Ponderosa pine restoration and turkey roost site use in northern Arizona

Steven L. Martin, Tad C. Theimer, and Peter Z. Fulé

Abstract Ecological restoration of ponderosa pine *(Pinus ponderosa)* forests in the southwestern United States is a relatively new, adaptive management practice that potentially alters wildlife habitat during and immediately after restoration treatments. To determine whether restoration treatments affected Merriam's wild turkey *(Meleagris gallopavo merriami)* use of roost sites, we relocated 91 of 120 turkey roost sites that originally had been mapped in 1985 in the Uinkaret Mountains of northern Arizona. We compared current turkey use of historical roost sites in stands that had been thinned and burned between 1995 and 2002 to adjacent (<800 m away) and distant (>800 m) stands. In 2002, 23 historical roosts were still in use, and in 2003, 13 were still in use, 5 of which had not been used in 2002. The number of historical roost sites still in use among treated, adjacent, and distant stands did not differ from that expected based on the total number of historical roosts in each stand type. We also searched for new roosts while traveling between historical roost sites and found 2.2 new roosts per hour searched in treated stands, 1.5 in adjacent stands, and 1.0 in distant stands. As expected, active roost sites in treated stands had significantly lower basal area, fewer stems, and less canopy cover compared to roost sites in untreated areas. However, roost trees in treated and untreated stands did not differ in diameter at breast height, height, or distance to the lower limb, indicating that treatment did not affect these characteristics. Several factors unique to our study site may have influenced our results: treated areas represented only 5% of total habitat available, treatments occurred primarily on flat areas and not on ridges or slopes, and treatments were implemented over several years.

Key words *Meleagris gallopavo, Pinus ponderosa*, restoration, roost site

Ponderosa pine (*Pinus ponderosa*) forests in the southwestern United States historically were more open and park-like, with a stand structure maintained through frequent, low-intensity fires (Covington and Moore 1994, Swetnam and Baisan 2003). Frequent fires maintained grass cover (Covington 2000) and created a clumped, uneven-aged forest dominated by large, old ponderosa pine trees (Mast et al. 1999). However, fire suppression, livestock grazing, and logging over the past century have led to increased tree density, smaller mean tree diameter, and reduced understory plant productivity, as well as a greatly increased hazard of stand-replacing fire (Moore et al. 1999). Recent management efforts have focused on thinning and burning in these forests to create stands more similar to those believed to have dominated the area historically (Fulé et al. 2001). As the move to implement these forest restoration projects over broader areas grows, understanding how such treatments affect wildlife during and immediately after their implementation becomes an important question.

The historical range of Merriam's wild turkey (*Meleagris gallopavo merriami*) largely coincides with that of ponderosa pine (Ligon 1946, Shaw and Mollohan 1992). As a result, restoration treatments in this habitat could alter a number of habitat parameters important for turkeys, including cover,

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food abundance and diversity, and roost-site availability. Restoration treatments involve thinning of small-diameter trees followed by low-intensity surface fires, both of which reduce stem density, basal area, and canopy cover, 3 attributes often reported in descriptions of turkey roost sites (Hoffman 1968, Boeker and Scott 1969, Mackey 1984, Mollohan et al. 1995, Wakeling and Rogers 1998).

The largest forest restoration experimental site in the southwestern United States (Mount Trumbull) was initiated in an area where Merriam's turkeys were successfully introduced in the 1960s. A survey of turkey roost sites was conducted in this area in 1985 (Moeller et al. 1985), and restoration treatments were implemented between 1995–2000, providing a unique opportunity to compare how use of historical roost sites was affected by restoration treatments. Our objectives were to 1) determine the number of historical roost sites still in use in treated and untreated areas, 2) search for new roost sites in treated and untreated areas, and 3) determine whether roost trees in treated and untreated areas differed in diameter at breast height (DBH), height, or distance to lowest branch. Our null hypothesis was that there would be no difference in the proportion of historical roosts still in use or of new roosts in treated and untreated areas.

Study area

The study site occupied an "island" of approximately 6,900 ha of ponderosa pine forest mixed with gambel oak (*Quercus gambelli)* and New Mexican locust (*Robinia neomexicana*) that rises out of surrounding desert. It was located in the Grand Canyon's Parashant National Monument in the Uinkaret Mountains of northwestern Arizona between the Colorado River and the Utah border (36°20′N, 113°10′W, and was managed by the Bureau of Land Management (BLM). Merriam's wild turkeys were initially introduced into this area in 1961. The population was isolated from other turkey populations due to surrounding unsuitable desert habitat. Between 1995 and 2002, selected areas were treated with thinning and low-intensity burning prescriptions designed to emulate the historical forest composition and structure that prevailed prior to disruption of the frequent fire regime, livestock grazing, and logging beginning circa 1870 (Moore et al. 1999). All old-growth (predating 1870 A.D.) trees were retained, as well as 3 younger trees of the same species within a 9–27-m radius of all pre-settlement evidences (stumps, logs, and snags). Tree thinning substantially reduced the hazard of stand-replacing fire (Fulé et al. 2001), but thinned stands were highly diverse in structure, reflecting the historical variability across the landscape (Waltz et al. 2003). Thinned slash was lopped and broadcast-burned. Of the total area of ponderosa pine forest in the area (approximately 6,900 ha Moore et al. 2003), approximately 1,900 ha were included in the restoration experiment, of which untreated controls and areas with slopes steeper than 40% comprised approximately 50%. Slopes steeper than 40% were not treated due to logistical difficulties in moving equipment through these areas and the potential for increased soil erosion. As of the end of 2003, approximately 330 ha (5% of the total available) had been fully treated with thinning and burning.

Methods

Moeller et al. (1985) divided 4,700 ha of the ponderosa pine habitat on our study area into 27 compartments of varying size and searched each compartment for 1–2 days for turkey roosts during the summer of 1985. They recorded the location of each roost site on a topographic map and made a number of measurements at each roost, including basal area and number of scats and feathers below roost trees. We attempted to relocate the 120 roosts they found by calculating Universal Transverse Mercator coordinates based on the original topographic maps. When we located these coordinates in the field, if a single stand of large trees was within 50 m, we assumed this group to be the historical roost site. If there was more than 1 group of large trees or no trees within 50 m, the location was not used in our analysis regardless of whether turkey sign was present under 1 of the groups of trees. This conservative approach reduced the chance of misidentifying new roosts as historical roosts. Instead we classified these ambiguous historical roost sites with turkey sign as new roosts.

To compare the relative abundance of historical roost sites in areas impacted by restoration treatments, we designated roosts as either 1) treatment roosts if they were located within restoration treated stands, 2) adjacent roosts if they were ≤800 m from treated stands, or 3) distant roosts if they were >800 m from a treated stand. The number of historical roosts still in use in treatment, adjacent, and untreated categories was then compared to the number expected to be in use based on the relative number of both used and unused historical roosts in each treatment category using chi-square.

We also searched for new roosts while traveling between historical roost locations by searching the ground under all large ponderosa pine within 20 m of our search path for turkey sign. Total time of these searches for new roosts across both years was 11 hours in treated stands, 30 hours in adjacent stands, and 6 hours in distant stands (relatively few historical roosts were located in distant stands). To test whether treatment, adjacent, and distant stands differed in number of new roosts detected, we compared the number of new roosts found in each area to the number expected based on search effort using chi square.

An index of the level of current turkey use of roosts was determined by counting scat and feathers under both historical and new roost trees. Following Moeller et al. (1985), we considered 1–3 scats or feathers to indicate low use, 4–10 moderate use, and >10 high use. To determine whether relative roost use (as measured by scat and feathers) differed in treated, adjacent, and distant stands compared to relative use for these roosts in 1985, we compared the number of roosts in use in either 2002 or 2003 in each use category in treated, adjacent, and distant stands and to the number expected based on the percentage originally recorded for historical roosts (Moeller et al. 1985) using chi square.

To determine whether historical roosts in the interior of treated areas were more likely to be abandoned, we compared the numbers of active historical roosts that were either >500 m or <500 m from a treatment edge to the expected number based on the number of historical roosts originally described in each area.

To determine whether treatment had altered roost-site or roost-tree characteristics, we randomly selected 28 of the historical and recent roost sites in use during 2002–2003 in untreated areas (adjacent and distant) and compared them to 14 of the historical and new roost sites in use in 2002–2003 in treated areas. At each of these sites, we recorded tree basal area, number of stems, and canopy cover within an 11.28-m fixed-radius plot at each relocated roost site. Canopy cover was estimated as the mean percentage covered of 4 spherical densiometer readings taken at the 4 cardinal directions from the center of each plot. In addition, we measured tree DBH, height, height of the lowest branch, and tree age for 1 roost tree at each of these sites. To determine tree age, we mounted and surfaced the increment cores from each tree to view all the rings clearly, then cross-dated the rings with a local tree-ring chronology. Rings were counted for cores that could not be cross-dated. We compared DBH, height, and height of the lowest branch of roost trees in treated versus untreated roosts using two-sample *t*-tests.

Results

In 2002 we relocated 91 of the 120 roost sites described by Moeller et al. in 1985 (Figure 1). Those not relocated were locations at which >1 group of large trees was present, making it impossible to unambiguously assign 1 group as the historical roost site or locations at which no obvious roost stand was present and no evidence of stumps could be found. Two historical roost sites had been destroyed; a roost site consisting of a single roost tree was broken at 5 m, apparently due to lightning strike, and a roost site consisting of small-diameter trees was destroyed due to thinning, but the stumps remained. Twenty-three of the unambiguously determined historical roost sites were used by turkeys in 2002 based on presence of scat and feathers, and an additional 5 were used in 2003. The number of historical roosts still in use in treated (7 out of 23), adjacent 16 out of 52), and distant stands (5 out of 14) combined across both years did not differ from that expected based on the relative proportion of total historical roosts in each area ($\chi^2 = 0.08$, $P > 0.75$) (Figure 2).

We located 72 new roost sites in 2002, and an additional 4 new roost sites in 2003, with similar search effort expended in both years (Figure 1). Of the 72 new sites located in 2002, 24 remained in use in 2003. Of the 76 new roosts we located, 24 were in treatment stands, 46 were in adjacent stands, and 6 were in stands >800m from a treated area. When the number of new roosts found in each treatment was compared to that expected based on search effort expended in each stand type, we found no significant difference among stand types in the number of new roosts found ($\chi^2 = 3.72$, $P > 0.10$). The number of historical roosts sites still in use in the interior of treated areas (1/6) or near the edge (8/15) was not significantly different ($\chi^2 = 1.12$, $P > 0.10$), but test power was limited by small sample size. The number of low-, moder-

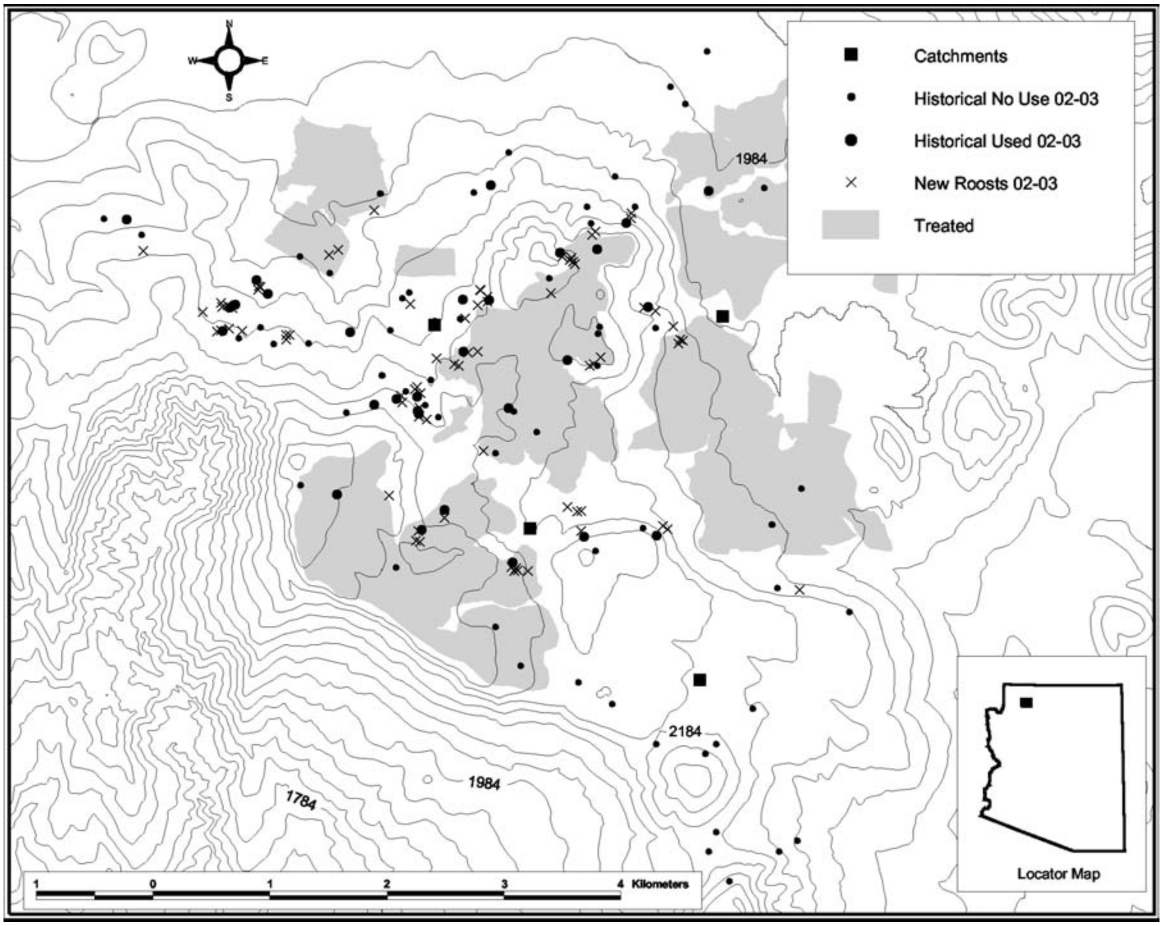

Figure 1. Locations of the 89 historical turkey roosts (circles) on the Uinkaret Mountain study area in northern Arizona. Historical roosts still in use in 2002–2003 are indicated as larger circles. Areas treated with thinning and burning are shaded.

ate-, and high-use roost sites (based on the feather and scat index) in treated, adjacent, and distant areas did not differ from that expected based on the relative number of each type in the original census in 1985 (Table 1). Older scats observed at roost sites indicated roosts were used in the fall and winter while more recent scats indicated roosts were currently in use during the summer as well. Turkeys on our study site apparently do not move to separate wintering areas due to the limited area of ponderosa pine available in this relatively isolated 6,800-ha "island" of habitat.

Based on the randomly selected subset of roost sites in treated (n=14) and untreated (n=28) stands at which we recorded site and tree characteristics, roost sites in treated stands had lower basal area, lower canopy cover, and fewer stems than roosts in adjacent and distant stands (Table 2). Roost trees in treated stands did not differ in DBH, tree height, or distance to lowest limb from those in untreated areas (Table 2). All roost trees (n=130) were mature ponderosa pines, with mean age of 263 years, ranging from 60 to at least 561 years of age.

Discussion

Several lines of evidence indicated that the restoration treatments implemented on this study site did not result in abandonment of roost sites by turkeys in treated areas. First, the number of historical roost sites still in use in treated, adjacent, and distant locations did not differ from that expected based on the relative abundance of historical sites in each area. Second, the number of new roosts we found in treated, adjacent, and distant stands did not differ when these numbers were controlled for search time in each stand type. Finally, the relative number of high-, moderate-, and low-use sites found in each stand type did not vary from that expected based on historical roost sites. If treatment caused

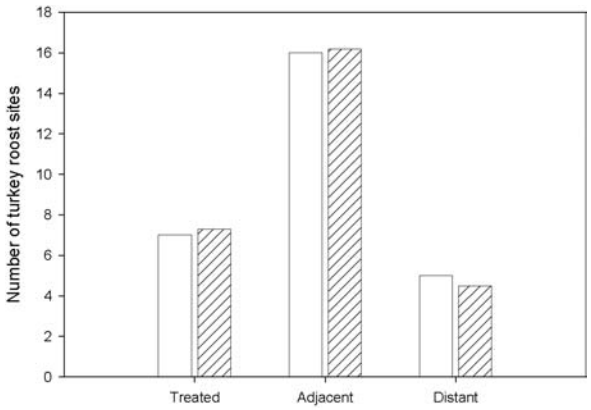

Figure 2. Number of 89 historical roost sites on the Uinkaret Mountain study area in northern Arizona that were still in use during 2002 (open bars) in areas treated by thinning and burning between 1995–2002 (treated), within 800 m of treatments (adjacent), or c) greater than 800 m from treatments (distant) compared to the number expected based on total number of historical roosts relocated in each treatment type (shaded bars).

turkeys to reduce use of roosts but not abandon them entirely, we would have expected the number of low-use roosts to have increased in treated areas relative to that expected based on historical (pretreatment) use of roosts in these areas.

Roost trees in treated areas were as large in both diameter and height as trees in untreated areas and within the ranges reported in other studies of Merriam's wild turkey roost-tree selection (Hoffman 1968, Boeker and Scott 1969, Mackey 1984, Mollohan et al. 1995, Wakeling and Rogers 1998). This was most likely due to the retention of large- diameter trees as part of the treatment protocol. Likewise, although tree basal area, number of stems and canopy cover were all significantly lower on roost sites in treated areas, these parameters remained at or above the minimums reported for Merriam's turkey roost sites in other areas (Hoffman 1968, Boeker and Scott 1969, Mackey 1984, Wakeling and Rogers 1998) and were above the 21 m^2/ha often recommended for roosting site management (Rumble 1992, Mollohan et al. 1995, Wakeling and Rogers 1995).

Table 2. Turkey roost-site and roost-tree characteristics for 14 roost sites in use in treated areas compared to 28 roost sites in use in untreated areas on the Uinkaret Mountain study area in northern Arizona, 2002–2003.

Parameter	Treated mean (SD)	Untreated mean (SD)	*t*-statistic	*P*
Basal area (m^2/ha)	26.4 (17.3)	44.1 (21.6)	2.87	0.003
# stems	22.4 (22.5)	60.5 (28.0)	3.18	0.001
% canopy	55.8 (14.2)	73.4 (13.5)	3.80	0.001
DBH (cm)	73.1 (13.5)	72.5 (17.4)	0.13	0.45
Height (m)	22.6 (3.3)	21.7 (4.7)	0.69	0.25
Lower limb ht (m)	3.4 (1.5)	3.4 (1.9)	0.03	0.49

Table 1. Observed number of roosts used in 2002–2003 (both historical and new) that were classified as high, moderate, or low use (based on presence of scat and feathers) in treated, adjacent, and distant stands compared to the number expected in each category based on a survey of roosts in these areas in 1985. Observed values are followed by expected values in parentheses. Chi square values indicated that none differed from expected at $P \leq 0.05$.

Use	Treated	Adjacent	Distant
High	16 (18.8)	40 (33.7)	7 (5.9)
Moderate	5 (5.1)	15 (14.8)	1 (3.1)
Low	8 (5.1)	7 (13.5)	3 (1.9)
χ^2	4.31	3.25	2.10
P	n.s.	n.s.	n.s.

Within both treated and untreated areas, turkey roosts occurred in areas with higher basal area than reported for other locations on our study site. The mean basal area of our roost sites in treated areas (26.4 m^2/ha) was 40% higher than the mean of 18 m^2/ha documented on 4 experimentally treated blocks scattered across the study area in a separate study (Waltz et al. 2003). Likewise, the basal area of our roost sites in untreated areas was 46 m^2/ha, 25% higher than the mean basal area of 32 m^2/ha in randomly selected untreated areas (Waltz et al. 2003).

Several unique aspects of this study caution against generalizing too greatly from these results. First, restoration efforts on our site created treated stands within undisturbed matrix, and made up only approximately 5% of the entire habitat available. Thus, treatments potentially could have reduced habitat quality in terms of nesting and brooding cover, but if turkeys simply shifted use to untreated areas while maintaining roost fidelity, we would not have detected this important effect. Likewise, most of the turkey roosts on our site were on ridges or slopes, consistent with other studies of turkey roost-site characteristics, while treatment areas were confined to areas with slopes with less than 40% grade. As a result, most of our roosts were located on the edges of treated areas, increasing the opportunity for turkeys to utilize nontreated habitat while maintaining roost-site fidelity. Although most of the active roosts on our sites were along the edges of treatments, suggesting that turkeys may avoid the interior of treated areas, the number of active roosts near the edge of treatments did not differ significantly from that expected based on the location of historical roosts relative to treatment boundaries. However, given our small sample size of active roosts within treated areas, this test was limited in power.

Finally, treatments on our site were implemented over several years, potentially allowing turkeys to shift areas of use from one area to another from year to year. Further studies are needed to document how restoration treatments affect other parameters important to wild turkeys such as nest, escape and brood-rearing cover, and food availability and how restoration at larger spatial scales, under different temporal patterns, may influence turkey habitat use and productivity.

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