BioOne RESEARCH EVOLVED

Painted Bunting Abundance and Habitat Use in Florida

Author(s): Michael F. Delany, Bill Pranty and Richard A. Kiltie
Source: Southeastern Naturalist, 12(1):61-72.
Published By: Eagle Hill Institute
DOI: http://dx.doi.org/10.1656/058.012.0105
URL: http://www.bioone.org/doi/full/10.1656/058.012.0105

BioOne (www.bioone.org) is a nonprofit, online aggregation of core research in the biological, ecological, and environmental sciences. BioOne provides a sustainable online platform for over 170 journals and books published by nonprofit societies, associations, museums, institutions, and presses.

Your use of this PDF, the BioOne Web site, and all posted and associated content indicates your acceptance of BioOne's Terms of Use, available at www.bioone.org/page/terms_of_use.

Usage of BioOne content is strictly limited to personal, educational, and non-commercial use. Commercial inquiries or rights and permissions requests should be directed to the individual publisher as copyright holder.

BioOne sees sustainable scholarly publishing as an inherently collaborative enterprise connecting authors, nonprofit publishers, academic institutions, research libraries, and research funders in the common goal of maximizing access to critical research.

Painted Bunting Abundance and Habitat Use in Florida

Michael F. Delany[1,*], Bill Pranty[2], and Richard A. Kiltie[1]

Abstract - A cooperative multi-state monitoring effort was initiated for *Passerina ciris* (Painted Bunting) in 2008 because of a suspected decline in its eastern population. The Florida component of this range-wide study was conducted during 3 consecutive breeding seasons to obtain a better understanding of abundance and habitat use (vegetation associations) than could be obtained from existing indices, to examine factors affecting detectability, and to determine whether short-term trends could be assessed. Sample units (three hundred two 0.01–27-km^2 blocks) were allocated for Florida from which 22 were randomly selected, within which 101 point-count survey stations were established. Point-count surveys (n = 906) were conducted annually from 2008 to 2010, and vegetation characteristics were quantified for each location. Abundances were estimated from the counts by an N-mixture model for open populations. Estimated mean breeding density of male Painted Buntings in Florida decreased from 12.4 males/km^2 in 2008 to 9.8 males/km^2 in 2010; these densities are at the low end of the range previously reported for the eastern population. In combination with an estimate of available habitat (1558 km^2), the mean estimate of the total number of males (maximum potential abundance) decreased from 19,319 in 2008 to 15,268 in 2010. Painted Bunting abundance in Florida was greater toward the northern end of its range. Abundance was positively associated with the amount of maritime forest and hammock at count points and negatively associated with the amount of planted pine. Conservation of remaining maritime forest and hammock will be fundamental in maintaining breeding populations of the Painted Bunting in Florida.

Introduction

Passerina ciris L. (Painted Bunting) occurs in two geographically distinct breeding populations: a western population occurring west of Florida south to parts of Mexico, and an eastern population limited to coastal areas from North Carolina to north Florida and extending inland in South Carolina and Georgia (Lowther et al. 1999, Sykes and Holzman 2005). Breeding records in the Florida panhandle (Ogden and Chapman 1967) may represent expansion of the western population or an overlap of occurrence of both populations (Thompson 1991). Because of suspected population declines, the Painted Bunting was listed on the Partners in Flight Watch List as a species of special concern (Lowther et al. 1999) and identified as a high priority for conservation action (Rich et al. 2004).

Although Breeding Bird Survey (BBS) data suggested that eastern Painted Buntings had declined, Meyers (2011) noted that the birds had become too rare in that part of their range for the BBS to serve as a useful source of population-trend estimates. He recommended that methods producing density estimates be applied, especially those that account for incomplete detection. Mean estimates

[1]Florida Fish and Wildlife Conservation Commission, 1105 SW Williston Road, Gainesville, FL 32601. [2]8515 Village Mill Row, Bayonet Point, FL 34667. [*]Corresponding author - mike.delany@myFWC.com.

of 9–42 singing males/km^2 (depending on habitat) from a distance-sampling approach based on 582 count points made in 2003 throughout the eastern range of the Painted Bunting (≈10% in NC, 38% in SC, 39% in GA, and 13% in FL) were reported (Meyers 2011).

Although BBS data for eastern Painted Bunting population trends are inconclusive at the state level, current analyses suggest the decline of the species may be most severe in Florida (Sauer et al. 2011; see especially http://www.mbr-pwrc.usgs.gov/cgi-bin/atlasa09.pl?06010&1&09). Such a decline might reflect land-use changes in the species' pericoastal habitats, which are more pronounced in Florida than in other states of the bird's eastern range.

Here we report results of a multi-year study designed to assess breeding-season abundance and habitat associations for the Painted Bunting in peninsular Florida. We used an alternative to distance sampling for estimating detection probability based on repeat visits to a site, and applied a new technique for estimating inter-year change in abundance from such data (Dail and Madsen 2011). We performed this study as participants in the Working Group for the Eastern Painted Bunting. The cooperative multi-state monitoring effort was organized by the Georgia Department of Natural Resources and the US Geological Survey Patuxent Wildlife Research Center in 2001, with representatives from Florida, North Carolina, South Carolina, and the US Fish and Wildlife Service.

Methods

A grid of potential sample blocks (0.05°, 27 km^2) was overlaid on the breeding range of Painted Buntings in Florida, as delineated by Sykes and Holzman (2005). The exclusion of blocks containing >30% unsuitable urban land cover and exclusion of unsuitable urban areas in the remaining blocks resulted in a sample area of 5360 km^2. The list of blocks was permuted by drawing them at random without replacement, where selection probability was proportional to block size (state boundaries and unsuitable land covers resulted in blocks of irregular size). Blocks were visited in the order drawn to determine whether survey points could be established. The range of the eastern Painted Bunting in Florida was 11% of its range-wide occurrence (Sykes and Holzman 2005), requiring a survey sample size of 20 blocks. The sampling scheme was developed by the Working Group for the Eastern Painted Bunting, with previous survey results (Meyers 2011) used to estimate variance and determine sampling effort based on a desired level of precision.

Proceeding in random block order, we identified the road intersection nearest to the center of the sample block. This represented the first of 6 possible survey points within the sample block. Successive roadside points were established at 500-m intervals in a random direction from the initial point. A point was included in the survey if a 200-m radius surrounding the point contained ≥1% habitat suitable for Painted Buntings and was accessible. For each established count point, we recorded the coordinates using a hand-held GPS receiver. All habitats were considered potential habitat for Painted Buntings except closed-canopy forest,

paved or impervious surfaces, open water, mowed lawns without trees or shrubs, and agricultural fields without shrubs or shrubby borders (i.e., unsuitable habitat). If at least 3 count points could not be established, the block was rejected in favor of the next one on the randomized list. This selection process allowed estimation of the percentage of Painted Bunting habitat available, and the proportion of the landscape that was excluded from the survey.

A total of 302 sample blocks (0.01–27-km^2, depending upon the grid overlay) was allocated for Florida from which 22 were selected (Fig. 1) and count points (n = 101) established. In the attempt to establish 3–6 survey points within each block, 21 blocks were rejected because of unsuitable habitat, 6 were rejected because access was unavailable, and 1 was rejected because it was located in an area we deemed to be unsafe. Within the 22 sample blocks accepted, 77 count points were rejected because the 200-m radius contained <1% potential habitat for Painted Buntings.

The Working Group for the Eastern Painted Bunting established the following survey protocol for use across the 4-state survey effort. Standard point-count surveys (Ralph et al. 1993) were restricted to an estimated fixed-radius (75-m) circle from the count point. Visual and auditory observations were recorded during a 5-minute interval at each count point. The annual survey period was from 1 May to 15 June (2008–2010). Counts were conducted in the 4.5-hour period beginning 0.5 hour before official sunrise, and during the 3-hour period prior to official sunset. Morning surveys (n = 663) were conducted from 0615 to 1048 hrs and evening surveys (n = 243) were conducted from 1709 to 2009 hrs.

Counts were conducted in weather conducive to detecting (i.e., seeing or hearing) Painted Buntings, and were not conducted during conditions of rain, high wind velocities (>12 kph), and high ambient noise. The number, age, and sex of Painted Buntings detected were recorded. The dataset included counts of birds at all individual within-year surveys. The number of cars passing during the time of observation and the estimated percent time of other disturbing noise in 4 categories (none, low, medium, and high) were recorded. Cloud cover, and wind speed (as 3-level ordinal variables) also were recorded. The survey protocol required that counts be conducted at each point on 3 independent occasions during each year's survey period by the same observer, and allowed repeated measures on the same day; the mean (with median, maximum, and minimum) times between sequential pairs of site visits were 61.8 (11.2, 623.2, and 0.4) hr in 2008, 44.2 (10.5, 529.2, and 0.4) hr in 2009, and 16.3 (0.9, 288.1, and 0.4) hr in 2010. Seven observers participated in the study. Seventy-five percent of the site visits were made by one observer, whereas 3–6% were made by each of the remaining six observers.

For the area within a 75-m radius around each point location, habitat was assessed by visual estimates (in 10% increments) for each of the following components: unsuitable habitat, maritime shrub, maritime forest and hammock, open pine and pine hardwood, early successional forest, interior shrub-scrub, riparian, agriculture, closed-canopy forest, and planted pine. For convenience and following precedent of related previous studies, we used

habitat to refer to the ecological descriptions of the census points provided by these 10 variables, although vegetation association may be a more suitable term for their information (Hall et al. 1997).

Correlations of the habitat variables were addressed by principal components analysis of the centered log-ratio covariance matrix after adding 0.01 to the values so that logarithms could be taken. This approach takes into account the non-independent nature of percent-composition variables, which must total 100% (Jackson 1997, Reyment and Jöreskog 1993) and transforms the decile estimates to a more continuous scale. Varimax rotation (which maintains independence of the axes) was performed to improve interpretability (Johnson and Wichern 2002).

Point-count analysis

Analyses were performed using package "unmarked", version 0.9-7 (Fiske and Chandler 2011, Fiske et al. 2012) for the R statistical environment, version 2.15.0 (R Development Core Team 2012). We applied Royle's (2004) maximum likelihood method for modeling abundance and detection probability from spatially replicated point counts with Dail and Madsen's (2011) extension to estimate between-year survival and recruitment. In this "robust design" approach, the model assumes that recruitment (births or immigration) and imperfect survival (deaths or emigration) may occur in the study population at each survey point between years but not between visits within years. Painted Bunting abundance in each year at each survey point was estimated either as an overall average ("intercept only") or as a function of an intercept, of survey point latitude (which was correlated with longitude), and of site scores on the 6 habitat factors accounting for 90% of the among-site variance in the original habitat variables. Either Poisson or negative binomial latent abundance distributions were assumed. Detection probability was estimated either as an overall average or as a function of an intercept and of 5 variables assessed at each survey visit: log(car count + 0.1) (rescaled to mean 0 and SD = 1), noise level, sky cover, wind level, and time of day (rescaled to mean 0 and SD = 1). Between-year recruitment and survival were estimated as averages over the three years of the study. Thus, there were eight models compared by assuming either Poisson or negative binomial latent abundance distributions with the following four combinations of predictors: intercept only for both abundance and detection probability, intercept only for abundance and intercept plus 5 covariates for detection probability, intercept plus 7 covariates for abundance and intercept only for detection probability, and intercept plus 7 covariates for abundance and intercept plus 5 covariates for detection probability. Relative goodness of fit was compared by AICc, and absolute goodness of fit was evaluated by the parametric bootstrap test using the sum of squared errors with 250 replicates (Kéry et al. 2005, MacKenzie and Bailey 2004). A likelihood-ratio test was also used to compare nested Poisson and negative binomial models (Cameron and Trivedi 1998).

Recruitment, survival, and average detection probability were estimated by backtransforming the appropriate model parameter estimates. Painted Bunting

abundance in the total sample area was estimated for 2008 as the sum of the back-transformed predicted abundances at the survey points. For 2009, the abundance estimates of 2008 were multiplied by the survival estimate, and the recruitment estimate was added (Dail and Madsen 2011). For 2010, the 2009 abundance estimates were multiplied by survival and recruitment was added. Confidence intervals for all estimates were based on a parametric bootstrap of the best model with 1000 simulations. Density estimates per km^2 were computed by dividing the estimated total yearly abundance summed over the 100 count points and their upper and lower 95% confidence limits by 1767 km^2, the total assumed area of the survey sites. Additional details of the modeling and estimation methods are provided (Supplementary Appendix 1, available online at http://www.eaglehill.us/SENAonline/suppl-files/s12-1-1058-Delany-s1, and, for BioOne subscribers, at http://dx.doi.org/10.1656/S1058.s1).

Results

The 906 point-count surveys detected Painted Buntings at 20 points within 8 sample units (Fig. 1). There were 134 observations of Painted Buntings (114 males, 4 females, and 16 of undetermined gender) during 3 years, with 8 of these detections occurring outside the 75-m point-count sample radius. Most males (n = 83; 73%) were detected auditorily; 19 (16%) were detected visually, and 12 (10%) were detected both auditorily and visually. No points were abandoned because of non-detection of birds. After excluding 31 observations during 9 surveys at a count point with a bird feeder, which could have biased results, only detections of known males (n = 75) within the 75-m-radius sample area were included in the analyses.

There was mild reduction of the habitat descriptor data through principal components analysis. Six habitat factors were able to account for 90% of the original variance before rotation. After rotation, scores on each factor were strongly positively correlated with one original variable and moderately negatively correlated with one or two other variables (Table 1). This result

Table 1. Loadings (correlations) of the original habitat variables with 6 factors after varimax rotation for Painted Buntings in Florida, 2008–2010. Major contributors to each factor are in bold underline, and lesser contributors with correlations ≥0.30 (an arbitrary distinction) are in bold.

	Rotated factor loadings					
	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6
% unsuitable habitat	**-0.33**	-0.08	-0.22	-0.15	-0.13	**0.88**
% maritime shrub	0.04	**0.98**	-0.13	0.06	-0.11	-0.03
% maritime forest and hammock	**0.96**	0.02	-0.14	-0.03	-0.13	-0.16
% open pine	-0.11	-0.10	-0.02	-0.01	**0.99**	0.07
% early succession forest	-0.16	**-0.38**	-0.02	**0.86**	**-0.30**	0.01
% interior shrub-scrub	0.03	-0.13	0.03	**-0.40**	-0.13	-0.01
% riparian	-0.03	-0.01	-0.05	-0.08	-0.07	-0.26
% agricultural	**-0.49**	**-0.37**	**-0.45**	**-0.37**	-0.09	**-0.49**
% closed canopy	0.16	0.06	-0.03	0.28	-0.02	0.08
% planted pine	-0.14	-0.15	**0.96**	-0.14	-0.03	-0.03

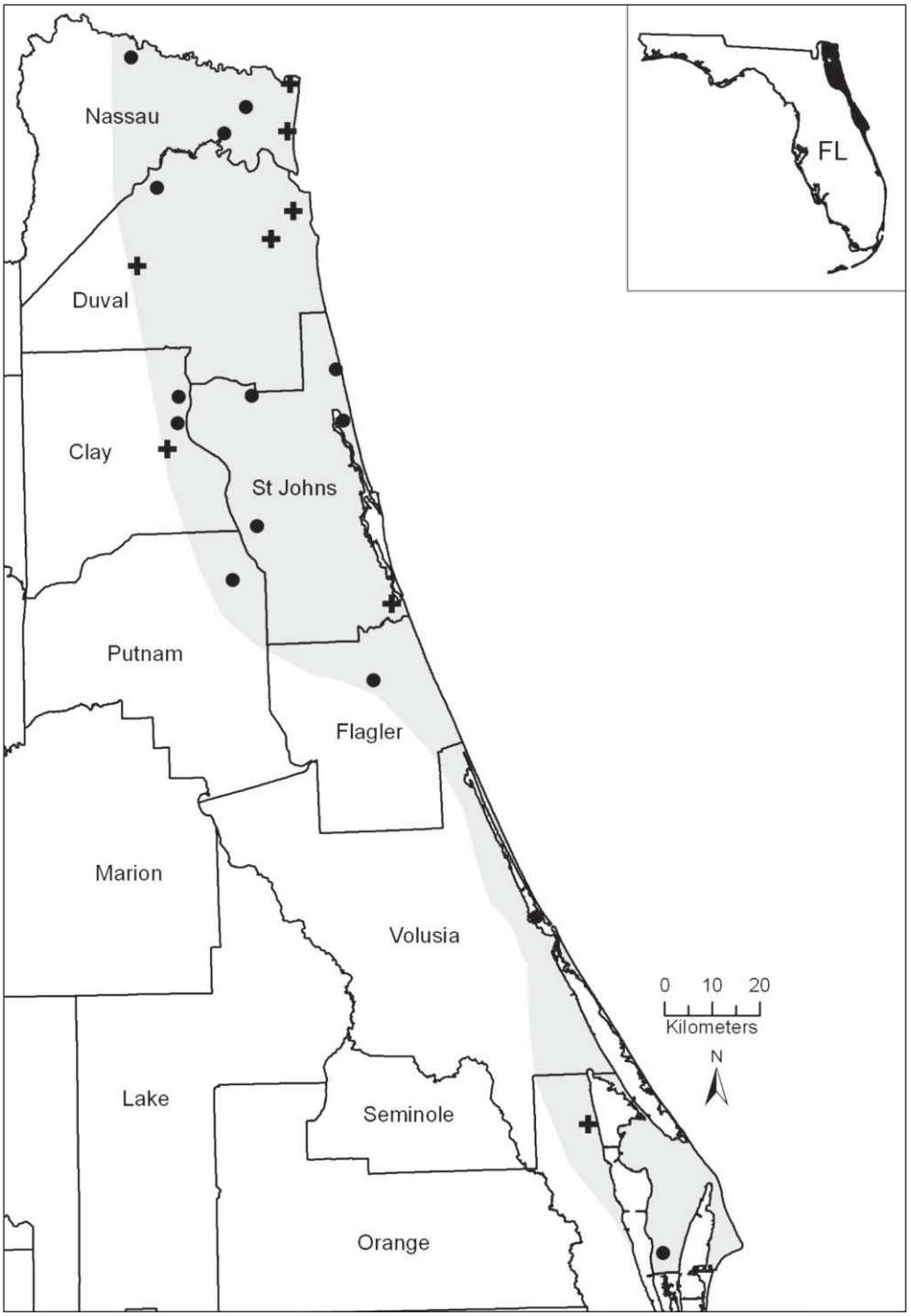

Figure 1. Centroids of 22 sample areas (randomly selected and verified 27 km^2 blocks) for Painted Bunting point count surveys in Florida, 2008–2010. + = blocks in which Painted Buntings were detected. • = blocks surveyed but no Painted Buntings detected. The breeding range of the Painted Bunting in Florida (Sykes and Holzman 2005) is shaded.

suggested that the factors represented habitat contrasts. For example, on factor 1, highest scores would be for sites with highest maritime forest cover and little unsuitable habitat and agricultural land; on factor 2, highest scores would be for sites with high percentage maritime shrub cover and little early succession or agricultural, etc. (see Table 1).

The best point-count model by AICc was one assuming a Poisson latent abundance distribution with covariates for abundance and only an intercept as predictor of detection probability (Table 2). Four models with no abundance covariates immediately could be dismissed as implausible given their AICc weights. Dispersion parameters for the remaining negative binomial models (2 and 4) were not significantly different from 0 ($z = 0.12$, $P = 0.91$ for model 2; $z = 0.-0.32$, $P = 0.75$ for model 4), and likelihood-ratio tests indicated that neither was significantly better than the corresponding Poisson model (model 1 vs. 2: $\chi^2 = 0.00$, $df = 1$, $P = 0.98$; model 3 vs. 4: $\chi^2 = 0.67$, $df = 1$, $P = 0.42$). The negative binomial models therefore appeared redundant to their corresponding Poisson models and were not considered further. When comparison was made only between models 1 and 3, model 1's AICc weight (0.86) fell slightly short of Burnham and Anderson's (2002) criterion (0.90) for acceptance as a single best model. However, none of the detection probability covariate effects of model 3 differed from 0 at $P \leq 0.05$, and abundance and density inferences from that model differed by $\leq 2\%$ from those of model 1. A parametric bootstrap test indicated good fit ($P = 0.426$) for model 1, so this model was used for abundance and density estimates.

Parameter estimates and associated statistics for model 1 are presented in Table 3. There was a significant positive association of abundance with latitude of survey point and with habitat factor 1, which represented a contrast between maritime forest and the combined class agriculture and unsuitable habitat (Table 1). There was a marginally significant negative association between abundance and habitat factor 3, the contrast between planted pine and agriculture.

Total abundance of Painted Buntings at the 100 survey points was estimated to be 22.0 (95% CI = 12.0–33.1) in 2008; 19.3 (95% CI = 11.0–28.6) in 2009;

Table 2. Model comparisons by information criteria. For abundance covariates, "none" indicates intercept only, "all" indicates intercept plus latitude rescaled to mean 0 and SD = 1 and scores on 6 habitat PCA axes. For detection probability covariates, "none" indicates intercept only, and "all" indicates intercept plus log(car count + 0.1) (rescaled to mean 0 and SD = 1), noise level, sky cover, wind level, and time of survey within day (rescaled to mean 0 and SD = 1). K is the number of model parameters.

Model #	Distribution	Abundance covariates	Det. Prob. covariates	K	AICc	ΔAICc	AICc weight	Cumulative weight
1	Poisson	All	None	11	320	0.00	0.66	0.66
2	Negative binomial	All	None	12	323	2.60	0.18	0.84
3	Poisson	All	All	16	324	3.61	0.11	0.95
4	Negative binomial	All	All	17	326	5.87	0.04	0.99
5	Negative binomial	None	All	10	328	7.90	0.01	1.00
6	Negative binomial	None	None	5	332	11.87	0.00	1.00
7	Poisson	None	All	9	336	15.81	0.00	1.00
8	Poisson	None	None	4	340	19.90	0.00	1.00

and 17.3 (95% CI = 8.7–27.9) in 2010. Density estimates of Painted Buntings implied by the abundance estimates were 12.4/km^2 (95% CI = 6.8–18.7) in 2008; 10.9/km^2 (95% CI = 6.1–16.2) in 2009; and 9.8/km^2 (95% CI = 4.9–15.8) in 2010. Detection probability was estimated to be 0.43 (95% CI = 0.31–0.54). The estimated recruitment at each site between years was 0.03 (95% CI = 0.0–0.07.). The estimated survival probability between years was 0.76 (95% CI = 0.55–0.95).

Discussion

Our mean estimates of the breeding density of male Painted Buntings in Florida are at the low end of the range previously reported for the subspecies. Hamel (1992) reported range-wide breeding densities from 5.2 to 9.0 males per 40 ha (13–23/km^2), depending on habitat conditions, with greater densities in maritime forest than in mixed pine hardwood forest. Densities throughout the breeding range estimated by Meyers (2011) ranged from 9 males per km^2 in pine plantations to 42 males per km^2 in maritime shrub; the overall average (weighted by habitat sample size) was about 23 males/km^2.

Several factors might contribute to our relatively low average density estimates and ostensibly declining population. One might be that the decline of the Painted Bunting in Florida is continuing as suggested by the BBS data. Annual mean estimates of abundance and density from our model suggest that the rate of decline of Painted Buntings in Florida may be even more rapid than suggested by the BBS over a longer time span. Continued monitoring will be needed to confirm whether such a change is occurring. Somewhat low abundance and density estimates also may be due to the method of survey-point determination. The count points were chosen to represent random locations within the known range of Painted Buntings in peninsular Florida where the birds could occur, but they

Table 3. Parameter estimates from Poisson open-population model for Painted Buntings in Florida, 2008–2010. Scaled abundance predictors were standardized to mean = 0, standard deviation = 1. *P* (> |*z*|) indicates significance level of test that the parameter is 0.

	Estimate	SE	*z*	*P* (>|*z*|)
Abundance (log scale)				
Intercept	-4.084	1.285	-3.18	0.001
scale (latitude)	1.105	0.548	2.02	0.044
Habitat factor 1	1.129	0.446	2.53	0.011
Habitat factor 2	-0.135	0.492	-0.27	0.784
Habitat factor 3	-3.235	1.822	-1.78	0.076
Habitat factor 4	0.468	0.438	1.07	0.285
Habitat factor 5	-0.352	0.481	-0.73	0.465
Habitat factor 6	-0.257	0.297	-0.87	0.386
Detection (logit scale)				
Intercept	-0.276	0.269	-1.03	0.305
Recruitment (log scale)				
Intercept	-3.641	0.535	-6.81	0.000
Survival (logit scale)				
Intercept	1.148	0.521	2.2	0.028

may differ from habitat representations used in previous studies. Our habitat data were measured on fundamentally continuous scales that make our results not directly comparable to those of other studies in which the goal was habitat-specific inferences. More appropriate comparisons may be made by examining densities predicted by our model at survey points representing the most favorable measured extremes of the significant habitat covariates: The mean predicted densities of males at the 10 survey points with greatest values for F1 (habitat factor most highly correlated with maritime forest and hammock and positively related to abundance) were 44.5 (2008), 33.8 (2009), and 25.7/km^2 (2010). The mean predicted densities of males at the 10 survey points with lowest values for F3 (habitat factor most highly correlated with planted pine and negatively related to abundance) were 13.6 (2008), 10.4 (2009), and 7.9/km^2 (2010).

Another consideration may be that our density estimates do not take into account any possible discrepancy between the assumed 100% detection rate within the 75-m count radius and a realized effective detection radius (EDR). Meyers (2011) obtained EDR = 57 m in undeveloped habitats and EDR= 70 m over all habitat types. If EDR in our study were 57, the point density estimates would have been 21.5 males/km^2 (2008), 18.9 males/km^2 (2009), and 16.9 males/km^2 (2010); if EDR were 70, the estimates would have been 14.3 males/km^2, 12.6 males/km^2, and 11.2 males/km^2 respectively. These density estimates for Florida would be closer to those reported for other areas (Hamel 1992, Meyers 2011).

Assuming that sample blocks and count points were representative of habitat available in Florida, and applying proportions of suitability that we found in our selection process (22 of 43 sample blocks and 101 of 178 count points, or about 29%), we estimate that there was 1558 km^2 of potential habitat in the 5360-km^2 sample area. Combining our mean estimates of Painted Bunting density and the estimate of potential habitat indicates a total estimated population of 19,319 (2008) to 15,268 (2010) males, but corresponding confidence intervals are wide (10,594–29,124 and 7634–24,616). This extrapolation of a state-wide population estimate should be viewed as the maximum potential abundance. Although our mean estimates of density seem low compared with previous estimates from other parts of the eastern range, the mean total population estimates extrapolated above are greater than an estimate by Partners in Flight of 7479 Painted Buntings in Florida (based on BBS data and Rosenberg and Blancher's [2005] corrections; PIF 2007).

Consistent with previous reports (Cox 1996, Robertson and Woolfenden 1992, Stevenson and Anderson 1994, Sykes and Holzman 2005), Painted Buntings in Florida were less abundant in the southern portion of their breeding range and used a variety of breeding habitats. Birds were found in agricultural fields bordered by mature oaks, overgrown fields, maritime shrub, citrus groves, and maritime forest. Painted Bunting abundance was greater in maritime forest than in other habitat types, with a weaker association between abundance and maritime shrub. In contrast, Meyers (2011) found greater densities of Painted Buntings in maritime shrub. Maritime forests and hammocks adjacent to salt marsh appeared

to be an important structural feature in habitat selection by Painted Buntings in Florida. Similarly, Lanyon and Thompson (1986) found that eastern Painted Buntings in coastal Georgia preferred "higher quality" territory locations at the edge of salt marshes to sites in interior forested areas. The edge of forests and open areas rather than interior forest locations also appeared to be important breeding habitat for Painted Buntings in eastern Texas (Dickson et al. 1995, Kopachena and Crist 2000) and Oklahoma (Parmelee 1959). Painted Buntings are usually absent from forests that have little understory (Lowther et al. 1999), and our results suggest a negative association in abundance in pine plantations and open pine habitat. However, habitat affinities of Painted Buntings presented here may be biased because roadside sampling of avian populations may not adequately represent available habitat (Betts et al. 2007).

Conservation and management of remaining maritime forest will be fundamental in the conservation of breeding Painted Buntings in Florida. Development of these habitats reduces density as much as 50% (Meyers 2011). Because maritime shrub is maintained by natural forces that create open areas, Springborn and Meyers (2005) did not recommend prescribed fire to manage this plant community. Mature maritime forests and hammocks with natural openings also require little management for Painted Buntings. Local extirpations may be related to the size and isolation of habitat fragments (Fahrig and Merriam 1994), so spatial relationships of extant populations and areas of potential habitat should be considered in management plans designed to maintain connectivity. Significant populations of Painted Buntings exist on public lands in Florida. Annual point-count surveys should be conducted at these locations to monitor populations and evaluate land-management actions. Based on our model estimates, future surveys and analysis should incorporate both site and observation covariates.

Acknowledgments

H. Alboher, G. Clark, P. Scalco, and M. Wooley (Florida Department of Environmental Protection) provided administrative support for work at Fort Clinch State Park. J. Ellenberger (Florida Fish and Wildlife Conservation Commission, [FWC]) assisted with access to Guana River Wildlife Management Area. J. Reister, with Ponte Vedra Beach Resorts, allowed access to private property. R. Clark, A. Kropp, K. Miller, A. Mitchell, J. Rodgers, Jr., and S. Schwikert assisted with surveys. K. Rogers helped with data management. Eastern Painted Bunting Working Group members D. Allen, L. Barnhill, D. Demarest, C. Depkin, J. Gerwin, L. Glover, M. Johns, T. Jones, K. Lulce, C. Moore, R. Mordecai, J. Meyers, B. Peterjohn, J. Rotenberg, J. Stanton, P. Sykes, Jr., B. Winn, and M. Wimer contributed to the design of this study. We thank R. Chandler and A. Royle for helpful advice on statistical methods. R. Butryn provided the figure. This project was supported by FWC targeted grant award NG07-101 administered by S. Cumberbatch. B. Crowder, K. Miller, C. Moore, J. Meyers, T. O'Meara, and J. Rodgers, Jr., and anonymous reviewers commented on previous drafts of this paper.

Literature Cited

Betts, M.G., D. Mitchell, A.W. Diamond, and J. Bety. 2007. Uneven rates of landscape change as a source of bias in roadside wildlife surveys. Journal of Wildlife Management 71:2266–2273.

Burnham, K.P., and D.R. Anderson. 2002. Model Selection and Multimodel Inference. Second Edition. Springer, New York, NY.

Cameron, A.C., and P.K. Trivedi. 1998. Regression Analysis of Count Data. Cambridge University Press, New York, NY.

Cox, J. 1996. Painted Bunting. Pp. 644–661, *In* J.A. Rodgers, Jr., H.W. Kale II, and H.T. Smith (Eds.). Rare and Endangered Biota of Florida. Vol. 5: Birds. University Press of Florida, Gainesville, FL. 688 pp.

Dail, D., and L. Madsen. 2011. Models for estimating abundance from repeated counts of an open metapopulation. Biometrics 67:577–587.

Dickson, J.G., J.H. Williamson, R.N. Conner, and B. Ortego. 1995. Streamside zones and breeding birds in eastern Texas. Wildlife Society Bulletin 23:750–755.

Fahrig, L., and G. Merriam. 1994. Conservation of fragmented populations. Conservation Biology 8:50–59.

Fiske, I., and R.B. Chandler. 2011. Unmarked: An R package for fitting hierarchical models of wildlife occurrence and abundance. Journal of Statistical Software 43:1–23.

Fiske, I., R. Chandler, A. Royle, and M. Kéry. 2012. Package "unmarked". Available online at http://CRAN.R-project.org/package=unmarked. Accessed 31 May 2012.

Hall, L.S., P.R. Krausman, and M.L. Morrison. 1997. The habitat concept and a plea for standard terminology. Wildlife Society Bulletin 25:173–182.

Hamel, P.B. 1992. Land manager's guide to the birds of the South. The Nature Conservancy, Chapel Hill, NC, and US Forest Service, Southern Region, Atlanta, GA.

Jackson, D.A. 1997. Compositional data in community ecology: The paradigm or peril of proportions. Ecology 78:929–940.

Johnson, R.A., and D.W. Wichern. 2002. Applied Multivariate Statistical Analysis, Fifth Edition. Prentice Hall, Upper Saddle River, NJ. 767 pp.

Kéry, M., J.A. Royle, and H. Schmid. 2005. Modeling avian abundance from replicated counts using binomial mixture models. Ecological Applications 15:1450–1461.

Kopachena, J.G., and C.J. Crist. 2000. Macro-habitat features associated with Painted and Indigo Buntings in northeast Texas. Wilson Bulletin 112:108–114.

Lanyon, S.M., and C.F. Thompson. 1986. Site fidelity and habitat quality as determinants of settlement pattern in male Painted Buntings. Condor 88:206–210.

Lowther, P.E., S.M. Lanyon, and C.W. Thompson. 1999. Painted Bunting (*Passerina ciris*). No. 398, *In* A. Poole and F. Gill (Eds.). The Birds of North America. The Birds of North America, Inc. Philadelphia, PA. 23 pp.

MacKenzie, D.I., and L.L. Bailey. 2004. Assessing the fit of site-occupancy models. Journal of Agricultural, Biological, and Environmental Statistics 9:300–318.

Meyers, J.M. 2011. Population densities of Painted Bunting in the southeastern United States. Southeastern Naturalist 10:345–356.

Ogden, J.C., and E.L. Chapman. 1967. Extralimital breeding of Painted Buntings in Florida. Wilson Bulletin 79:347.

Parmelee, D.F. 1959. The breeding behavior of the Painted Bunting in southern Oklahoma. Bird-Banding 30:1–18.

Partners in Flight (PIF). 2007. Partners in Flight landbird population estimate database. Available online at http://www.rmbo.org/pif_db/laped/default.aspx. Accessed 17 May 2011.

R Development Core Team. 2012. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. Available online at http://www.R-project.org. Accessed 30 May 2012.

Ralph, C.J., G.R. Geupel, P. Pyle, T.E. Martin, and D.F. DeSante. 1993. Handbook of field methods for monitoring landbirds. General Technical Report. PSW-GTR-144. Pacific Southwest Research Station, Forest Service, US Department of Agriculture, Albany, CA. 41 pp.

Reyment, R., and K.G. Jöreskog. 1993. Applied Factor Analysis in the Natural Sciences. Cambridge University Press, Cambridge, UK. 371 pp.

Rich, T.D., C.J. Beardmore, H. Berlanga, P.J. Blancher, M.S. Bradstreet, G.S. Butcher, D.W. Demarest, E.H. Dunn, W.C. Hunter, E.E. Inigo-Elias, J.A. Kennedy, A.M. Martell, A.O. Panjabi, D.N. Pashley, K.V. Rosenberg, C.M. Rustay, J.S. Wendt, and T.C. Will. 2004. Partners in Flight North American landbird conservation plan. Cornell Laboratory of Ornithology, Ithaca, NY. Available online at http://www.pwrc.usgs.gov/pif/cont_plan/PIF2_Part1WEB.pdf. Accessed 10 February 2011.

Robertson, W.B., Jr., and G.E. Woolfenden. 1992. Florida Bird Species: An Annotated List. Special Publication 6. Florida Ornithological Society, Gainesville, FL. 260 pp.

Rosenberg, K.V., and J. Blancher. 2005. Setting numerical population objectives for priority landbird species. Pp. 57–67, *In* C.J. Ralph and T.D. Rich (Eds.). Bird Conservation and Implementation in the Americas: Proceedings of the Third International Partners in Flight Conference. Vol. 1. USDA, Forest Service General Technical Report PSW-GTR-191. Albany, CA. Available online at http://www.fs.fed.us/psw/publications/documents/psw_gtr191/Asilomar/pdfs/57-67.pdf. Accessed 10 June 2011.

Royle, J.A. 2004. N-mixture models for estimating population size from spatially replicated counts. Biometrics 60:108–115.

Sauer, J.R., J.E. Hines, J. Fallon. K.L. Pardieck, D.J. Ziolkowski, Jr., and W.A. Link. 2011. The North American breeding bird survey. Results and analysis 1966–2011. Version 3.23.2011, US Geological Survey, Patuxent Wildlife Research Center, Laurel, MD. Available online at http://www.mbr-pwrc.usgs.gov/bbs/bbs.html. Accessed 17 May 2011.

Springborn, E.G., and J.M. Meyers. 2005. Home range and survival of breeding Painted Buntings on Sapelo Island, Georgia. Wildlife Society Bulletin 33:1432–1439.

Stevenson, H.M., and B.H. Anderson. 1994. The Birdlife of Florida. University Press of Florida, Gainesville, FL. 892 pp.

Sykes, P.W., Jr., and S. Holzman. 2005. Current range of the eastern population of Painted Bunting (*Passerina ciris*). North American Birds 59:4–17.

Thompson, C.W. 1991. Is the Painted Bunting actually two species? Problems determining species limits between allopatric populations. Condor 93:987–1000.