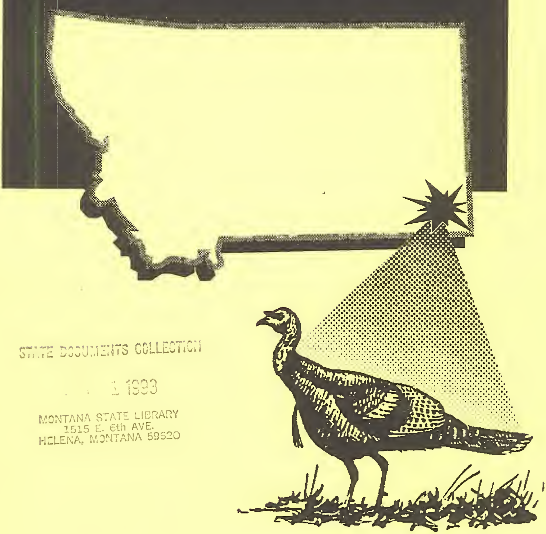
ECOLOGY OF MERRIAM'S TURKEYS

in Relation to Burned and Logged Areas in Southeastern Montana



Cooperators

Montana Department of Fish, Wildlife and Parks
USDA Forest Service - Custer National Forest
National Wild Turkey Federation
Montana State University

May 1993

JOB PROGRESS REPORT
RESEARCH PROJECT

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PREPARED BY William L. Thompson APPROVED BY John P. Weigand

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ABSTRACT

Merriam's turkeys (*Meleagris gallopavo merriami*) were captured, equipped with radio transmitters, and monitored via telemetry to study their ecology in relation to burned (1988 wildfire) and logged areas in southeastern Montana, 1989-1991. Neither burned nor logged areas appeared to restrict seasonal movements of monitored turkeys during spring and fall. However, males and subadult hens in the burned study division moved farther than those in the unburned during spring/fall. Hens tended to nest more in burned areas with each subsequent year following the fire. Nest success was highest during the spring with largest amounts of precipitation. High levels of precipitation during spring likely promoted understory plant growth and increased nesting cover especially where fire opened the canopy to more sunlight and increased nutrient release to soils. Only 1 of 49 nests occurred in logged areas. Clearcut logging may be more detrimental to nesting habitat in xeric (for example, southeastern Montana) than mesic regions because of slower vegetational growth and lower habitat structural diversity. Nests generally occurred in cover $\geq$6.5 dm high and on $\geq$20% slopes. Summer home range sizes were not correlated with percent burned or logged area that they contained. Roost trees within burned areas were larger in diameter than those in unburned areas. More "large" trees in severely burned areas may have become attractive to roosting turkeys through loss of dense canopy and simplified branch structure. Turkeys usually roosted in the taller (mean = 18 m) and larger diameter (mean = 41 cm dbh) trees available. On average, roosts occurred on 25% slopes with easterly or northeasterly aspects. Severely burned trees used for roosting may be lost over time because of their breakage and falling. No roosts occurred in forest stands subjected to any type of timber harvesting scheme. Survival rates of monitored turkeys were similar between burned and unburned areas. Overall, habitat quality for turkeys likely was lowered during the first year or 2 following the fire, but should generally increase (except roosting habitat) in subsequent years. The effects of logging on turkey habitat in southeastern Montana remain unclear; however, logged areas were rarely used by monitored turkeys during this study.

CHAPTER 1

INTRODUCTION

Merriam's turkey originally inhabited ponderosa pine-oak (scientific names for plant species are given in Appendix A, Table 1) forests in mountainous areas of Colorado, New Mexico, western Texas, and Arizona (Ligon 1946). State wildlife agencies have introduced this subspecies into non-native areas throughout the West. Merriam's turkeys now occur in North and South Dakota, Nebraska, Colorado, New Mexico and all states west to the Pacific coast (Kennamer and Kennamer 1990).

Wild turkeys were first introduced into Montana in 1954 when 13 Merriam's turkeys were translocated from Colorado to the Judith Mountains of central Montana (Rose 1956). The second introduction occurred in the Long Pines Division of Custer National Forest in southeastern Montana where 18 Merriam's turkeys from Wyoming were released during 1955. Rose (1956) initially evaluated these 2 introductions, whereas Jonas (1966) conducted more intensive ecological studies in the Long Pines. There has been no further

detailed research on the status and ecology of Merriam's turkeys in either the Long Pines Division or the adjacent Ekalaka Hills Division (where 13 turkeys were released in 1958, Jonas 1966) during 1963-1988. Currently, both divisions have viable turkey populations.

During 8-21 June 1988, 2 lightning-generated wildfires burned approximately 20,920 ha (74%) of the Long Pines Division creating a mosaic of burned and unburned timber and grasslands (Fig. 1) (Havig et al. 1988). The effect of these wildfires on habitat[1] use by Merriam's turkeys was unknown. Prior to 1988, there had been no research on effects of fire on habitat use by this species anywhere in its range. Although Gobeille (1992) studied habitat use by turkey broods in relation to burned areas in southeastern Montana during 1989-1991, the effects of wildfire on habitat use by non-brood flocks of turkeys during summer and on ecology of turkeys during the rest of the year was unknown.

In response to the 1988 wildfire, Custer National Forest (Sioux Ranger District) of the U.S.D.A. Forest Service developed a Fuels Management Program (FMP) to alleviate further threat of wildfire in the Long Pines and avoid

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1 I defined habitat as the physical space that contains the environmental and ecological components necessary for an organism to survive and reproduce (adapted from Morrison et al. 1992).

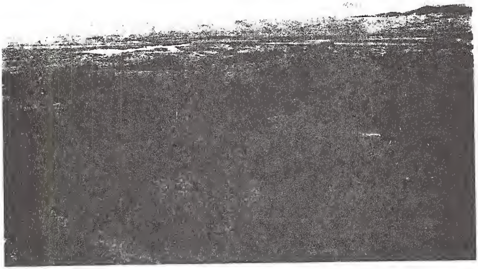

Fig. 1. Mosaic of burned and unburned stands of ponderosa pine in the Long Pines Division of Custer National Forest, 1990. The Ekalaka Hills Division is in the background.

catastrophic fire in the Ekalaka Hills. Specifically, the objective of the FMP was to "manipulate vegetation and fuels in specific treatment areas or zones by opening ponderosa pine forests, by separating continuous fuels, and by reducing the amount of fuels on the ground through various treatment methods while continuing to protect natural resources, forest facilities, improvements, and private property." As part of the FMP, 895 ha were scheduled for timber harvest (type of harvest determined by stand characteristics) or prescribed burning in the Ekalaka Hills during 1992-1995. Furthermore, 437 ha of timber had been harvested in the Ekalaka Hills during 1981-1991 (D. Sandbak, U.S. Forest Service, pers. commun.).

Effects of logging on habitat use by Merriam's turkeys have been reported for southern ranges, including New Mexico (Schemnitz et al. 1985), Arizona (Scott and Boeker 1975, Scott and Boeker 1977), and Colorado (Hoffman 1973). In the north, such research has been conducted only in Oregon (Lutz and Crawford 1987).

My study evaluated habitat use, movements, and survival of Merriam's turkeys in relation to both burned and logged areas in southeastern Montana. Chapter 2 summarizes vegetative communities located in the study area. Chapter 3 describes yearly use of wintering sites in unburned and unlogged lowlands. Chapters 4-6 describe spring/fall and summer habitat use and movements of turkeys. Chapter 7

reports both overall and disturbance-related survival rates. Chapter 8 describes research and management implications as related to both southeastern Montana and burned and logged habitats in the West.

CHAPTER 2

STUDY AREA

The study area is comprised of the Long Pines (total area = 27,424 ha) and Ekalaka Hills (total area = 2,150 ha) Divisions of Custer National Forest located in Carter County in southeastern Montana (Fig. 2). Each is an upland area that rises up to 350 m above the surrounding prairie. Both are vegetated by ponderosa pine-meadow parklands (Fig. 3) with scattered quaking aspen stands. Steep sandstone cliffs and outcroppings are common.

Major drainages in the study area include Little Beaver Creek to the northwest, Boxelder Creek in the center, Little Missouri River to the east, and Tie Creek to the south (Fig. 2). Numerous hardwood draws extend from upland areas to the prairie. Many drainageways branch out across the prairie, but most lack standing water except during spring. Permanent water sources include stock ponds, stock tanks, and natural springs. Upland soils are fine-silty, calcareous, well-drained, and sedimentary in origin (Montagne et al. 1982).

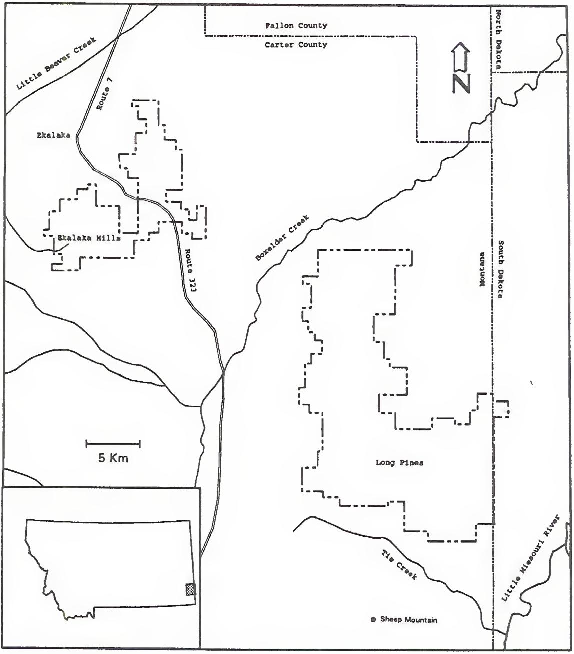

Fig. 2. The Long Pines and Ekalaka Hills Divisions (Sioux Ranger District) of Custer National Forest, Carter County, Montana.

Fig. 3. Ponderosa pine-meadow parkland in the Long Pines Division of Custer National Forest, Montana.

Extensive mixed grass and sagebrush prairie surround the study area. The prairie terrain is level to rolling. Soils are clayey, calcareous, well-drained, and sedimentary in origin (Montagne et al. 1982).

The climate of the study area is semi-arid; mean annual air temperature is 5.6 °C. Long-term mean air temperature is -7.2 °C during winter (December-February) and 18.5 °C during summer (June-September)(MAPS: Montana Agricultural Potential Systems, Montana State University Agricultural Extension Service). Mean annual precipitation is 39.4 cm; long-term means are 1.2 cm during winter and 8.3 cm during summer (EarthInfo 1992).

Upland game birds in the study area include wild turkey, sharp-tailed grouse (*Tympanuchus phasianellus*), sage grouse (*Centrocercus urophasianus*), ring-necked pheasant (*Phasianus colchicus*), gray partridge (*Perdix perdix*), and mourning dove (*Zenaida macroura*). Potential avian predators of subadult and adult turkeys include bald eagle (*Haliaeetus leucocephalus*) (winter and spring only), golden eagle (*Aquila chrysaetos*) and great-horned owl (*Bubo virginianus*) (Bergeron et al. 1992). Potential mammalian predators include mountain lion (*Felis concolor*) (Riley 1992), bobcat (*Felis rufus*), coyote (*Canis latrans*), and red fox (*Vulpes vulpes*) (Lampe et al. 1974).

The following summarizes vegetational characteristics of plant communities in and around the study area. More thorough descriptions are given in Jonas (1966) and Hansen and Hoffman (1988). Selected terms used in descriptions are defined in Appendix B, Table 2.

Upland Grassland Communities

The western wheatgrass/green needlegrass community occurs on more mesic, productive sites; for example, north-facing slopes and non-wooded draws (Havig et al. 1988). Needle-and-thread, rather than green needlegrass, was the codominant on most sites during my study (Fig. 4). Associated grasses included prairie junegrass, red threeawn, and blue grama. Threadleaf sedge also occurred. Apparently, blue grama and threadleaf sedge were more dominant in this community in the Long Pines during the early 1960's (Jonas 1966) than at present. Associated forb species included silver sagebrush, lambstongue groundsel, groundplum milkvetch, silvery lupine, low fleabane, plains wallflower, and field pussytoes (Hansen and Hoffman 1988). Areas subjected to heavy grazing by livestock often were dominated by needle-and-thread, woolly indian wheat, and plains pricklypear.

Fig. 4. Western wheatgrass/green needlegrass community in the Long Pines Division. Some plant species pictured include western wheatgrass, needle-and-thread, silver sagebrush, and common snowberry.

The little bluestem/threadleaf sedge community occurred on drier, less productive sites such as south, east, and west-facing slopes (Havig et al. 1988). The little bluestem/threadleaf sedge type seemed to be less common than the western wheatgrass/green needlegrass type. Associated grasses included prairie junegrass, western wheatgrass, and sideoats grama. Common forbs included fringed sagebrush, dotted gayfeather and purple prairieclover (Hansen and Hoffman 1988). Small soapweed also was common.

Miscellaneous grassland communities were located along roadsides. Grasses occurring along roadsides included cheatgrass, Kentucky bluegrass, smooth brome, crested wheatgrass, and foxtail barley. Forbs included rocky mountain beeplant, field bindweed, common flax, curlycup gumweed, annual sunflower, and yellow sweetclover.

Approximately 4,055 ha of grassland burned at light intensity and 2,185 ha burned severely during the 1988 wildfire. Effect of fire on species composition was probably minimal because grasslands in the area are fire tolerant (Havig et al. 1988). However, there may have been localized changes in community structure of grasslands between pre- and post-fire periods (Gobeille 1992).

Shrub Communities

The dominant shrub community in the Long Pines and Ekalaka Hills was common snowberry, which occurred mostly in scattered, dense stands on mesic sites such as draws and drainageways. Redshoot gooseberry and golden currant were other prominent shrubs (Hansen and Hoffman 1988). Grasses associated with this community included western wheatgrass and Kentucky bluegrass. Common forbs included northern bedstraw and Louisiana sagewort.

Rocky Mountain juniper/bluebunch wheatgrass and skunkbush sumac/bluebunch wheatgrass were less common than the snowberry communities. Both typically occurred on drier sites, particularly on slopes of southerly exposure. The Rocky Mountain juniper/bluebunch wheatgrass community was especially prevalent in the unburned, northern portion of the Long Pines (Havig et al. 1988). Other species associated with these 2 types included sideoats grama, common snowberry, starry cerastium, common yarrow, and broom snakeweed (Hansen and Hoffman 1988).

Stands of common chokecherry and quaking aspen regrowth dominated much of the logged area in the Ekalaka Hills (Fig. 5). Other plant species on logged areas included western wheatgrass, Kentucky bluegrass, Japanese brome, prairie

Fig. 5. Quaking aspen regrowth in a recently (<3 years) logged area in the Ekalaka Hills Division, 1990.

thermopsis, common yarrow, American vetch, and silvery lupine.

Vegetation Of Hardwood Draws

The green ash/common chokecherry community dominated moist draws, drainageways, and springs throughout the study area. Other plants characteristic of this community included Kentucky bluegrass, common snowberry, hawthorne, creeping barberry, Woods rose, wild bergamot beebalm, and Saskatoon serviceberry. Hawthorne thickets occurred at low to mid elevations. This community was frequented by livestock and likely was severely impacted by cattle grazing. On severely burned areas of the southern and central Long Pines, overstory trees were destroyed by fire. In the Ekalaka Hills, some green ash/common chokecherry stands were logged.

Scattered stands of the quaking aspen/creeping barberry community occurred throughout the study area, mostly in draws or as patches on some north-facing slopes. Associated plants included Kentucky bluegrass, common chokecherry, common snowberry, and Saskatoon serviceberry. This community also appeared to be heavily impacted by livestock grazing. Stands that had burned in the 1988 fire showed significant regrowth within 2 years of the fire (Fig. 6).

Fig. 6. Quaking aspen regrowth 2 years after the 1988 fire in a burned area in the Long Pines Division.

Pine Forest Communities

The main forest community was ponderosa pine/common chokecherry. This community occurred on mesic, north-facing sites in the study area. Common grasses included green needlegrass, needle-and-thread, and Kentucky bluegrass. Associated forbs included spreading pasqueflower, prairie onion, groundplum milkvetch, Louisiana sagewort, and northern bedstraw. Prominent shrubs were Saskatoon serviceberry, spreading dogbane, golden currant, redshoot gooseberry, and Woods rose (Hansen and Hoffman 1988). In the Ekalaka Hills, bearberry manzanita also was common.

In the Long Pines, approximately 1,850 ha of pine forest were lightly burned and 9,147 ha were severely burned (Havig et al. 1988). Ponderosa pine/common chokecherry stands having >40% canopy closure and large fuels buildup were severely impacted with many burned to the mineral soil.

For the first 2 years following the fires, vegetation in severely burned areas often was either partly or entirely comprised of dock, prickly lettuce, spreading dogbane, clasping pepperweed, wild licorice, or Canada horseweed (Fig. 7). However, by the third year, later successional plants dominated many areas (Fig. 8). Invasion by the latter may have been abetted by greater than average precipitation during Spring and early Summer 1991.

Fig. 7. Understory dominated by dock and clasping pepperweed 2 years after the 1988 wildfire in a severely burned stand of ponderosa pine in the Long Pines Division.

Fig. 8. Understory dominated by various grasses, forbs, and shrubs 3 years after the 1988 wildfire in a severely burned stand of ponderosa pine in the Long Pines Division.

The ponderosa pine/bluebunch wheatgrass community occurred on drier sites. Undergrowth typically was sparse and comprised mostly of bluebunch wheatgrass, little bluestem, sideoats grama, and sedge (Hansen and Hoffman 1988). Because this community was located on less productive sites with less fuels buildup, it was less severely impacted by the fires than the ponderosa pine/common chokecherry community (Havig et al. 1988). It also was common in the mostly unburned northern Long Pines. In the Ekalaka Hills, this community appeared to receive less logging pressure than ponderosa pine/common chokecherry stands.

Surrounding Prairie Communities

Major plant species inhabiting the prairie surrounding the study area include big sagebrush, silver sagebrush, western wheatgrass, bluebunch wheatgrass, prairie junegrass, threadleaf sedge, and rubber rabbitbrush (Montagne et al. 1982). Plains cottonwood, green ash, and boxelder maple are overstory species in more mesic drainages and along creeks.

CHAPTER 3

YEARLY SITE FIDELITY AND ROOSTING HABITAT ON WINTERING AREAS

Extreme environmental conditions make winter a critical period for most wildlife species inhabiting northern latitudes. Studies of eastern wild turkeys (*Meleagris gallopavo silvestris*) have indicated that snow depth, low temperature, and availability of food affect overwinter survival (Austin and DeGraaf 1975, Wunz and Hayden 1975, Porter et al. 1983). Location and reliability of food resources during winter also influence distribution and movements (Thomas et al. 1966, Ellis and Lewis 1967, Vander Haegan et al. 1989).

Eastern wild turkeys are known to return every year to a reliable source of winter food (Crockett 1973, Hayden 1980, Kulowiec and Haufler 1985). However, studies of Merriam's wild turkeys have reported both high (Crawford and Lutz 1984) and low (Jonas 1966, Liedlich et al. 1991) fidelity to wintering areas in their native and expanded ranges.

Roosting habitat, a critical component of winter habitat (Phillips 1980), has been described for Merriam's turkeys in Colorado (Hoffman 1968), New Mexico (Schemnitz et al. 1985), Arizona (Phillips 1980), South Dakota (Rumble 1992), Wyoming (Hengel 1990), Oregon (Lutz and Crawford 1987), and Washington (Mackey 1982). For Montana, Jonas (1966) reported general characteristics of roosting habitat of Merriam's turkeys in southeastern Montana, but did not specifically study habitats used during winter. This chapter examines yearly site fidelity and roosting habitat of Merriam's turkeys in southeastern Montana during winter.

Methods

One hundred eleven Merriam's turkeys were captured on wintering grounds during December-March, 1988-1991. These included 46 turkeys (4 adult males, 3 subadult males, 11 adult females, and 28 subadult females) during 1988-1989; 30 (1 adult male, 7 subadult males, 5 adult females, and 17 subadult females) during 1989-1990; and 35 (6 adult males, 13 subadult males, 3 adult females, and 13 subadult females) during 1990-1991. Turkeys that had been alive for at least 2 winters were classified as adults; those between their first winter and second fall (inclusive) were subadults.

Most turkeys were caught in walk-in, drop-gate traps (dimensions = 1.2 m x 1.9 m x 1.2 m) constructed of aluminum pipe covered with 2.5 cm mesh nylon netting (Fig. 9). The remainder were caught either in a larger drop-gate trap or a cannon net. Traps were placed at known feeding areas and baited with shelled corn and winter wheat. The drop-gate was manually triggered via a wire to a vehicle 45 m away.

Captured turkeys were weighed (to the nearest 0.25 lb converted to nearest 0.1 kg), aged (Petrides 1942), sexed (Keiser and Kozicky 1943), leg-banded (with numbered aluminum bands), and equipped with 94 g radio transmitters (AVM Instrument Co., Livermore, CA). (Masses of captured turkeys are listed in Appendix C, Table 3). Frequencies of transmitters were 150-152 mhz. Ninety-one cm lengths of 0.48 cm diameter nylon shock cord, encircling base of the wings, were used to attach and mount transmitters on the back of each turkey. Transmitters typically functioned for >2 years.

Transmitter-equipped turkeys were monitored using a Telonics TR2 scanner/receiver and a 2-element, handheld yagi antenna (Telonics, Inc., Mesa, AZ). The "loudest signal method" (Springer 1979) was used to obtain a compass bearing from at least 3 different locations. The "location" then was marked as the center of the smallest triangle formed from intersecting lines on a U.S.G.S. 7.5-minute topographic quadrangle. I also relocated turkeys from an airplane

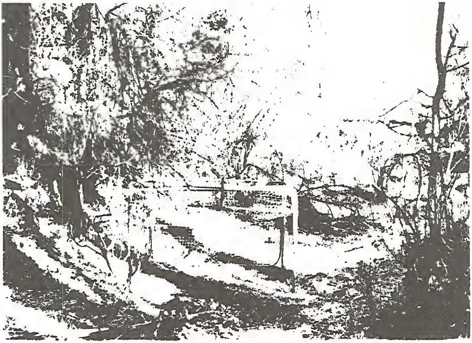

Fig. 9. Drop-gate trap used to capture Merriam's turkeys, Winters 1989-1991.

(Piper SuperCub) once a month during December-February, and 1-2 times a month during March-June. Many relocations from the airplane provided visual observations; non-visual relocations were within 150 m of the actual location.

Telemetry error was estimated by comparing locations of "dummy" transmitters to those estimated via telemetry. Eighty percent of the estimated locations fell within 200 m of transmitters placed <700 m from the central point of triangulation. Seventy-five percent of the estimated locations fell within 350 m of the actual locations of transmitters when placed 700-1000 m from the central point of triangulation. I discarded relocations more than 1000 m from the observer or those that could not be adequately pinpointed because of weak or inconsistent signals.

I used straight-line distance (km) between winter geographical activity centers (GAC) over consecutive years to quantify differences in site fidelity of turkeys. The minimum convex polygon method (Mohr 1947), computed by TELDAY (Lonner and Burkhalter 1983), was used to delineate wintering areas.

Nocturnal roosts were located by telemetry and verified by field observations. Habitat variables for each nocturnal roost were measured within a 25 m x 25 m plot (Oosting 1956) centered on the approximate geographical midpoint of the roost. Specific variables measured were: distance to nearest feedlot, permanent water, and meadow; slope and

aspect; tree species, height, and classification (roost or non-roost); and height to first branch. Descriptions of variables are listed in Appendix C, Table 4.

Comparative "random sites" for each roost were selected by plotting coordinates, generated from a random numbers table, on a U.S.G.S. 7.5 minute topographic quadrangle (Andrew and Mosher 1982). Area covered within the coordinate axes was based on the maximum size of home ranges (2.5 km^2) for Merriam's turkeys in Oregon (Crawford and Lutz 1984). The same variables were measured at both roost and random sites.

I used Wilcoxon 2-sample tests (Sokal and Rohlf 1981) to test (alpha = 0.05) for differences in all univariate comparisons except aspect. Watson's U^2 tests (Batschelet 1981) were used to compare aspects (circular statistics). Chi-square tests (Fienberg 1980) were used to analyze categorical data. I used stepwise logistic regression (Freeman 1987) to model multiple independent variables with probabilities to enter and remove set at 0.05. All logistic regression models had a minimum of 80% concordancy. SAS (SAS Institute, Inc. 1988) was used to compute all statistical tests and models except for Watson's U^2 tests, which were computed manually. Probabilities associated with significant statistical results are ($P \leq 0.01$) unless noted otherwise.

Results

Winter Site Fidelity

Twelve (27.3%) of 44 transmitter-equipped turkeys returned to the same wintering area the following year. This was significantly ($X^2 = 9.09$, $P < 0.01$) fewer than the 32 of 44 (72.3%) that moved to different wintering areas adjacent to the Long Pines and the Ekalaka Hills (Table 5).

Among turkeys using different wintering areas, adult females in the Long Pines moved farther between wintering areas used in consecutive years than subadult females in the Ekalaka Hills during 1989-1992 (Table 6). Further, subadult females in the Long Pines used wintering areas that were farther apart than those used by subadult males, adult females, and subadult females in the Ekalaka Hills (Table 6). In the Long Pines, both adult males and females used wintering ranges in consecutive years that were closer (P = 0.03) than those used by subadult females (Table 6).

Wintering sites were ranked *a posteriori* as either primary (used at least 3 of 4 years) or secondary (used 1-2 times in 4 years). Under this classification, there were 6 primary and 5 secondary sites in the Long Pines during 1989-1992 (Fig. 10). There were 5 primary and 4 secondary sites in the Ekalaka Hills (Fig. 11).

Table 5. Yearly fidelity rates of transmitter-equipped turkeys to wintering areas in the Long Pines and Ekalaka Hills, 1989-1992.

Age	Sex	No. returning turkeys	No. non-returning turkeys
Adult	Male	2	3
Adult	Female	2	11
Adult	Pooled	4	14
Subadult	Male	1	5
Subadult	Female	7	13
Subadult	Pooled	8	18
Pooled	Pooled	12	32

Table 6. Distances (km) between wintering areas occupied by turkeys in consecutive years in the Long Pines and Ekalaka Hills, 1989-1992.

			Distance (km) between wintering areas		
Division	Age	Sex	n	Mean	(SD)
Long Pines	Adult	Male	3	5.2	(3.5)
	Subadult	Male	4	13.3	(8.4)
	Adult	Female	3	5.0	(2.5)
	Subadult	Female	6	20.7	(5.9)
Ekalaka Hills	Adult	Male	-	---	
	Subadult	Male	2	3.7	(0.8)
	Adult	Female	8	4.6	(1.0)
	Subadult	Female	7	4.6	(0.5)

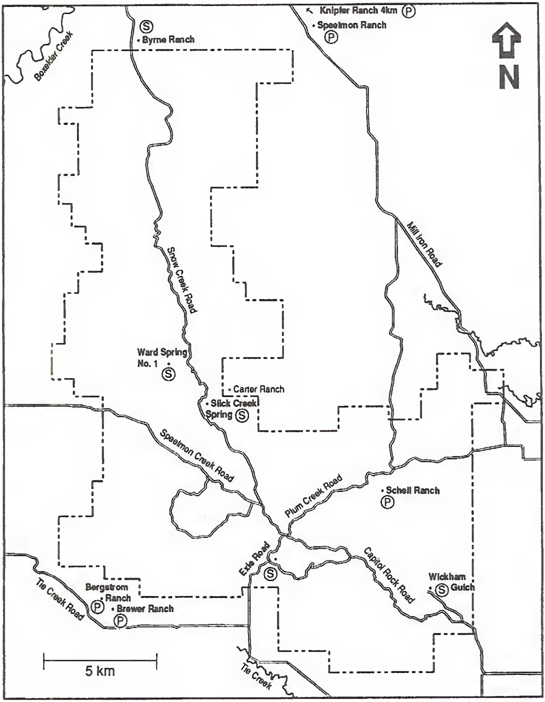

Fig. 10. Location of primary (p) and secondary (s) wintering sites used by transmitter-equipped turkeys in the Long Pines Division, 1989-1992. A primary site 5 km east of the Knipfer ranch is not shown.

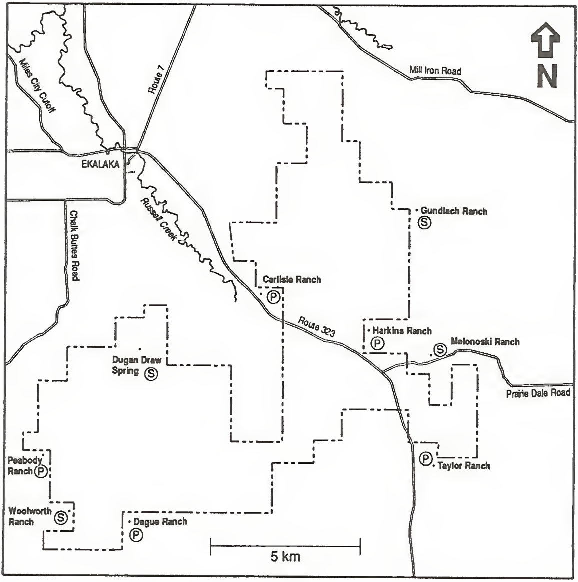

Fig. 11. Location of primary (p) and secondary (s) wintering sites used by transmitter-equipped turkeys in the Ekalaka Hills Division, 1989-1992.

Table 7. Comparison of characteristics measured at turkey roost and random sites in the Long Pines and Ekalaka Hills, Winters 1990-1991.

	Long Pines				Ekalaka Hills			
	Roost site		Random site		Roost site		Random site	
Characteristic	n	Mean (SD)	n	Mean (SD)	n	Mean (SD)	n	Mean (SD)
Dist. to feedlot (m)	6	230 (112)	6	791 (327)	4	252 (171)	4	592 (372)
Dist. to perm. water (m)	6	139 (107)	6	672 (447)	4	332 (242)	4	495 (79)
Dist. to meadow (m)	6	21 (15)	6	19 (9)	4	48 (32)	4	89 (96)
Slope (%)	6	10 (15)	6	15 (10)	4	25 (5)	4	20 (5)
Aspect in degrees	3	54 (61)[a]	5	348 (57)[a]	4	55 (46)[a]	4	50 (64)[a]
Number of trees	6	13 (7)	6	10 (5)	4	20 (7)	4	13 (4)

[a] Angular mean (angular deviation).

Winter Roost Characteristics

Sites used by roosting turkeys in the Long Pines were closer to feedlots and permanent water (P = 0.03) than random sites (Table 7). However, roost sites did not differ from random sites in the Ekalaka Hills.

Roosting turkeys did not select (X^2 = 0.53, P > 0.4) for numbers of coniferous (ponderosa pine, n = 26) over deciduous (plains cottonwood, green ash, and boxelder maple; n = 21) trees in the Long Pines. In the Ekalaka Hills, however, more (X^2 = 20.0, P < 0.01) birds roosted in coniferous (n = 40) than deciduous (n = 0) trees.

Coniferous trees used for roosting in the Long Pines were taller and had lower first branches than deciduous trees (Table 8). Consequently, coniferous and deciduous trees could not be pooled for analyses.

Coniferous trees used for roosting in the Long Pines were taller than non-roost trees, and taller and larger (P = 0.02) in diameter than trees at random sites (Table 8). Similarly, deciduous trees were taller (P = 0.02), larger diameter, and had higher first branches than non-roost trees. They also were larger in diameter and had higher (P = 0.05) first branches than trees at random sites (Table 8). In the Ekalaka Hills, roost trees were taller and larger in diameter than both non-roost trees and trees at random sites (P = 0.03 and $P < 0.01$, respectively) (Table 9). Stepwise logistic regression models comparing roost trees are listed in Appendix C, Table 10.

Discussion

Low fidelity to wintering sites by Merriam's turkeys during this study may have been due to: mixing of flocks during fall; density of ranch feedlots available in a given area; and availability of natural foods, water, grit, and roost trees in upland areas. As a result of flock mixing, subordinate subadult and younger adult turkeys probably

Table 8. Comparison of characteristics associated with turkey roost trees, non-roost trees, and trees at random sites in the Long Pines, Winters 1990-1991.

	Roost sites									Random sites		
	Coniferous roost trees			Deciduous roost trees			Non-roost trees			Trees ≥12.6 cm diameter		
Characteristic	n	Mean	(SD)	n	Mean	(SD)	n	Mean	(SD)	n	Mean	(SD)
Number of trees	2[a]	13	(3)	4[a]	5	(6)	6[a]	6	(1)	6[a]	10	(6)
Tree height (m)	26	16	(5)	21	12	(4)	29	10	(4)	58	13	(3)
Dbh (cm)[b]	26	29.7	(13.1)	21	42.0	(23.5)	29	24.3	(9.7)	58	22.3	(7.7)
Height to first branch (m)	26	1.7	(0.5)	21	2.4	(0.8)	29	1.9	(0.9)	58	2.3	(1.8)

[a] Number of sites (other n-values represent number of trees).
[b] Diameter breast height.

Table 9. Comparison of characteristics associated with roost trees, non-roost trees, and trees at random sites in the Ekalaka Hills, Winters 1990-1991.

	Roost sites						Random sites		
	Roost trees			Non-roost trees			Trees ≥12.6cm dbh		
Characteristic	n	Mean	(SD)	n	Mean	(SD)	n	Mean	(SD)
Number of trees	4[a]	10	(5)	4[a]	7	(3)	4[a]	12	(4)
Tree height (m)	40	18	(2)	29	17	(4)	60	16	(4)
Dbh (cm)[b]	40	32.5	(8.4)	29	18.5	(5.1)	60	23.9	(7.9)
Height to first branch (m)	40	3.4	(1.8)	29	3.2	(1.7)	60	3.1	(1.4)

[a] Number of sites (other n-values represent number of trees).
[b] Diameter breast height.

would follow dominant, older birds to their usual wintering areas. Further, the more feedlots available in a given area, the more likely turkeys would move to another feedlot within their general home range in a subsequent year. The Ekalaka Hills, with a greater density of ranches than the Long Pines, had fewer turkeys returning to the same feedlots. Here, however, the different feedlots were located in the same general area and turkeys moved shorter distances to new wintering areas than birds in the Long Pines.

Lack of available food, water, grit, and roost trees were not reasons for low fidelity of turkeys to feedlots. Ranches that were not used by individual turkeys in consecutive years were still used by others. Availability of a preferred food (such as pine nuts [Table 11]), water,

Table 11. Number of ponderosa pine nuts collected in 80 catch-boxes in the Long Pines and Ekalaka Hills, October-April 1989-1990 and 1990-1991.

Study division	Burn classification[a]	Stand type	No. pine nuts 1989-1990	No. pine nuts 1990-1991
Long Pines	Unburned	Pole-sized	133	5
	Light	Pole-mature	148	2
	Severe	Pole-mature	69	1
	Light	Pole-mature	78	16
	Severe	Mature	37	4
	Unburned	Pole-mature	124	12
Ekalaka Hills	Unburned	Pole-mature	158	8
	Unburned	Pole-mature	104	4
Total			851	52

[a] Light burn = understory lightly burned and overstory either lightly burned or unburned.
Severe burn = heavily scorched understory and overstory (>80% trees dead; Havig et al. 1989)

and grit could shift some birds to wintering in upland areas during periods of low snow cover.

Counts of turkeys on wintering grounds have been suggested as a method of monitoring population trends in other regions (Thomas et al. 1966, Kulowiec and Haufler 1985, Vangilder 1992). However, unless all wintering areas are identified, low fidelity of Merriam's turkeys to wintering areas could preclude the effective use of winter counts for monitoring populations in southeastern Montana. At present, identifying all wintering sites may not be feasible; hence, management may opt to monitor use only on selected wintering grounds. Inconsistent use of those sites

between years could result in inaccurate data on population trends.

Traditional use of winter roosts was probably related to their proximity to ranch feedlots, which changed little from year to year. Winter roosts were used repeatedly both during and among winters. This was similar to findings of Schemnitz et al. (1985) in New Mexico, but contradictory to Lutz and Crawford (1987) who reported few winter roosts were used traditionally. The association of permanent water with active winter roosts probably resulted because stock tanks were almost always associated with feedlots. In the Ekalaka Hills, the lack of association between distance to nearest feedlot and permanent water may have been due to the small (n = 4) sample size.

Turkeys roosted in taller and larger diameter trees that tended to have open growth forms and fewer and larger branches. These factors enhanced landing and taking off in the trees (Hoffman 1968). Use of tall, large diameter roost trees also has been reported from other studies (Hoffman 1968, Boeker and Scott 1969, Lutz and Crawford 1987, Hengel 1990). Deciduous trees apparently were used more for roosting in the Long Pines than in the Ekalaka Hills because they were the tallest and largest diameter trees available near feedlots. Conversely, ponderosa pines always were the closest "large" trees to ranch feedlots in the Ekalaka Hills.

Roost characteristics deemed important by other authors, including slope (Lutz and Crawford 1987), aspect (Schemnitz et al. 1985), and distance to nearest clearing (Hoffman 1968), likely were not important in my study because all roosts were associated with feedlots. Comparative random sites used to estimate overall availability of habitat were associated with open and flat lowland areas as well.

Although I only studied winter roosting habitat on ranches, habitat characteristics important to selection in these areas (for example, proximity to food, water, and grit) likely apply to upland areas as well. In the absence of data on upland roosting habitat, roost characteristics reported by other studies (Hoffman 1968, Hengel 1990, Rumble 1992) in nearby states should be used as guidelines for managing upland roosting habitat in the Long Pines and Ekalaka Hills during winter.

CHAPTER 4

MOVEMENTS AND ROOSTING HABITAT IN RELATION TO BURNED AREAS DURING SPRING/FALL

Movements and roosting habitat of Merriam's turkeys during spring and fall have been studied in New Mexico (Schemnitz et al. 1985), Arizona (Scott and Boeker 1975, Crites 1988), Colorado (Hoffman 1991), Wyoming (Hengel 1990), Montana (Jonas 1966), Oregon (Lutz and Crawford 1987, 1989), and Washington (Mackey 1982). However, effect of burned areas on movements and roosting habitat of Merriam's turkeys is unknown. Data on movements and roosting habitat of Merriam's turkeys in burned areas of southeastern Montana during spring (March-May) and fall (October-November) 1990-1991 provided some insight.

Methods

Methods for capturing, transmitter-equipping, and relocating turkeys were discussed in Chapter 3. Turkeys usually were relocated at least once weekly during spring and fall, at least 1 day apart, and at varying times of the

day. Relocations made from an airplane once a month during spring supplemented those made from the ground.

I recorded 426 relocations of 35 turkeys in the Long Pines during Spring 1990 and 1991. Fifty-nine relocations were recorded on 5 turkeys in the Long Pines during Fall 1990. In the Ekalaka Hills, I recorded 243 relocations of 24 turkeys during Spring 1990 and 1991; 114 relocations were recorded on 8 turkeys during Fall 1990. Spring movements of 3 transmitter-equipped turkeys recorded by J. Gobeille (Montana State Univ., pers. commun.) in both the Long Pines and Ekalaka Hills during 1989 were added to information gathered in 1990-1991. Data collected on the same turkey in different years were considered independent; hence, data from each year were treated as if from different individuals. Data were pooled over years because of small sample sizes.

The program TELDAY (Lonner and Burkhalter 1983) was used to calculate average distances traveled daily by turkeys and home ranges based on minimum convex polygons (Mohr 1947). Average daily distances and home ranges were computed only for turkeys that were alive throughout the spring or fall periods.

Nocturnal roosts were located via telemetry. As discussed in Chapter 3, randomly selected sites were used for comparisons with each roost site. Variables measured at

each site (except distance to nearest food source) are listed in Appendix C, Table 4.

Statistical methods used to analyze data were described in Chapter 3. In addition, I ran Kendall's tau correlations (Sokal and Rohlf 1981) between sizes of home ranges and both numbers of relocations and length of monitoring period. If the correlation was significant ($P \leq 0.05$) the largest and/or smallest home ranges were discarded until the correlation was non-significant (White and Garrott 1990). Multiple turkeys with transmitters in a flock were treated as 1 individual in analyses. Probabilities associated with significant statistical results are ($P \leq 0.01$) unless noted otherwise.

Results

Spring/fall Movements

There were no differences in either home range size or mean distance traveled among relocations by turkeys between spring and fall on either study division. Thus, data on spring and fall movements of turkeys were pooled within geographic units. Home range sizes are listed in Appendix D, Table 12.

Home range size of turkeys in the Long Pines during spring/fall were not correlated with either number of relocations (tau = -0.02, P = 0.86) or length of monitoring period (tau = 0.14, P = 0.22). After I removed the largest and smallest home ranges from analysis, home ranges in the Ekalaka Hills were not significantly correlated with either number of relocations (tau = 0.01, P = 0.93) or length of monitoring period (tau = 0.25, P = 0.08).

Home range size and mean linear distance of both males and females did not differ between ages within the Long Pines and Ekalaka Hills so data were pooled. Males in the Long Pines (Fig. 12) had larger home ranges and moved farther among relocations, on average, than those in the Ekalaka Hills (Table 13). Within the Long Pines, males had larger home ranges than females (Table 13).

Roost Characteristics

Data on roost stands were pooled within study divisions and across years because of small sample sizes for fall. Roost stands in the Long Pines were on flatter (P = 0.09) terrain than those in the Ekalaka Hills (Table 14).

Roost stands in the Long Pines did not differ between burned and unburned areas so data were pooled. They were located on steeper slopes than random sites (Table 14). Both roost and random sites occurred in 3 burned and 3

Fig. 12. A subadult male Merriam's turkey in the Long Pines Division, Spring 1990.

Table 13. Comparison of spring/fall home range size and mean linear distance among age and sex classes of turkeys in the Long Pines and Ekalaka Hills, 1990-1991.

		Long Pines			Ekalaka Hills		
			Home range (ha)	Linear distance (km)		Home range (ha)	Linear distance (km)
Age	Sex	n	Mean (SD)	Mean (SD)	n	Mean (SD)	Mean (SD)
Adult	Male	8	2040 (1380)	2.2 (0.6)	3	360 (320)	1.3 (1.0)
Subadult	Male	7	2990 (3430)	2.4 (0.5)	6	610 (620)	1.7 (0.9)
Pooled	Male	15	2480 (2500)	2.3 (0.6)	9	530 (530)	1.6 (0.9)
Adult	Female	9	570 (550)	1.4 (0.6)	10	650 (570)	1.5 (1.1)
Subadult	Female	16	1470 (2410)	1.8 (1.2)	8	450 (510)	0.9 (0.4)
Pooled	Female	25	1130 (1990)	1.7 (1.3)	18	560 (540)	1.2 (0.9)

Table 14. Comparison of site characteristics at turkey roost and random sites in the Long Pines and Ekalaka Hills, Spring/Fall 1990-1991.

	Long Pines				Ekalaka Hills			
	Roost site		Random site		Roost site		Random site	
Site Characteristic	n	Mean (SD)	n	Mean (SD)	n	Mean (SD)	n	Mean (SD)
Dist. to perm. water (m)	6	731 (216)	6	798 (244)	3	563 (536)	3	887 (175)
Dist. to meadow (m)	6	65 (77)	6	93 (190)	3	63 (12)	3	203 (32)
Slope (%)	6	25 (10)	6	10 (5)	3	35 (5)	3	10 (10)
Aspect in degrees	6	34 (53)[a]	6	280 (43)[a]	3	71 (63)[a]	3	1 (31)[a]
Number of trees	6	13 (6)	6	16 (3)	3	13 (8)	3	20 (7)

[a] Angular mean (angular deviation).

unburned stands. Roost stands in the Ekalaka Hills did not differ from random sites (Table 14). Neither roosts nor random sites in the Ekalaka Hills occurred in stands that had been logged in the last 60 years.

Burned roost trees in the Long Pines had larger diameters than unburned roost trees (Table 15). They also were larger in diameter than either non-roost trees or trees at random sites. Unburned roost trees were taller and larger diameter than non-roost trees, and taller than trees at random sites (Table 15). Stepwise logistic regression models comparing roost trees are listed in Appendix D, Table 16.

Table 15. Comparison of characteristics associated with turkey roost trees, non-roost trees, and trees at random sites in the Long Pines, Spring/Fall 1990-1991.

	Roost sites						Random sites	
	Burned roost trees		Unburned roost trees		Non-roost trees		Trees ≥12.6 cm diameter	
Characteristic	n	Mean (SD)	n	Mean (SD)	n	Mean (SD)	n	Mean (SD)
Number of trees	3[a]	2 (1)	3[a]	5 (2)	3[a]	13 (2)	3[a]	16 (3)
Tree height (m)	5	17 (5)	16	15 (2)	38	13 (3)	93	14 (4)
Dbh (cm)	5	39.7 (8.5)	16	23.5 (5.7)	38	18.6 (5.4)	93	23.8 (11.1)
Height to first branch (m)	5	2.6 (1.5)	16	2.4 (1.0)	38	2.1 (1.2)	93	3.0 (2.6)

[a] Number of sites (other n-values represent number of trees).

Table 17. Comparison of characteristics associated with turkey roost trees, non-roost trees, and trees at random sites in the Ekalaka Hills, Spring/Fall 1990-1991.

	Roost sites						Random sites		
	Roost trees			Non-roost trees			Trees ≥12.6cm dbh		
Characteristic	n	Mean	(SD)	n	Mean	(SD)	n	Mean	(SD)
Number of trees	3[a]	3	(3)	3[a]	10	(5)	3[a]	20	(7)
Tree height (m)	10	20	(3)	29	14	(3)	60	16	(4)
Dbh (cm)	10	41.0	(13.4)	29	21.9	(8.1)	60	25.7	(10.6)
Height to first branch (m)	10	4.0	(0.8)	29	2.7	(1.2)	60	4.2	(2.7)

[a] Number of sites (other n-values represent number of trees).

Roost trees in the Ekalaka Hills were taller, larger in diameter, and had lower first branches than non-roost trees (Table 17, Fig. 13). They also were taller and larger in diameter than trees at random sites (Table 17).

Winter Vs. Spring/fall Roosts

Winter roosts in the Long Pines were on flatter (P = 0.05) terrain and were closer to water than those used during spring/fall (Table 18). Those in the Ekalaka Hills also were located on flatter (P = 0.09) terrain than roosts used during spring/fall (Table 18).

Coniferous trees selected for roosting in the Long Pines during winter had lower first branches than unburned trees used during spring/fall (Table 19). Deciduous roost trees

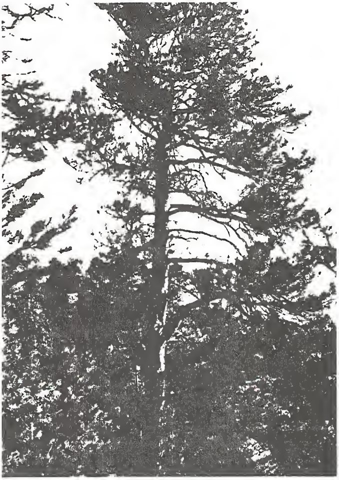

Fig. 13. Mature ponderosa pine used by roosting turkeys in the Ekalaka Hills Division, Spring 1991. Note the widely-spaced branches half way up the tree.

Table 18. Comparison of site characteristics at turkey roost and random sites in the Long Pines and Ekalaka Hills, Winter and Spring/Fall 1990-1991.

Site Characteristic	Long Pines				Ekalaka Hills			
	Winter roosts		Spring/fall roosts		Winter roosts		Spring/fall roosts	
	n	Mean (SD)	n	Mean (SD)	n	Mean (SD)	n	Mean (SD)
Dist. to perm. water (m)	6	139 (107)	6	732 (216)	4	332 (242)	3	563 (536)
Dist. to meadow (m)	6	21 (15)	6	65 (77)	4	48 (32)	3	63 (12)
Slope (%)	6	10 (15)	6	25 (10)	4	25 (5)	3	35 (5)
Aspect in degrees	3	54 (61)[a]	6	34 (53)[a]	4	55 (46)[a]	3	71 (63)[a]
Number of trees	6	13 (7)	6	13 (6)	4	17 (5)	3	13 (8)

[a] Angular mean (angular deviation).

were taller and larger in diameter than unburned trees (Table 19). In the Ekalaka Hills, winter roost trees were smaller ($P = 0.05$) in diameter than those used during spring/fall (Table 20).

Discussion

Large home ranges for male turkeys in the Long Pines compared to those in the Ekalaka Hills and other studies (Table 21) may have been related to low habitat complexity of severely burned areas in the first 2 years following the fires. Because of monotypic stands of understory

Table 19. Comparison of characteristics associated with winter and spring/fall roost trees used by turkeys in the Long Pines, 1990-1991.

	Winter						Spring/fall					
	Coniferous roost trees			Deciduous roost trees			Burned roost trees			Unburned roost trees		
Characteristic	n	Mean	(SD)	n	Mean	(SD)	n	Mean	(SD)	n	Mean	(SD)
Number of trees	2[a]	13	(3)	4[a]	5	(6)	3[a]	5	(2)	3[a]	2	(1)
Tree height (m)	26	16	(5)	21	12	(4)	16	15	(2)	5	17	(5)
Dbh (cm)	26	29.7	(13.1)	21	42.0	(23.5)	16	23.5	(5.7)	5	39.7	(8.5)
Height to first branch (m)	26	1.7	(0.5)	21	2.4	(0.8)	16	2.4	(1.0)	5	2.6	(1.5)

[a] Number of sites (other n-values represent number of trees).

Table 20. Comparison of characteristics associated with winter and spring/fall roost trees used by turkeys in the Ekalaka Hills, 1990-1991.

	Winter roost trees			Spring/fall roost trees		
Characteristic	n	Mean	(SD)	n	Mean	(SD)
Number of trees	4[a]	10	(5)	3[a]	3	(3)
Tree height (m)	40	18	(2)	10	20	(3)
Dbh (cm)	40	32.5	(8.4)	10	41.0	(13.4)
Height to first branch (m)	40	3.4	(1.8)	10	4.0	(0.8)

[a] Number of sites (other n-values represent number of trees).

vegetation, severely burned areas seemed to offer lower quality habitat for turkeys than unburned areas. If hens were more widely distributed in burned than unburned areas, then adult males would have to move farther to form courtship flocks. Spring/fall home range sizes were more influenced by their spring component because of the relatively few home ranges recorded in the fall.

Home range sizes were similar between adult hens in the Long Pines and either-age hens in the Ekalaka Hills possibly because of dominance behavior. Older, dominant hens may have taken the better quality habitat available. In the Long Pines, this seemed to be the unburned areas during the first 2 years following the fire. There apparently was enough quality habitat available in the Ekalaka Hills that dominance behavior did not greatly influence movements of subadult hens. I was unable to assess the effect of logging on movements of turkeys in the Ekalaka Hills because of the

Table 21. Combined spring/fall mean home range sizes of Merriam's turkeys in various parts of their range.

Location	Age	Sex	Mean home range (ha)	Author(s)
Long Pines, Southeast Montana	Adult	Male	2,040	This study
	Adult	Female	570	
	Subadult	Male	2,990	
	Subadult	Female	1,470	
Ekalaka Hills, Southeast Montana	Adult	Male	360	This study
	Adult	Female	650	
	Subadult	Male	610	
	Subadult	Female	450	
Westcentral Montana	Adult	Male	284	Holzer (1989)
	Adult	Female	448	
	Subadult	Female	766	
Oregon	Adult	Male	1,268	Lutz and Crawford (1989)
	Adult	Female	1,679	
	Subadult	Male	2,368	
	Subadult	Female	3,315	
Washington	Subadult	Male	150	Mackey (1982)
Colorado	Adult	Male	1,390[a]	Hoffman (1991)
	Subadult	Male	2,870[a]	

[a] Spring only.

small amount of recently logged areas relative to the size of the area.

Movement of subadult hens in the Long Pines during spring was probably underestimated because many hens were

killed during this period. Only hens that survived throughout the spring were included in analyses.

Hens that moved farthest during spring appeared to be more susceptible to predation; this may have been related to their lack of familiarity with escape cover along travel routes. Turkeys spending more time in unfamiliar areas during spring movements likely would be more susceptible to predators. Lutz and Crawford (1987) suggested that mobility was directly related to mortality in Merriam's turkeys in Oregon.

Slope may be an important site characteristic for roosting turkeys, both because of increased accessibility into trees and topographic protection from prevailing winds. Turkeys usually roost in the upper one-third of a tree; access to that part would be easier if the tree was located at least half way up a slope of a hill (roost trees usually were) and turkeys took flight at or near the top of the hill (most usually did). Steep slopes also have been reported as important to roosting Merriam's turkeys in Wyoming (Hengel 1990).

Although not statistically significant, most roosts occurred on east to northeast-facing slopes. These aspects provided greater protection from west-northwest prevailing winds than flat or less steep slopes (Rumble 1992).

During this study, as with Merriam's turkeys in Wyoming (Hengel 1990) and Oregon (Lutz and Crawford 1989), roosting

occurred in the taller and larger diameter trees available in a roost stand. Such trees usually have large, widely spread branches that provide easy access for turkeys.

Roost trees in burned stands were larger in diameter than those in unburned stands apparently because of their loss of dense branch structure. More "large" trees may have become structurally available after the fire because of their loss of dense canopy and branching (branches broken off).

No roosts occurred in recently (within 30 years) logged stands in the Ekalaka Hills. Near the end of the study, 1 turkey flock was displaced from an area being logged; however, I was unable assess the extent of the displacement.

Differences in specific features (such as distance to permanent water, slope, tree height, and dbh) between stands used for roosts in the Long Pines during winter and those used during spring/fall were likely because all winter roosts occurred on ranches. Those roosts were close to a permanent water source (stock tank) and several were located in deciduous woody draws that were on flat terrain and contained large diameter but relatively short trees. All spring/fall roosts occurred in ponderosa pines in upland areas.

In the Ekalaka Hills, the lack of significant differences in habitat features between spring/fall and winter roosts was probably because winter roosts on ranches

were on the margin of the upland areas and not out from the hills like most winter roosts in the Long Pines. Thus, habitat features were similar between winter and spring/fall roosts used by turkeys in the Ekalaka Hills.

CHAPTER 5

NESTING ECOLOGY IN RELATION TO BURNED AND LOGGED AREAS

Quality nesting habitat is important to reproductive success in wild turkeys. Attributes of nesting habitat for Merriam's turkeys have been reported for New Mexico (Ligon 1946, Schemnitz et al. 1985, Liedlich et al. 1991), Arizona (Crites 1988, Mollohan and Patton 1991), Colorado (Hoffman 1990), South Dakota (Petersen and Richardson 1975, Wertz and Flake 1988, Day et al. 1991), Wyoming (Hengel 1990), Oregon (Lutz and Crawford 1987), and Washington (Mackey 1982), but not for Montana. Additionally, effects of fire on nesting habitat has not been investigated in either native or expanded turkey range. Effect of logging on nesting habitat has only been reported for New Mexico (Schemnitz et al. 1985), Arizona (Mollohan and Patton 1991), and Oregon (Lutz and Crawford 1987). My studies provided opportunity to investigate effects of both fire and logging on nesting habitat of Merriam's turkeys in southeastern Montana.

Methods

I used a 7.5 minute U.S.G.S quadrangle to measure straight-line distance (nearest 0.1 km) between the winter geographical activity centers (GAC) of hens and their first confirmed nesting location. Differences (nearest 0.01 km) between locations of nests for the same hens over consecutive years were used to estimate fidelity to nest sites.

Hens with transmitters were relocated at least once a week during spring. Visual locations were made on hens found in the same spot on consecutive relocations to ascertain whether they were incubating or dead. Nests were located only after incubation had begun. If a hen was not visible due to vegetation, I triangulated on the nest from $\geq$20 m away. Nests were monitored 3 times weekly when eggs were close to hatching. J. Gobeille (Montana State Univ., pers. commun.) collected nest data during 1989.

Nesting rates were minimum estimates because nests were not located until incubation was underway. Some hens could have attempted to nest but had their nest predated during egg-laying and not attempted to renest. I would have recorded these as non-nesting hens.

Nesting habitat of Merriam's turkeys was quantified after poults had hatched or the nest was destroyed. Because

of uncertainty, I did not classify predated nests by type of predator. Potential mammalian nest predators included mountain lion, bobcat, coyote, red fox, raccoon (*Procyon lotor*), and striped skunk (*Mephitis mephitis*) (Lampe et al. 1974). Potential avian nest predators included American crow (*Corvus brachyrhynchos*), black-billed magpie (*Pica pica*), and blue jay (*Cyanocitta cristata*) (Bergeron et al. 1992).

Characteristics of randomly-selected sites were used to compare with those of nest sites as discussed for roosts in Chapter 3. Random sites were located in apparently suitable nesting habitat (tree, shrub patch, fallen log, etc.) closest to the random coordinates. Variables quantified at nest and random sites included: site disturbance; distance to permanent water, meadow, tree, and edge; patch length and width; dbh and height of tree; visual obstruction; slope and aspect; and plant species and coverage (descriptions are listed in Appendix E, Table 22). Stand classification (grassland, seedling/sapling, poletimber, and sawtimber) and overstory crown coverage (0-39%, 40-70%, and >70%) of stand types where nest and random sites were located were obtained from stand maps of the U.S.D.A. Forest Service (Custer National Forest, Sioux Ranger District). At nest sites, I also measured length, width, and depth of the nest bowl.

Each nest and random site was classified based on basic physical characteristics (located at base of tree, in a shrub patch, etc.), number of nesting attempts by the hen, success of the hen, and site disturbance (burned, unburned, logged, and unlogged). Nests initiated before 7 May were considered first nests based on back-dating numbers of days spent on nests (see below) from the average peak date of hatching. These peaks were adjusted *a posteriori* for delayed incubation caused by spring snowstorms in some years (Jonas 1968).

For successful nests (at least 1 poult hatched), I recorded clutch size (number of eggs) and hatching success (number of eggs hatched per total number of eggs). Initiation dates of nests for successful hens were calculated by backdating 28 days from the hatching date plus the number of days a hen spent laying eggs (1.3 times clutch size).

Statistical methods for analyzing data were discussed in Chapter 3. In addition, chi-square analysis was used to test for significance of categorical data that were in 2-dimensional tables; loglinear modeling was used for higher dimensional tables (Fienberg 1980). Probabilities associated with significant statistical results are ($P \leq 0.01$) unless noted otherwise.

Results

Distances From Winter Ranges To Nest Sites

Straight-line distances between winter GAC's and nest sites are listed in Appendix E, Table 23. These distances did not differ among years for either subadult or adult hens in either study division (range = 1.1-16.6 km; Table 24). Further, subadults did not move farther than adults within years. However, for all years combined, subadults moved greater ($P = 0.04$) distances than adults in the Long Pines, but not in the Ekalaka Hills.

For all ages pooled, hens in the Long Pines differed ($X^2 = 8.68$, $P = 0.01$) in distances moved between wintering areas and nests among years during 1989-1991 (Table 25). Distances were larger in 1989 than in 1990. There was no difference in distances moved among years in the Ekalaka Hills (Table 24).

Yearly Fidelity To Nest Sites

Seven of 10 hens constructed nests within 0.5 km of the previous year's nest. Distance between nests in consecutive years in the Long Pines (mean distance = 0.32 ± 0.23 [*SD*] km, $n = 2$) did not differ ($P > 0.05$) from that for the Ekalaka

Table 24. Comparison of straight-line distances (km) of movement by subadult and adult hens between winter GAC's and nest sites in the Long Pines and Ekalaka Hills, 1989-1991.

	Long Pines				Ekalaka Hills			
	Subadult		Adult		Subadult		Adult	
Year	n	Mean (SD)	n	Mean (SD)	n	Mean (SD)	n	Mean (SD)
1989	6	16.6 (6.4)	3	9.2 (9.0)	4	6.5 (2.2)	0	--
1990	5	6.1 (8.6)	4	1.1 (0.7)	3	3.9 (2.6)	5	3.9 (1.7)
1991	4	7.3 (5.2)	3	6.6 (7.2)	1	3.3 (--)	4	6.1 (2.8)
Pooled	15	10.5 (8.1)	10	5.2 (6.6)	8	5.1 (2.5)	9	4.7 (2.3)

Table 25. Comparison of straight-line distances (km) of movement by hens between winter GAC's and nest sites in the Long Pines and Ekalaka Hills, 1989-1991.

	Long Pines			Ekalaka Hills		
Year	n	Mean	(SD)	n	Mean	(SD)
1989	9	13.9	(7.6)	4	6.5	(2.2)
1990	9	3.9	(6.6)	8	3.9	(1.9)
1991	7	7.0	(5.6)	5	5.5	(2.7)

Hills (mean distance = 1.25 ± 2.02[*SD*] km, *n* = 7); therefore, data from both divisions were pooled. There were no differences in nest site fidelity with respect to previous hatching success. Nests constructed by all hens over successive years averaged 1.04 km (*SD* = 1.80) apart.

Nesting Rates

Forty-five of 53 hens that had an opportunity to incubate eggs did so during 1989-1991. These included 26 of 31 subadult and 19 of 22 adult hens (Table 26).

Table 26. Nesting rates (number of confirmed nesting hens/number hens alive during nesting period) among subadult and adult hens with in the Long Pines and Ekalaka Hills, April-July 1989-1991.

	Long Pines		Ekalaka Hills	
	Subadult	Adult	Subadult	Adult
Year	No. nesting/ no. alive	No. nesting/ no. alive	No. nesting/ no. alive	No. nesting/ no. alive
1989	8/9	1/2	5/5	---
1990	5/6	6/6	3/4	5/6
1991	4/6	3/4	1/1	4/4
Pooled	17/21	10/12	9/10	9/10

Two of 9 nesting attempts in the Long Pines were in burned areas (both lightly burned) during 1989, 3 of 11 (2 lightly burned and 1 severely burned) during 1990, and 4 of 7 (1 lightly burned and 3 severely burned) during 1991. No hens monitored in the Ekalaka Hills were documented nesting in logged areas during the study. The only Long Pines hen documented in a logged area was a subadult that nested in a 2-ha clearcut during 1989. Two subadults killed during the

nesting period (April-July) in the Long Pines during 1990 were recorded as non-nesters.

Nest Initiation And Hatching Dates

Differences between both nest initiation (Table 27) and hatching (Table 28) dates for 1990 compared to 1991 were not significant for the Long Pines (*P* = 0.09) and Ekalaka Hills (*P* = 0.08); however, results probably would have been significant with larger sample sizes. For initial nesting attempts, nests were initiated earlier (*P* = 0.05) in unburned than burned areas in the Long Pines (Table 29). Subadult hens initiated nests earlier (*P* = 0.05) than adult hens in burned areas.

Table 27. Comparison of initiation dates for first nesting and renesting attempts by hens between and among years in the Long Pines and Ekalaka Hills, 1989-1991.

	Long Pines						Ekalaka Hills					
	First nest			Renest			First nest			Renest		
Year	n	Mean	(SD)	n	Mean	(SD)	n	Mean	(SD)	n	Mean	(SD)
1989	1	22 Apr	(-)	5	22 May	(25)	0	---		0	---	
1990	2	10 Apr	(0)	5	6 Jun	(27)	3	13 Apr	(5)	2	23 May	(27)
1991	4	25 Apr	(6)	3	21 May	(21)	3	25 Apr	(4)	2	9 Jun	(1)

Table 28. Comparison of hatching dates for first nesting and renesting attempts by hens between and among years in the Long Pines and Ekalaka Hills, 1989-1991.

	Long Pines						Ekalaka Hills					
	First nest			Renest			First nest			Renest		
Year	n	Mean	(SD)	n	Mean	(SD)	n	Mean	(SD)	n	Mean	(SD)
1989	0	---		5	2 Jul	(25)	0	---		0	---	
1990	2	20 May	(0)	4	4 Jul	(11)	3	23 May	(2)	2	4 Jul	(10)
1991	4	6 Jun	(6)	3	1 Jul	(22)	3	7 Jun	(6)	2	23 Jul	(2)

Table 29. Comparison of nest initiation and hatching dates of hens nesting in burned and unburned areas in the Long Pines, April-July 1989-1991.

	Nest initiation date						Hatching date					
	Burned site			Unburned site			Burned site			Unburned site		
Variable	n	Mean	(SD)	n	Mean		n	Mean	(SD)	n	Mean	(SD)
First nest	4	26 Apr	(5)	3	13 Apr	(5)	3	7 Jun	(7)	3	25 May	(8)
Renest	3	19 May	(14)	10	30 May	(27)	3	29 Jun	(13)	9	4 Jul	(20)
Subadult	4	26 Apr	(3)	7	3 Jun	(31)	3	7 Jun	(7)	6	7 Jul	(24)
Adult	3	19 May	(14)	6	1 May	(21)	3	29 Jun	(13)	6	10 Jun	(20)

Clutch Sizes And Hatching Success

Clutch sizes, number of eggs hatched, and rates of hatching success (number of eggs hatched/clutch size) of successful hens did not differ among years either between ages or for pooled ages of hens in either or both study divisions. Therefore, data were pooled across ages and

years. Similarly, the variables did not differ between adults and subadults within, between or for both study divisions (Table 30). For the combined data, average number of eggs was 10.2 (*SD* = 2.0) eggs (Fig. 14); average hatched was 8.3 (*SD* = 2.5); and average percent hatched was 82.0 (*SD* = 19.0).

Nest and Hen Success

Nest success differed (X^2 = 3.94, *P* = 0.05) by age of hen over combined study divisions. There were more (X^2 = 5.12, *P* = 0.02) unsuccessful subadults than adults. Unsuccessful nesting resulted from predation (all but 1 case) and nest abandonment (1 case). Because of uncertainty, specific predators involved could not be determined. Nonetheless, coyotes were the most likely mammalian predator on nests; mountain lions, bobcats, red foxes, raccoons, and striped skunks did not appear to be common in upland areas. Crows and magpies were likely the main avian predators.

Of the 46 transmitter-equipped hens alive at the beginning of March, 10 of 30 subadults and 9 of 16 adults hatched poults in the Long Pines. Three of 16 subadults and 8 of 18 adults hens nested successfully in the Ekalaka Hills (Table 31). Overall, 13 of 46 (28.3%) subadult and 17 of 34

Table 30. Comparison of productivity between different aged hens in the Long Pines and Ekalaka Hills, 1989-1991.

	Long Pines						Ekalaka Hills						Both divisions					
	Subadult			Adult			Subadult			Adult			Subadult			Adult		
Variable	n	Mean	(SD)	n	Mean	(SD)	n	Mean	(SD)	n	Mean	(SD)	n	Mean	(SD)	n	Mean	(SD)
Clutch size	9	10.3	(1.6)	6	9.7	(1.9)	3	11.3	(0.6)	7	10.0	(2.9)	12	10.6	(1.4)	13	9.8	(2.4)
No. eggs hatched	9	8.0	(2.1)	6	8.8	(1.3)	2	9.0	(1.4)	7	8.1	(4.1)	11	8.2	(1.9)	13	8.5	(3.0)
Rate of hatching success (%)	9	78.0	(19.0)	6	92.0	(6.0)	2	79.0	(17.0)	7	78.0	(25.0)	11	78.0	(18.0)	13	85.0	(20.0)

Fig. 14. Clutch of 13 eggs (11 hatched) in a nest of an adult Merriam's turkey hen in the Ekalaka Hills Division. Note the 2 infertile eggs (including 1 undersized egg) at the top right of the nest.

Table 31. Rates of hen success for different aged hens in the Long Pines and Ekalaka Hills, 1989-1991.

	Long Pines		Ekalaka Hills	
	Subadult hens	Adult hens	Subadult hens	Adult hens
Year	Successful/ total no.	Successful/ total no.	Successful/ total no.	Successful/ total no.
1989	5/13	1/3	1/8	0/1
1990	1/8	5/7	1/7	4/10
1991	4/9	3/6	1/1	4/7
Pooled	10/30	9/16	3/16	8/18

(50.0%) adult hens hatched poults in the study area during 1989-1991.

Three of 6 subadults nesting in burned areas were successful. All 3 successes occurred in 1991. Three of 3 adult hens successfully nested in burned areas, 1 in each of 3 years.

Five of 17 subadults were successful in initial nesting attempts and 11 of 16 successfully renested. Eight of 17 adults were initially successful and 8 of 10 successfully renested. Overall, 13 of 34 (38.2%) hens were initially successful and 19 of 26 (73.1%) successfully renested (Table 32).

Table 32. Initial nesting success and renesting rates for hens in the Long Pines and Ekalaka Hills, 1989-1991.

	Initial nesting success				Renesting rates			
	Long Pines		Ekalaka Hills		Long Pines		Ekalaka Hills	
Year	Subad.	Ad.	Subad.	Ad.	Subad.	Ad.	Subad.	Ad.
1989	1/6	0/1	0/1	---	4/7	1/2	1/1	---
1990	0/3	2/5	1/3	2/4	3/3[a]	3/3	1/3	3/4
1991	3/4	1/3	0/1	3/4	1/1	---	1/1	1/1

[a] Included 1 second nesting attempt.

Nesting Habitat

Length, width, and depth of nest bowls did not differ among years, between ages of hens or between study divisions so data were pooled across years, ages of hens, and study divisions. Mean length of nests (n = 42) was 43.3 (SD = 9.2) cm, mean width was 34.1 (SD = 8.1) cm, and mean depth was 5.9 (SD = 2.9) cm.

Nest sites in the Long Pines were associated with larger (P = 0.02) diameter trees, located on different (P < 0.05) aspects, and contained greater (P = 0.04) percent cover of forbs than nest sites in the Ekalaka Hills (Table 33). They also were farther (P = 0.04) from the "edge", were associated with taller and larger diameter trees, had higher visual obstruction, and contained lower percent cover of grasses/sedges than random sites (Table 33). Slope and percent cover of shrubs were generally higher (P = 0.06 and

Table 33. Comparison of characteristics associated with turkey nest and random sites in the Long Pines and Ekalaka Hills, 1989-1991.

	Long Pines						Ekalaka Hills					
	Nest site			Random site			Nest site			Random site		
Characteristic	n	Mean	(SD)	n	Mean	(SD)	n	Mean	(SD)	n	Mean	(SD)
Dist. to permanent water (m)	21	623	(311)	21	534	(232)	13	546	(215)	13	736	(212)
Dist. to meadow (m)	21	16	(21)	21	14	(24)	13	56	(86)	13	60	(121)
Dist. to tree (m)	12	33	(25)	13	52	(24)	8	30	(14)	9	18	(30)
Dist. to edge (m)	21	1.3	(2.3)	21	0.2	(0.4)	13	0.8	(1.4)	13	0.1	(0.2)
Patch length (m)	12	21.2	(42.3)	6	3.8	(2.0)	9	14.5	(18.0)	3	4.6	(3.0)
Patch width (m)	12	6.4	(6.6)	6	2.4	(1.3)	9	8.8	(8.3)	3	2.6	(0.7)
Dbh of tree (cm)	12	26.8	(9.9)	13	13.8	(12.4)	8	17.3	(8.1)	9	17.5	(13.0)
Height of tree (m)	12	15	(4)	13	6	(3)	8	12	(5)	9	9	(5)
Visual obstruction (dm)	21	6.5	(1.9)	21	4.0	(2.2)	13	6.4	(2.1)	13	4.6	(2.5)
Slope (%)	21	20	(10)	21	10	(10)	13	20	(10)	13	10	(10)
Aspect (degrees)	21	339	(63)[a]	21	65	(75)[a]	13	96	(66)[a]	13	294	(73)[a]
Trees (%)	21	12	(10)	21	8	(6)	13	12	(24)	13	9	(11)
Shrubs (%)	21	32	(29)	21	22	(32)	13	59	(35)	13	31	(32)
Grasses-sedges (%)	21	13	(16)	21	33	(25)	13	7	(7)	13	33	(26)
Forbs (%)	21	12	(17)	21	12	(11)	13	2	(4)	13	13	(10)
Litter-rock-bare ground (%)	21	29	(22)	21	26	(25)	13	19	(22)	13	12	(21)

[a] Angular mean (angular deviation).

P = 0.07, respectively) around nests compared to random sites.

Nests in the Ekalaka Hills had greater (*P* = 0.04) visual obstruction, were located on steeper slopes, and had lower percent coverage of forbs and grasses/sedges than random sites (Table 33). Logistic regression models for both study divisions are listed in Appendix E, Table 34.

Nest sites of subadult hens in the Long Pines had greater (*P* = 0.03) percent coverage of trees than adults, whereas subadult nest sites in the Ekalaka Hills contained shorter (*P* = 0.03) trees (Table 35). Distance to permanent water was generally greater (*P* = 0.06) and forb cover lower (*P* = 0.06) in subadult as compared to adult nests in the Long Pines.

In the Long Pines, successful hens nested closer to permanent water than unsuccessful hens, whereas in the Ekalaka Hills successful hens nested closer (*P* = 0.03) to the nearest edge (Table 36). There were no differences in habitat variables between burned and unburned areas of the Long Pines (Table 37).

Hens nested on the uphill side or beside the base of trees, in shrub patches (mostly common snowberry), under slash or fallen logs, beside logs or stumps, and at the base of sandstone ledges (Table 38). Most nested at the base of trees (28 of 49) (Fig. 15) or in shrub patches (14 0f 49)

Table 35. Comparison of site characteristics at subadult and adult turkey nest sites in the Long Pines and Ekalaka Hills, 1989-1991.

Site Characteristic	Long Pines						Ekalaka Hills					
	Subadult			Adult			Subadult			Adult		
	n	Mean	(SD)	n	Mean	(SD)	n	Mean	(SD)	n	Mean	(SD)
Dist. to permanent water (m)	14	728	(281)	7	428	(284)	4	541	(121)	9	549	(253)
Dist. to meadow (m)	14	17	(23)	7	12	(14)	4	26	(25)	9	72	(104)
Dist. to tree (m)	8	26.6	(11.8)	1	20.0	(-)	1	25.0	(-)	4	30.5	(18.4)
Dist. to edge (m)	14	0.8	(1.6)	7	2.1	(3.2)	4	1.1	(0.9)	9	0.7	(1.6)
Patch length (m)	6	10.6	(16.5)	6	31.9	(58.3)	3	25.4	(29.3)	6	9.0	(8.3)
Patch width (m)	6	5.6	(7.3)	6	7.2	(6.4)	3	15.6	(9.0)	6	5.4	(5.8)
Dbh of tree (cm)	11	28.0	(9.3)	1	12.9	(-)	4	14.7	(8.8)	4	19.9	(7.5)
Height of tree (m)	11	16	(1)	1	8	(-)	4	8	(3)	4	17	(1)
Visual obstruction (dm)	14	6.2	(1.8)	7	7.0	(2.3)	4	5.7	(2.6)	9	6.7	(1.9)
Slope (%)	14	20	(10)	7	15	(15)	4	25	(10)	9	15	(10)
Aspect (degrees)	14	59	(52)[a]	7	66	(43)[a]	4	352	(77)[a]	7	354	(64)[a]
Trees (%)	14	16	(7)	7	15	(20)	4	24	(44)	9	8	(8)
Shrubs (%)	14	37	(27)	7	34	(34)	4	59	(46)	9	59	(31)
Grasses-sedges (%)	14	12	(17)	7	8	(14)	4	8	(8)	9	5	(6)
Forbs (%)	14	5	(10)	7	22	(24)	4	1	(1)	9	5	(6)
Litter-rock-bare ground (%)	14	27	(25)	7	17	(13)	4	10	(4)	9	20	(25)

[a] Angular mean (angular deviation).

Table 36. Comparison of site characteristics successful and unsuccessful at nest sites in the Long Pines and Ekalaka Hills, 1990-1991.

Site Characteristic	Long Pines						Ekalaka Hills					
	Successful			Unsuccessful			Successful			Unsuccessful		
	n	Mean	(SD)	n	Mean	(SD)	n	Mean	(SD)	n	Mean	(SD)
Dist. to permanent water (m)	11	416	(244)	10	829	(225)	10	546	(248)	2	550	(0)
Dist. to meadow (m)	11	18	(23)	10	13	(19)	10	72	(98)	2	7	(9)
Dist. to tree (m)	6	23.8	(10.9)	3	30.0	(13.2)	5	29.4	(16.1)	0	---	
Dist. to edge (m)	11	1.5	(2.6)	10	1.0	(1.9)	10	0.2	(0.3)	2	3.4	(2.2)
Patch length (m)	7	27.4	(54.5)	4	14.7	(19.6)	7	7.7	(7.0)	2	38.0	(29.7)
Patch width (m)	7	6.2	(6.4)	4	7.6	(8.4)	7	6.0	(6.9)	2	18.5	(4.9)
Dbh of tree (cm)	6	21.9	(8.2)	6	31.6	(9.6)	6	18.8	(7.1)	2	12.8	(12.3)
Height of tree (m)	6	14	(4)	6	16	(4)	6	15	(3)	2	6	(3)
Visual obstruction (dm)	11	7.2	(1.8)	10	5.7	(1.9)	10	6.4	(2.2)	2	5.6	(0.5)
Slope (%)	15	20	(15)	11	20	(10)	10	20	(10)	5	25	(20)
Aspect (degrees)	11	59	(50)[a]	11	58	(49)[a]	7	14	(61)[a]	5	319	(68)[a]
Trees (%)	11	15	(16)	10	16	(7)	10	15	(27)	2	2	(1)
Shrubs (%)	11	34	(31)	10	36	(29)	10	52	(37)	2	74	(25)
Grasses-sedges (%)	11	16	(15)	10	14	(17)	10	6	(7)	2	12	(4)
Forbs (%)	11	16	(22)	10	3	(2)	10	5	(5)	2	1	(1)
Litter-rock-bare ground (%)	11	16	(16)	10	29	(27)	10	20	(23)	2	11	(17)

[a] Angular mean (angular deviation).

Table 37. Comparison of site characteristics at burned and unburned nest sites in the Long Pines, 1990-1991.

	Burned			Unburned		
Site Characteristic	n	Mean	(SD)	n	Mean	(SD)
Distance to water (m)	7	601	(256)	13	634	(347)
Distance to meadow (m)	7	27	(27)	16	11	(16)
Distance to tree (m)	3	26.0	(16.5)	6	25.8	(9.7)
Distance to edge (m)	7	0.7	(0.7)	14	1.5	(2.8)
Patch length (m)	5	7.7	(8.3)	7	30.9	(54.6)
Patch width (m)	5	5.2	(5.2)	7	7.2	(7.7)
Dbh of tree (cm)	4	25.7	(10.6)	8	27.3	(10.3)
Height of tree (m)	4	17	(4)	8	14	(4)
Visual obstruction (dm)	7	6.7	(1.5)	14	6.4	(2.1)
Slope (%)	9	20	(15)	21	20	(15)
Aspect (degrees)	5	58	(62)[a]	17	58	(46)[a]
Trees (%)	7	8.0	(8.0)	13	12.0	(14.0)
Shrubs (%)	7	45.0	(30.0)	13	25.0	(27.0)
Grasses-sedges (%)	7	11.0	(15.0)	13	15.0	(17.0)
Forbs (%)	7	11.0	(13.0)	13	15.0	(19.0)
Litter-rock-bare ground (%)	7	23.0	(28.0)	13	31.0	(21.0)

[a] Angular mean (angular deviation).

(Fig. 16). Hens differed (X^2 = 17.56, P < 0.01) in their locations of initial nests and renests. They initially nested more (X^2 = 8.07, P < 0.01) often at the base of trees (n = 13) than in shrub patches (n = 2). However, hens that renested did not differ (X^2 = 1.00, P = 0.32) in their use of trees (n = 7) from shrub patches (n = 8).

Table 38. Location characteristics of turkey nests in the Long Pines and Ekalaka Hills, 1989-1991.

	Location characteristic of nest					
Year	Base of tree	Shrub patch	Under slash or fallen log	Beside log or stump	Base of sandstone ledge	Total nests
1989	8	4	1	---	2[a]	15
1990	10	8	1	2[b]	---	21
1991	10	2	1	---	---	13
Pooled	28	14	3	2	2	49

[a] One nest located on top of old porcupine nest.
[b] One nest located inside low (approximately 30 cm in height) stump.

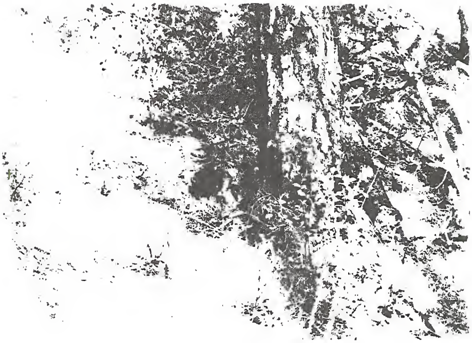

Fig. 15. Transmitter-equipped Merriam's turkey hen nesting at the base of a ponderosa pine in a lightly burned stand in the Long Pines Division, May 1991.

Fig. 16. Successful nest in a shrub patch of common chokecherry in the Long Pines Division, Spring 1990.

Fifteen of 20 hens that nested at the base of trees and 7 of 10 that nested in shrub patches successfully hatched poults. In burned areas, hens were successful 4 of 5 times when nesting at the base of trees, 1 of 2 when nesting in shrub patches, and 1 of 2 times when nesting under fallen logs or slash. The single hen that nested in a logged area (under a slash pile) in the Long Pines in 1989 was successful . No monitored hens nested in logged areas in the Ekalaka Hills.

Amount of spring precipitation (Table 39) was a significant (*P* = 0.01) component of a loglinear model (G^2 = 0.11, *P* = 0.74) fitting type of nesting habitat and amount of spring precipitation to nest success. The trend was for increased nest success with increased precipitation.

Table 39. Average yearly (1989-1991) precipitation and deviation from long-term average precipitation in the Long Pines and Ekalaka Hills, March-May.

	March-May 1989-1991 precipitation (cm)[a]			
	Camp Crook, SD	Ekalaka, MT	Pooled average	Deviation from long-term average
1989	12.42	14.86	13.70	+ 3.01
1990	7.87	9.55	8.71	- 1.98
1991	19.76	15.82	17.79	+ 7.10

[a] From U.S. Weather Bureau Climatological Stations in Camp Crook, SD (for Long Pines) and Ekalaka, MT (for Ekalaka Hills).

Discussion

Greater distances traveled by subadult hens between wintering and nesting areas in the Long Pines compared to the Ekalaka Hills probably reflected the overall lower quality habitat in the Long Pines. If dominance behavior occurred, subadult hens may have been forced to move farther from wintering areas by the dominant adult hens. Mackey (1982) also reported adult Merriam's turkey hens traveled shorter distances to nesting areas than subadult hens. Distances traveled by hens in this study were similar to those reported for Merriam's turkey hens in New Mexico (mean = 7.7 km, Liedlich et al. 1991), but shorter than reported for Washington (mean = 12.8 km, Crawford and Lutz 1984).

I was unable to quantify any effect of burning on seasonal movements because of the lack of pre-fire data on movements of hens. However, burned areas did not seem to impede seasonal movements. Logged areas in the Ekalaka Hills were probably not extensive enough to affect seasonal movements.

The strong fidelity of hens to nest areas in the Long Pines and the Ekalaka Hills was similar to findings in New Mexico (Liedlich et al. 1991). Familiarity with an area would provide a selective advantage in allowing hens to

select better nesting sites to avoid predators. Because of small sample size (n = 10), I could not quantify a difference between successful and unsuccessful nests as related to fidelity. However, the trend was toward increased distance between successful and unsuccessful nests over consecutive years compared to distances between successful nests. Small sample sizes precluded discerning any effects of burned and logged areas on nest fidelity.

The generally higher nesting rates in this study compared to those reported for other parts of the West (Table 40) may be related to quality of nesting habitat. Even in dry years, there is apparently sufficient cover available in southeastern Montana for nesting turkeys. In more arid parts of the range of Merriam's turkeys (for example, New Mexico and Arizona), nesting cover may be reduced during dry years. Consequently, increased competition for nesting sites could result in adult hens forcing less dominant adult and subadult hens into marginal or non-nesting habitats.

There also could be a physiological reason for low nesting rates among young hens in more arid parts of their range. Low precipitation during spring and summer would limit plant growth and adversely affect availability of food resources for turkeys during the following winter (if turkeys do not overwinter on ranches). Older, dominant

Table 40. Nesting rates of Merriam's turkeys in various parts of their range.

	Nesting				
	Subadult		Adult		
Location	n	Rate (%)	n	Rate (%)	Author(s)
Montana	31	84	22	86	This study
South Dakota	12	0	23	42	Wertz and Flake (1988)
Wyoming	9	56	9	78	Hengel (1990)
Oregon	13	31	12	100	Lutz and Crawford (1987)
Washington	5	40	5	100	Mackey (1982)
New Mexico	27	11	29	76	Schemnitz et al. (1985)
New Mexico	30	10	80	80	Liedlich et al. (1991)
Arizona	4	25	20	80	Crites (1988)

turkeys in flocks may obtain the majority of limited food resources leaving less and lower quality food for younger, less dominant turkeys. In a given year, subadult turkey hens in arid regions may not obtain sufficient minerals and nutrients from foods during winter to be able to produce eggs during spring; hence, they would not attempt to nest. Most turkeys in this study appeared to winter near feedlots where availability of sufficient food was not a problem.

Lutz and Crawford (1987) suggested only adult hens be used in transplants because of low nesting rates among subadult hens in Oregon. Nesting rates were similar between subadults and adults in my study. However, lower rates of success for subadults concur that adult hens be used in transplants in southeastern Montana.

Differences in initiation dates among years in the Long Pines may have been related to spring snowstorms delaying the onset of nesting during 1991. Jonas (1968) reported a delay in egg-laying after a severe snowstorm in the Long Pines during Spring 1967. Spring snowstorms may have affected nesting in the Long Pines more than the Ekalaka Hills because of less overhead cover in burned compared to unburned areas.

Earlier nest initiation in unburned areas compared to burned areas may reflect relative proximity of the 2 types to wintering sites. Unburned areas often were located around ranches, which were free of snow earlier than uplands. Consequently, hens nesting adjacent to wintering grounds could initiate nests earlier than hens using uplands.

Cold weather during spring may have reduced hatching rates for hens throughout the study area. Hatching rates observed during this study were similar to those reported in South Dakota (Petersen and Richardson 1975), higher than reported for New Mexico (Liedlich et al. 1991), but lower than Wyoming (Hengel 1990) and Washington (1982). Average clutch sizes in both study divisions were comparable to those (8.1-11.4) reported for Merriam's turkeys throughout their range.

Subadults had lower nest success than adults probably because of less familiarity with nesting areas, no previous nesting experience, and more activity around their nests (Lutz and Crawford 1987). Overall, rates of hen success in both study divisions were similar to those reported for Merriam's turkeys in Arizona (Crites 1988) and New Mexico (Schemnitz et al. 1985), and slightly lower (for adult hens) than reported for Oregon (Lutz and Crawford 1987).

Initial nest success was highest during 1991, the year of greatest spring precipitation. Liedlich et al. (1991) reported a positive correlation between nest success of turkeys and January-June precipitation. Beasom and Pattee (1980) also noted a positive association between success of Rio Grande turkey hens and precipitation in Texas.

Nest success is probably relatively high during years of high spring precipitation that created lush growths of understory vegetation as during 1991. Hens nesting at the base of trees in years of lush understory vegetation would be much more likely to escape the notice of predators than those nesting under in sparse understory vegetation. Perhaps shrub patches were searched systematically by predators like coyotes (R.L. Eng, Montana State Univ., pers. commun.), whereas sites at the base of trees could not be efficiently searched because of sheer numbers and distribution.

Large amounts of spring precipitation would particularly promote growth of understory vegetation in burned areas because of increased nutrients in the soil from the fire and more sunlight on the forest floor. Timing and type of spring precipitation also would be important. Extended periods of snowfall during egg-laying (Jonas 1968) and extended periods of cold rain at the peak of hatching (Gobeille 1992) could lower reproductive output of hens. Overall, spring precipitation is probably much more beneficial than detrimental to the reproductive output of turkeys in southeastern Montana.

As in my study, Merriam's turkeys often nested either at the base of trees or in shrub patches in South Dakota (Wertz and Flake 1988, Day et al. 1991), Wyoming (Hengel 1990), Arizona (Crites 1988), and Washington (Mackey 1982). Nests were most often associated with logging slash and downed timber in New Mexico (Liedlich et al. 1991) and Oregon (Lutz and Crawford 1987). Mollohan and Patton (1991) reported turkeys often nested against a cliff or ledge, although nest sites contained a high density of shrubs.

Hens in my study selected the uphill side of the base of trees for initial nesting attempts; later, in renesting they shifted to more even usage of trees and shrub patches. Day et al. (1991) noted a similar shift by turkeys nesting in woodland-prairie environments of South Dakota.

The importance of slope, obstructing vegetation, shrub density, and dbh of trees to nesting hens was apparently related to predator avoidance. Nesting cover has been reported to be important in other studies of Merriam's turkeys (Schemnitz et al. 1985, Lutz and Crawford 1987).

Percent coverage of grasses and sedges was lower at nest sites than at random sites, probably because nests often were associated with shrubs (even at the base of trees) and shrub dominance precluded dense grass/sedge development. Differences in percent coverage of forbs between nest sites in the Long Pines and those in the Ekalaka Hills probably reflected changes in vegetational composition resulting from fire; forbs dominated many burned areas in the first 2 years after the fire.

There are no published papers reporting the effect of fire on habitat use of nesting Merriam's turkey hens. In the southeastern United States, Hurst (1981) reported that prescribed fire was beneficial in maintaining nesting habitat of eastern wild turkeys in a grass-forb-brush stage. Sisson et al. (1990) noted that 82% of their sample of eastern wild turkeys nested in areas that had been prescribed burned within the previous 2 years, but further commented that prescribed burning may be either beneficial or detrimental depending upon the geographic location. No

differences in nesting habitat associated with burned and unburned areas were detected in this study.

Also, few studies have researched the effect of logging on ecology of Merriam's turkeys. Schemnitz et al. (1985) noted no differences in either number or success of nests in selectively logged and unlogged forest stands in the Sacramento Mountains of New Mexico. However, they also reported no nests were located in clearcuts. Mollohan and Patton (1991) noted a higher percentage (46%) of nests were located in unlogged areas compared to random sites (14%) in northcentral Arizona. Lutz and Crawford (1987) reported a widespread use of selectively logged and thinned stands of timber by Merriam's turkeys for nesting in Oregon. No nests were found in logged areas in the Ekalaka Hills during this study.

Selective logging in more mesic environments (for example, New Mexico [Sacremento Mountains] and Oregon) appears to have either a neutral or positive effect on nesting habitat, whereas selective logging in more xeric environments (for example, northcentral Arizona and southeastern Montana) appears to have a negative effect. Because xeric habitats have less undergrowth and generally are more open than mesic habitats, logging usually is not needed to remove dense vegetation. In systems where natural occurrences of fire have been suppressed (like the Ekalaka

Hills), logging is required to remove "unnaturally" occurring dense stands of timber. However, burned areas, with their irregularly-shaped edges, probably offer better habitat for turkeys than similar-sized logged areas.

Clearcut logging in xeric or semi-xeric environments probably detracts from the quality of habitat (at least in the short term) for nesting turkeys, whereas clearcut logging in more mesic environments (for instance, eastern and northwestern United States) may be beneficial to nesting turkeys because of the creation of clearings (Wunz 1990). Increased habitat complexity and understory growth potential in mesic areas would allow them to rebound quicker after logging than xeric areas.

CHAPTER 6

SUMMER HOME RANGE AND HABITAT USE BY NON-BROOD FLOCKS IN RELATION TO BURNED AND LOGGED AREAS

Availability of quality habitat during summer is important to all wild turkeys, especially hens raising broods. Poults require a protein-rich diet, like insects, particularly during their first 2 weeks of life (Hurst and Stringer 1975). Also, adequate reproductive output of females is important to the viability of any wildlife population. Consequently, most research on home range and habitat use of Merriam's turkeys during summer has focused on hens with broods (Schemnitz et al. 1985, Crites 1988, Hengel 1990, Gobeille 1992).

Little research has been conducted on summer home range and habitat use of flocks of male and unsuccessful females (Lutz and Crawford 1989, Rumble 1990). Except for Gobeille (1992), there are no studies reporting the effect of fire on habitat use of Merriam's turkeys during summer. Further, effects of logging on summer habitat use have been reported

for other areas (Scott and Boeker 1977, Schemnitz et al 1985, Lutz and Crawford 1989), but not Montana. My studies provided data on summer home range and habitat use by male and unsuccessfully-nesting female turkeys in relation to burned and logged areas in southeastern Montana.

Methods

Using methods discussed in Chapter 3, I made 209 relocations of 14 transmitter-equipped turkeys in the Long Pines and 117 relocations of 7 turkeys in the Ekalaka Hills during June-September 1990 and 1991.

Home ranges were delineated using the minimum convex polygon technique (Mohr 1947). Areas were calculated using the program TELDAY (Lonner and Burkhalter 1983). Straight-line distances between winter and summer geographical activity centers (GAC) were measured on 7.5-minute U.S.G.S. topographic quadrangle. Neither number of relocations nor length of monitoring periods were correlated ($P > 0.05$) with size of home ranges.

I categorized use of habitats by turkeys into macro- and microhabitat selection. Macrohabitat selection involved use and selection of vegetation cover types within home ranges and corresponded to third-order selection as defined by Johnson (1980). Descriptions of cover types are listed in

Appendix F, Table 41. Microhabitat selection was for specific features within macrohabitats (for example, specific sites or areas within a grassland used by foraging turkeys). This corresponded to fourth and higher orders of selection as defined by Johnson (1980).

Use of macrohabitats was quantified by overlaying acetate sheets, on which convex polygon home ranges were drawn, on to 1:24,000 stand maps developed by the U.S.D.A. Forest Service. Cover types within each home range were outlined on the overlay. Size, shape, and composition of stands were confirmed by overlaying outlined home ranges on to appropriate 1:24,000 black and white aerial photographs. Areas of each stand type were measured using a polar planimeter; sizes of stands too small to measure using a planimeter were estimated by comparing them with similar-shaped geometric shapes of known size.

Two randomly-selected "home" ranges were generated for each home range. These "random ranges" were the same size as their associated home range. Locations of random ranges were determined by random coordinates, generated from a random numbers table, plotted on x-y axes drawn on acetate sheets and overlaid on 7.5-minute topographic quadrangle. Origin of the x-y axes were centered on a given individual's winter GAC. Lengths of each set of axes were equivalent to the straight-line distance between winter and summer GAC's.

Roosting and feeding sites (that is, microhabitats) were identified by direct observation. Roost and random sites were quantified as described in Chapter 4. I quantified vegetative cover within areas used by foraging turkeys by placing a 50-m transect along the "feeding route" of the turkeys and recording vegetative coverage within 25 2x5 dm frames (Daubenmire 1959) spaced 2 m apart along the transect. Vegetative height within each frame was estimated by recording, at a distance of 4 m and a height of 1 m, height of vegetation to a calibrated Robel pole (Robel et al. 1970).

Insect availability was estimated along feeding routes of turkeys via 1 sweeping pass down the 50-m transect. I captured insects in a fine mesh net, transferred them to ziploc plastic bags, and froze them. Insects in each sample were counted, identified to family or order, and massed after having been air- and oven-dried for 24 hours (Cummins and Wuycheck 1971). Shannon-Weaver indices (Shannon and Weaver 1949) were computed for each sample to assess diversity of insects among sites. Statistical methods were discussed in previous chapters. Statistical tests were conducted at alpha = 0.05. Probabilities associated with significant statistical results were ($P \leq 0.01$) unless noted otherwise.

Results

Seasonal Movements And Home Ranges

Straight-line distances between winter and summer GAC's are listed in Appendix F, Table 42. Distances moved did not differ either between ages or sexes within the Long Pines or the Ekalaka Hills for pooled years (Table 43). When data for both divisions were combined, distances moved did not differ with age of turkeys, but appeared to generally differ ($P = 0.06$) between sexes (Table 43). One subadult male and an adult female trapped on the Bergstrom ranch in the southwestern Long Pines moved south approximately 9 km off the study division to the Sheep Mountain area (Fig. 2). These 2 turkeys were not included in analyses.

Flocks that included ≥1 transmitter-equipped turkeys consisted of either all males or a mixture of males and unsuccessful females. Only 1 non-brood female flock was observed. It consisted of 3 turkeys and was seen only once before rejoining a larger, male-female flock. Sizes of summer home ranges are listed in Appendix F, Table 44.

Flocks of 2-4 turkeys had similar-sized home ranges in the Long Pines and Ekalaka Hills. Home range size of single males and flocks of 2-4 birds also was similar. Thus, these data were pooled across flocks and study divisions.

Table 43. Comparison of straight-line distance (km) traveled by different aged turkeys between winter and summer range GAC's for the Long Pines, Ekalaka Hills, and combined study divisions, 1990-1991.

	Straight-line distance (km)								
	Long Pines			Ekalaka Hills			Pooled divisions		
Classification	n	Mean	(SD)	n	Mean	(SD)	n	Mean	(SD)
Age									
Subadult	7	7.7	(5.6)	5	4.8	(3.2)	12	6.5	(4.8)
Adult	7	5.8	(5.8)	2	3.2	(1.9)	9	5.2	(5.2)
Sex									
Male	12	7.6	(5.6)	4	5.3	(3.2)	16	7.0	(5.1)
Female	2	1.9	(2.1)	3	3.1	(2.0)	5	2.6	(1.9)

Home range size of flocks of 1-4 birds (mean = 300 ± 196[*SD*] ha, *n* = 13) was smaller than that of flocks of >4 (mean = 626 ± 232[*SD*] ha, *n* = 8) (Figs. 17 and 18).

Home Range Size In Relation To Habitat Disturbances

Size of summer home ranges (*n* = 14) was not correlated with either percent of home range burned (lightly burned mean = 10.9 ± 11.8[*SD*] %, severely burned mean = 43.4 ± 31.2[*SD*] %) or unburned (mean = 45.7 ± 38.0[*SD*] %). Home range size in the Ekalaka Hills was not correlated (*P* = 0.09) with the percentage area that was logged (mean = 3.4 ± 2.0[*SD*]) or unlogged (mean = 96.6 ± 3.0[*SD*]).

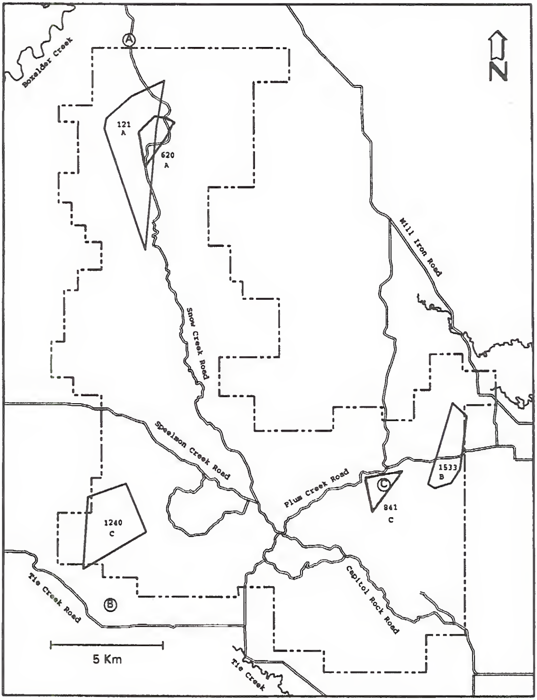

Fig. 17. Summer home ranges and associated winter trap sites (circled letters) of turkeys with transmitters in flocks of 1-4 (nos. 620, 841, and 1503) and >4 birds (nos. 121 and 1240) in the Long Pines Division, 1990-1991.

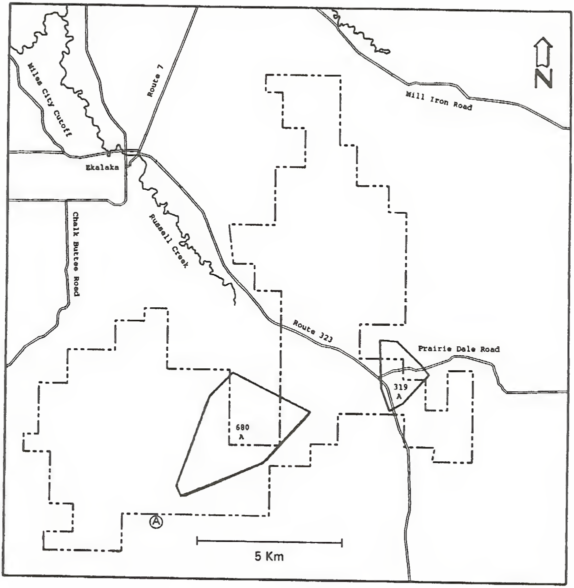

Fig. 18. Summer home ranges and associated winter trap sites (circled letters) of turkeys with transmitters in flocks of 1-4 (no. 319) and >4 birds (no. 680) in the Ekalaka Hills Division, 1990.

Summer Macrohabitat Use

In the Long Pines, turkeys generally avoided (P = 0.07) pine stands with distinct layers of understory and overstory trees (2-storied stands) in severely burned areas (Table 45). These areas also were avoided (P = 0.04) overall (Table 46). Turkeys selected (P = 0.04) mature (sawtimber) pine stands in unburned areas (Table 46). Hardwood draws in unburned areas were generally used less (P = 0.07) than their estimated availability in the Long Pines.

Areas that were logged since 1987 (mean percentage area = 0.3 ± 1.0[*SD*]) within home ranges of turkeys were similar in proportion to those within random ranges (mean percentage area = 1.5 ± 4.6[*SD*]) in the Long Pines. However, turkeys used areas logged before 1988 (mean percentage area = 0 ± 0[*SD*]) less (P = 0.03) than their availability estimated by random ranges (mean percentage area = 6.0 ± 1.4[*SD*]).

Logged pine stands composed of young trees (seedling/sapling) in mesic areas were selected for (P = 0.04) by turkeys in the Ekalaka Hills (Table 47). These stands also were selected for (P = 0.03) in logged areas overall (Table 48). Further, turkeys selected (P = 0.03) unlogged stands with 2 distinct layers of trees (2-storied) in mesic areas (Table 47).

Table 45. Comparison of different stand classes in lightly burned, severely burned and unburned ponderosa pine habitat types (see descriptions in Appendix F, Table 41) within turkey home (n = 14) and random (n = 28) ranges in the Long Pines, Summers 1990-1991. Data are percentage of each stand class within actual home ranges and similar-sized, randomly-located areas in lightly burned, severely burned, and unburned portions of the Long Pines.

	Stand class							
	Seedling/sapling (%)		Poletimber (%)		Sawtimber (%)		Two-storied (%)[a]	
Habitat type Habitat disturbance	Home range mean(SD)	Random range mean(SD)	Home range mean(SD)	Random range mean(SD)	Home range mean(SD)	Random range mean(SD)	Home range mean(SD)	Random range mean(SD)
Xeric ponderosa pine								
Light burn	0.1(0.3)	0.3(0.5)	0 (0)	0.02(0.1)	0.8(1.0)	1.1(1.4)	0.3(0.6)	0.4(1.1)
Severe burn	10.0(9.0)	7.8(8.4)	0 (0)	0.2 (0.6)	11.3(10.7)	11.9(9.9)	2.8(3.7)	6.2(6.3)
Unburned	1.7(2.6)	0.8(1.6)	0 (0)	0.03(0.1)	9.6(6.6)	8.8(12.8)	1.2(3.1)	1.9(2.6)
Mesic ponderosa pine								
Light burn	0.2(0.6)	0.1(0.2)	0 (0)	0.04(0.1)	0.9(1.8)	2.2(6.7)	0.1(0.1)	0.9(0.2)
Severe burn	5.9(5.9)	7.5(8.0)	0.2(0.6)	0.4 (1.1)	7.8(7.3)	8.5(8.2)	1.9(2.7)	3.2(3.8)
Unburned	1.5(1.6)	1.1(2.0)	0.2(0.4)	0.4 (1.0)	9.2(8.6)	8.8(12.8)	1.2(3.1)	1.9(2.6)

[a] Pine stands with distinct layers of understory and overstory trees.

Table 46. Comparison of lightly burned, severely burned, and unburned portions of different stand classes within turkey home (n = 14) and random (n = 28) ranges in the Long Pines, Summers 1990-1991. Data are percentage of each stand class within actual home ranges and similar-sized, randomly-located areas in lightly burned, severely burned, and unburned portions of the Long Pines. Data for pine habitat types (Appendix F, Table 41) were pooled within stand classes. Grasslands and hardwood draws are described in Appendix F, Table 41.

	Lightly burned		Severely burned		Unburned	
Stand class	Home range mean (SD)	Random range mean (SD)	Home range mean (SD)	Random range mean (SD)	Home range mean (SD)	Random range mean (SD)
Seedling/sapling (%)	0.3 (0.6)	0.2 (0.5)	15.9 (14.2)	15.3 (12.7)	3.2 (3.4)	1.9 (2.7)
Pole timber (%)	0 (0)	0 (0.1)	0.2 (0.6)	0.7 (1.5)	0.2 (0.4)	0.4 (1.0)
Sawtimber (%)	1.7 (2.6)	3.3 (7.5)	19.1 (15.6)	20.4 (14.3)	18.8 (13.4)	14.5 (16.5)
Two-storied (%)[a]	0.3 (0.6)	1.3 (2.8)	4.6 (5.0)	9.4 (8.1)	1.7 (3.2)	3.0 (3.1)
Grassland (%)	8.3 (10.0)	11.4 (9.5)	3.1 (4.0)	4.8 (7.3)	20.7 (26.1)	13.6 (25.9)
Hardwood draws (%)	0.2 (0.6)	0.4 (0.8)	0.4 (1.0)	0.8 (1.6)	1.1 (0.6)	2.2 (1.7)

[a] Pine stands with distinct layers of understory and overstory trees.

Table 47. Comparison of different stand classes in logged and unlogged ponderosa pine habitat types (see descriptions in Appendix F, Table 41) within turkey home (n = 6) and random (n = 12) ranges in the Ekalaka Hills, Summers 1990-1991. Data are percentage of each stand class within actual home ranges and similar-sized, randomly-located areas in logged and unlogged portions of the Ekalaka Hills.

	Stand class							
	Seedling/sapling (%)		Poletimber (%)		Sawtimber (%)		Two-storied (%)[a]	
Habitat type Habitat disturbance	Home range mean (SD)	Random range mean (SD)	Home range mean (SD)	Random range mean (SD)	Home range mean (SD)	Random range mean (SD)	Home range mean (SD)	Random range mean (SD)
Xeric ponderosa pine								
Logged	0.1 (0.3)	0.1 (0.4)	0 (0)	0.1 (0.4)	0 (0)	1.0 (1.8)	0 (0)	0.7 (2.1)
Unlogged	0.1 (0.2)	1.4 (3.0)	3.2 (3.7)	4.0 (5.8)	24.0 (15.3)	22.1 (15.9)	11.3 (8.9)	2.2 (5.4)
Mesic ponderosa pine								
Logged	1.3 (2.5)	0.03 (0.1)	1.5 (2.7)	0.4 (0.7)	0.03 (0.1)	0.03 (0.1)	0 (0)	0.1 (0.4)
Unlogged	0.8 (1.0)	3.9 (6.4)	2.0 (1.3)	4.8 (6.5)	20.3 (11.5)	25.1 (19.0)	17.9 (17.6)	1.5 (4.5)

[a] Pine stands with distinct layers of understory and overstory trees.

Table 48. Comparison of logged and unlogged portions of different stand classes within turkey home (n = 6) and random (n = 12) ranges in the Ekalaka Hills, Summers 1990-1991. Data are percentage of each stand class within actual home ranges and similar-sized, randomly-located areas in the Ekalaka Hills. Data for pine habitat types (Appendix F, Table 41) were pooled within stand classes. Grasslands and hardwood draws are defined in Appendix F, Table 41.

	Habitat disturbance							
	Logged				Unlogged			
Stand class	Home range mean	(SD)	Random range mean	(SD)	Home range mean	(SD)	Random range mean	(SD)
Seedling/sapling (%)	1.4	(2.7)	0.1	(0.5)	0.9	(1.2)	5.3	(9.2)
Poletimber (%)	1.5	(2.7)	0.5	(0.9)	5.2	(4.2)	8.8	(10.2)
Sawtimber (%)	0.03	(0.1)	1.0	(1.8)	44.2	(24.5)	47.2	(23.3)
Two-storied (%)[a]	0	(0)	0.9	(2.2)	29.2	(25.7)	3.7	(6.5)
Grassland (%)	0	(0)	0.1	(0.2)	27.6	(30.6)	24.9	(17.0)
Hardwood draw (%)	0.8	(0.9)	1.2	(2.2)	4.3	(4.9)	5.6	(7.8)

[a] Pine stands with distinct layers of understory and overstory trees.

Summer Microhabitat Use

Burned roost stands did not differ from unburned stands in the Long Pines so data were pooled. Roost stands throughout the study area had steeper (P = 0.02) slopes and different (P < 0.05) aspects than random sites (Table 49). Logistic regression models based on roost comparisons are listed in Appendix G, Table 50.

Data for roost trees in burned stands were analyzed separately from data for unburned stands because burned

Table 49. Comparison of various characteristics at turkey roost and randomly-selected sites in the Long Pines and Ekalaka Hills, Summers 1990-1991.

	Long Pines				Ekalaka Hills			
Character-	Roost site		Random site		Roost site		Random site	
istic	n	Mean (SD)	n	Mean (SD)	n	Mean (SD)	n	Mean (SD)
Dist. to water (m)	13	684 (324)	13	593 (321)	5	682 (325)	5	562 (279)
Dist. to meadow (m)	13	56 (56)	13	45 (36)	5	44 (29)	5	70 (84)
Slope (%)	13	25 (10)	13	15 (10)	5	30 (10)	5	10 (5)
Aspect in degrees	13	69 (68)[a]	13	308 (58)[a]	5	186 (30)[a]	5	18 (57)[a]
Number of trees	13	9 (6)	13	13 (7)	5	9 (7)	5	27 (19)

[a] Angular mean (angular deviation).

roost trees were larger in diameter. Turkeys selected burned roost trees that were taller and larger in diameter than either non-roost trees and trees in random sites (Table 51; Fig. 19). Similarly, they chose unburned roost trees that were taller with larger diameters than non-roost trees and trees in random sites.

Turkey selected roost trees in the Ekalaka Hills that were taller with larger diameters than non-roost trees within roost sites. They also chose larger diameter trees than those in random sites (Table 52). Logistic regression models incorporating roost tree variables are listed in Appendix G, Table 50.

Table 51. Comparison of characteristics associated with turkey roost trees, non-roost trees, and trees at randomly-selected sites in the Long Pines, Summers 1990-1991.

	Roost sites						Random sites	
	Burned roost trees		Unburned roost trees		Non-roost trees		Trees ≥ 12.6 cm dbh	
Characteristic	n	Mean (SD)	n	Mean (SD)	n	Mean (SD)	n	Mean (SD)
Number of trees	10[a]	2 (1)	3[a]	2 (1)	13[a]	7 (6)	13[a]	13 (7)
Tree height (m)	22	18 (4)	6	19 (2)	30	16 (3)	167	14 (5)
Dbh (cm)	22	41.5 (8.2)	6	30.0 (8.0)	30	24.5 (9.7)	167	21.3 (7.8)
Height to first branch (m)	22	3.9 (1.8)	6	2.7 (1.2)	30	2.4 (1.4)	167	4.8 (4.2)

[a] Number of sites (other n-values represent number of trees).

Fig. 19. Ponderosa pine in a severely burned area used by roosting turkeys in the Long Pines Division, Summer 1991.

Table 52. Comparison of characteristics associated with turkey roost trees, non-roost trees, and trees at randomly-selected sites in the Ekalaka Hills, Summers 1990-1991.

	Roost sites						Random sites		
	Roost trees			Non-roost trees			Trees ≥12.6 cm dbh		
Characteristic	n	Mean	(SD)	n	Mean	(SD)	n	Mean	(SD)
Number of trees	5[a]	2	(2)	5[a]	7	(7)	5[a]	27	(19)
Tree height (m)	11	17	(3)	34	13	(5)	135	15	(4)
Dbh (cm)[b]	11	38.9	(8.0)	34	28.4	(8.3)	135	21.8	(8.1)
Height to first branch (m)	11	2.2	(1.0)	34	1.7	(0.5)	135	3.0	(1.6)

[a] Number of sites (other n-values represent number of trees).
[b] Diameter breast height.

Percent area of cover types along feeding routes of turkeys did not differ between burned and unburned areas so data were pooled. Foraging turkeys did not select for specific vegetation cover types in the Long Pines (Table 53; Fig. 20). Further, they did not feed in taller vegetation (mean height = 2.6 ± 0.8[*SD*] dm) than what was available (mean height = 2.7 ± 1.4[*SD*] dm) in the Long Pines. Small sample size precluded analysis of feeding routes in the Ekalaka Hills.

Neither data for dry mass nor diversity of insects statistically differed across site disturbance in the Long Pines so each set was pooled. Neither of these quantities differed between feeding routes and random transects (Table

Table 53. Relative percentage of each cover category of vegetation measured along turkey feeding routes and randomly-selected transects in the Long Pines and Ekalaka Hills, Summers 1990-1991.

	Long Pines				Ekalaka Hills			
	Feeding route		Random transect		Feeding route		Random transect	
Cover category	n	Mean (SD)	n	Mean (SD)	n	Mean (SD)	n	Mean (SD)
Trees (%)	13	2 (9)	13	0 (1)	2	0 (0)	2	0 (0)
Shrubs (%)	13	24 (15)	13	17 (12)	2	11 (1)	2	10 (17)
Grasses/ sedges (%)	13	39 (21)	13	45 (19)	2	51 (14)	2	47 (6)
Forbs (%)	13	19 (7)	13	18 (10)	2	23 (1)	2	26 (14)
Litter-rock-bare grnd. (%)	13	14 (16)	13	19 (16)	2	16 (9)	2	17 (10)

54). Numbers of each insect order collected along feeding routes and random transects in both study divisions are listed in Appendix G, Tables 55, 56 and 57.

Winter Vs. Summer Roosts

Roosts used by turkeys during winter were closer to permanent water and meadows ($P = 0.05$), and occurred on flatter ($P = 0.02$) terrain than those used during summer in the Long Pines (Table 58). Characteristics measured at roosts in the Ekalaka Hills did not differ between winter and summer.

Fig. 20. Merriam's turkeys feeding at the edge of a ponderosa pine-meadow parkland in the Long Pines Division, Summer 1990.

Table 54. Comparison of dry mass (g) and diversity of insects sampled along turkey feeding routes and randomly-selected transects in the Long Pines and Ekalaka Hills, Summers 1990-1991.

	Long Pines												Ekalaka Hills					
	Feeding route									Random transect			Feeding route			Random transect		
	Burned site			Unburned site			Pooled sites											
Variable	n	Mean	(SD)	n	Mean	(SD)	n	Mean	(SD)	n	Mean	(SD)	n	Mean	(SD)	n	Mean	(SD)
Dry mass (g)	10	0.54	(0.77)	3	0.88	(0.99)	13	0.62	(0.80)	13	0.52	(0.71)	2	0.39	(0.03)	2	0.24	(0.04)
Shannon-Weaver index [a]	10	1.62	(0.23)	3	1.58	(0.26)	13	1.61	(0.23)	13	1.47	(0.52)	2	1.26	(0.63)	2	1.47	(0.11)

[a] Shannon-Weaver diversity index (Shannon and Weaver 1949).

Table 58. Comparison of site characteristics measured at winter and summer roosts used by turkeys in the Long Pines and Ekalaka Hills, 1990-1991.

	Long Pines				Ekalaka Hills			
	Winter roosts		Summer roosts		Winter roosts		Summer roosts	
Characteristic	n	Mean (SD)	n	Mean (SD)	n	Mean (SD)	n	Mean (SD)
Dist. to water (m)	6	139 (107)	13	684 (324)	4	332 (242)	5	682 (326)
Dist. to meadow (m)	6	21 (15)	13	57 (56)	4	48 (32)	5	44 (29)
Slope (%)	6	10 (15)	13	25 (10)	4	25 (5)	5	30 (10)
Aspect in degrees	3	54 (61)[a]	13	69 (68)[a]	4	55 (46)[a]	5	186 (30)[a]
Number of trees	6	13 (7)	13	9 (6)	4	17 (5)	5	9 (6)

[a] Angular mean (angular deviation).

Coniferous trees used by roosting turkeys in the Long Pines during winter were greater (P = 0.04) in number and smaller in diameter than burned roost trees, and had lower branches than both burned and unburned roost trees used in summer (Table 59). Deciduous roost trees used during winter had lower first branches than burned roost trees, and were shorter than both burned and unburned trees used in summer.

In the Ekalaka Hills, wintering turkeys roosted in trees that were greater (P = 0.05) in number, smaller (P = 0.03) in diameter, and had higher (P = 0.04) first branches than those used during summer (Table 60). Associated logistic

Table 59. Comparison of characteristics associated with winter and summer roost trees used by turkeys in the Long Pines, 1990-1991.

	Winter roosts						Summer roosts					
	Coniferous roost trees			Deciduous roost trees			Burned roost trees			Unburned roost trees		
Characteristic	n	Mean	(SD)	n	Mean	(SD)	n	Mean	(SD)	n	Mean	(SD)
Number of trees	2[a]	13	(3)	4[a]	5	(6)	10[a]	2	(1)	3[a]	2	(1)
Tree height (m)	26	16	(5)	21	12	(4)	22	18	(4)	6	19	(2)
Dbh (cm)	26	29.7	(13.1)	21	42.0	(23.5)	22	41.5	(8.2)	6	30.0	(8.0)
Height to first ranch (m)	26	1.7	(0.5)	21	2.4	(0.8)	22	3.9	(1.8)	6	2.7	(1.2)

[a] Number of sites (other n-values represent number of trees).

Table 60. Comparison of characteristics associated with winter, spring/fall, and summer roost trees used by turkeys in the Ekalaka Hills, 1990-1991.

	Winter roost trees			Spring/fall roost trees			Summer roost trees		
Characteristic	n	Mean	(SD)	n	Mean	(SD)	n	Mean	(SD)
Number of trees	4[a]	10	(6)	3[a]	3	(3)	5[a]	2	(2)
Tree height (m)	40	18	(2)	10	20	(3)	11	17	(3)
Dbh (cm)	40	32.5	(8.4)	10	41.0	(13.4)	11	38.9	(7.0)
Height to first branch (m)	40	3.4	(1.8)	10	4.0	(0.8)	11	2.2	(1.0)

[a] Number of sites (other n-values represent number of trees).

regression models for both divisions are listed in Appendix G, Table 50.

<u>Spring/fall Vs. Summer Roosts</u>

There were no differences between characteristics measured at roosts used in spring/fall and summer in either division (Table 61). Further, burned roost trees used during spring/fall did not differ from those used during summer in the Long Pines. However, unburned roost trees were shorter and generally smaller (P = 0.06) in diameter than those used during summer (Table 62). Roost trees used during spring/fall were taller (P = 0.05) and had higher first branches than those used during summer in the Ekalaka Hills (Table 60).

Table 61. Comparison of site characteristics measured at spring/fall and summer roosts used by turkeys in the Long Pines and Ekalaka Hills, 1990-1991.

	Long Pines				Ekalaka Hills			
	Spring/fall roost		Summer roost		Spring/fall roost		Summer roost	
Characteristic	n	Mean (SD)	n	Mean (SD)	n	Mean (SD)	n	Mean (SD)
Dist. to water (m)	6	732 (216)	13	684 (324)	3	563 (536)	5	682 (326)
Dist. to meadow (m)	6	65 (77)	13	57 (56)	3	63 (12)	5	44 (29)
Slope (%)	6	25 (10)	13	25 (10)	3	35 (5)	5	30 (10)
Aspect in degrees	5	72 (57)[a]	13	69 (68)[a]	3	70 (63)[a]	5	186 (30)[a]
Number of trees	6	13 (6)	13	9 (6)	3	13 (8)	5	9 (7)

[a] Angular mean (angular deviation).

Discussion

Merriam's turkeys in Arizona (Crites 1988) traveled considerably farther between winter and summer ranges (mean = 25.8 km) than male and female turkeys in my study (mean = 7.0 and 2.6 km, respectively) and those in westcentral Montana (mean = 2.3 and 2.5 km, respectively; Holzer 1989). This discrepancy may be a reflection of patchy nesting habitat in the more xeric environment of Arizona.

Longer distances traveled by males between winter-summer ranges than females was probably related to courtship behavior. A breeding male will stay with a courtship flock

Table 62. Comparison of characteristics associated with spring/fall and summer roost trees used by turkeys in burned and unburned portions of the Long Pines, 1990-1991.

	Spring/fall				Summer			
	Burned roost trees		Unburned roost trees		Burned roost trees		Unburned roost trees	
Characteristic	n	Mean (SD)	n	Mean (SD)	n	Mean (SD)	n	Mean (SD)
Number of trees	3[a]	2 (1)	3[a]	5 (2)	10[a]	2 (1)	3[a]	2 (1)
Tree height (m)	5	17 (5)	16	15 (2)	22	18 (4)	6	19 (2)
Dbh (cm)[b]	5	39.7 (8.5)	16	23.5 (8.7)	22	41.5 (8.2)	6	30.0 (8.0)
Height to first branch (m)	5	2.6 (1.5)	16	2.4 (1.0)	22	3.9 (1.8)	6	2.7 (1.2)

[a] Number of sites (other n-values represent number of trees).
[b] Diameter breast height.

until resident females begin incubating eggs. Then, the male often will move to form another courtship flock. Non-breeding males usually wander in small flocks before settling in an area.

Summer home ranges of non-brood flocks (mean = 300 ha [1-4 turkeys] and 626 ha [>4 turkeys]) in this study were larger than those (mean = 77 ha) reported for Washington (Mackey 1982). They also were larger than home ranges of brood (poults >15 days old) flocks in burned (mean = 139.5 ha) and unburned (mean = 123.8 ha) areas in the Long Pines and Ekalaka Hills (Gobeille 1992). However, summer home ranges in westcentral Montana (Holzer 1989) were larger (mean = 943 ha) and those in Oregon (Lutz and Crawford 1989) were considerably larger (mean size = 1509 ha) than in southeastern Montana. Other studies did not differentiate home ranges between small and large turkey flocks.

Differences in sizes of summer home ranges may be related to flock size, flock composition, and/or habitat quality (Wigley et al. 1986). A large flock (>4 birds) of subadults and adults may travel farther than a smaller one (1-4 birds) to obtain adequate food resources in habitats of similar quality. Brood flocks (small home ranges) in southeastern Montana often were located on or adjacent to ranches (lowlands) and associated with hardwood draws (Gobeille 1992). In contrast, non-brood flocks (large home

ranges) often were located in upland areas and not associated with hardwood draws.

Gobeille (1992) noted the importance of hardwood draws compared to grassland and pine cover types to brood flocks, particularly in supplying food (for example, insects) to young poults. Upland areas in the study area appeared to offer lower quality habitat than lowlands. Consequently, non-brood flocks would be expected to travel farther to obtain adequate food than brood flocks. Also, poults likely are not physically able to move as far or as fast as subadult and adult birds.

Turkeys would be benefited in the long-term if non-brood flocks were spatially segregated from brood flocks during summer to limit competition for food resources. Lessening competition between brood and non-brood flocks for food resources would likely enhance survival of poults. It also would lessen competition between males and poults that they sired or between females and poults of related females.

Small sample sizes may have precluded detecting significant correlations between size of summer home ranges and percent of lightly and severely burned areas. However, size of home ranges tended to increase with increasing percent area of lightly burned regions within home ranges. Lightly burned areas may have had temporarily (2 years

post-fire) lower quality habitat compared to unburned areas because of reduction in understory vegetation.

The lack of an apparent relationship between sizes of home ranges and percent area of severely burned areas was probably due to the extensiveness of severely burned areas. All but 1 summer home range contained extensive burned areas.

Effect of logging on sizes of summer home ranges in the Ekalaka Hills was similar to that of lightly burned areas in the Long Pines. That is, sizes of home ranges increased with increasing proportion of logged areas. Again, larger home ranges may have been related to temporary reductions in understory cover and possible decreases in food resources.

Low use of pine stands with distinct understory and overstory trees (2-storied stands) by turkeys in severely burned portions of the Long Pines may have been related to stem densities and food availability. Because of multiple layers, 2-storied stands probably would have burned hotter than other stand classes; hence, any seeds of plants in the soil would have been destroyed. Thus, revegetation of the understory likely would be slower than for other stand classes making this class less attractive to turkeys.

Amount of burned timber that was salvaged in an area probably did not significantly affect sizes of home ranges of turkeys because of timing and vegetation structure.

Salvaging operations in the Long Pines had essentially ended before I began monitoring turkeys; hence, turkeys were not disturbed by active logging operations. Further, salvaging operations occurred in severely burned stands and removing timber likely did not affect understory structure nearly as much as removing timber from unburned stands.

Larger than expected use of seedling/sapling-sized pines in logged, mesic regions by turkeys may have been related to cover. Land that had been cleared of timber in mesic areas would probably have more understory vegetation than in densely timbered areas. Also, much of the logging was done ≥3 years before I began following turkeys so that there was little possibility of disturbance by logging operations. However, logging operations displaced a flock of turkeys in the Ekalaka Hills during Summer 1991.

Turkeys in both divisions roosted in timbered stands on moderately steep to steep (30%-35%) slopes. Most studies (Jonas 1966, Mackey 1982, Mollohan and Patton 1991, Rumble 1992) of summer roosting habitat used by Merriam's turkeys concur that roosts tend to be located on at least moderately steep (25%-35%) slopes. In contrast, Lutz and Crawford (1987) reported slopes of 12% for roosting broods in Oregon, and Gobeille (1992) reported slopes of 19% for brood flocks in the Long Pines and Ekalaka Hills. Because brood flocks usually were located in lowland areas in these latter areas,

available roost trees would have been on gentler slopes than those in more rugged upland areas.

Turkeys roosted on easterly-northeasterly aspects, which agrees with other studies (Jonas 1966, Boeker and Scott 1969, Gobeille 1992). Boeker and Scott (1969) theorized that easterly aspects reduced exposure of roosting turkeys to prevailing winds and weather patterns.

Aspects of stands used by non-brood flocks probably were only important during summer because of familiarity of turkeys with a given area. Turkeys during summer would spend weeks or months in an area. This familiarity apparently enabled them to select the best available roost trees on easterly aspects. Conversely, movements during spring and fall likely precluded turkeys from acquiring sufficient knowledge of an area to select the best available roosting habitat. Instead, they probably used the best available trees adjacent to where they were feeding at the end of a day. Turkeys roosting on ranches during winter had a limited number of trees to choose from and probably selected the best available regardless of aspect.

As reported in numerous other studies (Hoffman 1968, Lutz and Crawford 1987), Mollohan and Patton 1991), turkeys in this study used the larger diameter and taller trees available (but see Rumble 1992). Use of these trees in burned compared to unburned stands likely was due to their

open branch structure that increases accessibility. Not all large trees may be usable or preferred by turkeys for roosting because of dense canopy and close branches (Hoffman 1968, Rumble 1992). If these same trees were severely burned (loss of needles and some branches), they could become more attractive to roosting turkeys. Therefore, guidelines for minimum height and dbh of roost trees should be higher in burned areas than unburned areas.

Gobeille (1992) reported larger dbh-values for trees used by roosting brood flocks in the Long Pines and the Ekalaka Hills than those reported for non-brood flocks in my study. Hengel (1990) also reported that brood flocks roosted in larger trees than non-brood flocks in Wyoming. Conversely, Schemnitz et al. (1985) did not detect any differences in sizes of roost trees used by brood and non-brood flocks of Merriam's turkeys in New Mexico.

In southeastern Montana and northeastern Wyoming, brood flocks of turkeys probably roosted in larger diameter trees because those trees provided more accessible branches for poorly flying poults than smaller trees. Managers should leave larger diameter trees for use by roosting brood flocks than would be left for non-brood flocks.

Other than thinning densely timbered stands, logging probably reduces habitat quality for roosting turkeys in southeastern Montana. No monitored turkeys roosted in

logged areas during this study. Scott and Boeker (1977) reported that lightly cut stands of timber had little effect on use by roosting Merriam's turkeys, whereas heavily cut stands were abandoned. Rumble (1992) noted that, of the roosts that occurred in logged areas, more occurred in selectively cut stands than in stands that had been largely thinned.

Although some studies (Boeker and Scott 1969, Mackey 1984, Rumble 1992) have reported little or no differences in roost trees used by Merriam's turkeys among seasons, others have noted differences (Hoffman 1968, Schemnitz et al. 1985, Lutz and Crawford 1987, Hengel 1990, Mollohan and Patton 1991). In this study, there were definite differences in roosting habitat among seasons. For instance, differences in slope, distance to meadow, distance to permanent water, and numbers of roost trees in winter compared to summer were due to location of winter roosts near feedlots.

Turkeys wintering near feedlots had a limited number of trees to roost in and likely used the closest trees that met their minimum requirements for roosting. Furthermore, trees available near feedlots were usually in narrow shelterbelts or strips that occurred on gentler slopes and were closer to permanent water (stock tanks) than upland roosts in other seasons. Also, larger flocks during winter required more roost trees than other seasons.

Apparently because of habitat heterogeneity and temporal differences in insect abundance during summer, more sample sites may have been required to detect possible differences in dry masses and diversity of insects between burned and unburned areas. Lower numbers, diversity and biomass of insects generally could be expected in homogeneous burned areas (first 2 years post-fire) than in more heterogeneous unburned areas. However, these characteristics of insect communities may increase in burned areas over time (>3 years post-fire) with increasing vegetation diversity and structure.

CHAPTER 7

SURVIVAL ANALYSES

Knowledge of survival rates and sources of mortality is an integral part of managing wild turkey populations. Radio telemetry has enabled wildlife researchers to obtain more reliable estimates of survival rates of turkeys (Kurzejeski et al. 1987) than either life table analysis (Pearl and Parker 1921, Haldane 1955) or mark-resight methods (Seber 1982). Because of restrictive assumptions, the life table model has been described as biologically unrealistic and the life table method as an invalid procedure (Anderson et al. 1985). Mark-resight methods (Seber 1982) require an estimate of the population total and a representative sample from a population, including correct age and sex ratios.

More recently, Pollock et al. (1989a) suggested use of the Kaplan-Meier method (Kaplan and Meier 1958) for estimating survival rates of transmitter-equipped animals. Kurzejeski et al. (1987) had applied this method for estimating survival rates of eastern wild turkeys in Missouri. Because appropriate survival data were available,

the Kaplan-Meier method was used to estimate survival rates and investigate effects of different factors on survival of Merriam's turkeys in southeastern Montana.

Methods

One hundred eleven wild turkeys were trapped and equipped with radio transmitters in December-March during 1989-1991. J. Gobeille (Montana State Univ., pers. commun.) collected survival data on turkeys that died during 1989. I continued collecting survival data through Spring 1992. Fates of all transmitter-equipped turkeys are listed in Appendix G, Table 63.

Because transmitters did not have mortality sensors, I monitored turkeys sufficiently to detect time of mortality to the nearest week. Survival was measured from August 1 of the year of capture to the week of death or radio signal loss. August 1 was used as the time of origin within each year (1989-1991) because all turkeys trapped during December-March were alive on the previous August 1. Thus, a "lifetime" or survival time of a turkey was the length of time from August 1 before its initial capture until its death, its radio signal was no longer received, or the study ended.

Mortality categories were predation, legal harvest, illegal kill, and unknown. Predation was pooled because I was unable to monitor turkeys closely enough to discern either class (avian or mammalian) or species of predator involved in most turkey deaths. Because there were no overt indications of disease during the study, I assumed that all natural mortality was due to predation. Potential mammalian predators of subadult and adult turkeys included mountain lion, bobcat, coyote, and red fox. Potential avian predators included bald eagle, golden eagle, and great-horned owl.

Qualitative Analyses

I qualitatively analyzed mortality data for turkeys of known fate to assess general trends in mortality associated with age, sex, and month of death. Annual survival rates were descriptively represented as numbers of turkeys with transmitters alive at the end of a year divided by those alive at the year's beginning. These estimates did not include right-censored (unknown fate) data; hence, they were biased and could not be quantitatively analyzed.

Quantitative Analyses

Kaplan-Meier estimates of yearly survival rates were calculated for the period covering August 1988-May 1992. Yearly estimates were calculated because of differences in survival among years. Both uncensored (known lifetime) and right-censored (unknown lifetime but known origin) data were used. Right-censored observations included turkeys that were either alive throughout the study, left the study area, had malfunctioning transmitters, or did not have their transmitters returned by hunters.

Using the notation of Kalbfleisch and Prentice (1980), the Kaplan-Meier estimate of the survivor function F(t) is:

$$\hat{F}(t) = \prod_{i/t_i < t} \left(\frac{n_i - d_i}{n_i}\right)$$

This represents the estimated probability that a given turkey will survive t units of time from the origin (t=0). I defined n_1, n_2,..., n_i as the number of turkeys at risk prior to time i and d_1, d_2,..., d_i as the number of turkeys that died during interval i (Pollock et al. 1989a). [See Pollock et al. (1989b) for specific examples for calculating the estimated survivor function]. The model assumptions were: a random sample of turkeys was trapped from the population; censoring times were random; all times of death

were known; all turkeys with functional transmitters were located; survival times of turkeys were independent (Pollock et al. 1989a); and any effects of transmitters were the same for all individuals.

Variables (and their subcategories) investigated for their possible influences on survival times of turkeys included: age at time of origin (subadult and adult); sex (male and female); month of mortality (January-December); mortality type (predation, legal harvest, illegal kill, and unknown); and habitat disturbance at mortality site (Long Pines: burned and unburned; Ekalaka Hills: all unlogged). The log rank test (Kalbfleisch and Prentice 1980) in the LIFETEST procedure (SAS Institute, Inc. 1985) was used to test (alpha = 0.05) for equality of distributions of Kaplan-Meier survival functions for subcategories within each variable listed above. The log rank test was used because the distributions generated for subcategories of each variable (stratum) were relatively close at shorter survival times and relatively far apart at longer survival times (SAS Institute, Inc. 1985).

After comparing survival distributions of subcategories for each stratum variable, data were pooled within each stratum. A forward stepwise sequence of chi-squares for the log rank test was used to test (alpha = 0.05) for significant effects of covariates (variables not defined as

the stratum variable on a given model run) on estimated survival times of turkeys. Thus, these models included a pooled stratum variable and its associated covariates. Some models did include all covariates because data were not available for some subcategories.

I was unable to distinguish directional (positive or negative) effects for subcategories of significant covariates under a given model because the subcategory parameters varied with time and thus could not be separated (Kalbfleisch and Prentice 1980). For example, if age was the stratum variable and sex was a significant covariate under the model, I was unable to discover which sex had a positive or negative association with survival time.

Results

Qualitative Analyses

In the Long Pines, 11 of 22 transmittered turkeys of known fate survived during 1989, 7 of 21 during 1990, and 17 of 31 during 1991 (Table 64). In the Ekalaka Hills, 7 of 16 survived during 1989, 11 of 22 during 1990, and 4 of 16 during 1991 (Table 65). Data from 1990 and 1991 included birds captured from previous years. In addition, 2 adult male turkeys were harvested by hunters during Spring 1992

Table 64. Known fates and associated numbers of males, females, and pooled sexes of turkeys with transmitters in the Long Pines, 1989-1991.

	Males			Females			Pooled sexes		
	1989	1990	1991	1989	1990	1991	1989	1990	1991
Fate	n	n	n	n	n	n	n	n	n
Hunter-killed[a]	2	1	4	1	0	0	3	1	4
Predator[b]	1	1	4	7	12	6	8	13	10
Alive	1	2	9	10	5	8	11	7	17
Unknown[c]	1	0	1	5	3	3	6	3	4

[a] Does not include 2 adult males harvested during Spring 1992.
[b] Does not include an adult female killed during Winter 1992.
[c] Lost contact with radio signal.

Table 65. Known fates and associated numbers of males, females, and pooled sexes of turkeys with transmitters in the Ekalaka Hills, 1989-1991.

	Males			Females			Pooled sexes		
	1989	1990	1991	1989	1990	1991	1989	1990	1991
Fate	n	n	n	n	n	n	n	n	n
Hunter-killed	0	2	1	2	0	1	2	2	2
Predator	0	1	1	7	8	7	7	9	8
Illegally killed[a]	0	0	0	0	0	2	0	0	2
Alive	1	2	1	6	9	3	7	11	4
Unknown[b]	0	2	1	0	1	0	0	3	1

[a] Killed during January, 1991 (non-hunting mortality).
[b] Lost contact with radio signal.

and 1 adult female turkey was killed by a predator during Winter 1992 in the Long Pines.

Sixteen (21.6%) of the 74 known mortalities were harvested by hunters in both divisions during 1989-1992. Nine of 10 mortalities in the Long Pines were males (Table 64) and 7 of 10 were adults (Table 65). Three of 6 killed in the Ekalaka Hills were males (Table 65) and all were adults (Table 66).

Fifty-six (75.7%) of the 74 known mortalities were apparently predator kills (Fig. 21). Thirty-two of 42 killed in the Long Pines (Table 64) and 24 of 32 dying in the Ekalaka Hills were from predation (Table 65). Sixteen of 39 subadults and 15 of 35 adults were killed in the Long Pines (Table 66). Eleven of 30 subadults and 13 of 24 adults were killed in the Ekalaka Hills (Table 66).

Thirty-six (48.6%) of 74 turkeys died during April-June (spring courtship and nesting period) (Figs. 22 and 23). Eighteen (24.3%) died during May. Ten of those that died during April-June were males and 26 were females; 6 males were harvested legally and all other turkeys were apparently killed by predators.

Fourteen (18.9%) of 74 turkeys were killed in the study area during September-November, the late fall movement and hunting period; 9 were males. Six of the 9 males and 3 of

Table 66. Known fates and associated numbers of subadult and adult turkeys with transmitters in the Long Pines and Ekalaka Hills, 1989-1991.

Division	Subadults			Adults		
	1989	1990	1991	1989	1990	1991
Fate	n	n	n	n	n	n
Long Pines						
Hunter-killed[a]	0	1	2	3	0	2
Predator[b]	6	5	5	2	8	5
Alive	6	4	10	5	3	7
Unknown[c]	5	2	2	1	1	2
Ekalaka Hills						
Hunter-killed	2	2	2	0	0	0
Predator	5	5	1	2	4	7
Illegally-killed[d]	0	0	2	0	0	0
Alive	5	5	1	2	6	3
Unknown[c]	0	1	0	0	2	1

[a] Does not include 2 adult males harvested during Spring 1992.
[b] Does not include an adult female killed during Winter 1992.
[c] Lost contact with radio signal.
[d] Killed during January 1991 (non-hunting mortality).

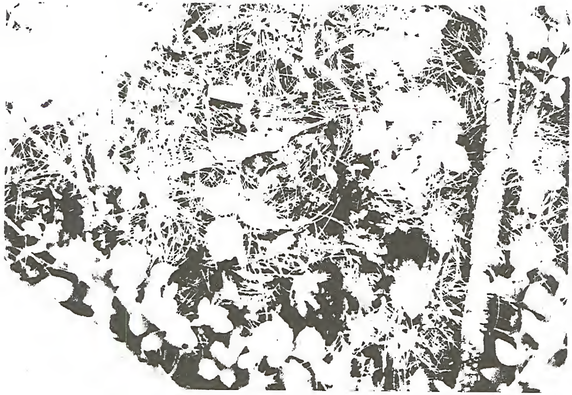

Fig. 21. Remains of a transmitter-equipped turkey killed by a predator in the Long Pines Division, June 1990.

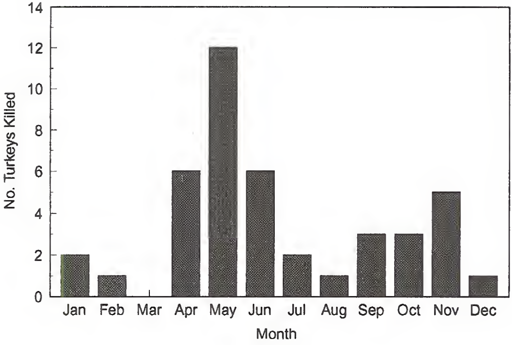

Fig. 22. Numbers of turkeys known to have died in the Long Pines Division by month, 1989-1992.

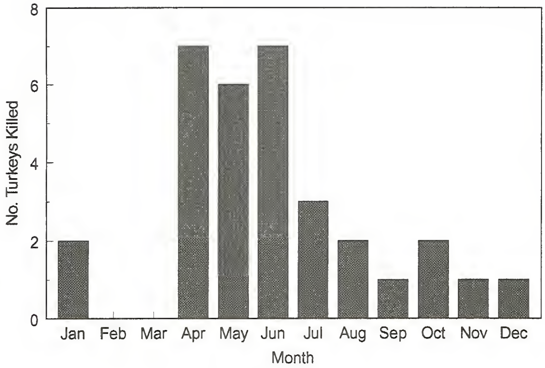

Fig. 23. Numbers of turkeys known to have died in the Ekalaka Hills Division by month, 1989-1991.

the 5 females were harvested by hunters; all other turkeys were considered predator kills.

Quantitative Analyses

Comparison Of Survival Distributions For Subcategories Within Strata. Turkeys ultimately killed by hunters had lived longer than those ultimately killed by predators in the Long Pines during 1991 (Table 67, Fig. 24). Turkeys that died in certain months had lived longer than others that died in other months in the Long Pines during 1989 (Fig. 25) and 1990 (Fig. 26) and in the Ekalaka Hills during 1989 (Fig. 27). There were no significant differences between survival distributions of turkeys that had ultimately died in burned areas and those that had died in unburned areas.

Comparison Of Survival Distributions Among Covariates For Pooled Strata. Type of mortality (fate) was important in the model that had age as the pooled stratum in the Long Pines during 1990 (Table 67). Age of turkeys was a significant component in models containing pooled mortality types and sexes in the Long Pines during 1990. Factors associated with months in which turkeys died were important components in models with pooled mortality types, site

Table 67. Modeling and log rank test results for comparing distributions of Kaplan-Meier survival estimates for turkeys in the Long Pines and Ekalaka Hills, 1989-1991. Results of comparisons within strata variables are listed under test for equality over strata. Final model probabilities for variables (covariates) that were modeled under pooled strata are listed in the last column.

Study division		Test for equality over strata[a]			Forward stepwise sequence for chi-squares[a]					
					Order entered in model				Increment	
Year	Strata	df	X^2	P	Covariate	df	X^2	P	X^2	P
Long Pines										
1989	Dmo[b]	10	27.91	<0.01	Sex	1	1.00	0.32	1.00	0.32
					Age	2	2.73	0.26	1.73	0.19
					Fate[c]	3	2.90	0.41	0.17	0.68
					Sdst[d]	4	3.08	0.55	0.18	0.68
1990	Fate	1	0.10	0.75	Sdst	1	0.42	0.52	0.42	0.52
					Age	2	7.01	0.03	6.59	0.01
					Dmo	3	7.18	0.07	0.17	0.68
	Dmo	6	14.82	0.02	Sdst	1	1.00	0.32	1.00	0.32
	Sex	1	1.22	0.27	Sdst	1	0.42	0.52	0.42	0.52
					Age	2	7.01	0.03	6.59	0.01
					Dmo	3	7.18	0.07	0.17	0.68
	Age	1	0.11	0.74	Sdst	1	0.42	0.52	0.42.	0.52
					Fate	2	7.01	0.03	6.59	0.01
					Dmo	3	7.18	0.07	0.17	0.68
1991	Fate	1	4.98	0.03	Dmo	1	4.25	0.04	4.25	0.04
					Sex	2	4.72	0.09	0.47	0.49
					Age	3	4.82	0.19	0.10	0.75
					Sdst	4	4.98	0.29	0.16	0.69
	Sdst	1	0.02	0.87	Dmo	1	5.74	0.02	5.74	0.02
					Age	2	6.30	0.04	0.55	0.46
					Fate	3	7.10	0.07	0.79	0.37
					Sex	4	7.18	0.07	0.09	0.77

Table 67. Continued:

	Sex	1	0.45	0.50	Dmo	1	7.46	<0.01	7.46	<0.01
					Age	2	7.56	0.02	0.10	0.75
					Sdst	3	7.67	0.05	0.11	0.74
					Fate	4	7.70	0.10	0.03	0.87
	Age	1	0.09	0.76	Dmo	1	6.76	<0.01	6.76	<0.01
					Sex	2	7.11	0.03	0.35	0.56
					Fate	3	7.37	0.06	0.27	0.61
					Sdst	4	7.39	0.12	0.02	0.89
Ekalaka Hills										
1989	Fate	1	0	0.99	Dmo	1	6.39	0.01	6.38	0.01
					Age	2	8.34	0.02	1.95	0.16
					Sex	3	8.39	0.04	0.05	0.82
	Dmo	6	26.4	<0.01	Age	1	0.04	0.84	0.04	0.84
1991	Age	1	1.48	0.22	Dmo	1	3.98	0.05	3.98	0.05
					Fate	2	4.18	0.12	0.21	0.65
					Sex	3	4.31	0.23	0.13	0.72

[a] Log rank test.
[b] Dmo = month of death.
[c] Fate = mortality type.
[d] Sdst = site disturbance (burned, unburned).

disturbances, sexes, and ages in the Long Pines during 1991. Month-related factors also were a significant part of a model containing pooled ages in the Ekalaka Hills during 1991 (Table 67).

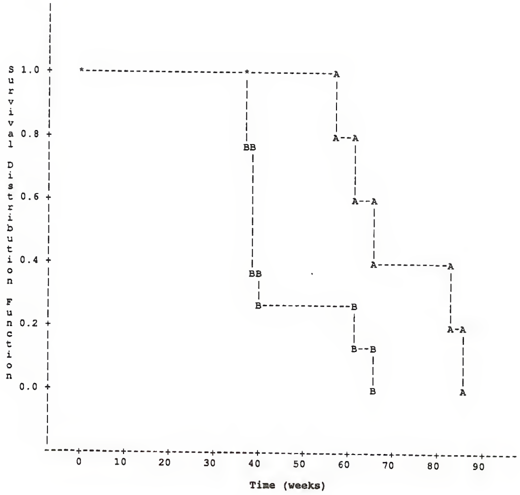

Fig. 24. Survival distribution plots for turkeys thought to have been killed by hunters (A) and predators (B) in the Long Pines Division, 1991.

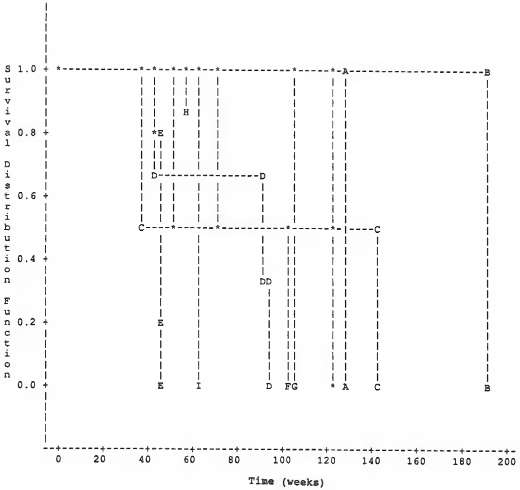

Fig. 25. Survival distribution plots for turkeys known to have died in January (A), February (B), April (C), May (D), June (E), July (F), August (G), and September (H) in the Long Pines Division, 1989.

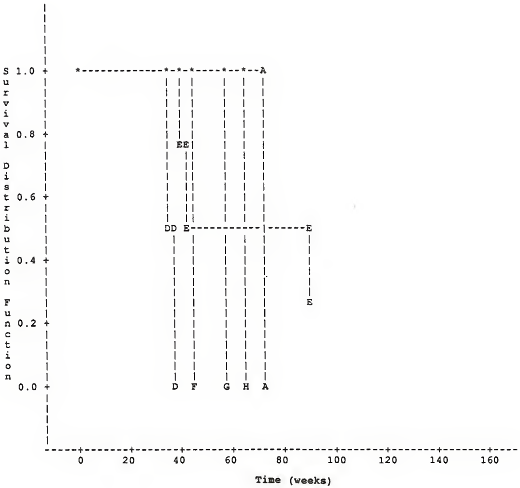

Fig. 26. Survival distribution plots for turkeys known to have died in January (A), February (B), March (C), April (D), May (E), June (F), August (G), and November (H) in the Long Pines Division, 1990.

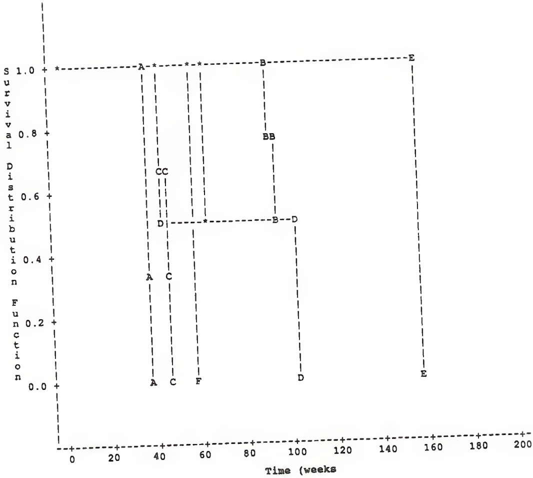

Fig. 27. Survival distribution plots for turkeys known to have died in April (A), May (B), June (C), July (D), August (E), September (F), and October (G) in the Ekalaka Hills Division, 1989.

Discussion

Qualitative Analyses

Comparatively lower survival of turkeys in the Long Pines during 1990 may have been related to the apparently reduced nesting and cover that resulted from low levels of spring precipitation. Understory vegetation in many burned areas was a variable cover of weedy, pioneer species during 1990. The Ekalaka Hills may not have been as affected because of their more diverse vegetation types and structure during 1990.

Males appeared to be more susceptible to hunting mortality than females in this study. Harvest rates for subadult and adult males appeared to be similar. Vangilder (1992) reported that adult males were more susceptible to harvest than subadult male eastern turkeys. Males may have been more susceptible to harvest in this study because of hunter preferences and the male-only spring hunting season.

Hunting apparently influenced survival of turkeys more than predation during fall hunting seasons and less during spring hunting seasons. Predation was likely a more important influence during spring because of nesting and courtship activities. Many of the turkeys killed during spring were hens, which were either nesting or in courtship flocks. Both activities may have increased their

susceptibility to predators. Speake (1980) and Everett et al. (1980) reported eastern turkey hens experienced greater mortality during nesting than other times of the year.

Quantitative Analyses

Turkeys ultimately harvested by hunters in 1991 probably had lived longer than those ultimately killed by predators because they only were hunted for 4 months, whereas predators hunted them for 12. This trend likely would have been more pronounced if data from all years could have been pooled.

Any differential survival of turkeys in burned versus unburned areas may be difficult to discern because of the mosaic of burned and unburned areas in the Long Pines. Turkeys likely were moving through both burned and unburned areas in many parts of the Long Pines.

Any relationship between age and survival rates of turkeys in my study remains unclear. Lack of a directional test for covariates under the Kaplan-Meier method precluded my discovering which age class contributed to longer survival times in the model containing a significant age component. Vander Haegan et al. (1988) reported higher survival rates for adult eastern turkey hens compared to subadult hens. If subadult hens are more susceptible to

mortality and have lower reproductive success (see Chapter 5) than adult hens, then adult hens should be used in transplants into similar areas (Lutz and Crawford 1987) in order to maximize establishment potential.

Although males qualitatively appeared to be more susceptible to hunting mortality than females, there was not a significant difference between their survival distributions in either study division. Perhaps the apparent increased loss of female turkeys during spring nesting and courtship counter-balance the apparent increased loss of males to hunting.

CHAPTER 8

MANAGEMENT AND RESEARCH IMPLICATIONS

Effects Of Fire

Habitat quality for turkeys will likely be selectively affected for at least several years following a major fire. Reductions in vegetational structure and composition could negatively impact nesting cover, escape cover, and food availability in severely burned areas. Availability of suitable roost trees will probably increase until severely burned trees begin breaking off and falling down in the third year after a fire. Adverse impacts on food, cover, and roosting habitat should be lower in lightly burned areas. Availability of water and grit in burned areas may not be affected.

Bare ground and/or a homogeneous understory of pioneer plants will be characteristic of severely burned forest stands during the first 2 years post-fire. Thereafter,

ground cover should improve with increasing diversity of forbs, shrubs, and grasses as mid and later successional species replace pioneering forb species. The increased edge created by the mosaic of burned and unburned areas could provide more diverse habitats for turkeys than unburned areas alone.

In dry areas like southeastern Montana, the rate of plant succession after a fire will depend on precipitation, especially during spring. Livestock grazing, when appropriately applied, may enhance the quality of habitat in burned areas by preventing understory vegetation from becoming too dense. However, grazing should not be allowed in severely burned areas until soils have been stabilized via plant growth.

Roosting Habitat

Turkeys readily roosted in ponderosa pines in burned portions of the Long Pines during the first 3 years post-fire. However, increasing numbers of trees in severely burned areas began to break off and fall during the third year. Unburned or lightly burned trees suitable for roosting may be available adjacent to severely burned regions because of the burn mosaic. Nonetheless, roost trees and potential roost trees may be lost over time in

severely burned areas; hence, these areas should be monitored for continued availability of trees suitable for roosting.

Adequate roost trees in burned areas would be at least 41.0 cm dbh and 18 m in height with widely-spaced branches (Fig. 19) and occurring on 25%, east or northeast-facing slopes. Roost trees in unburned areas should be at least 30 cm dbh and 19 m in height. At least 5 roost trees or potential roost trees (10 trees for winter roosts) should be within a 625 m^2 area at or near a forest edge or opening (>1 ha).

Nesting Habitat

Quality of nesting habitat for turkeys likely will be low in severely burned areas during the first 2-3 years following a major fire because of low understory cover and low shrub densities. Understory cover should return to adequate levels over time under average precipitation. Understory vegetation in lightly burned regions will probably recover sooner. Above average precipitation may increase understory cover, thereby increasing quality of nesting habitat. In general, nesting cover should be at least 6.5 dm high and located at the base of and around

trees (26 cm dbh and 15 m in height on average) situated on ≥20% slopes.

Seasonal Habitat

Most turkeys in the Long Pines wintered on ranches in unburned, peripheral lowlands. Quality of winter habitat in the uplands was likely very low immediately after the fire due to lack of grasses and shrubs to provide winter food. Also, pine nuts that characteristically occur in litter were probably eliminated in severely burned areas. Feedlots undoubtedly softened the adverse impacts of fire on turkeys that usually wintered in the uplands. Turkey mortality could be high during winter in severely burned areas where birds do not have access to alternative food sources.

Burned areas do not appear to deter either spring/fall movements or summer habitat use by turkeys. However, lower quality nesting cover could have influenced the greater movements by males and subadult hens compared to those in the Ekalaka Hills. In some cases, fire could increase quality of summer habitat by opening densely timbered stands, thereby increasing edge and structural diversity.

Effects Of Logging

Habitat quality of an area for turkeys may be improved or degraded by logging depending on timber harvest scheme. Quality might be improved if dense (doghair) stands of poletimber are removed or densely timbered stands are selectively logged to open stands and increase structural diversity. It could be decreased if large trees in either open or scattered stands were removed.

The effects of clearcutting on habitat quality of turkeys in southeastern Montana remain unclear because relatively few clearcuts occur in the study area. Nonetheless, existing clearcuts received little or no use indicating that these areas are, at the very least, not preferred by turkeys.

Roosting Habitat

Large trees on fairly steep slopes often were used by roosting turkeys. Extensive removal (for example, clearcut, liberation cut, seed tree seed cut, shelterwood removal cut, and shelterwood final cut) of these trees in known or potential roost areas would be detrimental to turkeys. Heavy thinning of trees was implicated as the probable reason for roost abandonment in New Mexico (Scott and Boeker

1977). A selective cutting regime (for example, moderate individual seed tree and shelterwood cuts without final removal) in known or potential roost areas likely would be less deleterious to turkeys provided that trees are preserved that meet the minimum criteria discussed earlier in this chapter. Both Schemnitz et al. (1985) in New Mexico and Phillips (1980) in Arizona suggested at least 18 m^2/ha residual basal area, including some sawlog trees, be left after logging operations.

Nesting Habitat

None of the logging schemes discussed earlier appeared to improve nesting habitat for turkeys in the Long Pines and Ekalaka Hills. Logging slash was used by only 1 nesting hen during my study, but 5 other nests were associated with fallen timber. Thus, timber cutting schemes that leave some slash, like precommercial thinning, could improve nesting habitat where ground cover is limited.

Seasonal Habitat

I was unable to ascertain effects of logging on habitat use by wintering turkeys because most wintered on lowland ranches. Removal of roost trees or potential roost trees

from wintering sites could be detrimental to turkeys if no other suitable trees are available in the vicinity.

Logging probably would not hamper seasonal spring/fall movements unless very large areas are clearcut. However, logging operations temporarily may exclude turkeys from an area. Summer habitat use may be more affected by clearcutting in xeric than mesic regions because of slower understory regrowth and the corresponding slower recovery of habitat complexity and diversity. Extensive removal of trees (that is, clearcut, liberation cut, seed tree seed cut, etc.) probably would make an area less attractive to turkeys by lowering its structural complexity and diversity.

Future Research Needs

Impacts Of Livestock Grazing

Impacts of livestock grazing on habitat use by turkeys and other wildlife is unknown for the Long Pines and Ekalaka Hills. Lowering the intensity of livestock grazing that currently is being practiced in both divisions may allow taller upland vegetation and increased food availability during winter. This, in conjunction with available water, grit, and roost trees, may shift more wintering turkeys to

upland areas and lessen their adverse impacts on grain bales and feed bunkers for livestock on lowland ranches.

Livestock grazing in upland areas probably should not be eliminated, however. The ecosystem in southeastern Montana evolved under grazing of large ungulates and likely functions best under appropriate levels of grazing pressure. Research is needed to compare effects of current grazing regimes, lower intensity season-long grazing, and rest-rotation systems to assess immediate and long-term impacts of livestock grazing in the Long Pines and Ekalaka Hills.

Winter Habitat Use In Upland Areas

Little is known about turkeys wintering in upland areas of the Long Pines and Ekalaka Hills. Future research could be conducted to learn more about their habitat use to possibly lessen their impacts on feedlots. Investigations could be made into enhancing current or previous wintering sites in the uplands to support more turkeys on an annual basis. Such enhancements should include any 1 or a combination of the following: food, water, grit, and roosting habitat. Secondary wintering sites in uplands (Figs. 10 and 11) may provide opportunity for this research. Knowledge of habitat use by turkeys wintering in upland

areas also may answer questions concerning their long-term persistence in southeastern Montana if access to feedlots was eliminated.

Population Estimation

Estimating turkey populations in Montana currently is not feasible. Developing a practical and statistically valid survey method to estimate population levels and long-term trends would compliment harvest surveys currently in use. Knowledge of population numbers, characteristics, and dynamics is fundamental to proper management of wild turkeys and should be a high priority of managers and biologists.

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APPENDICES

APPENDIX A

Common And Scientific Names of Plants

Table 1. Common and scientific names (Scott and Wasser 1980) of selected trees, shrubs, forbs, and grasses located (except for oak) in the Long Pines and Ekalaka Hills, 1989-1991.

Plant type	Common name	Scientific name
Trees and shrubs		
	Ponderosa pine	*Pinus ponderosa*
	Creeping juniper	*Juniperus horizontalis*
	Rocky mountain juniper	*Juniperus scopulorum*
	Quaking aspen	*Populus tremuloides*
	Plains cottonwood	*Populus sargentii*
	Green ash	*Fraxinus pennsylvanica*
	Boxelder maple	*Acer negundo*
	Oak	*Quercus spp.*
	Common chokecherry	*Prunus virginiana*
	American plum	*Prunus americana*
	Saskatoon serviceberry	*Amelanchier alnifolia*
	Common snowberry	*Symphoricarpos albus*
	Woods rose	*Rosa woodsii*
	Hawthorne	*Crataegus spp.*
	Creeping barberry	*Berberis repens*
	Bearberry manzanita	*Arctostaphylos uva-ursi*
	Redshoot gooseberry	*Ribes setosum*
	Golden currant	*Ribes aureum*
	Spreading dogbane	*Apocynum androsaemifolium*
	Plains pricklypear	*Opuntia polyacantha*
	Skunkbush sumac	*Rhus trilobata*
	Rubber rabbitbrush	*Chrysothamnus nauseosus*
	Big sagebrush	*Artemisia tridentata*
Forbs		
	Silver sagebrush	*Artemisia cana*
	Fringed sagebrush	*Artemisia frigida*
	Louisiana sagewort	*Artemisia ludoviciana*
	Common yarrow	*Achillea millefolium*

Table 1. Continued:

Canada horseweed	*Conyza canadensis*
Curlycup gumweed	*Grindelia squarrosa*
Broom snakeweed	*Gutierrezia sarothrae*
Common sunflower	*Helianthus annuus*
Dotted gayfeather	*Liatris punctata*
Lambstongue groundsel	*Senecio integerrimus*
Low fleabane	*Erigeron pumilus*
Prickly lettuce	*Lactuca serriola*
Plains wallflower	*Erysimum asperum*
Clasping pepperweed	*Lepidium perfoliatum*
Rocky mountain beeplant	*Cleome serrulata*
Starry cerastium	*Cerastium arvense*
Groundplum milkvetch	*Astragalus crassicarpus*
American licorice	*Glycyrrhiza lepidota*
Silvery lupine	*Lupinus argenteus*
Yellow sweetclover	*Melilotus officinales*
Purple prairieclover	*Petalostemon purpureum*
Prairie thermopsis	*Thermopsis rhombifolia*
American vetch	*Vicia americana*
Wild bergamot beebalm	*Monarda fistulosa*
Prairie onion	*Allium textile*
Common flax	*Linum usitatissimum*
Spreading pasqueflower	*Anemone patens*
Northern bedstraw	*Galium boreale*
Owl's clover	*Orthocarpus luteus*
Woolly plantain	*Plantago patagonica*
Dock	*Rumex spp.*
Small soapweed	*Yucca glauca*
Field pussytoes	*Antennaria neglecta*
Sedges	
Sedge	*Carex spp.*

Table 1. Continued:

Threadleaf sedge	*Carex filifolia*
Grasses	
Crested wheatgrass	*Agropyron cristatum*
Western wheatgrass	*Agropyron smithii*
Bluebunch wheatgrass	*Agropyron spicatum*
Little bluestem	*Andropogon scoparius*
Red threeawn	*Aristida longiseta*
Sideoats grama	*Bouteloua curtipendula*
Blue grama	*Bouteloua gracilis*
Smooth brome	*Bromus inermis*
Japanese brome	*Bromus japonicus*
Cheatgrass	*Bromus tectorum*
Foxtail barley	*Hordeum jubatum*
Prairie junegrass	*Koeleria cristata*
Kentucky bluegrass	*Poa pratensis*
Needle-and-thread	*Stipa comata*
Green needlegrass	*Stipa viridula*

APPENDIX B

Definitions Of Selected Vegetation Terms

Table 2. Definitions for selected terms used to describe vegetation/cover types in the Long Pines and Ekalaka Hills.

Term	Definition
Tree	A woody plant with the following characteristics: at least 6m in height at maturity; having a single trunk; is unbranched at least 1m above the ground; and has a definite crown (Harlow et al. 1979).
Shrub	A woody plant that is usually smaller than a tree at maturity, has several erect or spreading stems, and has a bush-like appearance (Harlow et al. 1979).
Grass	Herbaceous plant with blade-like leaves and member of Poaceae.
Sedge	Herbaceous, grass-like plant that is a member of Cyperaceae.
Forb	A broad-leaved herbaceous plant (Lincoln and Boxshall 1990).
Litter	Undecomposed or partially decomposed plant remains at the soil surface (Lincoln and Boxshall 1990).

APPENDIX C

Winter Information

Table 3. Masses (kg) of Merriam's turkeys trapped in the Long Pines and Ekalaka Hills, Winters 1989-1991.

Age	Sex	n	Masses (kg)[a] Mean	(SD)
Adult	Male	10	7.7	(0.6)
Subadult	Male	23	6.1	(0.8)
Adult	Female	13	5.1	(0.4)
Subadult	Female	43	4.2	(0.5)

[a] Masses were converted from weights (lbs) to nearest 0.1 kg.

Table 4. List, description, and procedure for measurement of habitat variables at turkey roosts and randomly-selected sites in the Long Pines and Ekalaka Hills, Winters 1989-1991.

Habitat variable	Description and procedure
Distance to nearest feedlot	Distance (m), as measured on a 7.5-minute topographic quadrangle, from the center of a 25m x 25m roost or random site to the nearest livestock feeding trough/grain bales associated with private ranching operations.
Distance to permanent water	Distance (m), as measured on a 7.5-minute topographic quadrangle, from the center of a roost or random site to the nearest permanent, standing water.
Distance to meadow	Distance (m), as measured on a 7.5-minute topographic quadrangle, from the center of a roost or random site to the nearest clearing >1 ha (Mackey 1986).
Slope	Measure (%), using a clinometer, of vertical rise over horizontal run (Hays et al. 1981) at the center of a roost or random site.
Aspect	Compass direction (degrees) down the slope at the center of a roost or random site.
Tree species	Species of pole-sized or greater ($\geq$12.6 cm dbh) tree within a roost or random site.
Tree classification	Classify pole-sized or larger tree in a roost site as roosting or non-roosting based on observing turkeys and presence or absence of droppings below a tree.
Tree height	Height (m), as measured with a clinometer, of pole-sized or larger tree within a roost or random site.
Height to first branch	Height (m), as measured with a clinometer, from the ground to the first branch ($\geq$2.5 cm diameter and $\geq$9.4 cm long), of a pole-sized or larger tree in a roost or random site.

Table 10. Covariates of significant logistic regression models defining important roost tree characteristics of winter roosts in the Long Pines and Ekalaka Hills, 1990-1991.

Roost Tree Comparison	Covariate	Parameter Estimate (SE)	X^2	P
	Logistic Regression Results			
Coniferous (LP) vs. coniferous (EH)	Height to first branch	- 1.5 (0.5)	8.78	<0.01
Deciduous (LP) vs. coniferous (EH)	Height	- 0.4 (0.1)	7.61	<0.01
	Dbh	0.2 (0.1)	5.76	0.02
Coniferous vs. non-roost[a] (LP)	Height	0.1 (0.0)	12.97	<0.01
Coniferous vs. random site (LP)	Dbh	0.1 (0.0)	7.48	<0.01
Deciduous vs. non-roost (LP)	Dbh	0.1 (0.0)	9.30	<0.01
Deciduous vs. random site (LP)	Height	- 0.2 (0.1)	11.30	<0.01
	Dbh	0.2 (0.0)	17.43	<0.01
	Height to first branch	0.6 (0.3)	4.14	0.04
Roost vs. non-roost (EH)	Dbh	0.1 (0.0)	17.01	<0.01
Roost (EH) vs. random site (LP)	Dbh	0.2 (0.2)	16.54	<0.01

[a] Non-roost trees (≥12.6 cm dbh) contained within roost sites.

APPENDIX D

Spring/fall Movement Information

Table 12. Home ranges of turkeys in the Long Pines and Ekalaka Hills, Spring/Fall 1989-1991.

Study unit	ID	Age	Sex	Year	Season	Spring/fall home range (ha)
Long Pines	700	Sub	F	89	Spr.	398
	891	Ad.	F	89	Spr.	536
	841	Ad.	F	90	Spr.	184
	941	Ad.	F	90	Spr.	73
	1041	Ad.	M	90	Spr.	549
	121	Sub.	M	90	Spr.	618
	1270	Ad.	F	90	Spr.	327
	620	Sub.	F	90	Spr.	177
	418	Sub.	M	90	Spr.	1518
	197	Sub.	F	90	Spr.	1766
	500	Sub.	F	90	Spr.	73
	398	Sub.	F	90	Spr.	71
	19	Sub.	F	90	Spr.	224
	1552	Ad.	F	91	Spr.	1181
	1204	Ad.	M	91	Spr.	2968
	1622	Ad.	M	91	Spr.	2570
	1299	Ad.	M	91	Spr.	3054
	1951	Sub.	M	91	Spr.	1706
	1702	Sub.	F	91	Spr.	943
	701	Sub.	F	91	Spr.	423
	278	Ad.	M	91	Spr.	2490
	20	Ad.	M	91	Spr.	540
	1503	Sub.	M	91	Spr.	3731
	992	Sub.	F	91	Spr.	2490
	145	Ad.	F	91	Spr.	65
	1013	Sub.	F	91	Spr.	176
	378	Sub.	M	91	Spr.	1679
	652	Sub.	F	91	Spr.	1920

Table 12. Continued:

	1161	Sub.	F	91	Spr.	10,028
	419	Sub.	F	91	Spr.	899
	1858	Ad.	F	91	Spr.	1403
	841	Ad.	F	91	Spr.	228
	121	Ad.	M	91	Spr.	3882
	500	Ad.	F	91	Spr.	1267
	438	Sub.	M	91	Spr.	10,463
	1041	Ad.	M	90	Fall	302
	121	Sub.	M	90	Fall	1194
	620	Sub.	F	90	Fall	1025
	500	Sub.	F	90	Fall	2086
	398	Sub.	F	90	Fall	367
Ekalaka Hills	1160	Sub.	F	89	Spr.	1528
	1014	Sub.	F	89	Spr.	144
	41	Ad.	M	90	Spr.	380
	1027	Ad.	F	90	Spr.	844
	1177	Sub.	F	90	Spr.	24
	680	Sub.	F	90	Spr.	53
	1480	Sub.	F	90	Spr.	1689
	223	Sub.	M	90	Spr.	519
	319	Sub.	M	90	Spr.	992
	953	Ad.	F	90	Spr.	22
	1297	Ad.	F	90	Spr.	35
	101	Sub.	M	90	Spr.	229
	1730	Ad.	F	91	Spr.	1820
	1814	Sub.	F	91	Spr.	262
	561	Sub.	M	91	Spr.	1679
	41	Ad.	M	91	Spr.	131
	581	Sub.	M	91	Spr.	70
	982	Ad.	F	91	Spr.	440
	680	Ad.	F	91	Spr.	383

Table 12. Continued:

1047	Ad.	F	91	Spr.	625
1480	Ad.	F	91	Spr.	725
41	Ad.	M	90	Fall	36
1047	Ad.	F	90	Fall	263
1077	Ad.	F	90	Fall	26
1177	Sub.	F	90	Fall	552
680	Sub.	F	90	Fall	208
1480	Sub.	F	90	Fall	1500
223	Sub.	M	90	Fall	193
599	Sub.	F	90	Fall	805

Table 16. Covariates of significant logistic regression models defining characteristics of trees used by roosting turkeys in the Long Pines and Ekalaka Hills, 1990-1991.

		Logistic Regression Results			
Seasonal Comparison	Roost Tree Comparison	Covariate	Parameter Estim. (SE)	X^2	P
Spr./fall vs. spr./fall					
	Unburned (LP) vs. roost (EH)	Dbh	- 0.3 (0.1)	4.55	0.03
	Burned vs. non-roost (LP)	Dbh	0.4 (0.2)	4.46	0.03
	Burned vs. random (LP)	Dbh	0.1 (0.0)	6.65	<0.01
	Unburned vs. non-roost (LP)	Height	0.2 (0.1)	9.81	<0.01
	Roost vs. non-roost (EH)	Height	0.2 (0.1)	7.14	<0.01
	Roost vs. random (EH)	Dbh	0.1 (0.0)	10.12	<0.01
Winter vs. spr./fall					
	Coniferous vs. unburned (LP)	Height to first br.	- 1.6 (0.7)	9.85	0.03
	Deciduous vs. unburned (LP)	Dbh	0.1 (0.0)	5.62	0.02
	Roost vs. roost (EH)	Dbh	0.1 (0.0)	5.12	0.03

APPENDIX E

Nesting Information

Table 22. Description and measurement procedures for habitat variables measured at turkey nest and random sites in the Long Pines and Ekalaka Hills, 1990-1991.

Habitat variable	Description and procedure
Site disturbance	Classification of the stand type containing a nest as unburned, lightly burned (little understory vegetation burned and lightly burned overstory), or severely burned (most or all understory vegetation burned off and at least 80% of the overstory trees died) (Havig et al. 1988) in the Long Pines. In the Ekalaka Hills, stands containing a nest were classified as either logged or unlogged.
Distance to permanent water	Distance (m), as measured on a U.S.G.S. quadrangel, from a nest or random site center to the nearest permanent water.
Distance to meadow	Distance (m), as measured on a U.S.G.S. quadrangle, from the nest or random site center to the nearest clearing >1 ha (Mackey 1986).
Distance to tree	Distance (m), as measured by a 10 m tape, from the nest or random site center to the adjacent tree (≥12.5 cm dbh) if the nest is located at the base of a tree.
Distance to edge	Distance (m), as measured by a 10 m tape, from the nest or random site center to the nearest interface of different vegetation types.
Patch length and width	Length (m), and width (m), as measured by a 25 m tape, of shrub patches containing nest or random sites.
Dbh of tree	Diameter breast height (cm), as measured by a diameter tape, of tree adjacent to nest or random site center.
Height of tree	Height (m), as measured by a clinometer, of tree mentioned above.
Visual obstruction	Height (dm) of vegetation as recorded from a Robel pole placed at the center of a nest or random site and read from a distance of 4 m and height of 1 m (Robel et al. 1970).
Slope	Measure (to the nearest 5%) of the vertical rise over horizontal run (Hays et al. 1981), using a clinometer, of the nest or random site.
Aspect	Compass direction (degrees) measured down the slope of a nest or random site.

Table 22. Continued:

Plant species	Record plant species or category (Appendix B, Table 2) within a 0.01 ha (James and Shugart 1970) square plot centered on a nest or random point.
Plant Coverage	Categorize plant species, based on percent cover, within a 0.01 ha square plot centered on a nest or random point. Cover categories include: 0-5%; 5-25%; 25-50%; 50-75%; 75-100% (Braun-Blanquet 1965).

Table 23. Straight-line distances (km) from winter GAC's to nest sites traveled by hens in the Long Pines and Ekalaka Hills, 1989-1991.

Unit	ID	Age	Year	Distance (km) from Winter GAC to nest site
Long Pines	1229	Sub.	89	24.99
	700	Sub.	89	9.72
	161	Sub.	89	19.45
	1689	Sub.	89	17.45
	1843	Ad.	89	19.26
	841	Ad.	89	1.79
	1657	Sub.	89	18.18
	891	Ad.	89	6.54
	991	Sub.	89	7.92
	398	Sub.	90	2.61
	841	Ad.	90	0.82
	620	Sub.	90	3.39
	941	Ad.	90	0.21
	1270	Ad.	90	1.83
	19	Sub.	90	1.67
	197	Sub.	90	21.39
	1880	Ad.	90	1.42
	500	Sub.	90	1.63
	992	Ad.	91	11.00
	145	Ad.	91	1.11
	1013	Sub.	91	2.02
	1552	Ad.	91	3.98
	1702	Sub.	91	12.53
	500	Ad.	91	14.85
	701	Sub.	91	3.67
Ekalaka Hills	1297	Sub.	89	4.28
	1160	Sub.	89	6.44
	1047	Sub.	89	9.55
	1014	Sub.	89	5.82

Table 23. Continued:

1177	Sub.	90	1.43
953	Ad.	90	2.95
1077	Ad.	90	6.15
1047	Ad.	90	2.42
1297	Ad.	90	2.69
680	Sub.	90	3.76
1480	Ad.	90	5.32
1948	Sub.	90	6.55
982	Ad.	91	10.21
1047	Ad.	91	4.34
680	Ad.	91	5.20
1480	Ad.	91	4.58
1814	Sub.	91	3.30
1047	Ad.	92	5.33
1480	Ad.	92	2.16

Table 34. Covariates of significant logistic regression models defining turkey nest site characteristics in the Long Pines (LP) and Ekalaka Hills (EH), 1989-1991.

Nest site Comparison	Logistic Regression Results			
	Covariate	Parameter Estimate (SE)	X^2	P
Nest vs. random site (LP)	Ht. of visual obst.	0.5 (0.2)	7.79	<0.01
Nest vs. random site (EH)	Distance to perm. water	- 0.04 (0.0)	4.00	0.05
Successful vs. unsuccessful (LP)	Distance to perm. water	- 0.01 (0.0)	5.08	0.02

APPENDIX F

Summer Information

Table 41. Descriptions of classifications used to categorize forest/cover stands in the Long Pines and Ekalaka Hills, 1990-1991.

Stand classification	Description
Xeric ponderosa pine[a]	Ponderosa pine stands occurring on level ground or slopes with southeast, southwest, or south-facing aspects.
Mesic ponderosa pine[a]	Ponderosa pine stands occurring on slopes with northeast, northwest, or north-facing aspects.
Grassland	All non-forested (<10% crown cover) areas. Xeric and mesic grasslands were pooled together because of insufficient delineation of mesic grassland types on U.S.D.A. Forest Service stand maps.
Hardwood draw	Mesic areas comprised in whole, part, or a combination of quaking aspen, plains cottonwood, green ash, boxelder maple, American plum, and hawthorne.

[a] M. Sexton, U.S.D.A. Forest Service, pers. commun.

Table 42. Straight-line distances (km) traveled by turkeys between winter and summer range GAC's in the Long Pines and Ekalaka Hills, 1990-1991.

Study unit	ID	Age	Sex	Year	Winter-summer distance (km)
Long Pines	1041	Ad.	M	90	7.3
	121	Sub.	M	90	4.1
	418	Sub.	M	90	14.6
	500	Sub.	F	90	3.4
	841	Ad.	F	91	0.4
	1204	Ad.	M	91	1.9
	1622	Ad.	M	91	11.2
	278	Ad.	M	91	15.5
	20	Ad.	M	91	0.6
	1503	Sub.	M	91	16.6
	1240	Sub.	M	91	3.5
	378	Sub.	M	91	8.1
	121	Ad.	M	91	3.4
	438	Sub.	M	91	3.9
Ekalaka Hills	680	Sub.	F	90	3.7
	1480	Ad.	F	90	4.6
	223	Sub.	M	90	5.0
	319	Sub.	M	90	9.7
	599	Sub.	F	90	0.9
	41	Ad.	M	91	1.9
	561	Sub.	M	91	4.7

Table 44. Summer home range sizes (ha) of turkey flocks in the Long Pines and Ekalaka Hills, 1990-1991.

Study unit	ID	Age	Sex	No. turkeys in flock	Year	Summer home range (ha)
Long Pines	1041	Ad.	M	≥5	90	514
	121	Sub.	M	≥5	90	985
	418	Sub.	M	≥5	90	411
	500	Sub.	F	2-4	90	337
	841	Ad.	F	2-4	91	130
	1204	Ad.	M	2-4	91	239
	1622	Ad.	M	1	91	180
	278	Ad.	M	1	91	132
	20	Ad.	M	1	91	730
	1503	Sub.	M	2-4	91	363
	1240	Sub.	M	≥5	91	627
	378	Sub.	M	≥5	91	966
	121	Ad.	M	1	91	545
	438	Sub.	M	2-4	91	461
Ekalaka Hills	680	Sub.	F	≥5	90	369
	1480	Ad.	F	≥5	90	558
	223	Sub.	M	≥8	90	578
	319	Sub.	M	2-4	90	242
	599	Sub.	F	2-4	90	17
	41	Ad.	M	2-4	91	153
	561	Sub.	M	2-4	91	367

Table 50. Covariates of significant logistic regression models defining seasonal turkey roost characteristics in the Long Pines and Ekalaka Hills, 1990-1991.

		Logistic Regression Results			
Seasonal Comparison	Roost Comparison	Covariate	Parameter Estim. (SE)	X^2	P
Summer vs. summer	Unlogged h.r.[a] vs. random (EH)	Percent 2-storied	0.1 (0.0)	4.00	0.04
	Roost vs. rand. site (LP)	Slope	0.1 (0.0)	5.19	0.02
	Roost vs. rand. site (EH)	Slope	0.2 (0.1)	6.95	<0.01
	Burned tree vs. unburned (LP)	Dbh	0.0 (0.1)	4.91	0.03
	Burned tree vs. non-roost (LP)	Dbh	0.2 (0.1)	19.51	<0.01
	Burned tree vs. random (LP)	Dbh	0.1 (0.0)	20.23	<0.01
	Unburned tree vs. random (LP)	Dbh	0.1 (0.0)	5.78	0.02
	Roost tree vs. non-roost (EH)	Dbh	0.2 (0.1)	9.57	<0.01
	Roost tree vs. random (EH)	Dbh	0.2 (0.0)	20.18	<0.01
Winter vs summer	Decid. tree vs. burned (LP)	Height	- 0.3 (0.1)	8.96	<0.01
		Dbh	0.1 (0.1)	5.41	0.02
	Decid. tree vs. unburned (LP)	Height	- 0.2 (0.1)	4.03	0.04
	Roost vs. roost tree (EH)	Dbh	- 0.1 (0.1)	5.12	0.02
		Height to first br.	0.6 (0.3)	3.88	0.05
Spr./fall vs. summer	Unburned vs. unburned (LP)	Height	0.3 (0.1)	5.63	0.02
	Roost vs. roost tree (EH)	Height to first br.	-1.8 (0.7)	6.60	<0.01

[a] Home range.

Table 55. Numbers of individuals in each insect order collected in sweep nets along turkey feeding routes in the Long Pines, Summers 1990-1991.

	Site disturbance												
	Light burn		Severe burn								Unburned		
	1990	1991	1990							1991	1990	1991	
Insect order	Jun 2	Jul 18	Jun 21	Jul 1	Jul 10	Sep 2	Sep 7	Sep 15	Sep 18	Jun 24	Jun 18	Jun 12	Jun28
Araneae	9		1	18	3	16	11	12	11	4	6	6	5
Acari													
Odonata													
Orthoptera	2		2	8		1	3			35	8	59	4
Psocoptera							5						1
Thysanoptera											1		
Hemiptera	47	14	14	77	6	76	25	20	15	54	81	19	373
Homoptera	10	19	14	153	3	299	36	39	20	20	225	26	16
Neuroptera			1	10		7	2	1	1				4
Coleoptera	5	11	2	38	5	27	4	8	4	27	6	57	10
Lepidoptera	1			3		1	3	2	4	7		1	3
Diptera	88	6	68	159	4	43	26	10	12	18	37	23	20
Hymenoptera	25	12	12	99		9	15	3	3	16	30	23	19

Table 56. Numbers of individuals in each insect order collected in sweep nets along randomly-located transects in the Long Pines, Summers 1990-1991.

	Site disturbance												
	Light burn				Severe burn							Unburned	
	1990				1990					1991		1990	1991
Insect order	Jun 21	Jun 23	Jul 20	Sep 15	Jul 12	Jul 19	Sep 2	Sep 7	Sep 18	Jun 2	Jun 24	Sep 30	Jun 12
Araneae		6	28	5	6	7	2	60	8	13	2	10	
Acari				1									
Odonata					1								
Orthoptera	7		11			1				1	18	6	12
Psocoptera									1		2		
Thysanoptera												1	
Hemiptera	7	4	115	18	12	11	8	397	96	40	37	7	19
Homoptera	235	14	138	25	13	26	9	2072	40	55	23	13	12
Neuroptera			1	1				14	2	2		1	1
Coleoptera	13		10	3	1	2	2	235	19	10	11	8	5
Lepidoptera		1	6	1			2	2		2	1	4	4
Diptera	155	7	4	8	14	9	15	152	8	100	31	3	18
Hymenoptera	18	6	5	4	12	15	8	37	10	35	5	1	10

Table 57. Numbers of individuals in each insect order collected in sweep nets along turkey feeding routes and randomly-located transects in the Ekalaka Hills, Summer 1991.

	Feeding route		Random transect	
	1991		1991	
Insect order	Jun 28	Jul 6	Jun 28	Jul 6
Araneae	5	6	2	3
Acari				
Odonata				
Orthoptera	4	3	1	3
Psocoptera	1	1		
Thysanoptera		1	1	
Hemiptera	373	6	120	2
Homoptera	16	43	120	35
Neuroptera	4	1	1	1
Coleoptera	10	10	4	8
Lepidoptera	3	1	5	
Diptera	20	42	40	39
Hymenoptera	19	38	27	21

APPENDIX G

Survival Information

Table 63. Trapping information and fates of transmitter-equipped Merriam's turkeys in the Long Pines and Ekalaka Hills, 1988-1992.

Trapping location (study division) Radio freq.	Sex	Approx. age when trapped (months)	Trapping date	Fate (approximate date) or date of last contact
Harkins ranch (Ekalaka Hills)				
151.588	F	6	12/30/88	Hunter kill (9/3/89)
151.430	F	6	12/30/88	Hunter kill (10/14/89)
150.800	F	6	12/30/88	Predator (6/8/89)
150.953	F	6	12/30/88	Unknown (10/1/90)
151.297	F	6	12/30/88	Predator (7/15/90)
151.160	F	6	12/30/88	Predator (5/15/90)
150.818	F	7	1/26/90	Unknown (6/1/90)
151.177	F	7	1/26/90	Predator (4/23/91)
151.117	M	7	1/26/90	Hunter kill (4/14/90)
150.759	F	≥19	1/26/90	Predator (4/25/90)
150.599	F	7	1/26/90	Predator (6/18/91)
151.971	M	≥19	1/30/90	Unknown (4/15/90)
151.904	F	7	1/30/90	Unknown (5/10/90)
150.982	F	7	1/30/90	Predator (8/20/91)
151.948	F	7	1/30/90	Predator (7/6/90)
Carlisle ranch (Ekalaka Hills)				
151.730	F	≥20	2/11/89	Alive
151.047	F	≥20	2/11/89	Alive
151.014	F	8	2/11/89	Predator (5/17/90)
150.144	F	8	2/11/89	Predator (1/15/89)
151.241	F	8	2/11/89	Predator (4/15/89)
151.269	F	8	2/11/89	Predator (4/15/89)
151.772	F	≥20	2/11/89	Unknown (6/1/89)
151.100	F	≥20	2/10/89	Predator (4/20/89)
151.970	F	8	2/10/89	Unknown (6/20/89)
150.041	M	8	2/10/89	Predator (8/15/91)
151.400	F	8	2/10/89	Unknown
150.859	F	8	2/11/89	Unknown

Table 63. Continued:

Dague ranch (Ekalaka Hills)				
150.461	F	≥21	3/24/90	Predator (4/21/91)
150.437	F	9	3/24/90	Predator (6/20/90)
151.480	F	≥21	3/24/90	Alive
150.319	M	9	3/24/90	Hunter kill (11/12/90)
151.621	M	9	3/24/90	Predator (5/10/91)
151.077	F	≥21	3/24/90	Predator (5/16/91)
150.101	M	8	3/24/90	Unknown (6/8/90)
150.223	M	8	3/24/90	Unknown (6/17/91)
150.680	F	9	3/26/90	Predator (6/12/91)
Near Peabody ranch (Ekalaka Hills)				
150.561	M	6	12/5/90	Alive
150.479	M	6	12/5/90	Hunter kill (5/2/91)
150.581	M	6	12/5/90	Predator (6/7/91)
150.181	F	6	12/5/90	Illegal kill (1/5/91)
151.101	F	6	12/5/90	Illegal kill (1/5/91)
151.814	F	6	12/5/90	Hunter kill (10/2/91)
Speelman ranch (Long Pines)				
151.689	F	6	12/29/88	Unknown (9/8/89)
151.460	F	≥18	12/29/88	Hunter kill (11/20/89)
151.330	F	≥18	12/29/88	Unknown (6/1/89)
150.891	F	≥18	12/29/88	Predator (12/20/90)
151.620	F	6	12/29/88	Predator (6/20/89)
151.552	F	≥18	12/29/88	Unknown (9/21/91)
Schell ranch (Long Pines)				
150.911	M	≥20	2/10/89	Predator (7/15/90)
150.841	F	≥20	2/10/89	Predator (2/1/92)
151.813	M	≥20	2/10/89	Hunter kill (10/21/89)
150.700	F	8	2/10/89	Predator (7/27/89)
150.100	F	8	2/10/89	Predator (6/10/89)
150.748	F	≥20	2/10/89	Predator (6/10/89)
150.300	M	8	2/10/89	Unknown (9/8/89)
151.130	F	8	2/10/89	Unknown (9/8/90)
150.539	F	8	2/2/90	Unknown (9/8/90)
150.377	F	8	2/2/90	Unknown (4/10/90)

Table 63. Continued:

150.418	M	8	2/2/90	Hunter kill (11/8/90)
150.197	F	8	2/2/90	Predator (6/19/90)
150.240	F	8	2/2/90	Predator (5/20/90)
150.019	F	8	2/2/90	Predator (5/26/90)
150.500	F	8	2/2/90	Alive
150.398	F	8	2/2/90	Predator (5/8/91)
151.434	M	8	2/26/91	Hunter kill (4/25/92)
151.240	M	8	2/26/91	Alive
150.438	M	8	2/26/91	Hunter kill (11/4/91)
150.419	F	8	2/26/91	Unknown (2/1/92)
Knipfer ranch (Long Pines)				
151.504	M	8	2/11/89	Predator (9/25/89)
151.533	F	8	2/11/89	Predator (11/15/90)
150.941	F	8	2/11/89	Predator (1/22/90)
150.991	F	8	2/11/89	Predator (8/22/90)
150.222	F	8	2/11/89	Predator (6/15/89)
Wickham gulch (Long Pines)				
150.651	F	9	3/11/89	Predator (5/25/89)
151.880	F	9	3/11/89	Predator (5/25/90)
150.083	F	9	3/11/89	Predator (5/1/90)
151.657	F	9	3/11/89	Unknown (9/8/89)
151.229	F	9	3/11/89	Unknown (12/20/90)
151.843	F	≥21	3/11/89	Unknown (9/8/89)
150.161	F	9	3/11/89	Unknown (9/8/89)
Exie road (Long Pines)				
150.120	M	≥21	3/24/89	Hunter kill (4/16/89)
151.041	M	≥21	3/24/89	Hunter kill (4/20/91)
Byrne ranch (Long Pines)				
150.121	M	9	3/8/90	Alive
151.270	F	≥21	3/8/90	Predator (9/16/90)
150.620	F	9	3/8/90	Predator (1/2/91)
151.203	F	9	3/8/90	Predator (4/25/90)
151.013	F	9	3/9/91	Unknown (2/1/92)
150.378	M	9	3/9/91	Predator (10/15/91)
151.461	M	9	3/9/91	Unknown (4/10/91)

Table 63. Continued:

Ward Spring No.1 (Long Pines)				
150.912	F	>18	12/2/90	Predator (5/10/91)
150.801	M	6	12/2/90	Predator (5/10/91)
151.378	F	6	12/2/90	Predator (5/18/91)
150.749	F	6	12/2/90	Predator (5/30/91)
Bergstrom ranch (Long Pines)				
151.204	M	≥18	12/13/90	Alive
151.622	M	≥18	12/13/90	Alive
151.299	M	≥18	12/13/90	Hunter kill (4/11/92)
151.951	M	6	12/14/90	Alive
151.702	F	6	12/14/90	Unknown (2/1/92)
150.701	F	6	12/16/90	Unknown (2/1/92)
151.858	F	≥21	3/6/91	Unknown (9/21/91)
150.992	F	9	3/6/91	Unknown (9/21/91)
150.778	F	9	3/6/91	Alive
150.145	F	≥21	3/6/91	Alive
151.161	F	9	3/6/91	Predator (5/22/91)
150.652	F	6	12/16/90	Unknown (3/13/91)
Slick Creek Spring (Long Pines)				
150.278	M	≥18	12/17/90	Predator (11/10/91)
150.940	M	≥18	12/17/90	Predator (5/13/91)
150.020	M	≥18	12/17/90	Hunter kill (9/22/91)
Brewer ranch (Long Pines)				
151.882	M	7	1/16/91	Unknown (4/15/92)
150.082	M	7	1/16/91	Hunter kill (10/15/91)
151.503	M	7	1/16/91	Alive