Habitat Selection by Northern Bobwhite Broods in Pine Savanna Ecosystems

William E. Palmer
Tall Timbers Research Station

D. Clay Sisson
Tall Timbers Research Station and Land Conservancy

Shane D. Wellendorf
Tall Timbers Research Stations and Land Conservancy

Allan M. Bostick III
Tall Timbers Research Station and Land Conservancy

Theron M. Terhune
Tall Timbers Research Station and Land Conservancy

See next page for additional authors

Follow this and additional works at: https://trace.tennessee.edu/nqsp

Recommended Citation
https://doi.org/10.7290/nqsp07okgd
Available at: https://trace.tennessee.edu/nqsp/vol7/iss1/70
Habitat Selection by Northern Bobwhite Broods in Pine Savanna Ecosystems

Authors
William E. Palmer, D. Clay Sisson, Shane D. Wellendorf, Allan M. Bostick III, Theron M. Terhune, and Tyson L. Crouch

This bobwhite brood ecology is available in National Quail Symposium Proceedings: https://trace.tennessee.edu/nqsp/vol7/iss1/70
HABITAT SELECTION BY NORTHERN BOBWHITE BROODS IN PINE SAVANNA ECOSYSTEMS

William E. Palmer
Tall Timbers Research Station, 13093 Henry Beadel Drive, Tallahassee, FL 32312, USA

D. Clay Sisson
Tall Timbers Research Station and Land Conservancy, Tallahassee, FL 32312, USA

Shane D. Wellendorf
Tall Timbers Research Station and Land Conservancy, Tallahassee, FL 32312, USA

Allan M. Bostick III
Tall Timbers Research Station and Land Conservancy, Tallahassee, FL 32312, USA

Theron M. Terhune
Tall Timbers Research Station and Land Conservancy, Tallahassee, FL 32312, USA

Tyson L. Crouch
School of Forestry and Wildlife Sciences, Auburn University, Auburn, AL 36849, USA

ABSTRACT

Habitat for northern bobwhite (Colinus virginianus) broods is a critical component of bobwhite management. Research within pine (Pinus spp.) savannas has provided contradictory results regarding the value of macro-habitats with studies demonstrating selection for annually-disked fallow fields and others showing avoidance of fields and selection for burned pine savannas. Field establishment (up to 30% of a property) is a published management recommendation for bobwhites in pine savannas but there are significant annual costs with fallow-field management; information on factors that influence habitat selection by broods can improve management recommendations and facilitate weighing costs/benefits. We examined 2nd and 3rd order habitat selection by 466 broods on 3 sites during 1999–2009. All sites had similar macro-habitats (e.g., pine savanna, fallow fields, hardwood drains) but differed in soil characteristics and species composition of ground vegetation. Annually-disked fields were preferred by broods in most years on sites with predominantly grass and hardwood scrub ground vegetation. Rainfall mediated use of hardwood drains and burned upland pine savannas; hardwood drains were used more during droughts whereas burned pine savannas were used more with increased rainfall. Burned upland pine savanna was preferred on higher fertility sites in 9 of 10 years at the 3rd order level, fields were avoided or used according to availability in 8 of 10 years, and drains were avoided. Managers should consider how soil, weather, and vegetation community in pine savannas influences habitat use by bobwhite broods when identifying the value of different macro-habitats. Field establishment may or may not provide brood habitat depending on site.


Key words: broods, chicks, Colinus virginianus, fields, fire, habitat use, northern bobwhite, pine, savanna

INTRODUCTION

High survival of chicks is critical to sustaining populations of northern bobwhites on managed lands; thus, creating habitat for broods is an important management consideration (Stoddard 1931, Hurst 1972, DeVos and Mueller 1993). Inadequate brood habitat, and resulting low chick survival, in bobwhite management (Burger 2001) is considered a major potential limiting factor for populations (Yates et al. 1995, Sandercoc et al. 2008). Habitat for bobwhite chicks is enhanced by insect-rich herbaceous/shrub plant communities that provide cover while maintaining an open structure at ground level to facilitate foraging (Stoddard 1931, Taylor and Guthery 1994, Taylor et al. 1999). Broods also require loafing and roosting areas typically provided by woody plants, such as shrubs and vines (Taylor and Guthery 1994). Researchers in pine savanna ecosystems have shown broods select for annually-disked fields composed of annuals, such as common ragweed (Ambrosia artemisiifolia) or showy partridge pea (Chamaecrista fasciculata) (Yates et al. 1995, Carver et al. 2001). Maintaining up to 30% of pine woodlands in 1–2 ha annually-disked agricultural fields is a recurring management recommendation (Yates et al.
and had a loblolly pine (\textit{Pinus taeda}) Plantation. TTRS (1,568 ha) is in Leon County, Florida, Research Station (TTRS), Pineland Plantation, and Sehoy (annually-disked fields) or were undisturbed for up to 3 years. Ragweed, partridge pea, and other annuals (hereafter varying levels of sand and clay. These soils are considered well-drained, moderately-fertile, fine-loam soils with Hammond 2001). Soils on TTRS are of the Fuquay-2001). Herbaceous ground cover was a mix of warm season grasses and a diverse legume and forb community typical of 'old-field' plant communities (Carver et al. 2001). Ground story communities were about equal proportions of grasses, forbs, and shrubs typical of 'old-field' plant communities (Carver et al. 2001). Herbaceous ground cover was a mix of warm season grasses and a diverse legume and forb community (Hammond 2001). Soils on TTRS are of the Fuquay-Orangeburg-Faceville series which are characterized as well-drained, moderately-fertile, fine-loam soils with varying levels of sand and clay. These soils are considered well-suited to agriculture, forestry, and pasture. Fallow fields were annually-disked in January to produce ragweed, partridge pea, and other annuals (hereafter annually-disked fields) or were undisturbed for up to 3 years to encourage development of grasses and blackberry (\textit{Rubus} spp.). Some fallow fields were planted to longleaf pine (\textit{P. palustris}) during the study but had vegetation characteristics similar to fallow fields and were classified as fallow fields. Pineland Plantation in Baker County, Georgia was 5,630 ha of a mixture of upland pine forests, primarily slash pine (\textit{P. elliotti}) with intermittent live oaks (\textit{Quercus} spp.). Each year 50% of the study area was burned. Soils on Pineland are primarily Orangeburg-Lucy-Grady and Norfolk-Wagram-Grady complexes typified as sandy-loam, moderately permeable with low natural fertility. Twenty percent of the site was annually-disked fields composed primarily of ragweed. Field management has varied over the study period. Fields were harvested in September and October, harrowed again in February, and fertilized in April to maximize growth of ragweed. Fields were no longer fertilized beginning in 2006, but some were deep plowed to break a hardpan and bring clay content to the surface to help hold moisture and promote plant vigor.

Sehoy Plantation was in northern Bullock County and southern Macon County in east-central Alabama. The study area was 972 ha and was involved in an intensive quail management program for > 10 years. Soils associated with upland pine woodlands are primarily Black Belt clayey soils. Hardwood drains were associated with poorly-drained clayey and loamy soils. Loamy terrace soils were found in transitional areas between the upland and hardwood habitats. Soils are generally of low fertility and acidic with poor suitability for pasture or cultivated crops. Pine forests covered 70% of the area and were of shortleaf, longleaf, loblolly, and slash pines. Ground story communities were primarily broomsedge (\textit{Andropogon virginicus}) as well as a variety of other bunch grasses (\textit{Andropogon} spp.). Other evident herbaceous plants included crown grasses (\textit{Paspalum} spp.), partridge pea, butterfly pea (\textit{Clitoria mariana}), and a variety of \textit{Desmodium} species. Annually-disked fields ranging from 0.5 to 3 ha were composed of ragweed and made up 16% of the site. Hardwood drains (4%) were thinned prior to the study with 90% of hardwoods removed. These drainages were burned each year to maintain a rich herbaceous ground cover.

**STUDY AREA**

We conducted field research on Tall Timbers Research Station (TTRS), Pineland Plantation, and Sehoy Plantation. TTRS (1,568 ha) is in Leon County, Florida, and had a loblolly pine (\textit{Pinus taeda}) and shortleaf pine (\textit{P. echinata}) mature overstory (66%) intermixed with hardwood drains and hammocks (21%), and fallow fields (13%) 0.4 to 1.2 ha in size. Ground story communities were composed primarily of ragweed. Field management has varied over the study period. Fields were harvested in September and October, harrowed again in February, and fertilized in April to maximize growth of ragweed. Fields were no longer fertilized beginning in 2006, but some were deep plowed to break a hardpan and bring clay content to the surface to help hold moisture and promote plant vigor.

Sehoy Plantation was in northern Bullock County and southern Macon County in east-central Alabama. The study area was 972 ha and was involved in an intensive quail management program for > 10 years. Soils associated with upland pine woodlands are primarily Black Belt clayey soils. Hardwood drains were associated with poorly-drained clayey and loamy soils. Loamy terrace soils were found in transitional areas between the upland and hardwood habitats. Soils are generally of low fertility and acidic with poor suitability for pasture or cultivated crops. Pine forests covered 70% of the area and were of shortleaf, longleaf, loblolly, and slash pines. Ground story communities were primarily broomsedge (\textit{Andropogon virginicus}) as well as a variety of other bunch grasses (\textit{Andropogon} spp.). Other evident herbaceous plants included crown grasses (\textit{Paspalum} spp.), partridge pea, butterfly pea (\textit{Clitoria mariana}), and a variety of \textit{Desmodium} species. Annually-disked fields ranging from 0.5 to 3 ha were composed of ragweed and made up 16% of the site. Hardwood drains (4%) were thinned prior to the study with 90% of hardwoods removed. These drainages were burned each year to maintain a rich herbaceous ground cover.

**METHODS**

**Field Procedures**

Bobwhites were captured in January and March using standard walk-in funnel traps (Stoddard 1931). We assigned gender and age class, weighed each captured bobwhite, and attached a uniquely-numbered aluminum leg band (National Band and Tag Co., Newport, KY, USA). We selected 2–3 bobwhites from each captured covey to be fitted with a 6-g radio transmitter (American Wildlife Enterprises, Monticello, FL, USA and Holohil Systems Limited, Carp, ON, Canada). Trapping, handling, and marking procedures were consistent with Palmer and Wellendorf (2007) and followed the guidelines of the Tall Timbers Research Inc. Institutional Animal Care and Use Committee Permit (# GB2001-01).

Radio-marked bobwhites were located 5 times per week during the nesting season (15 Apr-1 Oct) to locate nests. We documented nesting when locations were unchanged for 2 consecutive days. Broods were located once per day after hatching until 21 days of age. Only data through 14 days of age were analyzed on Sehoy. We located radio-marked individuals with broods using homing procedures (White and Garrott 1990) and plotted locations on detailed landcover maps developed in ArcGIS (ESRI, Redlands, CA, USA). The precision of calculated locations to actual coordinates of radio-marked bobwhites was not formally tested; we thoroughly trained technicians on use of the homing technique to ensure
locations were defined within at least a 30-m² area. We verified the correct macro-habitat landcover type (e.g., burned upland, unburned upland, field, hardwood drain) was assigned to the location.

We recorded daily rainfall totals on Pineland and TTRS but not Sehoy. We summed rainfall totals for April through June and compared these rainfall totals to habitat selection ratios for broods on these study areas.

Statistical Analyses

We computed a fixed-kernel home range for broods on TTRS and Pineland using a bivariate normal (Gaussian) kernel density estimator (HRT: Home Range Tools for ArcGIS; Version 1.1; Rogers et al. 2007) in ArcGIS 9.3. Bandwidth (h) was calculated for all broods using a least-squares cross-validation procedure (LSCV) for each year (Calenge 2006). Home ranges that did not converge were removed from further analysis. We estimated the median hscv value for all remaining home ranges for each year and this value was used as the bandwidth value for all home range calculations (Kenward 2001). We used a grid cell size of 10 m for the raster portion of the kernel home range procedure, which we estimated to be an appropriate scale for bobwhites, considering location resolution. We calculated a 95% volume contour from the grid that was produced, which was used in the habitat use analysis. Quail home ranges were calculated using the minimum convex polygon (MCP) method on Sehoy (Crouch 2010). We recognize that home ranges estimated using fixed-kernel method for broods on Pineland and TTRS may be larger than MCP used for broods on Sehoy (Kenward 2001). We do not believe differences in home range methodology among sites posed an issue for our study comparing habitat selection within study areas.

We categorized major habitat types on each study area to include pine woodlands burned that year, pine woodlands burned the previous year, hardwood drains, and annually-disked fields. Additional habitats on TTRS included marsh and fallow fields that were not annually disked. We followed Neu et al. (1974) using Resource Selection for Windows (Leban 1999). Second and 3rd order selection (Johnson 1980) were used to compare habitat use and availability for each year. We calculated habitat availability each year for 2nd order analysis by creating a 200-m buffered MCP polygon that encompassed all radio-marked bobwhite locations for that year. The buffered MCP was intersected with the annual landcover map to generate an overall proportion for each habitat. Second-order habitat use was defined as the proportion of each habitat type within the individual home ranges. Habitat use for 3rd order analysis was the proportion of telemetry locations within each habitat type; habitat availability was defined as the proportion of each habitat type inside the home range polygon of each brood (Neu et al. 1974). Second order analysis compared home range selection to available habitat for each individual brood and 3rd order analysis compared use of habitats to their availability within home ranges to measure habitat preference (Johnson 1980). Chi-square goodness-of-fit tests were calculated for both 2nd and 3rd order selection (Neu et al. 1974).

RESULTS

We monitored habitat use of 466 broods on 3 study sites during 1999–2009. Broods on Pineland Plantation (n = 167) used fields (43% of brood locations) more than pine woodlands burned that year (30% of locations) or burned the previous year (23% of locations). Annually-disked fields on Pineland were selected by broods in 8 of 9 years at the 2nd and 3rd order and used equal to availability in 1 year. Upland pine woodlands burned the previous year were avoided in 7 of 9 years at the 2nd order and used equal to availability in 2 years. Upland pine woodlands burned the previous year were avoided in 7 of 9 years at the 3rd order, selected in 1 year, and used equal to availability in 1 year. Burned pine woodlands were used less than available in 4 of 9 years and selected in 2 years at the 2nd order. Burned pine woodlands were selected in 1 of 9 years and used less than available in 6 years at the 3rd order. Amount of rainfall during April through June on Pineland was positively correlated with use of pine woodlands burned that year (r = 0.59, P = 0.09) but not use of fields (r = -0.08, P = 0.83). Brood use of pine woodlands burned that year in 2007, a severe drought year, was lowest (9% of locations) relative to other years (range = 15 to 54% use). Broods used pine woodlands burned the previous year more in 2007 (54% of brood locations) compared to other years (range = 4 to 32% use).

Broods on TTRS (n = 240) used pine woodlands burned that year (52% of brood locations) most followed by pine woodlands burned the previous year (27% of locations), annually-disked fields (6.2% of locations), fallow fields (5.8% of locations), and drains (2.9% of locations). Broods selected annually-disked fields in 3 of 10 years and used fields equal to availability in 7 years at the 2nd order. Broods selected annually-disked fields in 2 of 10 years and used fields equal to availability in 6 years at the 3rd order. Pine woodlands burned that year were selected in 7 of 10 years, avoided in 1 year, and used equal to availability in 2 years at the 2nd order. Pine woodlands burned that year were selected in 9 of 10 years and used equal to availability in 1 year at the 3rd order. Pine woodlands burned the previous year were avoided in 4 of 10 years and selected in 2 years at the 2nd order. Pine woodlands burned the previous year were avoided in 5 of 10 years and selected in 2 of 10 years at the 3rd order. The 2007 year had a severe drought and pine woodlands burned the previous year were selected at both the 2nd and 3rd orders. Hardwood drains were avoided in all years, except at the 2nd order in 2007 when they were used equal to their availability. Fallow fields with and without pines were selected in 6 of 10 years at the 2nd order and in 1 of 10 years at the 3rd order. Amount of rainfall was not correlated with use of fields or pine woodlands burned that spring; however, the selection ratio of hardwood drains was negatively correlated with rainfall (r = - 0.56, P = 0.09).
which was a severe drought year on the study area.

the 3rd order of selection. Drains were selected in 2006
woodlands burned the same year with increasing rainfall
and use of burned pine woodlands. Increased use of pine
the correlation between early spring and summer rainfall
following burning in March or April. This is supported by
lengthened the time needed for regrowth of the understory
content made these soils more drought prone and
groundstory. The lower soil fertility and greater sand
broods likely due to the lower overall herbaceous
content made these soils more drought prone and
groundstory. The lower soil fertility and greater sand
broods likely due to the lower overall herbaceous

Broods on Sehoy Plantation (n = 59) used annually-
disked fields (37% of brood locations) most followed by
pine woodlands burned the previous year (29% of
locations), pine woodlands burned that year (15% of
locations), and drains (14% of locations). Broods selected
annually-disked fields in 3 of 4 years at the 2nd and 3rd
orders. Pine woodlands burned that year were avoided in
3 of 4 years at the 2nd order and 2 of 4 years at the 3rd
order. Pine woodlands burned the previous year were
avoided in 1 of 4 years at the 2nd order and 3 of 4 years at
the 3rd order of selection. Drains were selected in 2006
which was a severe drought year on the study area.

DISCUSSION

Habitat use and selection was variable among sites
and largely consistent from year to year within sites.
Differences in brood habitat selection across years but
within sites were related to rainfall accumulation for a
given year. Brood habitat was characterized by areas with
abundant herbaceous vegetation, abundant insects, ample
(20–50%) bare ground, and well dispersed woody shrubs
for loafing, thermal protection, and roosting (DeVos and
Mueller 1993, Burger 2001). Different soil types and
vegetation communities can produce suitable brood
habitat. Thus, macro-habitat selection is likely to vary
depending on the suitability of the micro-habitat within a
site. Suitable micro-habitat conditions on soils of
moderate fertility at TTRS were provided by pine
woodlands burned the same year rather than annually-
disked fields. Higher clay content and fertility of the soils
allowed for a relatively quick resurgence of the
groundstory community after fires. Areas burned in
March were used by June broods and those burned later
in spring were used by broods during late summer. Broods
preferred more floristically-diverse open pine woodlands
and used this habitat for foraging, loafing, and roosting
habitat (Hammond 2001). Preference for upland pine
forests over annually-disked fields has also been observed
on other properties in the Red Hills region (Hammond
2001). Brood habitat is not limiting in this landscape and
the addition of fields would likely reduce the amount of
useable space and potentially have a negative effect on
bobwhite populations (Guthery 1997).

Annually-disked fields on sites with lower soil
fertility, such as Pineland and Sehoy, were highly selected
in all years except during severe drought in 2006 on
Sehoy when frequently-burned hardwood drains were
preferred. There is evidence that bobwhite abundance on
these types of soils increases with increasing amount (up
to 30%) of area in fields (Michener et al. 2000). Pine
woodlands burned the same year were less suitable for
broods likely due to the lower overall herbaceous
groundstory. The lower soil fertility and greater sand
content made these soils more drought prone and
lengthened the time needed for regrowth of the understory
following burning in March or April. This is supported by
the correlation between early spring and summer rainfall
and use of burned pine woodlands. Increased use of pine
woodlands burned the same year with increasing rainfall
suggests that as cover increased, so did the suitability of
pine forests for bobwhite broods. Rainfall may also
increase insect availability in burned pine woodlands
(Wolda 1978).

Bobwhite broods on both TTRS and Sehoy Plantation
shifted habitat use during periods of drought (2006 on
Sehoy and 2007 on TTRS). Bobwhites shifted habitat use
during periods of drought to drains or pine woodlands
burned the previous year (i.e., 1 year roughs). The use of
pine forests burned the previous year on Pineland
Plantation also increased and use of pine forests burned
that same spring was the lowest recorded during the 2007
drought. We also observed bobwhites selecting for
hardwood drains and wet-weather ponds, over traditional
brood habitats during the 1998 drought (Hammond 2001).
Managing a diversity of macro-habitat types using fire or
mechanical disturbance may be important to bobwhites
during periods of stress.

MANAGEMENT IMPLICATIONS

Managers developing habitat for northern bobwhites
in pine savanna ecosystems should consider how soils,
vegetation community, and weather may affect the
suitability of frequently-burned habitats for broods.
Annually-burned woodlands on sites with moderately
fertile soils supporting diverse ground cover including
annual and perennial forbs, grasses, and shrubs may be the
most suitable habitat. Increasing abundance of fields
given these habitat conditions may actually reduce
bobwhite nesting, brooding, and winter habitat provided
by frequently-burned pine woodlands resulting in lower
bobwhite densities. Conversely, on areas with lower
fertility due to sand or acidic soil chemistry, often
dominated by grasses and shrubs and relatively few forbs
and legumes, annually-disked fields can be a vitally
important component of brood habitat. Fields managed as
brood habitat fill an important gap in the annual habitat
needs for bobwhites and result in higher bobwhite
densities over time. However, even when annually-disked
fields are provided, our study indicates burned woodlands
and hardwood drains still serve as critical habitat
components, such as providing shrubs for roosting as
well as additional foraging habitats. Our study also
indicated that frequently burned drains can be important
brood habitat during drought periods. A diversity of
habitat types that are frequently burned, or disked,
provides the range of habitats needed to sustain bobwhites
across years and under differing weather regimes.

ACKNOWLEDGMENTS

This project was funded by the Pamela H. Firman
Quail Management Research Fund and the Gerry Quail
Endowment at Tall Timbers Research Station and Land
Conservancy. We appreciate the field assistance by V. A.
Carver, D. A. Butler, B. C. Faircloth, A. D. Hammond, R.
S. Miller, and E. S. Staller, and the dozens of dedicated
interns and technicians that collected field data for this
project.
LITERATURE CITED


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


