Rio Grande Wild Turkey Home Ranges in the Southern Great Plains

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Abstract: Previous studies on wild turkey (*Meleagris gallopavo*) home ranges have concentrated on the eastern subspecies (*M. g. silvestris*). Our objectives were to estimate spring-summer period (1 April–31 August) and annual home ranges of Rio Grande wild turkeys (*M. g. intermedia*) and compare them across study sites, age (adult, juvenile) and sex. From 2000–2004, we recorded 44,526 telemetry locations from 1,253 radiotagged Rio Grande wild turkeys on four study sites in the Texas Panhandle and southwestern Kansas. We used the 95% fixed kernel and 95% minimum convex polygon (MCP) methods to calculate home ranges. Mean 95% fixed kernel annual home ranges were 1,908 ± 112 ha for females and 1,578 ± 127 ha for males. Mean 95% fixed kernel spring-summer home ranges were 1,054 ± 76.1 ha for females and 1,097 ± 103 ha for males. Juvenile female annual home ranges were larger than other age and sex classes on Texas study sites. Turkeys on the Kansas study site had the largest home ranges ($P \leq 0.01$) regardless of period, age, or sex. Our Kansas home range estimates are much larger than previously reported for wild turkeys across all subspecies and may indicate longer distance movements were performed while searching for suitable habitat. Providing habitat near existing roost sites, especially in highly fragmented roosting areas, may allow managers to reduce Rio Grande wild turkey home range sizes.

Key Words: minimum convex polygon, Kansas, fixed kernel, home range, *Meleagris gallopavo intermedia,* Rio Grande wild turkey, Southern Great Plains, Texas

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Restoration of wild turkeys (*Meleagris gallopavo*) is one of North America's wildlife management success stories. They were at their lowest numbers at the end of the 19th century, with most populations surviving only in areas that included the most inaccessible cover (Kennamer et al. 1992). In Texas, increases in wild turkey numbers were greatly influenced by successful translocation efforts (Beasom and Wilson 1992). Today there are about 600,000 Rio Grande wild turkeys (*M. g. intermedia*) across Texas and Kansas (Tapley et al. 2001).

Home ranges are often calculated to investigate animal movements and their relationships to other species and vegetation types. Historically, the minimum convex polygon (MCP) was used as a simple home range estimate (Brown 1980). However, recent work has indicated fixed kernel methods provide a more accurate home range estimate than MCP and harmonic mean methods (Naef-Daenzer 1993, Worton 1995, Seaman and Powell 1996). Seaman et al. (1999) found that fixed kernel estimators with smoothing selected by least squares cross-validation (LSCV) provided the least biased estimates of 95% home range areas, with a minimum of 30 locations.

Wild turkey research has primarily concentrated on spatial use and habitat characteristics of the eastern subspecies (*M. g. silvestris*) (e.g. Everett et al. 1980, Bidwell et al. 1989, Miller et al. 1999). Food availability appears to be a primary determinant of

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home range size and habitat use (Mosby and Handley 1943, Miller et al. 1985, Kurzejeski and Lewis 1990) and seasonal home range variations were documented (Ellis and Lewis 1967, Bidwell et al. 1989, Miller et al. 1997) for this subspecies. However, few studies have examined home ranges and space use of Rio Grande wild turkeys within their occupied region and how they compare to eastern wild turkey home ranges. Godwin et al. (1990) postulated that understanding differences in wild turkey movement patterns may be important for making management decisions and home ranges may provide a good index of this movement. Thus, our primary objectives were to estimate spring-summer and annual Rio Grande wild turkey (hereafter turkeys for birds in our study) home ranges within the Southern Great Plains ecological region and compare home ranges across each study site, age, and sex class. Additionally, we compared our estimated turkey home ranges to other subspecies.

Study Sites

We used three study sites in the Texas Panhandle and one in the southwestern corner of Kansas. The southernmost site was the Matador study site (MSS) in Cottle County, Texas. It was located in the lower Rolling Plains at the confluence of the South and Middle Pease rivers and consisted of 11,370 ha of public land (Matador Wildlife Management Area, MWMA) with an additional 16,133 ha of adjacent private lands. The 17,000-ha Salt Fork study site (SFSS) was located in Collingsworth and Donley counties in Texas and was bisected by the Salt Fork of the Red River. It was located near the Caprock escarpment below the edge of the High Plains and was centered on private ranches. The Gene Howe study site (GHSS) was located in Hemphill County, near Canadian, Texas, and was bisected by the Canadian River. It was located in the Canadian River basin cutting through the High Plains and was centered on 2,180 ha of public land (Gene Howe Wildlife Management Area, GHWMA) with an additional 11,000 ha of adjacent private lands. The Cimarron study site (CSS) was in the southwestern corner of Kansas near Elkhart, Kansas, in Morton and Stevens counties on 29,648 ha of public (Cimarron National Grasslands) and 15,000 ha of adjacent private land. The Cimarron River bisected the study site. Butler et al. (2005) and Spears et al. (2002) provided a general description of the vegetative communities at each study site.

Methods

We trapped turkeys using rocket nets (Bailey et al. 1980), drop nets (Glazener et al. 1964), and funnel traps (Davis 1994) on sites baited with corn or grain sorghum from January through March 2000–2004. Upon capture, we recorded age (juvenile or adult) and sex of each bird (Pelham and Dickson 1992), and placed a 110-g backpack-style radiotransmitter (Advanced Telemetry Systems/ ATS, Isanti, Minnesota, or AVM Instruments, Livermore, California) on individuals using a nylon overbraid harness (ATS, Isanti, Minnesota). Radiotransmitters were equipped with a mortality switch that activated after eight hours of inactivity. We also fitted turkeys with Texas Parks and Wildlife Department (TPWD) aluminum leg bands (National Band and Tag Company, Newport, Kentucky; size eight for females, nine for males) for further identification. We located radiotagged turkeys with ATS receivers, a hand-held three-element yagi antenna, a truck-mounted omni-directional antenna, and a truck-mounted null-peak system (Balkenbush and Hallett 1988, Samuel and Fuller 1996). Our goal was to begin each year with 75 active transmitters at each study site. We located radiotagged turkeys ≥2 times per week during spring-summer period (1 April–31 August), and once per week during fall-winter period (1 September–31 March) 2000–2004. We collected both visual observations of radiotagged birds and radiotelemetry triangulation locations with a null peak system (Samuel and Fuller 1996). We collected Universal Transverse Mercator (UTM) coordinates on visual sightings using a Trimble Geoexplorer 2 or Geoexplorer 3 Global Positioning System (Trimble Navigation Limited, Sunnyvale, California). Our goal of triangulation was to obtain ≥3 compass bearings, separated by >45° within 30 minutes (White and Garrott 1990).

We stratified daily locations into four time periods based on turkey behavior: roosting (from dusk until dawn), morning feeding (first ⅓ of daylight hours), midday (second ⅓ of daylight hours), and afternoon feeding (third ⅓ of daylight hours). Turkeys were not located in the same time period more than once per week. We used the computer program, Location of a Signal (LOAS, Ecological Software Solutions, Sacramento, California) and associated maximum likelihood estimator to generate UTM positions. We determined study site specific telemetry error ≥1 time per year by triangulating radiotransmitters with known locations. We placed each radiotransmitter at distances commonly associated with our radiotelemetry (≤2 km). We also used radiotransmitters with known locations to adjust for system biases and to calibrate the truck mounted null-peak system (White and Garrott 1990, Samuel and Fuller 1996).

Previous studies have divided breeding and nesting activities into two periods: spring (1 February–31 May), summer (1 June–30 September) (e.g. Palmer et al. 1996), or spring (1 March–13 May), summer (14 May–1 Oct) based on biological seasons (e.g., Miller et al. 1997). We combined spring and summer periods to incorporate the earliest nest initiation date (1 April), remove variation due to juvenile dispersal (Phillips 2004), and include two months following last known nest attempt (3 July) to encompass brood rearing efforts. The spring-summer period (1 April-31 August) as we defined it provided adequate sample size for home range estimation. Fall-winter period home ranges were not estimated due to insufficient sample sizes across study sites.

We developed area-observation curves (Odum and Kuenzler 1955) to ascertain number of locations necessary for effective annual and seasonal 95% MCP home range estimation using a random sample of turkeys with ≥20 locations (≤3 turkeys from each study site, year, age, and sex class were randomly selected for a goal of 228 turkeys per area-observation curve). We used the sample size bootstrap function of the Animal Movements extension (Hooge and Eichenlaub 1997) in ArcView 3.2 (Environmental Research Systems Institute, Redlands, California) to develop the area-observation curve. Once the area-observation curve indicated needed number of locations for ≥80% home range coverage for annual and spring-summer home ranges, we eliminated all turkeys with less than the required number from further MCP home range analyses. We used each year of a bird's life as an independent 95% MCP for comparison to previously published research. We pooled years to investigate overall study site, age, and sex differences and assumed annual variation to be insignificant for purposes of our investigation. Previous studies used 100% (Hoffman 1991, Godwin et al. 1995) and 90% MCP (Badyaev et al. 1996) estimation, so we decided on 95% to provide the best opportunity to compare studies.

We also used the 95% fixed kernel method with smoothing selected by LSCV (Seaman and Powell 1996, Worton 1995) to calculate sprisng-summer and annual home range sizes of turkeys. Based on Monte Carlo simulations of Seaman et al. (1999), only turkeys with ≥30 locations were used in the fixed kernel analysis. We tested the following null hypotheses: (1) there were no differences in 95% kernel home ranges between study sites within each age-sex class for each home range period, and (2) there were no differences in 95% fixed kernel home ranges between each age-sex class within each study site for each home range period. We tested each hypothesis using Kruskal-Wallis *H*-tests (Zar 1999) with $\alpha = 0.05$, corrected for ties, so we reported the chi-square value and means for comparison to published literature. We used SPSS (Release 12.0.0, Chicago, Illinois) for all statistical analyses. This research was approved by Texas Tech University Animal Care and Use Committee (Protocol numbers 99917 and 01173B).

Results

We used 44,526 radiotelemetry locations from 324 turkeys at the GHSS, 216 turkeys at the CSS, 368 turkeys at MSS, 345 turkeys at SFSS for home range analyses. Mean radiotelemetry error, calculated among all sites and seasons using known location radiotransmitters ($N = 182$), fell within 118 ± 22 m of the true location. Radiotelemetry associated error polygons were 4.40 ± 0.15 ha or <1% of the average home range size.

Number of individual locations for each randomly selected turkey used in the area observation curve ranged from 20–90 locations. Area-observation curves for annual ($N = 222$ turkeys; Fig. 1) and spring-summer periods ($N = 189$ turkeys, Fig. 1) indicated ≥35 locations per turkey were required for annual home ranges and ≥25 locations per turkey were required for spring-summer home ranges to account for ≥80% of home range area. We calculated 574 annual and 545 spring-summer 95% MCP home ranges. Mean 95% MCP annual home ranges varied from 1,941 ha to 4,875 ha (Table 1). Mean 95% MCP spring-summer home ranges varied from 863 ha to 2,376 ha (Table 1).

We calculated 606 annual and 449 spring-summer 95% fixed kernel home ranges. Mean annual home ranges varied from 884 ha to 5,962 ha (Table 2) and mean spring-summer home ranges varied from 386 ha to 3,628 ha (Table 2). Home range comparison between study sites indicated CSS had the largest home ranges across all age and sex classes and in both annual and spring-summer home ranges ($\chi^2=11.280$, $P \leq 0.010$). Spring-summer home ranges were similar for each age-sex class within study sites ($\chi^2=3.835$, $P \geq 0.280$) except home ranges of adult females at CSS were smaller ($\chi^2=12.813$, $P = 0.005$) than the other CSS age-sex classes. Annual home range sizes were different ($\chi^2=11.014$, $P \leq 0.012$) between age-sex classes at MSS, SFSS, and GHSS and juvenile female home ranges were largest. The CSS annual home range estimates between age classes were similar ($\chi^2=2.496$, $P = 0.476$).

Discussion

Home range estimates vary depending on number of observations, time of year, density of vegetation, geographic location, and estimation techniques (Brown 1980). The reproductive period in wild turkeys is very dynamic and includes changes in flocking behavior, feeding habits, annual movement to summer areas, dispersal of juveniles, mating rituals, nesting activities, and brood rearing. Previous studies have assessed separate spring and summer home ranges (e.g., Badyaev et al. 1996, Miller et al. 1997) not related to spring flock dispersal to estimate seasonal range location and shifts. In an attempt to gain a larger sample size and summarize behaviors for males and females during the spring-summer period, we pooled activities and classes (i.e., non-nesters, successful nesters, adult brood rearing). Thus, results should be generally interpreted for comparison to many different studies.

The 95% MCP area-observation curve indicated ≥35 annual locations and ≥25 spring-summer locations were sufficient to ac-

Table 1. Mean reported wild turkey home range sizes from 1980 to 2005.

Source	Area (ha)	*N*	Subspecies	Sex	Period	State	Technique
Kurzejeski and Lewis 1980	780	12	eastern	female	annual	MO	≥10 locs, modified minimum area
	100	34	eastern	female	spring	MO	
Hoffman 1991	1,390	11	Merriam's	adult male	1 Apr–15 Jun	CO	100% MCP
	2,870	8	Merriam's	juvenile male	1 April–15 Jun	CO	
Godwin et al. 1995	1,941	10	eastern	male	annual	MS	≥40 locs, 100% MCP
Badyaev et al. 1996	1,414	33	eastern	adult female	annual	AR	90% MCP
	1,211	8	eastern	adult male	annual	AR	
	3,929	9	eastern	juvenile female	annual	AR	
	3,147	6	eastern	juvenile male	annual	AR	
	952	51	eastern	adult female	16 Mar–15 Jun	AR	
	538	12	eastern	adult male	16 Mar–15 Jun	AR	
	1,359	10	eastern	juvenile female	16 Mar–15 Jun	AR	
	1,465	6	eastern	juvenile male	16 Mar–15 Jun	AR	
Miller et al. 1997	711	18	eastern	adult male	1 Mar–13 May	MS	same study site as Godwin et al. 1995
	607	19	eastern	juvenile male	1 Mar–13 May	MS	≥29 locs, 95% MCP
	612	17	eastern	adult male	14 May–1 Oct	MS	
	690	20	eastern	juvenile male	14 May–1 Oct	MS	
	321	16	eastern	non-nesting female	1 Apr–13 May	MS	
	340	19	eastern	non-reproductive	15 Apr–1 Oct	MS	
Schaap 2005	2,146	81	Rio Grande	all combined	annual	TX	95% fixed kernel
This study	1,527	193	Rio Grande	adult female	annual	TX	≥35 locs , 95% MCP
	1,941	106	Rio Grande	adult male	annual	TX	
	2,974	88	Rio Grande	juvenile female	annual	TX	
	1,959	83	Rio Grande	juvenile male	annual	TX	
	4,003	71	Rio Grande	adult female	annual	KS	
	3,398	14	Rio Grande	adult male	annual	KS	
	4,875	9	Rio Grande	juvenile female	annual	KS	
	3,074	10	Rio Grande	juvenile male	annual	KS	
	863	182	Rio Grande	adult female	1 Apr–31 Aug	TX	≥25 locs , 95% MCP
	1,136	96	Rio Grande	adult male	1 Apr–31 Aug	TX	
	1,291	72	Rio Grande	juvenile female	1 Apr–31 Aug	TX	
	1,210	86	Rio Grande	juvenile male	1 Apr–31 Aug	TX	
	1,349	68	Rio Grande	adult female	1 Apr–31 Aug	KS	
	2,376	19	Rio Grande	adult male	1 Apr–31 Aug	KS	
	2,311	12	Rio Grande	juvenile female	1 Apr–31 Aug	KS	
	2,186	10	Rio Grande	juvenile male	1 Apr–31 Aug	KS	

Table 2. Mean 95% fixed kernel home range sizes (ha ± SE) of Rio Grande wild turkeys on four study sites in the Southern Great Plains, January 2000–August 2004 (sample size in parentheses).

		Female		Male	
Study site	Period	Adult	Juvenile	Adult	Juvenile
MSS	annual	1,170 ± 124 (85)	2,241 ± 380 (45)	1,330 ± 272 (51)	1,702 ± 314 (36)
SFSS	annual	1,070 ± 87.6 (61)	3,092 ± 465 (24)	1,604 ± 254 (31)	1,620 ± 356 (23)
GHSS	annual	884 ± 98.7 (74)	1,846 ± 324 (27)	601 ± 92.0 (35)	780 ± 101 (33)
KSS	annual	4,401 ± 423 (48)	5,962 ± 916 (7)	4,260 ± 815 (16)	3,989 ± 680 (10)
MSS	spring-summer	734 ± 73.8 (52)	840 ± 110 (28)	808 ± 124 (34)	1,131 ± 255 (30)
SFSS	spring-summer	564 ± 58.2 (40)	633 ± 204 (12)	775 ± 135 (18)	681 ± 115 (16)
GHSS	spring-summer	597 ± 68.3 (56)	822 ± 170 (19)	456 ± 65.5 (29)	605 ± 99.6 (24)
KSS	spring-summer	2,033 ± 240 (60)	3,103 ± 829 (9)	3,508 ± 543 (13)	3,628 ± 628 (8)

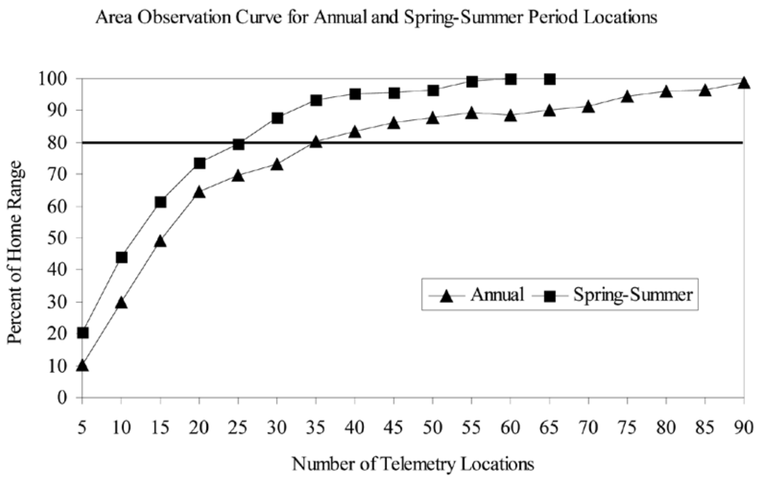

Figure 1. Mean area-observation curves for annual and spring-summer period home ranges describing the relationship between number of radiotelemetry locations and home range estimates for radiotagged Rio Grande wild turkeys in the Southern Great Plains, January 2000–August 2004.

count for ≥80% of home range area. Previous research did not indicate percent of home range accounted for by minimum number of locations used, rendering their calculations less useful for comparison purposes. Given this consideration, annual 95% MCP home range data from Texas study sites showed adult home range sizes were larger and juvenile home ranges were smaller (Table 1) than reported ranges for eastern wild turkeys. Seasonal 95% MCP home range calculations were very similar to published reports for other subspecies (Table 1) except for adult male range sizes which were larger than reported for eastern adult males (Badyaev et al. 1996). Some of these differences may be accounted for by estimation technique.

Attempts to compare home ranges across studies are difficult given various research conditions and attempts to try new and improved techniques. However, several trends in turkey home ranges were consistent with wild turkey spatial trends in other locations. Juvenile females had the largest annual fixed kernel home ranges at all study sites (Table 2). This may be due to large dispersal movements often exhibited by juvenile wild turkeys (Schmutz and Braun 1989, Miller et al. 1995, Phillips 2004). This trend was not evident in spring-summer ranges due to exclusion of the peak dispersal period, characteristic of Rio Grande wild turkey juvenile females (Phillips 2004). Adult male spring-summer home ranges were larger on three study sites (Table 2), which was also observed in eastern wild turkeys (Miller et al. 1997). Godwin (1991) noted that breeding attempts and hen movements may influence gobbler movements.

Rio Grande wild turkey home ranges may be a result of roost tree location and proximity to other available roosts, confounding other possible home range size explanations. The CSS fixed kernel home ranges were 2–4 times larger than home ranges from our Texas study sites (Table 2). Larger home range estimates at CSS indicated larger movement distances were exhibited in both annual and spring-summer home ranges than turkeys at our Texas study sites. Larger movement indices at CSS may be the result of roost location and proximity to other available roosts. Turkey roosts at CSS were restricted to a fragmented linear strip of eastern cottonwood (*Populus deltoides*) galleries in the Cimarron River basin that were separated by up to 4 km (aerial photograph analysis). Turkeys were observed moving between galleries during seasonal range shifts and one-way dispersals (Spears 2002). The riparian corridor is bordered immediately by sand sagebrush (*Artemisia filifolia*) shrubland, and secondarily by irrigated agriculture, leaving no other options for roosting outside of the corridor. At our Texas study sites, roost areas were associated with cottonwood galleries in riparian corridors (Brunjes 2005) but turkeys also used other available tree species dispersed throughout the wooded landscape (Holdstock et al. 2005).

Research has indicated movement of individuals from one part of their range to another can have negative effects on survival (Dingle 1980, Holdstock et al. 2006) and familiarity with a given area can improve foraging efficiency, predator avoidance, and reproductive success (Schieck and Hannon 1989, Beletsky and Orians 1991). Turkey populations on our Texas study sites were stable to increasing (Brunjes 2005) and home ranges were similar to other wild turkey populations. The CSS population was thought to be decreasing (Spears 2002) and home ranges were much larger than other reported wild turkey populations.

Management Implications

Management actions are often directed at reducing the distance an animal must travel to fulfill all of its needs. Based on our data, populations of Rio Grande wild turkeys in the Rolling Plains and riparian corridors of Texas and Kansas can exhibit different home range characteristics than eastern and other Rio Grande wild turkey populations. Even though home ranges exhibit variation, trends can be useful for determining differences between wild turkey populations. Comparisons across subspecies are more difficult due to biological differences in behavior and use of vegetative communities, but some basic trends appear to be substantiated across subspecies. However, it is important not to assume movement patterns are similar to other populations without verification when making management decisions. For example, CSS turkeys used larger areas to fulfill their habitat needs than other turkeys. Miller et al. (2001) postulated spatial shifts depend on habitat heterogeneity that may be drastic enough to impact survival or cause wild turkeys to move outside boundaries of the management unit. Perhaps survival on CSS may be improved by increasing habitat suitability near roosting areas, thus reducing travel lengths necessary to fulfill habitat requirements. However, links between habitat use, spatial movements, and survival need to be investigated further to determine impacts on population stability.

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Literature Cited

Badyaev, A. V., W. J. Etges, and T. E. Martin. 1996. Ecological and behavioral correlates of variation in seasonal home ranges of wild turkeys. Journal of Wildlife Management 60: 154–164.

Bailey, W., D. Dennett, H. Gore, J. Pack, R. Simpson, and G. Wright. 1980. Basic considerations and general recommendations for trapping the wild turkey. Proceedings of the National Wild Turkey Symposium 4: 10–23.

Balkenbush, J. A. and D. L. Hallett. 1988. An improved vehicle-mounted telemetry system. Wildlife Society Bulletin 16: 65–67.

Beasom, S. L. and D. Wilson. 1992. Rio Grande turkey. Pages 306–330 *in* J.G. Dickson, editor. The wild turkey: biology and management. Stackpole Books, Mechanicsburg, Pennsylvania.

Beletsky, L. D. and G. H. Orians. 1991. Effects of breeding experience and familiarity on site fidelity in female red-winged blackbirds. Ecology 72:787–796.

Bidwell, T. G., S. D. Shalaway, O. E. Maughan, and L. G. Talent. 1989. Habitat use by female eastern wild turkeys in southeastern Oklahoma. Journal of Wildlife Management 53:34–39.

Brown, E. K. 1980. Home range and movements of wild turkeys: a review. Proceedings of the National Wild Turkey Symposium 4:251–261.

Brunjes, J. H., IV. 2005. Landscape scale habitat use by Rio Grande turkeys in the Southern Great Plains. Dissertation, Texas Tech University, Lubbock.

Butler, M. J., M. C. Wallace, W. B. Ballard, S. J. DeMaso, and R. D. Applegate. 2005. From the field: the relationship of Rio Grande wild turkey distributions to roads. Wildlife Society Bulletin 33:745–748.

Davis, B. D. 1994. A funnel trap for Rio Grande turkey. Proceedings of the Southeastern Association of Fish and Wildlife Agencies 48:109–116.

Dingle, H. 1980. Ecology and evolution of migration. Pages 1–103 *in* S. A. Gauthreaux, editor. Animal migration, orientation, and navigation. Academic Press, New York, New York.

Ellis, J. E. and J. B. Lewis. 1967. Mobility and annual range of wild turkeys in Missouri. Journal of Wildlife Management 31:568–581.

Everett, D. D., D. W. Speake, and W. K. Maddox. 1980. Natality and mortality of a north Alabama wild turkey population. Proceedings of the National Wild Turkey Symposium 4:117–126.

Glazener, W. C., A. S. Jackson, and M. L. Cox. 1964. The Texas drop-net turkey trap. Journal of Wildlife Management 28:280–287.

Godwin, K. D. 1991. Habitat use, home range size, and survival rates of wild turkey gobblers on Tallahala Wildlife Management Area. Master's Thesis, Mississippi State University, Mississippi State.

———, G. A. Hurst, and B. D. Leopold. 1995. Size and percent overlap of gobbler home ranges and core-use areas in central Mississippi. Proceedings of the National Wild Turkey Symposium 7:45–52.

———, W. E. Palmer, G. A. Hurst, and R. L. Kelly. 1990. Relationship of wild turkey gobbler movements and harvest rates to management area boundaries. Proceedings of the Annual Conference of Southeastern Association of Fish and Wildlife Agencies 44: 260–267.

Hoffman, R. W. 1991. Spring movements, roosting activities, and home-range characteristics of male Merriam's wild turkey. Southwestern Naturalist 36: 332–337.

Holdstock, D. P., M. C. Wallace, W. B. Ballard, J. H. Brunjes, R. S. Phillips, B. S. Spears, S. J. DeMaso, J. D. Jernigan, R. D. Applegate, and P. S. Gipson. 2005. Male Rio Grande wild turkey habit characteristics in the Texas panhandle and southwestern Kansas. Proceedings of the National Wild Turkey Symposium 9:217-229.

———, ———, ———, ———, ———, ———, ———, ———, ———, and, ———. 2006. Male Rio Grande turkey survival and movements in the Texas panhandle and southwestern Kansas. Journal of Wildlife Management 70(4): 904-913.

Hooge, P. N. and B. Eichenlaub. 1997. Animal movement extension to arcview version 1.1. Alaska Science Center–Biological Science Office, U.S. Geological Survey, Anchorage, Alaska.

Kennamer, J. E., M. C. Kennamer, and R. Brenneman. 1992. History. Pages 6–17 *in* J.G. Dickson, editor. The wild turkey: biology and management. Stackpole Books, Mechanicsburg, Pennsylvania.

Kurzejeski, E. W. and J.B. Lewis. 1990. Home ranges, movements and habitat use of wild turkey hens in northern Missouri. Proceedings of the National Wild Turkey Symposium 6:67–71.

Miller, B. K., P. D. Major, and S. E. Backs. 1985. Movements and productivity of transplanted Eastern wild turkeys in westcentral Indiana farmland. Proceedings of the National Wild Turkey Symposium 5:233–244.

Miller, D. A., L. M. Conner, B. D. Leopold, and G. A. Hurst. 2001. Spatial fidelity of wild turkeys between the seasons in central Mississippi. Proceedings of the Annual Conference of Southeastern Association of Fish and Wildlife Agencies 55:475–487.

———., G. A. Hurst, and B. D. Leopold. 1999. Habitat use of Eastern wild turkeys in central Mississippi. Journal of Wildlife Management 63:210–222.

———., B. D. Leopold, and G. A. Hurst. 1997. Seasonal home ranges of wild turkeys in central Mississippi. Proceedings of the Annual Conference of Southeastern Association of Fish and Wildlife Agencies 51:414–425.

Miller, M. S., D. J. Buford, and R. S. Lutz. 1995. Survival of female Rio Grande turkeys during the reproductive season. Journal of Wildlife Management 59:766–771.

Mosby, H. S. and C. O. Handley. 1943. The wild turkey in Virginia. Virginia Commission of Game and Inland Fish, Richmond.

Naef-Daenzer, B. 1993. A new transmitter for small animals and enhanced methods of home-range analysis. Journal of Wildlife Management 57:680–689.

Odum, E. P. and E. J. Kuenzler. 1955. Measurement of territory and home range size in birds. Auk 72:128–137.

Palmer, W. E., K. D. Godwin, G. A. Hurst, and D. A. Miller. 1996. Effects of prescribed burning on wild turkeys. Transactions of the 61st North American Wildlife and Natural Resources Conference 61:228–236.

Pelham, P. H. and J. G. Dickson. 1992. Physical characteristics. Pages 32–45 *in* J.G. Dickson, editor. The wild turkey: biology and management. Stackpole Books, Mechanicsburg, Pennsylvania.

Phillips, R. S. 2004. Movements, survival, and reproduction of Rio Grande wild turkeys in the Texas panhandle. Thesis, Texas Tech University, Lubbock.

Samuel, M. D. and M. R. Fuller. 1996. Wildlife radiotelemetry. Pages 370–418 *in* T.A. Bookhout, editor. Research and management techniques for wildlife and habitats. Fifth edition. The Wildlife Society, Bethesda, Maryland.

Schaap, J. N. 2005. Ranges, movement, and spatial distribution of radiotagged Rio Grande wild turkeys in the Edwards Plateau of Texas. Thesis, Texas A&M University, College Station.

Schieck, J. O. and S. J. Hannon. 1989. Breeding site fidelity in willow ptarmigan: the influence of previous reproductive success and familiarity with partner and territory. Oecologia 81: 465–472.

Schmutz, J. A. and C. E. Braun. 1989. Reproductive performance of Rio Grande wild turkeys. The Condor 91: 675–680.

Seaman, D. E., J. J. Millspaugh, B. J. Kernohan, G. C. Brundige, K. J. Raedeke, and R. A. Gitzen. 1999. Effects of sample size on kernel home range estimates. Journal of Wildlife Management 63: 739–747.

——— and R. A. Powell. 1996. An evaluation of the accuracy of kernel density estimators for home range analysis. Ecology 77: 2075–2085.

Spears, B. L. 2002. Wild turkey pre-flight chick habitat characteristics and survival. Thesis, Texas Tech University, Lubbock.

———, W. B. Ballard, M. C. Wallace, R. S. Phillips, D. P. Holdstock, J. H. Brunjes, R. Applegate, P. S. Gipson, M. S. Miller, and T. Barnett. 2002. Retention times of miniature radiotransmitters glued to wild turkey poults. Wildlife Society Bulletin 30:861–867.

Tapley, J. L., R. K. Abernathy, and J. E. Kennamer. 2001. Status and distribution of the wild turkey in 1999. Proceedings of the National Wild Turkey Symposium 8:15–22.

White, G. C., and R. A. Garrott. 1990. Analysis of wildlife radio-tracking data. Academic Press Inc., San Diego, California.

Worton, B. J. 1995. Using Monte Carlo simulation to evaluate kernel-based home range estimators. Journal of Wildlife Management 59:794–800.

Zar, J. H. 1999. Biostatistical analysis. Prentice-Hall, Upper Saddle River, New Jersey.