ARIZONA GAME AND FISH DEPARTMENT

RESEARCH BRANCH
TECHNICAL REPORT #7

POPULATION AND NESTING CHARACTERISTICS OF MERRIAM'S TURKEY ALONG THE MOGOLLON RIM, ARIZONA

A Final Report

BRIAN F. WAKELING

August 1991

FEDERAL AID IN WILDLIFE RESTORATION PROJECT

Arizona Game and Fish Department Mission

To conserve, enhance, and restore Arizona's diverse wildlife resources and habitats through aggressive protection and management programs, and to provide wildlife resources and safe watercraft recreation for the enjoyment, appreciation and use of present and future generations.

Arizona Game and Fish Department
Research Branch

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CONTENTS

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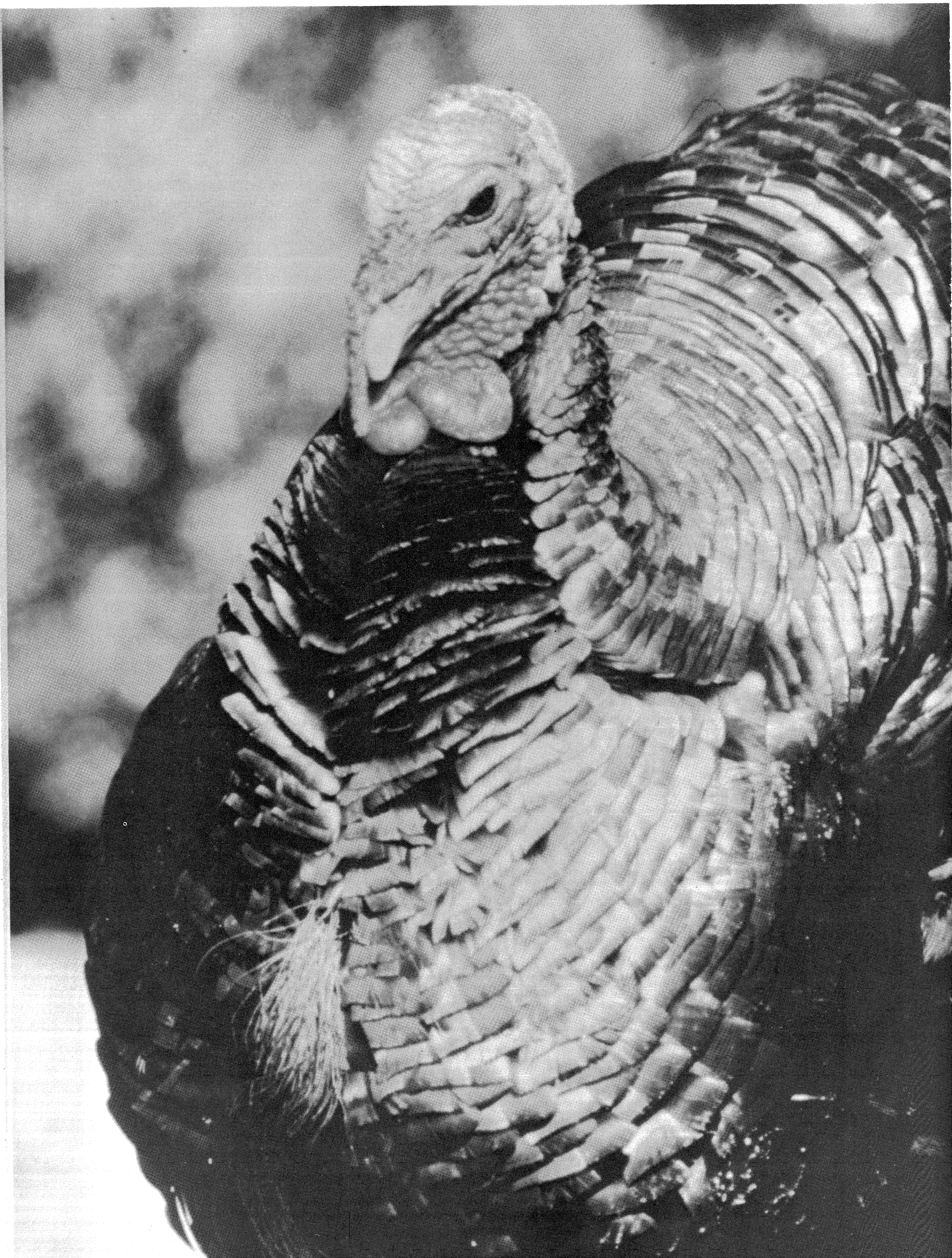


Population and Nesting Characteristics of Merriam's Turkey Along the Mogollon Rim, Arizona

Brian F. Wakeling

Abstract: Merriam's turkeys (*Meleagris gallopavo merriami*) were studied on the Mogollon Rim in northcentral Arizona from January, 1987, through March, 1991. Population characteristics and nest site selection were monitored. Survival and cause-specific mortality rates were obtained from 209 radio telemetered turkeys. Leading causes of mortality included coyote and avian predation. Fall hunting mortality rate averaged 3% for adult hens. Annual survival for all hens averaged 66%, although it fluctuated as much as 44% between years. Fluctuations in juvenile survival during the 4 years of study were found to influence population numbers the most, while theoretically, adult hen survival was believed to have the greatest potential influence on population numbers. Based upon average population parameters measured during the 4 years of study, the breeding population increased approximately 7.4% per year. Breeding population levels varied as much as 58.7% between years, and averaged 26.9% difference between years. Breeding population levels cycled between high and low levels, peaking every 2 years. Home ranges of 2 turkeys on the Mogollon Rim averaged 74.8 mi^2 for 90% harmonic mean contours. No habitat selection by vegetative type could be detected. Nest site selection was determined from 67 nests and 29 random plots. Nests were frequently located in canyons with clumped understories, overstories, and canopies. Grass, shrub, deciduous tree, and rock cover were greater in habitat selected for nesting. Horizontal cover was greater at nest sites than at random sites. Successful nests had a higher density of conifer trees than unsuccessful nests. Management implications of this research are discussed.

INTRODUCTION

A statewide decline in Arizona's turkey population was first suspected by natural resource managers in the mid-to-late 1970s. In August 1985, wildlife professionals from Arizona's resource management agencies and universities met in Williams, Arizona, to discuss turkey management problems. The consensus of the participants was that a decline had occurred. No single cause was implicated, although logging practices, increased human recreational use, fall hunting, disease, grazing, and long term changes in climatic patterns were suggested as factors. As early as 1920, turkey populations were suspected of suffering declining numbers due to these factors (Ligon 1946), although turkey populations were believed to have recovered from this early decline.

During the late 1950s and early 1960s, turkeys were surveyed in Arizona using standardized roadside survey routes. Those routes were driven at low speeds during early morning and late evening in mid-August, through all representative turkey habitat. The location and composition of all turkey flocks were recorded and summarized (Reeves 1953*a*, Shaw 1973). In the latter 1960s, formal surveys were replaced by classification counts of turkeys seen while on routine summer patrols by district Wildlife Managers. Trend data from those classification counts indicated a possible statewide population decline, beginning in 1979 (Shaw 1986). Shaw (1986) questioned the accuracy of classification counts because they lacked a statistically reliable sampling design. Consequently, survey routes in the White Mountains of Arizona that had been last run in 1959, 1960, and 1961 were rerun in 1985 and 1986. Results from those surveys indicated a 76% decline in the turkey population (Shaw 1986, Green 1990). Population numbers may have been depressed as a result of early snows, during the fall of 1978, followed by a severe winter (Shaw 1986).

Harvest information, from 1969 to the present, shows a different story. Game Management Unit (GMU) 4, which represents median climatic conditions for much of the ponderosa pine (*Pinus ponderosa)* turkey habitat in Arizona, experienced fluctuations of 30% of the highest harvest rate. Those fluctuations appeared cyclic, with highs occurring every 2 years (Fig. 1), but did not indicate a decline had occurred.

Data from classification counts also varied greatly. These data suffered from unequal survey effort between years which further clouded the issue of population trend. GMUs 5 and 6 (Fig. 2) had a larger decline in harvest rate between 1969 and 1986. It is also important that hunter densities declined during the same period. GMUs 7, 8, and 9 also reflected a decline in harvest rate during the same time.

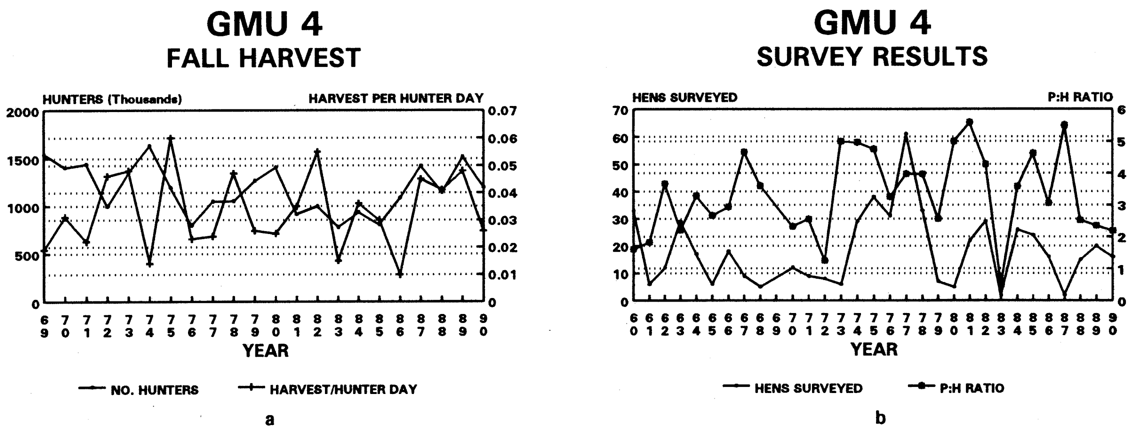


Figure 1.
GMU 4 (a) fall harvest and (b) survey results.

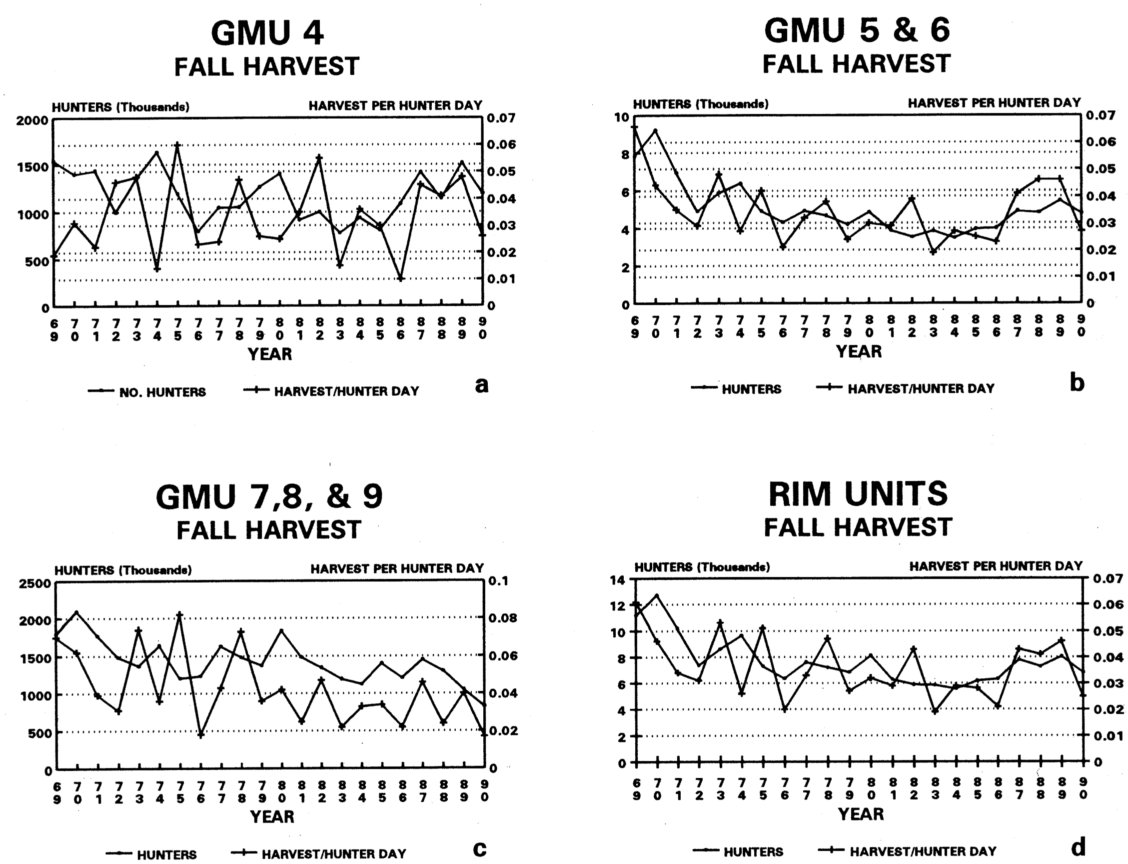


Figure 2.
Fall harvest by GMU; (a) 4, (b) 5 & 6, (c) 7,8,9, and (d) all combined.

Again, hunter densities declined concurrent with the waning harvest rate. In fact, the turkey harvest rate has decreased for all of these management units (Mogollon Rim units) combined.

On the other hand, GMUs 4, 5, and 6 have demonstrated increased harvest rates since 1986, with 3 of the highest years of hunter success in 1987-89. Assuming harvest rate is directly correlated to population size and turkey numbers were indeed declining, turkey harvest rates would be expected to decline, rather than increase.

Despite the conflicting trend information, most professionals involved in turkey management believed that a decline had occurred. Population trends are determined by natality, mortality, immigration, and emigration. Information on factors affecting wild turkey mortality and suitability of turkey habitat is therefore essential to understanding population trends.

Recent research has indicated that 1 type of turkey mortality, fall hunting, is not necessarily compensatory with winter mortality (Little et al. 1990). Mortality studies using radio telemetry data have been used to examine populations in Texas (Swank et al. 1985), southern ranges (Everett et al. 1980, Holbrook and Vaughan 1985), eastern populations (Porter 1978), Missouri (Kurzejeski et al. 1988) and New Mexico (Lockwood 1987). In each situation, the relative effects of hunting and predation were different. The causes and effects of mortality were unknown in Arizona's population of Merriam's turkeys.

Disease has been known to be a significant contributor of mortality to wildlife populations. Mycoplasmosis has infected wild turkey populations, but was not reported in wild or semi-wild, free ranging turkeys prior to 1980. Since then, it has been found in populations in Wisconsin, Minnesota, Missouri, Texas, Colorado, California, Georgia, and Arizona. Mycoplasmosis is caused by 3 species of *Mycoplasma*, *M. gallisepticum* (MG), *M. meleagridis* (MM), and *M. synoviae* (MS). Depending on the particular species, clinical symptoms of this disease include rales, coughing, inflammation of joints, and a general degradation of health. The effects of mycoplasmosis on wild populations, however, is poorly understood. For instance, MG, MM, and MS were isolated in 2 declining turkey populations and absent from 2 stable populations in Colorado (Adrian 1984). Since then, these pathogens have been located in expanding or stable populations. Additionally, no evidence was found to link mycoplasmosis with the decline of wild turkeys in Texas (Rocke and Yuill 1987). The incidence of these, or other, diseases on the Mogollon Rim is unknown, but may have been partially responsible for the perceived decline.

Habitat suitability, juxtaposition, and interspersion influence the species of wildlife that inhabit an area, and habitat changes can result in increased migration or mortality for wildlife. Timber harvesting and grazing levels by domestic livestock and elk (*Cervus elaphus*) may have impacted habitats along the Mogollon Rim (Shaw 1986).

Decades of visual observation data are available on Merriam's turkey in Arizona. Reeves (1953*b*) found that turkeys on the Mogollon Rim used large openings that provided food and cover within ponderosa pine habitats. A study in eastern Arizona reported high use of meadows by turkeys, though usually within 150 ft of cover (Scott and Boeker 1975).

With the advent of radio telemetry, turkey research was no longer limited to visual observation and the accompanying bias of higher visibility in open habitats. It was now possible to document behavior specific habitat use and the importance of dense habitat for nesting purposes became apparent (Goerndt 1983, Crites 1988). Though his sample size was small, Crites (1988) believed he could distinguish between successful and unsuccessful nest sites. Lockwood (1987) discovered the presence of brood lanes, or openings by which broods could leave the nest, at a high proportion of nest sites in New Mexico. Studies in New Mexico (Schemnitz et al. 1983, Lockwood 1987) also demonstrated that turkeys in southwestern environments have low nesting rates for yearling turkeys. Yearling Merriam's turkeys in South Dakota have been documented to nest at rates equal to adults (Rumble and Anderson 1989). Lack of yearling nesting and insufficient nesting habitat were believed to be factors that could limit productivity and resiliency of turkey populations on the Mogollon Rim.

Merriam's turkeys are known to require different habitat types for different behavioral activities. Roosting habitat is well documented (Hoffman 1968, Boeker and Scott 1969, Phillips 1980, 1982, Goerndt 1983). Turkeys prefer tall, overmature ponderosa pines with widely spaced, spreading branches. Descriptions of habitat selected for loafing purposes have been lacking until recently. The importance of habitat for this activity has been suggested historically (Ligon 1946) and more recently (Phillips 1982). This habitat had not been described until recently due to the difficulty of locating turkeys in those dense stands without the aid of radio telemetry. Brood habitat is likewise important. Inadequate amounts of suitable habitat for each of these activities could lead to the decline of a turkey population.

The selection of home ranges by individual Merriam's turkeys has not been documented in the Mogollon Rim area. As availability of habitats between individuals varies, their selection may vary. This potential interaction can be of crucial importance to land and forest managers. Home range size and seasonal movements of Merriam's turkeys on the Mogollon Rim are suspected to be large and this knowledge of home range selection is essential to proper habitat management.

Regardless of whether a decline in turkey numbers had occurred, information on turkey populations was needed. The goal of this study was to provide wildlife and habitat managers with information to better manage Merriam's turkey populations and habitat along the Mogollon Rim, Arizona. The objectives of this study were to investigate the following items:

- Determine seasonal and annual survival and cause-specific mortality rates.
- Determine the prevalence of mycoplasmosis.
- Determine how habitat characteristics affect mortality rates.
- Determine how home range size and habitat selection influence mortality and productivity.
- Determine the influence of habitat on nest selection and success.

Forested ecosystem data are conventionally recorded in English units. In order to provide commensurate information all data in this study were recorded and reported in English units.

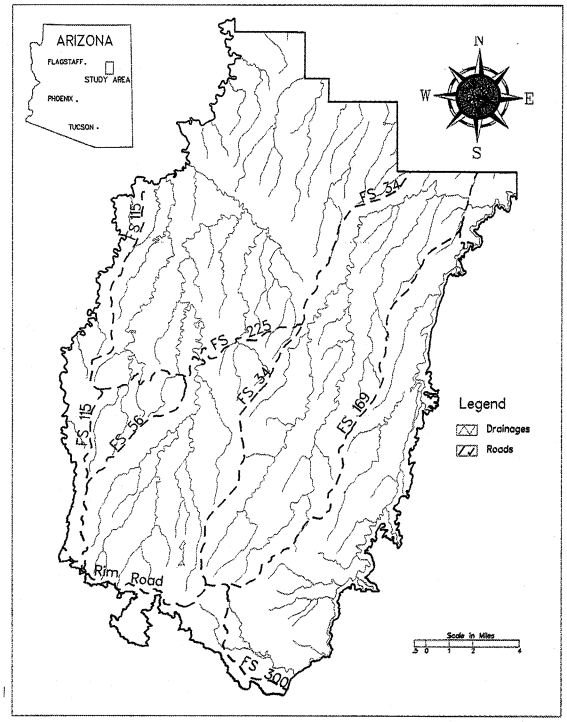


Figure 3.
Location of study area.

STUDY AREA

The study area, a portion of GMU 4A (Fig. 3), was located on the Mogollon Rim and represented median conditions of moisture and temperature for the Mogollon Rim habitat complex. The Mogollon Rim is a geologic uplift that occurs from northwestern Arizona through the mid-eastern portion of the state. The escarpment abruptly rises up to 1500 ft above the rolling hills to the south.

The study area encompassed approximately 335 mi^2. Elevations ranged from 6000 ft in the northern portion to 8000 ft at the edge of the Mogollon Rim itself. Parent material of the area was dominated by Kaibab limestone and Coconino sandstone (Darton 1965). Annual precipitation at Chevelon Ranger Station averaged 18.6 in over the past 20 years, with over 50% falling during winter storms (Natl. Oceanic and Atmos. Admin. 1990). Much of this winter precipitation was snow, and depths have reached 2-3 ft at higher elevations. Snow depth on the lower winter range has occasionally reached 8-12 in, but seldom persisted. Summer rainfall began in July and continued into September, usually in torrential and localized thunderstorms. Late April through June, and late September through mid-November have normally been dry periods. Temperature extremes ranged from -10 F to approximately 90 F (Natl. Oceanic and Atmos. Admin. 1990).

Plant communities on the study area were the Rocky Mountain Montane conifer forest and the Great Basin Conifer Woodland (Brown et al. 1979). The 3 major habitat types were the pinyon-juniper (*Pinus edulis-Juniperus* spp.) woodland, ponderosa pine forest, and mixed conifer forest. Ridge tops below 6800 ft were dominated by pinyon pine, alligator juniper (*Juniperus depeana*) and Utah juniper (*J. osteosperma*). Ponderosa pine dominated west facing slopes at higher elevations and mixed conifer species dominated east facing slopes. At elevations over 7600 ft, mixed conifer became the dominant vegetation type and included Douglas-fir (*Pseudotsuga menzesii*), white fir (*Abies concolor*), limber pine (*Pinus flexilis*), Rocky Mountain maple (*Acer glabrum*), and aspen (*Populus tremuloides*). A large component of Gambel oak (*Quercus gambelii*) occurred in localized pockets throughout the study area.

Logging and grazing were the major commercial land uses on the study area. Cutting of fuelwood, particularly in the pinyon-juniper woodland, has increased over the past 2 decades. Logging began on the study area in the late 1930s and most ponderosa pine stands have been logged at least once. However, little logging occurred on steeper slopes in larger canyons. Until the 1960s, sheep were the primary livestock on the area. Since then, summering cattle were predominant. One sheep allotment was active immediately east of the study area.

The study area received high use by recreationists and hunters during summer and fall. Camping and fishing activities were common throughout the summer. Many small and big game hunting seasons occurred during the fall.

Winter use was limited primarily to cross country skiers. Snowfall would frequently preclude motorized travel across the southern edge of the Mogollon Rim onto the study area.

A large elk population existed in the study area and shared both winter and summer range with turkeys. Mule deer (*Odocoileus hemionus*) summer and winter ranges also overlapped turkey habitat.

Pinyon jays (*Gymnorhinus cyanocephalus*) were common on the winter range and are known to gather and cache large numbers of pinyon nuts. Abert's squirrels (*Sciurus aberti*) occurred on both winter and summer turkey range and red squirrels (*Tamiasciurus hudsonicus*) were relatively common in the mixed conifer portions of the summer range. Black bears (*Ursus americanus*) and raccoons (*Procyon lotor*) were present, and may compete with turkeys for mast, in addition to being potential nest predators.

Major mammalian predators on the area were coyotes (*Canis latrans*), bobcats (*Felis rufus*), and gray fox (*Urocyon cinereoargenteus*). Mountain lions (*Felis concolor*) were also relatively common.

Avian predators included goshawks (*Accipiter gentilis*), Cooper's hawks (*A. cooperi*), and red-tailed hawks (*Buteo jamaicensis*). Both golden (*Aguila chrysaetos*) and bald eagles (*Haliaeetus leucocephalus*) wintered on site. The latter were observed attempting to prey on turkeys at trap sites. Ravens (*Corvus corax*) were also common.

METHODS

Capture and Telemetry

Wild Merriam's turkeys were captured with box traps, drop nets, and rocket nets. Box traps were constructed of wooden panels with a drop gate over the front. They were abandoned as a capture technique for a number of reasons. First, turkeys must become conditioned to coming to a bait source, and continue to use it while the trap is slowly constructed around the bait. This takes a period of days. For this technique to work, natural foods must be limited. Second, only a limited number of turkeys may be captured in a box trap at a given time. Finally, turkeys injured themselves much more severely in box traps than they did when captured by other methods.

The drop net was the second capture technique used. Drop nets, which measured approximately 40 ft on a side, were suspended on 9 poles approximately 6 ft above the ground. The nets were dropped using an automotive solenoid, a 12 volt automotive battery, and a simple normally open, push button switch to trigger the solenoid from a remote site. These nets proved to be superior to box traps by limiting injuries and

Figure 4.
Rocket net in use.

increasing the number of birds captured at a time. These nets still required time for the turkeys to adjust to their presence. If food availability was good, turkeys were less likely to use the baits after the box trap or net was in place.

Rocket nets yielded the highest capture rates with acceptable levels of capture injury. These nets measured approximately 60 ft x 40 ft. The net was folded accordion style along its length, within a 3 x 60 ft canvas tarp that was folded once along its length (opening towards the bait site). The net was secured to 3 rockets on a side and 5 anchor points on the other (Fig. 4). The rockets used solid rocket propellant, which was ignited by electronic current supplied by an automotive battery through a simple normally open, push button switch.

All sites were baited with whole oats throughout the winter months (December through March) of 1986-87, 1987-88, 1988-89, and 1989-90. Other bait items, corn, hay, and alfalfa sprouts, were used, but less successfully than oats.

Bait sites were selected close to major roads for accessibility, yet removed from major disturbance, throughout the winter range. Bait was placed in small openings only slightly larger

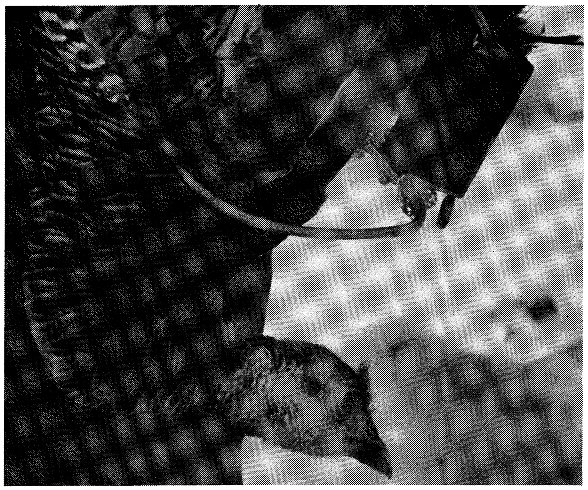


Figure 5.
Merriam's turkey with radio telemetry unit affixed.

Figure 6.
Release of turkey following capture and handling.

than the trap or net, and surrounded by dense vegetation. As with other capture devices, rocket nets were set at bait sites when sign at the site indicated turkeys were using the bait repeatedly. Emphasis was placed on the capture of female turkeys, because I considered hens to be reproductively more critical in a polygamous population.

Birds were equipped with radio transmitters manufactured by Telonics (Mesa, Arizona) or AVM Electronics (San Francisco, California). Each transmitter was attached to the back of a turkey by a leather harness passed through the unit and around both wings (Fig. 5). The antenna was oriented along the back and toward the tail of the turkey. In addition, each bird was also marked with 2 low visibility patagial wing tags.

Each transmitter had a motion sensor that would change pulse frequency after 2-13 h of inactivity. This feature allowed us to determine that the animal was no longer moving or dead.

During the winters of 1986-87 and 1988-89, blood samples were taken from 42 of the captured birds in order to test for exposure to mycoplasmosis. Cloacal and choanal swabs were also taken from the same birds to test for exposure to *Chlamydia psittaci*. If a specific disease could not be isolated from the samples, we evaluated the potential prevalence as described by Wehausen (1987). The evaluation was undertaken because of the low probability of detecting diseases that have a minor incidence. The evaluation was also used in cases where low level of disease were detected in the samples. All measuring and sampling work was performed on the turkeys at the capture site and all birds were released after data were recorded (Fig. 6).

Mortality Rates

An effort was made to locate a signal from each transmitter at least twice weekly (Fig. 7). Radio signals were at times obstructed by topography and aircraft were then used to aid telemetry location. When pulse frequency indicated that the transmitter had been motionless, the cause for inactivity was investigated as soon as possible. Mortalities were classified by cause of death. Those that we could not determine the cause of death were so noted.

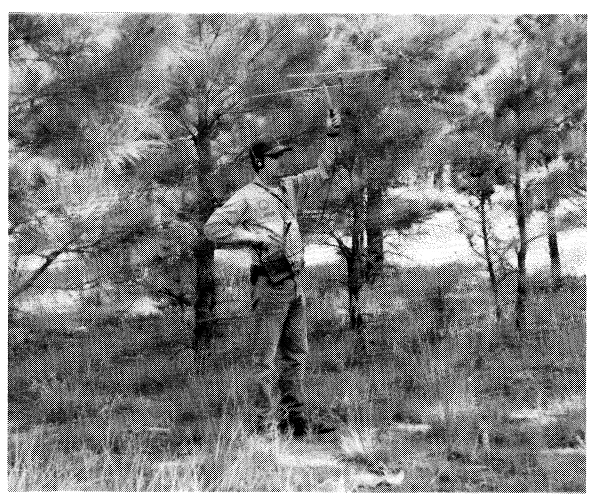


Figure 7.
Use of radio telemetry equipment to locate turkey.

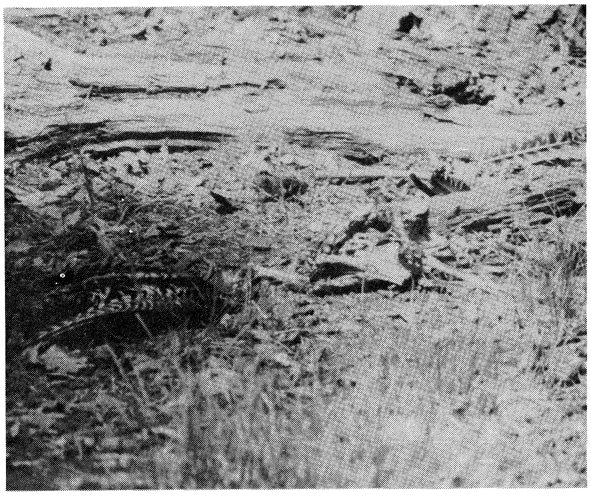


Figure 8.
Turkey mortality as a result of raptor predation.

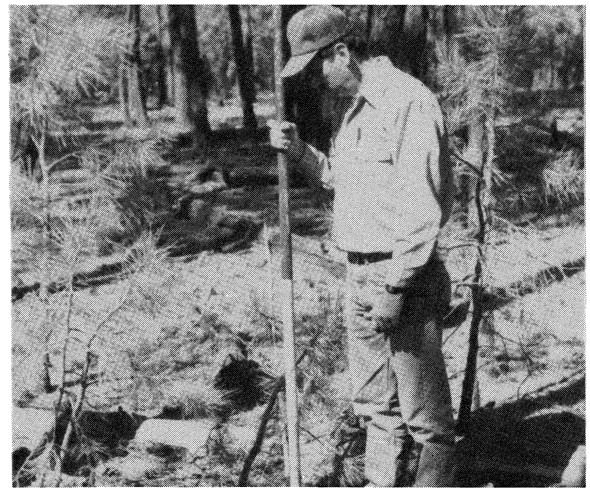


Figure 9.
Use of the line intercept transect to measure structure.

Mortality rates were calculated according to Heisey and Fuller (1985). Three time intervals were chosen that represented periods of constant mortality rate. The first interval corresponded to the breeding, nesting, and brood rearing season between April 1 and August 15. The second was from August 16 through October 20 and encompassed the hunting season. The final mortality interval corresponded to the late fall and winter, between October 21 through March 31. Likelihood ratio tests (Sokal and Rohlf 1981:695, White 1983) were used to determine if mortality rates for each interval remained constant. Cause-specific rates were calculated for major sources of mortality. Differences between cause-specific mortality rates were also determined with a likelihood ratio test.

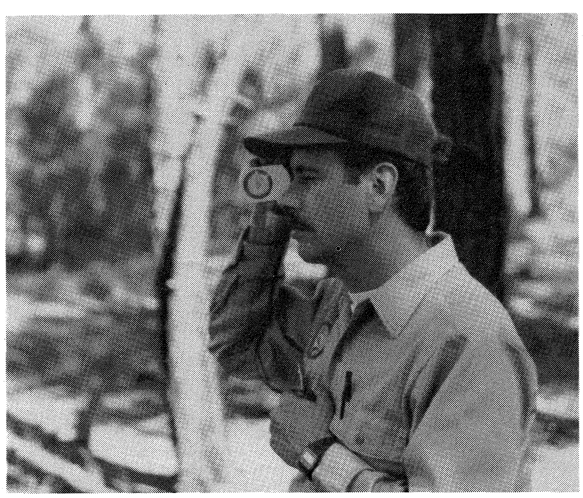


Figure 10.
Use of the clinometer to measure slope.

Because turkeys are difficult to age beyond their first year, juvenile birds were monitored through time to obtain age specific survival information. A life table (Downing 1980) was developed based on survival of known age turkeys and augmented with information on brood and juvenile survival.

Mortality Sites

The location of each mortality was plotted on 7.5' USGS topographic maps and digitized using the ARC/INFO geographical information system (GIS). If the exact location was discovered (Fig. 8), habitat characteristics of the site were measured. Four 25 ft line intercept transects (Fig. 9) were established, at right angles to each other. The first transect was oriented randomly and all radiated from the center of the mortality site. Percent canopy cover of forbs, grasses, rocks, shrubs, deciduous and coniferous trees, litter, and slash was estimated from these transects in 3 height categories; 0-17.9 in, 18-35.9 in, and 36-72 in, and the average height of cover in each category was estimated.

Slash volume was estimated using a photo key (Fischer 1981), and then classified into 4 slash volume index categories. This procedure was used because Mollohan and Patton (1991) suggested that slash volume from this key was useful only as an index. Slope (Fig. 10) and aspect were measured at each site. Vegetative association (Larson and

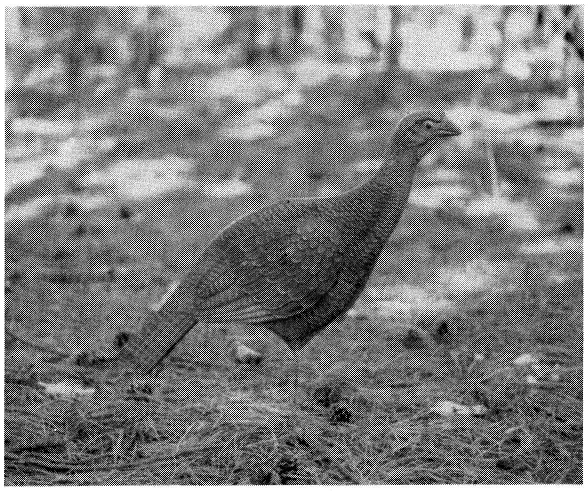


Figure 11.
Silhouette used to estimate horizontal visual distances.

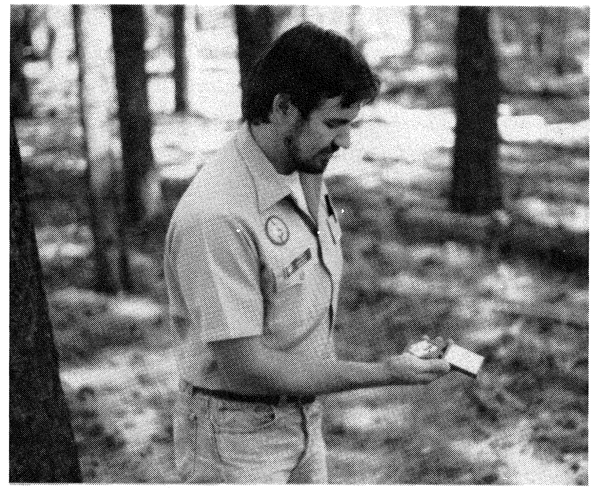


Figure 12.
Spherical densiometer used to derive canopy closure.

Moir 1986) and R03WILD structural stage (Byford et al. 1984) were also determined at each site. Canopy structure was classified as single canopy, 2 storied, multi-storied, indistinct stories, or clumpy (uneven aged multiple stories clumped in distribution).

Understory and overstory distribution was classified as clumped or uniform. The date of last logging entry was estimated to be current, within 1 year, 1-5 years, 6-20 years, greater than 20 years, or unlogged. Landform was classified as canyon header, minor canyon wall, minor canyon bottom, draw, main canyon wall, main canyon bottom, flat, wet meadow, or dry meadow and the relative position on slope determined.

Horizontal visibility at the site was determined by using 2 measures of vegetative and topographic cover. The first technique used a commercial turkey decoy silhouette (Fig. 11). The decoy was placed in the center of the site, and the distance was paced from the decoy to where it was totally obscured. This distance was estimated parallel to each line intercept transect. Similarly, the distance from the site center to the point where a person was totally obscured was determined. This procedure resulted in 4 estimates of horizontal visibility at each site. These 4 estimates were averaged to obtain a representative summary statistic that indicated horizontal obstruction (cover). In addition, green foliage volume was estimated according to MacArthur and MacArthur (1961).

Canopy closure was estimated using a spherical densiometer (Fig. 12) and a technique modified from Strickler (1959). Four readings were made at right angles to 1 another, 37.2 ft from the mortality site center on each of the same bearings as the orientation of the line intercept transects. These 16 readings resulted in 4 estimates of canopy closure. An average canopy closure value was then calculated. Stem density of shrubs and deciduous trees by seedling, sapling, and adult class was determined on a 0.01 ac circular plot. Stem density and diameter at breast height (4.5 ft, DBH) of coniferous trees (Fig. 13) was recorded on a 0.1 ac circular plot. The height to the first canopy was also estimated.

If an opening in canopy cover was present, the distance to, and the length and width of the

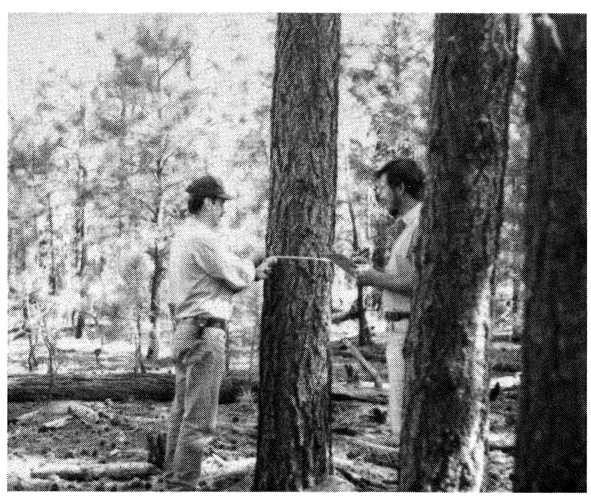


Figure 13.
Use of diameter tape to determine stand characteristics.

opening was recorded, along with, estimated percent ground cover, enumerated forb and grass species, and estimated height of herbaceous vegetation. Distance to cover from the mortality site and average height of herbaceous vegetation at the site were also recorded. A stand density index (SDI) was calculated according to Reineke (1933) and Smith (1987) using stem density of conifers and DBH of trees at the site.

Categorical habitat data collected at each mortality site were plotted as frequency distributions to examine each as a potential mortality influence. In this manner, the frequency of death by landform, position on slope, canopy structure, overstory and understory distribution, and fuels volume could be examined. Continuous habitat data were divided into 4 quartile classes of identical interval width. Each of these quartile classes were evaluated as a potential mortality source. Ground cover by height category, slope, aspect, canopy closure, turkey silhouette obstruction, and person obstruction were evaluated in this manner.

Population Model

A population model describing population fluctuations during the study was developed based upon 7 measured variables. Data from roadside surveys (Appendix 1) were compared to simulated August population levels. Poults were defined as young turkeys through August of their hatching year. Juveniles were defined as young turkeys that survived through the January following hatching. Yearlings were turkeys that survived until June of the year following hatching. Adult turkeys were considered to be those that survived at least 2 years from June in their hatching year.

The 7 variables in the population model were nesting rate, nesting success, clutch size, poult survival through August, juvenile survival to mid-winter, annual yearling survival to the next mid-winter, and annual adult survival. August population indices were calculated from a hypothetical population estimate using survival rates for adult and yearling hens from mid-winter to mid-August.

Nesting rate was defined as the proportion of instrumented adult hens that were known to have nested from the study population. This information was documented by locating the nest of an instrumented hen or locating an instrumented hen with a brood even though her nest was not located. This technique underestimates nesting rate because some hens may have nested before they could be located.

Nest success was defined as the proportion of nesting hens that successfully hatched at least 1 egg. This technique overestimates nest success due to the same bias mentioned for nesting rates. The effects are inversely related and should tend to nullify the overall effects of the bias on the population model. Clutch size was estimated based upon observations of eggs and egg shell fragments from successful nests.

Poult survival was defined as the proportion of poults that survived to mid-August. This value was estimated to be the quotient of poults per hen, considering only those observed with poults, divided by the average clutch size that year.

Poult:hen ratios were obtained by conducting brood surveys during the third week in August. These road survey routes were 15 miles in length and were conducted in both directions each morning at sunrise (Shaw 1973). Vehicle speed on these routes was limited to 15 mph. This technique overestimates brood survival because the proportion of hens that successfully nested and subsequently lost the entire brood cannot be determined.

An estimate of the proportion of each age class in the fall harvest was obtained from a hunter check station maintained during the opening weekend of the fall hunt. Hunters voluntarily allowed harvested turkeys to be aged and sexed. Age was determined by plumage development and sex was determined by gonadal examination.

Juvenile survival to mid-winter was defined as the proportion of poults that survived to mid-winter. Juvenile to hen ratios were calculated from winter classifications of captured turkeys. The juvenile to hen ratio was adjusted to correct for poultless hens observed during the August brood surveys. The ratio was multiplied by the quotient of the number of poults per hen observed with poults, divided by the number of poults per total hens observed.

Yearling and adult annual survival rates were calculated according to Heisey and Fuller (1985). Survival rates for juvenile and adult hens through the August brood survey period were also calculated according to Heisey and Fuller (1985), and corresponded to the breeding-nesting-brood interval rate.

Accordingly, next year's adult hen population (X_1) can be determined by:

$$X_1 = (X_0 * a) + b$$

where:

X_0 = this year's adult population,
a = this year's annual adult survival,
b = next year's recruitment of yearling hens.

Next year's recruitment (b) can be calculated by the equation:

$$b = X_{-1} * c * d * e * f * g * h$$

where:

X_{-1} = last year's adult population,
c = last year's adult nesting rate,
d = last year's adult nest success rate,
e = last year's clutch size,
f = last year's brood survival,
g = last year's juvenile survival to mid-winter,
h = this year's yearling survival.

The combined August adult and yearling population number (A) can be calculated by the equation:

$$A = (X_0 * a_1) + (b / h * h_1)$$

where:

a_1 = this year's breed-nest-brood adult survival,
h_1 = this year's breed-nest-brood yearling survival.

These equations require an estimate of the initial population size and an estimate of the initial year's recruitment into the adult population.

Once this model was completed, individual variables were averaged across years. The average annual population growth was calculated based upon the average variables. Individual variables were manipulated to the magnitude observed in measured variables during this study, while holding all other variables constant in order to isolate the factors that had the greatest influence on projected population numbers 5 years in the future. This was not developed as a predictive model primarily due to the multiplicative propagation of the error component associated with each variable. This model facilitated the evaluation of the effects of measured variables on the population.

Possible correlations between hatching date and the date of last recorded temperature less than 24 F (suggested by Reeves (1953*b*) as a factor in nesting), snow, and mast production were evaluated using simple regression (P = 0.10). Snowfall was categorized as a dominant factor during the winter, or as a non-dominant factor. Snow accumulations were considered to be dominant when accumulations exceeded 1 ft in depth for greater than 20% of December through March days.

Mast production was categorized as high or low. High production was assumed to occur on years that abundant mast crops were readily located. Low mast production was assumed to occur during years when concentrations of mast crops were difficult to locate. These categories were then coded as dummy variables for this analysis. Simple regression was also used to evaluate any relationship between nest success and rate, and snow presence code, mast production code, and precipitation in the prenesting quarter of the year. Correlations between clutch size and last date of recorded temperature less than 24 F, snow presence code, mast production code, and precipitation in the prenesting quarter of the year, were evaluated similarly. In like manner, potential relationships between brood survival and precipitation during June and June through July, as well as juvenile survival and mast production code and precipitation from October through December, were evaluated.

Habitat Selection

Home Range Selection. From 1987 through 1989, 3-6 radio instrumented turkeys were located twice weekly by visual location or triangulation. These birds were selected because the majority of their home range was in either pinyon-juniper, ponderosa pine, or mixed conifer habitats. Approximately 1/3 of the sampled birds used each habitat type. Locations were plotted on USGS 7.5' topographic maps. Locations were digitized using GIS. The minimum convex polygon and harmonic mean home ranges were calculated following exclusion of outliers (Samuel et al. 1985). Home range size was regressed on number of locations to evaluate sample size adequacy. Only those home ranges that exceeded 80 locations were used for analysis.

Observations were also tested for independence (Schoener 1981, Swihart and Slade 1985). Utilization distributions (UD) (Hayne 1949, Jennrich and Turner 1969) were determined from a grid cell system developed and adjusted to provide maximum resolution. Fourier transforms were used to smooth abrupt transitions between matrix cells (Anderson 1982). Matrix cells that exceeded equal use (Samuel et al. 1985) were ordered by proportion of use. Significance of use was tested against a uniform distribution using a 1-sided Kolmogorov-Smirnov goodness-of-fit test (Zar 1984). Areas where use significantly exceeded a uniform distribution ($P = 0.05$) were considered to constitute the core area. The 90% harmonic mean was considered to bound the habitat available to the animal.

Terrestrial ecosystem survey (TES) information (Laing et al. 1989) on vegetation types on the study area was entered into the GIS database. Eleven habitat types were identified for selection analysis. Habitat selection was considered to occur if the core area habitat composition was significantly different from that available (90% harmonic mean) using chi-square and Bonferroni analysis (Neu et al. 1974, Marcum and Loftsgaarden 1980, Zar 1984).

Nest Site Selection. The sites used for nesting were determined by locating and observing radio instrumented hens. Hens were suspected to have begun nesting when daily movements localized, and frequent inactivity was detected by radio telemetry signals. Specific location of nesting hens was not determined for 1-2 weeks following suspected onset of nesting to avoid disturbance. The location was determined prior to hatching and monitored to determine exact date of hatching. Clutch size was determined from egg shells remaining in the nest. Nesting success was defined as hatching at least 1 poult. Successful hatching was determined by eggshell characteristics and visual observations of the hen and brood following departure from the nest site.

Habitat characteristics of each nest site were measured after the hen left the nest. Habitat characteristics measured at each nest site were identical to those measured at mortality sites, with the site centered around the nest bowl. All data were tested for normality. Differences between successful and unsuccessful nests were determined by chi-square contingency table analysis for categorical data. Non-normal continuous data were ranked and tested with the Mann-Whitney U test. Normal data were compared with t-tests (Zar 1984).

Nest sites were also compared with identical measurements at random locations, and differences between categorical data were determined by chi-square contingency table analysis. Differences between habitat categories were determined using Bonferroni confidence intervals (Neu et al. 1974), and the degree of selection determined using Jacobs' D statistic (Jacobs 1974). Non-normal continuous data were ranked and compared with the Mann-Whitney test. Non-normal continuous paired data were ranked and tested with the Wilcoxon signed-ranks test. All tests were considered significant at $P \leq 0.10$.

Merriam's turkey hen on nest.

RESULTS

Mortality Rates

Two hundred nine turkeys were captured during the winters of 1986-87 through 1989-90 (Table 1). Radio instrumented turkeys were monitored equivalent to 120 turkey years. Yearling annual mortality fluctuated from a high of 54.8% in 1989 to a low of 16.2% in 1990 (Table 2). The leading causes of mortality, in descending order of magnitude, were coyote, bobcat, and hunting (Table 3).

Table 1. Method of capture and sex of tagged Merriam's wild turkey on the Chevelon Study Area, 1986-1990.

	Box Trap		Drop Net		Rocket Net		
Year/Sex	M	F	M	F	M	F	Total
1986-87	0	1	0	15	0	0	16
1987-88	5	20	14	52	0	0	91
1988-89	0	0	1	6	0	17	24
1989-90	0	0	0	0	6	72	78
Subtotal	5	21	15	73	6	89	
Total	26		88		95		209

Table 2. Annual survival and mortality rates (*P*) and confidence intervals (CI) for yearling and adult hen turkeys by year.

Year	Class	Yearling		Adult	
		P	(CI)	*P*	(CI)
1987	Survival	-	-	0.537	(0.288-1.000)
	Hunting	-	-	0.130	(0.000-0.367)
	Coyote	-	-	0.000	
	Bobcat	-	-	0.000	
	Avian Predator	-	-	0.203	(0.000-0.456)
	Other	-	-	0.130	(0.000-0.367)
	Total Mortality	-	-	0.463	
1988	Survival	0.783	(0.564-1.000)	0.518	(0.368-0.728)
	Hunting	0.000		0.056	(0.000-0.131)
	Coyote	0.174	(0.000-0.422)	0.093	(0.000-0.179)
	Bobcat	0.000		0.023	(0.000-0.068)
	Avian Predator	0.000		0.108	(0.004-0.213)
	Other	0.043	(0.000-0.126)	0.202	(0.055-0.349)
	Total Mortality	0.217		0.482	
1989	Survival	0.452	(0.180-1.000)	0.812	(0.675-0.978)
	Hunting	0.170	(0.000-0.473)	0.000	
	Coyote	0.189	(0.000-0.521)	0.076	(0.000-0.179)
	Bobcat	0.000		0.000	
	Avian Predator	0.000		0.036	(0.000-0.106)
	Other	0.189	(0.000-0.521)	0.076	(0.000-0.178)
	Total Mortality	0.548		0.188	
1990	Survival	0.838	(0.592-1.000)	0.736	(0.593-0.913)
	Hunting	0.000		0.000	
	Coyote	0.000		0.123	(0.008-0.238)
	Bobcat	0.162	(0.000-0.453)	0.000	
	Avian Predator	0.000		0.035	(0.000-0.104)
	Other	0.000		0.105	(0.000-0.218)
	Total Mortality	0.162		0.264	

Table 3. Mean annual survival and mortality rates (*P*) and confidence intervals (CI) for yearlings, adults, and combined.

Class	Yearling		Adult		Combined	
	P	(CI)	*P*	(CI)	*P*	(CI)
Survival	0.688	(0.509-0.929)	0.667	(0.580-0.768)	0.681	(0.598-0.775)
Hunting	0.045	(0.000-0.130)	0.030	(0.000-0.063)	0.026	(0.000-0.055)
Coyote	0.150	(0.000-0.314)	0.092	(0.037-0.147)	0.108	(0.050-0.864)
Bobcat	0.028	(0.000-0.083)	0.008	(0.000-0.024)	0.014	(0.000-0.032)
Avian Predator	0.000		0.077	(0.025-0.130)	0.050	(0.010-0.091)
Other	0.089	(0.000-0.215)	0.125	(0.058-0.192)	0.121	(0.058-0.184)
Total Mortality	0.312		0.333		0.319	

Table 4. Seasonal interval survival and mortality rates (*P*) and confidence intervals (CI) across all years for yearling and adult hen turkeys.

Time Interval	Class	Yearling		Adult	
		P	(CI)	*P*	(CI)
Breed-nest-brood (Apr 1-Aug 15)	Survival	0.915	(0.827-1.000)	0.877	(0.821-0.937)
	Coyote	0.028	(0.000-0.083)	0.057	(0.016-0.098)
	Bobcat	0.028	(0.000-0.083)	0.008	(0.000-0.064)
	Avian Predator	0.000		0.033	(0.001-0.064)
	Other	0.028	(0.000-0.083)	0.025	(0.000-0.052)
	Total Mortality	0.075		0.123	
Fall-hunt (Aug 16-Oct 20)	Survival	0.951	(0.862-1.000)	0.932	(0.881-0.986)
	Hunt	0.049	(0.000-0.142)	0.034	(0.000-0.072)
	Coyote	0.000		0.000	
	Bobcat	0.000		0.000	
	Avian Predator	0.000		0.011	(0.000-0.034)
	Other	0.000		0.023	(0.000-0.054)
	Total Mortality	0.049		0.068	
Winter (Oct 21-Mar 30)	Survival	0.790	(0.605-1.000)	0.816	(0.731-0.911)
	Coyote	0.140	(0.000-0.319)	0.042	(0.000-0.089)
	Bobcat	0.000		0.000	
	Avian Predator	0.000		0.042	(0.000-0.089)
	Other	0.070	(0.000-0.202)	0.100	(0.029-0.168)
	Total Mortality	0.210		0.184	

Adult annual mortality fluctuated from a high of 47.2% in 1988 to a low of 18.5% in 1989. Years that yearling mortality increased, adult mortality decreased, and *vice versa* (Table 2). The leading causes of mortality to adult turkeys included coyote, avian predators, and hunting, in descending order of magnitude. Bobcats also preyed on adult turkeys. Other causes of mortality were 3 illegal kills and 1 road kill.

Yearlings experienced low mortality rates through the breeding-nesting-brooding interval (Table 4). Mortality rates through the fall-hunt interval were also relatively low. The highest mortality rates experienced by yearling turkeys were during the winter interval.

Adult hens experienced higher mortality rates than yearlings during the breeding-nesting-brooding interval (Table 4). During 1987 and 1988, avian predators were responsible for the greatest mortality rates for adult hens (Table 2). These were the same years in which poult to hen ratios were the highest (Table 5).

Fall-hunt interval mortality rates for adult hens were similar to mortality rates for yearling hens, although hunting mortality was somewhat less for adults (Table 4). Fall hunting was not found to have a large impact on annual survival in this study. Fall hunting mortality averaged 2.6% and never exceeded 5.6% during any given year. Check station data indicated adult hens comprised 34.7% and juvenile hens 9.9% of the harvest.

Table 5. Summary of population statistics from August brood surveys.

Variable	1987	1988	1989	1990
Total Turkeys Surveyed	255	62	74	51
Total Hens Surveyed	49	23	21	16
Total Poults Surveyed	205	38	53	35
% Hens w/o Poults	0	52	24	19
Total P:H Ratio	4.18	1.65	2.52	2.18
P:H w/poults	4.18	3.45	3.31	2.69

Table 6. Life table to age 3 based on known aged turkey hens.

Age	q_x	l_x	d_x	L_x	e_x
0	0.842	1000	842	579	0.86
Juvenile	0.441	158	70	123	1.78
Yearling	0.412	88	36	70	1.81
2	0.125	52	7	48.5	1.71
3	0.200	45	9	40.5	0.90

q_x Age specific mortality rate
l_x Number attaining this age from a beginning cohort of 1000
d_x Number dying each age from a beginning cohort of 1000
L_x Mean number alive between classes
e_x Mean additional life expectancy

Adult males comprised 4% and juvenile males 51.4% of the fall harvest. Yearlings experienced slightly higher mortality rates as a result of hunting than adults, though the difference was not statistically significant.

Adult and yearling hens experienced the highest mortality rates during winter. Poults experienced the greatest overall mortality rates. Life table estimates of survival indicate that poults have a low probability of achieving juvenile age, and only a slightly higher probability of attaining yearling age (Table 6). Turkeys that reach yearling age can be expected to survive almost 2 more years, as can 2 year old turkeys. Life expectancy decreases at age 3, although 2 turkeys that were known to be older than 5 years were monitored.

Mycoplasmosis was not detected in blood samples taken from 42 turkeys. According to Wehausen's (1987) technique, this sample of turkeys indicated that the infection rate was likely to be no higher than 5% of the population ($P \leq 0.10$). One adult turkey hen was necropsied following death by avian predation. *Mycoplasma* was found, though the species was not determined. Mycoplasmosis was isolated from no other turkey on the study area.

Chlamydia psittaci was isolated from 5 of 42 turkeys tested for this disease. This infection rate is assumed to be representative of incidence in the population because this level (11.9%) was higher than that predicted by Wehausen's (1987) technique (5%, $P \leq 0.10$). No turkeys were observed displaying clinical symptoms of disease during the course of the study. Neither the observed *Mycoplasma* nor *Chlamydia* levels are indicative of those associated with populations declining due to disease.

Table 7. Annual population characteristics.

Characteristic	1988	1989	1990
Nest Rate	0.620	0.330	0.405
Nest Success	0.679	0.909	0.600
Clutch Size	9.500	5.600	7.500
Brood Survival	0.363	0.591	0.359
Juvenile Survival	0.644	0.285	0.197
Yearling Survival to August	0.913	1.000	0.838
Adult Survival to August	0.768	0.935	0.948

Mortality Sites

Mortalities occurred more frequently within certain habitat categories (Fig. 14). Measures of horizontal visibility indicated that mortalities frequently occur in areas with shorter sight distances, indicating the presence of greater cover.

The landforms in which most mortalities occurred were minor and major canyons. Gentle slopes and easterly aspects had higher frequencies of mortalities than others.

More open canopies and uneven aged clumpy forest structure had higher frequencies of mortality than other forest structures. Clumped overstories and understories also had a higher frequency of mortality occurrence than evenly spaced uniform ones. Those habitats with 41-50% ground cover that was less than 18 inches in height had a higher frequency of mortality. Habitats that had lower canopy cover in the 18-36 in and the 36-72 in height categories have a higher frequency of turkey mortality. Essentially, far more mortalities occurred in those habitats providing the greatest cover.

No information was collected that would relate the amount of time turkeys spent engaged in various activities to the habitat used for those activities. However, of those mortalities measured and classified, the largest proportion was classified as feeding sites. Characteristics of the average mortality site are representative of a clumped, dense, uneven aged forest (Appendixes 2 and 3).

Population Model

Estimates of nesting rates, nesting success, clutch size, poult survival, juvenile survival to mid-winter (Table 7), yearling survival to second

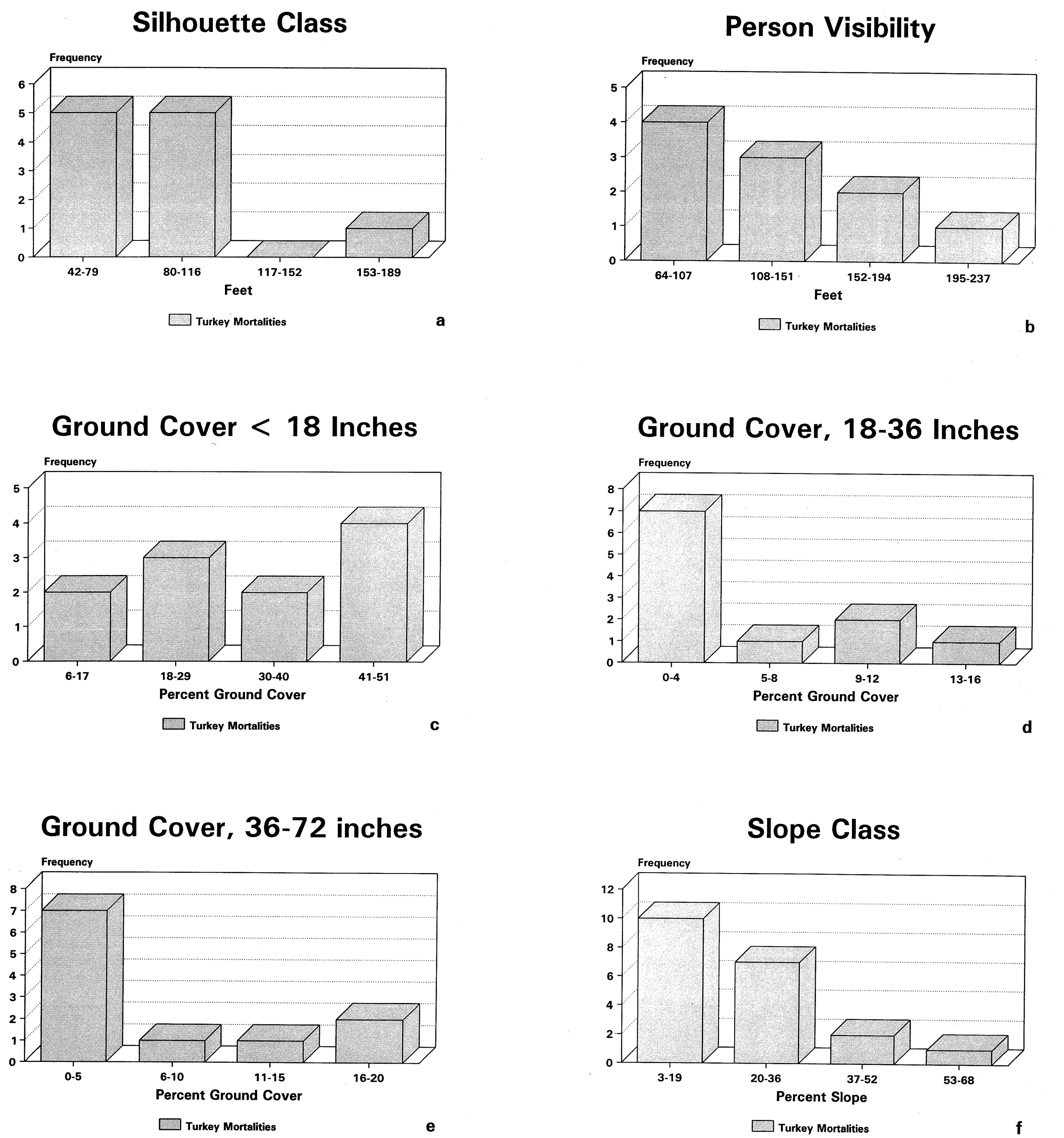
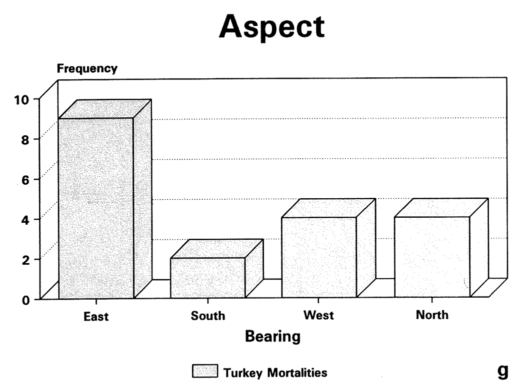


Figure 14.
Frequency of mortality by habitat category; (a) turkey silhouette visibility, (b) person visibility, (c) ground cover <18 in, (d) ground cover 18-36 in, (e) ground cover 36-72 in, (f) slope class, (g) aspect, (h) landform, (i) slash volume class, (j) canopy structure, (k) canopy closure, (l) overstory distribution, (m) understory distribution, and (n) probable activity engaged in at time of death.


Aspect
Frequency
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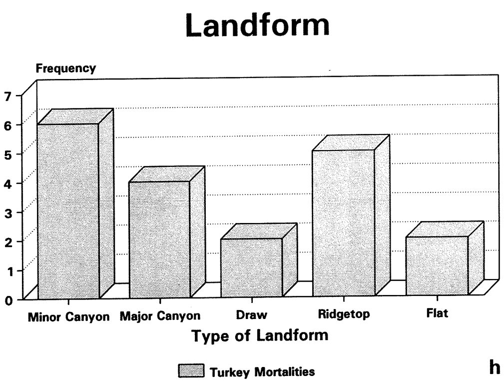
2
4
6
8
10
East
South
West
North
Bearing
Turkey Mortalities

g


Landform
Frequency
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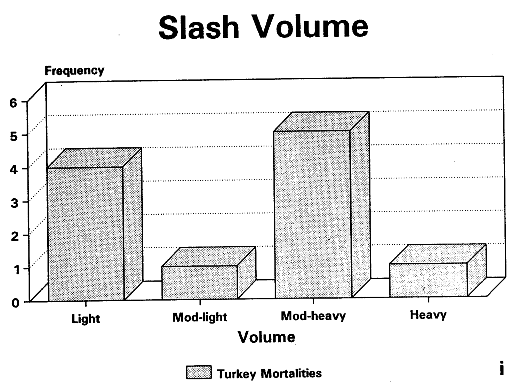
1
2
3
4
5
6
7
Minor Canyon
Major Canyon
Draw
Ridgetop
Flat
Type of Landform
Turkey Mortalities

h


Slash Volume
Frequency
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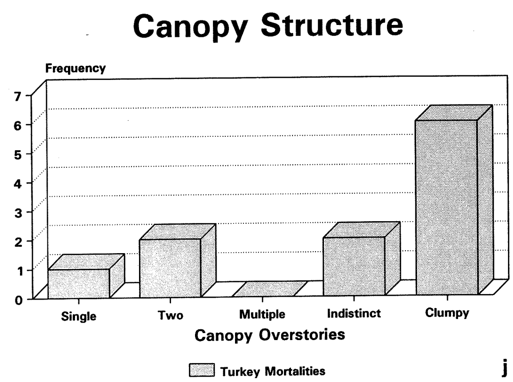
2
3
4
5
6
Light
Mod-light
Mod-heavy
Heavy
Volume
Turkey Mortalities

i


Canopy Structure
Frequency
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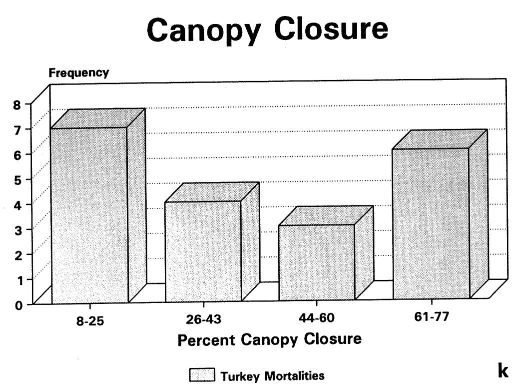
1
2
3
4
5
6
7
Single
Two
Multiple
Indistinct
Clumpy
Canopy Overstories
Turkey Mortalities

j


Canopy Closure
Frequency
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2
3
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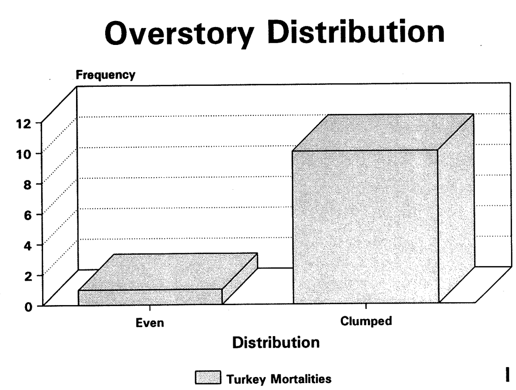
5
6
7
8
8-25
26-43
44-60
61-77
Percent Canopy Closure
Turkey Mortalities

k


Overstory Distribution
Frequency
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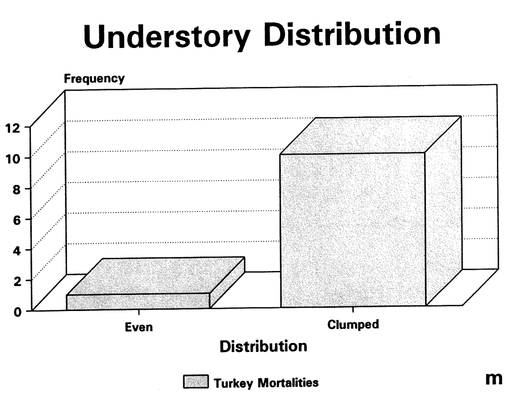
2
4
6
8
10
12
Even
Clumped
Distribution
Turkey Mortalities

l


Understory Distribution
Frequency
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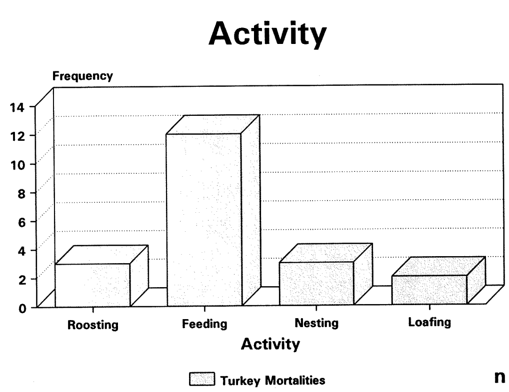
12
Even
Clumped
Distribution
Turkey Mortalities

m


Activity
Frequency
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2
4
6
8
10
12
14
Roosting
Feeding
Nesting
Loafing
Activity
Turkey Mortalities

n

Table 8. Simple regression equations between observed independent variables and measured dependent variables.

Equation	r^2	P
Hatch date = 217 - 0.541 (last day < 24 F)	0.754	0.3351
Hatch date = 113 - 4.250 (snow presence code)	0.066	0.8266
Hatch date = 115 + 11.750 (mast production code)	0.503	0.4985
Nest Rate = 0.421 - 0.091 (snow presence code)	0.490	0.5061
Nest Rate = 0.494 + 0.126 (mast production code)	0.938	0.1685
Nest Rate = 1.559 - 0.468 (precipitation prenest 1/4)	0.211	0.6905
Nest Success = 0.774 + 0.135 (snow presence code)	0.939	0.1664
Nest Success = 0.716 - 0.378 (mast production code)	0.074	0.8163
Nest Success = 2.112 - 0.585 (precipitation prenest 1/4)	0.289	0.6349
Clutch Size = 1.461 + 0.039 (last day < 24F)	0.056	0.8397
Clutch Size = 7.050 - 1.450 (snow presence code)	0.737	0.3473
Clutch Size = 8.025 + 1.475 (mast production code)	0.763	0.3291
Clutch Size = 14.348 - 2.883 (precipitation prenest 1/4)	0.048	0.8529
Brood Survival = 0.783 - 0.106 (June-July precipitation)	0.865	0.2477
Brood Survival = 0.476 - 0.041 (June precipitation)	0.203	0.6962
Juvenile Survival = 0.166 - 0.068 (mast production code)	0.422	0.5482
Juvenile Survival = 0.027 + 0.046 (Oct-Dec precipitation)	0.510	0.4937

winter, and adult survival rates (Table 2) were obtained from 1988 through 1990. No significant relationships ($P \leq 0.10$) could be found between observed population characteristics and measured climatic variables (Table 8).

August population indices were available from the population model for 1989 and 1990. The behavior of this index for 2 years was similar to August brood surveys (Fig. 15). This relationship was impossible to evaluate statistically, due to the lack of sufficient data points.

Based upon the deterministic model; observed maximum fluctuations in any single variable during the course of this study was sufficient to affect the population by 15% 5 years into the future (Table 9). The fluctuations observed in juvenile survival from poult age to mid-winter had

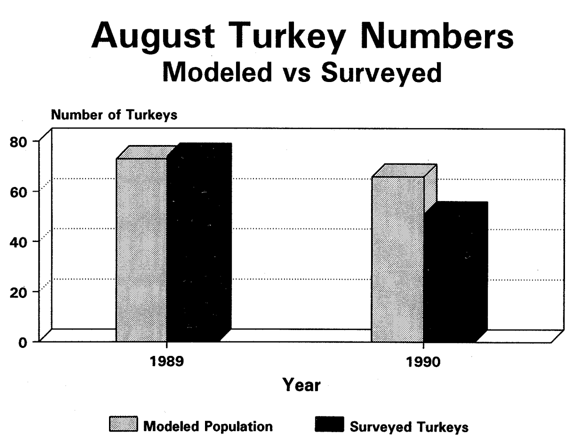


Figure 15.
Hypothetical projected August population numbers and surveyed numbers of turkeys.

Table 9. Projected fluctuations of 5-year population based on observed fluctuations and the percentage change in the 5-year population estimate as a result of a 10% change in factor.

Class	A	B	C
Nest Rate	64.2	23.1	3.6
Nest Success	42.4	15.3	3.6
Clutch Size	51.8	18.6	3.6
Brood Survival Rate	52.1	18.8	3.6
Juvenile Survival	119.6	43.5	3.6
Yearling Survival Rate	49.1	17.7	3.6
Adult Survival Rate	41.5	18.7	4.5

A Observed % fluctuation (max-min/$\bar{x}$)
B Projected 5-year population fluctuation (max-min/$\bar{x}$)
C Projected 5-year population fluctuation based upon 10% fluctuation in a given factor

the largest impact on the projected 5 year population level; 43.5% (Table 9). Nesting rate was found to be the next most influential factor, while nest success, clutch size, and brood, yearling, and adult hen survival have had similar impacts on the projected 5 year population level (Table 9). Adult hen survival was found to have the greatest impact on the population on a per unit change basis. In other words, a 5% change in adult hen survival was found to have a greater effect on the population than a 5% change in any other variable. The study population was determined to be increasing at the rate of 7.4% annually, during the 4 years of study, based upon average population characteristics. Breeding population levels declined by 3.8% between 1988 and 1989, increased by 58.7% between 1989 and 1990, and decreased by 18.2% between 1990 and 1991. The average annual fluctuation was 26.9%.

Habitat Selection

Home Range Selection. A sufficient number of relocations was obtained on 2 radio instrumented turkeys to achieve representative home range information. The size of the 90% harmonic mean annual home range for each was 82.5 and 67.0 mi^2. The core area, or that area which received higher use than expected if the distribution was uniform, was 32.0 and 26.1 mi^2. A 30% harmonic mean contour was computed because it enclosed clusters of observations most accurately. The area within the 30% harmonic mean encompassed 7.2 and 5.6 mi^2. The minimum convex polygon home range sizes were calculated as 59.7 and 40.2 mi^2. The home ranges of each of these birds included 8 of the 11 different habitat types identified on the study area (Fig. 16).

Analysis of the proportion of habitats within each contour and the use of that habitat by turkeys yielded no information that would suggest that a selection had been made. No significant differences between use and availability could be determined based on the 2 turkeys sampled. Seasonal areas of concentrated use were located within islands delineated by the 30% harmonic mean. Chi-square analysis indicated that the proportion of habitat associations used within the 30% harmonic mean contour, the core area, and the 90% harmonic mean contour were not significantly different ($P > 0.10$).

Nest Site Selection. Nests of 67 adult hens were located during the course of the study. No juvenile hens were documented to nest or lay eggs. Successful and unsuccessful nest sites could not be distinguished by habitat characteristics, with 1 notable exception. Successful nests had a higher ranked density of conifer trees per acre than did unsuccessful nests (Mann-Whitney, $P = 0.037$). No difference could be found in any other characteristic measured at nest sites (Appendixes 2 and 3).

A definite selection for nesting habitat, regardless of success, was documented. Instrumented turkeys selected nesting habitat dominated by clumpy, uneven aged forest structure (Appendixes 2 and 3). Nest sites were selected in areas containing more natural dead and down woody fuels than slash (Table 10). Only 2 nests were located in slash piles. Measures of visibility were less than expected based on random sites (Appendix 2). Canyons were the landform selected for nesting purposes (Table 10). Minor canyons were used to a much greater extent than they were available (Fig. 17). Steeper slopes were selected for nesting (Mann Whitney, $P < 0.0001$).

Mixed conifer vegetation was selected for nesting, while ponderosa pine types were avoided (Table 10). Habitat characterized by clumped understory and overstory vegetation, with clumpy, uneven aged canopy structures were selected for nesting. Average canopy coverage in the nest was 94.8%, 4 ft above the nest was 75.5%, and the canopy cover on the 0.1 ac surrounding the site was 52.2%. Though canopy cover of the site surrounding the nest was not significantly different from random locations (Mann Whitney, $P > 0.1$), it was significantly different than the canopy cover 4 ft above the nest (Wilcoxon, $P < 0.0001$). This latter cover was also significantly different than that found within the nest (Wilcoxon, $P < 0.0001$). Nest sites were selected in stands with clumped understories and overstories, and uneven aged clumped canopy structures. Single and 2 story canopied stands were avoided for nesting purposes (Table 10 and Fig. 17). Nest sites also possessed higher shrub and deciduous tree seedling density than random sites (Mann Whitney, $P < 0.0001$, and $P = 0.0114$, respectively). Densities of conifer trees at successful nests was not different than that found on random sites (Mann Whitney, $P > 0.10$).

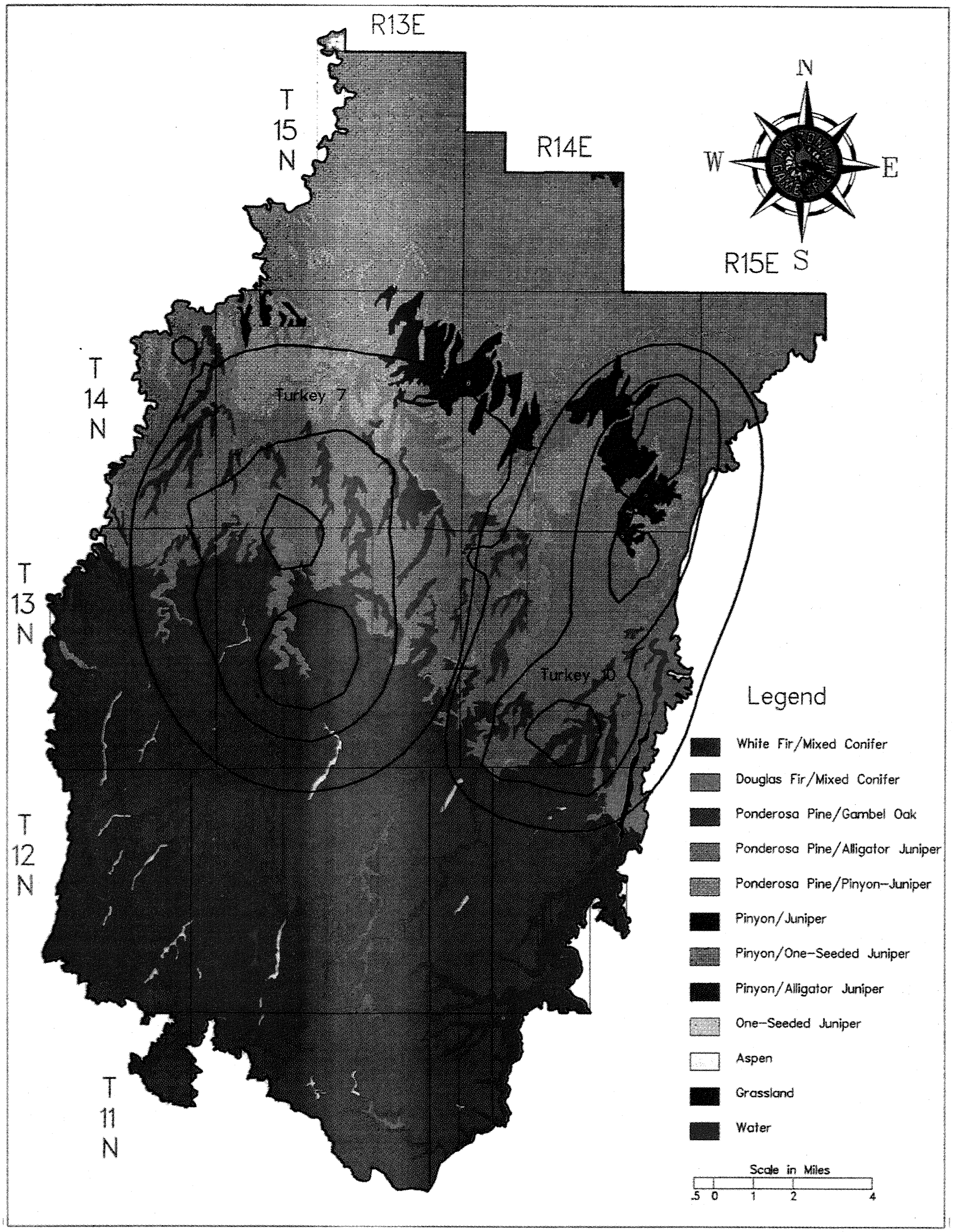


Figure 16.
Vegetation types on study area and home ranges of turkeys #7 and #10.

Table 10. Habitat components, Chi-square contingency table values, relative class proportions, and Bonferroni confidence intervals for turkey nesting.

Component	Observed	Available	CI	X^2	*P*
Landform				37.0719	<0.001
Minor Canyon	0.473	0.069	0.330 - 0.616		
Major Canyon	0.400	0.138	0.259 - 0.541		
Other	0.127	0.793	0.031 - 0.223		
n	55	29			
Fuels Class				7.3676	0.007
Natural	0.567	0.241	0.448 - 0.686		
Slash	0.433	0.759	0.314 - 0.552		
n	67	29			
Habitat Type				8.3862	0.004
Mixed Conifer	0.607	0.250	0.490 - 0.724		
Ponderosa Pine	0.393	0.750	0.276 - 0.510		
n	61	28			
Understory Distribution				4.5806	0.032
Even	0.222	0.448	0.111 - 0.333		
Clumped	0.778	0.552	0.667 - 0.889		
n	54	29			
Overstory Distribution				6.7172	<0.001
Even	0.241	0.552	0.127 - 0.355		
Clumped	0.759	0.448	0.645 - 0.873		
n	54	29			
Canopy Structure				17.0427	0.002
Single Storied	0.000	0.071	0.000 - 0.000		
2 Storied	0.151	0.429	0.036 - 0.266		
Multiple Storied	0.113	0.143	0.012 - 0.214		
No Distinct Stories	0.189	0.214	0.064 - 0.314		
Clumpy, Uneven Aged	0.547	0.143	0.388 - 0.706		
n	53	27			

The mean percent ground cover between 0 and 18 in was not different between nest and random sites. However, the composition of that cover was different. Nest sites were higher in the amount of grass, shrub, deciduous tree, and rock cover in the lowest height category (Mann Whitney, $P = 0.0175$, 0.0288, 0.0410, and 0.0218, respectively). The average height of this cover was also significantly greater than that found on random sites (*t*-test, $P = 0.0320$). Nest sites were also greater in canopy cover in the 18 to 36 in and 36 to 72 in height categories than random sites (Mann Whitney, $P = 0.006$, and 0.0483, respectively). Foliage volumes at heights less than 15 ft surrounding nest sites were greater than that measured at random sites (Fig. 18).

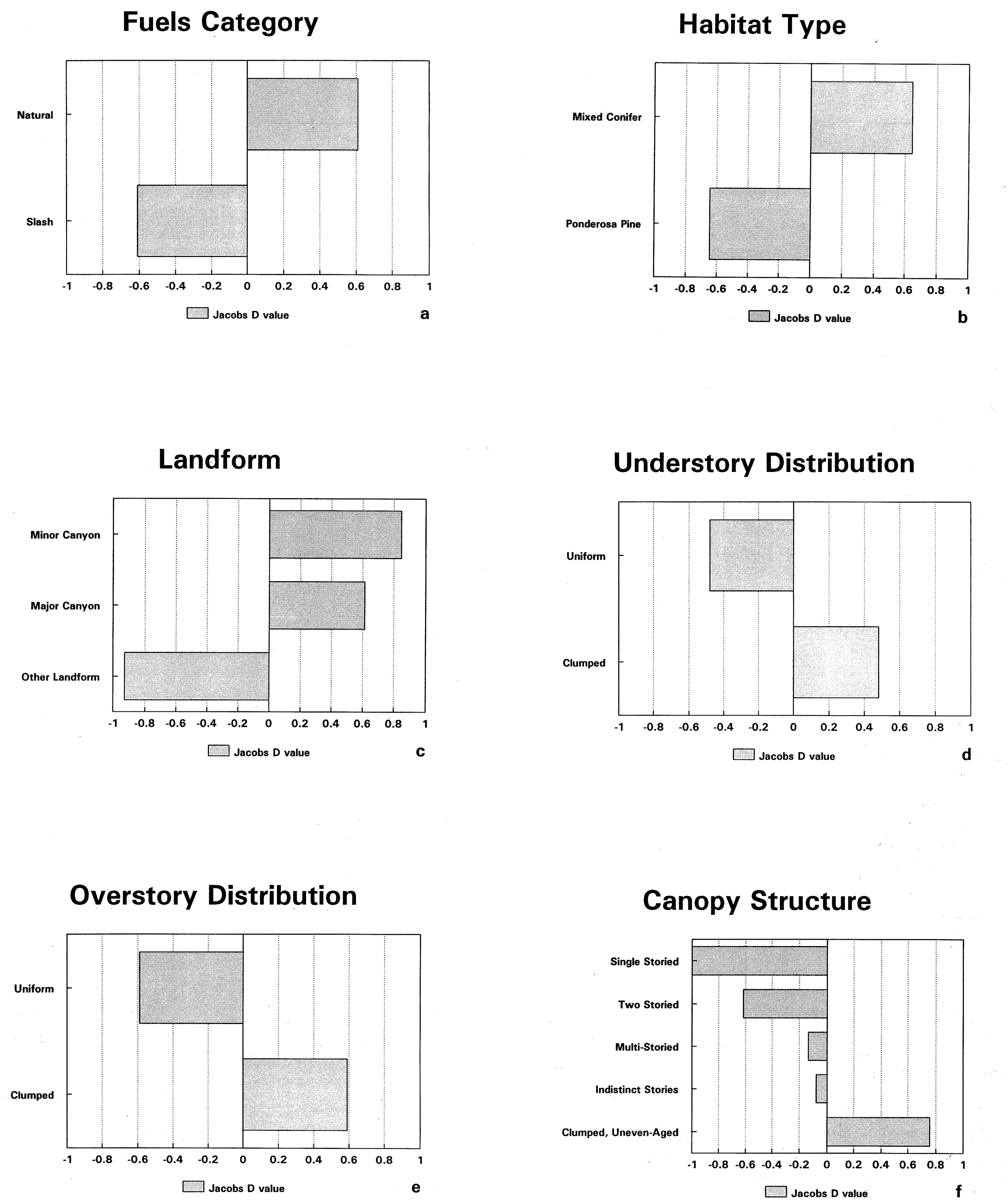


Figure 17.
Jacobs' *D* values for (a) fuels, (b) habitat type, (c) landform, (d) understory distribution, (e) overstory distribution, and (f) canopy structure.

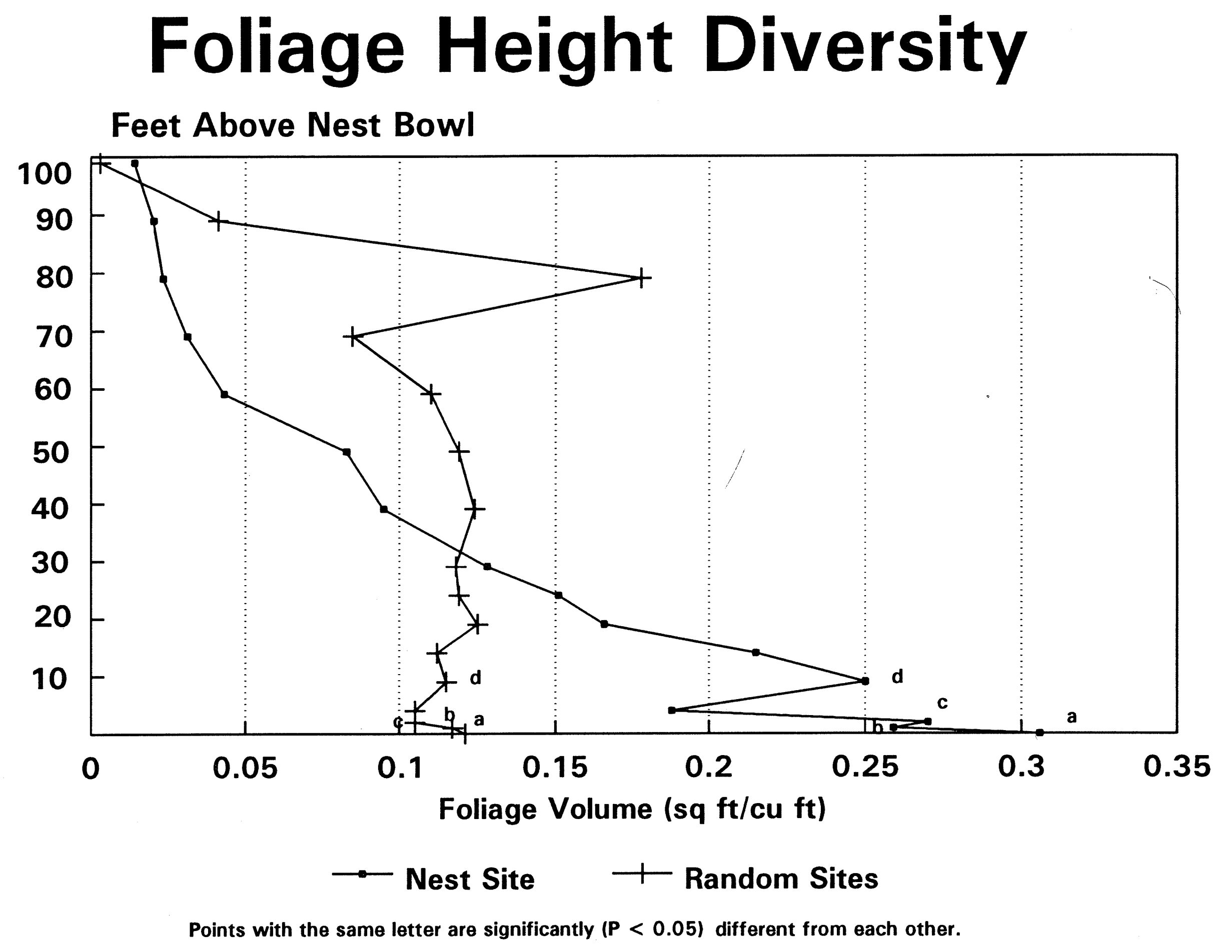


Figure 18.
Profile of foliage volume for nest and random sites.

DISCUSSION

Mortality Rates

Winter was the period of greatest mortality for hen turkeys on the Mogollon Rim. The degree of winter mortality in this study varied from year to year, and between adults and yearlings. Severe winters have long been suspected to result in fluctuations in turkey population numbers (Leopold 1931). This suspicion has been supported in many northern states (Austin and DeGraff 1975, Wunz and Hayden 1975, Porter et al. 1980). In more southern locations with less severe winters, spring is often a period of high mortality for turkeys (Speake 1980, Little et al. 1990). The breed-nest-brood time interval in the spring through summer was also identified as a period of high mortality for adult hens in my study.

Winter survival may be depressed due to a lack of winter food availability. Rumble (1990) determined ponderosa pine seed to be an important winter forage for Merriam's turkey in the Black Hills of South Dakota. Pearson (1951) documented different rainfall regimes in the Black Hills' and Arizona's ponderosa pine forests. He speculated that the effects of this rainfall on the Arizona habitats were increased growth and decreased regeneration, which would result in less food and cover. The study area appeared to lack a stable or diverse winter forage base and this may result in the subsequent higher winter mortality.

Turkey hen mortality during spring has been tied to the period of incubation and the first 2 weeks of brood rearing (Speake 1980). The breeding-nesting-brood interval had the second highest mortality rate for adult hens in my study. Avian predation was a larger factor in adult hen mortality at this time than at any other. Hens with broods were believed to be easy prey for many predators, and brood encumbrance jeopardizes the survival of a brood hen.

Yearling hens did not experience similar increases in mortality during the breed-nest-brood interval nor by avian predation in general. Yearling hens, because they did not nest, were not encumbered by the presence of broods.

Mollohan and Patton (1991) found that hens with broods used openings for feeding more frequently than hens without broods, during years when herbaceous vegetation was less abundant. This habitat use alone could account for increased predation rates, because predators could observe turkeys more easily in open habitat.

Survival for all hens varied between years. During years that adult hens had low mortality, yearling hens had high mortality. Conversely, years in which adults had high mortality, yearlings had low mortality. This mortality relationship appeared to be somewhat density dependent. During 1987, when adult hens had high mortality, they were also believed to comprise a large part of the population (based upon winter capture proportions). In 1989, yearlings comprised a larger portion of the population, and yearlings then experienced the greatest mortality rates (Table 2). Once again, when the yearling proportion of the population decreased in 1990, yearling survival increased and adult survival decreased.

In 1988, however, yearlings comprised the largest proportion of the population, and yet experienced a moderately high survival rate (Table 2). This departure from the relationship mentioned above may be the result of lower turkey numbers, as suggested by surveys that year (Table 5). The winter of 1988 was mild, with good food availability, which may have improved annual survival. Mild winters and improved food availability tend to result in decreased winter mortality (Wunz and Hayden 1975, Porter et al. 1980).

The effect of fall hunting on Arizona's turkey population is not readily apparent. Fall hunting in Missouri accounted for 3.2% of the mortality, despite the fact that hunter densities exceeded 3.5 hunters per mi^2 (Kurzejeski et al. 1988). Arizona fall hunter densities average approximately 1.5 per mi^2 (AGFD 1987) and resulted in a 2.6% annual mortality on the study population. Based upon this information, fall hunting does not appear to have much of an impact on Arizona turkey populations. Little et al. (1990) found that fall hunting did have a significant impact in their study, especially in mild winters when fall hunting mortality exceeded 10%. When fall harvest was closed in Arizona's GMU 3, spring harvest rate 2 years hence increased markedly (AGFD 1990). No correlary increase was observed in the adjacent GMU 4. Little et al. (1990) also found that the adult hen segment of the population was impacted the least in their study. Arizona check station information indicated that adult hens may comprise 30-40% of the fall harvest.

The mortality rate due to hunting may have been underestimated when hunters harvested an instrumented turkey, but failed to return the unit. This was not believed to have occurred frequently because large numbers of transmitter frequencies did not disappear following hunting seasons. Nevertheless, the adult hen segment of the population comprised a large proportion of the harvest during the fall hunt. Because adult hen survival was determined to have the greatest impact on the population reproductive potential, fall harvest may have a greater impact than fall hunting mortality rates indicated.

Survival of known age birds (Table 5) depicted a rather low survival rate for poults through the age of yearling. High mortality occurred amongst the poult and juvenile segment of the population. Young turkeys generally have high mortality rates (Glidden and Austin 1975, Everett et al. 1980, Speake 1980, Metzler and Speake 1985). The influence of habitat quality on the survival of young may be greater than that on older cohorts of the population (Metzler and Speake 1985). Mollohan and Patton (1991) pointed out the importance of herbaceous and horizontal cover in brood habitat in Arizona. Good cover in openings may result in improved brood survival. In order to provide adequate cover, control of grazing animals is of paramount importance. The impact of grazing animals, such as cattle, sheep, and elk on ground cover and herbaceous vegetation can be greatest during drought years.

Habitat quality can also affect productivity (Metzler and Speake 1985). Low recruitment can lower population numbers for an extended time, partially due to the lack of yearling nesting. Williams et al. (1976) concluded that the reproductive potential of the wild turkey was frequently underestimated. In xeric southwestern habitats, realistic limits of that potential may be easily overestimated because of periodic low adult and nonexistent yearling nesting rates. Again, due to the lack of juvenile nesting, turkey population numbers in Arizona may not respond as rapidly to favorable climatic conditions as other gallinaceous birds.

Turkeys on the Mogollon Rim showed low levels of disease, although it is conceivable that disease may have played a role in a historic decline. The prevalence of mycoplasmosis and *Chlamydia* in this study was such that they were not of concern; they did not play a role in the observed population fluctuations.

Mortality Sites

Many of the habitat parameters measured at mortality sites were similar to those measured at use sites by Mollohan and Patton (1991). The average mortality site yielded limited information on causal factors associated with turkey mortalities. Turkeys engaged in several activities throughout the day, and throughout the year. Consequently, if a hen was nesting when she was preyed upon, the site appeared to be a nesting site. If the bird was feeding, the site appeared to be a feeding site. Habitat use differs by season and behavior (Rumble 1990, Hengel 1990, Mollohan and Patton 1991), therefore average characteristic values of mortality sites approximated average characteristic values from all use sites.

Some insight was provided by the frequency of mortality by behavior. Feeding sites appeared to be the habitat where most mortalities occurred. Feeding sites tend to be more open than other behavioral use sites (Rumble 1990, Mollohan and Patton 1991), thus turkeys are more exposed when feeding. Feeding sites, however, did not tend to be more open than the sites where most mortalities occurred. In addition, the turkey's attention while feeding may have been diverted from vigilance and they were frequently moving. These activities might have made it harder for the birds to detect a predator and may have improved the possibility of a predator detecting the turkey. A relatively large proportion of time appears to be spent feeding, thereby increasing the amount of time at risk in that activity. In addition, any factor which forces turkeys to forage longer may increase the chances of predation.

Although fewer mortalities were associated with roosting and nesting, these activities appeared to endanger individual turkeys. Observed behavior at roost sites prior to roosting included a large amount of calling and activity on the ground for perhaps an hour prior to roosting. In the morning, turkeys call before leaving the roost, mill about on the ground, and congregate with a series of calls before they leave the roost site. All of these activities increased the chances of predation for turkeys at the roost site.

As extreme as roosting activities were in noise and motion, nesting activities tend toward the other extreme. Hens brooded for extended periods, unmoving and making no sound. Hens seldom left the nest site and little besides their scent could have possibly lured a predator to their location. Hens appeared reluctant to leave the nest, which probably enhanced nest success and increased the probability of hen predation.

Loafing sites were perhaps the safest habitat that a turkey could occupy. The sites provided cover for the turkeys, and yet they had good visibility from within the loafing clump (Mollohan and Patton 1991). A group of turkeys frequently loafed together, and at least a few of the turkeys were unmoving and vigilant at any time.

The habitat at mortality sites was representative of that used during the course of daily and annual activities. Because the characteristics of mortality sites were divided into quartile classes for analysis, I determined very few mortalities occurred in extremely open habitat. When compared with the characteristics of use sites, most mortality sites were similar to the less dense feeding habitat. Habitat management should be directed toward providing adequate habitat for the behavioral activities described by Mollohan and Patton (1991).

Population Model

Insufficient data were collected in this study to adequately evaluate the influence of environmental and climatic factors on measured population parameters (Table 8). However, 2 relationships appeared likely. Nest success seemed to be positively correlated with increased snow prevalence during the winter (r^2 = 0.939, P = 0.1664). The increased snow provides soil moisture in the spring that results in superior herbaceous and deciduous vegetation development. Both of these habitat components are important in nest site selection. Also, nesting rate appeared to be directly correlated with mast production (r^2 = 0.938, P = 0.1685). While mast does not provide a large quantity of vitamin A or E, frequently tied with reproductive performance, it does provide complex carbohydrates that can maintain body condition throughout the winter. Conversely, if mast items are absent and no other food source is available, body condition may decline to the point that nesting is reduced. I suspect that there are other relationships between climatic and environmental factors and population parameters, however, sample size precluded analysis.

Other research has documented or led to the suspicion of relationships between climatic and population parameters. Reeves (1953*b*) found a relationship between the number of consecutive nights during April and May that temperatures fell below 28 F and the poult:hen ratio observed in August brood surveys. He also believed weather conditions during early spring influenced hatching rates. His study documented that rainfall and low temperatures during the first few weeks following hatching could seriously affect poult survival. Lockwood (1987) speculated that there was a relationship between fall soil moisture and nesting rates. This relationship was also suggested by Beasom and Pattee (1980). The relationship of early spring moisture for green forage production and reproductive status has been identified for other gallinaceous birds (Swank and Gallizioli 1954). Some green plants may actually produce compounds that inhibit reproduction in dry years (Leopold et al. 1976). Reeves (1953*b*) recognized that a relationship between rainfall and turkey populations was likely through its effects on vegetation.

Nesting rates measured during this study were much lower than those found in other states. Nesting rates of 80% in New Mexico (Lockwood 1987) were higher than those found here. Mackey (1982) and Crawford and Lutz (1984) both found Merriam's turkeys nesting at rates of 100%, though sample sizes in both studies were small. Hengel (1990) found adult Merriam's hens in Wyoming to nest at rates of 78%, and yearlings to nest at rates of 56%. The highest rate observed during my study was 62% in 1988. Crites' (1988) average nesting rate in the Williams, Arizona, area (54%) was within the range of nesting rates observed during my study.

Nest predation rates tend to be high for turkeys in all habitats. Ligon (1946) reported almost a 50% loss from predation. Predation rates slightly higher than 40% were reported by Speake (1980) and Williams et al. (1980). Nest loss on my study was similar between the years of 1988 and 1990, but decreased to about 9% in 1989. The sample size in 1989 was the smallest during the study and may not have been representative of the population. However, this nesting period also followed the winter with the best food availability. Physiological fitness of the hens may have resulted in higher nest success due to a decreased need to leave the nest for food.

The population model developed from the various population parameters appeared to compare favorably with the number of turkeys surveyed in August. Although only 2 data points were available to evaluate the performance of the model, the relationship was encouraging. If additional data points were available, the ability of roadside surveys to monitor population trends could be evaluated. Yet, the limited data indicated that August roadside surveys may provide an index to population levels.

August surveys also provided an apparent index to the juvenile proportion of the population. The proportion of yearlings in the population was found to be correlated with percent of hens surveyed that were not accompanied by poults. This relationship:

$$\% \text{ poultless hens} = -2.8 + 71.3 \text{ J:H ratio}$$
$$r^2 = 0.742, P = 0.1100$$

has implications in the determination of the proportion of breeding hens in a population and the relative vigor of that population. If, for instance, August brood surveys indicate a poult:hen ratio of 4:1, it might appear that the population is expanding. However, if no yearlings appear in the population, 2 additional years will be required before any recruitment into the breeding population is realized. This may have been the case during the first year of this study. No juvenile birds were captured during the first winter, and no poultless hens were observed during the August brood surveys of 1987. This estimate in other instances might be verified with winter flock counts at points of winter concentrations. Criteria for aging turkeys in mid-winter has been described by Phillips (1982), but extensive practice is required.

Habitat Selection

Home Range Selection. Home ranges on my study area were quite large in comparison to those of eastern turkeys, which may be as small as 3 mi^2 (Kurzejeski and Lewis 1990). Home range size has been suggested as an inverse correlate of habitat quality (McNab 1963, Ables 1969, Brown and Balda 1977). A great deal of habitat is necessary in order for Merriam's turkey to live on the study area. However, the large home ranges of the turkeys on the Mogollon Rim may not reflect poor habitat quality, but rather an opportunity to escape snow accumulations and access different food sources. This opportunity may not be available to eastern populations that occupy habitats with less topographic relief.

Movements from summer to winter range seemed to correspond with the first heavy snowfalls. In years of good mast production, turkeys appeared to spend more time in concentrations of mast. At this time, group size tended to increase, probably in response to concentrated areas of food production. Eventually, snow depths appeared to make foraging difficult, and turkeys would migrate to lower elevations. Food availability appeared to control turkey movements in other habitats as well as in Arizona (Kurzejeski and Lewis 1990, Rumble 1990).

On at least 5 occasions, turkeys that were captured on the winter range north of road FS225, left the study area and moved south off of the Mogollon Rim. These birds generally returned to the study area in the spring, but would winter as far as 40 air miles from the capture site. The reasons for leaving the study area when these same turkeys have obviously wintered on the study area during previous winters was not discovered. Aberrant winter movements occasionally occurred, and there may not be fidelity to a given winter range.

Habitat selection, then, is difficult to assess on a large scale for an animal that uses such large areas of habitat. It would appear that turkeys have an apparent first order selection (Johnson 1980) that corresponds with ponderosa pine forests in Arizona. However, some of the densest populations occur in habitats with copious quantities of other vegetation types, such as mixed conifer forests in the White Mountains, or oak pinyon juniper habitats of lower elevations. Second order (Johnson 1980) selection appears to be less critical. The particular selection of the area in which a home range was located was not crucial, so long as the habitat structure and food base within that home range was adequate.

Third and fourth order (Johnson 1980) selection by Merriam's turkey was documented for specific habitat traits within vegetation types (Rumble 1990, Hengel 1990, Mollohan and Patton 1991). Turkeys seem capable of living in any vegetation type that provides those characteristics.

Diversity of mast and forage species (fourth order, Johnson 1980) are probably the most essential items for any range to support turkeys, so long as minimal cover and spatial habitat requirements are met. However, if the food base diversity is lacking in any habitat, the structure of that habitat is even more important. Though the forage base (fourth order) on the Mogollon Rim has not been studied since Reeves and Swank (1955), observations indicated that food was at least seasonally limited on the study area. Third order selection of habitat structure on the study area has been documented by Mollohan and Patton (1991), and the importance of the habitat selected by the turkeys for their continued survival cannot be overestimated.

Nest Site Selection. Habitat characteristics of successful and unsuccessful nest sites were identical on my study area, except for 1 characteristic; the density of conifer trees. Conifer tree density provided horizontal and overhead cover at nests. Both of these factors were important in nest site selection, although there was no difference in this characteristic between successful and unsuccessful nests. Average distance to water was less on unsuccessful nests (1045 ft) than successful nests (1679 ft), but differences were not significant. However, it may reflect the opportunistic encounter of nests by predators whose own densities might be higher near water.

Other studies in the southwest have detected differences between successful and unsuccessful nests. Crites (1988) believed he could distinguish between successful and unsuccessful nests based upon sapling density and down woody fuel volumes. Both were higher in number on successful nests. Lockwood (1987) believed nests were more frequently successful when selected in higher volumes of down woody fuels. Additionally, Lockwood (1987) determined nests in openings tended to be less successful. Habitat characteristics selected for nesting on the Mogollon Rim were similar to those of successful nests identified in their research.

Clumpy, uneven aged forests may have been important to turkeys for nesting purposes because this type of structure provided a multitude of potential nest sites. Few differences appeared between successful and unsuccessful nests, which indicated that nest predation is largely an opportunistic event. The availability of a large number of potential nest sites results in a greater effort by each predator for each nest encountered, and provides a larger selection of sites to a laying hen.

Rumble (1990), found in South Dakota that deciduous cover was important on second nests, because the later nesting took advantage of the phenological development of the vegetation. Earlier warm temperatures in Arizona's spring may have augmented the development of deciduous vegetation and improved the suitability of these sites for nesting at earlier dates. In years of late cold snaps or late winter storms, inhibited phenological development of deciduous plant species could impact the suitability of nesting habitat.

Mixed conifer habitats appear to be superior in providing adequate nesting components, and were selected for nesting purposes. Horizontal cover of mixed conifer nest sites was greater than ponderosa pine habitats (Mollohan and Patton 1991). Foliage volume estimates were greater at heights less than 15 ft, thus confirming the importance of cover in lower height categories. This cover requirement was also apparent in shrub densities and rock and grass abundance on nest sites. Mixed conifer nest sites had lower horizontal visibility than any other behavioral use site on the study area (Mollohan and Patton 1991).

Landforms most frequently used for nesting include minor and major canyons. These habitats are dominated by the habitat characteristics mentioned above. In addition, these landforms have steep slopes, another characteristic that turkeys selected for during the course of my study. Hengel (1990), Mackey (1982), and Goerndt (1983) all found the use of steep slopes for nesting similar to those on the Mogollon Rim. Goerndt (1983) believed more mesic slopes were used for nesting. Canyons on the Mogollon Rin tend to be the most mesic land feature, however, individual sites could be quite xeric due to the overstory and exposure.

Canyons were dominated by mixed conifer even at lower elevations. Due to the fact that the canyons have not been logged for the most part, stand structure tended to be uneven aged and clumped in distribution. Canyons, then, may have appeared more attractive to the turkeys for nesting due to characteristics found within them. Even nests that were located out of canyons had many of the same characteristics found at nests within canyons. These landforms and the characteristics found within them are extremely limited on the study area. The value of these areas to turkeys was extremely high during a short, but critical, time period.

Summary

Mortality rates of hen turkeys on the Mogollon Rim were lower than other southwestern states. In my study, winter mortality rates were higher than hunting and poaching rates. Because the adult hen segment appears to comprise 30-40% of the fall harvest, the impact of that harvest may be greater on the population than the low harvest rate may indicate.

Mortality sites measured, by definition, reflect the habitat in which the turkeys died. Comparison of these sites with specific behavioral use sites indicate that mortality sites are not different from those sites. Characteristics of mortality sites may be misinterpreted by managers to represent poor habitat. Habitat should not be managed to minimize characteristics of mortality sites, but rather be managed to provide for optimum nesting, loafing, and roosting sites. Feeding sites were generally available, however, the diversity and quantity of forage items may be limited. Diversity of forage should be a goal.

The survival of young turkeys through their first year was found to create the greatest fluctuations in population numbers. Perhaps the biggest factor affecting brood survival is the quality of the brood habitat. Adult hen mortality though, appears to have the greatest impact on the population on a per unit change basis. In other words, improving adult hen survival by 5% will have a larger impact on the population than improving any other variable. Consequently the effects of fall hunting on adult hens on the population may not be fully realized. Although the average population parameters appear representative of a stable population, average values can be misleading due to the magnitude of annual variation.

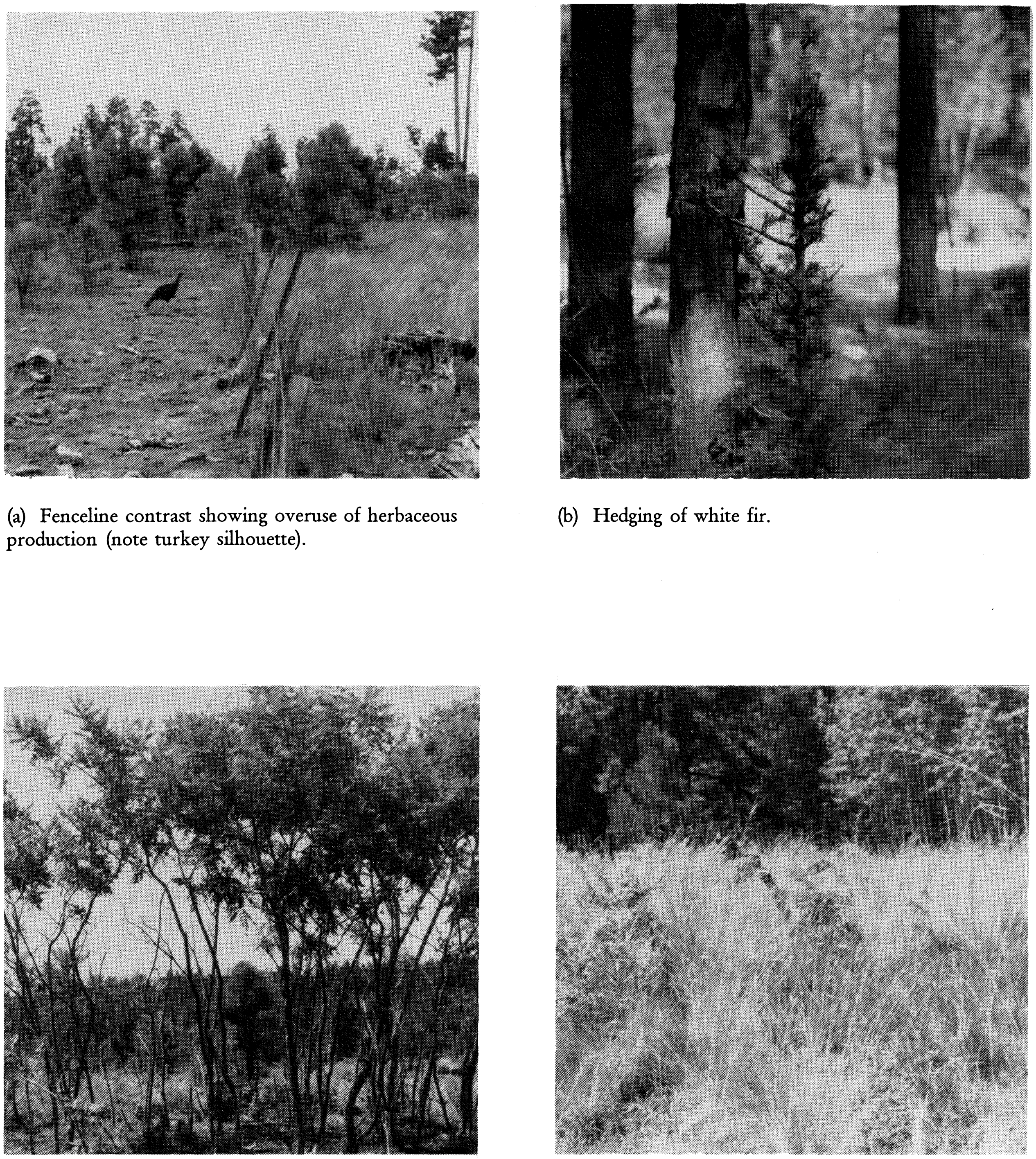
The leading cause of mortality to hen turkeys in my study was predation, and coyotes were the most successful predator. Coyote density should affect predation rates, but controlling coyote densities, in the long term, is a difficult, if not impossible task. Adult hen survival should improve if suitable nesting, loafing, and escape cover are available. Effects of habitat improvement are usually longer lasting, though frequently slower to occur, than the effects of predator control.

The habitat required for self-sustaining populations of Merriam's turkeys appears to cover a broad spectrum. The habitat type must provide roosting, feeding, loafing, nesting, and brood habitat, but ponderosa pine forests in association with many other vegetation types in Arizona can provide those features. Turkeys appear to select habitat at a scale finer than gross habitat type. The habitat type was of less importance, but the cover, density, and distribution of habitat components was of utmost importance.

The characteristics of habitat used by turkey on the Mogollon Rim for nesting and other behavioral use areas (Mollohan and Patton 1991) were selected in a greater proportion than that in which they were randomly available. Timber and grazing management practices appear to directly alter turkey habitat (Fig. 19). Turkeys select areas with high cover values and clumpy distributions. Even aged management of timber on large blocks (greater than 80 ac) of habitat necessitates a reduction of cover values and emphasizes uniform tree distribution. Turkeys that may continue to use this habitat are likely to be susceptible to higher predation rates due to reduced escape cover.

Turkeys require tall herbaceous vegetation for nesting and brood rearing. Grazing levels that result in low herbaceous cover directly influence the suitability of habitat. Turkeys also rely on grass seed during late fall and early winter (Reeves and Swank 1955). Grazing levels on winter range can influence winter survival by reducing forage availability. Grazing pressure may be exerted by either cattle, elk, or any other grazing animal. Regardless of the source, grazing levels that reduce herbaceous cover below 10 in on nesting and brood range, or remove more than 60% of the seed heads on winter range, probably reduce the productivity and survival of turkeys.

Although population numbers appear to fluctuate greatly between years, the fluctuation seems cyclic and may be indicative of a relatively stable population. this does not rule out the possibility of a historic decline. The magnitude of that decline, however, was indiscernible. Data suggest that turkey numbers will decline if additional habitats are modified to reduce horizontal and vertical diversity and sound range management principles are not applied.



(a) Fenceline contrast showing overuse of herbaceous production (note turkey silhouette).

(b) Hedging of white fir.

(c) Browse line on New Mexican locusts.

(d) Excellent forage production and edge contrast (note turkey silhouette).

Figure 19.
Examples of an array of turkey ranges.

MANAGEMENT IMPLICATIONS

Population Monitoring

The study of Merriam's turkey on the Mogollon Rim provided insight which may be addressed in an array of management options. In order to determine population trends in turkey range, population levels must be monitored across years. Turkey populations fluctuate markedly between years, and consequently long term databases are superior to short term ones in evaluating population trends. Following is an array of options which may be employed to monitor turkey population levels. Once an option is selected, the longer and less altered the method of obtaining the data remains in use, the more useful the data will be for determining population trends.

Maximum Survey Efforts. This option requires 3 separate monitoring efforts, standardized summer brood surveys, opportunistic winter flock classification, and fall hunter harvest evaluation. Summer brood surveys yield an estimate of brood survival, the yearling proportion of population based upon correlation with hens observed without poults, and a gross index to population levels. Winter flock surveys yield an estimate of the juvenile proportion of the population and juvenile survival. Fall harvest per hunter day may be the most reliable index of population trend, assuming harvest rate is related to population density and hunter densities do not vary markedly.

Summer range can be monitored annually using roadside surveys during the third week in August. Routes would be established on existing roads throughout all representative habitat. If used, routes should be 15 miles in length and placed at the rate of approximately 1 route per 30 mi^2 of summer range. Surveys should be conducted along these routes in both directions for 4 consecutive days, driven at speeds not to exceed 15 mph, and surveyed at daybreak with 1 observer per vehicle. Because most observations of turkeys are in the morning, evening routes are not necessary. This should result in approximately 12 hours of effort for every 30 mi^2 of habitat surveyed. Locations of all sightings should be marked and possible repeat observations noted. Each observation is recorded individually. The objective of this survey is to encounter and classify as many different groups of turkeys as possible.

Summer surveys can be complemented by winter flock counts. The counts may be conducted in any area of winter turkey concentration if sampling from the same population from which summer surveys were conducted. These flock counts are not as repeatable as summer surveys because concentrations change with winter severity and food availability. Consequently, concentrations can be classified whenever they may be found on winter range. Criteria for classification of age in winter flocks was described by Phillips (1982).

Following is a list of parameters and calculations that may be obtained from these surveys:

Brood survival = poult:hen ratio /9
- 9 is the average clutch size

Yearling proportion of population = % hens w/o poults

Population index = number of nonrepeat observations

Juvenile proportion of population = juvenile:adult ratio in winter

Juvenile survival = (juvenile hen:adult hen ratio/ % poultless hens in summer surveys)/ (poult:hen ratio in August)/2)
- compares ratios of hens to juveniles in 2 time periods
- the 2 as divisor corrects for sex ratios in summer poults

This approach allows managers to evaluate the population index from summer surveys with that from fall harvest rates. By monitoring various parameters of survival and mortality, managers will also develop justification for concerns over increasing or decreasing population numbers.

Disadvantages of this approach include expense and human resource needs. Despite increased effort, this methodology is not guaranteed to detect every fluctuation experienced by the population. Additionally, there is no statistical analysis suggesting that this approach will detect significant deviations in population levels.

Minimal Survey Efforts. Classification counts may be conducted throughout routine summer activities. Turkeys that are encountered can be classified. This approach has a gross correlation with population density and less with brood survival. Because turkeys are classified throughout the summer, broods are encountered at various ages. Mortality continues to reduce brood size, at various rates, throughout the summer. Because of the long sampling period and the lack of standardization, mortality rates cannot be adequately assessed. Nonrepeat observations cannot be ascertained and true proportions of hens without broods cannot be determined. Although effort cannot be duplicated between years, data should be recorded on a unit effort basis.

Benefits of this sampling method include less expense and manpower. Harvest information is still available to monitor population levels.

No Survey Efforts. Classification counts may be abandoned. This approach would decrease expense and effort and allow limited resources to be redirected. Harvest information could be monitored for population trend. Shortcomings of harvest data include influence of climatic variables during hunt periods and unequal harvest effort.

This approach would not provide data if a hunt was closed or changed. Population levels would remain unmonitored until the hunt was reopened. If an interim survey was then implemented, no data would exist for comparison purposes.

Population Options

Population management objectives generally relate to a decrease or increase in a target population. A response to management activities by the turkey population may not parallel responses by other species, and each must be evaluated separately. The following options are designed to provide the manager with an array from which a selection may be implemented to attain the desired objective. This array has been developed based upon conditions observed on the study area. The fact that populations in other areas exist at greater densities suggest that optimal conditions do not occur on the study area. However, the following options should function to affect turkey population numbers in most Arizona habitats. Managers are encouraged to implement any option from within this array that would help meet specific management objectives for their area.

Increase Turkey Population Numbers. In order to increase turkey numbers, habitat management should be emphasized. Timber treatments that improve within stand diversity, retain clumpy characteristics, and maintain high cover values provide suitable turkey habitat. Uneven aged management or group selection cuts tend to provide these characteristics. If even aged management must be implemented, stand size should not exceed 20 acres. Adjacent stands should differ by at least 30 ft^2/ac basal area and average mean DBH differences of 4 in. Stands that contain mast producing trees should not be harvested beyond the point that a person is observed at 150 ft. No logging should occur on slopes greater than 25%. Operations should cease at slope breaks and not reach beyond the slope edge. No logging should occur, between April 15 and June 15, adjacent to steep slopes to minimize disturbance of nesting and brooding hens. Clumps of trees with basal areas in excess of 140 ft^2/ac can be left surrounding large (greater than 12 in) downed logs. Large down logs and culls from logging operations should be left in the forest. Logs that remain in decks following sales and clean up should be replaced in dense clumps of trees beneath dense forest canopies. Slash cleanup adjacent to drainages should be by hand piling. This practice would ensure large logs were not piled and burned. All habitat manipulations should have the objective of achieving habitat described by Mollohan and Patton (1991) for each behavioral use site.

Grazing levels should be moderate. Brood range should not be grazed until after July 1. Rest rotation grazing systems should be used. Winter range pastures should provide good grass seed to improve overwinter forage for turkeys. Keep elk populations at levels that do not exceed carrying capacity.

Factors Detrimental to Healthy, Stable Populations. Turkey numbers can be influenced for long time periods by altering habitat. Large stands of monotypic, open ponderosa pine were not used by turkeys on the Mogollon Rim. A long term decline in numbers may result from even aged management of large stands (>100 ac) of timber on a landscape basis. The practice of removing mature and overmature trees along the edges of slopes and canyons has harvested suitable and active roost sites. Complete slash clean up following timber harvests will remove cover and increase horizontal visibility distances. Underburning slopes will remove structural materials used for nest sites.

Heavy grazing activities in brood range during early spring and areas used by turkeys in fall and winter after seedhead development may limit seasonally important food items. Grassy areas are important to broods because of insect and succulent herbaceous production. Seedheads are an important fall and early winter food source for all age classes of turkeys.

Hunting structures that emphasize the harvest of adult (≥2 year) hens may have a pronounced effect on turkey populations. This effect is the result of a lack of yearling reproduction and relatively short life expectancies of most turkeys. Hunters appear to harvest, either intentionally or by unconscious choice, the largest bird in fall flocks. Moving the hunt to an earlier date would result in fewer poults attaining adult size at the time of the hunt, and probably a larger proportion of adult hens in the harvest. Moving the hunt to a later date, however, might result in concentrations of turkeys in areas of fall mast crops, and hence achieve larger overall harvests.

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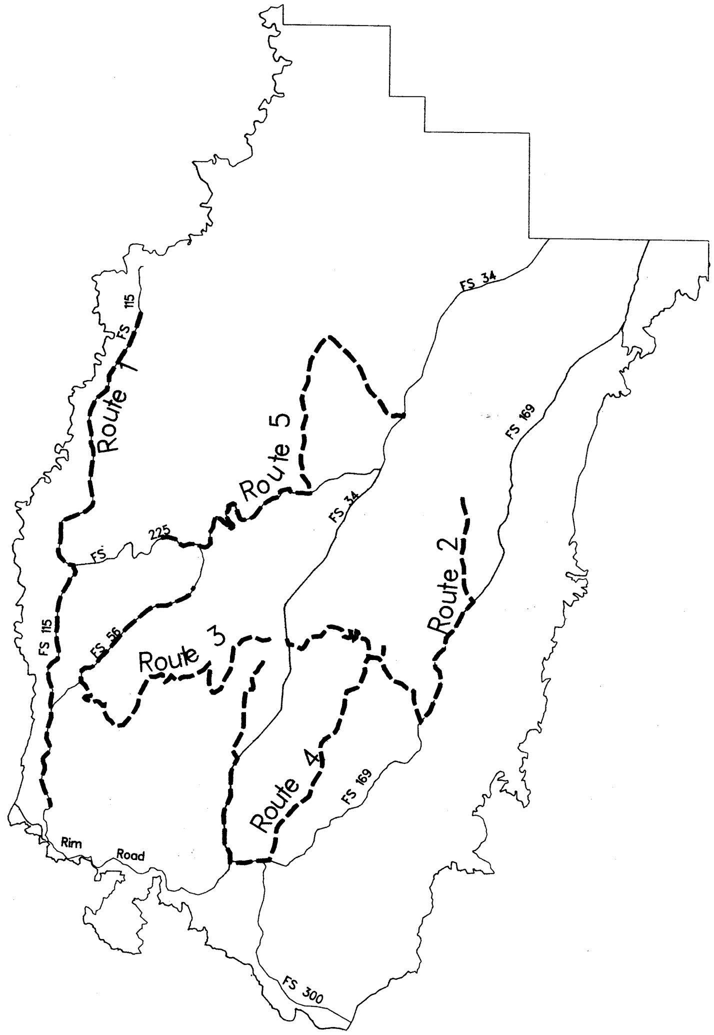
Appendix 1.



Route 1. From the junction of the 115 and 91 roads, drive 15 miles north on the 115 road.

Route 2. From the junction of the 34 and 100 roads, follow the 100 road east 8.1 miles to the junction of the 100 and 169 roads. Drive north 4.1 miles to the junction of the 169 and 213 roads. Drive northeast on the 213 road 2.8 miles to the end of the route (15 miles).

Route 3. From the northern junction of the 78 and 75 roads, drive west on the 75 road to its junction with the 89 road. Drive west on the 89 road to its junction with the 91 road. Follow the 91 road to its junction with the 40 road. follow the 40 road to its junction with the 56 road. Follow the 56 road northeast to the end of the route (15 miles).

Route 4. From the Vincent ranch road on the 78 road, drive south on the 78 road to the junction with the 75 road. Follow the 75 road east to its junction with the 34 road. Follow the 34 road south to its junction with the 300 road. Follow the 300 road east to its junction with the 169 road. Follow the 169 road northeast to its junction with the 117 road. Follow the 117 road north to its junction with the 100 road. Follow the 100 road east to its junction with the 116 road. Follow the 116 road to the end of the route (15 miles).

Route 5. From the juinction of the 34 and 70A roads, drive east on the 70A road to its junction with the 70 road. Follow the 70 road west and south to the 225 road. Follow the 225 road west to the end of the route (15 miles).

Appendix 2. Summary statistics for mortality, nest, and random habitat variables.

	Mortality			Nest			Random		
	$\bar{x}$	(SD)	*n*	$\bar{x}$	(SD)	*n*	$\bar{x}$	(SD)	*n*
Slope (%)	20.7	(17.4)	20	53.6	(24.8)	66	17.7	(11.9)	28
Turkey Silhouette (ft)	82.0	(39.6)	11	49.0	(27.0)	52	111.2	(39.6)	29
Person Visibility (ft)	134.9	(57.0)	11	76.0	(45.3)	53	160.2	(62.5)	29
Canopy Cover (%)	39.1	(22.6)	20	52.2	(21.7)	54	48.8	(25.1)	29
Shrubs/Acre	4000.0	(9757)	12	5959.7	(8884)	67	1017.2	(1719)	29
Deciduous Seedlings/Acre	1466.7	(3077)	12	2228.4	(4720)	67	169.0	(458)	29
Deciduous Saplings/Acre	58.3	(124)	12	300.0	(826)	67	10.3	(56)	29
Deciduous Adults/Acre	60.0	(123)	12	119.6	(398)	67	6.9	(37)	29
Average Height of Fuels (in)	17.5	(10.3)	21	17.7	(10.5)	63	16.3	(9.0)	29
Average Size of Fuels (in)	5.9	(2.7)	11	11.0	(5.8)	53	9.6	(4.5)	29
Height to First Canopy (ft)	12.0	(9.3)	8	8.8	(8.5)	43	6.7	(6.1)	17
Conifer/Acre	58.9	(33.7)	12	49.9[a]	(55.1)	67	60.2	(48.1)	29
Forb Cover <18.0 in	2.1	(2.7)	11	4.4	(5.3)	53	7.3	(8.8)	29
18.0-36.0 in	0.0	(0.0)	11	0.2	(0.8)	53	0.4	(1.5)	29
36.1-72.0 in	0.0	(0.0)	11	T	(0.1)	53	0.0	(0.0)	29
Grass Cover <18.0 in	5.6	(6.4)	11	6.0	(6.2)	53	10.8	(8.6)	29
18.0-36.0 in	0.3	(0.6)	11	0.2	(0.5)	53	0.1	(0.3)	29
36.1-72.0 in	0.0	(0.0)	11	0.0	(0.0)	53	0.0	(0.0)	29
Slash Cover < 18.0 in	5.2	(6.5)	11	4.7	(11.9)	53	6.0	(11.6)	29
18.0-36.0 in	0.6	(1.3)	11	1.5	(5.4)	53	0.7	(2.1)	29
36.1-72.0 in	0.1	(0.5)	11	0.6	(3.0)	53	0.0	(0.0)	29
Litter Cover < 18.0 in	8.5	(12.8)	11	8.0	(8.0)	53	6.4	(5.6)	29
18.0-36.0 in	T	(0.1)	11	0.6	(1.2)	53	0.1	(0.6)	29
36.1-72.0 in	0.0	(0.0)	11	0.3	(0.9)	53	0.0	(0.0)	20

[a] Successful 57.2 (63.9) 45
Unsuccessful 34.8 (25.7) 22

Appendix 2. (continued)

	Mortality			Nest			Random		
	$\bar{x}$	(SD)	*n*	$\bar{x}$	(SD)	*n*	$\bar{x}$	(SD)	*n*
Conifer Tree Cover <18.0 in	2.6	(3.8)	11	2.0	(3.0)	53	2.0	(2.5)	29
18.0-36.0 in	3.1	(4.0)	11	2.7	(3.7)	53	4.9	(6.4)	29
36.1-72.0 in	4.8	(5.6)	11	4.6	(6.5)	53	4.9	(6.4)	29
Deciduous Tree Cover <18.0 in	0.9	(1.8)	11	1.7	(3.0)	53	0.1	(0.3)	29
18.0-36.0 in	0.9	(2.6)	11	2.5	(4.6)	53	0.3	(1.6)	29
36.1-72.0 in	1.4	(3.4)	11	3.5	(6.3)	53	T	(0.1)	29
Shrub Cover <18.0 in	1.4	(2.8)	11	3.0	(4.7)	53	0.7	(1.4)	29
18.0-36.0 in	0.3	(0.7)	11	1.8	(3.0)	53	0.2	(0.8)	29
36.1-72.0 in	0.1	(0.2)	11	1.1	(2.8)	53	0.1	(0.3)	29
Rock Cover <18.0 in	5.3	(7.1)	11	14.4	(13.0)	53	8.1	(8.6)	29
18.0-36.0 in	0.0	(0.0)	11	3.9	(7.2)	53	0.2	(0.6)	29
36.1-72.0 in	0.0	(0.0)	11	2.3	(5.4)	53	0.0	(0.0)	29
Snag Cover <18.0 in	0.0	(0.0)	11	0.2	(0.7)	52	0.0	(0.0)	29
18.0-36.0 in	T	(0.1)	11	0.2	(0.9)	52	0.0	(0.0)	29
36.1-72.0 in	0.0	(0.0)	11	0.2	(0.7)	52	0.0	(0.0)	29
Total Cover <18.0 in	31.5	(14.0)	11	44.5	(19.6)	52	41.3	(16.7)	29
18.0-36.0 in	5.3	(4.5)	11	13.5	(10.7)	52	4.7	(6.5)	29
36.1-72.0 in	6.4	(6.9)	11	12.8	(9.5)	52	4.9	(6.4)	29
Average Height of Cover <18.0 in	6.5	(3.7)	11	10.6	(4.1)	49	8.2	(5.2)	29
18.0-36.0 in	25.1	(3.7)	11	25.4	(5.5)	49	25.2	(4.4)	22
36.1-72.0 in	55.4	(9.8)	10	57.5	(11.7)	48	54.0	(10.3)	20
Average Height of Cover Above Nest (ft)	--	--	--	4.0	(6.0)	47	--	--	--
Average Height of Herbaceous Vegetation at Sites (in)	7.6	(4.8)	11	--	--	--	9.5	(5.7)	29

Appendix 2. (continued)

	Mortality			Nest			Random		
	$\bar{x}$	(SD)	*n*	$\bar{x}$	(SD)	*n*	$\bar{x}$	(SD)	*n*
Distance to Opening (ft)	4.5	(9.2)	11	-	-	-	7.1	(14.6)	29
Length of Opening (ft)	71.4	(43.0)	11	-	-	-	127.0	(81.9)	26
Width (ft)	39.0	(31.5)	11	-	-	-	70.7	(45.7)	26
Number of Forb Species	5.4	(3.2)	11	-	-	-	8.8	(3.0)	29
Number of Grass Species	2.6	(1.6)	11	-	-	-	2.7	(1.0)	29
Average Height of Vegetation in Opening	7.0	(4.7)	11	-	-	-	9.8	(5.7)	29
Percent Ground Cover in Opening	27.5	(20.3)	10	-	-	-	47.3	(22.5)	27
Distance to Cover (ft)	33.2	(56.7)	11	-	-	-	36.4	(29.1)	29
Basal Area (ft^2)	109.3	(85.1)	6	96.1	(100.1)	36	73	(57)	29
SDI	199.8	(107.1)	7	143.9	(92.7)	64	-	-	-
Average Foliage Volume at Feet Above Ground									
1	0.126			0.306			0.121		
2	0.122			0.259			0.117		
3	0.115			0.270			0.105		
5	0.068			0.188			0.105		
10	0.058			0.250			0.115		
15	0.070			0.215			0.112		
20	0.060			0.166			0.125		
25	0.049			0.151			0.119		
30	0.036			0.128			0.118		
40	0.026			0.095			0.124		
50	0.023			0.083			0.119		
60	0.018			0.043			0.110		
70	0.009			0.031			0.085		
80	0.005			0.023			0.178		
90	0.0003			0.020			0.041		
100	0.0003			0.014			0.003		

Appendix 3. Frequency of habitat category classification for mortality, nest, and random variables.

	Mortality	Nest	Random
Logging History			
Unlogged	3	26	5
Current - 5 yrs	4	9	3
6-20 yrs	9	18	11
> 20 yrs	5	14	10
Aspect			
East	9	15	11
South	2	10	5
West	4	27	4
North	4	15	9
Landform			
Canyon Header	1	2	0
Minor Canyon Wall	3	20	2
Minor Canyon Bottom	2	4	0
Draw	2	3	10
Main Canyon Wall	4	21	3
Main Canyon Bottom	0	0	1
Ridge Top	5	3	1
Flat	2	1	12
Dry Meadow	1	0	0
Canyon Bench	0	1	0
Position on Slope			
Upper	5	13	5
Middle	6	20	0
Lower	5	31	2
Habitat Type			
Mixed Conifer	3	37	7
Ponderosa	9	24	21
Pinyon Juniper	7	1	0
RO3WILD			
10-40	7	34	22
41-70	3	16	5
71-100	1	2	1
RO3WILD			
2	4	2	1
3	3	18	18
4	1	14	5
5	3	13	1
6	0	5	3

Appendix 3. (continued)

	Mortality	Nest	Random
Canopy Structure			
1 Story	1	0	2
2 Story	2	8	12
Multiple Stories	0	6	4
Indistinct Stories	2	10	6
Clumpy, Uneven Aged	6	29	4
Understory Distribution			
Even	1	12	13
Clumped	10	42	16
Overstory Distribution			
Even	1	13	16
Clumped	10	41	13
Wood Type			
Dead & Down	8	38	7
Slash	13	29	22
Fuel Wood			
Light	4	10	4
Mod Light	1	1	3
Mod Heavy	5	14	12
Heavy	1	13	10

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Key Words: Habitat selection, *Meleagris gallopavo merriami*, Merriam's turkey, mortality, nest, survey, survival.

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