Volume 4

Article 44

2000

Habitat Characteristics of Northern Bobwhite Quail-Hunting Party Encounters: A Landscape Perspective

William K. Michener
Ecological Research Center

Jimmy B. Atkinson
Ecological Research Center

Don G. Edwards
University of South Carolina

Jeffrey W. Hollister
Ecological Research Center

Paula F. Houhoulis
Florida Department of Environmental Protection

See next page for additional authors

Habitat Characteristics of Northern Bobwhite Quail-Hunting Party Encounters: A Landscape Perspective

Authors

William K. Michener, Jimmy B. Atkinson, Don G. Edwards, Jeffrey W. Hollister, Paula F. Houhoulis, Paula M. Johnson, and Robert N. Smith

HABITAT CHARACTERISTICS OF NORTHERN BOBWHITE QUAIL-HUNTING PARTY ENCOUNTERS: A LANDSCAPE PERSPECTIVE

William K. Michener
Joseph W. Jones Ecological Research Center, Route 2, Box 2324, Newton, GA 31770

Jimmy B. Atkinson
Joseph W. Jones Ecological Research Center, Route 2, Box 2324, Newton, GA 31770

Don G. Edwards
Department of Statistics, University of South Carolina, Columbia, SC 29208

Jeffrey W. Hollister
Joseph W. Jones Ecological Research Center, Route 2, Box 2324, Newton, GA 31770

Paula F. Houhoulis
Florida Department of Environmental Protection, Florida Marine Research Institute, 100 8th Avenue S.E., St. Petersburg, FL 33701-5095

Paula M. Johnson
Joseph W. Jones Ecological Research Center, Route 2, Box 2324, Newton, GA 31770

Robert N. Smith
RNS Resource Management Services, Route 2 Box 245, Arlington, GA 31713

ABSTRACT

Landcover data and bobwhite hunting records were used to assess both hunter habitat preferences and the frequency of northern bobwhite encounters by hunting parties in relation to habitat composition during the 1994–1995 and 1995–1996 hunting seasons at the Joseph W. Jones Ecological Research Center in southern Georgia. Patterns of habitat use by hunters, and the frequency of bobwhite encounters varied within and between years, depending on habitat quality, food availability, and other factors. Landscape-scale analyses of standardized bobwhite covey densities (based on coveys pointed in the field) and habitat composition and configuration for the 1994–1995 hunting season revealed that bobwhite densities were: (1) positively associated with the overall percentage agriculture and food plot habitat (reaching a maximum at 30–35% agriculture); and (2) positively associated with edge complexity, and positively associated with agricultural mean patch size [reaching a maximum at 2–3 hectares (5–6 acres)]. Consequently, larger food plots may be more important for increasing bobwhite encounter rates than numerous very small food plots [< 0.1 hectares (0.25 acres)]. Results of this, and related ongoing studies, have important implications for both landscape design and multiple use resource management activities in the context of northern bobwhite habitat management in southern upland pine forest ecosystems.

Citation: Michener, W.K., J.B. Atkinson, D.G. Edwards, J.W. Hollister, P.F. Houhoulis, P.M. Johnson, and R.N. Smith. 2000. Habitat characteristics of northern bobwhite quail-hunting party encounters: a landscape perspective. Pages 173–182 *in* L.A. Brennan, W.E. Palmer, L.W. Burger, Jr., and T.L. Pruden (eds.). Quail IV: Proceedings of the Fourth National Quail Symposium. Tall Timbers Research Station, Tallahassee, FL.

INTRODUCTION

Northern bobwhite (*Colinus virginianus*) populations have experienced precipitous declines in the southern region of the United States since the 1960's (Brennan 1991). Likely causes of the decline include broad-scale land use changes (e.g., increasing size of agricultural patches, increases in intensive pine silviculture, urbanization), loss of weedy fence rows and other edge habitats, and decreased use of prescribed burning (Klimstra 1982, Brennan 1991). Implementation of the Conservation Reserve Program (CRP) in the mid-1980's has not played a significant role in reversing the decline in bobwhite throughout their range (Roseberry and David 1994), although the CRP has been recently modified to benefit such wildlife species.

The spatial structure of habitat (e.g., size, shape, and degree of patch isolation) within a landscape is known to affect biodiversity and species' population dynamics (Martin 1992). Since the 1930's, significant research and management effort has been devoted to understanding, implementing, and promoting management practices (use of fire, field and food plot design, etc.) that benefit northern bobwhite populations (Stoddard 1931, Rosene 1969, Landers and Mueller 1989). The importance of landscape structure and composition for bobwhite populations was also initially recognized by bobwhite biologists. For example, Stoddard and Komarek (1941) reported that "good populations of quail can be maintained on heavily wooded lands provided at least 25% of the terrain consists of openings or small fields." Rosene (1969) described an optimal landscape for bobwhite that was comprised of small agricultural fields with complex edge habitats that were well-dispersed within a forest matrix. Despite the decades-long decline in bobwhite abundance, our understanding of the relationship between bobwhite population dynamics and landscape composition and structure has not improved appreciably since these earlier investigations. Consequently, in 1996 the Southeast Bobwhite Study Group (unpublished technical report) identified the "effects of landscape pattern (structure and composition) on bobwhite population dynamics" as a research topic that should receive priority attention.

Analyses of high-resolution Geographic Information System (GIS) data layers, coupled with extensive bobwhite hunting records, allowed us to assess habitat preferences by hunters and bobwhite encounter rates in different habitats within a longleaf pine-dominated ecosystem in southwestern Georgia. Although bobwhite encounter rates may be related to habitat preference, it is important to note that bobwhite detectability by dogs probably varies among habitats and that all habitats (e.g., wetlands) are not sampled at the same frequency throughout the hunting season. The objectives of this study were to: (1) compare habitat composition of hunt course routes (routes traveled by hunt parties within a course) with courses (22 large contiguous areas, each of which may be hunted during a half-day or a full-day hunt) by hunting season and month; (2) compare habitat composition of covey locations (points) with course routes by hunting season and month; (3) compare habitat composition of 2-hectare (5-acre) covey activity areas that surround points where coveys were initially sighted with course routes by hunting season and month; and (4) characterize the relationship between bobwhite covey density and habitat composition and structure. The long-term purposes of this study are to design and implement different landscape configurations that can meet differing landowner objectives (e.g., wildlife, silviculture, agriculture).

METHODS

Study Area

The Joseph W. Jones Ecological Research Center is located at Ichauway, a 115 kilometer^2 (45 mile^2) ecological reserve located in Baker County in southwest Georgia, 45 kilometers (28 miles) southwest of Albany (Figure 1). The site is located along the Flint River at its confluence with Ichawaynochaway Creek. Forested upland communities comprise 8,474 hectares (20,931 acres) and are dominated primarily by longleaf pine (*Pinus palustris*), slash pine (*Pinus elliotti*), and mixed pines and hardwoods (primarily longleaf pine and oaks, *Quercus* spp.) (Table 1). Other plant communities include hardwoods (dominated by live oak (*Q. virginiana*), laurel (*Q. hemisphaerica*), and water oak (*Q. nigra*)), forested wetlands (*Taxodium* spp. and *Nyssa* spp.), and herbaceous wetlands or open water. Agricultural fields and small wildlife food plots are scattered across the Ichauway landscape and comprise a total of 2,239 hectares (5,530 acres).

Northern Bobwhite Management at Ichauway

The landbase at Ichauway was first assembled as a hunting plantation in the late 1920's, and the northern bobwhite was a featured species on the property through the early 1990's. Southern-style hunting of wild bobwhites is a unique, historical landuse that is being maintained on Ichauway in selected areas. Prescribed fire, field, and woodland management play key roles in providing nesting, brood, feeding, escape, loafing, and roosting habitats for bobwhites. Harvest management, including daily, covey, and course limits, is also an important component of maintaining a long-term, sustainably harvestable population of bobwhites.

Food plots are managed to provide an old-field rim with a 3- to 6-year old rough of bluestem (*Andropogon* spp.) and blackberry (*Rubus* spp.) that also contains brushy cover, typically patches of Thunbergii lespedeza, Chickasaw plum, or dwarf live oak. The interior of the field contains a strip of summer crop, typically corn, and a winter crop, typically wheat, that are rotated through the field so that there is always current summer and winter agriculture and fallow summer and winter agriculture. Small food plots [0.1 to 0.4 hectares (0.25 to 1 acre)] in the woodlands are planted with a mixture of agricultural species (e.g., browntop millet, iron-clay peas, grain sorghum, Egyptian wheat) in late spring to provide bare ground, insects, and agricultural and weed seeds. Larger food plots also have woody escape cover. Approximately 500 hectares (1,235 acres) of agricultural crops are planted for bobwhites and other wildlife each year. Bobwhites are supplementally fed through the winter and early spring by broadcasting feed into heavy overhead cover throughout the hunting courses approximately every two weeks.

Current woodland manipulation consists of converting agricultural fields to woodlands, controlling hardwood encroachment into agricultural fields, and prescribed burning. Portions of some fields have been planted with longleaf pine in a window-pane pattern to produce smaller fields with more edge. Fire-maintained habitats are burned, typically in March and April, on a 1- to 3-year return interval. Five to six thousand hectares (12,000–15,000 acres) are burned annually.

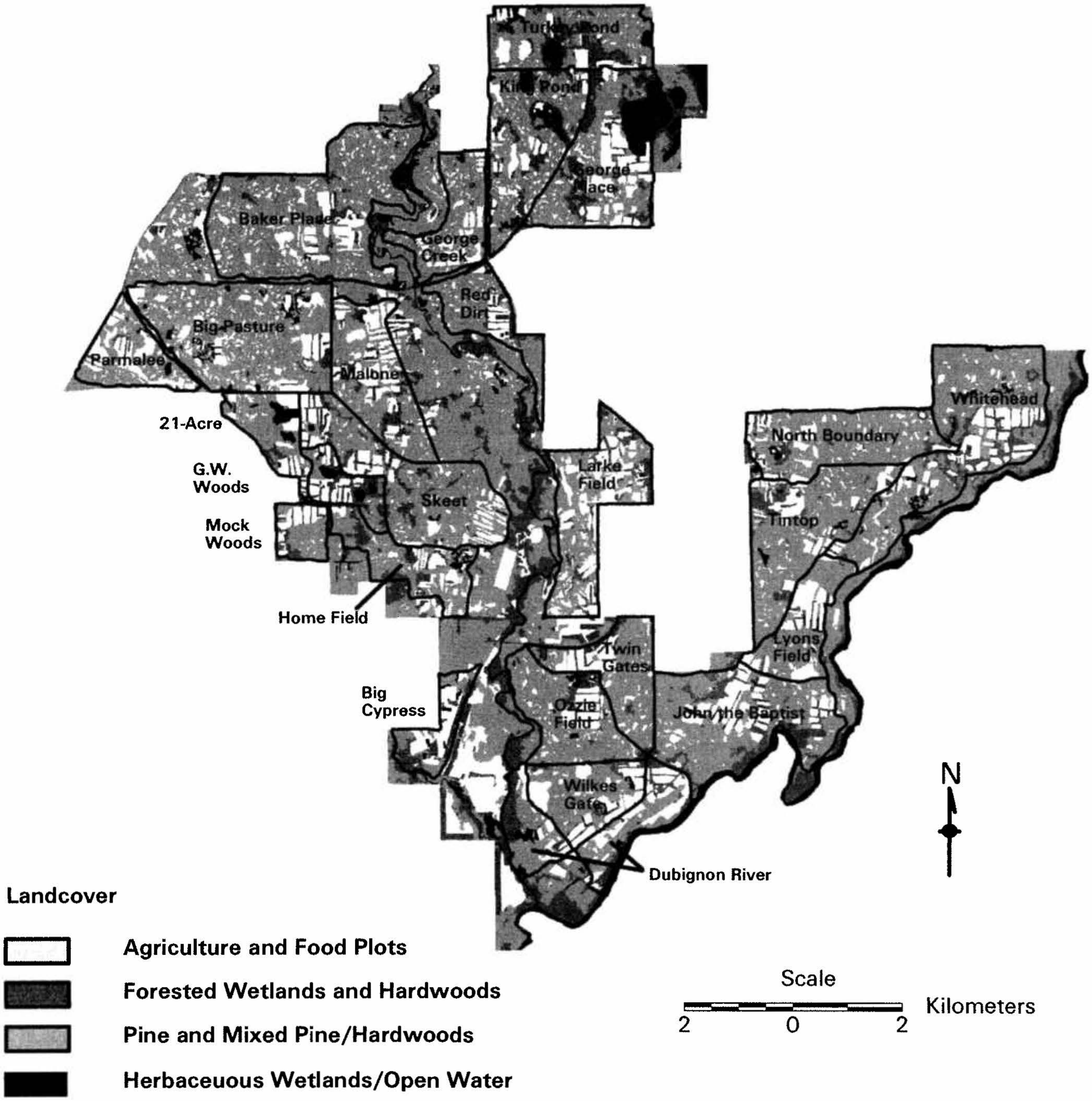

Fig. 1. Map of study site showing generalized landcover and hunt courses at Ichauway.

Table 1. Landcover classes for all active hunt courses and for Ichauway (total).

Landcover	Course (hectares)	Course (%)	Ichauway (hectares)	Ichauway (%)
Agriculture	1636	19.4	1958	16.7
Wildlife Food Plots	240	2.8	278	2.4
Forested Wetlands	87	1.0	100	0.9
Hardwoods	911	10.8	1463	12.4
Longleaf and Slash Pine	2790	33.0	3839	32.6
Mixed Pine/Hardwoods	2427	28.7	3169	26.9
Other (see text)	15	0.2	66	0.6
Pine Strips	133	1.6	188	1.6
Scrub/Shrub	116	1.4	184	1.6
Herbaceous Wetland/Open Water	92	1.1	509	4.3

Geographic Information System Database

Landcover data were developed in conjunction with the Mississippi Remote Sensing Center (MRSC) at Mississippi State University, Starkville, Mississippi. Detailed landcover classes were interpreted from 1: 12,000 scale color infrared (CIR) aerial photographic transparencies and verified during field surveys. Data were transferred using a vertical sketchmaster to USGS quads, digitized, with attributes identified using Environmental Systems Research Institute's ARC/INFO software. Landcover classification attributes included tree species composition, age class, and stand density for all forested areas. Generalized landcover classes developed for this study included: agriculture, food plots, forested wetlands, hardwoods, mixed pines, mixed pines/hardwoods, scrub/shrub, planted pine strips, wetland/open water, and other (i.e., urban, borrow pits, etc.) (Table 1).

Field Observations

Bobwhite hunting records for the two seasons incorporated in the comprehensive analysis (November 1994–February 1995; November 1995–February 1996) included: hunt course routes and covey sightings mapped in field, habitat characteristics, weather, dogs, members of the hunt party, and other parameters. Typical hunt parties consisted of: 2 hunters, 1 dog handler, 1 scout, 1 horse holder, 1 data collector, 1 mule-drawn wagon and driver, as well as horses, pointers, and a retriever. Generally, hunt courses were hunted repeatedly during the season with a two-week lag between repeats. Hunt courses were hunted in a similar fashion each time by experienced personnel (i.e., dog handler and scout). Approximately 100 hunts were conducted each season.

Data Analysis

Covey sightings (points by hunting dogs) were assumed to represent centers of 2.0-hectare (5-acre) activity areas for the analyses, and hunt course routes were treated as 100-meter (330-feet) wide sampling transects (Figure 2). Three habitat indices (P_i) were similarly derived as follows:

$$P_i = U_i - A_i$$

where U (Use) = proportion of study area subunit [hunt course route, covey activity area, or individual covey sightings (points); respectively] associated with landcover type 'i', and A = proportion of study area (hunt course, hunt course route, or hunt course route; respectively) associated with landcover type 'i'. Although the index can theoretically vary from approximately −100 (avoidance; quail never or less frequently encountered than expected based on habitat availability) through 0 (no preference; quail encounters are directly proportional to habitat availability) to approximately +100 (preferred; quail are more frequently encountered than expected based on habitat availability), most of the values reported in this study ranged from approximately −25 to +40. [Note: inferences based on

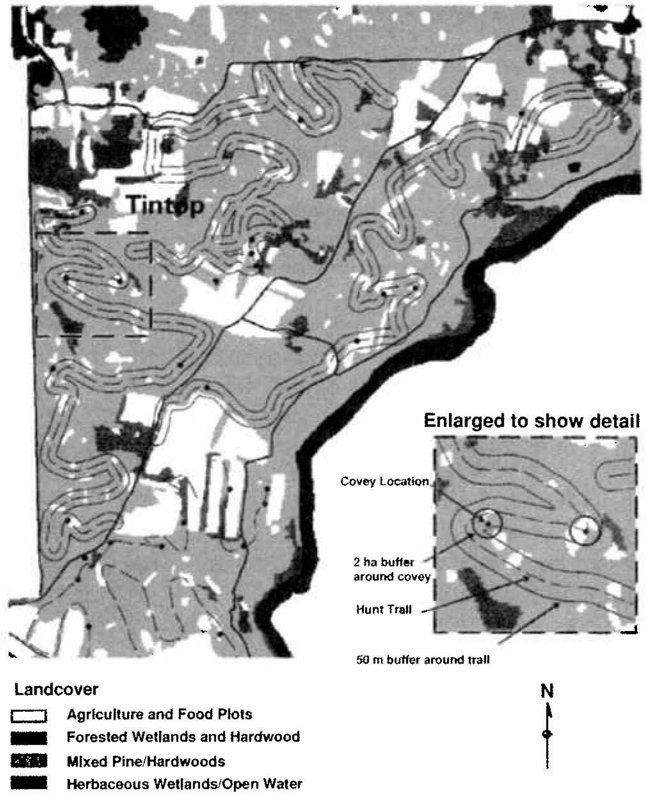

Fig. 2. Map illustrating hunt course routes (dashed line) within a hunt course, covey sightings (dots), and 2-hectare (5-acre) covey activity areas (circles) at Ichauway.

the magnitude of P_i are unwarranted, since the index is not standardized among different landcover classes; consequently, values of P_i are not presented.] Multivariate analysis of variance (MANOVA) based on habitat preference indices was designed to compare habitat composition between hunt course routes and hunting courses, covey activity areas and hunt course routes, and covey field sightings (points) and hunt course routes. Multivariate analyses were performed on both annual (hunting season) and seasonal (month within season) data for each year.

Landscape-level analyses were based on the comparison of agricultural field and food plot patches (a single class comprising 22% of the total hunt course area) to a single background matrix. The background matrix encompassed all remaining landcover types, but was comprised primarily of forested habitat (> 73% of the total hunt course area). Landscape metrics were calculated for each of the 22 hunt courses using FRAGSTATS (McGarigal and Marks 1995). Estimates of standardized bobwhite covey densities for each hunt course (average number of different coveys encountered per hour along hunt course routes) were derived from hunt records for the 1994–1995 hunt season. Backward stepwise regression analysis was initially used to assess the relationship between bobwhite covey densities and landscape metrics and to arrive at the most parsimonious multiple regression model. Three landscape metrics proved to be most closely associated with covey densities: percentage of agriculture and

Table 2. Hunter habitat preference at Ichauway by hunting season[1].

Landcover type	1994–1995[2]	1995–1996[3]
Agriculture	–	+
Food Plot	0	+
Forested Wetland	–	–
Hardwoods	–	–
Pines	0	0
Pine/Hardwoods	0	0
Other	0	0
Scrub/Shrub	0	0
Pine Strips	–	–
Wetland/Water	0	–

[1] Notes: (+) indicates use exceeded availability, (0) indicates no significant difference ($P > 0.05$) between use and availability, and (–) indicates availability exceeded use.
[2] MANOVA test criteria (Roy's Greatest Root): $F = 17.4012$; Numerator DF = 9, Denominator DF = 86; $P = 0.0001$.
[3] MANOVA test criteria (Roy's Greatest Root): $F = 8.5521$; Numerator DF = 9, Denominator DF = 88; $P = 0.0001$.

food plots, mean shape index of agriculture fields and food plots (a measure of edge complexity ranging from 1 for circular patches to 2 for complex shapes), and agricultural mean patch size. All statistical analyses (regression and MANOVA) were performed using SAS software (SAS Institute, Inc. 1989) following procedures outlined by Scheiner (1993) and Sokal and Rohlf (1995).

RESULTS

Hunter Preferences (Hunt Course Routes vs. Hunt Courses)

Approximately 50% of the total area set aside in hunt courses (see Table 1 and Figure 1) was hunted during each year of the study. The area "sampled" by hunting parties encompassed all landcover classes (Table 1). Hunter habitat preference (i.e., landcover composition of hunt course routes in comparison to landcover composition of hunt courses) varied by hunting season and month within a hunting season. For the two years of the study, hunting parties generally favored food plots, but avoided wetland/open water and forested wetland habitat (Tables 2, 3). Although agricultural habitat was not preferred or avoided on a monthly basis in 1994–1995, it was preferentially hunted during December and January of 1995–1996 (Table 3). This shift in preference to agricultural habitat in 1995–1996 coincided with the increasing age of pine strips that were planted in large agricultural fields to enhance landscape heterogeneity. Pine and scrub/shrub habitats were favored in 1994–1995, but were not consistently favored or avoided in the following year (1995–1996), except for a preference for pine habitat in February 1996. The apparent decreased hunting use of these two habitats in 1995–1996 coincided with an overall increased preference for agricultural habitat, especially in December 1995 and January 1996. Although hardwood habitat was avoided in 1994–1995 (especially December and January), this trend was less apparent in 1995–1996, a year coinciding with a heavy oak mast crop. Pine/hardwood and other habitats were not consistently favored or avoided in either of the two hunting seasons. Although results suggested that pine strips were avoided during both hunting seasons (Table 2), monthly data indicated that the relatively consistent avoidance of pine strip habitat observed throughout the 1994–1995 hunting season was not repeated the following year (Table 3).

Bobwhite Habitat Selectivity

Covey Activity Areas vs. Hunt Course Routes

Comparisons of habitat composition of 2.0-hectare (5-acre) covey activity areas and hunting courses indicated a higher than expected covey encounter rate during the hunting season for agriculture and food plots, and a lower than expected covey encounter rate for hardwood habitats (Table 4). However, the habitat composition of covey activity areas shifted seasonally as indicated by a higher than expected encounter rate for food plot habitat in February during both years (Table 5). The relatively consistent low covey encounter rates for hardwood, scrub/shrub, and "other" habitats in 1994–1995 was not evident in 1995–1996, a year of heavy oak mast production (Table 5). Trends in covey encounter rates for other habitats were generally not consistent between and within hunting seasons. For ex-

Table 3. Hunter habitat preference by month within hunting season[1] at Ichauway.

	1994–1995[2]				1995–1996[3]			
Landcover type	November	December	January	February	November	December	January	February
Agriculture	0	0	0	0	0	+	+	0
Food Plot	0	+	+	+	0	0	+	+
Forested Wetland	–	–	–	–	0	–	–	–
Hardwoods	0	–	–	0	0	0	0	0
Pines	0	+	+	+	0	0	0	+
Pine/Hardwoods	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	–
Scrub/Shrub	0	0	0	+	0	0	0	0
Pine Strips	0	–	–	–	–	0	0	0
Wetland/Water	0	–	–	0	0	–	–	–

[1] Note: (+) indicates use exceeded availability, (0) indicates no significant difference ($P > 0.05$) between use and availability, and (–) indicates availability exceeded use.
[2] MANOVA test criteria (Roy's Greatest Root): $F = 6.2465$; Numerator DF = 9, Denominator DF = 14; $P = 0.0013$.
[3] MANOVA test criteria (Roy's Greatest Root): $F = 3.0246$; Numerator DF = 9, Denominator DF = 14; $P = 0.0312$.

Table 4. Covey encounter rates (activity areas) in comparison to habitat composition of hunt course routes[1] at Ichuway.

Landcover type	1994–1995[2]	1995–1996[3]
Agriculture	+	+
Food Plot	+	+
Forested Wetland	0	0
Hardwoods	–	–
Pines	–	0
Pine/Hardwoods	0	0
Other	0	0
Scrub/Shrub	–	0
Pine Strips	0	–
Wetland/Water	0	0

[1] Note: (+) indicates covey encounter rate exceeded expectation based on availability of that habitat type, (0) indicates no significant difference (P > 0.05) between encounter rate and habitat availability, and (–) indicates covey encounter rate was lower than expected based on availability of that habitat type.
[3] MANOVA test criteria (Roy's Greatest Root): F = 8.0813; Numerator DF = 9, Denominator DF = 1011; P = 0.0001.
[3] MANOVA test criteria (Roy's Greatest Root): F = 8.7932; Numerator DF = 9, Denominator DF = 943; P = 0.0001.

Table 6. Covey encounter rates (points) in comparison to habitat composition of hunt course routes[1].

Landcover type	1994–1995[2]	1995–1996[3]
Agriculture	+	+
Food Plot	+	+
Forested Wetland	–	0
Hardwoods	0	0
Pines	–	0
Pine/Hardwoods	–	0
Other	0	0
Scrub/Shrub	+	0
Wetland/Water	0	0

[1] Note: (+) indicates covey encounter rate exceeded expectation based on availability of that habitat type, (0) indicates no significant difference (P > 0.05) between encounter rate and habitat availability, and (–) indicates covey encounter rate was lower than expected based on availability of that habitat type.
[2] MANOVA test criteria (Roy's Greatest Root): F = 46.5093; Numerator DF = 8, Denominator DF = 87; P = 0.0001.
[3] MANOVA test criteria (Roy's Greatest Root): F = 81.3137; Numerator DF = 9, Denominator DF = 85; P = 0.0001.

ample, although pine strips were hunted more frequently in 1995–1996, coveys were infrequently encountered in these habitats during all months sampled (Table 5). Similarly, a lower than expected bobwhite encounter rate for forested wetland habitat was apparent only during February 1996 (Table 5).

Covey Sightings (points) vs. Hunt Course Routes

Comparisons of covey sightings and habitat composition of hunting courses indicated higher than expected encounter rates for agriculture and food plots during both hunting seasons, as well as most months within a season (Tables 6, 7). Like the covey activity area comparisons, overall bobwhite field sightings indicated lower than expected encounter rates in pine habitat during 1994–1995 and no consistent trends during 1995–1996 (Table 6). However, monthly comparisons indicated that bobwhite coveys were not encountered as frequently as expected in both pine and pine/hardwood habitats throughout both hunting seasons (Table 7). Unlike the covey activity area comparisons, lower than expected encounter rates for forested wetland habitat were indicated during both January and February 1996, a period coinciding with higher water elevations and decreased availability and quality of *Nyssa* fruits (Table 7).

Bobwhite Covey Density and Landscape Pattern

Analysis of the relationship between standardized bobwhite covey densities and landscape habitat composition and configuration indicated that covey densities were positively associated with percentage agriculture and food plot habitat (reaching a maximum at approximately 30–35%; Figure 3a), positively associated with mean patch size for agriculture and food plot habitat [reaching a maximum at 2–3 hectares (5–7 acres); Figure 3b], and positively associated with mean shape index of agriculture and food plot habitat (Figure 3c). The most parsimonious model ($F = 6.765$; $P = 0.0033$; Adjusted $R^2 = 0.46$; $N = 22$) of the relationship between covey density and landscape metrics is expressed in Equation 1.

Table 5. Covey encounter rates (activity areas) in comparison to habitat composition of hunt course routes by month within hunting season[1] at Ichauway.

	1994–1995[2]				1995–1996[3]			
Landcover type	November	December	January	February	November	December	January	February
Agriculture	0	0	+	0	0	+	0	0
Food Plot	0	+	+	+	0	0	–	+
Forested Wetland	0	0	0	0	0	0	0	–
Hardwoods	–	–	–	0	0	0	–	0
Pines	0	0	–	0	0	–	0	0
Pine/Hardwoods	0	0	0	0	0	0	0	0
Other	–	0	–	–	0	0	0	0
Scrub/Shrub	0	–	–	0	0	0	0	0
Pine Strips	–	0	0	0	–	–	–	–
Wetland/Water	0	0	0	0	0	0	0	0

[1] Note: (+) indicates covey encounter rate exceeded expectation based on availability of that habitat type, (0) indicates no significant difference (P > 0.05) between encounter rate and habitat availability, and (–) indicates covey encounter rate was lower than expected based on availability of that habitat type.
[2] MANOVA test criteria (Roy's Greatest Root): F = 3.8505; Numerator DF = 9, Denominator DF = 244; P = 0.0001.
[3] MANOVA test criteria (Roy's Greatest Root): F = 3.1341; Numerator DF = 9, Denominator DF = 194; P = 0.0001.

Table 7. Covey encounter rates (points of individual covey sightings) in comparison to habitat composition of hunt course routes by month within hunting season[1] at Ichauway.

Landcover type	1994–1995[2] November	December	January	February	1995–1996[3] November	December	January	February
Agriculture	0	+	+	0	0	+	0	+
Food Plot	+	+	0	+	+	+	+	+
Forested Wetland	0	–	0	+	0	0	–	–
Hardwoods	0	0	–	0	0	0	0	0
Pines	–	–	–	–	0	–	–	–
Pine/Hardwoods	0	–	–	–	–	–	–	–
Other	0	–	–	–	0	–	–	0
Scrub/Shrub	0	0	0	0	0	0	0	0
Wetland/Water	0	0	–	0	0	–	0	0

[1] Note: (+) indicates covey encounter rate exceeded expectation based on availability of that habitat type, (0) indicates no significant difference ($P > 0.05$) between encounter rate and habitat availability, and (–) indicates covey encounter rate was lower than expected based on availability of that habitat type.
[2] MANOVA test criteria (Roy's Greatest Root): F = 25.7386; Numerator DF = 8, Denominator DF = 15; P = 0.0001.
[3] MANOVA test criteria (Roy's Greatest Root): F = 21.9953; Numerator DF = 8, Denominator DF = 15; P = 0.0001.

$$SCD = 2.562 + 2.820(AgMSI) + 0.373(AgMPS) - 0.197(AgMPS^2) \quad (1)$$

where SCD = standardized covey density in hunt course, AgMSI = mean shape index of agriculture and food plot patches in a hunt course, and AgMPS = average size of patches of agriculture and food plot habitat in a hunt course. Examples of landscape (hunt course) composition and patterns associated with high and low bobwhite covey densities are depicted in Figure 4.

DISCUSSION

Analyses of habitat composition of covey activity areas and points associated with individual covey sightings indicated higher than expected encounter rates of bobwhite coveys for food plots and agricultural fields in a forest-dominated landscape (Tables 4–7). Previous studies have demonstrated a similar "preference" for field habitat (Bell et al. 1985, Fuller 1994, Lee 1994, Dixon et al. 1996) that was related to availability of food and roosting and escape cover. All habitat types were "sampled" during each year of the study. Not surprisingly, hunting parties generally hunted more frequently in or near those habitats where bobwhite coveys were more frequently encountered (i.e., food plots and agricultural fields; Tables 2, 3). The apparent increase in hunter use of agricultural habitat during the 1995–1996 hunting season, which may have been related to the perceived increased quality of the aging pine strip habitat, was not reflected in higher bobwhite encounter rates in those habitats (Tables 4–7). Similarly, hunting parties appeared to utilize (or exhibit less avoidance) pine and pine/hardwood habitat more than would be warranted on the basis of habitat composition of covey activity areas and individual covey encounters (Tables 2–7). These findings likely reflect the necessity for hunters to travel through the forested background matrix to reach new patches of perceived bobwhite habitat as well as the importance of horseback riding through the forested savannas as an integral aesthetic component of the bobwhite hunting experience.

Analysis of covey sightings (Table 7) revealed that covey encounter rates for hardwood and scrub/shrub habitats were not as low as would have been inferred from similar analyses of the habitat composition of covey activity areas (Table 5). These findings probably reflect the importance of these habitats for escape and foraging (e.g., oak mast), as well as the importance of supplemental feeding activities. Furthermore, it should be emphasized that differences in habitat use based on analyses of covey activity areas or home ranges as opposed to points associated with individual covey sightings can often be attributed to the scale of the observer. For example, the minimum mapping unit for landcover in this study was approximately 0.01 hectares (0.025 acres), despite the fact that landcover data were based on photointerpretation of high resolution (1:12,000) color infrared photos. Consequently, small patches of suitable quail habitat that are missed or under-represented in analyses based on covey activity areas may, nevertheless, be disproportionately used by bobwhite coveys for foraging or escape.

Although analyses demonstrated the importance of specific habitats for encountering bobwhite coveys (i.e., food plots and agricultural fields), results of such analyses can not be readily incorporated into the design of optimal landscapes for northern bobwhite quail since they provide no indication of the ideal composition and configuration of habitats. The landscape-scale analyses performed as part of this study do, however, indicate that bobwhite covey densities are related to the specific composition and configuration of habitat. For example, covey densities increased as the percentage of the hunting course comprised of agriculture increased, reaching an apparent maximum at 30–35% agriculture (Figure 3a). This finding supports the recommendation by Stoddard and Komarek (1941) that at least 25% of forested lands should be comprised of small fields to support good quail populations. We have found only one other study documented in the literature where the investigators attempted to identify optimal combinations of different land uses for supporting bobwhite populations. In an analysis of the relationship between covey densities and composition

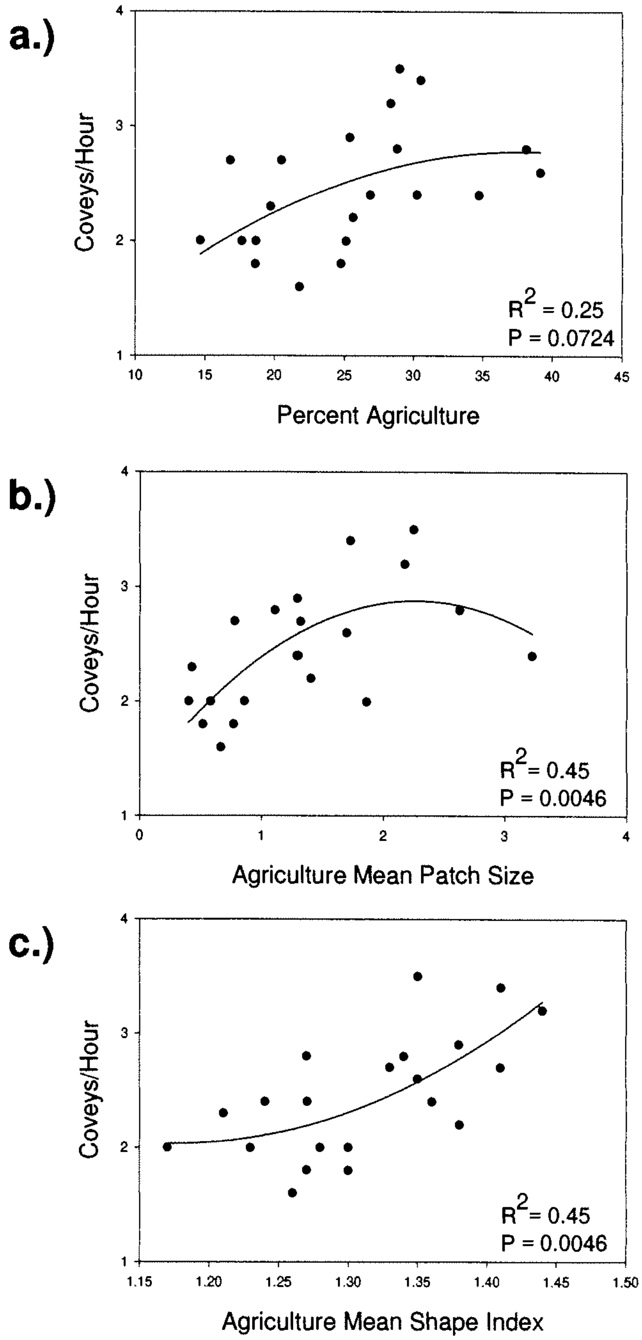

Fig. 3. Relationship between standardized covey densities and (a) percentage agriculture and food plot habitat; (b) mean shape index of agricultural fields and food plots; and (c) mean patch size of agricultural fields and food plots using a 30-meter (98-foot) buffer.

(pasture, woodland, cropland) of small [20–120 hectares (50–299 acres)] Tennessee farms, only approximately 5% of the total variability in covey densities could be attributed to percentage pasture or cropland (Schultz and Brooks 1958, Schultz 1959).

The positive relationship between covey density and increased edge complexity (Figure 3c) supports the contention by Rosene (1969) that optimal landscapes for bobwhite populations are comprised of small, well-dispersed agricultural fields with complex edge habitat. Results of other studies of the association between bobwhite and edge habitat are mixed. For example, Best (1983) observed a positive relationship between bobwhite quail and fencerow habitat, whereas Dixon et al. (1996) reported that bobwhite quail avoided edge habitat. The positive association between covey densities and agricultural patch size is more complex, but indicates the relative importance of fewer large food plots and small- to medium-sized agricultural fields [>0.1 hectares (0.25 acres)], as opposed to the use of large numbers of very small food plots [<0.1 hectares (0.25 acres)] (Figure 3b). Increased sample sizes and replication of this study on other areas are required to further clarify the relationship between bobwhite covey encounter rates and landscape characteristics, including the influence of multiple habitat types.

IMPLICATIONS FOR CONSERVATION, MANAGEMENT, AND FUTURE RESEARCH

Less than 14% of the historical 282,283 kilometer^2 (108,989 mile^2) longleaf pine-dominated forest remains in the southeastern United States (Noss 1989). Increasing conversion of longleaf pine forests for agriculture, timber plantation production, and urban needs (Ware et al. 1993) probably threatens the continued existence of many bird (Hunter et al. 1993), reptile, and amphibian species (Dodd 1995). Increased recognition of the importance of forest structure for ecosystem function and biodiversity has recently led many ecologists and foresters to recommend alternative management approaches for maintaining multiple values (such as commodity production, ecosystem function, etc.) in anthropogenic forested landscapes by controlling spatial structure and dynamics (Franklin and Forman 1987, Franklin 1993, Noss 1989, Hansen et al. 1993, Sharitz et al. 1992). Unfortunately, very little is known about the effects of specific forest structures on timber and non-timber values (Baskent and Jordan 1996).

This study represents an initial attempt to understand how one important game species, the northern bobwhite, responds to different landscape configurations in a longleaf pine-dominated ecosystem. Analyses of bobwhite covey sightings and activity areas in relation to habitat composition indicated higher than expected encounter rates for agricultural fields and food plots, as well as monthly and seasonal differences in encounter rates for other habitats. Landscape-level analyses of habitat composition and configuration in a forest-dominated landscape demonstrated increased bobwhite covey encounter rates with increasing amounts of agriculture (reaching an apparent peak at 30–35% agriculture). Results also indicated the importance of fewer large food plots with complex edge habitat for increasing bobwhite encounter rates, in contrast to many small [<0.1 hectares (0.25 acres)], well-dispersed food plots.

This study focused on hunter habitat selectivity as

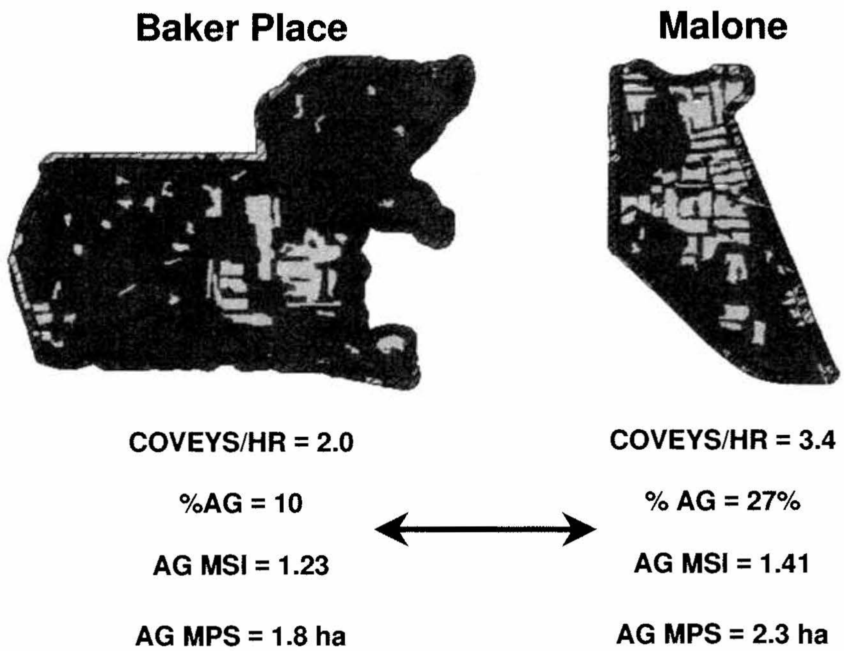

Fig. 4. Examples of landscape patterns associated with high and low bobwhite covey encounter rates.

well as landscape structure and other habitat features that may support bobwhite populations and facilitate bobwhite-hunting party encounter rates. In addition to managing landscape structure and composition, the importance of prescribed fire, harvest management, and field-woodland management in the longleaf pine ecosystem cannot be overemphasized; all are crucial for maintaining sustainable and harvestable bobwhite populations and providing essential nesting, brood, feeding, escape, loafing, and roosting habitats. For instance, prescribed burning in forested uplands promotes open savanna-like conditions, reduces hardwood encroachment and midstory canopy development, and produces habitats that support diverse wildlife communities, including northern bobwhite quail. Similarly, the weeds and insects associated with soil disturbance in fields at different times are critical for foraging by bobwhite quail and other species.

Additional analyses are underway to (1) characterize bobwhite food habits on a monthly and annual (hunting season) basis; (2) develop a spatially explicit model of bobwhite covey population dynamics in relation to landscape composition and structure; and (3) design and examine bobwhite population dynamics in response to landscape units differing in composition and structure. We anticipate that additional research throughout the range of the northern bobwhite quail will be necessary to identify optimal habitat composition (e.g., Schultz 1959) and configuration (e.g., Robel et al. 1974), as well as to document year-round responses by bobwhite populations, predators (e.g., Bowman and Harris 1980), and other species (e.g., neotropical migrants; Martin 1992). Future forest landscape management and restoration of the longleaf pine ecosystem in the Coastal Plain of the southeastern U.S. will ultimately depend to a large degree on understanding how we can: (1) design forested landscapes that can maintain an economic timber supply; (2) meet seasonal food and habitat requirements of bobwhite and other game species; and (3) support healthy, functioning pine ecosystems complete with endangered species, associated habitats, and other ecological amenities.

ACKNOWLEDGMENTS

We thank the numerous hunters and technicians who participated in ground survey efforts; Frank Miller, Mary Grace Chambers and Linda Garnett of the Mississippi Remote Sensing Center, and Jean Brock for GIS support; and the Ichauway management and hunting staff.

LITERATURE CITED

Baskent, E.Z., and G.A. Jordan. 1996. Designing forest management to control spatial structure of landscapes. Landscape and Urban Planning 34:55–74.

Bell, B., K. Dancak, and P.J. Zwank. 1985. Range, movements and habitat use by bobwhites in southeastern Louisiana pinelands. Proceedings Annual Conference Southeastern Association of Fish and Wildlife Agencies 39:512–519.

Best, L.B. 1983. Bird use of fencerows: implications of contemporary fencerow management practices. Wildlife Society Bulletin 11:343–347.

Bowman, G.B., and L.D. Harris. 1980. Effect of spatial heterogeneity on ground-nest depredation. Journal Wildlife Management 44:806–813.

Brennan, L.A. 1991. How can we reverse the northern bobwhite population decline? Wildlife Society Bulletin 19:544–555.

Dixon, K.R., M.A. Horner, S.R. Anderson, W.D. Henriques, D. Durham, and R.J. Kendall. 1996. Northern bobwhite habitat use and survival on a South Carolina plantation during winter. Wildlife Society Bulletin 24:627–635.

Dodd, C.K., Jr. 1995. Reptiles and amphibians in the endangered longleaf pine ecosystem. Pages 129–131 *in* E.T. LaRoe, G.S. Farris, C.E. Puckett, P.D. Doran, and M.J. Mac (eds.). Our living resources: a report to the nation on the distribution, abundance, and health of U.S. plants, animals, and ecosystems. U.S. Department of the Interior, National Biological Service, Washington, DC.

Franklin, J.F., and R.T.T. Forman. 1987. Creating landscape structures by forest cutting: ecological consequences and principles. Landscape Ecology 1:5–18.

Franklin, J.F. 1993. Preserving biodiversity: species, ecosystems, or landscapes? Ecological Applications 3:202–205.

Fuller, R.S. 1994. Relationships between northern bobwhite habitat use and forest stands managed for red-cockaded woodpeckers at Noxubee National Wildlife Refuge. M.S. Thesis, Mississippi State University, Starkville.

Hansen, A.J., S.L. Garman, B. Marks, and D.L. Urban. 1993. An approach for managing vertebrate diversity across multiple-use landscapes. Ecological Applications 3:481–496.

Hunter, W.C., D.N. Pashley, and R.E.F. Escano. 1993. Neotropical landbird species and their habitats of special concern within the Southeast region. Pages 159–171 *in* D.M. Finch and P.W. Stangel (eds.). Status and management of neotropical migratory birds. Rocky Mountain Forest and Range Experiment Station, U.S. Department of Agriculture, Fort Collins, CO.

Klimstra, W.D. 1982. Bobwhite quail and changing land use. National Bobwhite Quail Symposium Proceedings 2:1–5.

Landers, J.L., and B.S. Mueller. 1989. Bobwhite quail management: a habitat approach. Quail Unlimited and Tall Timbers Research Station, Tallahassee, FL.

Lee, J.M. 1994. Habitat ecology of the northern bobwhite on Copiah County Wildlife Management Area. M.S. Thesis, Mississippi State University, Starkville

Martin, T.E. 1992. Landscape considerations for viable populations and biological diversity. Transactions North American Wildlife and Natural Resources Conference 57:283–291.

McGarigal, K., and B.J. Marks. 1995. FRAGSTATS: Spatial Pattern Analysis Program for Quantifying Landscape Structure. Version 2.0, Forest Science Department, Oregon State University, Corvallis, OR (ftp.fsl.orst.edu).

Noss, F.R. 1989. Indicators for monitoring biodiversity: a hierarchical approach. Conservation Biology 4:355–364.

Noss, R.F. 1989. Longleaf pine and wiregrass: keystone components of an endangered ecosystem. Natural Areas Journal 9:211–213.

Robel, R.J., R.M. Case, A.R. Bisset, and T.M. Clement. 1974. Energetics of food plots in bobwhite management. Journal Wildlife Management 38:653–664.

Roseberry, J.L., and L.M. David. 1994. The Conservation Reserve Program and northern bobwhite population trends in Illinois. Transactions of the Illinois State Academy of Science 87:61–70.

Rosene, W. 1969. The bobwhite quail: its life and management. Rutgers University Press, New Brunswick, NJ.

SAS Institute, Inc. 1989. SAS/STAT User's Guide. Version 6, Fourth Edition, Volume 2, Cary, NC.

Scheiner, S.M. 1993. MANOVA: Multiple response variables and multispecies interactions. Pages 94–112 *in* S.M. Scheiner and J. Gurevitch (eds.). Design and Analysis of Ecological Experiments. Chapman & Hall, New York, NY.

Schultz, V., and S.H. Brooks. 1958. Some statistical aspects of the relationship of quail density to farm composition. Journal of Wildlife Management 22:283–291.

Schultz, V. 1959. Further notes on quail density and farm composition. Journal of Wildlife Management 23:354–355.

Sharitz, R.R., L.R. Boring, D.H. Van Lear, and J.E. Pinder, III. 1992. Integrating ecological concepts with natural resource management of southern forests. Ecological Applications 2: 226–237.

Sokal, R. R., and F.J. Rohlf. 1995. Biometry. Third edition. W. H. Freeman and Company, New York, NY.

Stoddard, H.L. 1931. The bobwhite quail: its habits, preservation, and increase. Charles Scribner's Sons, New York, NY.

Stoddard, H.L., and E.V. Komarek. 1941. The carrying capacity of southeastern quail lands. Transactions of the North American Wildlife Conference 6:148–155.

Ware, S., C. Frost, and P.D. Doerr. 1993. Southern mixed hardwood forest: the former longleaf pine forest. Pages 447–493 *in* W.H. Martin, S.G. Boyce, and A.C. Echternacht (eds.). Biodiversity of the Southeastern United States. Lowland Terrestrial Communities. John Wiley and Sons, New York, NY.