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Spatial ecology, habitat selection, and survival of wild turkey gobblers in a managed bottomland hardwood forest

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SPATIAL ECOLOGY, HABITAT SELECTION, AND SURVIVAL OF WILD TURKEY GOBBLERS IN A MANAGED BOTTOMLAND HARDWOOD FOREST

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ABSTRACT

Wild turkey (*Meleagris gallopavo*) males were captured and radio-tagged in a bottomland hardwood forest of south-central Louisiana. Turkeys were monitored year round from fixed telemetry stations on Sherburne Wildlife Management Area, Atchafalaya National Wildlife Refuge, and Bayou des Ourses to observe seasonal patterns of space use, habitat selection and survival from 2005-07.

The largest seasonal home range was in fall/winter (966.41 ha; Oct 1-Feb 28). Spring home range (767.77 ha; Mar 1- May 31) size was lower than reported in previous studies and was a function of female availability. Season and age interacted to influence core area size ($F_{5/63}$ = 2.35, P = 0.051), but not home range size ($F_{5/63}$ = 1.49, P = 0.207). Males did not move about their home range differently before or during the breeding season (t_{20} = 1.11, P = 0.282). Additionally, males did not display spatial shifts of core areas before and during the breeding season at the population level (t_{20} = -0.92, P = 0.367).

Upland forests and water-based forests were selected by adults and juveniles at all 3 spatial scales (habitat selection in home ranges vs. habitat availability across study area [1st order], habitat selection in core areas vs. habitat availability across home ranges [2nd order], and habitat availability across home ranges [3rd order]), whereas lowland forests were avoided at all 3 spatial scales. Habitat selection in spring was based on location of females. Water-based forests were essential to male habitat as they provide quality roosting and feeding sites.

Survival was lowest in spring (0.43, SE = 0.09; Mar 1- May 31) due to the spring harvest. Fall/winter survival averaged 0.74 (SE = 0.05; Oct 1-Feb 28) and survival during

summer averaged 0.74 (SE=0.06; Jun 1-Sept 30). Mean annual survival was 0.64 (SE = 0.06), among the highest ever reported for wild turkey males. The conservative harvest strategy on Sherburne was likely related to high survival rates for males.

CHAPTER 1
INTRODUCTION

The wild turkey was once abundant across the contiguous United States, but with colonial settlement and subsequent over-harvest wild turkey numbers rapidly decreased by the end of the 19^{th} century (Kennamer et al. 1992). Restoration programs began shortly after World War II, but it was not until the advent of the cannon net that wild turkey numbers increased. In the southeastern United States, wild turkey populations increased from about half a million birds to over 2 million turkeys from 1970 to 1999 (Dickson 2001).

Since 1973, there has been a 450% increase in the number of wild turkey hunters in the United States (Wynveen et al. 2005). In 1991, hunters in the Southeast spent $5 billion on hunting activities (Southwick 1994). Total expenditures by spring wild turkey hunters in six states (Missouri, Arizona, South Carolina, West Virginia, Pennsylvania and Minnesota) in 1988 were approximately $74 million (Baumann et al. 1990). In Mississippi, turkey hunters spent an estimated $14.8 million or $44.27 per hunter day in 1993 (Grado et al. 1997). In 1991, Louisiana totaled $322,852,000 in retail sales for hunting supplies and had 9,370 jobs with $171,238,000 in salary related to wildlife and resource conservation (Southwick 1994). As popularity in wild turkey hunting increases, natural resource managers must strive to ensure sustainable wild turkey populations.

In Louisiana, there is an estimated 26,000 turkey hunters (Fred Kimmel, Louisiana Department of Wildlife and Fisheries, personal communication), with considerable hunting pressure on public lands. On Ben's Creek Wildlife Management Area (BCWMA) in south Louisiana, hunter effort on public land was two times greater

than on private hunting clubs (5,007 hunter days vs. 2,570 hunter days) from 1991-94 (Stafford et al. 1997). This trend is consistent across Louisiana, and many management areas must hold hunting lotteries for wild turkeys because of hunting pressure. With the continuing trend toward the commercialization of wildlife (Rasker et al. 1992), it is important to provide quality hunting experiences to hunters on public land.

Numerous studies have described ecology of wild turkeys in pine-dominated systems, yet there is little information on wild turkeys in bottomland hardwood forests (Smith and Teitelbaum 1986, Cobb and Doerr 1997, Williams et al. 1997). Bottomland hardwood forests and other southern forested wetlands are considered high quality habitat for wild turkeys (Dickson 1992, Miller et al. 1996). However, little research has been conducted on wild turkeys in the Mississippi Alluvial Valley (MAV; Chamberlain 1995, Wilson et al. 2005*a, b*). During the 1970s and1980s, a total of 364,212 ha of forested wetlands were converted in the MAV of Louisiana, Arkansas, and Mississippi (King and Keeland 1999). Current plans for restoration on public and private land suggest that as many as 200,000 ha could be restored in the MAV (Stanturf et al. 2001). Since 1989, the Conservation Reserve Program (CRP) added 12,140 ha of reforested bottomland hardwoods in Louisiana. In 1999, greater than 89,009 ha of bottomlands were planned for reforestation in Louisiana, Arkansas, and Mississippi, with nearly 60% (52,608) as a result of the Wetland Reserve Program and CRP (King and Keeland 1999). Also, 20 of 24 land bird species identified as of in need of management are dependent on bottomland hardwood forests (Twedt and Loesch 1999). With the current increase in wild turkey populations and hunting throughout the southeast, it is important to understand the ecology of turkeys in these forests.

Long-term studies on ecology of wild turkeys are lacking in Louisiana. The Louisiana Department of Wildlife and Fisheries (LDWF) initiated a research program on Sherburne Wildlife Management Area (hereafter Sherburne) in the late 1990s to determine space use, survival, reproduction, and predation of wild turkey populations. This project is a continuation of the LDWF program, and will evaluate spatial ecology, movements, and survival of wild turkey males in a bottomland hardwood forest.

Study Area

Research was conducted on a 17,243 ha tract of bottomland hardwood forest in Iberville, St. Martin, and Point Coupee Parishes, Louisiana, located in the Atchafalaya floodway system. Sherburne includes Sherburne Wildlife Management Area (4,767 ha) owned by the Louisiana Department of Wildlife and Fisheries, Bayou des Ourses (6,317 ha) owned by the United States Army Corps of Engineers, and the Atchafalaya National Wildlife Refuge (6,159 ha) owned by the U. S. Fish and Wildlife Service. Additionally, there are approximately 770 ha of private lands interspersed throughout the state and federal lands. Sherburne is bordered on the north by Highway 190, on the south by Interstate-10, on the west by the Atchafalaya River, and on the east by the East Protection Guide Levee. See Wilson (2005) for a more direct description of Sherburne.

Methods

Turkeys were captured in winter (January-March) and summer (May-August) 2005-2007 with rocket nets at permanent bait sites (*N* = 9-30; Bailey et al. 1980). Bait sites were mowed to prevent the net from snagging vegetation. A 70 foot net line was mowed at the back of the bait site and a 1 x 2 m patch of sand was placed 1 m in front of the center of the net line to determine sex of the visiting birds. All turkeys were banded

with a metal leg band and all males were fitted with "backpack" style radio-transmitters (Wilson and Norman 1995). Brood hens were captured during late summer to allow banding of juvenile turkeys. Banding in late summer allowed me to determine sex of the poult because 56 days after hatching the leg length, body mass, and molt sequence differ by sex (Eaton 1992).

All males fitted with transmitters were located using triangulation (Cochran and Lord 1963) from 2-6 fixed telemetry locations (*N* =157) using a hand-held 3 element Yagi antenna and a Telonics T-2 receiver (Telonics, Inc., Mesa, AZ, U.S.A.). Males were located 3 times weekly in the fall and 1 time daily throughout the rest of the year. In the spring harvest season, focal telemetry was used to determine the location of males at 3 hour intervals, with 1 location recorded each hour. A 20 minute time interval for triangulation of each male was used to minimize error from movement. If mortality was suspected, homing was used to locate the bird to verify the cause of death (when possible). Locate III (Pacer Computing, Tatamagouche, Nova Scotia, Canada) was used to obtain Universal Transverse Mercator (UTM) coordinates. If radio-tagged birds were sighted, a hand held Garmin Etrex Vista (Garmin International Inc., Olathe, KS, U.S.A.) global positioning unit was used to determine UTM coordinates.

Telemetry error was calculated during the leaf-on (spring, summer, and fall) and leaf-off (winter) periods (Withey et al. 2001), using dummy radios (*N* = 45). Dummy radios were placed at similar height of a male to minimize error and observers did not know the true location of the dummy radio. Average angle error for leaf- on season was ±6.9° and ±6.0° during the leaf-off season.

CHAPTER 2
SPATIAL ECOLOGY

Introduction

Burt (1943) first defined home range as the area where animals conduct their daily activities. Samuel (1985) expanded upon this idea and defined core areas as areas of concentrated use within the home range. Core areas are those areas used more frequently than other areas and contain home sites, refuges, and dependable food sources. Brown (1980) suggested that wild turkey home range sizes are influenced by sex, age, season, habitat quality, method of determination, and human populations.

Several studies have reported wild turkey space use in pine-dominated systems (Martin 1984, Wigley et al. 1986, Exum et al. 1987, Kelley et al. 1988, Godwin et al. 1995), but few have reported space use in bottomland hardwood forests (BHF; Wilson et al. 2005*b*). Dickson (1992) suggested that BHF are considered high quality habitat for wild turkeys. Since space use can be a function of habitat quality, it is important to document space use in BHF to better understand turkey ecology.

Miller et al. (2001) defined spatial fidelity as the tendency of an animal to maintain similar space use patterns among periods of interest and described fidelity in terms of differences in dispersion of locations (distance of individual locations from the geographic median location) and shifts in space use. Spatial fidelity of wild turkey males is poorly understood (Miller et al. 2001) and there is no published information on spatial shifts of males during spring. It is important to know if shifts in space use occur before and during the breeding season because areas used may provide insight to managing quality habitats for turkeys. Areas used pre-breeding may contain abundant and reliable

food resources. Wild turkeys use resource defense polygny (Eaton 1992); hence areas used during breeding most likely contain resources preferred by fe males. I hypothesized males would display a greater dispersion of locations during the pre-breeding season because during this season they spend considerable time searching for food and females (Eaton 1992). Furthermore, I predicted males would shift space use between seasons because male movements during the breeding season may be influenced more by female location rather than food resources (Godwin et al. l1994). In addition to the aforementioned hypotheses, my objectives in this chapter were to estimate seasonal space use, describe the dispersion of locations before and during the breeding season, and assess potential shifts in space use before and during the breeding season by wild turkey males in a BHF.

Methods

Home Range Analysis

Locations of males were obtained via radio telemetry as described in chapter 1. Males were monitored year round and locations were divided into 3 seasons: spring (1 March – 31 May), summer (1 June – 30 September), and fall/winter (1 October – 28 Feburary; Godwin et al. 1995). Fall and winter seasons were pooled because of the warm climate in south Louisiana, similar food availability (hard mast), and behavior (winter flocking; Healy 1992*a*).

Locations were imported into ArcMap 9.1 (ESRI, Redlands, CA, U.S.A.) as point themes. Area observation curves were conducted on 10 males to detect the minimum number of locations needed to determine a home range. Only males with = 23 locations per season were used for analysis. Adaptive-kernel density estimators (Seaman and Powell 1996) were used to determine home range (95%) and core areas (50%) for eligible

males. Home Range Tools for ArcGIS 9.1 (Rodgers et al. 2005) in ArcMap 9.1 was used to construct kernel contours. A factorial analysis of variance was used to test for season by age interactions in home range and core area size using SAS V9 (SAS Institute 1996, Cary, NC, U.S.A.). A one-way analysis of variance was used to test for effects of season and age on home range and core area size when no significant different was found in factorial analysis.

Spatial Fidelity

Males were captured and located following the protocol described in chapter 1. Seasons used to estimate shifts in space use differed from seasons used for home range analysis because my objective was to quantify spatial shifts before and during the breeding season, not throughout the year. The pre-breeding season began on February 15th and ended on March 14th. The pre-breeding season lies within the first peak of gobbling (Larry Savage, LDWF, personal communication), a time associated with flock breakup on Sherburne (Wilson 2005). The breeding season began on March 15th and ended on April 14th. The second peak of gobbling is associated with peak breeding. April 14th served as an end date for the analysis because the seasons are equal in length (equal number of locations) and later in the breeding season fewer females are receptive (switch over from breeding to nesting) and breeding activity may decrease (Badyaev et al. 1996). Data were pooled across years to assess dispersion of locations and space use shift before and during the breeding season. Age groups were combined due to limited sample size (White and Garrott 1990).

A geographic information system was developed to compare dispersion of locations and shifts in space use between seasons. Locations were imported into ArcMap

9.1 (ESRI, Redlands, CA, U.S.A.) as point themes. The geographic center for each point theme (bivariate median) was calculated and dispersion of locations was determined as the distance of each location (m) from the bivariate median. Van Valen's test was used to determine if dispersion of locations did not differ between seasons (Van Valen 1978, see Miller et al. 2001 for more details). There is not a straightforward way to determine shift in space use, therefore, the equation $Weightedmean = ((DISP_1)(n_1) + (DISP_2)(n_2))/(n_1+n_2)$ was used to determine if seasonal shifts occurred (Miller et al. 2001). $DISP_1$ is the dispersion of locations in pre-breeding, n_1 is the number of locations in pre-breeding, $DISP_2$ is the dispersion of points in breeding, and n_2 is the number of locations in breeding. A shift occurred if the distance between the bivariate median centers between seasons (i.e. distance between pre-breeding bivariate median and breeding bivariate median) exceeded the weighted mean in the formula. A paired *t*-test was used to determine if dispersion of points differed at the population level (the turkey as the experimental unit). Likewise, a paired *t*-test was used to determine if shifts in space use differed at the population level (the turkey as the experimental unit).

Results

Home Range Analysis

Seasonal home ranges and core areas for 3 males were excluded because of an insufficient number of locations. Sixty-nine home ranges and core areas from 29 males were used for analyses. Home range ($F_{2/66} = 0.12$, $P = 0.889$) and core area ($F_{2/66} = 0.45$, $P = 0.637$) size did not differ among years, so years were pooled for further analysis. Mean home range size was 879.8 ha in 2005, 818.4 ha in 2006, and 793.9 ha in 2007. Mean core area size was 151.2 ha in 2005, 130.0 ha in 2006, and 144.3 ha in 2007. Season and age did not interact to affect home range size ($F_{5/63} = 1.49$, $P = 0.207$), but did

for core area sizes ($F_{5/63}$ = 2.35, *P* = 0.051; Table 1). Home range ($F_{2/66}$ = 1.56, *P* = 0.219) size did not differ by season, but tended to be larger in fall/winter than spring and summer. Mean home range size was 764.1 ha in summer, 966.4 ha in fall/winter, and 767.7 ha in spring. Home range ($F_{1/67}$ = 0.87, *P* = 0.355) did not differ by age. Mean home range size was 774.9 ha for adults and 868.8 ha for juveniles.

Table 1. Mean seasonal home range (HR) and core area (CA) size (ha) of adult and juvenile radio-marked male wild turkeys on Sherburne Wildlife Management Area, Atchafalaya National Wildlife Refuge and Bayou des Ourses, Louisiana, U.S.A., from 2005-2007.

Season	Age	HR Size	HR Standard Error	CA Size	CA Standard Error
Summer					
	Adult	805.9	126.4	110.4	15.2
	Juvenile	732.6	155.2	112.9	15.7
Fall/Winter					
	Adult	1018.1	71.4	176.3	9.6
	Juvenile	924.9	52.8	155.6	13.2
Spring					
	Adult	663.6	109.1	116.4	21.2
	Juvenile	975.9	114.9	178.0	23.7

Adults had larger core areas in fall/winter than in spring (t_{63} = 2.10, *P* = 0.039) and summer (t_{63} = -1.99, *P* = 0.051). Juvenile core area size was larger in spring than in summer (t_{63} = -2.23, *P* = 0.029). Core area sizes were larger for juveniles in spring compared to adults (t_{63} = -2.34, *P* = 0.023).

Spatial Fidelity

Twenty birds were used for analysis. One bird (T5) was monitored in 2006 and 2007. From pre-breeding to breeding 8 males had greater dispersion of locations during pre-breeding and 11 displayed the reverse. Nine males (38%) displayed spatial shifts

between pre-breeding and breeding. Overall, dispersion of points did not differ between pre-breeding and breeding (t_{20} = 1.11, P = 0.282; Table 2). Likewise, males did not shift space use between seasons (t_{20} = -0.92, P = 0.367; Table 3)

Table 2. Mean and standard error (SE) of dispersions of points from the bivariate median for males on Sherburne Wildlife Management Area, Atchafalaya National Wildlife Refuge and Bayou des Ourses, Louisiana, U.S.A., from 2006-2007.

	Pre-breeding Dispersion (m)		Breeding Dispersion (m)	
Seasonal Comparison	Mean	SE	Mean	SE
Pre- breeding to breeding	1010.7	92.4	855.1	101.3

Table 3. Mean and standard error (SE) used to test for shifts in space use for males on Sherburne Wildlife Management Area, Atchafalaya National Wildlife Refuge and Bayou des Ourses, Louisiana, U.S.A., from 2006-2007.

	Distance between seasonal bivariate medians (m)		Weighted Mean (m)	
Seasonal Comparison	Mean	SE	Mean	SE
Pre- breeding to breeding	851.0	117.7	927.2	73.0

Discussion

My results of this study did my prediction that males should display an increase of dispersion of locations during the pre-breeding season. Additionally, the results did not support my prediction that males would shift space use between the pre-breeding and breeding season. Miller et al. (2001) suggested that individual males vary widely in their patterns of spatial fidelity. The lack of consistency among individuals suggests that several factors are acting synergistically or on an individual level to influence spatial fidelity of male wild turkeys on Sherburne (Miller et al. 2001). These factors likely

influence both space use and site fidelity patterns; therefore, they will be discussed together herein.

Home range size may be a function of habitat quality (Everett et al. 1979). When habitat quality is low, turkeys must range over a larger area to meet basic requirements for survival (Everett et al. 1979, Brown 1980). The juxtaposition of different stand types on Sherburne reduces the likelihood that turkeys would have to increase distance moved to find food, cover, and roosting sites. Seasonal home range sizes in this study are consistent with past studies, but most of these studies used minimum convex polygons to establish home ranges (Exum et al. 1987, Kelley et al. 1988, Godwin et al. 1995), so comparisons of space use results must be done with caution.

Previous studies have noted that space use increased in winter and spring for 2 different reasons. Winter space use is driven by need for foraging, spring for breeding (Martin 1984, Wigley et al. 1986, Exum et al. 1987, Kelley et al. 1988, Godwin et al. 1995). Although no statistical differences were found in seasonal home range sizes, a general trend was noted. In cold climates winter reduces the amount of succulent vegetation and turkeys must rely on hard mast to survive the winter. Much of Sherburne was privately owned until the Louisiana Department of Wildlife and Fisheries purchased the land in 1985 (T. Vidrine, LDWF, personal communication). The privately owned areas were intensively logged (Walter Stokes, Stokes Forestry Consulting, personal communication), resulting in young stands of hard mast producing trees. Therefore, hard mast is relatively scarce on Sherburne; however, the warm climate allows succulent vegetation to grow year around (Wilson et al. 2005*a*). Hurst et al. (1991) and Godwin et al. (1995) reported largest seasonal home ranges in the fall/winter seasons. Also, Wilson

et al. (2005*b*) found that females on Sherburne had the largest seasonal home range in the pre-incubation period. Pre-incubation is consistent with the latter part of the fall/winter season (February) and during this time, winter flocks begin to break up and males start establishing core use areas for breeding (Hurst et al. 1991, Healy 1992*a*). Males are highly mobile (Kelly et al. 1988) and other factors such as human intrusion (deer hunting; Wright and Speak 1974) and flooding (Kimmel 1984) may increase space use in fall/winter.

Badyaev et al. (1996) predicted that breeding season movements of older males should center on suitable breeding sites and therefore encompass a smaller area used by subordinate males. Healy (1992*a*) suggested that turkeys share home ranges during the spring, but defend established areas during the breeding season. The results from this study support Badyaev's claims as juveniles had larger spring core areas than adults. These results are also consistent with resource-defense polygyny, where males establish and defend areas with resources preferred by females (Emlen and Oring 1977). Larger juvenile core areas can potentially be explained by the fact that older, more dominant males forced juveniles out of the adult's established core area. This pattern may explain why dispersion rates and spatial shift differed among individuals. During pre-breeding, males feed and search for suitable display sites. Dominant males move around their display sites, increasing dispersion of locations around the bivariate median. Also, male movements may increase during the breeding season due to hunting pressure and dominance status.

CHAPTER 3
HABITAT SELECTION

Introduction

Quality wild turkey habitat was once described as large, contiguous tracts of mature timber interspersed with openings and water (Mosby and Handley 1943, Porter 1992). However, due to the success of many restoration programs, wild turkey researchers realized the flexibility of wild turkeys in their habitat, and biologists began to assess patterns of habitat use. Habitat use is an important feature of behavior and population dynamics (Mysterud and Ims 1998), and research is needed to evaluate wild turkey habitat use in different ecosystems. Dickson (1992) reported that bottomland hardwoods were high quality habitat for wild turkeys, yet little research has been conducted in bottomland hardwood forests compared to upland forests (Chamberlain 1995, Wilson et al. 2005*a*, *b*).

Numerous studies have reported habitat selection of wild turkey females (Palmer et al. 1996, Chamberlain and Leopold 2000, Thogmartin 2001, Miller and Conner 2007); however, information detailing habitat use by males is limited (Hurst et al. 1991, Godwin et al. 1992, Miller et al. 1999). Also, past studies have focused primarily on habitat use at one spatial scale (Speake et al. 1975), were limited to low sample size (Smith and Teitelbaum 1986), and/or reported habitat use in only one season or age group (Hurst et al. 1991). Most studies on habitat use of turkeys have occurred in mixed pine/hardwood ecosystems (Kurzejeski and Lewis 1990, Godwin et al. 1992, Palmer et al. 1996, Miller et al. 1999, Chamberlain and Leopold 2000, Miller and Conner 2007), whereas literature pertaining to habitat use in bottomland hardwood forests is lacking (Kimmel and Zwank 1985, Wilson et al. 2005*b*).

Methods

To assess habitat use, a land cover was established for Sherburne using ArcMap 9.1 (ESRI, Redlands, CA, U.S.A.) from 2004 digital orthophoto quarter quadrangles (DOQQs). DOQQs were obtained from the Louisiana State University Atlas website (http://www.atlas.lsu.edu). DOQQ's were photographed in February 2004, the wet season in south Louisiana. Bottomland hardwood stands can be determined based on presence or absence of water (Hodges 1997). Habitats were delineated into 4 types: water-based forest, upland forest, openings, and lowland forest (Wilson et al. 2005*b*). Water-based forests contain cypress-tupelo bottoms as well as elevated forests associated with waterways (Figure 1). Streamside areas were delineated based on areas that were elevated, non-flooded areas near waterways. Due to telemetry error, waterways were delineated as water-based forests, because if a relocation fell in a bayou, it was likely that the true location of the bird was on the bank or near water. Cypress-tupelo stands were delineated based on presence of water, as well as an open canopy. Upland forests are elevated and do not flood annually, and were delineated by absence of water within the stand. Lowland forests flood annually, and were delineated based on presence of water within the stand as well as a closed canopy. Examples of openings included roads, pipelines, railroad tracks, and right of ways.

Home range, core area, and point themes were intersected with the land cover using the intersect tool in ArcTools for ArcMap 9.1. Compositional analysis (Johnson 1980, Aebischer et al. 1993) was used to determine habitat selection at three spatial scales: habitat selection in home ranges vs. habitat availability across study area (1^{st} order), habitat selection in core areas vs. habitat availability across home ranges (2^{nd}

order), and habitat selection vs. availability within home ranges (3rd order; Wilson et al. 2005*b*).

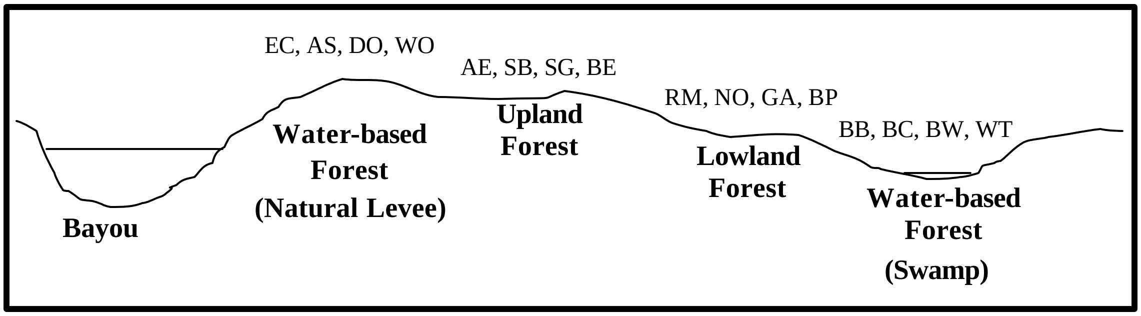

Figure 1. General plant assemblages of forest-types located on Sherburne Wildlife Management Area, Atchafalaya National Wildlife Refuge, and Bayou des Ourses, Louisiana, U.S.A. (taken from Wilson 2005).
AE = American elm; AS = American sycamore; BB = buttonbush; BC = baldcypress; BE = boxelder; BP = bitter pecan; BW = black willow; DO = delta post oak; EC = eastern cottonwood; GA = green ash; NO = Nuttall oak; RM = red maple; SB = sugarberry; SG = sweetgum; WO = water oak; WT = water tupelo

Resource selection analysis is a controversial topic in wildlife studies. Until the wide-spread use of geographic information systems (GIS) software, resource selection analysis was rare, and most studies focused on individual sightings of tagged animals to determine habitat selection (Erickson et al. 2001). Compositional analysis has recently been scrutinized because of associated risk of type I error (Aebischer et al. 1993, Bingham and Brennan 2004). Bingham et al. (2007) determined that misclassification error rates are higher when small positive values (i.e., 0.0001; Hartke and Hepp 2004) are substituted for zero in compositional analysis. Wilson et al. (2005*b*) determined that no significant difference existed in the small non-zero values of 0.1, 0.3, and 0.7 when substituting for zero when habitats were not used on Sherburne. Therefore, 0.7 was used in place of zero to minimize risk of type I error (Bingham and Brennan 2004). Data collected and used for this analysis met the assumptions for compositional analysis. All relocations of radio-tagged animals were at random times throughout the day, the number

of radio relocations among animals did not vary widely, and since animals were captured at random (i.e., the animal is the sample unit); I assumed multivariate normality of the residuals.

Multivariate analysis of variance (MANOVA) was used to determine if a significant difference occurred between log ratios of habitat availability and selection. Differences in habitat use relative to a season by age interaction were determined using SAS 9.1 (SAS Institute 1996, Cary, NC, U.S.A.). If no significant difference was found in the season by age interaction, the data were pooled for analysis. If a significant difference was found in habitat use, a matrix of *t*-tests was established to determine order of habitat preference.

Results

Sixty-nine home ranges were estimated for 29 males to determine habitat use. All 69 home ranges included every habitat type, and 55 of 68 core areas contained every habitat type. Season and age interacted to influence habitat selection at the 1st order scale ($F_{3, 60} = 16.13$, $P < 0.001$; Table 4) 2nd order scale ($F_{3, 60} = 27.61$, $P < 0.001$), and 3rd scale ($F_{3, 60} = 12.41$, $P < 0.001$). Upland forests were preferred by adults and juveniles at all three spatial scales, whereas lowland forests were avoided at all three spatial scales. Upland forests were preferred by adults and juveniles at the second order scale, but adults selected water-based forest and openings equally with upland forest. Juveniles also selected openings. Water-based forests were preferred by adults and juveniles.

Discussion

Female habitat use may influence male habitat use in spring (Godwin et al. 1992). Wilson et al. (2005*b*) determined that females selected upland forest during preincubation

on Sherburne. Adult males preferred upland forest in spring at all 3 spatial scales, and this can be attributed to males establishing areas of preferred resources to secure mating opportunities. Juveniles preferred upland forest and water-based forest in spring. This finding is consistent with resource-defense polygyny as juveniles do have breeding potential (Lewis and Breitenbach 1966, Krakauer 2005), but are less likely to establish and maintain breeding opportunities because dominant males are forcing juveniles out of preferred habitat (Badyaev et al. 1996). In summer, upland forests were selected by both age groups. However, juveniles preferred upland forest and openings whereas adults preferred upland forest and water-based forest. This discrepancy is likely due to competition for food between dominant adults and subordinate juveniles (Badyaev et al. 1996). Upland forest, water-based forest, and openings are all highly productive areas on Sherburne, and it probable that juveniles used openings to avoid conflict with adults. Also, openings are areas of high insect abundance and travel corridors for wild turkeys (Healy and Nenno 1983, Hurst and Dickson 1992). Food selection drives habitat use in fall/winter (Porter 1992); upland forests were selected by adults and juveniles at all 3 spatial scales in fall/winter.

Upland forests provide herbaceous material during fall/winter due to the warm climate in south Louisiana. Although hard mast is not abundant on Sherburne (see Chapter 2), the combination of some mast producing trees and succulent vegetation provide adequate food during fall/winter. Furthermore, adult males preferred openings at the third order selection. In Louisiana, baiting is allowed on private land for deer hunting. There are several areas of private land interspersed in Sherburne, and several hunt clubs do bait (Bill Stiles, Cajun Heaven Hunt Club, personal communication).

Adults may force juveniles from openings to take advantage of planted cereal grain and bait.

At all spatial scales, adults and juveniles consistently selected water-based forest throughout the year. Water-based forests contain cypress-tupelo bottoms as well as higher elevation riparian forest. Cypress-tupelo bottoms have been reported as preferred roosting sites for females (Chamberlain et al. 2000, Wilson et al. 2005*b*). Although roost site data were not collected for this project, I did witness several flocks of turkeys roosting over water. Natural levees in the riparian zones on Sherburne have a reduced understory and can serve as natural corridors for travel. Also, riparian forests are highly productive and hard mast bearing trees are usually associated with waterways (Hodges 1997, Wilson et al. 2005b). The combination of easy travel, quality roost sites, and abundant food resources make water-based forests on Sherburne desirable habitat at all three spatial scales.

Males consistently avoided lowland forest throughout the year at all levels of selection although Wilson et al. (2005*b*) determined that females preferred lowland forest in fall/winter on Sherburne. I never witnessed a mixed flock of female and male turkeys in fall/winter; single sex flocks may use different habitat types to reduce competition, with males driving females from areas with preferred resources (Miller et al. 1999). However, flooding may push birds out of preferred habitat types in fall/winter (Cobb et al. 1993). During the 2006 fall/winter season, lowland forests on Sherburne were flooded (http://www.mvn.usace.army/mil/cgi-bin/wcmanual.pl ; accessed June 14th, 2007) and it

Table 4. Season by age and mean ranks (0 = lowest, 3 = highest) of habitat preference across three spatial scales (habitat selection in home ranges vs. habitat availability across study area [1st order], habitat selection in core areas vs. habitat availability across home ranges [2nd order], and habitat availability across home ranges [3rd order]) based on compositional analysis of male wild turkeys on Sherburne Wildlife Management Area, Atchafalaya National Wildlife Refuge, and Bayou des Ourses, Louisiana, USA, 2005-2007.

		1st Order				2nd Order				3rd Order			
Age		Season				Season				Season			
	Habitat Type	Summer	Fall/Winter	Spring	Mean	Summer	Fall/Winter	Spring	Mean	Summer	Fall/Winter	Spring	Mean
Adult	Water-Based Forest	2	2	2	2.00	2	0	2	1.33	3	2	2	2.33
	Lowland Forest	0	0	0	0.00	0	1	0	0.33	0	0	0	0.00
	Opening	1	1	1	1.00	1	2	1	1.33	2	3	1	2.00
	Upland Forest	3	3	3	3.00	3	3	3	3.00	1	1	3	1.67
Juvenile	Water-Based Forest	2	2	1	1.67	1	1	0	0.67	2	3	3	2.67
	Lowland Forest	0	1	0	0.33	0	2	1	1.00	0	1	0	0.33
	Opening	3	0	2	1.67	2	0	2	1.33	1	0	2	1.00
	Upland Forest	1	3	3	2.33	3	3	3	3.00	3	2	1	2.00

is possible that males were forced out of flooded lowland forest during this time. Higher elevation upland forests likely serve as refuges for males during periods of flooding, increasing their importance to males.

CHAPTER 4
SURVIVAL

Introduction

Wild turkey survival is dependent on factors such as predation (Vangilder 1995, Miller et al. 1998), extreme weather (Austin and DeGraff 1975, Wunz and Hayden 1975, Roberts et al. 1995, Wright et al. 1996), harvest (Godwin et al. 1991, Paisley et al. 1995, Lint et al. 1995, Stafford et al. 1997), body condition (Blankenship 1992) and illegal harvest (Kimmel and Kurzejeski 1985, Kurzejeski et al. 1987). Wild turkey males typically have high annual survival rates (0.31-0.51; Godwin et al. 1991, Lint et al. 1995, Paisley et al. 1995, Stafford et al. 1997) and spring harvest is the most significant source of mortality (Godwin et al. 1991, Lint et al. 1995, Paisley et al. 1995). Survival rates are an effective management tool for wild turkey populations (Kurzejeski et al. 1987) as they provide information for harvest strategies.

With an increase of wild turkey populations over the past 3 decades, there has been an increase in demand for quality turkey hunting. This is more evident on public land, where hunting pressure has led many state agencies to control hunting access. The Louisiana Department of Wildlife and Fisheries (LDWF) has established several different harvest strategies on public management areas (Larry Savage, LDWF, personal communication) to meet this demand and effectively manage wild turkey populations. Sherburne was purchased from private landowners in 1982 and in 1991 LDWF began a wild turkey reintroduction program. The first harvest season on Sherburne occurred in 1995 with 122 birds harvested. Banding of birds has continued annually until present and provides opportunities to assess male harvest rates on Sherburne.

Past studies on wild turkey survival have focused on females (Palmer et al. 1993, Roberts et al. 1995, Chamberlain et al. 1996, Hubbard et al. 1999, Nguyen et al. 2003, Wilson et al. 2005*a*). Research on male survival (Porter 1978, Campo et al. 1984, Godwin et al. 1991, Lint et al. 1995, Paisley et al. 1995, Vangilder 1995, Stafford et al. 1997) particularly within bottomland hardwood forests (Chamberlain 1995, Wilson et al. 2005*a*) is lacking. Furthermore, previous studies on male survival rates have relied on radiotelemetry data or banding data, not a combination of 2 types (Vangilder 1995). New statistical software (e.g., Program MARK) allows researchers to effectively estimate population parameters using a combination of these data. Therefore, my objective was to determine survival rates using banding and radiotelemetry data obtained over an 11 year period on Sherburne.

Methods

Juvenile and adult males were captured from 1998-2007 using the protocol described in chapter one. Banding began in 1991 with reintroduced birds, but these birds may have different behavior patterns than native birds (Eaton 1992), therefore, reintroduced birds were excluded from further analysis. Sherburne has a 9 day lottery hunt for males. All males harvested during this time are required to be checked in with Sherburne personnel. Some hunters may be unaware that radio-equipped turkeys are legal game, and may not report these harvested birds (Godwin et al. 1991). To alleviate this problem, signs were placed around Sherburne check stations to encourage hunters to check in harvested birds with radio-transmitters. Age classes were combined to assess seasonal and yearly survival. Although it is important to assess juvenile and adult survival, low sample size for juveniles prevented age by time analysis. Several other

studies found no significant difference in juvenile and adult survival (Godwin et al. 1991, Lint et al. 1995, and Paisley et al. 1995). Also, high standard errors from low sampling frequency would make any survival estimates ambiguous.

Barker's joint live-recapture, live-resight, and tag-recovery model (Barker 1997) was used to model survival and tag recovery rates using Program MARK (G. White, Colorado State University, Fort Collins, CO, U.S.A.). Although the purpose of this analysis is to model survival rates, Barker's model was used because live resightings provide more accurate estimates of desired parameters (Cooch and White 2005). Several a priori candidate models were developed to compare parameter estimates (Anderson et al. 2000). Akaike's information criterion (AIC_c), change in AIC_c values ?AIC_c, and Akaike weights (AIC_w) were used to evaluate which candidate model was the best model (Anderson et al. 2000).

Model Parameters

S_i- the probability an animal alive at i is alive at i +1

p_i- the probability an animal at risk of capture at i is captured at i + 1

r_i- the probability an animal that survives from i, i + 1 is found dead and the band reported

R_i- the probability an animal that survives from i to i + 1 is resighted some time between i and i + 1

R'_i- the probability an animal that dies in i, i + 1 without being found dead is resighted alive in i, i +1 before it died

F_i- the probability an animal at risk of capture at i is at risk of capture at i + 1

F'_i- the probability an animal not at risk of capture at i is at risk of capture i + 1

(.)- Parameter is constant

(t)- Parameter is time dependent

The model parameters listed differ from Barker (1997) because Program MARK enforces certain internal constraints that arise in joint probability (Cooch and White 2005). The list of a priori candidate models (Table 5) was developed based on wild turkey behavior. Survival rates are known to vary by time because of spring harvest season (Godwin et al. 1991, Lint et al. 1995, Paisley et al. 1995). Recapture rates also can vary by time, because after initial capture, wild turkeys may become wary of bait sites. Resightings for this study are considered time dependent because of the radio-telemetry protocol described in chapter 1. The model S(.) p(.) r(.) R(.) R'(.) F(.) F'(.) was included in the a priori hypothesis for the principle of parsimony. Models with large numbers of parameters often find little support (Anderson et al. 2001) and it is important to compare residual variance between the reduced model [S(.) p(.) r(.) R(.) R'(.) F(.) F'(.); i.e. reduced number of parameters] and the global (full) model [S(t) p(t) r(t) R(t) R'(t) F(t) F'(t); i.e. full number of parameters]. The c-hat value (c) was used to determine if the data fits Barker's model (Cooch and White 2005, Anderson and Burnham 2001).

Table 5. A priori list of candidate models to estimate survival and tag return rates of wild turkey males on Sherburne Wildlife Management Area, Atchafalaya National Wildlife Refuge and Bayou des Ourses, Louisiana, U.S.A., from 1998-2007.

Model
S(t) p(t) r(t) R(t) R'(t) F(t) F'(t)
S(t) p(t) r(t) R(.) R'(.) F(.) F'(.)
S(t) p(.) r(t) R(.) R'(.) F(.) F'(.)
S(.) p(.) r(.) R(.) R'(.) F(.) F'(.)
S(t) p(.) r(.) R(.) R'(.) F(.) F'(.)

Results

Mandatory check-in of all harvested males on Sherburne resulted in recovery of all radio-marked turkeys harvested by hunters in this study. I included 108 birds in this analysis; 5 birds were excluded due to capture myopathy. The global model S(t) p(t) r(t) R(t) R'(t) F(t) F'(t) had a c value of 0.00, indicating that the data used in this analysis fits Barker's model. According to the AIC_c, $?AIC_c$, and AIC_w value, the model S(t) p(.) r(t) R(.) R'(.) F(.) F'(.) was the best fit for the data (Table 6). Therefore, I interpreted survival rates using this model.

Table 6. Output from 5 a priori candidate models used to estimate survival rates for wild turkey males from banding and radiotelemetry data obtained on Sherburne Wildlife Management Area, Atchafalaya National Wildlife Refuge, and Bayou des Ourses, Louisiana, U.S.A., from 1998-2007.

MODEL	AIC_c	$?AIC_c$	AIC_w	K	DEVIANCE
S(t) p(.) r(t) R(.) R'(.) F(.) F'(.)	599.50	0.00	0.95	52	273.63
S(t) p(.) r(.) R(.) R'(.) F(.) F'(.)	605.73	6.23	0.04	35	350.67
S(.) p(.) r(.) R(.) R'(.) F(.) F'(.)	631.07	31.57	0	6	456.56
S(t) p(t) r(t) R(.) R'(.) F(.) F'(.)	755.03	155.53	0	76	268.97
S(t) p(t) r(t) R(t) R'(t) F(t) F'(t)	1086.41	486.91	0	107	85.81

Survival was lowest in spring (0.43, SE = 0.09). Fall/winter survival averaged 0.74 (SE = 0.05) as did survival during summer (SE = 0.06). Mean annual survival was 0.64 (SE = 0.06) with highest survival in 2007 and lowest in 2000 (Table 7). Tag returns were highest in spring (0.81, SE = 0.04).

Of 35 radio-tagged males, only one morality was attributed to predation. However, this bird died within one month of capture and the death could have been influenced by capture.

Table 7. Mean annual survival rates (with standard error) for wild turkey males on Sherburne Wildlife Management Area, Atchafalaya National Wildlife Refuge, and Bayou des Ourses, Louisiana, U.S.A., from 1998-2007.

Year	Survival	Standard Error
1998	0.58	0.11
1999	0.46	0.09
2000	0.39	0.03
2001	0.86	0.06
2002	0.84	0.12
2003	0.42	0.08
2004	0.67	0.00
2005	0.44	0.00
2006	0.79	0.12
2007	0.92	0.04
Mean	0.64	0.06

Discussion

Godwin et al. (1991) reported that 74 of 81 known male moralities (91%) were recorded during the spring harvest season. Furthermore, Vangilder (1995) reported a 66% chance of survival for males on 2 study areas in Missouri during the spring harvest season. Stafford et al. (1997) reported 0.65 harvest season survival for juveniles and 0.79 for adults in Louisiana on Ben's Creek Wildlife Management Area. My findings parallel these studies as survival was lowest during spring because of harvest.

Summer survival rates (0.74) were lower for this study than in previous studies. Vangilder (1995) reported an average survival of 0.82 for summer in the Missouri Ozarks and Godwin et al. (1991) reported that only 9% of all known mortalities occured outside of the spring harvest season. Lower survival rates during summer season on Sherburne could be attributed to extreme weather and lack of food sources. The mean temperature for south Louisiana in the summer is 33.1° C (92.1°F) with average relative humidity of 72% (http://www.weather.gov/climate/index.php?wfo=lix;accessed August 1st, 2007). Extreme weather in the north has a direct effect on survival by killing turkeys in years of

excessive snowfall and cold weather (Healy 1992*b*). Although turkey movements are not directly limited by extreme heat, it is plausible that high temperatures and relative humidity can stress a bird to the point of death. Wild turkeys have high metabolism (Eaton 1992) due to requirements for flight. If stress is put upon a bird (i.e. predation attempt, capture) it is less likely to recover in times of high temperatures. High capture mortality of females in summer led Miller et al. (1996) to recommend not capturing wild turkeys until temperatures are below 21.1° C. Additionally, late summer is a time when food resources are less available. Hard mast is not ready, and most soft mast produced earlier in the year is either rotten or consumed. Therefore, extreme heat and low food resources during summer may combine to reduce survival during this time period.

Survival was 0.74 during fall/winter. Mild winters promote stable food sources during this time. Therefore, it is logical that abundant resources would increase survival rates during fall/winter. Previous studies have reported that illegal harvest during deer season is cause for mortality in fall/winter (Everett et al. 1978). However, illegal harvest is shown to be more prevalent in females (Vangilder and Kurzejeski 1995, Chamberlain et al. 1996, Miller et al 1998, Lopez et al. 1998, Hubbard et al. 1999, Thogmartin and Schaeffer 2000, Nguyen et al. 2003, Roberts et al. 1995). There are an increased number of hunters during the spring harvest season; however, wildlife agents are stationed on Sherburne during the deer season and all harvested deer taken by rifle are required to be checked in with Sherburne personnel (T. Vidrine, LDWF, personal communication). The presence of state officials likely reduced illegal harvest and helped survival of males during this time.

The mean annual survival rate (0.64) for males on Sherburne is among the highest ever reported. Godwin et al. (1991) reported annual survival rates for males in Mississippi to vary from 0.39 to 0.51. In Missouri, survival for males averaged 0.44 on Peck Ranch Conservation Area and 0.37 for South Study Area (Vangilder 1995). Stafford et al. (1997) reported annual survival rates of 0.16 for adults and 0.46 for juveniles on Ben's Creek WMA and surrounding private lands in Louisiana. Wilson (2005*a*) suggested that high survival rates for females on Sherburne were a tradeoff for low reproductive success. My findings parallel those of Wilson (2005), although the underlying mechanisms contributing to greater survival relative to other areas are unclear.

CHAPTER 5
CONCLUSION

Although wild turkey ecology is well understood in pine-dominated systems, there is a lack of information concerning wild turkey ecology in bottomland hardwood forests. My results suggest that wild turkey ecology in BHF is similar to other habitat types; however, some significant differences are apparent and should be addressed. The largest reported home range during my study was in fall/winter. Kurzejeski and Lewis (1990) found that winter habitat needs exerted the greatest influence on turkey movements. Although turkeys in south Louisiana are not exposed to extreme weather in fall/winter, I believe Kurzejeski and Lewis' statement applies for Sherburne. A cold, wet winter could destroy the main food source (succulent vegetation) for wild turkeys, potentially harming the population. Therefore, forestry practices that encourage hard mast producing trees should be implemented. Habitat analysis revealed that males and females (Wilson 2005) prefer water-based forest at smaller spatial scales. Therefore, the ideal solution would be to encourage water-tolerant species such as water hickory (*Carya aquatica*), water oak (*Quercus nigra*), Nuttall oak (*Quercus texana*), and cherrybark oak (*Quercus pagoda*) in lowland and water-based forests on Sherburne. I agree with Wilson's (2005) statement suggesting individual and group selection cuts to release these species.

After the breeding season, males restore fat deposits lost during the breeding season. Maintaining rights of way and openings create beneficial feeding sites for males during this time. Additionally, male turkeys preferred upland forest in spring at all 3 spatial scales (see chapter 3). Creating areas in upland forests with small select cuts

would encourage herbaceous vegetation and cover, both critical items to wild turkey ecology. If select cuts are to be implemented, I recommend placing these cuts on topographically higher areas (natural levees near bayous) on Sherburne. Excellent sites produce herbaceous vegetation but poor sites may not produce the desired results. Therefore, site quality for cuts should be examined closely (Healy and Nenno 1983).

Forestry practices should be expanded to the central and eastern part of Sherburne. Although individual and group selection cuts exist on the western edge of Sherburne, zero radio relocations fell within the group selection cuts. Several locations did fall within stands managed with individual cuts. Wild turkeys prefer areas with a diversity of stands (Miller et al. 1999). Placing individual and group selection cuts in areas that contain a wide diversity of stands in close proximity would create quality habitat for males. For example, the powerline area near the levee campground on Hwy. 975 has openings, natural areas, cypress-tupelo bottoms, and individual cuts. This arrangement should be a template for forestry practices on Sherburne.

Check-in stations provide accurate harvest and biological data. However, since the only check-in station is on the north end of Sherburne, hunters on the south end of Sherburne are more likely to leave the area unchecked with a harvested bird. This is a serious concern, as current records may not truly reflect the number of birds harvested. I recommend placing another check-in station at the south kiosk to reduce this potential. Additionally, I recommend that a wildlife enforcement agent be stationed at the Bayou DeGlasies boat ramp under the I-10 Bridge during the 9 day harvest season. This boat ramp is the only other access point to the main area of Sherburne, and many hunters use it to locate areas with lower hunting pressure.

Previous studies suggest that spring harvest is the key determinant in survival of males. This is no different on Sherburne, as the lowest survival rates were in spring. However, survival rates were higher for Sherburne in spring than in previous studies (see Chapter 4). Although any harvest season does not contribute to increased survival for male wild turkeys, Sherburne's conservative harvest strategy may not decrease survival as much as harvest strategies that allow longer seasons and have higher bag limits. Currently there is a two day youth lottery hunt followed by a week of no hunting. The next week is a combination lottery and public access hunt. Hunters are allowed one male during the lottery and one male during the public access.

The mean annual survival for this study was 64%; however, yearly survival varied from 39% to 92% (see Chapter 4). Since spring harvest is attributed as the major mortality factor for male wild turkeys (Godwin et al. 1991, Lint et al. 1995, Paisley et al. 1995), annual survival rates could be considered an indication of over-harvest (annual survival < 30%; Porter et al. 1990). Due to the high variability in annual survival and lack of survival data for juveniles, I do not recommend changing harvest strategies at this time. Reliable survival rates could not be obtained for juveniles in this study due to low sample size. Harvest data shows that 37% of all birds harvested since 1998 are juveniles. In 2006, 61% (37 of 61) of males harvested were juveniles. Before harvest parameters for juveniles can be reported, the sample size of banded birds must be increased. I recommend banding a minimum of 15 birds of each age group per year. Ample sample size would decrease standard error in survival estimates and increase reliability of the results.

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VITA

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