Pine-Grassland Bird Occupancy and its Relationship to Fire Management and Vegetation Structure on the Carolina Sandhills National Wildlife Refuge

Bachman's Sparrow

Prepared by

James Cox[1], Nancy Jordan[2], and Whitney Wallett[3]

[1]Tall Timbers Research Station
13093 Henry Beadel Dr.
Tallahassee, FL 32312

[2]Carolina Sandhills National Wildlife Refuge
23734 U.S. Hwy 1
McBee, SC 29101

[3]Murray State University
102 Curris Center
Murray, KY 42071

Some of the birds associated with longleaf pine (*Pinus palustris*) ecosystems in the southeastern U.S. have undergone widespread population declines in recent decades (Hunter *et al.*, 2001). Species experiencing especially precipitous declines include Northern Bobwhite (*Colinus virginianus*), a popular game species, and three songbirds: Bachman's Sparrow (*Peucaea aestivalis*), Brown-headed Nuthatch (*Sitta pusilla*), and Loggerhead Shrike (L*anius ludovicianus*). Nearly every southeastern state now lists these four pine-grassland specialists as species of conservation concerns, and efforts to stabilize populations on public lands are widespread (Cox and Widener, 2008). In South Carolina, where CSNWR is located, all four species are identified as the Highest Priority for Conservation in the South Carolina Deparment of Natural Resource's Comprehensive Conservation Plan (SCDNR 2005).

The status of these declining pine-grassland birds is not well known on many public landholdings because monitoring programs either do not exist or else fail to detect the declining species sufficiently. For example, 20 breeding bird point counts were established >15 years ago on longleaf forests in the Ocala National Forest in central Florida. Point counts generally are an excellent monitoring tool, but the Brown-headed Nuthatch has been observed on <2% of the counts conducted on the national forest. The counts affirm that a small population exists in the areas sampled, but the low detection rates also mean that the point counts are not capable of monitoring population declines. Nuthatch populations essentially will have to be eliminated before a significant trend will be observable using the available point count data (Cox *et al.*, 2012).

Many land managers are keenly interested in learning more about the status of declining species that occur on the properties they manage but lack the training needed to conduct breeding season point counts and other multi-species surveys. Monitoring programs that are designed to focus more narrowly on declining species often require less training and may provide these managers with a method for collecting important data and also increasing personal awareness of the haunts and habits of declining species. Depending on the information a single-species survey collected, the surveys also could increase understanding about specific habitat relationships on the site.

Monitoring programs that rely on the use of playback vocalizations have been developed to improve detection rates for species of interest and also reduce the training required for observers (Marion *et al.*, 1981). When the song of a Bachman's Sparrow is broadcast in a pine forest in the southeastern U.S., the bird that responds most vigorously will be a Bachman's Sparrow, not one of the other 50 species that might be present, and this territorial behavior can be used to monitor sparrow populations more efficiently than multi-species counts. The data collected in focal species surveys also typically involve simple presence/absence rather than counts of individuals, and this further simplifies survey procedures without sacrificing the utility of data in terms of trend monitoring. Recent evaluations have shown that presence/absence data provide a wealth of information because of the strong correlation between presence/absence and abundance (Cox *et al.*, 2012). Focal species monitoring also allow surveys to be tailored more specifically to local conditions. For example, Bachman's Sparrows are detected on >50% of the breeding season point counts established on the Ocala National Forest. This species is being adequately monitored by the established counts, so focal species monitoring might look solely at species such as the Brown-headed Nuthatch that are not adequately monitored by existing

counts. Finally, playback procedures and analyses also can help land managers easily measure the success of any land management efforts that might be put in place to help improve habitat conditions for declining species.

Focal species monitoring was conducted for Northern Bobwhite, Bachman's Sparrow, Brown-headed Nuthatch, and Loggerhead Shrike on the Carolina Sandhills National Wildlife Refuge (CSNWR) in 2012. The Comprehensive Conservation Plan (CCP) for CSNWR cites an objective of "developing and implementing habitat management response surveys to identify species response to treatments in longleaf pine habitat" (USFWS 2010). The strategy identified in the CCP to obtain this goal is to "monitor response to habitat treatments of pine-associated breeding birds (e.g. Bachman's Sparrow and Northern Bobwhite)." Grassland birds in general and Bachman's Sparrows in particular are also identified as "Resources of Concern" in the refuge's draft Habitat Management Plan (HMP).

Monitoring procedures follow those developed by J. Cox (Tall Timbers Research Station, Tallahassee, FL) for use by the Florida Fish and Wildlife Conservation Commission. All monitoring was performed by CSNWR interns and staff who had little previous experience in conducting focal species surveys. CSNWR encompasses nearly 46,000 acres and was established in 1939 to restore and maintain the rapidly diminishing longleaf pine/wiregrass ecosystem. The refuge supports the largest population of the endangered Red-cockaded Woodpecker (*Picoides borealis*) on Service-owned lands and also employs prescribed burning and other management techniques to maintain the longleaf ecosystem. The Red-cockaded Woodpeckers often is thought to serve as umbrella species for some of the pine-grassland birds under evaluation here, but recent studies point to distinctive habitat requirements and suggest more information be collected before assuming this relationship holds (Cox *et al*, 2012

METHODS

Refuge boundaries, timber stands, and roads were merged in ArcView GIS (version 3.2, ESRI Inc., Redlands, CA) and used to establish 65 survey points where Bachman's Sparrow, Brown-headed Nuthatch, and Northern Bobwhite would be monitored. Survey points were generated randomly using the Animal Movement extension in ArcView and were restricted to (1) pine timber stands on CSNWR, (2) an area within 10 m of established roads, and (3) locations > 300 m from other sample points. The placement of sampling points along roads reduced travel time and improved overall efficiency. Loggerhead Shrikes occur largely in association with fields on the refuge, so a separate set of 40 random points was established for this species (1) in large fields on CSNWR and (2) within 10 m of established roads. Candidate points were visited to confirm that appropriate conditions existed prior to sampling.

Each survey point was visited three times for each focal species during March-June 2012. Sampling was conducted under fair skies and when wind as measured by the Beaufort scale was ≤3. A total of 585 visits were made to the 65 points established for Northern Bobwhite, Brown-headed Nuthatch, and Bachman's Sparrow, and 120 visits were made to points established for Loggerhead Shrike. A 3-min recording containing conspecific vocalizations was broadcast during each visit, and the presence/absence of the focal species was recorded. The recorded vocalizations broadcast at each point included simple songs, aggressive calls, contact notes, and

covey calls that alternated with 15 sec of silence at the end of each min interval. The vocalizations were broadcast using an MP3 player and battery-powered external speakers with volume held constant (ca. 85 decibels). Surveys were conducted between 08:00 and 16:30, and times varied so that sites were visited at early and later periods of the day.

Forest structure was quantified at four 0.1-acre plots established 60 m from survey points along major compass headings. A 10-factor prism was used to quantify pine and hardwood basal area within each plot, and the number of snags was estimated within four distance categories (<25, 25-50, 50-100, and >100 m). Diameter at breast height (dbh) was recorded for the five closest pine trees to centerpoint of plot. Other structural vegetation measurements included estimates for the number of shrubs ≥1 m in height, canopy closure, and ground cover characteristics (i.e., prevalence of five dominant categories: grass, forb, litter, woody, and bare ground). Finally, the number of prescribed fires applied since 2000 was also calculated for each sample point. When the sample point fell between two or more burn units, the average number of prescribed fires conducted among all units was calculated as well as the highest number for individual units. Accordingly, a sample point situated between two burn units that received 4 and 6 prescribed fires during the 10-year time interval, respectively, would have an average of 5 and a maximum of 6.

Statistical Analysis

Program PRESENCE (MacKenzie *et al.*, 2002) was used to assess variation in the probability of focal species occupancy (ψ) and detection probabilities (p). The probability of occupancy is a measure of the likelihood of a focal species occurring at a sample point after adjusting for the probability of detecting the species. If a focal species is extremely abundant and recorded during all visits made to a sample point, the probability of occupancy would be 1.0 (as would the probability of detection). If a focal species is extremely rare and not observed during any visits to sampling points, occupancy would be 0.0 (and detection 0.0). If the species is observed at a portion of the visits made to some points, occupancy and detection fall between 0.0 and 1.0 (with error rates calculated for both occupancy and detection).

Program PRESENCE also allows occupancy and detection probabilities to be evaluated in relation to the habitat conditions encountered at each sample point. For example, Bachman's Sparrows and Northern Bobwhite are known to disappear from sites that are not burned regularly (Cox and Widener, 2008). The probability of occupancy can be compared to the number of burns applied to the area surrounding a sampling point for the past several years to determine what effect burn frequency might have on occupancy. Based on established literature, occupancy for both species should be higher in areas receiving more frequent burns.

Evaluating relationships between the occupancy estimated for individual focal species and site-specific habitat variables is performed using the Akaike information criterion (AIC) in Program PRESENCE. This criterion measures the fit of the relationship between habitat variables and occupancy and detection and is based on the tradeoff between accuracy and complexity (Anderson *et al.*, 2000). For example, a strong relationship between focal species occupancy and fire frequency would have a better AIC score than a strong relationship between occupancy and 3 habitat variables. Fire is considered to be a better predictor in this instance

because it is more parsimonious and involves fewer variables. Prior to performing an evaluation using AIC, it is important to develop candidate relationships for focal species *a priori* because hundreds of different habitat combinations might be considered given the number of variables measured here. AIC evaluations should be based on the potential relationships suggested by previous work and knowledge about species' habitat requirements.

RESULTS

Summary statistics for vegetation measurements are provided in Appendix 1. Results for the four focal species follow.

Bachman's Sparrow

Bachman's Sparrows were recorded at 18 of the 65 sample points. The naïve estimate for sparrow occurrence rates was 0.28. Based on previous studies, sparrow occurrence probabilities were compared to (1) pine basal area, (2) grass ground cover, (3) shrub cover, (4) the maximum of prescribed burns conducted since 2000, and (5) canopy cover at individual survey points.

The analyses performed using Program PRESENCE suggested sparrow occurrence rates were best predicted by the **number of burns** conducted since 2001 and **pine basal area**. The estimated occurrence probability averaged 0.25 (± 0.22) throughout CSNWR, and occurrence probabilities increased with both factors (Figs. 1-2). The highest occurrence probabilities (≥0.5) were associated with areas where pine basal area averaged 40-70 ft^2 per acre and portions of the area had been burned at least 5 times since 2001 (i.e., 2-3 year fire return intervals). The occurrence probabilities for each sampling location on CSNWR (Fig. 3) suggest sparrow occurrence probabilities can vary widely within subunits of the refuge.

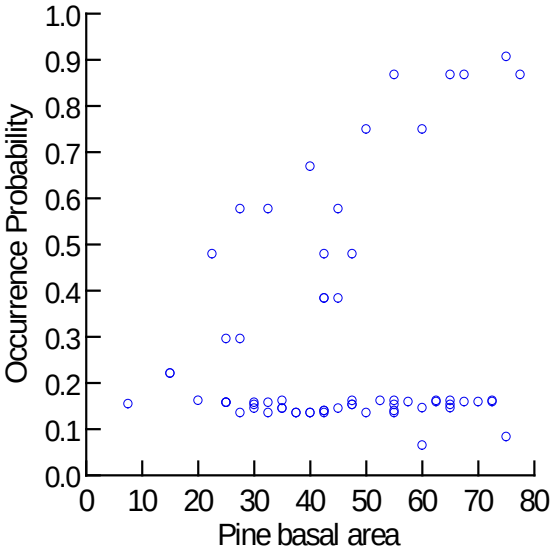


Fig. 1. Relationship between sparrow occurrence probabilities and pine basal area.

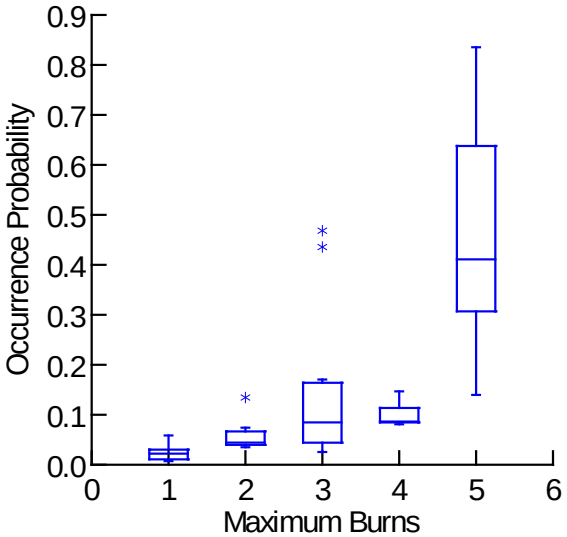


Fig. 2. Relationship between sparrow occurrence probabilities and the maximum number of fires applied since 2001.

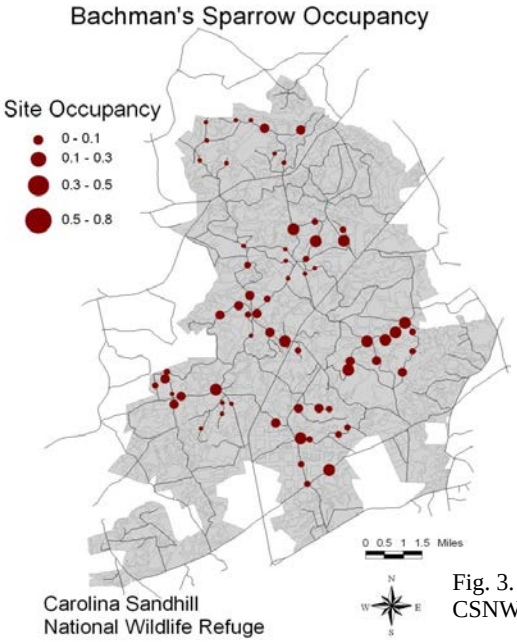


Fig. 3. Sparrow occurrence probabilities on CSNWR.

Brown-headed Nuthatch

The Brown-headed Nuthatch was recorded at 56 of the 65 sample points. The naïve estimate for nuthatch occurrence rates was 0.86. Based on previous studies, nuthatch occurrence probabilities were compared to (1) pine basal area, (2) total number of snags, (3) hardwood basal area, (4) shrub cover, and (5) the number of prescribed burns conducted since 2000.

Based on the analyses performed using Program PRESENCE, nuthatch occurrence rates were best predicted by the **total snags** recorded at sample points. The estimated occurrence probability averaged 0.90 (± 0.05) throughout CSNWR, and occurrence probabilities increased with the number of snags recorded (Fig. 4). The lines shown in Fig. 4 represent the modeled relationship with total snags and the standard error about this estimate. The distribution of occurrence probabilities on CSNWR is shown in Fig. 5.

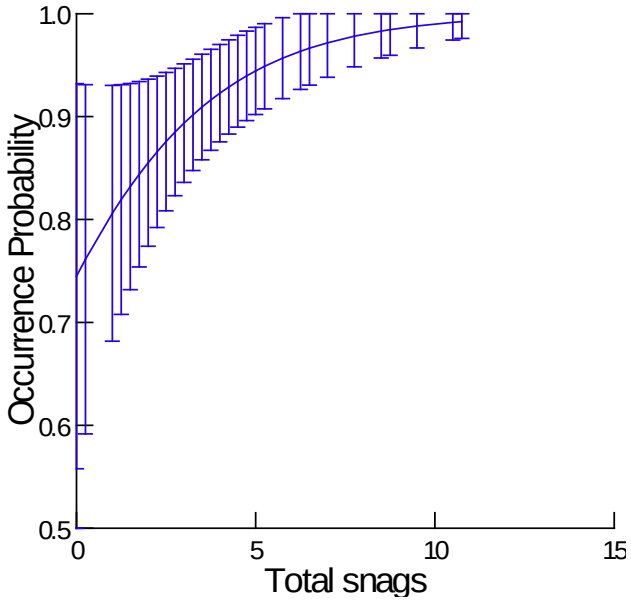


Fig. 4. Relationship between nuthatch occurrence probabilities and the number of snags recorded at sample locations.

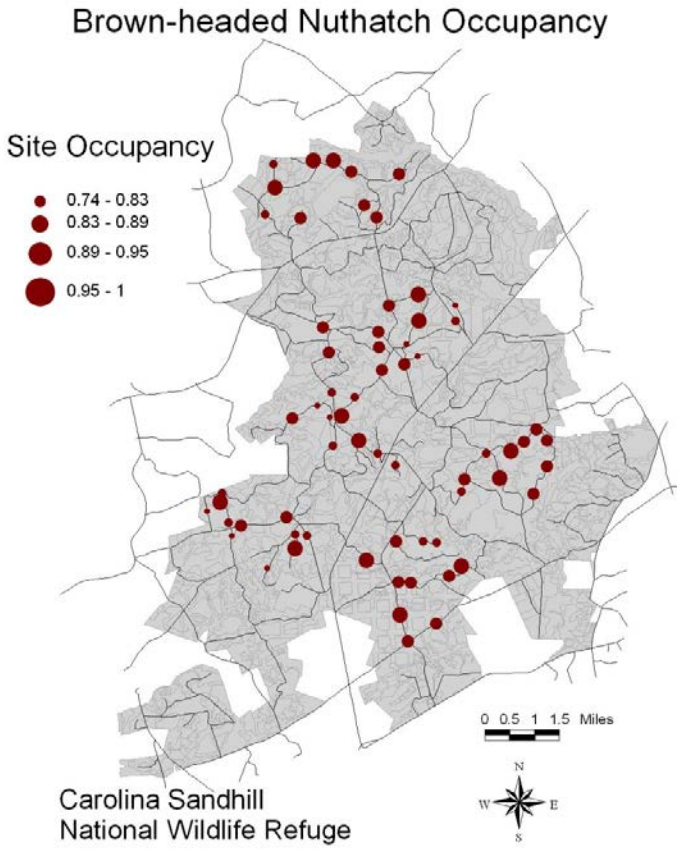
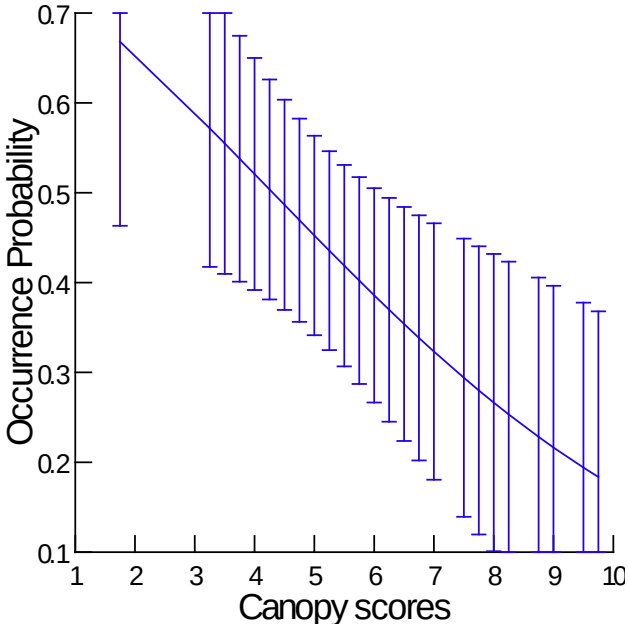


Fig.5. Nuthatch occurrence probabilities on CSNWR

Northern Bobwhite

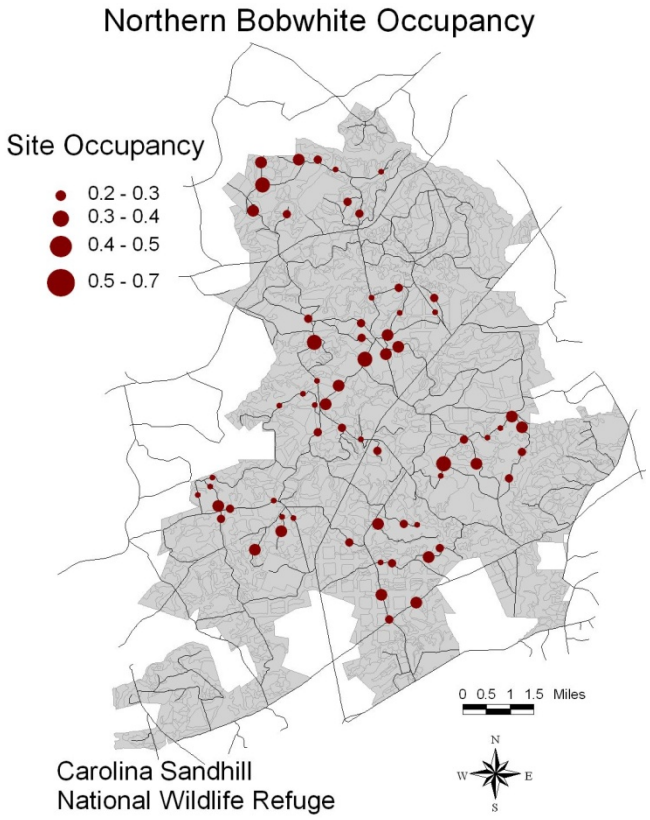
The Northern Bobwhite was recorded at 18 of the 65 sample points. The naïve estimate for bobwhite occurrence rates was 0.28. Based on previous studies, quail occurrence probabilities were compared to (1) pine basal area, (2) grass ground cover, (3) shrub cover, (4) the number of prescribed burns conducted since 2000, and (5) canopy cover.



The occurrence of bobwhites was best predicted by the **canopy scores** recorded at sample points. The estimated occurrence probability averaged 0.41 (± 0.12) across CSNWR, and occurrence probabilities decreased with increasing canopy cover (Fig. 6). The distribution of Northern Bobwhite occurrence probabilities on CSNWR is shown in Fig. 7. Similar to results for Bachman's Sparrow, variation within subunits of the refuge is evident.

Loggerhead Shrike

Loggerhead shrikes were not detected at any sampling stations and are very rare within the refuge.



DISCUSSION

Monitoring programs should be efficient, easy to conduct, and accurate. Rarely are all three conditions satisfied, and, as a result, monitoring programs typically represent a trade-off between ease, speed, accuracy, and staff availability. The data analyzed here were collected with minimal training, but the procedures required significant staff time and should therefore be compared to other monitoring procedures that might be used for these four species. The principal breeding bird monitoring program now used on CSNWR is a breeding bird survey (BBS) established in 1994. Data from this roadside survey were downloaded and analyzed for each focal species. Trends for species detected in this monitoring program are provided in Appendix 2.

Bachman's Sparrows were uncommon on focal species surveys and the BBS route. Sparrows were recorded only at an average of 1.9 (± 2.8) BBS stops each year (<10% of the survey points), and while sparrow occurrence probabilities was higher on the focal species surveys (0.25 ± 0.22), they still were lower than the probabilities recorded for Bachman's Sparrows at other sites. Sparrow occurrence probabilities on Tall Timbers Research Station and other properties in the Red Hills region of Florida and Georgia were significantly higher (>0.80) than occupancy rates recorded on Carolina Sandhill National Wildlife Refuge (Fig. 8).

Sparrow occurrence probabilities were strongly associated with fire frequencies <3 years. This is consistent with other findings and suggests more frequent burning may be the best mechanism for increasing sparrow numbers. Factors that might affect burn frequencies on CSNWR are unknown, but methods for increasing burn frequency might include conducting burns over a broader window of the annual period (including the sparrow breeding season), burning larger acreages, and strategically burning some areas consistently at <3 year return intervals. Burn frequency generally is more important that burn season and burn extent in establishing suitable conditions for Bachman's Sparrows. Burning some areas consistently at <3year intervals could establish stable sparrow populations in selected areas while other parts of the refuge are burned using longer rotations. This might be accomplished through the established of 4 or more 5,000-acre demonstration areas where frequent fire intervals are applied.

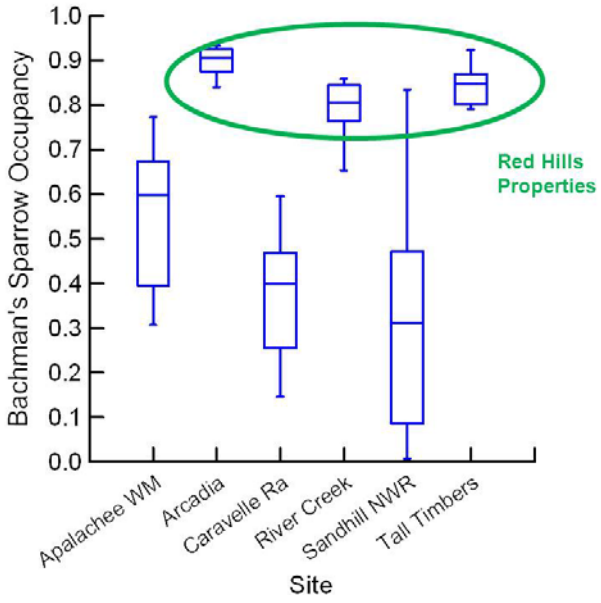


Fig. 8. Bachman's Sparrow occupancy on 6 sites where focal species monitoring was conducted 2011-12.

Continued sparrow declines, should they occur, will not likely to be monitored adequately using the BBS data currently available for CSNWR. The BBS also may not monitor population increases that take place if burning of selected areas away from the BBS is pursued as a strategy for improving sparrow numbers. On the other hand, the focal species procedures used here could monitor sparrow response to alternate management procedures because current occupancy rates are <1.0 and strong responses to increasing burn frequencies seem likely (Fig. 2). For example, given the current occurrence rates (0.25 ± 0.22) observed on the refuge, an increase in occurrence to 0.5 would be statistically significant (assuming $P < 0.05$). Accordingly, focal species monitoring for Bachman's Sparrow should be continued every 2-3 years to help

supplement the data collected on the BBS. Reduced variation in the estimated occupancy rates might be achieved if each point were visited four times rather than three times during years when the surveys were conducted, and this modification should be considered during the next sampling interval to assess potential improvements. In addition, initiation of a mark-resighting study of Bachman's Sparrow also could have value. Current numbers appear to vary substantial within smaller areas, and understanding how sparrows disperse and make use of recently burned areas could help inform management.

The Brown-headed Nuthatch is common on CSNWR and appears to be monitored adequately by the established BBS (averaging 6.4 ± 3.8 individuals on the route). The occurrence probabilities exceeded 0.8 at all the sample locations and also had low variability (SD = 0.05). The strong relationship between nuthatch occupancy and snag numbers also is consistent with other studies, though occurrence probabilities were relatively high (>0.5) even at sites with low cavity resources.

The high occurrence probabilities found for nuthatches on CSNWR differed markedly from the occurrence probabilities found on sandhill forests of the Ocala National Forest in central Florida (ca. 0.4 ± 0.2) and point to interesting variation within this broad community type (Cox *et al*, 2012). The declining trend shown for nuthatches on the BBS route at CSNWR should be monitored. The trend may be the result of extrinsic factors that are unrelated to population declines (e.g., road-side bias), but, if declines continue for another 5 years, a second focal species effort for nuthatches should be considered so that more precise occupancy information is gathered across the refuge.

The Northern Bobwhite was uncommon on focal species surveys and exhibits pronounced downward trends on the CSNWR BBS. Northern Bobwhites had higher occurrence probabilities on focal surveys than Bachman's Sparrows, and bobwhite occurrence was best predicted by the measure of canopy closure. As evident in Fig. 6, there were wide error bars about the estimated relationship (e.g., the range spanned 0-.05 where the probability was estimated at 0.3), and it is likely that additional sampling will be needed to model the relationship more accurately. Recent studies also have suggested that some bobwhite vocalizations will elicit stronger responses and could help improve detection probabilities during the breeding season. Once this is addressed, focal species monitoring should be pursued for this species every 2-3 years to help supplement BBS data. In addition, initiation of a mark-resighting study of Northern Bobwhite could have value similar to that described for Bachman's Sparrow.

The Loggerhead Shrike was not observed on focal surveys and has not been observed on BBS routes. Unlike the other species discussed, this declining species is not likely to benefit from subtle changes in habitat management on CSNWR.

In summary, focal species monitoring should continue for Bachman's Sparrow and Northern Bobwhite on CSNWR. Both species are declining and appear to occur at low densities,

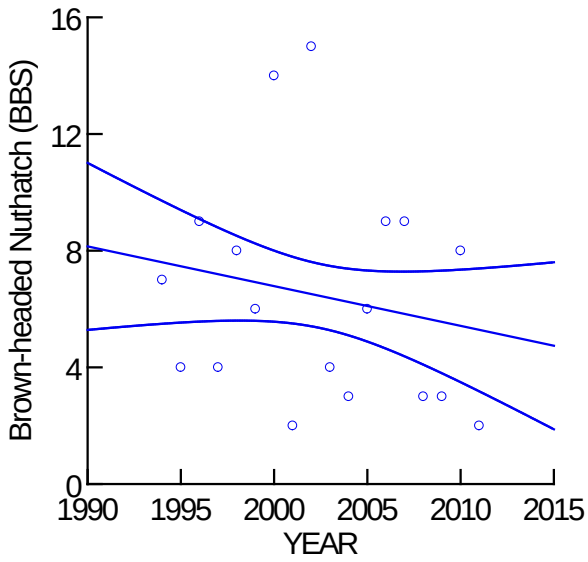
and data collected through focal species monitoring could provide important improvements over the data currently available through the BBS route on CSNWR. Focal species monitoring for sparrows and quail could be conducted in alternating years so as not to increase staff requirements significantly. Biennial surveys likely could be completed in 2 weeks by interns and provide more detailed information on population trends and responses to management. The number of visits made to each site also might be increased to four during the next sampling period to assess whether additional visits improve survey precision, and recent publications suggest alternate playback vocalizations should be developed for Northern Bobwhite (Rusk *et al.*, 2006). Fire frequency likely will be the most important variable influencing habitat occupancy for these species, so collection of additional habitat information may be unnecessary and could be done as time allows. Future habitat variables to be measured also should be limited to subset of the variables gathered here.

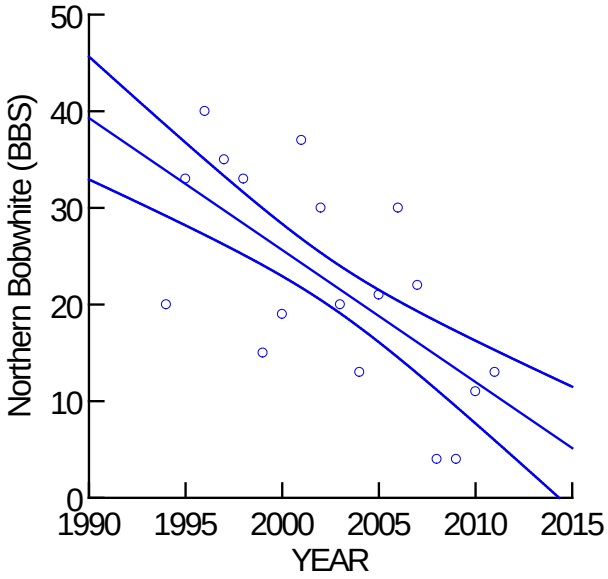
Appendix 1. Summary statistics for the habitat and burn information compiled for survey points.

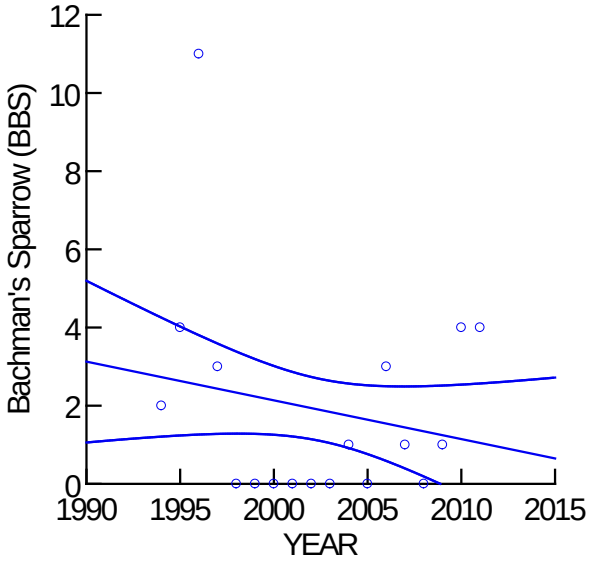
Variable	Mean	SD	Median	Min	Max
Forb Count	5.4	4.9	4	0	20
Wood Ground Cover	5.1	3.9	4	0	17
Bare Ground	6.1	5.5	5	0	20
Litter Ground Cover	18.3	3.4	20	0	20
Shrub Count	5.3	2.8	6	0	10
PDBH1	10.9	4.5	11.15	0	20.2
PDBH2	10.3	4.3	10.4	0	20.6
PDBH3	10.3	4.5	10.3	0	21.7
PDBH3	10.3	4.4	10.5	0	20.1
PDBH4	10.5	4.6	10.35	0	22
PDBH5	6.0	3.0	6	0	10
Canopy Cover	6.1	4.1	6	0	20
Pine basal area	45.5	28.9	40	0	150
Hardwood basal area	6.0	13.1	0	0	90
Fires since 2001	3.0	1.4	3	0	5
Snags < 25m	0.8	1.6	0	0	19
Snags 25-50m	0.8	1.5	0	0	14
Snags 50-100m	1.1	1.9	0	0	12
Snags >100m	1.6	1.9	1	0	10
Total Snags	4.3	4.1	4	0	26

Appendix 2.

Trends for focal species on the breeding bird survey established on CSNWR. The lines shown in each plot depicts the regression line computed for counts against year and the 95% confidence interval about the regression. All trends were significantly negative.







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