AN ABSTRACT OF THE THESIS OF

Thomas Wright Keegan for the degree of Doctor of Philosophy in Wildlife Science presented on April 5, 1996. Title: Habitat Use and Productivity of Rio Grande Wild Turkey Hens in Southwestern Oregon

Abstract approved: ______________________

John A. Crawford

Wild turkey (*Meleagris gallopavo*) ecology has been examined within its native range, but knowledge of extralimital populations of Rio Grande wild turkeys (*M. g. intermedia*) is lacking. I investigated habitat use, characteristics of activity sites, home ranges and movements, productivity, and survival of Rio Grande turkey hens from 1989 through 1991. I obtained >6,000 locations of 76 radio-tagged hens in Douglas County, Oregon and quantified characteristics of 99 roosts, 126 nests, and 64 brood-rearing sites.

Turkeys selectively used meadows and hardwood/conifer cover types during winter and summer ($P \leq 0.05$). Adult hens roosted in dense young conifer stands more often than expected throughout the year; hardwood/conifer woodlands were used more than expected for roosting by all flocks ($P \leq 0.05$). Hens nested in 8 of 10 cover types; recent clearcuts were used more than expected ($P < 0.05$). Use of meadows and hardwood/conifer habitats by brood hens exceeded availability ($P < 0.05$). Dense sapling/pole and mature conifer stands were used less than expected at all times ($P < 0.05$).

Adults roosted in Douglas firs (*Pseudotsuga menziesii*) more than expected ($P < 0.05$), but hen-poult flocks roosted in tree species in proportion to availability ($P \geq 0.50$).

Nest sites were characterized by relatively dense understory, but no relationship was observed between nest success and vegetation characteristics. Brood-rearing sites had sparse horizontal screening and moderate vegetative cover.

The overall nesting rate was 97% and renesting accounted for 17% of poults hatched. In contrast to other populations, renesting after brood loss was common among adult hens. Annual survival rates varied among years (0.50 to 0.89) but did not differ between adults and yearlings ($P \geq 0.17$).

Prescribed burning to reduce dense shrub cover should improve stands for nesting and brood rearing. Maintaining or increasing areas of mixed hardwood/conifer cover types would ensure availability of habitat for brood rearing, roosting, and year-round use. My research indicated that Rio Grande turkeys were more adaptable and productive than Merriam's wild turkeys (*M. g. merriami*) in Oregon. High nest success in several cover types and use of several cover types for brood rearing and roosting indicated that Rio Grande turkeys would thrive under a variety of habitat conditions.

Habitat Use and Productivity of Rio Grande Wild Turkey Hens in Southwestern Oregon

by

Thomas W. Keegan

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APPROVED:

Major Professor, representing Wildlife Science

Head of Department of Fisheries and Wildlife

Dean of Graduate School

I understand that my thesis will become part of the permanent collection of Oregon State University libraries. My signature below authorizes release of my thesis to any reader upon request.

Thomas Wright Keegan, Author

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Dedicated to the memory of Calloghan, a Knight of Sigma Nu.
He was always there to fetch 'em up.
Good-bye old bud.

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INTRODUCTION

Rio Grande wild turkeys (*Meleagris gallopavo intermedia*) historically occupied relatively dry, brush-grassland and oak savanna (see Porter 1992) habitats in the southcentral Great Plains (Glazener 1967). The geographic range included Texas, Oklahoma, Kansas, northeastern New Mexico (Bailey 1980), and possibly Nebraska (Suetsugu 1976). After population declines in the late 1800's and early 1900's (Gore 1970), Rio Grande turkeys were re-established in much of their native range. Additionally, they were introduced successfully into California, Colorado, Hawaii, Idaho, Nevada, North Dakota, Oregon, South Dakota, Utah, and Washington (Wunz 1992).

Rio Grande wild turkeys were translocated to southwestern Oregon in 1975 (Durbin 1975). Turkey populations in the Umpqua National Forest originated from 2 releases of birds from Texas: 26 females and 6 males at Nichols Ranch in 1982 and 21 females and 5 males near Joe Hall Creek in 1983 (K. Durbin, ODFW, unpubl. data; R. R. Denney, ODFW, unpubl. data). Populations thrived and expanded, but ecology of the subspecies in this extralimital portion of the range was poorly understood.

Variability in wild turkey movements and home ranges among geographic regions and subspecies was attributed primarily to variation in resource availability (Brown 1980). Although use of cover types indicated a high level of adaptability, turkeys were selective with respect to vegetative characteristics within cover types (Holbrook et al. 1987). Environmental factors that affect roosting, nesting, and brood-rearing habitats are critical to population maintenance.

Wild turkeys require roost sites that provide protection from predators and adverse weather conditions (Crockett 1973). Availability of roost trees and proximity to habitats that provide other requirements (e.g., food and cover) may influence turkey use of an area. Boeker and Scott (1969) conjectured that availability of suitable roosts may limit the range of Merriam's wild turkeys. Wild turkeys often roost in the largest trees within a stand (Crockett 1973, Lutz and Crawford 1987a), but tree species selected for roosting differ widely among geographic regions and subspecies. Quantitative information about Rio Grande turkey roosts in Oregon was unavailable.

Nesting habitat affects annual recruitment because hens are most vulnerable to predation during nesting (Everett et al. 1980, Kurzejeski et al. 1987, Vander Haegen et al. 1988). Nest predation, which may limit population growth (Ransom et al. 1987), is affected by nesting cover (Beasom 1970, Baker 1979). Turkeys typically nest in relatively dense understory cover or logging slash (Lutz and Crawford 1987b, Ransom et al. 1987).

Brood-rearing habitat is a basic requirement of wild turkeys. Everett et al. (1980) suggested that poult survival was directly related to suitability of brood-rearing habitat. Vegetative composition and structure in brood range influence protection from predators, poult mobility, arthropod abundance, and exposure to dew (which can induce hypothermia). Brood-rearing habitats often were characterized as early seral stages with well-developed herbaceous layers (Williams et al. 1975, Pack et al. 1980, Porter 1980). Habitat use by Rio Grande turkeys in their native range was studied extensively (e.g., Thomas et al. 1966, Cook 1973, Crockett 1973, Logan 1974, Baker 1979, Baker et al. 1980), but there is a paucity of information about brood-rearing habitat. Furthermore, habitat use by introduced populations in the Pacific Northwest has received limited attention.

Little data about age-related productivity of Rio Grande turkeys have been published (N. Silvy, Tex. A&M Univ., pers. commun.). Understanding of age-related productivity is important for determining age composition of turkey releases in stocking efforts and managing populations (Lewis 1967). Reproductive capacity may be controlled by population density (Porter 1978:115) and influenced by several other factors. These factors include habitat quality (Porter 1978:106); weather (Beasom and Pattee 1980, Porter et al. 1983); differences among subspecies (Lockwood and Sutcliffe 1985); illegal hen kill (Kimmel and Kurzejeski 1985); predation on nests, poults, and adults (Glidden 1977, Vander Haegen et al. 1988); disease (Rocke and Yuill 1987); and intergradation of subspecies. Few yearling Merriam's wild turkey hens in Oregon attempted to nest and contributed little to annual recruitment (Lutz and Crawford 1987b). However, yearling Florida wild turkeys (*M. g. osceola*) were as productive as adults for first nests (Williams et al. 1972, 1978) and productivity of adult and yearling eastern wild turkeys (*M. g. silvestris*) was comparable (Austin et al. 1973). Precise information about age-related productivity of Rio Grande turkeys is unknown, but yearlings contributed 40% of all broods produced in a Texas study (Reagan and Morgan 1980). Although yearling hens may not renest as frequently as adults, contribution to total production may nearly equal that of adults, and yearlings are sometimes more productive with respect to parameters such as clutch size and egg hatching success (Williams et al. 1972, Glidden 1977). The influence of renesting on total natality of Rio Grande wild turkeys in Texas was unclear (Reagan and Morgan 1980, Ransom et al.

1987) but was considered important in eastern wild turkey populations (Porter et al. 1983, Vangilder et al. 1987).

The success of Rio Grande wild turkey introductions in southwestern Oregon led to interest in the efficacy of introductions in other parts of Oregon and adjacent states. As with other polygynous species, females are the key to establishing and maintaining populations. Habitat requirements of hens have direct bearing on annual recruitment and maintenance of populations (Lindzey 1967); consequently hens were the focus of this study. Yearling hens were included in the sample because of the need to understand age-related productivity and habitat use (Bailey and Rinell 1967). The purpose of this research was to examine several aspects of wild turkey ecology and construct a better understanding of Rio Grande wild turkeys and their habitat relationships in Oregon. Specific objectives of the research were 1) to determine habitat use by Rio Grande wild turkey hens in southwestern Oregon with emphasis on roosting, nesting, brood-rearing, and seasonal habitat use, 2) to quantify characteristics of sites used by hens for roosting, nesting, and brood-rearing, 3) to determine seasonal home ranges and movements, and 4) to describe life-history characteristics of the population including productivity, nesting success, nest-site fidelity, and survival rates.

The main body of this thesis is organized in 6 chapters, each relating to a specific portion of the research. Each chapter represents a manuscript that was submitted to a peer-reviewed journal for publication, but herein follows the style of The Journal of Wildlife Management. John A. Crawford was a co-author for each of the 6 chapters. The final section is a comprehensive Synthesis, Interpretation, and Implications chapter that applies to the entire thesis.

Chapter 1

ROOST HABITAT USE BY RIO GRANDE WILD TURKEYS IN OREGON

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ABSTRACT

Although wild turkey (*Meleagris gallopavo*) roost sites have been described previously, roost tree characteristics and roost habitat use for introduced Rio Grande wild turkeys (*M. g. intermedia*) in the Pacific Northwest were unknown. Consequently, we determined locations of 375 roost sites and examined 99 roost sites used by a recently established population of Rio Grande wild turkeys in southwestern Oregon from February 1989 through January 1991. Adult turkeys roosted in all available forested cover types whereas hen-poult flocks roosted in 4 of 7 cover types. Adults roosted in dense young mixed-conifer stands more often than expected throughout the year (41%); mixed hardwood/conifer woodlands were used more than expected for roosting by hen-poult (35%) and adult (18%) flocks ($P \leq 0.05$). Dense large/mature mixed-conifer and all sapling/pole mixed-conifer cover types were used less than expected. Adults roosted in Douglas fir (*Pseudotsuga menziesii*) more than expected ($P \leq 0.05$), but hen-poult flocks used tree species in proportion to availability. Roost trees were as large or larger than other trees available in stands used for roosting. Land managers should maintain dense young mixed-conifer and mixed hardwood/conifer woodland cover types with >80 year-old trees adjacent to mixed hardwood/conifer savannas and meadows to provide roost habitat for Rio Grande wild turkeys in southwestern Oregon.

INTRODUCTION

Rio Grande wild turkeys were native to the southcentral Great Plains, but translocation programs resulted in establishment of populations in 9 western states (Wunz 1992). Wild turkeys require roost sites that provide protection from predators and adverse weather conditions (Crockett 1973). Roost tree availability and proximity to habitats that provide other requirements (e.g., food and cover) may influence turkey use of an area. Rio Grande wild turkeys in Texas possibly were limited by roost site distribution (Glazener 1967) and birds frequently roosted on man-made structures. Boeker and Scott (1969) conjectured that availability of suitable roosts may limit the range of Merriam's wild turkeys (*M. g. merriami*).

Wild turkeys often roost in the largest trees within a stand (Crockett 1973, Mackey 1984), but species of trees selected for roosting differed widely among geographic regions and subspecies. Although several authors investigated roost site characteristics of native Rio Grande wild turkeys and Merriam's turkeys in western states (Crockett 1973, Lutz and Crawford 1987, Rumble 1992), we are not aware of any descriptions of roost sites used by Rio Grande wild turkeys outside of their native range, particularly the Pacific Northwest. Because of the importance of roost habitat to wild turkey populations, we quantified roost tree and roost site characteristics and investigated seasonal roost habitat use by Rio Grande wild turkey hens in southwestern Oregon.

Research was supported by the Oregon Department of Fish and Wildlife (ODFW), the U.S. Forest Service LaGrande Forestry and Range Sciences Laboratory, the National Wild Turkey Federation, Inc., and Oregon State University. We thank personnel of the Umpqua National Forest and ODFW for their assistance and support. S. R. Denney and R. A. Zalunardo were particularly helpful throughout the course of the research. We appreciate the field work of P. I. Burns, N. E. Golly, and B. C. Quick. L. L. Mauer was instrumental in office assistance. This is Technical Paper 10787 of the Oregon

Agricultural Experiment Station. We followed wild bird research guidelines described by Oring et al. (1988).

STUDY AREA

The 675-km^2 study area was located in the upper South Umpqua River Basin, Douglas County, Oregon. The area was dissected with steep east-west ridges, and elevation ranged from 310 to 1,525 m. Diverse edaphic and geologic conditions produced a heterogeneous association of plant cover types (Franklin and Dyrness 1973:130). Overstories were dominated by Douglas fir and other conifers or Oregon white oak (*Quercus garryana*) and Pacific madrone (*Arbutus menziesii*). The ODFW released 58 Rio Grande wild turkeys from Texas and Kansas on the study area in 1982 and 1983 (R. R. Denney, ODFW, unpubl. data).

METHODS

Capture and Radio Telemetry

We used rocket nets to capture turkeys during winters of 1988-89 and 1989-90. Age was determined by characteristics of the primary feathers (Larson and Taber 1980) and individuals were equipped with 90- to 110-g radio transmitters attached with a modified backpack harness (Kenward 1987:103). Expected transmitter life ranged from 1 to 3 years.

During 2 trapping seasons, we captured 181 wild turkeys. All radio-tagged hens survived $\geq$2 weeks after release. In 1988-89, we equipped 26 adult and 19 yearling hens with transmitters. Fifteen adults and 15 yearlings (considered adults during the second year) survived to 1990. We equipped 10 more adults and 21 yearlings with transmitters during the 1989-90 trapping season. Therefore, the total sample included 36 adult and 40 yearling hens. On 31 January 1991, 25 adult hens were still carrying functional radios.

Hens were monitored ≥ 2 times/week throughout the year from February 1989 through January 1991. For defining hen-poult flocks, we considered young birds poults until 12 weeks of age. We verified brood survival by audio or visual evidence weekly until all poults perished or until broods were integrated into autumn flocks.

Direction to radio signals was ascertained by the peak-signal method (Springer 1979). Preliminary bearings and signal strength were used to move within approximately 0.5 km of birds; subsequent bearings provided triangulation data. Locations were recorded at night (1 hr after sunset to 1 hr before sunrise) by triangulation from ≥ 3 locations or by visual observations. Each hen was located while roosting at least once in each 2-week interval.

Accuracy of telemetry procedures was tested by triangulating transmitters at 5 locations from 3 distances that represented the range of tracking situations. Differences between estimated and actual azimuths were used to calculate error within and among distances and locations. Variances of error angle estimates were not homogeneous among all observers and distances. Therefore, standard deviations of error angles were pooled when appropriate and assigned to triangulations based on observer and distance from transmitter. Mean difference between estimated and true azimuths for all observer-distance combinations was 1° (SE = 0.4).

Azimuths and receiver locations were entered into program XYLOG (Dodge and Steiner 1986) to process triangulation data. Habitat availability was defined by a minimum convex polygon (Mohr 1947) for all hen locations (except for 2 hens that were excluded because of movements >30 km to inaccessible areas).

Habitat Mapping and Quantification

Habitat maps were constructed from aerial photographs (taken summer 1989) and classifications were verified with direct observation of stands. Ten cover types were delineated and descriptions were developed by sampling overstory and midstory strata at 56 randomly selected sites in all cover types. Sample sites consisted of 3 points located 30 m apart. Description of sites included quantification of the following physiographic and vegetative variables: percent slope, aspect, elevation, percent non-forested habitat within 0.3 km, species composition, density, basal area, percent cover, and canopy height. We estimated slope with a clinometer, aspect with a compass, and elevation from topographic maps. Percent non-forested habitat within 0.3 km of each roost was determined from habitat maps with an overlay of 50 randomly distributed points (Marcum and Loftsgaarden 1980). Species, distance to sample point, and diameter-at-breast-height (dbh) of the nearest individual in each "quarter" were recorded for midstory and overstory strata to determine density and basal area (Cottam and Curtis 1956). Percent cover of overstory and midstory strata (combined) was estimated with a sighting tube (James and Shugart 1970) by determining presence or absence at 2-m intervals along 4 10-m transects originating at sample points. Heights of 5 randomly selected trees in each strata were measured with a clinometer to estimate overstory and midstory canopy height.

Cover types included mixed hardwood/conifer woodland (HCW), which was characterized by canopy closure ≥40%, whereas canopy closure in mixed hardwood/conifer savanna (HCS) was 10 to 40%. Savannas were the rarest habitat and generally had not been managed for timber production. In contrast, timber management likely influenced stand structure in HC woodlands. Douglas fir was a prominent component of mixed-conifer stands, but several other conifer species were present, frequently occurring as co-dominants, and included ponderosa pine (*Pinus ponderosa*), sugar pine (*P. lambertiana*), white fir (*Abies concolor*), and incense-cedar (*Calocedrus decurrens*). Canopy closure ≥70% was considered dense in mixed-conifer stands, whereas closure <70% was classified as open. Dense large/mature mixed conifer (DMC) contained overstory trees that averaged ≥50 cm dbh and >110 years old. Open large/mature mixed conifer often developed from natural or management-related thinning. Dense medium/young mixed-conifer (DYC) stands were characterized by overstory trees that were 23-50 cm dbh and 30-110 years old. Open sapling/pole/young mixed-conifer (OSPC) stands usually developed as a result of sparse regeneration or precommercial thinning. Dense sapling/pole mixed-conifer (DSPC) stands resulted from normal tree growth after even-age regeneration harvest or catastrophic disturbance. The remainder of the area (12%) consisted of non-forested (<10% tree cover) cover types (recent clearcut, brushfield; and meadow/grassland) that were not used by roosting turkeys and therefore, not considered as available roost habitat (i.e., non-forest was disregarded and availability was recalculated based on 7 forested cover types).

Roost Site Quantification

We randomly selected 1 active roost site/week for measurement of site characteristics; a different hen was selected for each roost-site location (within a traditional 3-month season) to ensure that different birds contributed to roost measurements. Roost trees were identified by visual observation of turkeys or presence of droppings under trees. We recorded sex and age composition of flocks at roost sites. Individual roost trees were examined to determine species, height, height to lowest living and dead limbs, dbh, and age.

The center of each roost site was a focal point for sampling trees with the point-centered quarter method (Cottam and Curtis 1956). Methods for measuring density, basal area, and percent cover were identical to those employed to develop general stand descriptions. Age of trees was determined from increment borings. We estimated tree heights, slope, aspect, elevation, and percent forested habitat with methods used for randomly located sites.

Statistical Analyses

We analyzed data sets with a series of univariate and multivariate procedures. Data sets were examined to assess outliers, normality, multicolinearity, and homogeneity of variance-covariance matrices. Although we noted wide variation among some observations, we detected few distinct outliers and inclusion of those observations did not alter results or interpretations. Several variables displayed non-normal distributions. However, transformations did not improve normality nor alter results, so original values were retained for all analyses. When $\geq$2 variables were highly correlated ($r > 0.7$), we selected those variables with the greatest ecological relevance and/or management application that contributed to the most parsimonious description of relationships.

We used analysis of variance to help identify variables that differed between groups (e.g., random sites and roosts). Stepwise discriminant analysis (SAS 1989) was employed to select optimal sets of variables for separation of groups of observations. We then included variable sets selected in stepwise procedures in canonical analyses of discriminance (SAS 1989) to determine correlations between discriminating variables and canonical functions. For all comparisons considered, only 47-59% of variation in canonical functions was attributable to between-group differences. Therefore, only univariate test results are reported.

We compared several habitat variables with paired and unpaired *t*-tests to better understand relationships of individual habitat characteristics important to wild turkeys. For example, we used paired *t*-tests to determine if tree dbh differed between roost sites (20-m diam) and sites 30 m away from roosts.

Habitat Use

Chi-square analysis was used to test the null hypothesis that cover types and tree species were used in proportion to availability (Neu et al. 1974, Byers et al. 1984). When the null hypothesis was rejected, simultaneous confidence intervals were calculated to identify which cover types contributed to differences in use and whether use was greater or less than expected. Initially, use and availability were analyzed within and among years, seasons, and hen age-classes (within constraints imposed by sample size). Preliminary analyses, however, indicated that habitat use did not vary with year or hen age for any comparisons. Consequently, observations were pooled accordingly for examination of seasonal and social group habitat use.

RESULTS

Habitat Use

Analysis of roost habitat use was based on 375 locations used for roosting by wild turkeys from February 1989 through January 1991. Among these locations, we quantified habitat characteristics of 99 roosts containing 565 trees. Adult flocks accounted for 315 locations (79 measured sites) and we located 60 roosts used by hen-poult flocks (20 measured sites). Roost habitat use by adult flocks did not differ seasonally, so observations were pooled among seasons. However, hen-poult use of roost habitats differed from that of adults and was examined separately.

Adult and hen-poult flocks used roost habitats disproportionately to availability ($P \leq 0.005$). Although adults roosted in all forested cover types, 88% of roosts were located in DY conifer, DM conifer, and HC woodland (Table 1.1). Of cover types used heavily by adults, DYC and HCW were used more than expected and DMC was used less than expected ($P \leq 0.05$). Hen-poult flocks used HCW more than expected and DMC less than expected (Table 1.1). More than 96% of hen-poult roosts were located in the 3 cover types used extensively by adult flocks. In contrast to adults, hen-poult flocks used HCS less than expected and used DYC in proportion to availability. All age groups used dense and open SPC cover types less than expected and used OMC as expected.

Table 1.1 Habitats used for roosting by adult (n = 315 locations) and hen-poult (n = 60 locations) Rio Grande wild turkey flocks, Douglas County, Oregon, 1989-91.

	Percent	Adults		Hens with poults	
Cover type	Available	No. roosts	Selection[a]	No. roosts	Selection
Open sapling/pole mixed conifer[b]	3.9	4	-	0	-
Dense sapling/pole mixed conifer	9.1	3	-	0	-
Dense young mixed conifer	16.4	129	+	15	0
Dense mature mixed conifer	55.8	93	-	22	-
Open mature mixed conifer	4.9	16	0	2	0
Mixed hardwood/ conifer woodland[c]	7.7	55	+	21	+
Mixed hardwood/ conifer savanna	2.3	15	0	0	-

[a] A 0 represents use in proportion to availability, + represents greater use of a habitat than expected, and - represents less use of a habitat than expected ($P \leq 0.05$).

[b] In conifer cover types open defined as canopy closure <70%.

[c] Woodland defined as canopy closure ≥40%, savanna canopy closure was <40%.

Habitat Characteristics

All but 1 roost selected for intensive measurement were located in 4 cover types: DY conifer, DM conifer, OM conifer, and HC woodland. Preliminary analyses indicated that stand characteristics at roosts in DMC and OMC were comparable. Therefore, roosts in DMC and OMC were combined (for roost stand and roost tree characteristic analyses only). Further, with respect to roost stand characteristics within cover type, we did not observe differences among years, seasons, or social groups, so roost stand characteristics were combined within cover type.

Random site, roost stand, and roost tree characteristics differed among cover types (Table 1.2). Average overstory tree height in roost stands ranged from 24 m in HC woodlands to 37 m in mature conifer (Table 1.3) and tree dbh ranged from 36 cm to 58 cm. Midstory tree characteristics and densities were similar in young and mature conifer roost stands. Overstory tree density was lowest in mature conifer stands (131 trees/ha) and highest in DY conifer (217 trees/ha). Basal area of overstory trees ranged from 16.4 m^2/ha in HCW to 38.5 m^2/ha in mature conifer roost stands. The amount of non-forest habitat within 0.3 km of roosts averaged $\leq$6% in all cover types.

Characteristics of individual roost trees differed among cover types and social groups. Roost trees used by adults in mature conifer stands averaged 40 m tall, 66 cm dbh, and were >150 years old (Table 1.4). Adults roosted in smaller trees in DYC and HCW stands, ranging from 28 to 31 m tall, 44 to 50 cm dbh, and 87 to 118 years old. Hen-poult roost trees averaged 21 to 32 m tall, 39 to 50 cm dbh, and 80 to 117 years depending on cover type. Among all cover types, the average roost tree was 33 m tall (range 8-82), 50 cm dbh (range 10-155), and 106 years old (range 34-499). Higher

Table 1.2 Characteristics of forested habitats sampled in Rio Grande wild turkey study area, Douglas County, Oregon, 1990-91.

	Dense young conifer (n=11)		Dense mature conifer (n=15)		Open mature conifer (n=2)		Hardwood/conifer woodland (n=7)	
Variable	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE
Overstory								
height (m)	22	1	50	2	43	11	16	1
dbh (cm)	30	1	82	4	86	25	25	3
basal area (m^2/ha)	31	6	52	5	14	7	10	1
density (trees/ha)	396	70	100	12	23	1	213	31
Midstory								
height (m)	8	1	15	1	10	2	7	1
dbh (cm)	11	1	16	1	16	2	9	1
basal area (m^2/ha)	10	3	16	2	2	0.4	4	1
density (trees/ha)	1005	250	545	82	82	1	701	153
Canopy cover (%)	83	4	91	3	31	9	61	7
Non-forest within 0.3 km (%)	5	2	6	2	11	1	15	4
Elevation (m)	710	57	808	59	1072	74	15	2
Slope (%)	15	2	19	3	15	2	14	2

Table 1.3 Structural characteristics of roost stands used by Rio Grande wild turkeys, Douglas County, Oregon, 1989-91.

	Dense young conifer (n=42)		Mature conifer (n=41)		Hardwood/conifer woodland (n=15)	
Variable	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE
Overstory						
height (m)	29	1	37	1	24	1
dbh (cm)	39	1	58	2	36	2
basal area (m^2/ha)	26	1	39	4	16	2
density (trees/ha)	217	18	131	12	163	22
Midstory						
height (m)	11	0.4	12	1	8	1
dbh (cm)	14	1	14	1	11	1
basal area (m^2/ha)	10	1	12	2	10	3
density (trees/ha)	546	48	563	63	797	187
Canopy cover (%)	89	2	82	3	79	3
Non-forest within 0.3 km (%)	6	1	6	2	4	1
Elevation (m)	599	22	600	22	604	24
Slope (%)	21	2	18	2	14	3

Table 1.4 Characteristics of roost trees used by adult and hen-poult Rio Grande wild turkey flocks, Douglas County, Oregon, 1989-91.

	Dense young conifer				Mature conifer				Hardwood/conifer woodland			
	Adult (*n*=351)[a]		Hen-poult (*n*=21)		Adult (*n*=150)		Hen-poult (*n*=13)		Adult (*n*=24)		Hen-poult (*n*=5)	
Variable[b]	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE
Height (m)	31	0.4	26	1.6	40	0.9	32	2.4	28	1.9	21	4.2
Dbh (cm)	44	0.7	41	2.3	66	2.0	50	5.0	50	3.2	39	6.2
Age (yr)	87	1.6	81	3.1	154	7.8	117	9.8	118	14.0	80	5.4
LLL (m)	13	0.3	10	1.2	15	0.5	11	1.1	10	1.2	7	0.6
LDL (m)	6	0.2	6	0.8	9	0.5	7	1.4	6	1.1	4	1.0
Trees/site	10	2.1	3	1.2	5	0.9	2	0.2	2	0.4	1	0.3
Birds/site	16	3.3	10	2.3	9	2.1	7	1.2	5	1.2	4	1.9

[a] Number of trees as noted except as follows. DYC adult: LLL, 348; LDL, 345; age, 350. DYC hen-poult: LDL, 20. MC adult: LDL, 139. MC hen-poult: LDL, 11. HCW adult: LLL, 22; LDL, 20; age, 23. HCW hen-poult: LDL, 4.

[b] LLL = lowest live limb, LDL = lowest dead limb.

numbers of trees/roost used by adults reflected larger flocks (autumn and winter) and a tendency for poults to roost in the same tree as brood hens.

Within DYC and HCW cover types, differences between roost trees used by adult and hen-poult flocks were small. In mature conifer stands, hen-poult roost trees were smaller (height and dbh) with living limbs closer to the ground than trees used by adults ($P \leq 0.03$). In mature conifer cover types, adult and hen-poult flocks roosted in trees with smaller height and dbh than randomly located trees ($P \leq 0.007$). Comparisons in DYC and HCW were mixed. Adults roosted in larger (height and dbh) than average trees ($P \leq 0.001$) in both cover types. Heights of roost trees used by hen-poult flocks did not differ from random trees in HCW or DYC ($P > 0.10$), but roost tree dbh was larger ($P \leq 0.05$).

Within cover type and social group, differences between height or dbh of roost trees compared to trees 30 m away from roosts centers were inconsistent. Adult roost tree diameters were larger ($P \leq 0.03$) than surrounding trees in all cover types and roost tree height was greater in mature conifer stands ($P \leq 0.01$). Height and dbh of roost trees used by hen-poult flocks did not differ ($P = 0.14$ to 0.62) from surrounding trees in roost stands.

Use of available aspects for roosting was similar for adult and hen-poult flocks. Northerly aspects (315°-45°) were used less than expected by adult flocks ($P < 0.01$), but use of other aspects did not differ from availability. Although the trend of aspect use by hen-poult flocks paralleled that of adults, use did not differ from availability (probably because of relatively low sample size, $n = 20$). When adult and hen-poult roosts were combined, northerly aspects were used less than expected and southerly aspects were used more than expected ($P < 0.01$).

Turkeys roosted in 11 species of trees (Table 1.5). Adult use of tree species was disproportionate to availability ($P < 0.005$), but hen-poult flocks used species as they occurred in stands ($P > 0.50$). Douglas fir and ponderosa pine accounted for >90% of adult roost trees, whereas 9 other species were used infrequently: sugar pine, incense-cedar, white fir, western redcedar (*Thuja plicata*), Oregon ash (*Fraxinus latifolia*), Oregon white oak, California black oak (*Q. kelloggii*), big-leaf maple (*Acer macrophyllum*), and Pacific madrone. Only Douglas fir was used more than expected by adults ($P \leq 0.05$). Adult turkeys roosted in white fir, white oak, and madrone less often than expected and other species were used in proportion to availability. Hen-poult flocks roosted in 7 species of trees with Douglas fir accounting for 70%. We did not observe hen-poult flocks roosting in 4 species used infrequently by adults (sugar pine, white oak, madrone, and ash). However, hen-poult use of some alternate tree species (incense-cedar, western redcedar, white fir, black oak, and big-leaf maple) exceeded use by adults. We did not observe any turkeys roosting in western hemlock (*Tsuga heterophylla*) or red alder (*Alnus rubra*).

DISCUSSION

Habitat Use

Differences in cover types hampered direct comparisons of roost habitat use between Rio Grande wild turkeys in the southern Oregon Cascades and Merriam's turkeys in the northern Oregon Cascades (Lutz and Crawford 1987). However, some

Table 1.5 Roost tree use by adult (n = 526 trees) and hen-poult (n = 39 trees) Rio Grande wild turkey flocks, Douglas County, Oregon, 1989-91.

	Percent	Adults		Hens with poults	
Tree species	Available	No. trees	Selection[a]	No. trees	Selection
Douglas fir	68.9	408	+	27	0
Ponderosa pine	11.2	69	0	2	0
Sugar pine	2.7	19	0	0	0
Incense-cedar	4.7	14	0	2	0
White fir	4.0	8	-	1	0
Other[b]	1.9	5	0	7	0
Oregon white oak	3.3	2	-	0	0
Pacific madrone	3.2	1	-	0	0

[a] A 0 represents use in proportion to availability, + represents greater use of a specie than expected, and - represents less use of a specie than expected ($P \leq 0.05$).

[b] Other species included big-leaf maple, California black oak, Oregon ash, and western redcedar. Red alder and western hemlock were available but unused.

aspects of roost habitat use were similar between the populations. Mature mixed conifer was used heavily by both populations but was used more than expected by Merriam's flocks (75% of roosts, 14% availability) and less than expected by Rio Grande flocks (30% of roosts, 56% availability). Because tree-growth patterns differed between study areas, trees in many mature mixed-conifer stands described by Lutz and Crawford (1987) were similar in size to trees in young mixed-conifer stands in Douglas County. Indeed, combined use of young and mature conifer stands by Rio Grande turkeys (71%) was similar to use of mature conifer stands by Merriam's turkeys. Both populations avoided sapling/pole stands, but use of mixed HC forests differed. Relatively strong roost habitat selection patterns by Rio Grande flocks contrasted with findings for Merriam's turkeys in South Dakota (Rumble 1992).

Habitat Characteristics

Comparisons of roost characteristics among studies were difficult because of differences in variables measured and geographic regions. Several differences were apparent among roosts used by Rio Grande turkeys in Oregon and Merriam's turkeys in Oregon (Lutz and Crawford 1987) and Washington (Mackey 1984). Canopy cover at Rio Grande roosts (84%) was greater than reported for Merriam's turkeys (20-58%) in other areas (Lutz and Crawford 1987, Rumble 1992). Height, dbh, and lowest living limbs of roost trees used by Rio Grande turkeys were greater than reported by Mackey (1984). In contrast, Merriam's turkeys in Washington roosted in stands with greater basal area and lower canopy height (Mackey 1984) than those stands used by Rio Grande hens. Values for roost tree height and dbh in southwestern Oregon exceeded those reported for Merriam's turkeys in South Dakota (Rumble 1992). Although dbh and height to lowest living limb of roost trees used by Rio Grande and Merriam's hen-poult flocks in Oregon were similar, adult Merriam's hens in Oregon roosted in larger diameter trees (Lutz and Crawford 1987) than Rio Grande hens.

Absolute values of roost characteristics differed among areas, but some patterns of use were similar. Within some mature conifer stands, hen-poult roosts used by both subspecies in Oregon were differentiated from adult roosts in that they consisted of smaller, younger trees with lowest living limbs closer to the ground. Although the same trend was evident for Rio Grande hen-poult flocks, the relationship was not significant in cover types other than mature conifer. We observed trends toward use of larger than average trees by Rio Grande turkeys that were consistent with reports for some Merriam's populations. However, we did not discern strong selection for the tallest trees available noted by Mackey (1984) and Lutz and Crawford (1987). Rather, relative roost tree size varied with cover type and social group. Adult flocks roosted in larger dbh trees than those available in the surrounding stand (i.e., 30 m away), but roost trees used by hen-poult flocks were not different from surrounding trees. Similar trends were described by Rumble (1992).

Compared with random sites in young cover types (DYC, HCW), Rio Grande adults roosted in stands consisting of larger than average trees, but roost stands in mature conifer cover types contained smaller than average trees. Lower tree densities in younger stands may have led to development of branch structures more conducive to roosting (particularly in DYC). A different pattern of tree development could explain roost tree use patterns in dense mature conifer stands; smaller trees might have branches better suited to roosting at lower heights than very large trees that had undergone high degrees of self-pruning during early stand development. Porter (1992) stressed the importance of horizontal branch structure for roosting and Rumble (1992) felt that branch structure was more important than tree diameter.

Because Rio Grande turkeys in this study did not select the largest, oldest trees available, they may be less sensitive to even-age management than Merriam's wild turkeys and may be able to better utilize areas with larger amounts of medium/young forest stands (<50 cm dbh and <110 years old) or stands at the lower end of our large/mature classification. Conversely, stand selection within DYC and HCW cover types indicated that turkeys used older stands with lower overstory tree densities. Further, fragmentation of HC woodlands, as measured by forested habitat within 0.3 km, may discourage use of this heavily used roost habitat.

In contrast to Porter (1992), we observed greater than expected use of southerly aspects and less than expected use of north-facing slopes for roosting. Mild winter climate in our study area may ameliorate requirements for thermoregulatory protection afforded by northeasterly slopes, but Merriam's turkeys in Oregon often roosted in exposed situations (R. S. Lutz, Tex. Tech. Univ., pers. commun.), indicating that thermoregulatory needs may be tempered by other factors.

Tree species with relatively low branches (e.g., maple) and smaller understory species (e.g., black oak) on upslope sites probably provided easier access for poults than taller canopy dominants. Hen-poult use of tree species in proportion to availability was consistent with use of individual trees that were indistinguishable (height and dbh) from adjacent trees. Adult Rio Grande turkeys in Oregon roosted in Douglas firs frequently

(69%) and use exceeded availability. Merriam's turkeys in Washington roosted primarily in Douglas fir (Mackey 1984), whereas Merriam's hens in Oregon most often used ponderosa pine (Lutz and Crawford 1987). However, these other researchers did not report tree species use relative to availability.

MANAGEMENT IMPLICATIONS AND RECOMMENDATIONS

Our research indicated that Rio Grande wild turkeys were more adaptable than Merriam's wild turkeys in the Oregon Cascades. Use of several cover types for roosting indicated that Rio Grande turkeys may thrive under a variety of habitat conditions, including some not conducive to Merriam's turkey populations. We contend that, in a relative sense, Rio Grande wild turkeys are generalists compared with Merriam's turkeys and, therefore, recommend that managers consider available habitat and likely future land management scenarios before selecting a subspecies for translocation. Rio Grande wild turkeys will likely fare better than Merriam's turkeys in relatively disturbed environments in the Oregon Cascades. Esthetic and economic returns of translocation programs will be enhanced by selection of subspecies best suited to regional habitat conditions.

Only unforested cover types and sapling/pole stands resulting from relatively recent perturbations were virtually unused for roosting. Maintaining or increasing areas of mixed hardwood/conifer habitats (particularly oak woodland complexes) would ensure availability of roost habitat as well as benefit other wildlife.

Because dense mature conifer was avoided for roosting, Rio Grande turkeys may thrive in landscapes dominated by relatively young forests (30-110 years old and 23-50 cm dbh). We caution, however, that average roost trees were 50 cm dbh and 106 years old and, therefore, at the upper limit of our stand classification criteria. Stands in this conifer age class exceed many current harvest rotations. Further, dense mature conifer received heavy use for most components of turkey life-history (ranked first or second for roost habitat use). Therefore, we do not recommend reducing average stand age or extensive harvest of mature timber as a means of increasing Rio Grande wild turkey numbers. We must caution that, because this research was not replicated outside the specified area, our scope of inference is limited to the study area and all results must be viewed as such.

Chapter 2

NEST HABITAT USE BY RIO GRANDE WILD TURKEYS IN OREGON

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ABSTRACT

Although wild turkey (*Meleagris gallopavo*) nest sites have been described, characteristics of nest sites and nest habitat use for introduced Rio Grande wild turkeys (*M. g. intermedia*) in the Pacific Northwest were unknown. Consequently, we examined 133 nest sites used by a recently established Rio Grande wild turkey population in southwestern Oregon from March 1989 through July 1991. Nests were located in 8 of 10 available cover types. Only clearcuts were used more often than expected for nesting (17% of observations, $P < 0.05$). Dense mature mixed conifer was used less than expected ($P < 0.05$) whereas meadows and dense sapling/pole conifer habitats were unused. Nest sites were characterized by dense horizontal screening (>93%), understory vegetation >20 cm tall, and low shrubs covering 37 to 69% of nest sites. Nests were located on southeast facing slopes more often than expected and north slopes were used less than expected ($P < 0.01$). A land management scheme that provides a mosaic of small clearcuts, dense young conifer stands, and mixed hardwood/conifer woodland and savanna cover types would provide nest habitat for Rio Grande wild turkeys in southwestern Oregon.

INTRODUCTION

Rio Grande wild turkeys were native to the southcentral Great Plains, but translocation programs resulted in population establishment in 9 western states (Wunz 1992). Variability in wild turkey movements and home ranges among geographic regions and subspecies was attributed primarily to differences in resource availability (Brown 1980). Although use of cover types indicated a high level of adaptability, turkeys were selective with respect to vegetative characteristics within cover types (Holbrook et al. 1987).

Habitat use by Rio Grande turkeys in their native range was studied extensively (e.g., Beasom 1970, Ransom et al. 1987), but few researchers described nest sites quantitatively. Habitat use by hens has direct bearing on annual recruitment and maintenance of populations (Lindzey 1967). Annual recruitment is influenced by nesting habitat because predation on hens and nests may limit population growth (Ransom et al. 1987). Nest sites used by Merriam's wild turkeys (*M. g. merriami*) were usually located in relatively dense understory cover or logging slash (Lutz and Crawford 1987), which provides a high level of concealment (Holbrook et al. 1987), and therefore influences predation on hens and nests (Beasom 1970). Descriptions of nest sites used by Rio Grande turkeys outside of their native range were scarce, and we are unaware of any in the Pacific Northwest. Availability of nest habitat and proximity to habitats that provide other requirements (e.g., brood-rearing habitat and roosts) may influence turkey use of an area. Because of the importance of nesting and nest habitat to annual recruitment in wild turkey populations, we quantified nest site characteristics and investigated nesting habitat used by Rio Grande wild turkey hens in southwestern Oregon and made comparisons to habitat use by Merriam's wild turkeys in the northern Oregon Cascades.

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STUDY AREA

The 675-km^2 study area was located in the upper South Umpqua River Basin, Douglas County, Oregon. Steep east-west ridges dissected the area and elevation ranged from 310 to 1,525 m. A heterogeneous association of plant cover types resulted from diverse edaphic and geologic conditions (Franklin and Dyrness 1973:130). Overstories were dominated by Douglas fir (*Pseudotsuga menziesii*) and other conifers or Oregon white oak (*Quercus garryana*) and Pacific madrone (*Arbutus menziesii*). Three non-forested (<10% tree cover) cover types accounted for 12% of the study area: recent clearcut (<10 years since harvest); brushfield; and meadow/pasture. Mixed hardwood/conifer (HC) savanna (10 - 40% canopy cover) was the rarest habitat (2%) and usually had not been managed for timber production. In contrast, timber management likely influenced stand development in HC woodland (7% of the area), which was defined by canopy closure >40 %. Remaining cover types were seral stages of mixed-conifer stands where canopy closure >70% was considered dense and closure <70% was classified as open. Douglas fir was a prominent component of most stands, but several other conifer species were present. Dense large/mature mixed conifer (DMC) was the most common cover type (49%); overstory trees were >50 cm dbh and >110 years old. Open large/mature mixed conifer (OMC, 4% occurrence) often developed from natural or management related thinning. Dense medium/young mixed-conifer (DYC) stands were characterized by overstory trees that were between 23 and 50 cm dbh and 30-110 years old (14% of the area). Open sapling/pole/young mixed-conifer (OSPC) stands occupied 3% of the area and likely developed as a result of sparse regeneration or precommercial thinning. Dense sapling/pole mixed-conifer (DSPC) stands resulted from normal tree growth after even-age regeneration harvests or catastrophic disturbance (8% of the area). The ODFW released 58 Rio Grande wild turkeys from Texas and Kansas on the study area in 1982 and 1983 (R. R. Denney, ODFW, unpubl. data).

METHODS

Capture and Radio Telemetry

Rocket nets were used to capture turkeys during winters of 1988-89 and 1989-90. We examined characteristics of primary feathers (Larson and Taber 1980) to determine hen age and equipped each hen with a 90- to 110-g radio transmitter attached with a modified backpack harness (Kenward 1987:103). Transmitters were equipped with motion sensitive switches; expected transmitter life ranged from 1 to 3 years.

During 2 trapping seasons, we captured 181 wild turkeys. In 1988-89, we equipped 26 adult and 19 yearling hens with transmitters. Fifteen adults and 15 yearlings (considered adults during the second year) survived to 1990 and we equipped 10 more adults and 21 yearlings with transmitters during the 1989-90 trapping season. Therefore, the total sample included 36 adult and 40 yearling hens. At the beginning of the 1991 nesting season, 21 hens were alive. All radio-tagged hens survived >2 weeks after release.

We monitored hens >5 times/week during reproductive seasons (Mar-Sep) from 1989 to 1991. Direction to radio signals was ascertained by the peak-signal method (Springer 1979). To the extent possible, signals were monitored daily to aid in identification of nest initiation, incubation, mortality, and hen locations. Egg-laying and incubation were identified by repeated radio locations at the same site and activation of motion sensors (indicating no movement) followed by resumption of normal pulse rates. We minimized disturbance of nesting hens to reduce risk of observer-induced abandonment. Nest locations were determined by visual observation or by triangulation from several points within 30 m of incubating hens. Nests were located within 48 hours of hatching or failure (abandonment or predation) by searching the area indicated by triangulation. We monitored all hens after nest termination and identified renest attempts with the same procedure.

We did not monitor 13 hens (7 ad, 6 yrl) during nesting seasons because of deaths or transmitter failures. We monitored 33 hens for 1 nesting season, 22 for 2 seasons, and 8 for 3 seasons. Consequently, the number of times hens were available to attempt first nests in each breeding season amounted to a maximum potential sample of 101 first nests during the 3-year study (e.g., a hen alive for 3 years could initiate 3 first nests, 1 each year).

Habitat Mapping and Quantification

We identified 10 cover types from aerial photographs (taken summer 1989) and ground reconnaissance. Sites ($n = 56$) for quantifying physiographic and vegetative variables were randomly located in all cover types and consisted of 3 points located 30 m apart. We delineated cover types and developed descriptions by sampling physiographic characteristics and 4 vegetative strata: overstory (woody plants >3 m tall), midstory (woody plants >3 m tall, but beneath canopy), shrub (woody plants 1-3 m tall), and understory (woody and herbaceous plants <1 m tall).

We quantified several physiographic and vegetative (overstory and midstory) variables at each site: percent slope, aspect, elevation, percent non-forested habitat within 0.3 km, species composition, density, basal area, percent cover, and canopy height. We estimated slope with a clinometer, aspect with a compass, and elevation from topographic maps. Percent non-forested habitat within 0.3 km of each brood-rearing site was estimated from habitat maps with an overlay of 50 randomly distributed points (Marcum and Loftsgaarden 1980). We recorded species, distance to sample point, and diameter-at-breast-height (dbh) of the nearest midstory and overstory tree in each "quarter" to estimate density and basal area (Cottam and Curtis 1956). Percent cover of overstory and midstory strata (combined) was estimated with a sighting tube (James and Shugart 1970) by presence or absence at 2-m intervals along 4 10-m transects originating at sample points. We measured heights of 5 randomly selected trees in each stratum with a clinometer to estimate overstory and midstory canopy height.

We quantified the following shrub and understory characteristics at all sample sites: tall shrub cover, understory vegetation height, understory ground cover, and horizontal screening. We estimated tall shrub cover along each of 4 10-m transects with the line-intercept method (Canfield 1941). Understory vegetation was sampled in 5 1-m^2 circular plots, 1 at the central sample point and 4 at randomly selected points within 4 m. We measured understory vegetation height at 4 random locations in each 1-m^2 plot and estimated percent cover of grasses and grasslike plants, forbs, low shrubs (<1 m), bare ground, and woody debris. A vegetation profile board (0.3 x 1.2 m) (Nudds 1977) was placed at sample points and observed from 4 locations at a distance of 10 m (at 0.75 m above ground level) to provide an index of horizontal cover. We estimated percent horizontal screening for each 0.3-m interval on profile boards.

Vegetative and physiographic characteristics of nesting habitat were sampled at 3 points, 1 at the nest and 2 located 30 m from the nest at random compass bearings. Procedures for quantification of physiographic variables and vegetation in all strata in nesting habitat were identical to those employed to develop general cover-type descriptions.

Statistical Analyses

Data were analyzed with a series of univariate and multivariate procedures. We combined nests (based on year, hen age, or nest success) within each cover type because of small sample sizes. However, first nest attempts and renest attempts were examined separately. All data sets were examined to assess outliers, normality, multicolinearity, and homogeneity of variance-covariance matrices. We noted wide variance for several observations, but few distinct outliers were identified and inclusion of those observations did not alter results. Although several variables displayed non-normal distributions, transformations did not improve normality nor alter results, so original values were retained for all analyses. When ≥ 2 variables were highly correlated ($r > 0.7$), we selected those variables with the greatest ecological relevance and/or management application that contributed to the most parsimonious description of relationships.

We used analysis of variance to help identify variables that differed between groups (e.g., random sites and nests) and reduce the number of variables entered in multivariate procedures. Stepwise discriminant analysis was employed to select optimal sets of variables for separation of groups of observations. We then subjected the reduced variable sets selected in stepwise procedures to canonical analyses of discriminance to determine correlations between discriminating variables and canonical functions. Results of discriminant function analyses should be considered descriptive. Lack of compliance with inherent assumptions of these procedures can produce unpredictable distortion and alter resulting interpretations.

To better understand relationships of individual habitat characteristics important to wild turkeys, we compared several habitat variables with paired and unpaired t-tests. For example, we used paired t-tests to determine whether understory cover, understory vegetation height, or horizontal screening differed between nests sites (10-m diameter) and sites 30 m away from nests.

We employed Chi-square analysis to test the null hypothesis that cover types were used in proportion to availability (Neu et al. 1974, Byers et al. 1984). Habitat availability was defined by a minimum convex polygon (Mohr 1947) for all annual hen locations. When null hypotheses were rejected, we calculated simultaneous confidence intervals to identify which cover types contributed to differences in use and whether use was greater or less than expected. Initially, use and availability were analyzed within and between nest types (first or renest) and hen age-classes (within constraints imposed by sample size). Preliminary analyses indicated that habitat use did not differ with nest or hen age (regardless of whether multiple nests for individual hens were included). Consequently, observations were pooled accordingly for examination of habitat use.

RESULTS

Habitat Use

Nests ($n = 133$) were located in 8 cover types (Table 2.1) and use of habitats by nesting hens was disproportionate to availability ($P < 0.05$). Meadow/pasture and dense sapling/pole mixed conifer (SPC) were unused, and dense mature conifer (MC) was used less than expected ($P < 0.05$). Recent clearcut was the only cover type used more than expected ($P < 0.05$), whereas use of brushfields, all hardwood/conifer (HC) stands, open sapling/pole, open mature conifer, and dense young conifer did not differ from availability. Although use of HCW and HCS stands (examined separately) did not exceed availability ($P > 0.15$), when HC stands were combined, use was greater than expected ($P < 0.01$). Patterns of nest habitat use changed from year to year. During 1989, recent clearcut was most commonly used for nesting (30%); however, <13% of nests occurred in this cover type in subsequent years. Dense MC stands received the heaviest use during 1990 (36%). Dense young and mature conifer each accounted for 26% of nests in 1991. Use of clearcuts was the only situation that changed substantially when first nests and renests were examined separately (first nests were initiated in

Table 2.1 Habitats used by nesting Rio Grande wild turkey hens (n = 59 hens), Douglas County, Oregon, 1989-91 (n = 133 nests).

		Percent			
Cover type	No. nests	Available	Used	Selection[a]	Nest success[b] (%)
Clearcut	23	6.1	17.3	+	62
Meadow/pasture	0	2.5	0	-	
Brushfield	3	3.8	2.3	0	33
Open sapling/pole mixed conifer[c]	13	3.4	9.8	0	50
Dense sapling/pole mixed conifer	0	8.0	0	-	
Dense young mixed conifer	22	14.4	16.5	0	78
Dense mature mixed conifer	36	48.9	27.1	-	69
Open mature mixed conifer	6	4.3	4.5	0	40
Mixed hardwood/ conifer woodland[d]	19	6.8	15.0	0	37
Mixed hardwood/ conifer savanna	10	2.0	7.5	0	60

[a] Where 0 represents use in proportion to availability, + represents greater use of a habitat than expected, and - represents less use of a habitat than expected ($P \leq 0.05$).

[b] Infertile clutches incubated >30 days considered successful, excludes observer induced abandonment.

[c] In conifer cover types open defined as canopy closure <70%.

[d] Woodland defined as canopy closure ≥40%, savanna canopy closure was <40%.

clearcuts in proportion to availability and renest attempts were located in clearcuts more often than expected).

For all years combined, hens were most successful in the 3 most heavily used cover types: DY conifer (78%), DM conifer (69%), and recent clearcut (62%) (Table 2.1). Nests in brushfields, HC woodlands, and open MC were least likely to hatch.

Nest Site Characteristics

We completed habitat measurements at 126 nest sites from 1989 to 1991. The number of nests used for this analysis was less than the number included in habitat use analysis because we were unable to identify cover type for 7 nests before hens left nests or died. First nest attempts (n = 87) accounted for 69% of all nests and we identified 39 renest attempts (second, third, and fourth nests within a year).

Overstory characteristics differed among cover types and between nest attempts (Tables 2.2 and 2.4). However, several understory variables at first nests were relatively consistent among cover types (Table 2.3). For example, understory vegetation height at first nests was >20 cm in all cover types. Further, horizontal screening from 0 to 30 cm was >93% and screening from 30 to 60 cm ranged from 73 to 100% at first nests regardless of cover type. High horizontal screening at nests apparently was provided by low shrubs. Low shrubs were the dominant understory component at first nest sites (37-69%) in all cover types whereas grass contributed least to ground cover estimates (2-11%). Forbs, bare ground, and woody debris each accounted for >11% of ground cover at first nests. Forbs and bare ground reached their highest coverage (25% and 22%, respectively) in DM conifer. The greatest amounts of woody debris occurred in

Table 2.2 Overstory and midstory habitat characteristics at Rio Grande wild turkey first nest attempts, Douglas County, Oregon, 1989-91.

	Clearcut (n=13)		Shrub (n=3)		Open SPC[a] (n=9)		Dense YC (n=17)		Dense MC (n=26)		Open MC (n=5)		HCW (n=9)		HCS (n=5)	
Variable[b]	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE
Overstory																
height (m)	15	3	7	2	15	1	27*	1	42	2	44	6	17	2	15	4
dbh (cm)	22	7	12	4	23	1	34	1	66*	3	72	8	28	4	25	6
basal area (m^2/ha)	2	1	5	2	10	1	19	3	38	4	13	1	11	2	5	1
density (trees/ha)	82	33	262	166	258	66	181	26	111	12	35	10	213	40	170	90
Midstory																
height (m)	3	1	2	2	6	1	8	0.5	13	1	10	1	5	0.4	5	1
dbh (cm)	4	1	4	4	8	1	11	1	15	1	13	1	8	1	6	2
basal area (m^2/ha)	0.2	0.1	1	1	2	0.5	4	1	11	2	3	1	2	0.4	1	0.2
density (trees/ha)	69	22	254	254	334	110	345	55	381	45	139	40	403	109	141	42
Canopy cover (%)	14	4	14	6	47	4	69	4	77	3	35	9	57	5	35	5
Elevation (m)	789	61	555	3	669	77	573	31	676	31	662	87	601	42	538	62
Slope (%)	15	2	20	8	16	2	14	2	18	2	17	4	15	3	16	3
Non-forest within 0.3 km (%)	25*	3	18	7	5	3	3	1	4	1	8	4	7	3	3	2

[a] SPC = sapling/pole conifer, YC = young conifer, MC = mature conifer, HCW = hardwood/conifer woodland, HCS = hardwood/conifer savanna.

[b] Variable means followed by an asterisk were selected by stepwise discriminant analysis when compared to randomly located sites within the same cover type.

Table 2.3 Understory habitat characteristics at Rio Grande wild turkey first nest attempts, Douglas County, Oregon, 1989-91.

	Clearcut		Shrub		Open SPC[a]		Dense YC		Dense MC		Open MC		HCW		HCS	
	(n=13)		(n=3)		(n=9)		(n=17)		(n=26)		(n=5)		(n=9)		(n=5)	
Variable[b]	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE
Tall shrub cover (cm/10m)	66	10	288	102	85	34	98	27	95	19	139	48	98	42	81	18
Horizontal screening (%)																
0-30 cm	96	2	100	0	97	2	94	3	93*	2	95*	3	93	3	96	3
30-60 cm	88*	3	100	0	91	4	82	4	74	5	83	9	77	7	90	6
60-90 cm	74	4	99	1	76	9	64*	6	53	5	71	11	62	9	79	9
90-120 cm	62	5	99	1	75	9	57	5	47	5	65	14	60	8	62	11
Understory height (cm)	26	4	60	4	21	4	30*	4	30	3	40	9	35	5	37	4
Understory cover (%)																
Grass	11	5	5	3	4*	1	4	3	2	1	8	3	7	3	11	5
Forb	14	2	13	3	19	4	16	3	25	4	22	5	11	3	20	6
Bare	16	3	15	4	18	4	19	3	22	3	11	6	14	2	13	3
Low shrub	37	5	69	11	39	7	44	5	45	4	53	6	49*	7	47*	4
Debris	34	5	11	1	30	6	26*	4	13*	2	16	6	28*	7	20	7

[a] SPC = sapling/pole conifer, YC = young conifer, MC = mature conifer, HCW = hardwood/conifer woodland, HCS = hardwood/conifer savanna.

[b] Variable means followed by an asterisk were selected by stepwise discriminant analysis when compared to randomly located sites within the same cover type.

Table 2.4 Overstory and midstory habitat characteristics at Rio Grande wild turkey renest attempts, Douglas County, Oregon, 1989-91.

Variable[b]	Clearcut (n=10) $\bar{x}$	Clearcut SE	Open SPC[a] (n=3) $\bar{x}$	Open SPC SE	Dense YC (n=4) $\bar{x}$	Dense YC SE	Dense MC (n=8) $\bar{x}$	Dense MC SE	Open MC (n=1) $\bar{x}$	Open MC SE	HCW (n=10) $\bar{x}$	HCW SE	HCS (n=3) $\bar{x}$	HCS SE
Overstory														
height (m)	13	3	18	0.4	32	5	46	4	42		18	1	12	1
dbh (cm)	20	4	25	4	40	4	74	6	49		30	3	22	2
basal area (m^2/ha)	2	1	3	0.3	14	4	42	7	14		6	1	6	2
density (trees/ha)	36	8	54	12	111	25	99	21	68		86	13	107	28
Midstory														
height (m)	3	1	6	1	12	3	13	1	15		6*	0.4	5	0.2
dbh (cm)	4	2	8	2	11	2	15	2	17		9	1	9	1
basal area (m^2/ha)	1	1	1	1	4	1	10	2	10		2	0.4	1	0.1
density (trees/ha)	128	59	185	44	319	68	425	69	327		256	42	104	43
Canopy cover (%)	14	7	29	8	64	11	84	3	48		46	5	38	5
Elevation (m)	709	44	645	24	693	122	742	77	495		622	38	636	7
Slope (%)	16	7	10	1	13	1	16	3	10		12	1	16	4
Non-forest within 0.3 km (%)	16*	3	0	0	1	1	5	2	0		6	1	11	5

[a] SPC = sapling/pole conifer, YC = young conifer, MC = mature conifer, HCW = hardwood/conifer woodland, HCS = hardwood/conifer savanna.

[b] Variable means followed by an asterisk were selected by stepwise discriminant analysis when compared to randomly located sites within the same cover type.

clearcuts (34%). The pattern of understory composition was similar for renest attempts but differed in some cover types, particularly HC savanna (Table 2.5).

We noted consistently greater values for understory height, low shrub cover, and horizontal screening (0-30 cm) in a comparison of nests sites to locations 30 m away from nests ($P < 0.0001$). These differences were, with few exceptions, universal with respect to cover type and nest attempt. Although we did not attempt to quantify nest distribution with respect to travel lanes, we estimated that 60% of nests were <50 m from travel lanes (e.g., animal or skid trail, or road).

During 3 years of study, 23 nests were located in recent clearcuts. Horizontal screening from 30 to 60 cm and amount of non-forested habitat within 0.3 km discriminated between first nest sites ($n = 13$) and randomly located sites (Tables 2.6-2.8). Differences between first nest sites and random sites accounted for 74% of canonical function variation ($P = 0.0002$). Nest sites were characterized by more forested habitat within 0.3 km and more horizontal screening than at random sites. The same variables discriminated between renest sites and random sites in clearcuts (a situation unique to the clearcut cover type). Discrimination between renest sites and random sites was stronger than for first nests; 82% of canonical function variance was attributed to site differences ($P = 0.0002$). Trends for horizontal screening and forest habitat within 0.3 km were the same as observed for first nest attempts. Horizontal screening at all nests in clearcuts was approximately 55% greater than at random sites.

We located 21 nests in DY conifer stands and 4 variables allowed discrimination between first nests ($n = 17$) and random sites: understory vegetation height, overstory tree height, woody debris, and horizontal screening (60-90 cm). These variables

Table 2.5 Understory habitat characteristics at Rio Grande wild turkey renest attempts, Douglas County, Oregon, 1989-91.

	Clearcut		Open SPC[a]		Dense YC		Dense MC		Open MC		HCW		HCS	
	(*n*=10)		(*n*=3)		(*n*=4)		(*n*=8)		(*n*=1)		(*n*=10)		(*n*=3)	
Variable[b]	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE
Tall shrub cover (cm/10m)	51	16	136	20	55	27	90	32	56		73	20	39	38
Horizontal screening (%)														
0-30 cm	96	2	100	0	88	6	93	3	93		92*	3	78	7
30-60 cm	91*	2	100	0.1	64	13	73	7	66		78	5	67	11
60-90 cm	71	6	92	4	48	13	53	6	43		57	6	48	15
90-120 cm	66	8	68	8	49	13	51	6	29		53	8	36	18
Understory height (cm)	29	5	51*	2	19	1	31*	3	18		30	4	14*	1
Understory cover (%)														
Grass	11	6	11	5	1	0.3	3	1	41		16	5	15	8
Forb	16	4	43	4	13	2	21	4	2		14	2	5	1
Bare	16	2	11	1	19	1	16*	3	12		21	4	50	10
Low shrub	34	3	38	10	50*	5	50	6	48		44	6	22	10
Debris	32	6	13	4	26	5	18	3	5		16	2	10	1

[a] SPC = sapling/pole conifer, YC = young conifer, MC = mature conifer, HCW = hardwood/conifer woodland, HCS = hardwood/conifer savanna.

[b] Variable means followed by an asterisk were selected by stepwise discriminant analysis when compared to randomly located sites within the same cover type.

Table 2.6 Overstory and midstory characteristics of available habitats in Rio Grande wild turkey study area, Douglas County, Oregon, 1990-91.

		Overstory								Midstory							
		Height (m)		Dbh (cm)		Basal area (m^2/ha)		Trees/ha		Height (m)		Dbh (cm)		Basal area (m^2/ha)		Trees/ha	
Cover type[a]	*n*	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE
CC	3	4	2	6	3	0.1	0.1	19	10								
B	1	7		5		1.2		356									
OSPC	8	14	1	23	2	5.5	1.3	126	36	5	1	7	1	2	0.5	282	77
DYC	11	22	1	30	1	30.8	5.5	396	70	8	1	11	1	10	2.5	1005	250
DMC	15	50	2	82	4	52.4	5.3	100	12	15	1	16	1	16	2.4	545	82
OMC	2	43	11	86	25	14.4	6.8	23	1	10	2	16	2	2	0.4	82	1
HCW	7	16	1	25	3	10.0	1.1	213	31	7	1	9	1	4	1.0	701	153
HCS	4	20	5	33	10	6.5	1.4	130	66	8	1	14	6	2	0.3	294	117

[a] CC = clearcut, MP = meadow/pasture, B = brushfield, OSPC = open sapling/pole mixed conifer, DSPC = dense sapling/pole mixed conifer, DYC = dense young mixed conifer, DMC = dense mature mixed conifer, OMC = open mature mixed conifer, HCW = hardwood/conifer woodland, and HCS = hardwood/conifer savanna.

Table 2.7 Characteristics of available habitats in Rio Grande wild turkey study area, Douglas County, Oregon, 1990-91.

		Canopy cover (%)		% non-forest within 0.3 km		Elevation (m)		Slope (%)		Tall shrub cover (cm/10m)		Understory height (cm)	
Cover type[a]	*n*	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE
CC	3	0	0	55	11	937	202	11	3	13	6	22	1
B	1	37		48		888		32		73		21	
OSPC	8	36	5	18	12	945	56	17	3	69	24	25	5
DYC	11	83	4	5	2	710	57	15	2	49	14	9	2
DMC	15	91	3	6	2	808	59	19	3	43	16	15	3
OMC	2	31	9	11	1	1072	74	15	2	1	1	5	2
HCW	7	61	7	15	4	701	36	14	2	34	11	11	2
HCS	4	46	7	1	1	684	78	8	1	31	21	12	3

[a] CC = clearcut, MP = meadow/pasture, B = brushfield, OSPC = open sapling/pole mixed conifer, DSPC = dense sapling/pole mixed conifer, DYC = dense young mixed conifer, DMC = dense mature mixed conifer, OMC = open mature mixed conifer, HCW = hardwood/conifer woodland, and HCS = hardwood/conifer savanna.

Table 2.8 Understory characteristics of available habitats in Rio Grande wild turkey study area, Douglas County, Oregon, 1990-91.

		Horizontal screening (%)								Ground cover									
		0-30 cm		30-60 cm		60-90 cm		90-120 cm		Grass		Forb		Bare		Low shrub		Debris	
Cover type[a]	*n*	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE
CC	3	81	8	60	9	37	10	31	9	25	10	16	5	25	10	17	2	23	4
B	1	96		85		81		83		5		15		33		39		13	
OSPC	8	85	5	76	7	65	9	60	8	14	3	26	5	28	4	22	5	16	4
DYC	11	73	4	62	4	50	4	51	5	3	2	16	4	51	5	15	3	19	2
DMC	15	72	5	56	5	41	5	37	4	2	1	12	2	39	3	26	3	25	2
OMC	2	51	3	40	3	30	4	22	4	7	5	8	1	50	10	5	2	31	15
HCW	7	60	7	47	7	38	5	40	4	11	2	13	3	58	8	10	3	10	2
HCS	4	59	14	40	14	28	11	30	13	21	9	16	1	41	6	11	6	12	4

[a] CC = clearcut, MP = meadow/pasture, B = brushfield, OSPC = open sapling/pole mixed conifer, DSPC = dense sapling/pole mixed conifer, DYC = dense young mixed conifer, DMC = dense mature mixed conifer, OMC = open mature mixed conifer, HCW = hardwood/conifer woodland, and HCS = hardwood/conifer savanna.

accounted for 75% of canonical variation ($P = 0.0001$). First nest sites had taller understory vegetation and overstory trees, more woody debris, and more horizontal screening from 60 to 90 cm than random sites.

Hardwood/conifer woodlands contained 15% of all measured nest sites. Nine nests were first attempts and 10 were renest attempts, making HCW the only cover type in which renest attempts exceeded first attempts. Low shrub cover and woody debris discriminated between first attempts and random sites, accounting for 85% of variation in the canonical function ($P = 0.0001$, invalidated by unequal variance-covariance matrix). Low shrub and woody debris coverage at nests were 5 and 3.5 times greater, respectively, than values at random sites in HC woodlands. Midstory tree height and horizontal screening from 0 to 30 cm discriminated between random locations and renesting sites. Based on discriminant analysis, 76% of canonical function variance was attributable to differences between renest locations and random sites ($P = 0.0001$). Renest sites in HC woodlands were typified by increased horizontal screening and shorter midstory trees compared with random sites. Horizontal screening from 0 to 30 cm at nests was 50% greater than at random sites (92% vs. 60%).

Relatively few hens nested in HC savanna stands: 5 nests were first attempts and 3 were renest attempts. A canonical function including shrub cover accounted for 85% of variation between first nest sites and random locations ($P = 0.0004$). First nest sites were characterized by more low shrub cover than random locations. Understory vegetation height discriminated between random and renest locations and 80% of canonical function variation was attributed to differences between locations ($P = 0.007$). Understory vegetation at random sites was shorter than at nest bowls.

Dense MC stands contained more nests ($n = 34$) than any other cover type, but canonical analysis provided weak discrimination (40-50%) between nests and random sites. Horizontal screening in the 0-30 cm stratum at first nests was 90% compared with 72% at random locations and contributed most to discrimination. Vegetation at renesting locations was 2 times taller than at random sites and bare ground only occupied one-half as much area at renest sites. Similarly, discrimination between nest sites and random locations in open sapling/pole conifer was weak (50%), but grass cover at random sites was 3.5 times that observed at nests.

All nests were pooled for analysis of aspect use. Hens nested at sites with easterly aspects (45°-135°) more often than expected ($P < 0.05$), used west and north aspects less than expected (225°-45°, $P < 0.05$), and nested on southerly aspects (135°-225°) in proportion to availability.

DISCUSSION

Nest Habitat Use

In contrast to Merriam's turkeys in the northern Cascades of Oregon (located 260 km north of the Douglas County study area, Lutz and Crawford 1987), Rio Grande hens nested in most available habitats and 6 of 10 cover types were used in proportion to availability. Merriam's hens used thinned sapling/pole conifer stands more than expected and >90% of successful nests were located in that cover type (Lutz and Crawford 1987). Only 2 of 133 Rio Grande nests were located in comparable stands. Cover type use by nesting Merriam's turkeys in South Dakota was not different from availability (Rumble and Hodorff 1993).

Dense mature conifer was used heavily (27% of nests) but less than expected. Although annual shifts in cover-type use were apparent, there was no evidence of concurrent changes in nest success. Although nest success was highest in the 3 most frequently used cover types, success in all cover types was equal to or exceeded that reported in many other studies (e.g., Porter et al. 1983, Vangilder et al. 1987). High nest success in a variety of habitats further demonstrated the adaptability of Rio Grande wild turkeys. Whereas Merriam's turkey nest location and success in northcentral Oregon seemed closely associated with a single stand condition (Lutz and Crawford 1987), Rio Grande hens were successful in a variety of cover types and stand conditions.

Contrary to observations of Day et al. (1991) and Schmutz et al. (1989), we did not observe a trend toward initiation of late season nests (particularly renest attempts) in open habitats nor for hens to renest in "opposite" habitats (e.g., first nest in woodland and second nest in grassland). Indeed, >50% of subsequent nest attempts (within and among years, $n = 43$) by Rio Grande hens were in the same cover types as previous nests. Differences between our findings and those of Day et al. (1991) and Schmutz et al. (1989) may have been a consequence of their renest sample sizes (2 and 4, respectively). Conversely, temporal nest habitat use patterns may have reflected different plant phenology among areas. Both Day et al. (1991) and Schmutz et al. (1989) indicated that grass-forb cover types provided increased nest cover as nest seasons progressed. In Oregon, however, cover in grass-forb associations decreased as dry conditions caused plant senescence by mid- to late nest season.

Nest Site Characteristics

Although we noted considerable variation among cover types, a small number of understory variables were useful for characterizing nests. Height and density of understory vegetation (particularly low shrubs) were frequent contributors to discriminant functions. Grass and forb cover rarely were useful for discriminating between nest sites and random sites; the role of woody debris was difficult to discern.

Some structural characteristics that differentiated nests from random sites were similar for Rio Grande and Merriam's hens in Oregon (Lutz and Crawford 1987). Specifically, nests in both areas were characterized by relatively dense shrub cover and sparse grass and forb cover. Greater shrub cover at nest sites compared to surrounding areas and random sites also were noted by Day et al. (1991), Schmutz et al. (1989), and Rumble and Hodorff (1993). In most cover types, Rio Grande hens nested in relatively isolated patches (<20 m diam) of low shrubs, as indicated by shrub cover, horizontal screening, and vegetation height differentials for immediate nest sites compared to sites 30 m from nests. Rumble and Hodorff (1993) thought that nest site selection was based on areas <5 m in diameter and noted that vegetation at nests (23 cm) was taller than in surrounding areas. We noted a similar trend; average vegetation height at nests was 30 cm and decreased to <20 cm in surrounding areas.

Horizontal screening values at nests frequently exceeded values from surrounding locations in both Oregon study areas. Screening at Merriam's nests was attributed primarily to logging slash although low shrubs also contributed (Lutz and Crawford 1987), whereas low shrubs were the main source of screening at Rio Grande nests and amounts of slash varied. Patterns of greater horizontal screening at Rio Grande nests were consistent with observations of nests of other subspecies across the U.S. (Porter 1992). Our estimates of horizontal cover below 60 cm were the same as those reported by Schmutz et al. (1989).

The observation that nest success was largely unrelated to habitat characteristics agreed with results from South Dakota (Rumble and Hodorff 1993) and Colorado (Schmutz and Braun 1989) and may indicate that turkeys were not habitat-limited with respect to nests. We recognized, however, that different variables or scales of resolution may be important to nest success. Disproportionate use of easterly slopes for nesting may have reflected cover type distribution in southwestern Oregon where mixed HC stands and open sapling/pole conifer stands were more common on east and south facing slopes. Rumble and Hodorff (1993) did not observe disproportionate use of aspects in South Dakota.

MANAGEMENT IMPLICATIONS AND RECOMMENDATIONS

Our research indicated that Rio Grande wild turkeys were more adaptable and productive than Merriam's wild turkeys in the northern Oregon Cascades. High nest success in several cover types and use of most available cover types for nesting indicated that Rio Grande turkeys would thrive under a variety of habitat conditions, including some not conducive to Merriam's turkey populations. We contend that, in a relative sense, Rio Grande wild turkeys are generalists compared with Merriam's turkeys and, therefore, recommend that managers consider available habitat and likely future land management scenarios before selecting a subspecies for translocation. Rio Grande wild turkeys will likely fare better than Merriam's turkeys in relatively disturbed environments in the Oregon Cascades. Esthetic and economic returns of translocation programs will be enhanced by selection of subspecies best suited to regional habitat conditions.

Although Rio Grande turkeys used a variety of cover types successfully, several management practices would enhance nest habitats. Small clearcuts provided nest habitat, but dense stands resulting from relatively recent perturbations (conifer or tall shrub stands that developed after even-age management practices or disturbance) were virtually unused. When compatible with other objectives, patch thinning in dense sapling/pole and prescribed burning to reduce dense shrub cover in brushfields should improve stands for nesting (35-55% low shrub cover). In contrast to Merriam's turkey management, moderate slash treatment may be desirable in Oregon's Rio Grande wild turkey range; patches of low shrub cover (<20 m diam) can be maintained for nesting cover. Conservation of mixed hardwood/conifer habitats (particularly oak woodland and savanna complexes) would maintain habitat diversity and should benefit wild turkeys and other wildlife species.

Because dense mature conifer was used less than expected for nesting, roosting (Keegan and Crawford 1995a), and brood rearing (Keegan and Crawford 1995b), Rio Grande turkeys will probably thrive in landscapes dominated by relatively young forests (30-110 years old and 23-50 cm dbh). However, dense mature conifer received heavy use for most components of turkey life-history (ranked first or second for roost, brood, and summer habitat use, Keegan and Crawford 1995a, b). Therefore, we do not recommend reducing average stand age or extensive harvest of mature timber as a means of increasing Rio Grande turkey numbers.

Other practices that might benefit wild turkeys, by reducing disturbance to pre-incubating hens and hens with broods, include closing roads to motor vehicle traffic during early reproductive season (Apr-Jun) and delaying spring gobbler hunting until most hens begin incubation. Management programs that ameliorate disturbance of pre-incubating hens and hens with broods may positively influence productivity. Poaching and crippling loss were more prevalent near open roads in Virginia (Holbrook and Vaughn 1985). We documented little disturbance of incubating hens related to hunting activities, but we could not assess disturbance of laying hens or hens with broods. Alterations in road management could limit disturbance by reducing human contact with laying hens (Steffen et al. 1988). Because this research was not replicated outside the specified area, our scope of inference is limited to the study area and all results must be viewed as such.

Chapter 3

PRODUCTIVITY AND SURVIVAL OF RIO GRANDE WILD TURKEY HENS IN OREGON

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ABSTRACT

Although reproductive characteristics of wild turkeys (*Meleagris gallopavo*) have been documented for most subspecies in a number of locations, productivity and survival of introduced Rio Grande wild turkey (*M. g. intermedia*) hens in the Pacific Northwest were unknown. Consequently, we examined 126 nests of 63 hens and estimated age-specific survival rates of a recently established Rio Grande turkey population in southwestern Oregon from March 1989 through June 1991. Measures of productivity for first nests did not differ between adults and yearlings ($P > 0.10$), but adults were more prolific renesters. Annual survival differed among years, but not between age classes ($P \geq 0.17$). Wildlife managers should consider effects of spring and autumn hunting on nest and brood disturbance and hen survival, respectively.

INTRODUCTION

Rio Grande wild turkeys were native to the southcentral Great Plains, but translocation programs resulted in establishment of populations in 9 western states (Wunz 1992). Nesting rates, productivity, and survival are basic components of annual recruitment and population maintenance for wild turkeys. Reproductive capacity may be controlled by population density (Porter 1978:115) and influenced by several factors, such as hen age. Understanding age-related productivity is important for determining age composition of turkey releases in stocking efforts and managing populations (Lewis 1967). Yearling Merriam's wild turkey (*M. g. merriami*) hens in Oregon rarely attempted to nest and contributed little to annual recruitment (Lutz and Crawford 1987). However, productivity of adult and yearling eastern wild turkeys (*M. g. silvestris*) and

Florida wild turkeys (*M. g. osceola*) were comparable (Austin et al. 1973, Williams et al. 1978). Little data about age-related productivity of Rio Grande turkeys have been published, but yearlings contributed 40% of all broods produced in Texas (Reagan and Morgan 1980).

Productivity of Rio Grande turkeys in their native range was studied by Baker et al. (1980), Reagan and Morgan (1980), and Ransom et al. (1987), but sample sizes were small or age classes were not separated. Several researchers reported survival rates and causes of mortality for other wild turkey subspecies (e.g., Kurzejeski et al. 1987, Ransom et al. 1987), but rates and causes of Rio Grande wild turkey mortality outside of the native range were unknown. Because of the importance of productivity and hen survival to wild turkey populations, we investigated reproductive characteristics and survival of Rio Grande turkey hens in southwestern Oregon.

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STUDY AREA

The 675-km^2 study area was located in the upper South Umpqua River Basin, Douglas County, Oregon. The area was dissected with steep east-west ridges and elevations ranged from 310 to 1,525 m. Diverse edaphic and geologic conditions produced a heterogeneous association of plant cover types (Franklin and Dyrness 1973:130). Three non-forested (< 10% tree cover) cover types accounted for 12% of the study area: recent clearcut (< 10 years since harvest); brushfield; and meadow/pasture. Mixed hardwood/conifer savannas and woodlands contained ≥30% hardwoods, primarily Oregon white oak (*Quercus garryana*) and Pacific madrone (*Arbutus menziesii*), and occupied 9% of the area. Remaining cover types (79% of the area) were seral stages of mixed-conifer stands dominated by Douglas fir (*Pseudotsuga menziesii*). Mature mixed-conifer stands contained overstory trees ≥50 cm diameter-at-breast-height (dbh) and >110 years old. Young conifer stands were characterized by trees that were 23-50 cm dbh and 30-110 years old. Sapling/pole conifer stands were <30 years old with trees <23 cm dbh. Detailed habitat descriptions were provided in Keegan and Crawford (1996b). Our study area on the west slope of the southern Cascade Range was approximately 260 km south of the northern Oregon Cascade (east slope) study area where Lutz and Crawford (1987) examined habitat use by Merriam's wild turkeys. The ODFW released 58 Rio Grande turkeys from Texas and Kansas on the study area in 1982 and 1983 (R. R. Denney, ODFW, unpubl. data).

METHODS

Capture and Radio Telemetry

We used rocket nets to capture turkeys during winters of 1988-89 and 1989-90. Age of hens was determined by characteristics of primary feathers (Larson and Taber 1980) and individuals were equipped with 90- to 110-g radio transmitters attached with a modified backpack harness (Kenward 1987:103). Transmitters were equipped with motion sensitive switches; expected transmitter life ranged from 1 to 3 years.

During 2 trapping seasons we captured 181 wild turkeys. In 1988-89 we equipped 26 adult and 19 yearling hens with transmitters. Fifteen adults and 15 yearlings (considered adults during the second year) survived to 1990. We equipped 10 more adults and 21 yearlings with transmitters during the 1989-90 trapping season, bringing the total sample to 36 adult and 40 yearling hens. All radio-tagged hens survived $\geq$2 weeks after release.

Hens were located $\geq$2 times/week from February 1989 through September 1991. Radio-tracking was more intensive (3-4 locations/week) during spring and early summer to accurately determine nesting activities. To the extent possible, signals were monitored daily to identify mortality and general hen locations. Egg-laying and incubation were identified by repeated radio locations at the same site and activation of motion sensors. We minimized disturbance of nesting hens to reduce risk of observer-induced abandonment. Nest locations were determined by visual observation or by triangulation from several points within 30 m of incubating hens. Onset of laying and incubation were used to predict hatching dates. In some cases, we counted eggs while hens were away from nests; otherwise, clutch size, fertility, and egg hatching success were determined within 48 hours of nest termination. Nests were considered successful if $\geq$1 egg hatched. We verified brood survival weekly until all poults perished or until broods were integrated into autumn flocks. Hens were monitored after nest termination and renesting was identified by following the same procedures.

Deaths of hens or transmitter failures precluded monitoring of 13 hens (7 ad, 6 yrl) during nesting seasons. We monitored 33 hens for 1 nesting season, 22 for 2 seasons, and 8 for 3 seasons. Therefore, the maximum potential sample was 101 first nests during the 3-year study (e.g., a hen could initiate 3 first nests, 1 during each year of the study).

We recovered bodies of dead birds as soon as possible after death to identify causes of mortality. When sufficient remains were intact and cause of death was not readily apparent, birds were frozen and submitted to the Veterinary Diagnostic Laboratory, College of Veterinary Medicine, OSU, for necropsy.

Statistical Analyses

We calculated fertility as the number of eggs with embryonic development divided by total number of eggs laid. Egg hatching success was defined as number of eggs hatched divided by total number of fertile eggs in successful nests. Reproductive parameters (nesting rate, clutch size, fertility, egg hatching success, and number of poults hatched/clutch) were examined with t-tests to identify differences between adult and yearling hens.

We analyzed hen survival with 2 methods: a modified Mayfield (MICROMORT; Heisey and Fuller 1985) and the Kaplan-Meier product limit (Pollock et al. 1989). For MICROMORT analyses, we included information from censored hens (radio or signal loss without evidence of fate) up to the point of signal loss as recommended by Vangilder and Sheriff (1990). Both methods allowed calculation of daily survival rates that were used to estimate seasonal and annual survival within and among hen age classes. We used likelihood-ratios (Heisey and Fuller 1985) to test for differences in monthly and seasonal survival rates and log-rank tests (Pollock et al. 1989) to determine whether annual survival differed within and among age classes.

RESULTS

Productivity

Minimum nesting rates for adults and yearlings were 99% and 94%, respectively (Keegan and Crawford 1993). Success for all nests combined was 50% and first-nest success ranged from 47 to 71% among years and age classes. Renesting success was more variable among years than for first nests, ranging from 0 to 50%. During 3 nesting seasons, researchers accidentally flushed hens from nests on 35 occasions (28% of all nests identified), resulting in 10 abandonments; disturbed hens resumed incubation 71% of the time (25 of 35 occasions). Approximately 28% of clutches laid by a renesting adults were infertile; many of which were third or fourth nests initiated after 10 June. The persistence of Rio Grande hens was indicated by renesting rate of 74% for adults (Keegan and Crawford 1993) and time spent incubating infertile clutches. Twelve hens incubated infertile eggs for 35 to ≥105 days (7 to ≥77 days longer than a normal 28-day incubation period).

Measures of first nest productivity did not differ between adult and yearling hens ($P > 0.10$) (Table 3.1). Fertility of eggs for yearling renesting attempts exceeded that of adults ($P \leq 0.05$); however, sample size for yearlings was small ($n = 3$). Although clutch size of first nests and renest attempts did not differ ($P > 0.10$), fertility, number of poults hatched/clutch, and egg hatching success declined by approximately 50% ($P < 0.001$).

Based on hatching dates and onset of incubation, nest initiation among the 3 years ranged from 29 March to 13 July. Mean nest initiation dates for adults differed <1 week among years, ranging from 8 April (SE = 1.4) to 15 April (SE = 2.0). In contrast, yearling nest initiation occurred approximately 18 days later during 1989 (5 May ± 3.2) than in 1990 (17 Apr ± 2.2). Yearlings initiated nests later than adults during both years ($P < 0.01$). Mean hatching dates ranged from 17 to 24 May for adults and 28 May to 15 June for yearlings.

Survival

Analyses with modified Mayfield (MICROMORT; Heisey and Fuller 1985) and Kaplan-Meier product limit methods (Pollock et al. 1989) yielded similar results (Table 3.2). Annual survival rates among wild turkey hens differed among years (0.50 to 0.89, $P < 0.01$) but were generally high. Annual survival did not differ between adults and yearlings within years ($P \geq 0.17$), however, no yearlings died from natural causes during 1989. Seasonal and monthly survival rates did not differ within years for either age class ($P \geq 0.15$).

Table 3.1 Productivity of Rio Grande wild turkey hens, Douglas County, Oregon, 1989-91.

	Adult	Yearling	Renest	Total
Number of nests located[a]	48	18[b]	30	96
Clutch size	11.2	11.5	10.6	11.1
Fertility (%)	97	95	57	83
No. of eggs hatched/clutch	10.2	9.4	4.3	8.0
Egg hatching success (%)	92	83	43	73

[a] Incomplete or destroyed clutches were not included.

[b] One infertile clutch was considered anomalous and excluded.

Table 3.2 Age specific Rio Grande wild turkey hen survival rates, Douglas County, Oregon, 1989-91.

	Adult			Yearling		
Variable	1989	1990	1991	1989	1990	Total
No. radio-tagged	26	10	0	19	21	76
Alive 1 January	26	34	27	19	21	
Censored[a]	4	7	7	2	3	21
Died	7	15	4	2	9	37
Alive Dec 1991	5	5		3	5	18
Annual survival						
Mayfield[b]	0.712	0.554	0.794	0.882	0.511	
Kaplan-Meier[c]	0.712	0.561	0.796	0.889	0.500	

[a] Fate of hen unknown, included radio failure or radio recovery with no sign of predation.

[b] Determined with methods of Heisey and Fuller (1985).

[c] Determined with methods of Pollock et al. (1989).

Annual survival was lowest for both age classes in 1990, but there was no clear reason for lower survival. Mortality during the late March-June nesting period was high in 1990 ($n = 11$) compared with 1 to 2 deaths in other years. Although mortality from predation was greater in 1990, only 6 of 11 deaths during laying, incubating, or brood rearing were classified as predator kills.

Poaching accounted for $\geq$11% of hen mortality and was suspected in $\geq$2 other cases. Over 3 years, 73% of mortality was attributed to predation. However, scavenging and predation on birds predisposed to death by disease and injury probably masked actual causes of mortality. During the project, we submitted 9 hens to the OSU Veterinary Diagnostic Laboratory for necropsy. Apart from predation, natural mortality was attributed to accidental death (blunt trauma) and several diseases: renal gout, histomoniasis, neoplasia, hemopericardium (probably a congenital defect), and bacterial infection (*Enterobacter* spp. and *Listeria* spp.).

Approximately 51% of broods died from exposure, predation, or other causes; 13% were classified as censored observations because of radio failure or loss. We did not attempt to document survival of individual poults because observation was difficult in dense vegetation (flush counts were inaccurate and caused excessive disturbance) and brood flocks often mixed at approximately 2 weeks of age, which made identification of hen-poult relationships impossible. Although we did not quantify individual poult survival, we estimated that $\geq$1 poult was recruited to the autumn population from $\geq$37% of all broods hatched. Approximately 40% of broods with adult hens and 25% of broods with yearling hens survived until autumn.

DISCUSSION

Several measures of productivity for Rio Grande turkeys in Oregon were similar to those reported for other populations. Clutch sizes for first nests of Rio Grande turkeys in Texas were 10.3 eggs (Reagan and Morgan 1980) and 11.1 eggs (Ransom et al. 1987) compared with 11.3 eggs in Oregon. Reagan and Morgan (1980) determined that renest attempts produced fewer eggs (approximately 8.8) and we noted a similar trend (10.6 eggs/renest). Yearling Rio Grande clutches were equal to or larger than adult clutches in this study and in Texas (Reagan and Morgan 1980), but not in Colorado (Schmutz and Braun 1989). Fertility and egg hatching success for first nests in Oregon equaled or surpassed values for most wild turkey populations in the U. S. (Vangilder 1992).

For Rio Grande turkeys in Oregon, overall reductions in fertility, poults hatched/clutch, and egg hatching success for renest attempts were heavily influenced by the number of completely infertile clutches (n = 10) produced in relatively late nest attempts. Low late-season productivity in Oregon may have been related to physiological changes affecting male fertility. Poor nutrition for hens was suggested as a potential cause of infertile clutches in New Mexico (Schemnitz et al. 1985).

Nesting rates in Oregon, particularly of yearling hens, exceeded those reported by Reagan and Morgan (1980) for a native Rio Grande population, but were similar to rates for a recently introduced Rio Grande population in Colorado (Schmutz and Braun 1989). Similarly high yearling nesting rates were noted for eastern wild turkeys by Vangilder et al. (1987) and Vander Haegen et al. (1988). Merriam's yearling hens nested infrequently (Schemnitz et al. 1985, Lutz and Crawford 1987) and some researchers suggested that low productivity may be characteristic of the Merriam's subspecies (Vangilder 1992).

Yearling Rio Grande hens in Oregon renested less frequently than adults, the same pattern noted by Rumble and Hodorff (1993).

Our observation that yearling hens initiated nests later than adults was consistent with observations by Schmutz and Braun (1989). Vangilder et al. (1987) attributed late nest initiation to below normal spring temperatures. We observed the same phenomenon in 1989, when nest initiation was delayed 1 week by adults and approximately 2.5 weeks by yearlings after unusually severe winter and early spring weather.

Keegan and Crawford (1993) speculated that high productivity of Rio Grande turkeys in Oregon, as indicated by total natality, yearling nesting rates, and renesting after brood loss, supported Porter's (1978:67) evidence for density-dependent population regulation in wild turkeys. The population response in Oregon may have been a response to relatively high resource availability (Keegan and Crawford 1993) and the positive relationship between nesting rates and habitat quality suggested by Rumble and Hodorff (1993) further substantiated this supposition.

Rio Grande wild turkey annual survival (70%) was higher than that of Merriam's wild turkeys in Oregon (60%, Crawford and Lutz 1984). Rio Grande survival was similar to that reported for Rio Grande hens in Texas (73%, Ransom et al. 1987) and eastern wild turkey hens (68-73%, Everett et al. 1980, Palmer et al. 1993). However, survival of yearling hens exceeded levels reported for several eastern wild turkey populations, which ranged from 39 to 57% (Porter 1978:51, Kurzejeski et al. 1987, Vander Haegen et al. 1988).

Predation accounted for >80% of Merriam's turkey non-hunting mortality (Crawford and Lutz 1984) compared with 73% for Rio Grande hens. Conversely, accident and disease comprised 17% of Rio Grande mortality and only 9% of Merriam's turkey mortality (accident only). Because no mortalities in the Oregon Merriam's population were attributed to disease, higher predation rates may have reflected higher scavenging rates or loss of birds predisposed to mortality rather than an actual difference in predation rates. Poaching accounted for approximately 10% of losses in each population. Contribution of predation to Rio Grande hen mortality in Oregon was comparable to that of unhunted eastern wild turkey hens (Vander Haegen et al. 1988, Porter 1978:56, Everett et al. 1980), and Rio Grande hens in Texas (Ransom et al. 1987).

MANAGEMENT IMPLICATIONS AND RECOMMENDATIONS

Our research indicated that Rio Grande wild turkeys were more productive than Merriam's wild turkeys in the northern Oregon Cascades. High nest success and hen survival suggested that Rio Grande turkeys may be better suited than Merriam's turkeys to parts of Oregon. Esthetic and economic returns of translocation programs will be enhanced by selection of subspecies best suited to regional habitat conditions.

Practices that might positively influence wild turkey productivity, by reducing disturbance to laying hens and hens with broods, include closing roads to motor vehicle traffic during the reproductive season (Apr-Jun) and delaying spring gobbler hunting until most hens begin incubation. We did not document appreciable disturbance of incubating hens related to hunting activities, but we could not adequately assess disturbance of laying hens or hens with broods. Road closures would reduce human contact with laying hens (Steffen et al. 1988) and increase turkey use of areas (Smith et al. 1990).

Adjusting season dates and length to coincide more closely with incubation might reduce incidence of accidental and intentional hen shooting and disturbance of laying and brood hens. Spring hunting seasons during this study preceded mean onset of incubation by 12 to 22 days. The 1989 season ended before nests hatched, but subsequent seasons were lengthened by 2 weeks, extended 13 days into hatching, and ended within 2 days of mean hatch dates. Although weather and elevation affect nesting chronology, we believe that if the need arises, scheduling spring gobbler seasons to bracket incubation might reduce hen and brood disturbance. Harvest strategies should be designed to meet population management goals and objectives as well as take into account regional differences, nesting chronology, hunt quality, illegal activity, disturbance levels, and hunter preferences. We caution that, because this research was not replicated outside the specified area, our scope of inference is limited to the study area and all results must be viewed as such.

Chapter 4

RENESTING BY RIO GRANDE WILD TURKEYS AFTER BROOD LOSS

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ABSTRACT

Although the importance of renesting by wild turkeys (*Meleagris gallopavo*) after clutch loss has been documented, the contribution to turkey populations of renesting after brood loss is unknown. Consequently, we examined renesting capacity of an introduced Rio Grande wild turkey (*M. g. intermedia*) population in southwestern Oregon from 1989 through 1991. Eleven of 15 adult hens initiated 13 nests after losing broods (within 2 weeks of hatching of first or second clutches). Of these, 9 nests were depredated or abandoned and 4 nests hatched. Clutch size, fertility, egg hatching success, and poults hatched per nest did not differ between renest attempts after brood loss and renest attempts after clutch loss ($P = 0.65$ to 0.95). No yearling hens attempted to renest after losing a brood. Total renesting efforts contributed 17% of poults in this study, and renesting after brood loss accounted for 6% of all poults hatched. We concluded that renesting after brood loss was a common and important reproductive strategy in this population, and may have represented a density-dependent response to relative resource availability.

INTRODUCTION

Rio Grande wild turkeys were native to the southcentral Great Plains, but translocation programs (designed to provide recreational opportunities) resulted in establishment of populations in 9 western states (Wunz 1992). Several researchers investigated productivity of native and introduced Rio Grande wild turkey populations (Beasom and Pattee 1980, Ransom et al. 1987, Schmutz and Braun 1989), but the occurrence of renesting after brood loss and the contribution to overall productivity was unknown. Among subspecies of wild turkeys, renesting after clutch loss was relatively common depending on age, subspecies, and population densities (Reagan and Morgan 1980, Williams et al. 1978). Porter et al. (1983) stated that renesting after clutch loss was important to overall reproduction because 22% of all poults hatched from renesting attempts. Similarly, renesting after clutch loss accounted for 19% of successful nests in Missouri (Vangilder et al. 1987). However, only 1 instance of renesting after brood loss was reported for eastern wild turkeys (*M. g. silvestris*; Sisson et al. 1991). Williams et al. (1978:375) characterized the failure of wild turkey hens to renest after losing broods as "a limitation on the breeding potential of the species." Because of the importance of renesting to total natality among wild turkey subspecies, we investigated the occurrence of renesting activity, especially renesting after brood loss, in an introduced population of Rio Grande wild turkeys in southwestern Oregon.

Research was supported by the Oregon Department of Fish and Wildlife (ODFW), the U.S. Forest Service LaGrande Forestry and Range Sciences Laboratory, the National Wild Turkey Federation, Inc., and Oregon State University. We thank personnel of the Umpqua National Forest and ODFW for their assistance and support. S. R. Denney and R. A. Zalunardo were particularly helpful throughout the course of the research. We appreciate the field work of P. I. Burns, N. E. Golly, and B. C. Quick. L. L. Mauer was instrumental in office assistance. R. L. Jarvis, G. P. Keister, J. P. Leonard, and T. H. Williams critically reviewed drafts of the manuscript. This is Technical Paper 10017 of the Oregon Agricultural Experiment Station. We followed wild bird research guidelines described by Oring et al. (1988).

STUDY AREA AND METHODS

The 635-km^2 study area was located in the upper South Umpqua River Basin, Douglas County, Oregon. The area was dissected with steep east-west ridges, and elevation ranged from 310 to 1,525 m. Annual rainfall during the study was approximately 6 cm below the long-term average of 102 cm (Douglas County Public Works Dep., unpubl. data). Mean temperatures in January and July were within 2 C of regional 30-year averages (3 C and 19 C, respectively) (Natl. Climatic Data Cent. 1989, 1990, 1991). Diverse edaphic and geologic conditions produced a heterogeneous association of plant cover types (Franklin and Dyrness 1973:130). Overstories were dominated by Douglas fir (*Pseudotsuga menziesii*) and other conifers or Oregon white oak (*Quercus garryana*) and Pacific madrone (*Arbutus menziesii*). The ODFW released 58 Rio Grande wild turkeys from Texas and Kansas on the study area in 1982 and 1983 (R. R. Denney, ODFW, unpubl. data). A release of 100 game farm-raised eastern wild turkeys in the study area during 1971 was unsuccessful (R. R. Denney, ODFW, unpubl. data).

We used rocket nets to capture turkeys during winters of 1988-89 and 1989-90. Age of hens was determined by characteristics of the primary feathers (Larson and Taber 1980) and individuals were leg-banded and equipped with a 90 to 110-g radio transmitter package attached with a modified backpack harness (Kenward 1987:103). Transmitters were equipped with motion sensitive switches; expected transmitter life ranged from 1 to 3 years.

We equipped 36 adult and 40 yearling hens with transmitters, but did not monitor 13 (7 ad, 6 yearling) hens during any nesting season because of death of the bird or transmitter failure. We monitored 33 hens for 1 nesting season, 22 for 2 nesting seasons, and 8 for 3 nesting seasons. Consequently, the number of hens available to attempt first nests in each breeding season amounted to a maximum potential sample of 101 first nests during the 3-year study. Hens were monitored ≥ 5 times/week during the breeding season (Mar-Sep) from 1989 to 1991 to identify nest initiation, loss, and hatching. Once hens began incubating, we approached within 30 m to identify nest locations. In some cases, eggs were counted while hens were away from nests. Otherwise, clutch size, fertility, and egg hatching success were determined within 48 hours of nest termination. Nests were considered successful if ≥ 1 egg hatched. All hens were monitored after nest termination and we verified brood survival by audio or visual evidence weekly until all poults perished or until broods were integrated into autumn flocks.

Estimates of turkey density are difficult to obtain (Kurzejeski and Vangilder 1992), particularly in rugged montane environments where dense vegetation and diverse topography hamper sampling techniques. However, based on direct observations of winter flocks by personnel of the U.S. Forest Service and ODFW, and local residents, we estimated the winter population in our study area was approximately 400 birds (2.5 birds/km^2).

We used unpaired *t*-tests to test for differences in clutch size, fertility, hatching success, and number of poults hatched per clutch between renests after clutch loss and renests after brood loss. Statistical significance was accepted at $P < 0.05$.

RESULTS

Adult and yearling hens initiated 67 and 31 first nests, representing nesting rates of 99% (67 of 68) and 94% (31 of 33), respectively. These were minimum nesting rates because we may not have identified all nests that were destroyed before hens reached incubation. After omitting observer-caused abandonment, 37 adults (60%) and 14 yearlings (48%) were successful. Renesting rates for adult and yearling hens that lost clutches were 74% (39 of 53) and 25% (4 of 16), respectively, for all years combined. Total renesting accounted for 30% (43 of 141) of all nests, 19% (12 of 63) of successful nests, and 17% (98 of 568) of poults hatched during our study. Fourteen successful adult hens that survived the breeding season lost 15 broods within 2 weeks of hatching (3 in 1989, 6 in 1990, 6 in 1991). Eleven of these hens initiated 13 nests after brood loss; 3 of 3 in 1989 (4 nests), 4 of 6 in 1990, and 5 of 6 in 1991. Two hens each initiated 2 nests after brood loss (one renested twice within 1 year, whereas another hen initiated renests after brood loss in consecutive years). Renesting after brood loss accounted for 30% (13 of 43) of all renesting attempts and 33% (4 of 13) of all successful renesting attempts. Only 3 adult hens that lost broods within 2 weeks of hatching and 1 adult hen that lost a brood >2 weeks after hatching did not attempt to renest. However, no yearling hens that lost broods (n = 16) renested.

Of 13 renesting attempts after brood loss, 4 nests hatched, 3 were destroyed by predators, 2 were abandoned (observer induced), and 4 contained infertile eggs that were incubated for 35-82 days until destroyed or abandoned. Poults that hatched from renests after brood loss (n = 32) accounted for 6% of all poult production and 33% of poults produced from all renesting attempts. During 1990, 1 hen recruited 8 poults from a renest after brood loss, whereas poults of another hen died. Fates of 2 broods from renests after brood loss in 1991 were unknown because of transmitter failure. A comparison of reproductive measures of renests after brood loss and renests after clutch loss (Table 4.1) revealed no differences among adult hens for clutch size ($P = 0.75$), fertility ($P = 0.65$), egg hatching success ($P = 0.67$), and poults hatched per clutch ($P = 0.95$).

DISCUSSION

Reproductive output of wild turkeys may be controlled by population density (Porter 1978:115) and influenced by several other factors. These factors include predation on adults, eggs, and poults (Glidden 1977, Vander Haegen et al. 1988); illegal hen kill (Kimmel and Kurzejeski 1985); weather (Beasom and Pattee 1980, Porter et al. 1983); habitat quality (Porter 1978:106); differences among subspecies (Lockwood and Sutcliffe 1985); disease (Rocke and Yuill 1987); and hybridization.

Natality in this study exceeded that reported by Reagan and Morgan (1980) and Ransom et al. (1987) for native Rio Grande wild turkey populations. Total natality and yearling nesting rates in Oregon, however, were comparable to an introduced population of Rio Grande wild turkeys in Colorado (Schmutz and Braun 1989). All aspects of yearling hen reproductive contribution (except nest success) in Oregon were consistent with those reported by Porter (1978:67) as indicative of a density-dependent population response. Because of the relatively high prevalence of renesting after brood loss, we suspect that this behavior was not anomalous but instead represented a response to > 1 factor affecting reproductive output (although the phenomenon may be restricted to our locality or genetic stock). We speculate that if Porter's (1978) assessment of density-dependent reproduction was applicable to our area, then high reproductive output by both age classes, particularly yearlings, may have been a response to relative resource availability. Data presented here are contrary to the assessment of Sisson et al. (1991:304) that, for wild turkeys, "double broods are undoubtedly a rare occurrence." Clearly, renesting after brood loss was a common and important reproductive strategy among adult hens on our study area.

Table 4.1 Reproductive characteristics of renesting attempts of Rio Grande wild turkey hens, Douglas County, Oregon, 1989-91.

	Renest after clutch loss			Renest after brood loss			
Parameter	n[a]	$\bar{x}$	SD	n[a]	$\bar{x}$	SD	P
Clutch size	17	10.7	1.7	9	10.4	2.4	0.75
Fertility (%)	16	55	50	10	46	46	0.65
Egg hatching success (%)	13	45	50	8	35	44	0.67
Poults hatched/clutch	13	4.2	5.2	8	4.0	5.3	0.95

[a] n = number of nests.

Chapter 5

BROOD-REARING HABITAT USE BY RIO GRANDE WILD TURKEYS IN OREGON

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ABSTRACT

Wild turkey (*Meleagris gallopavo*) brood-rearing sites have been described for portions of their range, but brood-rearing habitat use and characteristics of brood-rearing sites used by Rio Grande wild turkeys (*M. g. intermedia*) in the Pacific Northwest were unknown. Consequently, we determined cover type of 362 brood-rearing sites and measured habitat characteristics at 64 of these sites used by a recently established Rio Grande wild turkey population in southwestern Oregon during May-September 1989 and 1990. Hens with broods used 9 of 10 available cover types. Meadows, mixed hardwood/conifer woodlands, and savannas were used more often than expected (47% of observations, $P \leq 0.05$). Hens with poults used mature mixed-conifer and dense sapling/pole mixed-conifer cover types less than expected and did not use brushfields. Many brood-rearing sites were characterized by a park-like appearance. Understory vegetation averaged <20 cm tall and occupied 44-52% of brood-rearing sites whereas bare ground accounted for 35-55%. Brood-rearing sites were located on southeast facing slopes more often than expected and north slopes were used less than expected ($P \leq 0.05$). We suggest that land managers maintain mixed hardwood/conifer woodland and savanna cover types adjacent to meadows on south slopes to provide brood-rearing habitat for Rio Grande wild turkeys in southwestern Oregon.

INTRODUCTION

Rio Grande wild turkeys were native to the southcentral Great Plains, but translocation programs established populations in 9 western states (Wunz 1992). Variability in wild turkey movements and home ranges among geographic regions and subspecies was attributed primarily to variation in resource availability (Brown 1980). Wild turkeys frequently demonstrated a high level of adaptability by using a variety of cover types, but turkeys were selective with respect to vegetative characteristics within cover types (Holbrook et al. 1987).

Environmental factors that affect brood-rearing habitats are critical to population maintenance. Everett et al. (1980) suggested that poult survival was directly related to the suitability of brood-rearing habitat. Vegetative composition and structure in brood range influence protection from predators, poult mobility, arthropod abundance, and exposure to dew (which can induce hypothermia). Brood-rearing habitats often were described as park-like with moderate understory vegetation and nearby escape cover (Porter 1992). Habitat use by adult Rio Grande turkeys in their native range was studied extensively (e.g., Logan 1974, Baker et al. 1980), but quantitative descriptions of brood-rearing habitats were lacking. Brood-rearing habitat use by introduced Rio Grande wild turkey populations received little attention or was investigated in simple systems (e.g., 2-3 cover types). Because brood-rearing habitat is important to wild turkey populations, we examined habitat use by Rio Grande wild turkey hens with poults in southwestern Oregon and quantified brood-rearing site characteristics.

Research was supported by the Oregon Department of Fish and Wildlife (ODFW), the U.S. Forest Service LaGrande Forestry and Range Sciences Laboratory, the National Wild Turkey Federation, Inc., and Oregon State University. We thank personnel of the Umpqua National Forest and ODFW for their assistance and support. S. R. Denney and R. A. Zalunardo were particularly helpful throughout the course of the research. We appreciate the field work of P. I. Burns, N. E. Golly, and B. C. Quick. L. L. Mauer was instrumental in office assistance. E. C. Pelren and R. J. Steidl reviewed drafts of the manuscript. This is Technical Paper 10858 of the Oregon Agricultural Experiment Station. We followed wild bird research guidelines described by Oring et al. (1988).

STUDY AREA

The 675-km^2 study area was located in the upper South Umpqua River Basin, Douglas County, Oregon. Elevation ranged from 310 to 1,525 m and the area was dissected with steep east-west ridges. Franklin and Dyrness (1973:130) attributed the heterogeneous association of plant cover types to diverse edaphic and geologic conditions. Overstories were often dominated by Douglas fir (*Pseudotsuga menziesii*) and other conifers or Oregon white oak (*Quercus garryana*) and Pacific madrone (*Arbutus menziesii*). Deciduous midstory tree species included Oregon ash (*Fraxinus latifolia*) and big-leaf maple (*Acer macrophyllum*). Common shrubs included poison oak (*Rhus diversiloba*), Oregongrape (*Berberis* spp.), ceanothus (*Ceanothus* spp.), and manzanita (*Arctostaphylos* spp.) The ODFW released 58 Rio Grande wild turkeys from Texas and Kansas on the study area in 1982 and 1983 (R. R. Denney, ODFW, unpubl. data).

METHODS

Capture and Radio Telemetry

We used rocket nets to capture turkeys during winters of 1988-89 and 1989-90. Hen age (yearling or adult) was determined by characteristics of primary feathers (Larson and Taber 1980), and we equipped each individual with a 90- to 110-g radio transmitter attached with a modified backpack harness (Kenward 1987:103). Transmitters were equipped with motion sensitive switches; expected transmitter life ranged from 1 to 3 years.

During 2 trapping seasons we captured 181 wild turkeys. In 1988-89 we equipped 26 adult and 19 yearling hens with transmitters. Fifteen adults and 15 yearlings (considered adults during the second year) survived to 1990. During the 1989-90 trapping season, we equipped 10 additional adults and 21 yearlings with transmitters, bringing the total sample to 36 adult and 40 yearling hens. All radio-tagged hens survived ≥2 weeks after release.

Hens with broods were monitored ≥2 times/week from May-September throughout 1989 and 1990. We considered young birds poults until 12 weeks of age. We verified brood survival by audio or visual evidence weekly until all poults perished or until broods were integrated into autumn flocks.

We ascertained direction to radio signals by the peak-signal method (Springer 1979). Preliminary bearings and signal strength were used to move within 0.5 km of birds; subsequent bearings provided triangulation data. Hens were located by triangulation from ≥ 3 locations or by visual observation. Locations were determined in 3 approximately equal time periods: morning (0.5 hr before sunrise to 4 hr after sunrise), midday (4 hr after sunrise to 4 hr before sunset), and evening (4 hr before sunset to 0.5 hr after sunset). We located each hen ≥1 time during each daytime period in every 2-week interval. To the extent possible, hens were monitored daily to identify mortality and movements.

Accuracy of telemetry procedures was tested by taking bearings on transmitters at 5 locations from 3 distances that encompassed the range of tracking situations. Differences between estimated and actual azimuths were used to calculate error within and among distances and locations. Variances of error angle estimates were not homogeneous among observers and distances. Therefore, standard deviations of error angles were pooled when appropriate and assigned to each triangulation based on observer and estimated distance from transmitter. Mean difference between estimated and true azimuths for all tested observer-distance combinations was 1° (SE = 0.4). We entered azimuths and receiver locations into program XYLOG (Dodge and Steiner 1986) to process triangulation data. Habitat availability was defined by a minimum convex polygon (Mohr 1947) for all hen locations (except for 2 hens that were excluded because of movements >30 km to inaccessible areas).

Habitat Mapping and Quantification

We identified 10 cover types from aerial photographs (taken during summer 1989) and ground reconnaissance. Sites (n = 56) for quantifying physiographic and vegetative variables were randomly located in all cover types and consisted of 3 points located 30 m apart. Cover types were delineated and descriptions were developed by sampling physiographic characteristics and 4 vegetative strata: overstory (woody plants >3 m tall), midstory (woody plants >3 m tall, but beneath canopy), shrub (woody plants 1-3 m tall), and understory (woody and herbaceous plants <1 m tall).

We quantified several physiographic and overstory and midstory vegetative variables at each site: percent slope, aspect, elevation, percent non-forested habitat within 0.3 km, species composition, density, basal area, percent cover, and canopy height. We estimated slope with a clinometer, aspect with a compass, and elevation from topographic maps. Percent non-forested habitat (<10% tree cover) within 0.3 km of each brood-rearing site was determined from habitat maps with an overlay of 50 randomly distributed points (Marcum and Loftsgaarden 1980). We recorded species, distance to sample point, and diameter-at-breast-height (dbh) of the nearest tree in each "quarter" for midstory and overstory strata to determine density and basal area (Cottam and Curtis 1956). Percent cover of overstory and midstory strata (combined) was estimated with a sighting tube (James and Shugart 1970) by presence or absence at 2-m intervals along 4 10-m transects originating at sample points. We measured heights of 5 randomly selected trees in each stratum with a clinometer to estimate canopy heights.

We quantified the following shrub and understory characteristics at all sample sites: tall shrub cover, understory vegetation height, understory ground cover, and horizontal screening. We estimated tall shrub cover along each of 4 10-m transects with the line-intercept method (Canfield 1941). Understory vegetation was sampled in 5 1-m^2 circular plots, 1 at the central sample point and 4 at randomly selected points within 4 m. We measured understory vegetation height at 4 random locations in each 1-m^2 plot and estimated percent cover of grasses and grasslike plants, forbs, low shrubs (<1 m), bare ground, and woody debris. A vegetation profile board (0.3 x 1.2 m) (Nudds 1977) was placed at sample points and observed from 4 locations at a distance of 10 m (at 0.75 m above ground level) to provide an index of horizontal cover. We estimated percent horizontal screening for each 0.3-m interval on profile boards.

Three non-forested cover types covered 12% of the study area: recent clearcut (<10 years since harvest); brushfield; and meadow/pasture (Table 5.1). Savannas were the rarest habitat, typified by scattered trees or clumps of trees that usually had not been managed for timber production. In contrast, timber management likely influenced stand development in hardwood/conifer woodlands (HCW). Remaining cover types were seral or management stages of forested mixed-conifer stands. Douglas fir was a prominent component of most stands, but several other conifer species frequently occurred as co-dominants: ponderosa pine (*Pinus ponderosa*), sugar pine (*P. lambertiana*), white fir (*Abies concolor*), and incense-cedar (*Calocedrus decurrens*). Dense large/mature mixed conifer (DMC) was the most common cover type, with overstory trees ≥50 cm dbh and >110 years old. Open large/mature mixed conifer (OMC) often developed from natural or management-related thinning in dense stands. Some OMC stands may have developed following sparse regeneration in areas under even-age management. The second most prevalent cover type was dense medium/young mixed conifer (DYC). Open medium/young mixed-conifer stands were rare (<0.2%) and structurally similar to open sapling/pole conifer stands. Therefore, we combined open medium/young mixed-conifer stands with open sapling/pole stands. Open sapling/pole/young mixed-conifer (OSPC) stands likely developed as a result of sparse regeneration or precommercial thinning. Dense sapling/pole mixed-conifer (DSPC) stands resulted from normal to good tree growth after even-age regeneration harvest or catastrophic disturbance.

Table 5.1 Descriptions of habitats available to Rio Grande wild turkeys in Douglas County, Oregon, 1989-91

A) Mixed hardwood/conifer (2 classes)

At least 30% hardwoods in canopy layer. Usually dominated by Oregon white oak and Pacific madrone with scattered conifers. All tree size classes present. Understory dominated by bare ground with approximately equal proportions of grasses, forbs, low shrubs, and debris. Poison oak was a common low shrub. Generally found at lower elevations (<750m) on southerly aspects. Included relatively rare riparian zones dominated by Oregon ash and big-leaf maple. Relatively sparse tall shrub cover.

1. Woodland: Stand canopy closure $\geq$40%; occupied 7% of the area.
2. Savanna: Overall stand canopy closure 10-40%; rarest cover type (2%).

B) Mixed conifer (5 classes)

Less than 30% hardwoods in canopy layer. Most stands were dominated by Douglas fir, but often contained $\geq$1 co-dominants.

1. Dense large/mature: Overall stand canopy closure $\geq$70%. Average dbh of overstory conifers $\geq$50 cm; trees of this size were mature (usually $\geq$110 years old). Disturbance, if any, was related to fire, wind, or selective/salvage logging. Characterized by sparse grass cover, large amounts of bare ground, low shrubs, and slash. Most common cover type (49%).
2. Open large/mature: Same size classes as in B-1 with canopy closure between 10 and 70%. Stands generally resulted from shelterwood regeneration harvest,

Table 5.1 Continued.

commercial thinning, or sparse regeneration. Understory dominated by bare ground and slash; few shrubs, grasses, or forbs. Covered 4% of the area.

3. Dense medium/young: Canopy closure $\geq$70%. Average dbh of overstory conifers was from 23 to 50 cm; these diameters corresponded to approximate ages of 30-110 years. Typically, understory vegetation was <10 cm with little grass cover and much bare ground. Occurred on 14% of the area. Virtually all stands in this size class were classified as dense.
4. Dense sapling/pole: Canopy closure $\geq$70%. Average conifer dbh was <23 cm; trees were usually 10 to 30 years old. Grass was scarce, whereas woody plants were dominant in the understory. These stands generally resulted from even-age management such as clearcut or shelterwood regeneration harvests. Found on 8% of the area.
5. Open sapling/pole young: Canopy closure was between 10 and 70%. In most stands, overstory dbh was <23 cm. Open stands generally resulted from precommercial thinning or sparse regeneration. There was much variation among stands, but tall understory vegetation and high horizontal screening values were characteristic features. Most forb-rich cover type. In some stands, well developed shrub layers contributed to horizontal screening. Because of structural similarities, open medium/young stands were combined with open sapling/pole stands. Occupied 3% of the area.

Table 5.1 Continued

C) Brushfield

Tree canopy was <10% and tall shrub cover was ≥15%. Seral or climax communities dominated by a diverse association of shrubs including ceanothus, manzanita, and poison oak. Dense shrub growth provided high horizontal screening. Sparse grass cover and large amounts of bare ground occurred in understories. Commonly occurred on areas that were previously clearcut or burned, particularly where regeneration failed. Included rocky areas with scattered shrubs. Found on 4% of the area.

D) Meadow/pasture

Natural or management-induced openings with <10% tree canopy. Dominated almost entirely by low grasslike plants and bare ground. Shrubs were rare and horizontal screening was low. Coverage of 3% included small pastures and hayfields.

E) Clearcut

Areas where overstory was harvested within 10 years and generally with <10% tree canopy. Often included seed tree regeneration and shelterwood regeneration after residuals were removed. Bare ground was the most common understory component. Relatively tall understory vegetation dominated by grasses with similar amounts of forbs, slash, and low shrubs (including conifer seedlings). Occupied 6% of the area.

Brood-rearing Site Quantification

The steep terrain and dense vegetation of the study area sometimes hampered direct observation of undisturbed broods. Therefore, telemetry locations and visual observations of undisturbed broods defined sample sites. We considered hen-poult flocks undisturbed when turkeys were apparently unaware of observer presence or did not alter their activity (e.g., feeding or loafing).

We quantified 2 randomly selected brood-rearing sites each week during 1989 and 1990 brood-rearing seasons (mid-May through mid-Sep) with the provision that each brood hen was included ≥ 1 time/season. Each hen with a brood contributed a average of 2.7 measured sites (range, 1-7). Although a single hen was randomly selected as a focal hen, broods frequently joined in larger groups and brood rearing sites were sometimes occupied by up to 4 radio-marked hens as well as unmarked hens with and without broods.

Vegetative characteristics of brood-rearing habitats were sampled at 3 points, 1 at the observation or triangulation point and 2 located 30 m from the site at random compass bearings. Brood-rearing sites were quantified with the same methods employed to develop general cover-type descriptions.

Statistical Analyses

We analyzed data sets with a series of univariate and multivariate procedures. We combined all brood-rearing sites within cover types (based on year, hen age, poult age, and brood fate) because of small sample sizes. All data sets were examined to assess outliers, normality, multicolinearity, and homogeneity of variance-covariance matrices.

Although data were variable, we detected few distinct outliers and inclusion of those observations did not alter results. Several variables displayed non-normal distributions. However, transformations did not improve normality nor alter results, so original values were retained for all analyses. When ≥ 2 variables were highly correlated ($r > 0.7$), we selected those variables with the greatest ecological relevance or potential for management application that contributed to the most parsimonious description of relationships.

We used analysis of variance to identify variables that differed between groups (e.g., random sites and brood-rearing sites) and to reduce the number of variables entered in subsequent multivariate procedures. Stepwise discriminant analysis (SAS 1989) was employed to select variable sets to distinguish between groups of observations. We then included variable sets selected in stepwise procedures in canonical analyses of discriminance (SAS 1989) to determine correlations between discriminating variables and canonical functions. Numbers of variables included in these analyses were restricted according to sample size considerations for each group.

Chi-square analysis was used to test the null hypothesis that cover types were used in proportion to availability (Neu et al. 1974, Byers et al. 1984). When the null hypothesis was rejected, simultaneous confidence intervals were calculated to identify which cover types contributed to differences in use and whether use was greater or less than expected. Preliminary analyses indicated that habitat use did not differ with year or hen age for any comparisons. Consequently, observations were pooled for examination of habitat use.

RESULTS

Habitat Use

We identified cover type at 362 locations of hens with broods <12 weeks old ($\bar{x}$ = 11.7 locations/hen, range 1-49) and 64 of these sites were subjected to detailed vegetation sampling. Brood-rearing sites were derived from 31 hens with 33 broods, but sites frequently were occupied by several broods. Hens used 9 cover types for brood rearing (Table 5.2), and habitat use differed from availability ($P \leq 0.005$). Nearly 50% of brood locations were in the 3 types used more often than expected: HC woodland (27%), meadow/pasture (12%), and HC savanna (8%). Collectively, these cover types represented only 11% of available habitat. Further, when 90% confidence intervals were applied to brood habitat data, use of DYC exceeded availability. Brushfields were not used, and open and dense MC and dense SPC stands were used less than expected ($P \leq 0.05$). Use of clearcuts and OSP conifer stands did not differ from availability.

Habitat Characteristics

Most characteristics of randomly located sites differed among cover types available to wild turkeys (Tables 5.3-5.5). Similarly, several differences were apparent among cover types used for brood rearing (Tables 5.6 and 5.7).

Brood-rearing sites were structurally simple. Mean understory vegetation height at sites was ≤20 cm in all cover types (Table 5.7). Horizontal screening from ground level to 30 cm ranged from 43% in meadows to 80% in OSP conifer stands, whereas screening in strata above 30 cm rarely exceeded 50%. Tall shrub cover was sparse (≤77

Table 5.2 Habitats used for brood rearing by Rio Grande wild turkey hens, Douglas County, Oregon, 1989-90 ($n = 362$ locations associated with 31 hens).

		Percent		Bonferroni 95% confidence interval		
Cover type	No. sites	Available	Used	Lower	Upper	Selection[a]
Clearcut	17	6.1	4.7	0.8	8.6	0
Meadow/pasture	44	2.5	12.2	7.1	17.2	+
Brushfield	0	3.8	0	-1.9	1.9	-
Open sapling/pole mixed conifer[b]	8	3.4	2.2	-0.6	5.0	0
Dense sapling/pole mixed conifer	2	8.0	0.6	-2.4	3.5	-
Dense young mixed conifer	76	14.4	21.0	14.0	27.9	0
Dense mature mixed conifer	84	48.9	23.2	15.2	31.2	-
Open mature mixed conifer	5	4.3	1.4	-1.3	4.0	-
Mixed hardwood/ conifer woodland[c]	97	6.8	26.8	19.8	33.8	+
Mixed hardwood/ conifer savanna	29	2.0	8.0	3.8	12.3	+

[a] Where 0 represents use in proportion to availability, + represents greater use of a habitat than expected, and - represents less use of a habitat than expected ($P \leq 0.05$).

[b] In conifer cover types, open defined as canopy closure <70%.

[c] Woodland defined as canopy closure ≥40%, savanna canopy closure was <40%.

Table 5.3 Overstory and midstory characteristics of available habitats in Rio Grande wild turkey study area, Douglas County, Oregon, 1990-91.

		Overstory								Midstory							
		Height (m)		Dbh (cm)		Basal area (m^2/ha)		Trees/ha		Height (m)		Dbh (cm)		Basal area (m^2/ha)		Trees/ha	
Cover type[a]	*n*	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE
CC	3	4	2	6	3	0.1	0.1	19	10								
MP	3																
B	1	7		5		1.2		356									
OSPC	8	14	1	23	2	5.5	1.3	126	36	5	1	7	1	2	0.5	282	77
DSPC	2	17	3	21	1	11.6	3.5	291	69	7	2	6	0.2	3	0.02	749	38
DYC	11	22	1	30	1	30.8	5.5	396	70	8	1	11	1	10	2.5	1005	250
DMC	15	50	2	82	4	52.4	5.3	100	12	15	1	16	1	16	2.4	545	82
OMC	2	43	11	86	25	14.4	6.8	23	1	10	2	16	2	2	0.4	82	1
HCW	7	16	1	25	3	10.0	1.1	213	31	7	1	9	1	4	1.0	701	153
HCS	4	20	5	33	10	6.5	1.4	130	66	8	1	14	6	2	0.3	294	117

[a] CC = clearcut, MP = meadow/pasture, B = brushfield, OSPC = open sapling/pole mixed conifer, DSPC = dense sapling/pole mixed conifer, DYC = dense young mixed conifer, DMC = dense mature mixed conifer, OMC = open mature mixed conifer, HCW = hardwood/conifer woodland, and HCS = hardwood/conifer savanna.

Table 5.4 Characteristics of available habitats in Rio Grande wild turkey study area, Douglas County, Oregon, 1990-91.

		Canopy cover (%)		% non-forest within 0.3 km		Elevation (m)		Slope (%)		Tall shrub cover (cm/10m)		Understory height (cm)	
Cover type[a]	*n*	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE
CC	3	0	0	55	11	937	202	11	3	13	6	22	1
MP	3	0	0	69	15	910	89	8	2	0	0	11	4
B	1	37		48		888		32		73		21	
OSPC	8	36	5	18	12	945	56	17	3	69	24	25	5
DSPC	2	79	7	0	0	928	68	13	1	154	48	16	4
DYC	11	83	4	5	2	710	57	15	2	49	14	9	2
DMC	15	91	3	6	2	808	59	19	3	43	16	15	3
OMC	2	31	9	11	1	1072	74	15	2	1	1	5	2
HCW	7	61	7	15	4	701	36	14	2	34	11	11	2
HCS	4	46	7	1	1	684	78	8	1	31	21	12	3

[a] CC = clearcut, MP = meadow/pasture, B = brushfield, OSPC = open sapling/pole mixed conifer, DSPC = dense sapling/pole mixed conifer, DYC = dense young mixed conifer, DMC = dense mature mixed conifer, OMC = open mature mixed conifer, HCW = hardwood/conifer woodland, and HCS = hardwood/conifer savanna.

Table 5.5 Understory characteristics of available habitats in Rio Grande wild turkey study area, Douglas County, Oregon, 1990-91.

		Horizontal screening (%)								Ground cover									
		0-30 cm		30-60 cm		60-90 cm		90-120 cm		Grass		Forb		Bare		Low shrub		Debris	
Cover type[a]	*n*	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE
CC	3	81	8	60	9	37	10	31	9	25	10	16	5	25	10	17	2	23	4
MP	3	25	10	9	8	3	3	0.3	0.3	36	4	2	1	63	4	0	0	0	0
B	1	96		85		81		83		5		15		33		39		13	
OSPC	8	85	5	76	7	65	9	60	8	14	3	26	5	28	4	22	5	16	4
DSPC	2	98	2	93	6	89	6	86	9	2	1	11	2	43	2	30	11	17	8
DYC	11	73	4	62	4	50	4	51	5	3	2	16	4	51	5	15	3	19	2
DMC	15	72	5	56	5	41	5	37	4	2	1	12	2	39	3	26	3	25	2
OMC	2	51	3	40	3	30	4	22	4	7	5	8	1	50	10	5	2	31	15
HCW	7	60	7	47	7	38	5	40	4	11	2	13	3	58	8	10	3	10	2
HCS	4	59	14	40	14	28	11	30	13	21	9	16	1	41	6	11	6	12	4

[a] CC = clearcut, MP = meadow/pasture, B = brushfield, OSPC = open sapling/pole mixed conifer, DSPC = dense sapling/pole mixed conifer, DYC = dense young mixed conifer, DMC = dense mature mixed conifer, OMC = open mature mixed conifer, HCW = hardwood/conifer woodland, and HCS = hardwood/conifer savanna.

Table 5.6 Overstory and midstory habitat characteristics at Rio Grande wild turkey brood-rearing sites, Douglas County, Oregon, 1989-90.

	Clearcut (n=2)		Meadow (n=7)		Open SPC[a] (n=7)		Dense YC (n=15)		Dense MC (n=11)		Open MC (n=3)		HCW (n=12)		HCS (n=6)	
Variable[b]	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE
Overstory																
height (m)	30	12	27	3	21*	3	26	1	37	1	40	1.3	19	1	16	1
dbh (cm)	44	17	54	4	31	4	38	2	60	4	80	5	29	3	27	2
basal area (m^2/ha)	9	6	5	2	10	3	20	3	29	4	17	9	12	1	4	1
density (trees/ha)	37	1	17	4	175*	95	166	22	96	14	28	13	189	36	61	12
Midstory																
height (m)	10	4	9	1	7	1	9	0.5	10*	0.5	9	2	6*	0.3	6*	0.4
dbh (cm)	13	7	17	2	9	2	11	1	12	1	12	3	9	1	9	1
basal area (m^2/ha)	3	3	1	0.4	3	1	7	2	8	1	1	0.5	5	1	1	0.3
density (trees/ha)	101	28	44	21	268	123	493	95	580	99	59	7	594	162	156	28
Canopy cover (%)	25	20	32	9	45	7	71	4	69	5	23	12	67	3	30	5
Elevation (m)	570	5	658	35	658	106	603	30	524	20	653	56	580	20	586	39
Slope (%)	11	3	15	2	16	2	13	2	15	2	18	5	12	1	11	3
Non-forest within 0.3 km (%)	9	1	14	3	6	2	6	1	3	1	3	2	5	1	6	2

[a] SPC = sapling/pole conifer, YC = young conifer, MC = mature conifer, HCW = hardwood/conifer woodland, HCS = hardwood/conifer savanna.

[b] Variable means followed by an asterisk were selected by stepwise discriminant analysis when compared to randomly located sites within the same cover type.

Table 5.7 Understory habitat characteristics at Rio Grande wild turkey brood-rearing sites, Douglas County, Oregon, 1989-90.

	Clearcut (*n*=2)		Meadow (*n*=7)		Open SPC[a] (*n*=7)		Dense YC (*n*=15)		Dense MC (*n*=11)		Open MC (*n*=3)		HCW (*n*=12)		HCS (*n*=6)	
Variable[b]	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE
Tall shrub cover (cm/10m)	9	9	13	7	67	15	48	11	77	13	12	3	50	12	12	3
Horizontal screening (%)																
0-30 cm	44	9	43	5	80	6	67	5	71	3	65	11	57	5	63	5
30-60 cm	23	3	22	5	69	6	50	5	53	4	47	11	43	5	36	6
60-90 cm	11	6	12	4	54	6	36	4	38*	4	26	5	34	5	22	4
90-120 cm	13	10	12	5	51	7	36	4	36	4	23	6	38	5	21	3
Understory height (cm)	5	2	15	2	20	3	15	2	15	1	12	4	13	1	18	3
Understory cover (%)																
Grass	8	6	42	7	8	2	10	3	12	3	7	2	17	3	37*	8
Forb	12	1	18	4	28	2	15	2	16	3	22	6	10*	2	12	1
Bare	57	15	28*	5	37	5	40	4	36	3	43	15	48*	4	38	8
Low shrub	8	6	10	2	18	4	23	4	27	2	11	3	18	3	11	3
Debris	19	14	7	3	15	4	17	2	13*	2	22	8	9	2	7	2

[a] SPC = sapling/pole conifer, YC = young conifer, MC = mature conifer, HCW = hardwood/conifer woodland, HCS = hardwood/conifer savanna.

[b] Variable means followed by an asterisk were selected by stepwise discriminant analysis when compared to randomly located sites within the same cover type.

cm/10 m in any cover type). Except in meadows, understory composition at brood-rearing sites was dominated by bare ground (36-57%). We observed considerable variability among proportions of other understory components; grass cover ranged from 7% in OM conifer to 42% at meadow/pasture sites. Forbs, low shrubs, and woody debris each accounted for 7 to 28% of brood-site understory cover among 8 cover types. However, total understory vegetative cover (grass, forb, and low shrub) at brood-rearing sites was consistent and ranged from 44 to 52% among all cover types except meadow/pasture.

Brood-rearing sites in meadows and pastures ($n = 7$) were distinguished from random locations by the amount of bare ground. Based on discriminant analysis, we determined that group differences explained 70% of variation in the canonical function ($P = 0.003$). Random sites in meadows and pastures were characterized by twice as much bare ground as brood sites.

Two variables, overstory tree height and density, in the OSP conifer cover type provided discrimination between brood sites ($n = 7$) and random locations ($P = 0.009$). However, only 54% of the function variation was attributed to group differences. Random locations tended to have fewer, shorter overstory trees compared with brood-rearing sites.

Within the DM conifer cover type, midstory tree height, woody debris, and horizontal screening (60-90 cm) discriminated between brood sites ($n = 11$) and random locations. The canonical function with these variables accounted for 81% of the variation between brood and random sites ($P = 0.0001$). Random sites had taller midstory trees, more woody debris, and greater horizontal screening than brood-rearing sites.

Twelve brood sites were measured in HC woodlands. Bare ground and forb cover and midstory tree height discriminated between brood sites and random locations, accounting for 67% of between-group differences ($P = 0.0007$). Random sites had more bare ground and forb cover and taller midstory trees than brood-rearing sites.

Midstory tree height and grass cover discriminated between random and brood-rearing sites ($n = 6$) in HC savannas, encompassing 89% of variation in the canonical function ($P = 0.0004$). Midstory tree height followed the same trend noted in HC woodlands (higher values at random sites); grass cover was greater at random sites compared with sites used by broods

Broods were most often found on southeast slopes and those aspects were used more than expected ($P < 0.01$). All north facing slopes were used less than expected for brood rearing ($P < 0.01$) and southwest slopes were used in proportion to availability.

DISCUSSION

Habitat Use

Comparisons of brood habitat use among Rio Grande wild turkey populations were difficult because of the scarcity of quantitative evaluations in other regions or the relative simplicity of vegetation where other populations existed. For example, Schmutz et al. (1990) delineated only 3 habitats for an introduced Rio Grande turkey population in northeastern Colorado. Our results were similar to those of Mackey (1986) for Merriam's wild turkey (*M. g. merriami*) broods in Washington where oak and oak-pine habitats were used more than expected, but only 2 other cover types were available. Our results also supported findings of Rumble and Anderson (1993) for Merriam's turkeys in South Dakota; brood hens in both populations used meadows more than expected and dense conifer stands less than expected. We conjecture that Rio Grande brood use of cover types was influenced by habitat patchiness, particularly in dense mature conifer stands. For example, less debris, less canopy cover, and more grass cover at brood-rearing sites in DMC stands probably indicated use of small openings or park-like areas in otherwise dense stands. Use of small openings (<1 ha) within larger forest tracts was noted for Merriam's turkeys in Washington (Mackey 1986). Rumble and Anderson (1993) reported that hens with poults <12 weeks old rarely moved >10 m into meadows. Similarly, we saw few broods near centers of large openings until poults were $\geq$3 months old.

Our findings coincided with patterns of habitat use summarized by Porter (1992). Savannas and open woodlands provided brood-rearing habitat, and these cover types were used more than expected by Rio Grande wild turkey hens with broods in southwestern Oregon. We interpreted observations of hens with broods in a number of habitats as evidence that hens made use of a range of conditions available in several cover types. However, we recognized that we could not ascertain specific activities associated with some locations, and measured sites may have represented a blend of areas used for several reasons (e.g., food, rest, or escape).

Habitat Characteristics

Descriptions of specific brood site characteristics for Rio Grande turkeys in native range were lacking, however brood-rearing habitats used by other subspecies were described as park-like (Porter 1992). Our observations were consistent with previous observations throughout many parts of the country. The relatively open character of sites occupied by brood hens probably allowed for greater poult mobility and foraging opportunity and reduced contact with wet vegetation. Conversely, sites typified by heavy slash concentrations and dense understory vegetation (e.g., >80% horizontal screening from 0 to 1.2 m) probably were used little because poult mobility and hen vision were restricted. Mackey (1986) thought that similar dense vegetation conditions limited use of some sites in Washington.

Structural characteristics of sites used by Rio Grande hens with broods were different from those described by Mackey (1986) for Merriam's turkeys and by Schmutz et al. (1990) for Rio Grande turkeys in Colorado. Merriam's and Rio Grande brood sites outside Oregon were composed of taller understory vegetation (44 cm) than we found in southwestern Oregon (15 cm). We also observed different trends in total understory cover and horizontal screening compared with other areas. Merriam's brood sites (Mackey 1986) had greater screening than random sites. Average horizontal screening was moderate (33-64%) at Rio Grande brood-rearing sites in Oregon, but little different from random locations. By contrast, total understory vegetation cover at Washington brood sites (34%) was less than at random sites (Mackey 1986), but total cover was higher at brood-rearing sites (52%) than random sites in Oregon.

Schmutz et al. (1990) found more grass cover at some Rio Grande brood sites, similar to that in southwestern Oregon, but Day et al. (1991) noted less grass cover at some brood sites than at random locations (however, available grass cover in study areas outside Oregon was much higher than that in southwestern Oregon). Like Schmutz et al. (1990), we did not observe differences in sites used by different age broods, nor did we record consistent differences between brood-rearing sites and random locations. Rather, Rio Grande brood-rearing sites in Oregon encompassed a variety of plant associations and structures, but fell within ranges observed in other parts of wild turkey range. Southeast slopes provided poults with the best opportunities for feeding and easy travel because these slopes dried quickly each day and supported cover types used most by brood hens.

MANAGEMENT IMPLICATIONS AND RECOMMENDATIONS

Our research indicated that Rio Grande wild turkeys in the southern Oregon Cascades were more adaptable and productive (Keegan and Crawford 1996a) than Merriam's wild turkeys in the northern Oregon Cascades. Because they used most available cover types for brood rearing, Rio Grande turkeys would probably thrive under a variety of habitat conditions, including some not conducive to Merriam's turkey populations. We contend that, in a relative sense, Rio Grande wild turkeys are generalists compared with Merriam's turkeys. Therefore, before selecting a subspecies for translocation, managers should consider the types of habitat available and likely future land management scenarios. In relatively disturbed environments in the Oregon Cascades, Rio Grande wild turkeys likely will be more successful than Merriam's turkeys.

Esthetic and economic returns of translocation programs will be enhanced by selection of subspecies best suited to regional habitat conditions.

Although Rio Grande turkeys used a variety of habitats successfully, several management practices would enhance brood habitat. Only dense stands resulting from recent perturbations (conifer or tall shrub stands that developed after even-age management practices or disturbance) received little use. When compatible with other objectives, we speculate that prescribed burning (e.g., in brushfields) or patch thinning (e.g., in dense sapling/pole stands) to reduce excessively dense vegetation (to <25% low shrub cover and <25 cm vegetation height) would likely increase wild turkey use, particularly in areas where brood habitat is limited. Maintaining areas of mixed hardwood/conifer cover types (particularly oak woodland and savanna complexes) would ensure availability of brood-rearing habitat. Turkeys would also benefit from conservation and enhancement of openings and park-like areas in conifer cover types, particularly in areas with low hardwood/conifer stand abundance or distribution.

Because dense mature conifer was used less than expected for brood rearing, Rio Grande turkeys will probably thrive in landscapes dominated by relatively young forests (30-110 years old and 23-50 cm dbh). However, dense mature conifer received heavy use for most components of turkey life-history (e.g., ranked second for brood habitat use and first for hen-poult roosts) (Keegan and Crawford 1995). Therefore, we do not recommend extensive harvest of mature timber as a means of increasing wild turkey numbers. Other practices that might benefit wild turkeys include reducing disturbance to hens with broods by closing roads to motor vehicle traffic during the reproductive season (Apr-Jun) and delaying spring gobbler hunting until most hens begin incubation. Road closures would reduce human contact with hens (Steffen et al. 1988) and increase turkey use of areas (Smith et al. 1990). Because this research was not replicated outside the specified area, our scope of inference is limited to the study area.

Chapter 6

SEASONAL HABITAT USE AND HOME RANGES OF RIO GRANDE WILD TURKEY HENS IN OREGON

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ABSTRACT

Wild turkey (*Meleagris gallopavo*) habitat use and home ranges have been described for most of the subspecies, but such knowledge of introduced Rio Grande wild turkeys (*M. g. intermedia*) in the Pacific Northwest was lacking. Consequently, we investigated habitat use and home ranges of hens in a recently established Rio Grande wild turkey population in southwestern Oregon from February 1989 through June 1991. Hens used all available cover types, but meadows and mixed hardwood/conifer woodlands and savannas were used more often than expected ($P \leq 0.05$) during summer (33% of Apr-Sep observations) and winter (56% of Oct-Mar observations). Brushfields and dense sapling/pole and mature mixed-conifer cover types were used less than expected. Annual 95% minimum convex polygon home ranges ranged from 2,784 ha for adult hens to 5,302 ha for yearlings. Unsuccessful and yearling hens moved farther to nest in successive years than did successful and adult hens ($P \leq 0.03$). Rio Grande wild turkeys were generalists compared to Merriam's wild turkeys (*M. g. merriami*) and will likely be successful in relatively disturbed habitats in the Oregon Cascades.

INTRODUCTION

Rio Grande wild turkeys were native to the southcentral Great Plains, but translocation programs resulted in establishment of populations in 9 western states (Wunz 1992). Differences in wild turkey movements and home ranges among geographic regions and subspecies were attributed primarily to variation in resource availability (Brown 1980). Although use of cover types indicated a high level of adaptability, turkeys were selective with respect to vegetative characteristics within cover types (Holbrook et al. 1987). Activity-specific site fidelity (e.g., traditional roost sites) plays an important role in turkey ecology and management. Availability and juxtaposition of habitats influence wild turkey movements and use within ecosystems, and therefore, population maintenance and viability.

Habitat use by Rio Grande turkeys in their native range was studied extensively (e.g., Thomas et al. 1966, Baker et al. 1980) and seasonal habitat use by Merriam's wild turkeys was examined by Lutz and Crawford (1989) and Rumble and Anderson (1993) in extralimital populations. However, habitat use and home ranges of Rio Grande wild turkey populations in the Pacific Northwest have received limited attention and nest site fidelity is poorly understood. Because habitat requirements and movements of females have direct bearing on annual recruitment and maintenance of populations, we examined seasonal habitat use, home ranges, and nest site fidelity of Rio Grande wild turkey hens in southwestern Oregon.

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STUDY AREA

The 675-km^2 study area was located in the upper South Umpqua River Basin, Douglas County, Oregon. Elevations ranged from 310 to 1,525 m and the area was dissected with steep east-west ridges. A heterogeneous association of plant cover types developed in the study area because of diverse edaphic and geologic conditions (Franklin and Dyrness 1973:130). We identified 10 cover types based primarily on overstory characteristics from aerial photographs (taken summer 1989) and ground reconnaissance (Keegan and Crawford 1996b). Three non-forested (< 10% tree cover) cover types accounted for 12% of the study area: recent clearcut (< 10 years since harvest, 6%); brushfield (4%); and meadow/pasture (3%). Common overstory species in mixed hardwood/conifer woodland (HCW) included Oregon white oak (*Quercus garryana*) and Pacific madrone (*Arbutus menziesii*). Woodlands were characterized by canopy closure ≥40%, whereas canopy closure in mixed hardwood/conifer savanna (HCS) was 10 to 40%. Savannas covered only 2% of the area and generally had not been managed for timber production. In contrast, timber management likely influenced stand structure in HCW (7% of the area).

Douglas fir (*Pseudotsuga menziesii*) was a prominent component of mixed-conifer stands, but other conifer species occurred as co-dominants: ponderosa pine (*Pinus ponderosa*), white fir (*Abies concolor*), and incense-cedar (*Calocedrus decurrens*). In mixed-conifer stands, canopy closure ≥70% was considered dense, whereas closure <70% was classified as open. Dense large/mature mixed conifer (DMC) contained overstory trees that averaged ≥50 cm diameter-at-breast-height (dbh) and >110 years old and was the most common cover type (49% of the area). Open large/mature mixed conifer (OMC, 4% occurrence) often developed from natural or management-related thinning. Dense medium/young mixed-conifer (DYC) stands occupied 14% of the area and were characterized by overstory trees that were 23-50 cm dbh and 30-110 years old. Open sapling/pole/young mixed-conifer (OSPC) stands often developed as a result of sparse regeneration or precommercial thinning (3% of the area). Dense sapling/pole mixed conifer (DSPC, 8% occurrence) often resulted from normal tree growth after even-age regeneration harvest.

METHODS

Capture and Radio Telemetry

We used rocket nets to capture turkeys during winters of 1988-89 and 1989-90. Age of hens (yearling or adult) was determined by characteristics of the primary feathers (Larson and Taber 1980) and each individual was equipped with 90- to 110-g radio transmitter attached with a modified backpack harness (Kenward 1987:103). Expected transmitter life ranged from 1 to 3 years. In 1988-89, we equipped 26 adult and 19 yearling hens with transmitters. Fifteen adults and 15 yearlings (considered adults during the second year) survived to 1990. We equipped 10 more adult and 21 yearling hens with transmitters during the 1989-90 trapping season, bringing the total sample to 36 adults and 40 yearlings. All radio-tagged hens survived ≥2 weeks after release.

We ascertained direction to radio signals by the peak-signal method (Springer 1979). Preliminary bearings and signal strength were used to move within 0.5 km of birds; subsequent bearings provided triangulation data. Hens were located by triangulation from ≥ 3 locations or by visual observation. We recorded locations in 3 approximately equal time periods: morning (0.5 hr before sunrise to 4 hr after sunrise), midday (4 hr after sunrise to 4 hr before sunset), and evening (4 hr before sunset to 0.5 hr after sunset). Each hen was located at least once during each daytime period in each 2-week interval. To the extent possible, we monitored hens daily to identify mortality and approximate locations.

We tested accuracy of telemetry procedures by taking bearings on transmitters at 5 locations from 3 distances that represented the range of tracking situations. Differences between estimated and actual azimuths were used to calculate error within and among distances and locations. Variances of error angle estimates were not homogeneous among all observers and distances. Therefore, we pooled standard deviations of error angles when appropriate and assigned error to each triangulation based on observer and estimated distance from transmitter. Mean difference between estimated and true azimuths for all tested observer-distance combinations was 1° (SE = 0.4). We entered azimuths and receiver locations into program XYLOG (Dodge and Steiner 1986) to process triangulation data. Habitat availability was defined by a minimum convex polygon (Mohr 1947) for all hen locations (except that 2 hens that moved >30 km to inaccessible areas were excluded).

Statistical Analyses

We used Chi-square analysis to test the null hypothesis that cover types were used in proportion to availability (Neu et al. 1974, Byers et al. 1984). When null hypotheses were rejected, simultaneous confidence intervals were calculated to identify which cover types contributed to differences in use and whether use was greater or less than expected. Initially, use and availability were analyzed within and among years, traditional 3-month seasons, times of day, and hen age classes (within sample size constraints). Preliminary analyses indicated that habitat use did not differ with year, time of day (except night), or hen age. Diurnal habitat use was separated into 2 seasonal/social group categories and observations were pooled accordingly for analysis of habitat use. Winter (Oct-Mar) habitat use was based on 445 independent locations that encompassed the non-reproductive period for wild turkeys. Winter was primarily a cool, wet period that included autumn flock formation and winter range occupation. We disregarded locations influenced by availability of bait stations maintained for turkey trapping. Analysis of summer (Apr-Sep) habitat use analysis included 1,112 independent locations during the reproductive period and included pre-laying hens, hens without broods, and hens with poults >12 weeks old.

We analyzed location data with 2 methods to identify annual and seasonal home ranges; 2 seasons were again delineated to coincide with reproductive and non-reproductive periods for wild turkeys. We estimated 2 harmonic mean (Dixon and Chapman 1980) and 2 convex polygon (Mohr 1947) estimates of home ranges. The 95% estimates for each method provided estimates of turkey home ranges that were not distorted by effects of outlier observations. Core harmonic mean values and 75% convex polygons represented core areas or activity centers that accounted for large portions of turkey observations within home ranges. For example, most core harmonic mean values accounted for 60 to 70% of the harmonic mean utilization volumes. Individual turkey locations used in harmonic mean estimation were weighted by the number of radio-marked birds in a flock (to correct for dependent observations). However, each observation was given equal weight in other procedures.

The harmonic mean method included assumptions of independence of consecutive locations and convex polygon estimates may be affected by a lack of independence. Serial correlation was assessed with 3 indices included in program HOME RANGE (Ackerman et al. 1990). Statistical independence of consecutive locations was rare in our data sets; however, we did not delete observations because of the excessive number of deletions needed to achieve complete statistical independence. For example, trial analyses of some data sets indicated that statistical independence would not be achieved until approximately 90% of locations were deleted (leaving only 5-6 locations in a 1-year interval). Further, our observations of turkey movements led us to conclude that wild turkeys were mobile and that locations were biologically independent (i.e., hens could have traversed home ranges during 2- to 3-day intervals between successive locations). Tests of bivariate uniform distribution (appropriateness of convex polygon method) were rejected for approximately 65% of telemetry data sets, however we included convex polygon estimates for comparison with published literature.

We measured distance between consecutive nests and distance moved from winter range to nests for all hens and we calculated distance between successive nests as a percentage of distance moved from winter range (Fischer et al. 1993). A small value indicated that a hen returned to a relatively localized area compared to the distance moved from winter range. We used Wilcoxon rank-sum tests to test for differences in distances between consecutive nests between adult and yearling hens and between successful and unsuccessful hens.

RESULTS

Habitat Use

We identified cover types at 1,557 sites used by hens between 1 February 1989 and 31 January 1991. During winter, turkey use of habitats was different from availability ($P < 0.005$). Three habitats were used more than expected (meadow/pasture, hardwood/conifer woodland, and savanna) and collectively accounted for 56% of diurnal winter locations (Table 6.1). Most dense cover types (brushfield and dense sapling/pole and mature conifer) were used less than expected, whereas open conifer stands (clearcut, open sapling/pole and mature conifer) and dense young conifer were occupied in proportion to availability.

Summer habitat use also was disproportionate to availability ($P < 0.005$), but differed in several ways from winter use. Although turkeys continued to use meadows and hardwood/conifer cover types more than expected (Table 6.1), collective occurrence in these 3 habitats decreased from 56% in winter to 33% during summer. Proportional use of dense young conifer shifted from neutral during winter to more than expected in summer even though actual use increased less than 3%. Similarly, use of open sapling/pole conifer increased by 5% and shifted from less than expected in winter to proportional in summer. Although use of other habitats relative to availability was unchanged from winter to summer, there was a large overall shift toward greater use of all conifer habitats during summer.

Table 6.1 Seasonal habitat use (%) by adult Rio Grande wild turkey hens, Douglas County, Oregon, 1989-91.

		Winter[a] (445 locations)		Summer[b] (1,112 locations)	
Cover type	Availability (%)	Use	Selection[c]	Use	Selection
Clearcut	6.1	6.5	0	8.9	0
Meadow/pasture	2.5	14.2	+	7.6	+
Brushfield	3.8	1.1	-	0.9	-
Open sapling/pole mixed conifer[d]	3.4	1.1	-	5.8	0
Dense sapling/pole mixed conifer	8.0	0.9	-	2.5	-
Dense young mixed conifer	14.4	18.0	0	20.6	+
Dense mature mixed conifer	48.9	13.5	-	24.4	-
Open mature mixed conifer	4.3	3.1	0	4.3	0
Mixed hardwood/ conifer woodland[e]	6.8	27.0	+	17.0	+
Mixed hardwood/ conifer savanna	2.0	14.6	+	8.1	+

[a] Winter defined as 1 October - 31 March (non-reproductive period).

[b] Summer defined as 1 April - 30 September (reproductive period).

[c] A 0 represents use in proportion to availability, + represents greater use of a habitat than expected, and - represents less use of a habitat than expected ($P \leq 0.05$).

[d] In conifer cover types open defined as canopy closure <70%.

[e] Woodland defined as canopy closure ≥40%, savanna canopy closure was <40%.

Home Ranges and Movements

Methods used to evaluate location data influenced home range estimates. In most cases, estimates derived with harmonic mean procedures (Dixon and Chapman 1980) were 2-3 times greater than comparable convex polygon estimates (Table 6.2). Harmonic mean seasonal core areas ranged from 930 ha for adults during winter to >3,000 ha for yearling hens in summer. Annual home range estimates ranged from 2,784 ha (convex polygon for adults) to 13,630 ha (harmonic mean for yearlings). Annual and winter home ranges did not differ between adult and yearling hens ($P = 0.11$ to 0.52) except that annual 75% convex polygons for yearlings were larger than for adults ($P = 0.07$). Yearling hens, however, had larger home ranges than adults during summer ($P = 0.03$-0.07). Trends in seasonal home range size differed between adults and yearlings. Adults occupied larger areas in winter than in summer, whereas the reverse occurred for yearlings. Larger yearling summer home ranges were related to longer movements from winter range to nesting and summer range locations (8.0 km for yearlings and 6.3 km for adults).

Nest Site Fidelity

Fidelity to nesting areas differed within and among individuals; however, some individuals demonstrated strong fidelity to a relatively small area. Twenty-seven hens initiated nests in consecutive years, producing 62 nests. We measured 33 distances between consecutive-year nests (21 hens with 2 annually consecutive nests and 6 hens with nests in 3 years). Median distance between first nests in successive years was 0.68 km (range 0.03-12.4 km) and median distance moved from winter range to nests was 4.4 km (range 0.2-25.1) for hens that nested in consecutive years. Median distance between

Table 6.2 Annual and seasonal home range estimates (ha) for Rio Grande wild turkey hens, Douglas County, Oregon, 1989-91.

	Harmonic mean						Minimum convex polygon				
	95% contour			Core area				95%		75%	
	n	$\bar{x}$	SE	*n*	$\bar{x}$	SE	*n*	$\bar{x}$	SE	$\bar{x}$	SE
Adult											
Summer[a]	40	3,190	1,044	36	976	287	40	1,210	319	421	64
Winter[b]	25	5,358	422	24	930	141	25	1,533	130	907	130
Annual[c]	28	9,024	1,294	28	2,316	364	28	2,784	472	1,244	211
Yearling											
Summer	28	12,637	4,168	27	3,017	877	28	3,462	951	990	301
Winter	20	6,637	1,906	19	1,461	440	20	1,819	396	644	118
Annual	25	13,630	3,986	25	3,231	891	25	5,302	1,439	2,678	211

[a] Summer defined as 1 April - 30 September (reproductive period).

[b] Winter defined as 1 October - 31 March (non-reproductive period).

[c] Annual period was 1 February - 31 January.

successive nests, measured as a percentage of distance moved from winter range, represented approximately 13% and 25% of median annual movements for adults and yearlings, respectively. Distance moved between consecutive nests differed ($P < 0.03$) between yearlings (median = 2.07 km, $n = 14$, range 0.13-12.4 km) and adults (median = 0.51 km, $n = 19$, range 0.03-3.6 km). Within age classes, we did not detect differences in distance between consecutive nests based on nest success ($P > 0.15$). However, when all nests were combined, hens nested farther ($P = 0.007$) from previously unsuccessful nests (median = 2.73 km, $n = 12$, range 0.47-12.4) than from previously successful attempts (median = 0.51 km, $n = 21$, range 0.03-11.7).

DISCUSSION

Habitat Use

Shifts in seasonal habitat use likely were related to several factors. Hens encountered larger amounts of conifer forest as they moved to higher elevations during spring and summer. Conversely, mixed hardwood/conifer (HC) and meadow cover types were more available at lower elevations. Although use declined, hens still sought out HC cover types during summer and they also made use of conifer habitats that were structurally similar to woodlands and savannas. For example, we observed hens in precommercially thinned or sparsely regenerated conifer stands that were characterized by lower stem densities and more understory vegetation than typically found in dense regeneration stands.

Seasonal habitat use patterns for Rio Grande wild turkeys outside the native range were unknown. Lutz and Crawford (1989) reported that Merriam's turkeys in Oregon used habitats in proportion to availability on a seasonal basis. However, they found that annual habitat use included selection for mixed-species cover types but not monotypic habitats or cover types simplified by logging. In contrast, Rumble and Anderson (1993) reported strong seasonal habitat selection by Merriam's turkeys in South Dakota and suggested that greater than expected use of ponderosa pine stands in autumn and winter was related to pine seed availability and thermal cover. We frequently observed evidence of winter foraging activity in leaf litter in hardwood/conifer cover types. Conversely, dense conifer stands in Oregon probably provided cooler sites during summer, thereby attracting increased turkey use. Year-round preferential use of meadows by Rio Grande hens was the opposite of that observed by Rumble and Anderson (1993) in South Dakota.

Home Range

Home ranges of Rio Grande wild turkey hens in Oregon were comparable to Merriam's turkey hen ranges in Oregon (Lutz and Crawford 1989) but substantially larger than noted for other populations. Although direct comparisons were not possible because of different season lengths, our estimates of Rio Grande turkey seasonal home ranges (100% convex polygon) generally overlapped those reported by Lutz and Crawford (1989) for Merriam's hens. Estimates of annual (140-448 ha) and reproductive season (150-425 ha) home ranges for eastern wild turkey hens (Brown 1980) were <20% of equivalent 95% convex polygon estimates for Rio Grande hens in Oregon. Our combined annual home range (3,972 ha, 95% convex polygon) was >5 times that reported by Kurzejeski and Lewis (1990) for hens in Missouri (780 ha, modified minimum area). We are not aware of home range estimates for other Rio Grande turkey populations, however movements >14 km from winter range to nests were observed by Thomas et al. (1966) and Schmutz and Braun (1989). Therefore, a pattern of long movements and associated large home ranges appears typical for the Rio Grande subspecies.

In contrast, we noted that for many hens, most activity was concentrated in relatively small portions of home ranges. Use of core areas separated by large distances likely was indicative of large tracts of less used habitats (e.g., dense sapling/pole conifer) between more heavily used mosaics of mixed hardwood/conifer stands and meadows. We interpreted Rio Grande turkey movements and home range sizes as opportunistic use of ample, albeit scattered, high quality habitats.

Longer movements to nest areas by yearling Rio Grande hens compared with adults were similar to Rio Grande populations in Colorado (Schmutz and Braun 1989) and Merriam's populations in Oregon (Lutz and Crawford 1987). We did, however, discern that although yearlings moved farther and occupied larger areas than adults, there were 2 general classes of birds: those that dispersed widely and those that did not. Long distance dispersal behavior was not limited to yearling hens. Rather, a far-ranging yearling frequently also dispersed long distances in subsequent years (often to the same area).

Nest Site Fidelity

Fidelity to nest areas is poorly understood for galliforms. Fischer et al. (1993) reported that sage grouse (*Centrocercus urophasianus*) showed strong fidelity to nesting areas (median distance between consecutive nests was 740 m and represented 3.5% of annual movement). They summarized fidelity in lekking grouse populations and reported that distance between consecutive nests represented 1.6 to 11.3% of annual movements. Although Rio Grande turkeys did not display the level of fidelity (distance between nests was 16% of annual movement) reported by Fischer et al. (1993) for grouse, median distance between consecutive nests was similar for turkeys (680 m) and sage grouse (740 m). Hayden (1980) and Ellis and Lewis (1967) noted that some wild turkey hens returned to the same "nesting range" or "area" in successive years, but they did not quantify site fidelity because of small sample sizes. Rumble and Hodorff (1993) reported that some Merriam's hens initiated nests within 50 m of previous nest sites.

We observed further indications of fidelity for renest attempts and non-consecutive first nests (not included in our analysis). For example, some hens nested within 100 m of previous renest attempts or nests initiated in alternate years. Patterns of nest area fidelity were confounded by hen age and possibly nest success (first and renest attempts), but we interpreted movement patterns as indicative of fidelity to nest areas, particularly for adult hens. Indeed, all long distances (>3.5 km) between consecutive nests were attributed to yearling hens that moved >6 km to nest but then nested much closer to respective winter ranges in succeeding years. Fischer et al. (1993) reasoned that sage grouse showed strong nest area fidelity because nesting habitat was readily available yet hens moved long distances to nest (presumably through suitable nesting habitat). We contend that the same situation applied to wild turkeys in Oregon. The tendency for previously successful hens and adults to nest nearer previous nests than unsuccessful hens and yearlings was similar to that observed for several scolopacids (Oring and Lank 1982, Gratto et al. 1985). In contrast, Fischer et al. (1993) did not detect differences in distances between consecutive nests based on sage grouse age or nest success.

Our research indicated that Rio Grande wild turkeys were more adaptable and productive (Keegan and Crawford 1996a) than Merriam's wild turkeys in the Oregon Cascades. Use of most available habitats indicated that Rio Grande turkeys would thrive under a variety of habitat conditions, including some not conducive to Merriam's turkey populations. We contend that, in a relative sense, Rio Grande wild turkeys are generalists compared with Merriam's turkeys and that Rio Grande wild turkeys will likely be more successful than Merriam's turkeys in relatively disturbed environments in the Oregon Cascades. Because this research was not replicated outside the study area, our scope of inference was limited to the study area.

SYNTHESIS, INTERPRETATION, AND IMPLICATIONS

Rio Grande wild turkeys in southwestern Oregon successfully used a variety of habitats and seral stages. Only dense stands, resulting from relatively recent perturbations (conifer or tall shrub stands that developed after even-aged management practices or disturbance), were virtually unused. When compatible with other objectives, several habitat manipulations can improve habitat for wild turkeys. Specifically, prescribed burning (in brushfields) or patch thinning (in dense sapling/pole stands) to reduce excessively dense vegetation likely would increase wild turkey use, particularly in areas where brood-rearing habitat is limited. In contrast to Merriam's turkey management, moderate slash treatment may be desirable in Oregon's Rio Grande wild turkey range; managers should design manipulations to maintain or create patches of low shrub cover ($\leq$20 m diam and 30-50% cover) for nesting. Maintaining or creating areas of <25% low shrub cover and <25 cm vegetation would provide adequate brood range. Mixed hardwood/conifer habitats were important for wild turkeys and provided benefits for many other wildlife species. Therefore, conservation and maintenance of hardwood/conifer habitats should be a priority for land managers. Similarly, turkeys would benefit from maintenance, conservation, and enhancement of openings and park-like areas within mixed conifer cover types, particularly in areas with low mixed hardwood/conifer stand abundance or distribution (e.g., high elevation sites). In the Douglas County study area, unique hardwood/conifer and mixed conifer mosaics in the Nichols Ranch and Tallow Butte areas should be maintained and enhanced for wildlife.

Land managers who wish to promote wild turkey range expansion and use of new areas should devise manipulations for mixed conifer habitats that would create structural characteristics that simulate those of mixed hardwood/conifer savannas and woodlands. I observed that wild turkeys at elevations >650 m and >16 km from population cores used conifer plantations with low stocking rates (e.g., sparse regeneration or thinned with slash treatment) and shelterwood regeneration areas with herbaceous understories. Therefore, group selection regeneration systems or relatively heavy thinning may improve stands for wild turkeys in conifer cover types. Removing or piling felled trees in precommercial thinning operations in dense conifer stands should create structural characteristics conducive to wild turkey use. Green tree retention, particularly in shelterwoods where understory conditions are similar to hardwood/conifer woodlands, may enhance wild turkey use.

Because dense mature conifer was used less than expected seasonally as well as for roosting, nesting, and brood rearing, Rio Grande turkeys may thrive in landscapes dominated by relatively young forests (30-110 years old and 23-50 cm dbh). However, average roost trees were 50 cm dbh and 106 years old and, therefore, at the upper limit of my classification criteria for young conifer stands. Stands at the upper end of the young stand classification may be older than stands that develop under many current harvest rotations. Further, dense mature conifer received frequent use for most components of turkey life-history (ranked first or second for roost, nest, brood, and summer habitat use). Therefore, I do not recommend reducing average stand age or extensive harvest of mature timber as a means of increasing Rio Grande wild turkey numbers.

Evaluation of habitat manipulations should include monitoring procedures appropriate to the management objectives. Effects of manipulations on wild turkey use of traditional roost sites can be monitored over time by counting droppings under roost trees or by direct counts of turkeys using roosts. Because of the difficulty associated with locating wild turkey nests, radio telemetry is probably the best tool available to evaluate changes designed to improve nesting habitat. However, increased use of a general area, as evidenced by spring gobble counts, could provide an index to the effectiveness of nest habitat manipulations. Monitoring the effectiveness of management that creates or improves brood-rearing habitat should include brood counts during late spring or summer. Track counts in manipulated areas could provide evidence of turkey use by different social groups, thereby allowing managers to evaluate how habitat changes affect different sex and age groups. Habitat management practices designed to increase year-round use by turkeys could be monitored with several methods depending on season. Counts or simple observation of tracks in snow or on suitable substrates, droppings, and molted feathers indicate wild turkey presence. Expanding counts to a transect or plot based sampling scheme could provide an approximate index of relative abundance among seasons, years, or areas. Gobble counts can indicate use of habitats during the breeding season and observations by hunters, foresters, and other people can be used to identify general areas of wild turkey use at other times of year. Conversely, effects of habitat changes that may be detrimental to wild turkeys should be monitored by observing similar indices of turkey use.

In general, habitat management for wild turkeys in southwestern Oregon appears compatible with a variety of other wildlife species. Among the many species that might benefit, directly or indirectly, from habitat management for wild turkeys are Roosevelt elk (*Cervus elaphus roosevelti*), Columbian black-tailed deer (*Odocoileus hemionus* *columbianus*), ruffed grouse (*Bonasa umbellus*), blue grouse (*Dendragapus obscurus*), mountain quail (*Oreortyx pictus*), coyote (*Canis latrans*), bobcat (*Felis rufus*), and mountain lion (*Felis concolor*). Managers should be aware that some increases in habitat fragmentation that may benefit species such as wild turkeys may not have positive effects on species that require large unbroken tracts of specific habitats. Management plans should encompass large areas (e.g., watersheds) to accommodate the desired species diversity and composition.

Because overall productivity and survival of yearling hens was similar to that of adults, managers can include yearlings as part of translocated flocks without jeopardizing success of introduction efforts. Reproductive characteristics of the population in my study area were indicative of a population that was responding in a density-dependent manner. Specific evidence of a reproductive response to low population density included high nesting rates by all hens and, particularly, yearlings; high renesting rates by adults; and renesting after brood loss by adults, a behavior first documented during this research project. Evidence of these reproductive characteristics in other Rio Grande wild turkey populations in Oregon may indicate growing populations, thereby allowing managers to focus translocation efforts in other areas and design hunting seasons accordingly.

Management programs that minimize disturbance of nesting hens and broods may positively influence productivity. Hens rarely flushed from nests unless approached within 10 m and 71% of flushed hens resumed incubation. However, alterations in road management and hunting seasons could reduce hen disturbance. Road closures would reduce human contact with laying and incubating hens (Steffen et al. 1988), increase turkey use of areas (Smith et al. 1990), improve quality of hunts, and increase harvest if desired. Hunter density was negatively correlated with hunter success in eastern states (Palmer et al. 1990, Porter et al. 1990). Poaching and crippling loss were more prevalent near open roads in Virginia (Holbrook and Vaughn 1985). Road closure should decrease hunter density in some areas and would allow for higher hunter success and higher quality hunting experiences in terms of hunter interference (Steffen et al. 1988), number of adult gobblers available, and long-term annual harvest (Kurzejeski and Vangilder 1992).

Adjusting season dates and length to more closely coincide with incubation might reduce incidence of accidental and intentional shooting of hens and disturbance of laying and brood hens. Spring hunting seasons during this study began before hens started incubation, preceding mean onset of incubation by 12 to 22 days. The 1989 season ended before nests hatched, but subsequent seasons were lengthened by 2 weeks, extended 13 days into hatching, and ended within 2 days of mean hatch dates. Although weather and elevation affect nest chronology, spring gobbler seasons that occur between 21 April and 14 May could reduce hen and brood disturbance (in normal years) without seriously reducing recreational opportunities.

KEY FINDINGS OF RIO GRANDE WILD TURKEY RESEARCH

1. Rio Grande wild turkeys displayed less habitat specificity than Merriam's wild turkeys within Oregon and Rio Grande turkeys should fare better in more disturbed, fragmented systems.
2. Rio Grande wild turkeys were more productive than Merriam's turkeys in Oregon, primarily because of high yearling nesting rates and overall renesting rates.
3. Rio Grande wild turkeys selectively used mixed hardwood/conifer woodlands for roosting, brood rearing, and on a seasonal basis.
4. Mixed hardwood/conifer savannas and meadow/pasture cover types were used more than expected seasonally and for brood rearing.
5. Dense sapling/pole mixed conifer, dense mature/large mixed conifer, and brushfield cover types were used less than expected at all times.
6. Roosts were characterized by moderately large trees and dense canopy cover, nests by moderate low shrub cover, and brood-rearing sites by parklike, savanna structure.
7. Predation accounted for 75% of hen mortality, but annual survival was high (70%) and no serious disease problems were observed.

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