

**Brood Habitat Use and Availability and Daily and Seasonal Covey Movements of
Northern Bobwhites in East-central Alabama**

by

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Abstract

We examined home range habitat composition and preferred habitats within home ranges for Northern bobwhite quail (*Colinus virginianus*) broods during the breeding seasons (April 1 – October 31) of 2003 – 2006 on Sehoy Plantation, Alabama. Home range and habitat use data were collected for 59 quail with broods during this study. Second order habitat selection analyses showed that the composition of home ranges differed from availability during all breeding seasons. Within home ranges, hens with broods used habitats selectively for all breeding seasons. When selecting home ranges, hens with broods consistently preferred ragweed fields except for the 2003 breeding season. These hens also either preferred or showed a positive association with thinned bottoms three out of four years and preferred unburned mature pine woods only one year. Within home ranges, hens preferred ragweed fields three out of four breeding seasons and thinned bottoms were preferred during half of the breeding seasons in this study.

We additionally investigated covey movements and daily activity patterns in relation to supplemental feed lines during the quail season of 2006 – 2007 (Nov 18 – Feb 28). Because feed lines often influence movements, survival, and home ranges, we tested the hypothesis that most quail activity would occur during the first two hours following sunrise. We predicted that daily movements would be similar to those observed on similarly managed sites in Georgia. We also predicted that, because of higher predicted activity patterns in the morning, covey movement rates would be significantly higher during the morning time period. We also hypothesized that daily home ranges would

increase with distance from feed lines. Our results indicated that covey movements fell between those observed on intensively managed sites in Georgia and Kansas and those found on less intensively managed sites in Virginia. We found that movement rates were not different across time periods. We also found no difference in home range or distance to feed lines across time periods. We observed that quail coveys were most active around one hour after sunrise, lasting approximately two hours, and around one hour before sunset.

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I. NORTHERN BOBWHITE BROOD HABITAT USE AND AVAILABILITY IN EAST-CENTRAL ALABAMA

ABSTRACT

Potential major limiting factors affecting quail densities are the availability and suitability of brood habitat. During the breeding seasons (April 1 – October 31) of 2003 – 2006, we examined home range habitat composition and preferred habitats within home ranges for Northern Bobwhite (*Colinus virginianus*) broods on Sehoy Plantation, Alabama. We collected home range and habitat use data for 59 quail broods throughout the study. Second order habitat selection analyses showed that the composition of home ranges differed from availability during all breeding seasons. Quail with broods used habitats selectively for all breeding seasons within home ranges. With the exception of the 2003 breeding season, quail with broods consistently preferred ragweed fields. These quail preferred unburned mature pine woods only one year, whereas, thinned bottoms were preferred or had a positive association three out of four seasons. Within home ranges, quail with broods preferred ragweed fields three of four seasons and thinned bottoms were preferred for half of the breeding seasons in this study. Based on home range composition and habitat use we observed during this study, ragweed fields may be an important resource in managing for quail in east-central Alabama.

INTRODUCTION

The Northern Bobwhite (*Colinus virginianus*; hereafter quail), is one of the most intensively studied game birds in the world; however, many questions regarding these small game birds remain unanswered (Brennan 1991, 1993). Adults receive most of the research attention, whereas broods are the least investigated aspects of quail ecology (DeMaso et al. 1997). Even though quail may be one of the most intensively studied game birds in the world, much of the life history and ecology surrounding the young from hatch through their first summer is unknown due to a lack of published documentation (Roseberry and Klimstra 1984). DeVos and Mueller (1993) found daily survival rates to be lowest for chicks during the first two weeks of life. DeMaso et al. (1997) showed that the bobwhite's population growth rate is sensitive to fecundity and recruitment and that cover manipulations that reduce exposure to predation and provide abundant invertebrates are critical to the chicks' lives. The availability and suitability of brood rearing habitat are potential major limiting factors affecting the maintenance and production of quail densities. Also, many researchers seem to recognize that brood habitat characteristics, ecology, and even summer habitat use are poorly understood (Jackson et al. 1987, DeVos and Mueller 1993, DeMaso et al. 1997, Hammond 2001).

In our study area, the amount of suitable natural brood rearing habitat may be limited due to habitat homogeneity. Since quail broods are very susceptible to predation, especially in the pre-fledging stage, one of the major limiting factors affecting density is the amount of available brood rearing habitat. Habitat types conducive to brood rearing are those that provide overhead cover to the quail, accompanied with an open understory or ground level vegetation, along with an abundance of insects (DeMaso et al. 1997). To

maintain these habitat types in a form suitable for quail broods, one must continue to set back succession to prevent perennial grasses from establishing and to maintain an abundance of invertebrates (Greenfield 1997). Overhead cover helps provide important hiding areas from avian predators, as well as, possibly refuge from high temperatures (Guthery 1997). An open understory is important for providing escape routes from various ground and avian predators (Jones and Chamberlain 2004). These habitats must also provide an abundance of insects for broods to feed upon. Invertebrate food resources are critical to the growth and survival of Galliform chicks during the pre-fledging stage (Whitmore et al. 1986, Basore et al. 1987, Enck 1987, Erpelding et al. 1987, Dobson et al. 1988, Dahlgren 1990, Nelson et al. 1990, Panek 1992, Greenfield 1997).

Previous research on quail brood habitat use conducted in the southern United States had shown habitat selection for small cultivated patches in Alabama (Sermons 1987), recently burned pine woods in north Florida (DeVos and Mueller 1993), fallow fields in south Georgia (Yates et al. 1995), and recently burned pine woods in Florida and Georgia (Hammond 2001).

Ragweed fields were established on our study area, based on recommendations from the Albany Quail Project (Sisson and Stribling 2009), in order to provide additional brood rearing habitats. Their maintenance, provided through soil disturbances and herbicide applications, is intended to optimize brood rearing habitat, and decreases home range size. Invertebrate diversity may be maximized by providing semi natural habitats as well as habitat disturbances (Duelli et al. 1990). Yates et al. (1995) showed that “fallow fields” contained higher insect abundance than other typical habitat types found

on sites managed for quail. Strip disking and herbicide applications help improve quail habitat quality, primarily brood rearing habitat, by maintaining early seral stages and increasing insect abundance (Hurst 1970, 1972, Madison 1994, Manley 1994, Burger et al. 1995, Ryan et al. 1995, Greenfield 1997); thus, these ragweed fields provide all the essential requirements for quail broods when they are most susceptible, the pre-fledging stage.

According to Hammond et al. (2001), quail brood home ranges averaged approximately 8.5 ha. Data from previously unpublished research on our study area found that quail brood home ranges were usually between 0.5-5 ha; however, the sizes depended on habitat quality as defined by increased survival and production (S. Mitchell, Alabama Quail Project, personal communication). Home range size is important to quail survival, especially quail brood survival, because a reduction in movements generally improves survival (Landers and Mueller 1986, Curtis et al. 1988, Sisson et al. 2000, Terhune et al. 2006). Mobility and dispersal are generally lower on land intensively managed for quail (Loveless 1958, Smith et al. 1982); conversely, movement is greater in less intensively managed habitats (Kabat and Thompson 1963). Sisson et al. (2000) also found that habitat quality regulates home range size where habitat quality is inversely related to home range size. According to these findings, minimizing home range size by determining the highest quality and most preferred brood rearing habitats may be crucial to the future production of the bobwhite. We hypothesized that in comparison to other habitat types, quail broods would utilize the planted, seasonally disked, herbicide treated ragweed fields more frequently than expected based on availability. For the purposes of this research, we estimated brood home ranges; identified the major habitat type(s) that

quail broods used most based on availability; and used these findings to provide land managers and/or land owners with management recommendations for promoting habitat types that are best suited for quail broods.

METHODS

Study Area

We collected data on a northern section of Sehoj Plantation, located in northern Bullock County and southern Macon County in east-central Alabama. This study area is approximately 972 hectares and has been involved in an intensive quail management program for more than ten years. The study area lies in the Upper Coastal Plain physiographic region, and is dominated by old field, low density pine forests. Common pines found within this forest type are shortleaf (*Pinus echinata*), longleaf (*P. palustris*), loblolly (*P. taeda*), and slash (*P. elliotii*) pines. Pine forests account for approximately 70% of the area. For the purposes of my project, pine forests were separated into two categories: burned mature pine woods (BMW) and unburned mature pine woods (UBMW). Both types are managed for the promotion of early successional plant communities. These plant communities include broomsedge (*Andropogon virginicus*) as well as a variety of other bunch grasses (*Andropogon* spp.). Other evident plants are Crown grasses (*Paspalum* spp.), various legumes (Fabaceae) such as partridge pea (*Chamaecrista fasciculata*), butterfly pea (*Clitoria mariana*), and various *Desmodium* species. The management practices used to promote these plant communities include warm season burning on 1-2 year rotations, roller chopping (i.e. drum chopping) and mowing, and seasonal disking. Further management practices to benefit quail production

and survival more directly are supplemental feeding with milo sorghum through the establishment of feed lines (continuous tractor trails that wind through the woods where feed is spread every two weeks at approximately 1-2 bu/ac/year) and the seasonal removal of mammalian nest predators (i.e. opossums (*Didelphis virginiana*), raccoons (*Procyon lotor*), armadillos (*Dasypus novemcinctus*), gray foxes (*Urocyon cinereoargenteus*), bobcats (*Lynx rufus*), and coyotes (*Canis latrans*).

Ragweed (*Ambrosia artemisiifolia*) fields ranging from around 0.5 ha and 3 ha, make up approximately 16% of the area. These ragweed fields have been planted and maintained on this study area but are not necessarily planted every year, though they are maintained for seasonal use. In the fall, these fields are disked to build up the seed bank and reduce the amount of perennial grasses that may choke out the understory (Greenfield 1997). Late the following winter, the fields are disked again to agitate the soil and promote the germination of new ragweed plants. Following germination, the fields are sprayed with herbicides to further control perennial grasses that may eventually out compete more desirable understory plants possibly making them less suitable for the quail broods (Hurst 1970, 1972, Madison 1994, Manley 1994, Burger et al. 1995, Ryan et al. 1995, Greenfield 1997). Ragweed fields are available to the quail broods throughout the nesting and brood rearing season.

Thinned bottoms as well as hardwood stands make up the remaining 14% of the study area and were not generally considered suitable quail habitats but must be included because they are available to the quail broods for use. Thinned bottoms, or drainages, originate along the southern border of the study area and appear as narrow “fingers” extending and branching northward through the central portions of the study area.

Approximately 6 years ago, bottoms were thinned heavily, where approximately 90% of the hardwoods were removed from these areas. Hardwood habitats (approximately 4% of the study area) are found mostly along the southeastern border of the site and extend along a portion of the northeastern border of the study area for only a short distance.

Only three major soils groups are found throughout this study area, and these generally correspond with major habitat types in this area. Mature pine woods are found primarily on the first major soil type, “Black Belt clayey soils”. Hardwood and thinned bottom habitat components occur on “poorly drained clayey and loamy soils”. “Loamy terrace soils” are found in transitional areas between the mature pine woods and the thinned bottoms and hardwood habitats. These soils groups were provided by Sehoj Plantation Conservation Easement: Soils Groups (J. Stivers, registered forester, unpublished report).

Field Methods

Quail were trapped during February and March using pre-baited funnel traps similar to those described by Stoddard (1931). Upon capture, the quail were classified according to sex and age (Adult/Juvenile), weight (± 1 g), banded with consecutively numbered aluminum leg bands, fitted with an approximately 6 gram motion sensing necklace style radio collar, and were then released at the trap site. Survival and reproductive status of the birds was determined throughout the breeding season; each quail was located about every other day (2-3 times per week) through the use of radio telemetry and “homing” (White and Garrott 1990). If a quail was found to be stationary for two consecutive days, the cause of mortality was determined or the nest was located. If a nest was found intensive monitoring was used to estimate a hatch date and to

determine the fate of the nest (success or failure). If the nest was successful, the broods were tracked and located twice daily for approximately two weeks, the pre-fledging stage. The first location was determined in the morning and the second was determined in the afternoon (times were recorded), optimally allowing for estimation of daily movement patterns.

Spatial Analysis

Each brood location was digitized in ArcView GIS on a previously digitized coverage of the study area. Within this coverage, the habitat types had been digitized and were distinct. These habitat types consisted of burned mature pine woods (BMW), unburned mature pine woods (UBMW), hardwoods (HW), thinned bottoms (TB), and fields (F). Because no brood was ever found in hardwoods, this habitat type was excluded from the habitat selection analysis. To avoid misclassification errors, habitat use was verified in the field using maps. We then used the Spatial Analyst Extension within ArcView GIS to generate a minimum convex polygon of the home range. Habitat preferences were determined based on the resulting estimated home range for each brood (Yates 1995).

Statistical Analysis

We used the Neu et al. (1974) resource selection method in Resource Selection for Windows (Leban 1999). Second and third order selection (Johnson 1980) was used to compare habitat use and availability for each of the 2003-2006 breeding seasons. For second order analysis, use was defined as the proportion of habitat types within the polygons (i.e. home ranges) and available was defined as the total habitat available within the study area. However, for third order analysis, use was the proportion of telemetry

locations within each habitat type, and available was defined as the proportion of each habitat type inside the home range polygon (Neu et al. 1974). Thus, second order analysis compared home range selection to the available habitat for each individual brood; and, third order analysis compared the use of habitats to their availability within home ranges in order to measure habitat preference (Neu et al. 1974). Chi-square goodness-of-fit tests were calculated for both second and third order selection (Neu et al. 1974).

RESULTS

During the breeding seasons (April 1 – October 31) of 2003 through 2006, we radio-collared 219 adult quail, including 179 females. Approximately 20 locations were recorded for each brood-rearing hen during the first two weeks after hatching, the pre-fledging stage.

Over the four years in this study, habitat data was collected for 59 broods. The composition of home ranges differed from available habitats during the breeding seasons of 2003 ($\chi^2 = 19.691$, $P \leq 0.0001$), 2004 ($\chi^2 = 798.061$, $P \leq 0.0001$), 2005 ($\chi^2 = 763.936$, $P \leq 0.0001$), and 2006 ($\chi^2 = 668.147$, $P \leq 0.0001$) (Table 1). Within home ranges hens with broods used habitats selectively during 2003 ($\chi^2 = 98.898$, $P \leq 0.0001$), 2004 ($\chi^2 = 56.153$, $P \leq 0.0001$), 2005 ($\chi^2 = 56.134$, $P \leq 0.0001$), and 2006 ($\chi^2 = 61.285$, $P \leq 0.0001$) (Table 2).

In 2003, hens with broods ($n = 11$) did not prefer mature pine woods or thinned bottoms ($P \geq 0.05$) though there were positive associations with habitat use and expected use. Hens avoided ragweed fields ($P \leq 0.001$) in selecting home ranges (Table 1). Within

home ranges, hens preferred fields ($P \leq 0.0001$) but avoided mature pine woods ($P \leq 0.05$) and did not significantly avoid thinned bottoms ($P \geq 0.05$) though there was a negative association with their use (Table 2).

During the 2004 breeding season, hens with broods ($n = 12$) preferred fields and thinned bottoms ($P \leq 0.0001$) and avoided burned mature pine woods ($P \leq 0.0001$). They did not avoid unburned mature pine woods (second order) though use was less than expected. Within their home ranges hens preferred fields ($P \leq 0.0001$), avoided burned mature pine woods ($P \leq 0.05$) and thinned bottoms ($P \leq 0.0001$), and did not avoid unburned mature pine woods though they were also used less frequently than expected.

In 2005, hens with broods ($n = 8$) preferred fields ($P \leq 0.0001$) and unburned mature pine woods ($P \leq 0.001$), but avoided burned mature pine woods and thinned bottoms ($P \leq 0.0001$) when selecting home ranges. Within home ranges, fields ($P \leq 0.05$) and thinned bottoms ($P \leq 0.0001$) were preferred. Burned mature pine woods ($P \leq 0.05$) were avoided though unburned mature pine woods were used less frequently than expected.

In 2006, hens with broods ($n = 28$), preferred home ranges in fields and thinned bottoms ($P \leq 0.0001$), and avoided both burned mature pine woods ($P \leq 0.05$) and unburned mature pine woods ($P \leq 0.0001$). Within their home ranges, thinned bottoms were preferred ($P \leq 0.05$), but fields and burned mature pine woods were also used more frequently than expected. Unburned pine woods were avoided ($P \leq 0.0001$).

DISCUSSION

The Neu et al. (1974) resource selection method determines habitat preference or avoidance through comparisons of proportionate use and proportionate availability (Allredge and Ratti 1986). The method performs well when using a small, less than 7, number of habitat types (Allredge and Ratti 1986). In this case, 4 types were used in the analysis. Based on the availability of habitat when selecting home ranges, quail on our study area preferred habitats that provided the best cover and insect abundance, when raising broods. Within these home ranges, quail tended to use habitats that were more suitable (ragweed fields) for brood rearing though they were not the most available habitat type (burned mature pine woods).

During the pre-fledging stage, quail broods need overhead cover accompanied with an open understory and an abundance of high protein foods (insects) (Jones and Chamberlain 2004). When selecting home ranges, hens with broods consistently preferred ragweed fields each year with the exception of 2003, during which the ragweed fields needed replanting (S. Mitchell, Alabama Quail Project, personal communication).

These hens also either preferred or showed a positive association with thinned bottoms during three of the four breeding seasons and preferred unburned mature pine woods only one year. Within home ranges, hens preferred ragweed fields in three of four breeding seasons and thinned bottoms were preferred during half of the years in this study. Hens likely selected these habitat types because they provide overhead cover, an open understory, and abundant insects for food that are critical to the growth and survival of Galliform chicks during the pre-fledging stage (Whitmore et al. 1986, Basore et al.

1987, Enck 1987, Erpelding et al. 1987, Dobson et al. 1988, Dahlgren 1990, Nelson et al. 1990, Panek 1992, Greenfield 1997).

These planted, seasonally disked, herbicide treated ragweed fields seem to provide the appropriate cover and the abundance of insects that quail broods need for growth and survival. During the breeding season of 2006, brood hens did not show a strong preference for ragweed fields within their home ranges. This may be due largely to the beginning of a three year drought during the breeding season of 2006. Because of the drought, the ragweed did not exhibit its usual vigorous growth that seems to promote the abundance of insects that broods need as well as develop the closed canopy they need for cover (Steven Mitchell, Alabama Quail Project, personal communication). In some areas with similar climates, insect abundance decreases during drier periods but increases during periods of more rainfall (Wolda 1978). During the breeding season of 2006, thinned bottoms were preferred on both second and third order scales. Broods may have preferred these bottoms because they are lower lying areas and the soils retained more moisture than the uplands. Thus, vegetation grew more vigorously and most likely provided better insect foraging grounds. These thinned bottoms also provided woody cover for loafing areas and bare ground for escape routes (Cantu and Everett 1982 and Taylor and Guthery 1994).

MANAGEMENT IMPLICATIONS

Based on our results for selection of home ranges and use of habitats within home ranges, ragweed fields may be an important habitat component for quail management in east-central Alabama. If managing for ragweed fields, they must be properly maintained

in order to promote overhead cover with an open understory and insect abundance. These fields should also be as evenly dispersed as possible throughout the site so that they are available to as many broods as possible. Thinned bottoms were also preferred by quail broods through much of the study. Even during dry periods, these bottoms and ditches produced many early succession plant species and an abundance of insects. The retention of some thinned bottoms and ditches may also be important to quail management in that they may provide quail broods cover and food, especially during drought years.

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Table 1. Breeding Season (April 1 – October 31) home range composition compared to available habitat (second order habitat selection) for Northern Bobwhites on Sehay Plantation, Alabama, 2003-2006. Habitat types included mature pine woods (MW), burned mature pine woods (BMW), unburned mature pine woods (UBMW), thinned bottoms (TB), and fields (F).

Year	Habitat Type	Available Habitat	Expected Resource Use	Observed Use	Proportion Available	Bailey Confidence Intervals (95% confidence coefficient)
2003	MW	762.85	801.25	827.63	0.7280	$0.7190 \leq p_1 \leq 0.7822$
	TB	110.44	116.00	140.01	0.1054	$0.1032 \leq p_2 \leq 0.1529$
	F	174.57	183.36	132.96	0.1666	$0.0980 \leq p_3 \leq 0.1460$
2004	BMW	399.24	417.70	64.28	0.3481	$0.0384 \leq p_1 \leq 0.0717$
	UBMW	446.16	466.79	424.92	0.3890	$0.3195 \leq p_2 \leq 0.3892$
	TB	116.88	122.28	274.69	0.1019	$0.1990 \leq p_3 \leq 0.2603$
	F	184.68	193.22	436.11	0.1610	$0.3285 \leq p_4 \leq 0.3986$
2005	BMW	296.72	311.09	67.64	0.3889	$0.0614 \leq p_1 \leq 0.1117$
	UBMW	264.24	277.04	353.50	0.4860	$0.3973 \leq p_2 \leq 0.4860$
	TB	78.24	82.03	1.26	0.0091	$0.0019 \leq p_3 \leq 0.0091$
	F	123.84	129.84	377.60	0.1623	$0.4270 \leq p_4 \leq 0.5162$
2006	BMW	1070.16	1070.16	955.32	0.3822	$0.3188 \leq p_1 \leq 0.3638$
	UBMW	946.96	946.96	483.93	0.3382	$0.1552 \leq p_2 \leq 0.1913$
	TB	343.28	343.28	620.20	0.1226	$0.2020 \leq p_3 \leq 0.2857$
	F	439.60	439.60	740.55	0.1570	$0.2437 \leq p_4 \leq 0.2857$

Table 2. Use of habitats within home ranges compared to home range composition (third order habitat selection) of Northern Bobwhite broods during breeding seasons (April 1 - October 31) on Sehoj Plantation, Alabama, 2003-2006. Habitat types included mature pine woods (MW), burned mature pine woods (BMW), unburned mature pine woods (UBMW), thinned bottoms (TB), and fields (F).

Year	Habitat Type	Available Habitat	Expected Resource Use	Observed Use	Proportion Available	Bailey Confidence Intervals (95% confidence coefficient)
2003	MW	827.63	827.23	729.44	0.7520	$0.6276 \leq p_1 \leq 0.6966$
	TB	140.01	139.94	130.34	0.1272	$0.0959 \leq p_2 \leq 0.1435$
	F	132.96	132.82	240.22	0.1208	$0.1889 \leq p_3 \leq 0.2494$
2004	BMW	64.28	64.28	39.29	0.0536	$0.0210 \leq p_1 \leq 0.0476$
	UBMW	424.92	424.92	410.80	0.3541	$0.3080 \leq p_2 \leq 0.3772$
	TB	274.69	274.69	203.87	0.2289	$0.1434 \leq p_3 \leq 0.1983$
	F	436.11	436.11	546.04	0.3634	$0.4186 \leq p_4 \leq 0.4911$
2005	BMW	67.64	67.64	42.86	0.0846	$0.0352 \leq p_1 \leq 0.0763$
	UBMW	353.50	353.50	312.21	0.4419	$0.3467 \leq p_2 \leq 0.4340$
	TB	1.26	1.26	7.69	0.0016	$0.0028 \leq p_3 \leq 0.0216$
	F	377.60	377.60	437.24	0.4720	$0.5012 \leq p_4 \leq 0.5902$
2006	BMW	955.32	955.32	998.55	0.3412	$0.3339 \leq p_1 \leq 0.3795$
	UBMW	483.93	483.93	336.55	0.1728	$0.1052 \leq p_2 \leq 0.1362$
	TB	620.20	620.20	714.41	0.2215	$0.2347 \leq p_3 \leq 0.2761$
	F	740.55	740.55	750.49	0.2645	$0.2472 \leq p_4 \leq 0.2893$

II. DAILY AND SEASONAL COVEY MOVEMENTS OF NORTHERN BOBWHITES IN EAST-CENTRAL ALABAMA

ABSTRACT

As part of an investigation of intensive management practices on quail populations and quail hunting in east-central Alabama, we investigated covey movements and daily activity patterns in relation to feed lines during the quail season (Nov 18 – Feb 28) of 2006 – 2007 on Sehoy Plantation, Alabama. We hypothesized that most quail activity would occur during the first two hours following sunrise because feed lines often influence movements, survival, and home ranges. We predicted that daily movements would be similar to those observed on other intensively managed sites. Because of higher predicted activity patterns in the morning, we predicted that covey movement rates would be significantly higher during the morning time period. We also hypothesized that daily home ranges would increase with distance from feed lines. Our observed covey movements fell between those observed on intensively managed sites in Georgia and Kansas and those on less intensively managed sites in Virginia. We observed no difference in movement rates across time periods, indicating that these rates were relative and mean daily movements were influenced by rate. We found no difference in home range or distance to feed lines across time periods. We observed two peaks of activity within coveys throughout quail season. The first peak occurred about an hour after sunrise and lasted for approximately two hours; the second peak occurred about an hour before sunset. Covey activity patterns, daily movements, and home ranges were apparently influenced by the presence of the established feed lines.

INTRODUCTION

We studied the movements of Northern Bobwhite (*Colinus virginianus*; hereafter quail) on intensively managed private lands in east-central Alabama. As with any game species, the habits and movements of the animal being pursued should be understood to be effective at hunting. Quail are considered one of the least mobile of the Galliformes (Townsend 2003). Even so, movements and home range sizes of the quail have been studied in great detail. However, very little of that research has focused on daily activity and seasonal movements during the hunting season. According to Williams et al. (2000), mean daily movements of wild quail in Kansas was < 300 m. This lack of mobility may result in increased over-winter survival and make them less vulnerable to hunters. According to both Curtis et al. (1988) and Sisson et al. (2000), home range sizes were smaller, movements were decreased, predation was reduced, and individual coveys were less susceptible to hunters (though overall success was higher because of higher densities) on intensively managed habitats. By contrast, quail on less intensively managed habitats tended to move more and were more susceptible to predation and hunters (Loveless 1958 and Smith et al. 1982).

The intensive management regime on our study area included supplemental feeding along established transects. These feed lines were central to hunting activity and the majority of quail covey home ranges on the area. Though the hunters use feed lines intensively, the lines are intended primarily to benefit quail populations. This form of supplemental feeding is designed to maximize fitness and winter survival of the birds (Sisson et al. 2000). However, supplemental feeding may not influence movements or

activity in coveys that reside more than 200 m from the feed lines (Haines 2003 and Hardin 2005).

Improving hunting efficiency was an important objective on our study area as it is on most areas intensively managed for quail populations. Quail densities on our study area closely rivaled those found on other intensively managed plantations in the heart of “quail Country” (south Georgia and north Florida). Densities on the study area were approximately 2 quail/acre based on fall covey counts conducted between October 15 – November 15 (Sehoy Fall Covey Count 2006, unpublished report). However, hunting efficiency was lower on our study area than many sites in Georgia and Florida (4 coveys/hour versus 8 coveys/hour) with comparable quail densities (Sisson et al. 2000).

Lower hunting efficiency could be the result of local hunting practices because most hunting takes place within 100m of feed lines. However, similar practices are used on quail plantations in the Albany, Georgia area where hunting efficiency is much higher. As part of a large investigation of intensive management practices on quail populations and quail hunting in east-central Alabama, we investigated covey movements in relation to feed lines. Our objectives were to determine daily activity patterns; whether daily movements and movement rate estimates were affected by sampling period; and to determine whether daily home ranges extended beyond the areas along feed lines that were normally used by hunters. We hypothesized that because movements, predation, and home ranges are often reduced near feed lines, most quail activity would occur during the first two hours following sunrise. We predicted that daily movement distances would be similar to those measured on other similarly managed sites. We predicted that covey movement rates would be significantly higher during the morning time period

because of higher predicted activity patterns. We also hypothesized that daily home ranges would increase with distance from the feed lines.

METHODS

Study Area

We collected data on a northern section of Sehoj Plantation, located in northern Bullock County and southern Macon County in east-central Alabama. This study area is approximately 972 hectares and has been intensively managed for quail for more than ten years. The study area lies in the Upper Coastal Plain physiographic region, and is dominated by old field, low density pine forests, which cover approximately 70% of the study area. Common pines found within this forest type are shortleaf (*Pinus echinata*), longleaf (*P. palustris*), loblolly (*P. taeda*), and slash (*elliotii*) pines. These forests are managed to promote early successional plant communities under the pine overstory. These plant communities include broomsedge (*Andropogon virginicus*) and a variety of other bunch grasses (*Andropogon* spp.). Other common plants are Crown grasses (*Paspalum* spp.), various legumes (Fabaceae) such as partridge pea (*Chamaecrista fasciculate*), butterfly pea (*Clitoria mariana*), and various *Desmodium* species. The management practices used to promote these plant communities include frequent warm season burning on 1-2 year rotations, roller chopping (drum chopping) and mowing, and seasonal disking. Additional management practices intended to benefit quail production and survival directly include supplemental feeding with milo sorghum along 43.5 km of feed lines (continuous tractor trails that wind through the woods where feed is spread every two weeks at approximately 1-2 bu/ac/year) and the seasonal removal of

mammalian nest predators (i.e. opossums (*Didelphis virginiana*), raccoons (*Procyon lotor*), armadillos (*Dasyus novemcinctus*), gray foxes (*Urocyon cinereoargenteus*), bobcats (*Lynx rufus*), and coyotes (*Canis latrans*).

Planted ragweed (*Ambrosia artemisiifolia*) fields ranging from around 0.5 ha and 3 ha, make up approximately 16% of the area. These fields are not planted every year, though they are maintained seasonally by disking (Greenfield 1997) once during November and again in January. Following germination, the fields are sprayed with herbicides to further control any perennial grasses that might out-compete more desirable forbs and bunch grasses (Hurst 1970, 1972, Madison 1994, Manley 1994, Burger et al. 1995, Ryan et al. 1995, Greenfield 1997).

Thinned bottoms and hardwood stands make up the remaining 14% of the study area and were not generally considered suitable quail habitats but must be included because they were used by quail broods. Thinned bottoms, or drainages, covered approximately 10% of the study area and originated along the southern border of the study area appearing as narrow “fingers” extending and branching northward through the central portions of the study area. Approximately 90% of the hardwood trees in these drainages were removed approximately 6 years ago. Hardwood stands covered approximately 4% of the study area, and occurred mostly along the southeastern border and a portion of the northeastern border of the study area.

Only three major soils groups are found throughout this study area, and these generally correspond with major habitat types in this area. Mature pine woods are found primarily on the first major soil type, “Black Belt clayey soils”. Hardwood and thinned bottom habitat components occur on “poorly drained clayey and loamy soils”. “Loamy

terrace soils” are found in transitional areas between the mature pine woods and the thinned bottoms and hardwood habitats. These soils groups were provided by Sehoy Plantation Conservation Easement: Soils Groups (J. Stivers, registered forester, unpublished report).

Field Methods

Quail were trapped during the fall (October-November) using pre-baited funnel traps similar to those described by Stoddard (1931). Upon capture, each quail was classified according to sex and age (Adult/Juvenile), weighed (± 1 g), banded with a consecutively numbered aluminum leg band, fitted with a necklace-style radio collar (approximately 6 g), and then released at the trap site. Each radio collar also had a motion sensor that varied the transmitted pulse rate when the birds were moving. Covey movements and activity were monitored up to twice a week for three different time periods (full-day, morning, and afternoon) throughout the 2006-2007 quail season (November 18 – February 28). For full-day monitoring, each covey was monitored once an hour beginning at just before sunrise and ending just after sunset. For morning only, monitoring began just before sunrise and ended at noon. For the afternoon period, locations began at noon and ended just after sunset. For all coveys through all time periods; locations, activity levels, and proximity to feed lines were recorded, mapped, and digitized. Coveys were assigned an activity score (1-4; 4 being most active) based on the transmitter pulse rate variability of individual birds within each covey during each time interval.

Statistical Analysis

All covey locations were recorded in the field on a previously digitized map of the study area that included feed lines. Once the recorded locations were digitized, minimum convex polygons were calculated for each covey to determine daily ranges (Terhune 2006). Mean daily covey movement distances (m), movement rates (m/hr) and the mean proximity to feed lines using were estimated using ArcView GIS 3.2 (Terhune 2006). Means, standard errors, and ranges were calculated for all variables (daily movements, daily movement rates, daily home ranges, and daily distance from feed lines) across all time periods using the Means Procedure in SAS (SAS Institute 1999). We then used a mixed-effects model, to account for pseudo-replication, in the statistical software program R to identify differences in means across time periods (R Development Core Team 2005). Activity levels for all coveys were summarized for each time period.

RESULTS

We marked and monitored 57 quail in 8 different coveys (4 – 6 individual quail per covey) during the 2006 – 2007 quail season (November 18 – February 28). Each covey was monitored up to twice a week throughout the season.

Mean daily movement during a full day was 341.75 m (SE = 21.45, $n = 36$) and ranged from 190.15 – 738.13 m. Daily movement distances during morning ($\bar{x} = 169.25$ m, SE = 20.58, 190.15 – 738.13 m, $n = 8$) and afternoon ($\bar{x} = 180.47$ m, SE = 22.43, 93.93 – 354.81 m, $n = 12$) were similar (SE = 50.72, $P = 0.83$), although movement distances in afternoon tended to be somewhat greater. It follows then that movement rates were similar over the entire day, ($\bar{x} = 34.18$ m/hr, SE = 2.14, $n = 36$) when

compared to either morning ($\bar{x} = 33.85$ m/hr, SE = 4.11, $n = 8$, $P = 0.92$), or afternoon ($\bar{x} = 36.09$ m/hr, SE = 4.49, $n = 12$, $P = 0.69$).

The mean daily home range for all coveys observed throughout a full day was 0.39 ha (SE = 0.07, $n = 36$) and ranged from 0.06 – 2.23 ha. Daily home range for coveys observed during the morning period was 0.31 ha (SE = 0.07, $n = 8$) with a range of 0.04 – 0.62 ha. Mean morning ($\bar{x} = 0.31$ ha, 0.04 – 0.62 ha, $n = 8$) and afternoon ranges ($\bar{x} = 0.44$ ha, SE = 0.10, 0.16 – 1.49 ha, $n = 12$) were also similar (SE = 0.18, $P = 0.46$), thus indicating that coveys used the same area throughout the day and did not shift their ranges between morning and afternoon.

When measured over the entire day the mean distance that coveys moved from feed lines was ($\bar{x} = 59.97$ m, SE = 5.44, 3.50 – 133.64 m, $n = 36$). Distance from feed lines was similar (SE = 13.38, $P = 0.66$) during mornings ($\bar{x} = 33.71$ m, SE = 7.99, 1.49 – 77.57 m, $n = 8$) and afternoons ($\bar{x} = 42.08$ m, SE = 7.89, 3.12 – 85.48 m, $n = 12$).

The peak of covey activity levels started approximately one hour after sunrise and persisted until mid-morning, from around 0730 h – 0930 h. There was moderate to low activity from approximately 1130 h – 1330 h. Activity levels were low until approximately one hour before sunset when they increased substantially from 1630 h – 1730 h (Figure 1).

DISCUSSION

Because of the intensity of the management on this site, we expected our mean daily movements to be comparable to movements on similarly managed sites. Our mean daily movements fell within the ranges observed on similarly managed areas in Kansas

and less intensively managed areas in Virginia. Our observed mean daily movement distance was only slightly larger than the 275 m reported by Williams et al. (2000) in Kansas. Fies et al. (2002) observed late winter maximum daily movements of 1,528 m in Virginia, which was more than twice the maximum of 738 m we observed during a full day.

Because quail hunts on this property may be conducted on a full or half-day basis, we were interested to note that movement rates were similar for both full and half day monitoring periods. Mean daily movements for the periods of morning and afternoon were not different. As a result, movement rates for all coveys across all time periods were not different.

Supplemental feeding has been shown to potentially concentrate and localize quail during the winter (Frye 1954, Landers and Mueller 1986, and Sisson et al. 2000). However, Sisson et al. (2000) showed no evidence of any detrimental impacts on quail numbers and observed lower mortality rates where supplemental feeding was practiced in Georgia. Our observed mean distance to feed lines was lower than those reported in Texas by Haines et al. (2004). We found that mean distance from feed lines was similar across all time periods though the distance was somewhat greater when quail were monitored over the entire day.

Home ranges tended to be smaller and movements more localized, resulting in lower foraging time and distances traveled to meet daily food requirements where supplemental feeding is implemented (Frye 1954, Landers and Mueller 1986, and Sisson et al. 2000). For full day observations, we reported mean daily home ranges similar to morning and afternoon daily home ranges. Our observations suggest that even though

covey daily home ranges were localized around feed lines, they may have moved into denser cover during mid-day.

Because increased movements and longer periods of activity may leave quail more vulnerable to predation (Sisson et al. 2000), offering supplemental feed by way of established feed lines should increase survival. Though this may benefit quail, it tends to make individual coveys more difficult for hunters to locate. We observed two peaks of activity during each day throughout the quail season. The first peak of activity usually occurred around one hour after sunrise and lasted for approximately 2 hours. The second peak occurred about one hour before sunset. Coveys that are often localized around feed lines may be less accessible to hunters if coveys move into dense cover after peak activity periods (Sisson et al. 2000). However, Sisson and Stribling (2009) have reported similar activity and movement patterns in south Georgia while finding a higher percentage of coveys. Based on our observations and the apparent similarities between activity and movement patterns on our site and other intensively managed sites, there may be other variables that have resulted in lowered hunting efficiency, such as the heavy grass cover found throughout this site.

MANAGEMENT IMPLICATIONS

Quail activity and movement patterns and home ranges observed in this study were apparently influenced by the presence of the established feed lines. Based on what we found, efficiency should be best when hunting is centered around the feed lines, at least when the quail are most active (i.e. early in the morning and again late in the afternoon).

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Figure 1. Mean daily activity level for coveys (0630 h – 1730 h) during the 2006 – 2007 quail season (Nov. 18 – Feb. 28) on Sehoy Plantation, Alabama.

