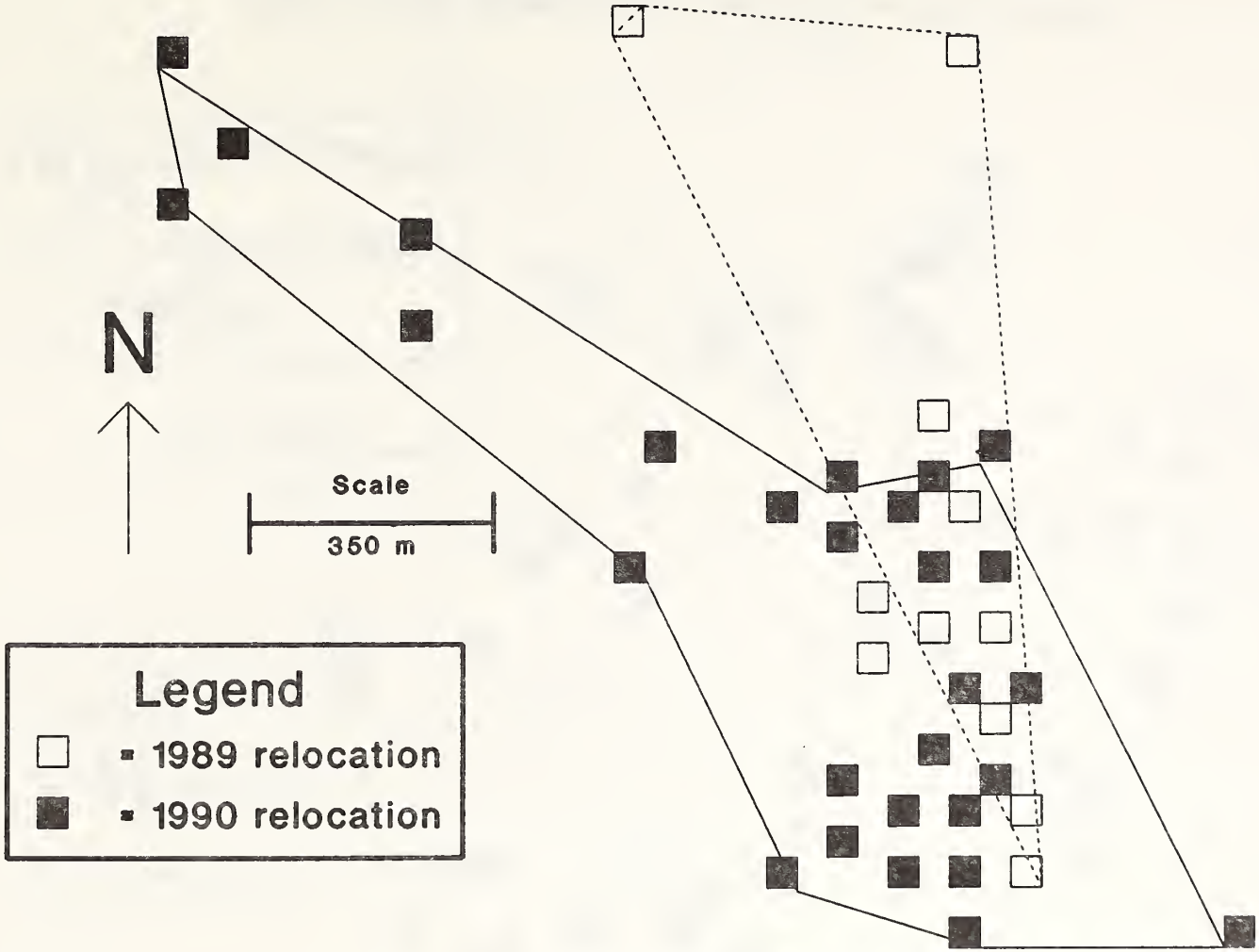

Figure 3. Home ranges of brood hen #0953 in 1989 and 1990 in the Ekalaka Hills.

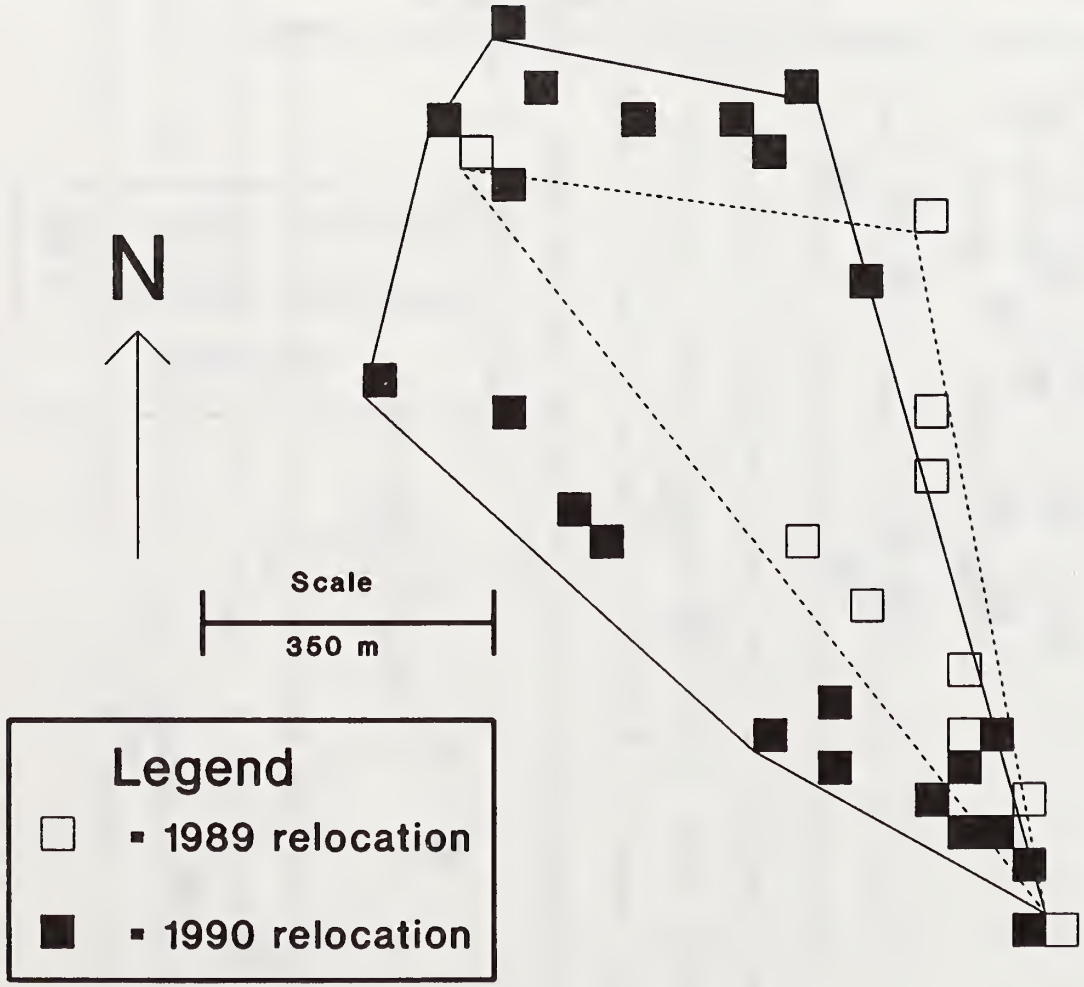

Figure 4. Home ranges of brood hen #1297 in 1989 and 1990 in the Ekalaka Hills.

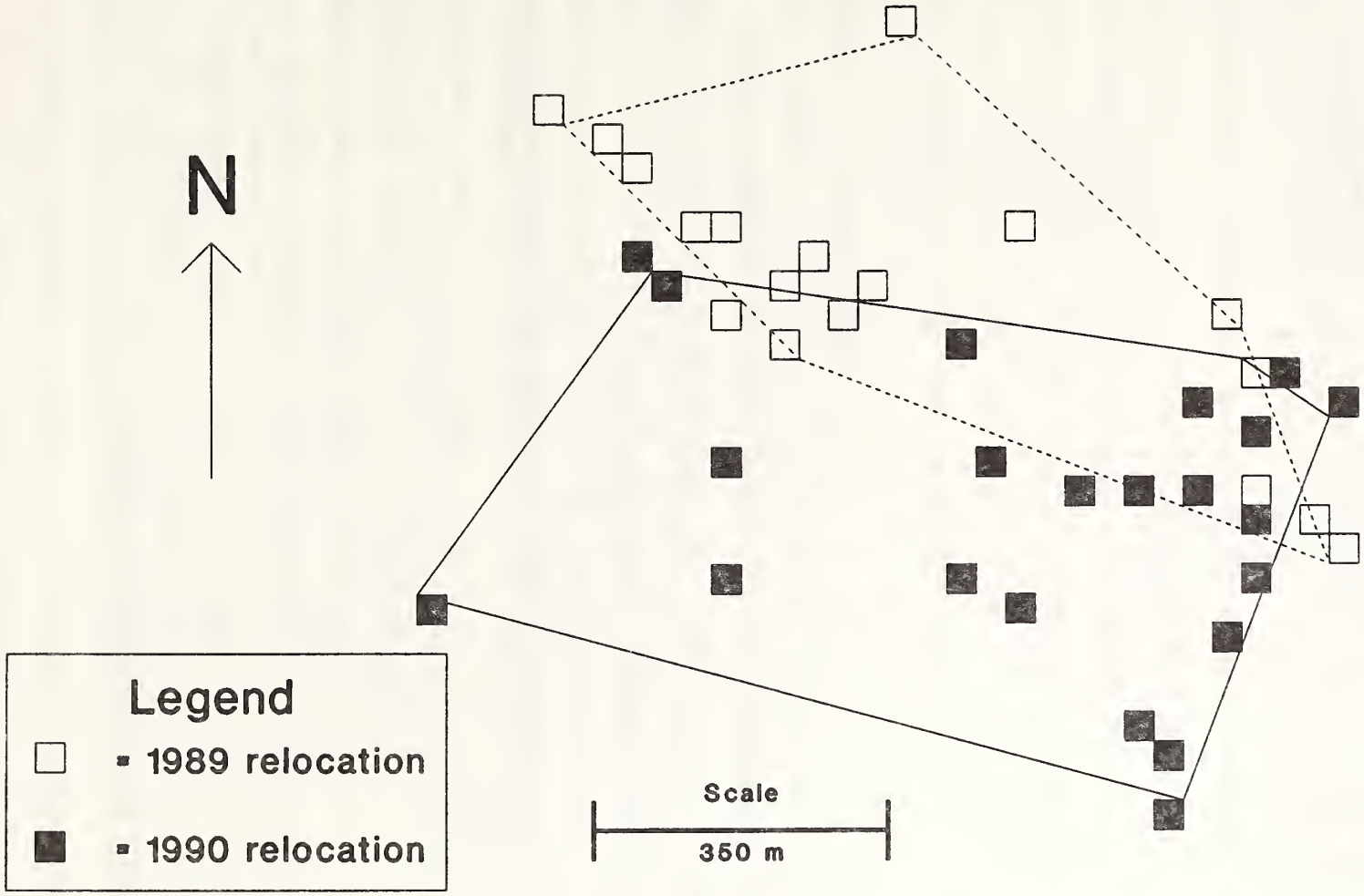

Figure 5. Home ranges of brood hen #0841 in 1989 and 1990 in the Long Pines.

Table 4. Mean daily movements (km/day) of broods in burned and unburned areas, May-September 1989 and 1990.

Brood I.D. #	Burned	Unburned
0841	0.694	
1270	0.470	
0700	1.000	
1843	0.454	
0161	0.966	
1177		0.503
1047		0.179
1297		0.459
0953		0.459
1588		0.590
Average	0.717	0.438
SD	0.261	0.154

nest site than juvenile hens (1373 m, SD=830). Seventy-eight percent of hens exhibited a home range shift when poults reached two weeks of age. Again, adult hens shifted a lesser distance than juvenile hens (Table 5).

Table 5. Comparison of mean distance (m) travelled by brood hens from nest site to first GAC and subsequent GAC.

	Nest to GAC #1				GAC #1 to GAC #2			
Age	Mean	SD	N	p*	Mean	SD	N	p
Juvenile	1373	830	6	.401	1821	2590	6	.747
Adult	820	500	14		928	712	14	

* Computed with Mann-Whitney U-test.

Macrohabitat Use

Figures 6 and 7 display observed relative to expected use of habitat types by broods irrespective of age and burn conditions in the Long Pines. Young broods occupied home ranges wherein FRPE/PRVI occurred in greater proportion than generally available, and selected against large dry grasslands. Other types occurred in proportion to availability. Older broods also selected the FRPE/PRVI habitat type. All other types occurred in home ranges in lesser proportion than their availability.

Broods in Unburned Areas

Table 6 compares macrohabitat use by broods in unburned areas with relative availability of habitat in the Long Pines and Ekalala Hills. The FRPE/PRVI habitat type was used more than expected ($p = \leq .10$) by broods in both age categories, while AGSM/STVI was used less. PIPO/PRVI, PIPO/AGSM, and SYAL/MOFI types were used in proportion to availability by young broods. In the case of older broods, PIPO/PRVI and PIPO/AGSM types were used less than expected, while SYAL/MOFI was used in proportion to availability.

Young broods did not select for a particular type of timber stand size class, although 88% of the relocations in timbered areas (including FRPE/PRVI) were in pole (12.7cm - 22.6cm DBH) or mature (22.9cm - 35.3cm DBH) stands (Table 6). Older broods showed a strong preference for pole stands

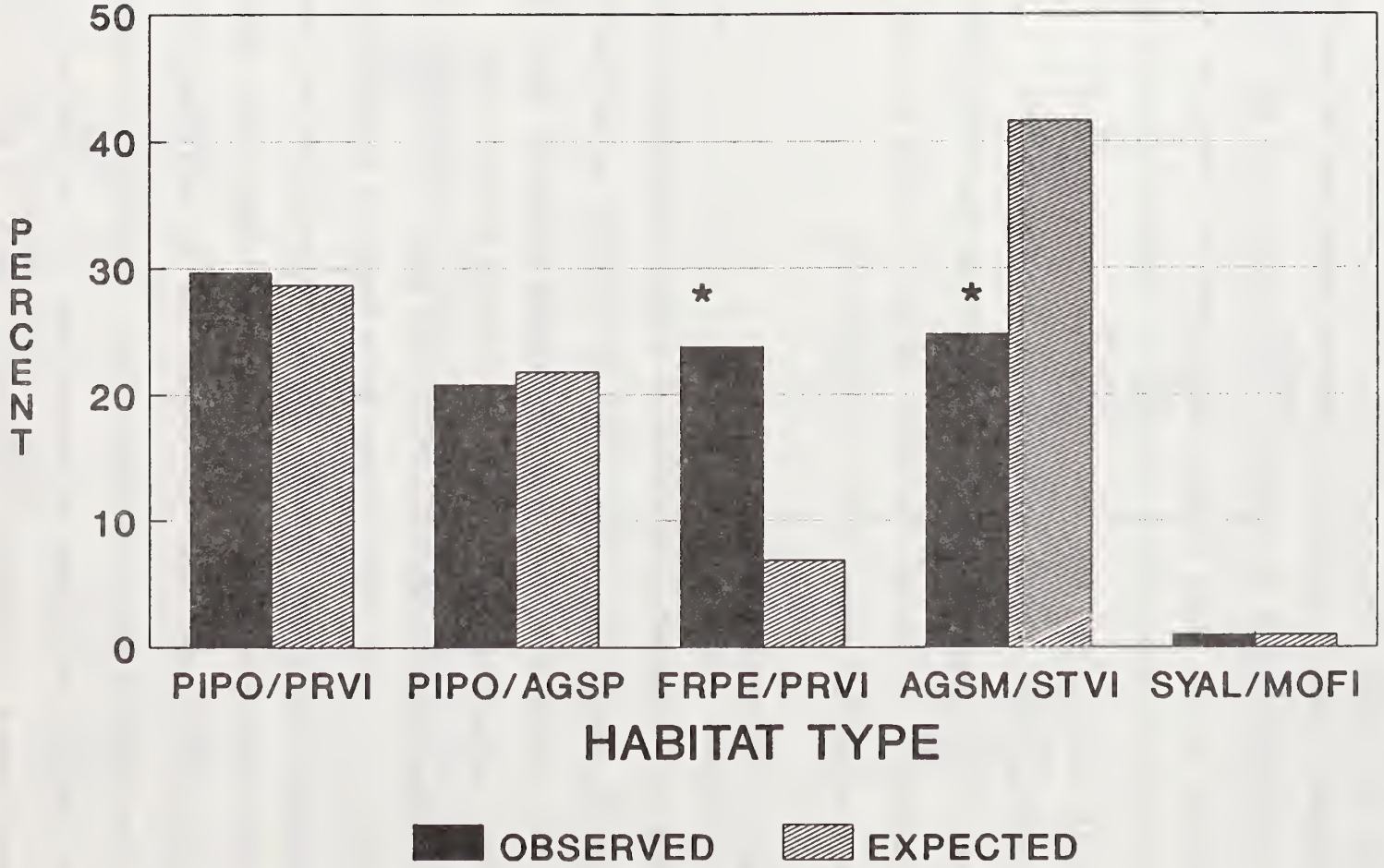

Figure 6. Use and expected use of habitat types by young broods in burned and unburned habitat.
* Different ($p < .10$) from expected value. ($n=101$)

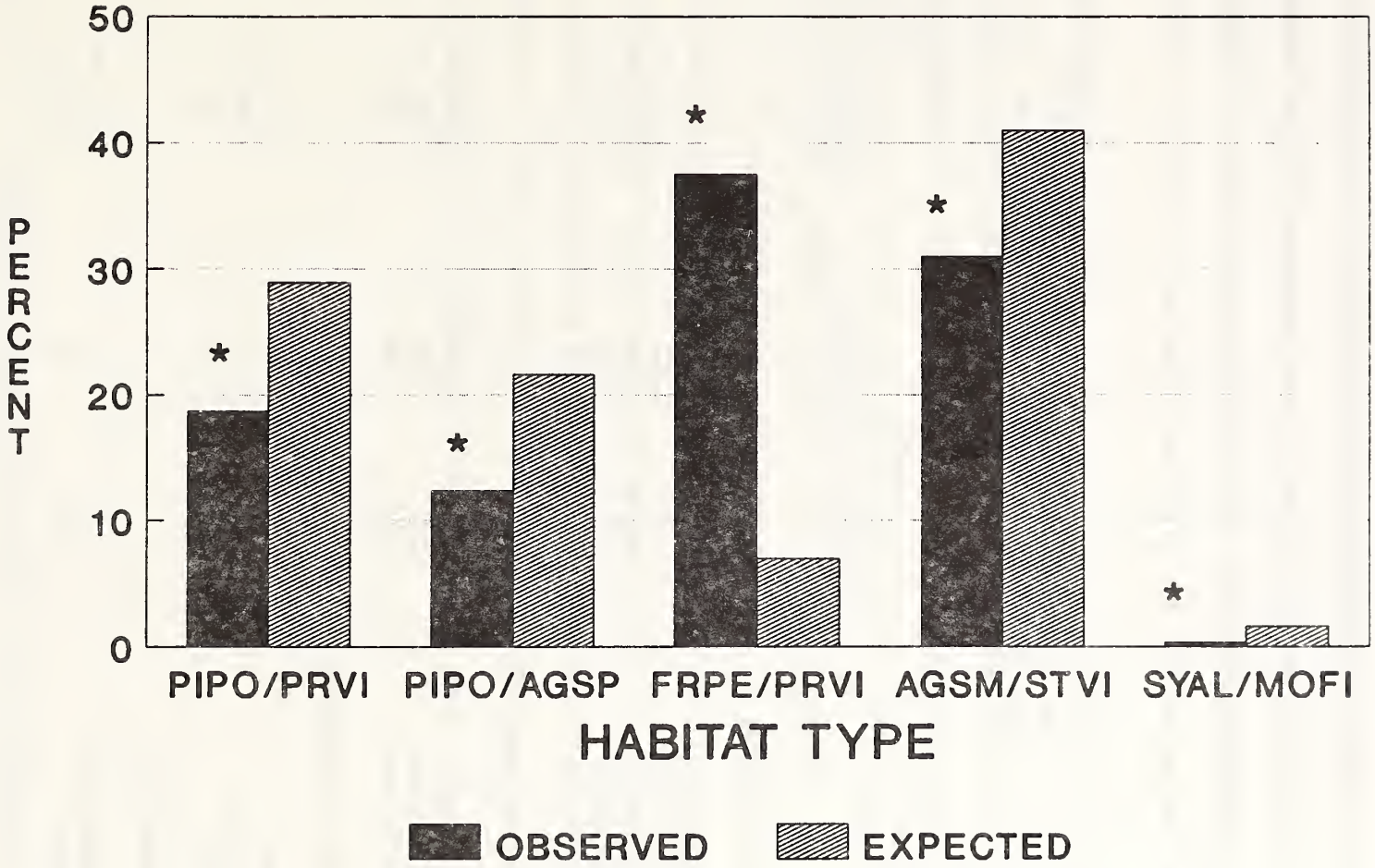

Figure 7. Use and expected use of habitat types by older broods in burned and unburned habitat.
* Different ($p < .10$) from expected value. ($n=315$)

and selected against seedling/sapling (<2.5cm - 12.4cm) and mature stands. The preponderance of pole stands is also due to the fact that the majority of hardwood draws consist of this stand size class. Mature hardwood draws on the study area are rare due to grazing impacts.

Table 6. Use and availability of habitat by young broods (59 relocations) and older broods (232 relocations) in unburned areas in the Long Pines and Ekalaka Hills, May-September 1989 and 1990.

Habitat Category	Young Broods (n=9)		Older Broods (n=12)	
	Observed	Expected	Observed	Expected
Habitat Type				
PIPO/PRVI	14	16	33 *	62
PIPO/AGSP	05	08	14 *	33
FRPE/PRVI	24 *	06	111 *	23
AGSM/STVI	15 *	28	73 *	110
SYAL/MOFI	01	01	01	03
Timber Class				
Seed/sap.	05	05	02 *	18
Poletimber	19	12	103 *	44
Sawtimber	19	26	55 *	98
Timber Stocking				
Low	32 *	45	114 *	177
Medium	15 *	04	88 *	16
High	12	10	30	39
Understory				
Herbaceous	21 *	37	88 *	146
Woody	38 *	22	144 *	86

* Different ($p < .10$) from expected value.

Young and older broods selected against low stocked (0-33%) stands and for medium stocked stands (34-66%). Highly stocked (67-100%) stands were used in proportion to availability. They also selected for a woody rather than herbaceous understory.

Broods in Burned Areas

Older broods used all habitat types and characteristics in proportion to availability (Table 7). Seventy percent of the relocations were in timbered types and 30% were in grassland types. Younger broods used habitat types in proportion to availability with the exception of the burn severity. Severely burned areas were selected for while moderately burned areas were selected against. Areas that experienced a light burn or were unburned were used in proportion to their availability. Seventy-six percent of the relocations were in timbered types and 24% were in grassland types.

Table 7. Use and availability of habitat by younger broods (42 relocations) and older broods (83 relocations) in burned areas in the Long Pines, May-September 1989 and 1990.

Habitat Category	Young Broods (n=5)		Older Broods (n=6)	
	Observed	Expected	Observed	Expected
Habitat Type				
PIPO/PRVI	16	13	26	27
PIPO/AGSP	15	14	25	29
FRPE/PRVI	01	01	07	01
AGSM/STVI	09	13	25	25
SYAL/MOFI	01	01	00	01
Timber Class				
Seed/sap.	00	04	03	06
Poletimber	04	05	12	11
Sawtimber	28	23	43	41
Timber Stocking				
Low	20	15	28	29
Medium	01	01	07	02
High	21	26	48	51
Understory				
Herbaceous	25	28	50	55
Woody	17	14	33	28
Burn Severity				
Low	03	05	11	10
Moderate	08 *	17	31	34
Severe	24 *	12	24	24
Unburned	07	08	17	15

* Different ($p < .10$) from expected value.

Microhabitat Use

Feeding Habitat

Twenty-two feeding sites were obtained from observing broods, and 22 random sites were located for comparison of site characteristics (Table 8). The AGSM/STVI habitat type accounted for 73% of observed sightings. Other habitat types could not be analyzed due to small sample sizes. Habitat variables measured in the AGSM/STVI type did not differ from random points except in distance to forested cover (x=9.5m, SD=9.8). All observations found broods feeding along the periphery of grassland meadows adjacent to the forest or along hardwood draws extending into the prairie. Broods were never found feeding more than 31 m from forested cover. One brood was seen moving quickly through a large grassland opening in the Long Pines but the birds were not feeding.

No significant differences between observed and random sites were evident among brood age groups (Tables 9 and 10), however younger broods were seen feeding in areas with denser canopy cover (average = 20%) than older broods (average = 7%). Table 11 gives the percentage of all turkey observations in each cover type by time period. Morning and evening hours are periods of highest activity when turkeys are most often feeding. The higher percentage of sightings in AGSM/STVI and FRPE/PRVI habitat types seemed to indicate a preference for a herbaceous understory for feeding.

Table 8. Comparison of feeding site characteristics in the dry grassland habitat type in the Long Pines and Ekalaka Hills.

	Observed (n=16)		Random (n=14)		
	x	SD	x	SD	p*
Grass coverage (%)	26.3	13.5	30.0	9.2	.618
Shrub coverage (%)	9.1	10.9	6.1	8.0	.575
Forb coverage (%)	13.1	8.3	9.7	4.9	.279
Total ground cover (%)	49.0	11.0	45.0	9.8	.479
Robel pole height (dm)	1.5	0.8	1.5	.79	.884
Distance to cover (m)	9.5	9.8	75.3	69.9	.000
Distance to water (m)	485.0	317.3	456.0	291.6	.739

* Computed with Mann-Whitney U-tests.

Table 9. Comparison of feeding site characteristics at observed and random sites for young broods in the Long Pines and Ekalaka Hills.

	Observed (n=10)		Random (n=10)		p*
	x	SD	x	SD	
Mean grass coverage (%)	25.2	14.29	26.3	13.97	.621
Mean shrub coverage (%)	12.9	14.31	9.6	11.97	.468
Mean forb coverage (%)	12.5	5.90	10.7	5.98	.537
Robel pole height (dm)	1.7	0.86	1.6	.948	.623
Canopy coverage (%)	20.0	32.2	24.5	30.6	.596
Distance to water (m)	468	182	546	279	.623

* Computed with Mann-Whitney U-tests.

In the morning hours the AGSM/STVI type had the highest percentage of relocations (39%). The highest use in the evening hours occurred in FRPE/PRVI (40%).

Table 10. Comparison of feeding site characteristics at observed and random sites for older broods in the Long Pines and Ekalaka Hills.

	Observed (n=12)		Random (n=12)		p*
	x	SD	x	SD	
Mean grass coverage (%)	28.2	16.72	27.1	11.10	.597
Mean shrub coverage (%)	7.1	7.10	8.4	10.44	.675
Mean forb coverage (%)	11.0	10.04	7.4	4.62	.268
Vegetation density (dm)	1.4	0.62	1.6	0.97	.642
Canopy coverage (%)	6.7	18.90	5.0	10.71	.683
Distance to water (m)	521	430.8	570	386.7	.879

* Computed with Mann-Whitney U-tests.

Table 11. Percentage of all turkey relocations in each habitat type by time period from May-September 1989 and 1990.

Cover type	Morning (dawn-1000) (n=89)	Midday (1001-1400) (n=122)	Evening (1401-dusk) (n=141)	Night (dusk-dawn) (n=64)
PIPO/PRVI	24.7	23.0	19.9	32.8
PIPO/AGSP	13.5	14.8	14.9	18.8
FRPE/PRVI	21.3	39.3	40.4	42.2
AGSM/STVI	39.3	21.3	24.8	6.3
SYAL/MOFI	1.1	1.6	0	0

No difference was found in species diversity between observed and random sites for young broods, but differences were significant for older broods (Tables 12 and 13).

Table 12. Plant species diversity (e H') at observed and random feeding sites for young broods in the Long Pines and Ekalaka Hills, May - September, 1990.

Site	(e H')	SD	N	p*
Observed	2.209	.3807	10	.526
Random	2.341	.3377	10	

* Computed with Mann-Whitney U-test.

Table 13. Plant species diversity (e H') at observed and random feeding sites for older broods in the Long Pines and Ekalaka Hills, May-September, 1990.

Site	(e H')	SD	N	p*
Observed	2.208	.3812	12	.047
Random	2.147	.3737	12	

* Computed with Mann-Whitney U-test.

Roosting Habitat

Young broods roosted exclusively on the ground. Most (75%) of the sites were in the PIPO/PRVI habitat type, and 25% were in AGSM/STVI. Observed and random roost sites differed significantly only in the amount of canopy closure and aspect (Table 14). Young broods were found in stands with more closed canopies on easterly aspects. Although not significant, Robel pole readings averaged higher and the distance to a meadow opening was less on observed sites. Young broods were most often found on the edge of a meadow.

The only exception was 1 brood in the Ekalaka Hills which roosted within a PIPI/PRVI stand approximately 50 m from a meadow. Two broods, 1 in the Long Pines and 1 in the Ekalaka Hills, used open meadows (AGSM/STVI) as roost sites on several occasions.

Table 14. Comparison of roost site characteristics between observed and random sites for young broods in the Long Pines and Ekalaka Hills, May-September 1990.

Variable category	Site Type		
	Observed (n=8)	Random (n=8)	p*
Slope (%)	19	14	.345
Robel height (dm)	3.3	2.2	.270
Stand DBH (cm)	21.2	16.0	.563
Tree height (m)	7.4	5.7	.462
Distance to Branch	1.3	1.3	1.000
Canopy closure	40	11	.031
Distance to meadow	10	39	.462
Distance to water	404	551	.528

* Determined by Mann-Whitney U-tests.

Older broods roosted exclusively above the ground. The FRPE/PRVI habitat type accounted for 57% of the roost sites analyzed, 29% were in PIPO/AGSP, and 14% were in PIPO/PRVI. Mean DBH and mean tree height were significantly greater at observed sites than at random sites (Table 15). Broods were found in large mature trees (average DBH = 59.2 cm). The distance to the nearest meadow was also significantly less at roost sites than random sites. Aspects were entirely on easterly slopes (Fig. 8).

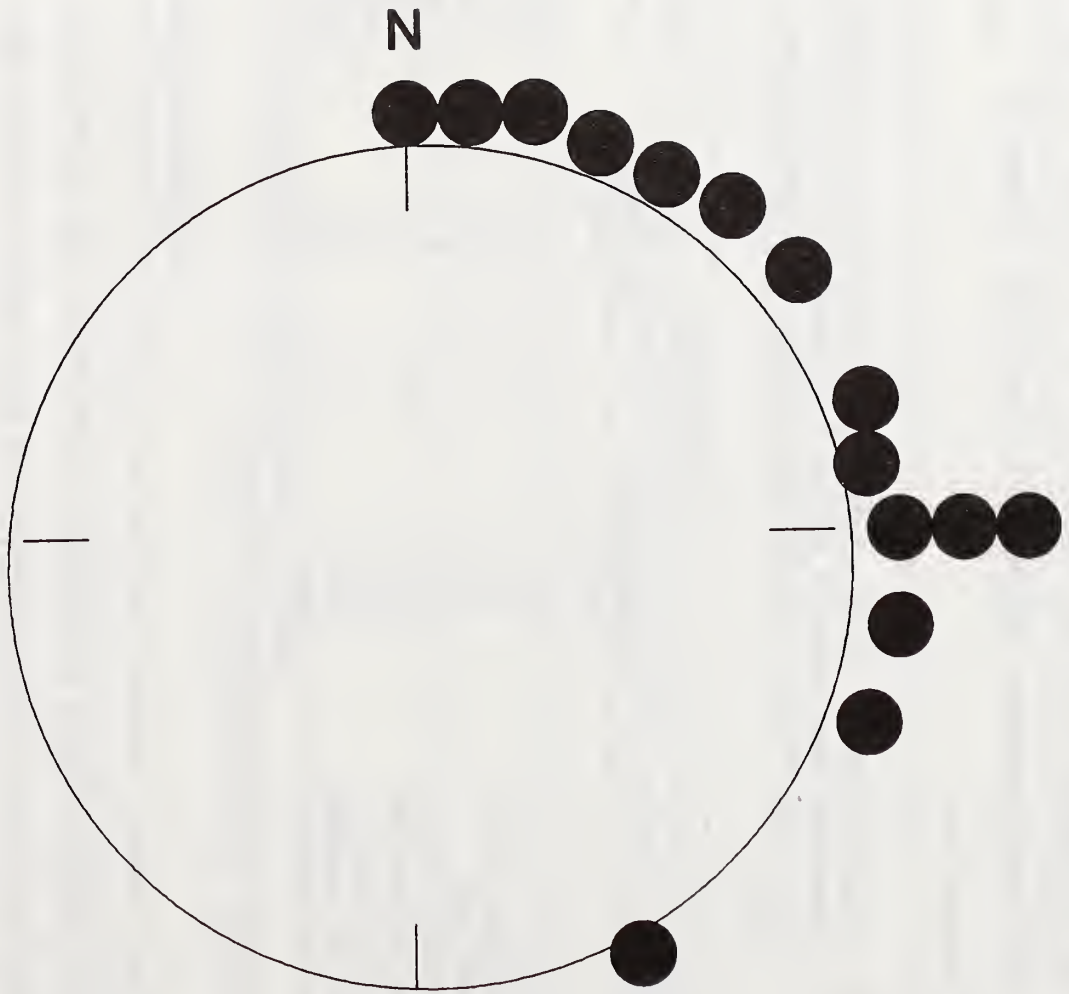

Figure 8. Aspect at turkey brood roost sites during 1990 in the Long Pines and Ekalaka Hills.

Table 15. Comparison of roost site characteristics between observed and random sites for older broods in the Long Pines and Ekalaka Hills, May-September 1989-1990.

Variable category	Site Type		
	Observed (n=7)	Random (n=7)	p*
Slope (%)	14	16	.848
Robel height (dm)	1.2	1.6	.898
DBH (cm)	59.2	25.4	.002
Tree height (m)	17.6	9.4	.004
Distance to branch (m)	4.2	3.0	.179
Canopy closure (%)	66.6	48.7	.277
Distance to meadow (m)	10.9	33.9	.035
Distance to water (m)	469	430	1.000

* Determined by Mann-Whitney U-tests.

Characteristics of trees used by broods for roosting were compared with unused trees within observed sites (Table 16). Because no brood was found roosting in a tree that was less than 22.9 cm (DBH), only trees of equal or greater diameter were included in the analysis. Roost trees were significantly larger in diameter and average height than unused trees. Canopy closure was lower on roost trees. The distance to the first live branch on roost trees was not significantly different than unused trees.

Roost sites occurred most often in the FRPE/PRVI type and the PIPO/PRVI type when both age categories are pooled together (see Table 11). Two young broods roosted in the AGSM/STVI type.

Table 16. Characteristics of roost trees compared to unused trees within observed plots for older broods in the Long Pines and Ekalaka Hills, May-September 1989-1990.

Variable category	Trees within plots		
	Used (n=10)	Unused (n=37)	p*
DBH (cm) **	55.6	37.8	.000
Tree height (m)	16.5	13.7	.038
Distance to branch (m)	3.3	3.9	.369
Canopy closure (%)	58.0	80.6	.024

* Determined by Mann-Whitney U-tests.
** Trees > 22.9 cm

The percentage of roost relocations in each available habitat type are given in Figure 9. Younger broods were found roosting in the PIPO/PRVI habitat type predominantly, while older broods mainly used the FRPE/PRVI habitat type.

Loafing Habitat

Although small samples precluded analysis of characteristics of loafing sites, some inferences about such sites can be made based on relocation data and from visual observations in the field. Most loafing occurs during mid-day when turkeys are relatively inactive. As seen in Table 11, the FRPE/PRVI h.t. accounted for the largest percentage of relocations during the loafing period with PIPO/PRVI second in importance. Younger broods were often observed loafing in dense cover along the PIPO/PRVI-AGSM/STVI ecotone.

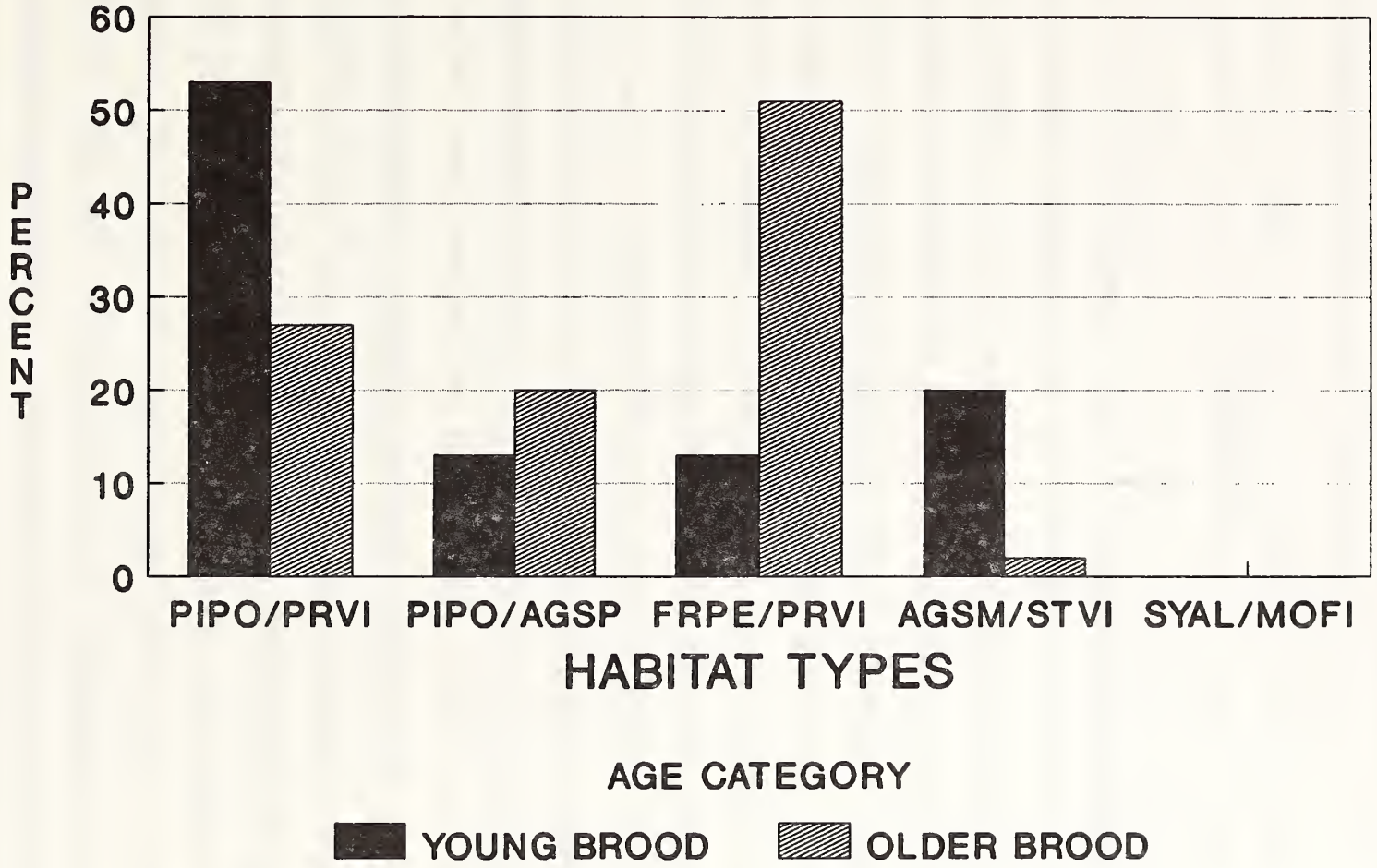

Figure 9. Percentage of roost relocations in various habitat types in the Long Pines and Ekalaka Hills.

DISCUSSION

Johnson (1980) reported that a hierarchical order of selection exists in habitat studies on many animal species. The results of this study pertained more to Johnson's third-order level of selection, or the selection of important habitat components within the brood home range. It is probable that brood habitat selection occurred previously on a more general level (second-order), wherein turkey hens prior to nest initiation left their winter range and moved to summer range to nest and raise broods.

Home range size is apparently related directly to habitat quality (Williams 1981). This also appeared to be true in my study. Broods with the largest home ranges tended to be in areas that lacked an adequate interspersion of different cover types, an important factor for productive turkey brood habitat (Healy 1981). Broods with the smallest home range sizes had a variety of cover types available. For example brood #0941 (home range size = 21.9 ha) remained on a ranch throughout the rearing period. Her home range contained an alfalfa field used for feeding and dense riparian vegetation along Box Elder creek for cover and roosting.

During the brood-rearing stage there appeared to be an initial home range shift when poults had reached approximately 2 weeks of age and a secondary shift after 4 weeks, however variability existed between broods. Adult hen movements (km/day) were 40% less than juveniles, which may suggest that adults choose and utilize brood habitat more efficiently than juveniles.

Home range shifts and brood movements in this study area may have been influenced by human disturbances, the presence of predators, changing food sources, separate brood flocks joining together, and disturbances by livestock. For example, in the summer of 1990 brood #'s 1297 and 0953 (a multiple brood flock) were displaced by a herd of cattle from a hardwood draw and moved into an adjacent draw that was ungrazed at the time. After 1 week the cattle had moved to another area and the brood flock returned to the original draw.

Each brood home range appeared to include areas that were highly favored. Such areas were used from several days up to the entire summer. Jonas (1966) also recognized such areas and stated they were approximately 80 ha in size.

Poult mortality was difficult to assess due to inability to observe very young poults in herbaceous cover. However, some broods appeared to suffer heavy mortality due to wet spring weather as reported by Jonas (1968). Hen #1177 lost 70% of her poults during the first 3 weeks after

hatching when 3.5 cm of rain occurred in the Ekalaka Hills. The majority of this fell in 2 storms over a 4 day period.

Broods in Unburned Areas

Several authors have noted the importance of forested cover for turkey broods (Mackey 1986, Dickson et al. 1978, Latham 1956.) Poult production appears to be highest when forested habitat consists of 20% in openings (Dickson et al. 1978). Turkey broods in my study used openings for feeding, where insects, a prime source of protein for developing poults, are found in greater abundance than under a forested canopy (Hurst and Springer 1975, Hurst 1978). Martin and McGinnes (1975) found that insect abundance was 75% higher in a forest clearing than in the adjacent forest.

Healy (1981) stated a herbaceous understory may be more important than woody cover during the early brood-rearing stage. It is generally believed that the best habitat for turkey broods consists of a moderately dense overstory canopy, and scattered openings with a well-developed herbaceous ground cover for feeding.

During this study, observed feeding sites differed from random sites only with respect to distance from forested cover. Broods did not appear to be selecting for very dense herbaceous cover. This was possibly due to its limited availability on the intensively grazed study area. However, older broods did appear to select for more species-rich

sites such as found in the deciduous draw cover type. Low summer rainfall and grazing by ungulates probably precludes extensive development of dense herbaceous cover in southeastern Montana. Moderate grazing may permit a greater ease in mobility for poults during feeding as discussed by Metzler and Speake (1985).

In unburned areas of the Long Pines and Ekalaka Hills all broods seemed to show a distinct preference for forested areas with woody understories and scattered small openings with herbaceous cover. The most commonly used habitat type was the deciduous draw.

The PIPO/PRVI h.t. was used in proportion to availability by young broods, although the broods were usually in or near small openings (< 4 ha.) within the type. This type provided an adequate overstory of trees with an understory consisting of chokecherry, scattered snowberry, and herbaceous cover. As broods became older and more mobile they used this type less. Instead, they increasingly used more diverse habitat such as that found in the deciduous draws. Several broods which displayed home range shifts moved from upland forested stands to deciduous draws at lower elevations.

The PIPO/AGSP habitat type was selected against, possibly because this type generally is too open and provides limited protection from raptors. A thick herbaceous understory of grass in this type may also impede travel when

poults are very young (Healy 1981). However, older broods used this type for roosting. This may have been related to the open canopy which facilitated flying to and from the roost.

Hayden (1979) noted that broods avoided large, open meadows. Dry grasslands (and shrub types) were also used less than expected based on their availability in my study. Turkeys did, however, use the edges of these areas. Grassland-forest edges with denser herbaceous cover provided adequate roosting cover for poults incapable of flight as indicated by observations of several young broods found roosting in grassland cover within 30 m of the forest.

Seven of 12 broods monitored used the hardwood draw cover type for the majority of the brood-rearing season. Other studies have also noted use of habitat types similar to the deciduous draw type in southeastern Montana (Hayden 1961, Campo et al. 1989). Turkeys were reported as common residents in deciduous draws of western North Dakota (Faanes 1983). In the Long Pines and Ekalaka Hills this habitat type is also the most diverse in plant species and abundance. Dubois (1979) stated that the most diverse avian fauna occurred in this habitat type in the Long Pines. Healy (1981) stated that species diversity is a key factor in productive turkey habitat.

Deciduous draws on the study area typically consist of poletimber size stands which turkeys seem to prefer (Campo

et al. 1989, Jonas 1966). This stand size class also provides overstory protection from raptors, and a cooler microclimate during hot summer months. At the same time enough light penetrates for an herbaceous understory to develop.

Jonas (1966) reported that broods in the Long Pines were sighted mostly in the snowberry-grass ecotone at the edge of the forest. I identified this as the pine/cherry-open meadow (PIPO/PRVI-AGSM/STVI) ecotone, and found it important mostly during the early brood-rearing stage. Like Jonas (1966), I found very little use of pure snowberry stands. Pure snowberry stands are very dense and likely provide concealment for mammalian predators. Thus, they were avoided by broods.

Jonas (1966) also did not note important use of the deciduous draw community by turkey broods during the summer. He did, however, note a sharp increase in the use of draws during the fall. Jonas's study was based entirely upon visual observations (radio telemetry was not available). The dense overstory and understory cover in the deciduous draw community during the summer months would likely make turkey broods less visible than in the forest-grassland ecotone. Observability would increase in the fall when leaves are shed.

Surface water was available in some draws, usually in the form of stock tanks and stock ponds but turkeys were

rarely seen near them. The tendency for livestock to congregate around these areas probably precludes use by turkey broods. Two broods on the Box Elder Creek had plentiful running water and were seen drinking occasionally throughout the summer. Although the presence of permanent surface water does not appear to be a limiting factor for the Merriam's subspecies, moisture may be important to poults at least in the form of dew or succulent vegetation. Adult turkeys are capable of obtaining their required moisture from their food (Blakey 1937, Ligon 1946, Williams 1981).

Rose (1956), in a dietary analysis of turkeys in the Long Pines, noted high use of the fruits of fragrant sumac, bearberry, snowberry, and chokecherry. He also reported grasshoppers as being the most abundant insect in the summer diet. Jonas (1966) also observed a large preponderance of insects (mostly grasshoppers) during summer months in collected turkey crops. Holzer (1989) indicated that summer food items in westcentral Montana consisted heavily of arthropods, brome grasses, sumac seed, and various flowers.

The patchy woody understory typical of the draw community consists of a variety of berry-producing species such as chokecherry, bearberry, hawthorn, serviceberry, snowberry, and buffaloberry which provide an abundance and variety of food items for broods later in the summer. During field inspection of turkey droppings in this habitat type, I

noted a large amount of insect exoskeletons and chokecherry seeds.

Roost trees in all cover types, except deciduous draws, tended to be large, mature ponderosa pine. Along with Lutz and Crawford (1987), these were some of the largest recorded turkey roost trees. Brood hens seemed to be highly selective in choosing the roost. The availability of large roost trees is not a limiting factor to turkeys in the study area at present.

I found no roost sites on or near logged areas during this study. Jones (1981) had 46% of known roost sites in logged areas while Lutz and Crawford (1987) had only 7.5%. Hoffman (1968) in Colorado noted that all roost sites were in unlogged areas. The absence of large-scale logging activity (especially clearcutting) on my study area precludes any conclusions about the possible effects of logging on turkey roost site selection. However, it might be assumed that unless slash from logging activity is piled, burned, or both, turkeys would be unlikely to use a roost in a logged area due to the difficulty in moving through thick downed material.

Hoffman (1968) noted repeated use of the same roost trees in the fall, winter, and early spring. In general, turkey broods with more sedentary movements tended to use the same roost or a few selected roost sites repeatedly. The depth of the droppings at some roost sites revealed that

these areas had been used by turkeys for several years. Adequate roost trees seem to be few in number in deciduous draws due to the fact that this habitat type rarely attains its potential climax. Therefore, turkeys may have to use one or two sites repeatedly.

Young broods were observed roosting on the ground in poletimber stands. Although sample size was small (n=8), broods seemed to prefer a relatively dense ground cover (ave.density reading = 3.3dm). Although little information is available on roosting behavior of poults during the pre-flight stage, the presence of a dense herbaceous ground cover is likely more important than a woody overstory for roosts (Healy 1981, Williams 1981).

Broods in Burned Areas

Ligon (1946) stated that forest or grass fires may severely affect turkeys by destroying nests and young, and make parts of their range temporarily uninhabitable. Alternatively, it has been suggested that burning may encourage new growth, increase insect abundance, and prevent fuel buildups that could lead to more devastating fires. Leopold (1932) noted that fire leads to a mosaic of seral and climax stages providing more "edge" for feeding, nesting, loafing, and escape cover.

Broods in the Long Pines did not avoid burned areas. Six radioed turkey hens raised broods in burned areas during

the two years of the study. Hen #0841 raised a brood in both years. Older broods were observed using burned ponderosa pine trees as roosts. Zontek (1966) noted turkeys using burned areas on the Marks National Refuge in Florida, and Rose (1956) also noted a sharp increase in turkey use of a small 0.3 ha burn in the Long Pines. Additionally, the Long Pines fire probably masked any effects logging had on habitat selection.

It is most likely that hens with broods were selecting more for vegetation structure rather than species composition in the early brood-rearing stage. In fact, young broods selected for certain severely burned areas with dense herbaceous cover over adjacent unburned cover.

Forested areas that had high amounts of fuel in the duff and litter layers burned the hottest (Resource Opportunity Analysis 1988). Shading, litter, and soil nitrogen depletion are the primary factors that depress understory herbaceous growth in ponderosa pine forests (Wright and Bailey 1982, Moir 1966). Fire may have prepared a seed bed, increased the amount of light reaching the ground, and broken dormancy in the soil seed bank encouraging new growth to develop in severely burned stands (Daubenmire 1947). Thus, these areas were attractive to broods.

Older broods in burned areas used habitat types in proportion to their availability. Holbrook et al. (1987), in their study on turkey habitat use on intensively managed

pine plantations in Virginia, found that turkeys used habitat in proportion to availability. They suggested that mature hardwood stands were an important component in turkey habitat and their availability may have influenced turkey use in other cover types. The reduction in availability of deciduous draws in the Long Pines due to fire mortality may have similarly caused broods to use other available types more often.

MANAGEMENT IMPLICATIONS

1. Turkey broods in the Long Pines and Ekalaka Hills showed a preference for deciduous woody draws and pine/cherry habitat throughout the brood-rearing season. The presence of many potential food items, moisture, cool microclimate during hot summer temperatures, and cover from predators makes the hardwood draw habitat type especially favorable for turkey brood-rearing. There is minimal information about the relationships between wildlife and deciduous draws in Montana, and more effort should be expended to better understand their importance to the plains flora and fauna.

2. The impact of logging was difficult to define due to the limited amount of logging in unburned areas remaining after the fire. The fire overrode any effects logging may have had on brood habitat use. Silvicultural treatments proposed in the Ekalaka Hills to lessen the chances of a major fire occurring in the future may benefit turkeys by opening up dense, stagnant ponderosa pine stands and encouraging herbaceous growth. Slash treatment would encourage turkey use in these areas. An interspersion of large, mature ponderosa pine trees with open canopies and large, horizontal branches should be left for turkey roost

trees in planned logging areas. Except for small-scale firewood cutting, no logging should take place in deciduous woody draws.

3. The impact from grazing, the dominant land use in the area, deserves more study. Turkey broods were observed on several occasions to avoid areas where cattle were present. It is likely that overgrazing would limit turkey brood productivity by reducing herbaceous and woody cover.

4. The effects of the Long Pines fire in 1988 on turkeys will probably be evident for years to come. The initial effect on turkey broods was that it made resources less contiguous, forcing hens to increase their daily activity. It is expected that the Long Pines will become a more open forest once dead trees begin to fall from windthrow and insect damage. Thus, the remaining ponderosa pine/chokecherry and hardwood draw stands become of even greater importance for turkey broods and should be maintained for brood cover and other wildlife.

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APPENDIX

Table 17. Ages, date of capture, and fate of turkey brood hens captured during winters of 1988-89 and 1989-90 in the Long Pines and Ekalaka Hills.

Turkey I.D.	Age	Capture date	Fate
1533	J	02-11-89	Died 11-15-90 (M) *
0941	J	02-11-89	Died 08-22-90 (M)
1047	A	02-11-89	Alive
1843	A	03-11-89	Unknown
0161	J	03-11-89	Unknown
1588	J	12-30-88	Died 09-03-89 (H)
0953	J	12-30-88	Unknown
1297	J	12-30-88	Died 07-15-90 (M)
1552	A	12-29-88	Alive
0841	A	02-10-89	Alive
0700	J	02-10-89	Died 07-27-89 (A)
1177	J	12-06-90	Died 04-23-91 (M)
0398	J	02-02-90	Died 05-08-91 (M)
1270	A	03-08-90	Died 09-16-90 (M)
1077	A	03-24-90	Died 05-16-91 (M)

* (M = mammalian predator, A = avian predator, H = hunter).

Table 18. Individual home range sizes (ha) for broods ≤ 15 days and > 15 days for the period of May-September 1989 and 1990.

Year	Brood I.D.	≤ 15 days	> 15 days
1989			
	0841	17.1	50.7
	0700	17.4	265.4
	0161	25.2	140.3
	1297	8.6	44.9
	0953	8.6	44.9
	1843	*	39.7
	1588	*	102.4
1990			
	1177	7.0	268.6
	1297	16.2	91.5
	0953	26.6	62.0
	1047	21.4	111.4
	1533	*	45.1
	0941	2.0	21.9
	1270	14.5	252.5
	1552	*	22.3
	0841	7.5	88.3
	1077	24.0	444.2
	0398	16.2	227.2

* Data not available.