J. Field Ornithol. 73(1):53–59, 2002

A comparison of point-count and mist-net detections of songbirds by habitat and time-of-season

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Received 26 September 2000; accepted 21 March 2001

ABSTRACT. We compared the results of point-count and mist-net surveys during the breeding and post-breeding seasons in four Missouri Ozark habitats: mature upland forest, mature riparian forest, 9- to 10-yr-old upland forest and 3- to 4-yr-old upland forest created by clearcutting. We determined whether differences in abundance estimates among habitats or between breeding and post-breeding seasons varied with survey method (i.e., habitat × method, season × method, or habitat × season × method interaction effects). The habitat × method interaction was significant for 13 of 16 species. The general pattern was for canopy or sub-canopy species to be detected by point counts more often in the mature-forest habitats, and to be detected by mist nets more often in the young-forest habitats. The season × method interaction was significant for 6 species largely because there was a greater decrease from breeding to post breeding season in mist-net captures than point-count detections. Two species had a significant habitat × season × method interaction. Differences in the patterns in abundance among habitats and between seasons, by survey method, are indicative of bias in the survey methods. Individuals planning bird surveys should recognize these biases and select the method that best samples the segment of the community they are surveying and that is least likely to confound treatment effects. Often this may require the use of multiple survey methods.

SINOPSIS. **Una comparación del contaje de puntos y del uso de redes de niebla para la detección de Passeriformes en términos de habitat y de período de la temporada**

Comparamos los resultados de censos por conteos de puntos y usando redes de niebla durante las temporadas reproductivas y post-reproductivas en cuatro habitats del Ozark en Missouri: bosque alto maduro, bosque ribereño maduro, bosque alto con 9 a 10 años de edad, y bosques altos de 3 a 4 años de edad creados por desmonte. Determinamos si las diferencias en estimados de abundancia entre habitats o entre temporadas reproductivas y post-reproductivas variaban con el método de muestreo (e.g., efectos de interacción en datos de habitat × método, temporada × método, o habitat × temporada × método). La interacción de habitat × método fué significativa en 13 de 16 especies. El patrón general fué para especies de dosel o sub-dosel a ser detectadas por conteos de pinto más comúnmente en los hábitats de bosque maduro, y ser detectados por redes de niebla en los habitats de bosque joven. La interacción de temporada × método fué significativo para seis especies, mayormente porque hubo una mayor reducción en las capturas en redes de niebla entre las temporadas reproductiva y post-reproductivas que en las detecciones por conteos de punto. Dos especies tuvieron una interacción significativa de habitat × temporada × método. Las diferencias en patrones en abundancia entre hábitats y entre temporadas, por métodos de muestreo, son indicativos de vicios en los métodos de muestreo. Investigadores planificando muestreos de aves debieran reconocer estos vicios y seleccionar el método que mejor muestree el segmento de la comunidad en que están interesados, y que sea menos dado a confundir los efectos de tratamientos. A menudo esto puede requerir el uso de múltiples métodos de muestreo.

Key words: forest habitat, habitat effects, Missouri, seasonal effects, survey methods

INTRODUCTION

A goal of survey methods is to assess the relative abundance of a species in habitats. In an earlier study we used mist-netting to determine the relative abundance of forest songbirds in several habitats during the breeding and post-breeding periods (Pagen et al. 2000). However, because biases of mist-netting data have been widely reported (Karr 1981; Petit et al. 1992; Remsen and Good 1996), we supplemented mist-netting with point counts. Comparisons of point counts and mist-netting have shown the two methods are often not well correlated for some species (Lynch 1989; Rappole et al. 1993;

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Gram and Faaborg 1997; Whitman et al. 1997). However, these studies either compared detections by each method in one habitat during the breeding season (Rappole et al. 1993) or several habitats during the non-breeding season (Lynch 1989; Gram and Faaborg 1997). We know of no studies that compared multiple habitats across both breeding and non-breeding seasons.

We compared the detections of species surveyed in different habitats by point counts and mist-netting during the breeding season and post-breeding period. Mist nets may detect fewer individuals of forest-canopy species (Ralph et al. 1993), and point counts may detect fewer individuals as the breeding season proceeds because singing decreases (Kroodsma and Parker 1977; Albrecht and Oring 1995; Faaborg et al. 1996). We determined if differences in abundance estimates among habitats or between breeding and post-breeding seasons varied with survey method (point counts versus mist nets). That is, we determined if there was a significant habitat × method, season × method, or habitat × season × method interaction effect. We predicted that forest canopy and subcanopy species would be detected more readily by mist-nets, as compared to point counts, in young forest habitats than mature forest habitats, but that ground and shrub species would be detected similarly with both methods. We predicted that during the post-breeding period, point counts would detect fewer individuals of all guilds, as compared to mist nets, because of the decrease in singing after the breeding season. Ideally, comparisons of survey methods would be made to known absolute numbers of birds (Verner 1985). Nevertheless, we believe it is instructive to know how these popular survey techniques compare to each other. In an earlier paper (Pagen et al. 2000), we compared habitat use during breeding and post-breeding habitat use; here we concentrate on interaction effects with survey method.

METHODS

Study area and design. We surveyed bird numbers in 1998 on the Houston-Rolla Ranger District of the Mark Twain National Forest (Pulaski, Laclede, and Texas counties) and on Horseshoe Bend Natural Area, a Missouri Department of Conservation managed property owned by the Lad Foundation (Texas County). This area is on the Ozark Plateau in south-central Missouri and is characterized by rolling terrain dissected by numerous streams. The three-county area in which we we worked is approximately 54% forested (Miles 1990; Smith 1990). The forest is primarily mature, even-aged forest that regenerated after extensive clearcutting during the early 1900s. Young forest stands created by recent timber harvests are interspersed throughout the area. The area is approximately 43% sawtimber, 28% poletimber, and 29% sapling-seedling sized forest (Miles 1990; Smith 1990). Non-forested land consists of cattle pastures and small towns.

We compared results of point-count and mist-net surveys in four habitats: mature upland forest, mature riparian forest, 9- to 10-yr-old upland forest ("9-yr old"), and 3- to 4-yr-old ("3-yr old") upland forest. All habitat treatments were spatially interspersed throughout the study area. The mature upland and mature riparian sites had not received any silvicultural treatment for at least 50 yr. Both 9- to 10-yr-old forest and 3- to 4-yr-old forest were created by clearcutting and had abundant natural tree regeneration. Three sites (replicates) of each habitat were surveyed for a total of 12 sites. Study site areas were 3.6 to 3.9 ha ($\bar{x}$ = 3.73) for mature upland forest, 3.1 to 4.3 ha ($\bar{x}$ = 3.81) for mature riparian forest, 2.5 to 2.7 ha ($\bar{x}$ = 2.57) for 9- to 10-yr-old upland forest, and 3.6 to 4.8 ha ($\bar{x}$ = 4.02) for 3- to 4-yr-old upland forest. All sites were surrounded by forest.

Upland sites were in mixed oak forests, dominated by oak (*Quercus* spp.) and hickory (*Carya* spp.). Dogwood (*Cornus florida*), cherry (*Prunus serotina*) and sassafras (*Sassafras albidum*) were also present. Common shrubs included black raspberry (*Rubus occidentalis*), poison ivy (*Toxicodendron radicans*), fragrant sumac (*Rhus aromatica*), and buckbrush (*Symphoricarpos orbiculatus*). Riparian sites were dominated by elm (*Ulmus* spp.), box elder (*Acer negundo*), maple (*Acer* spp.), and sycamore (*Platanus occidentalis*). Ash (*Fraxinus* spp.), paw paw (*Asimina triloba*), and hackberry (*Celtis occidentalis*) were also present, while spicebush (*Lindera benzoin*) was the most common shrub. Ground cover was dense with forbs such as nettle (*Laportea canadensis*), giant ragweed (*Ambrosia trifida*), and wingstem (*Verbesina* spp.).

Field methods. We surveyed bird communities by point counts and constant-effort mist-netting. We surveyed each site twice during the breeding season from 21 May to 27 June, and twice during the post-breeding period from 17 July to 23 August. Visits to each site during each season were approximately 2.5 wk apart. We captured birds at each site with 12 nets that were 12 m long and 2.6 m high, with 30-mm mesh. Nets were placed in two rows of six nets (numbered counterclockwise 1–12) with each row 75 m apart and >25 m from the edge of the site. Within a row nets were perpendicular to the row and 50 m apart. We surveyed each site for approximately 5.5 h beginning 20 min before sunrise. We banded birds with a USFWS aluminum band and recorded the species, age, and sex. Banding protocol followed Ralph et al. (1993). Birds were surveyed by point counts on the same day a site was surveyed by mist nets. We located point count stations at nets 3, 5, 9, and 11. Each point was surveyed for 10 min, and birds were recorded as inside or outside a 50-m radius circle. All birds heard or seen within the study site were recorded.

Statistical analyses. We calculated the mean detections/10-min point count for each species from the four points surveyed during each visit to a site. We used all detections (aural and visual) within a 50-m radius for the calculations. We standardized net captures for each visit to a site to captures/100 net-h. We included only captures of adults in the analysis because nearly all point-count detections were of singing males. We used the mean of the two breeding season surveys and the mean of the two post-breeding surveys in the statistical analysis.

We used analysis of variance to determine if method × habitat, method × season, and method × habitat × season interactions were significant, but did not test the effect of method because we had no reason to expect detections/point to equal captures/100 net-h. We used a split-plot design ANOVA because surveys for each method and season were conducted on the same site (SAS Institute 1990). Because of non-normal distributions in abundance estimates and heterogeneous variances, we used a rank transformation on the abundance data for the analysis of variance tests but report actual means (detections/point and captures/100 net-h) and standard errors of abundance estimates. We interpreted tests with a *P*-value of ≤ 0.1 as significant to increase statistical power and reduce the probability of type II error (Steidl et al. 1997).

RESULTS

We detected a total of 60 species by point counts and 56 species by mist nets. Point counts detected 18 species not detected by mist nets, and mist nets detected 14 species not detected by point counts. We focused our analysis on 16 species that were present in two or more habitats and for which 90% confidence intervals, around the mean abundances for each habitat, did not include zero for at least one habitat. Many species were detected at low levels, and it would be impossible to conclude for these species whether differences were due to the survey method or sampling error.

Thirteen species had a significant habitat × method effect (Table 1). For example, the Blue-gray Gnatcatcher was frequently detected by point counts on the mature upland or riparian sites but not captured by mist nets on those sites. The Acadian Flycatcher was only detected by point counts in mature upland and riparian habitats, was never captured with mist nets in upland or riparian habitats, and had the highest captures in 9-yr old habitats (Table 2). Similarly, the Red-eyed Vireo had highest point-count detections in the mature habitats, but the greatest mist-net captures in the 3-yr-old forest (Table 2), where we did not expect to capture Red-eyed Vireos at all.

Six species showed significant season × method effects (Table 1). Indigo Buntings, Summer Tanagers, Kentucky Warblers, and Blue-winged Warblers showed lower detections during the post-breeding season with mist-net captures, compared to point counts (Table 2).

Yellow-billed Cuckoos and Black-and-white Warblers were the only species with significant habitat × season × method interactions (Table 1). Yellow-billed Cuckoos were captured by mist nets more in the post-breeding season than in the breeding season, and in young forest more than in mature. However, they were detected by point counts more during the breeding season and in similar abundances across all habitats (Table 2).

Table 1. *P*-values from ANOVA tests of the interactions among survey method, habitat, and season effects on relative abundance estimates of forest songbirds in the Missouri Ozarks, 1998.

Species	Habitat × method	Season × method	Habitat × season × method
Yellow-billed Cuckoo (*Coccyzus americanus*)	0.549	0.297	0.061
Eastern Wood-Pewee (*Contopus virens*)	0.052	0.860	0.899
Acadian Flycatcher (*Empidonax virescens*)	0.006	0.339	0.325
White-eyed Vireo (*Vireo griseus*)	0.001	0.591	0.684
Red-eyed Vireo (*Vireo olivaceus*)	0.000	0.641	0.716
Blue-gray Gnatcatcher (*Polioptila caerulea*)	0.018	0.323	0.785
Blue-winged Warbler (*Vermivora pinus*)	0.002	0.008	0.123
Prairie Warbler (*Dendroica discolor*)	0.011	0.528	0.414
Black-and-white Warbler (*Mniotilta varia*)	0.036	0.388	0.050
Worm-eating Warbler (*Helmitheros vermivorus*)	0.222	0.070	0.615
Ovenbird (*Seiurus aurocapillus*)	0.060	0.081	0.582
Kentucky Warbler (*Oporornis formosus*)	0.489	0.011	0.549
Yellow-breasted Chat (*Icteria virens*)	0.046	0.916	0.998
Summer Tanager (*Piranga rubra*)	0.013	0.021	0.118
Northern Cardinal (*Cardinalis cardinalis*)	0.012	0.312	0.682
Indigo Bunting (*Passerina cyanea*)	0.020	0.010	0.112

DISCUSSION

The habitat × method interaction was significant for 13 species. The general pattern was for canopy or subcanopy species to be detected by point counts more often in the mature-forest habitats, and to be detected by mist nets more often in the young-forest habitats (e.g., Eastern-wood Pewee, Blue-gray Gnatcatcher, Acadian Flycatcher, Red-eyed Vireo). The observed patterns in canopy species could result in part because they are more susceptible to mist nets in the low canopy of the 3- and 9-yr old forest. This doesn't explain, however, why these species were rarely detected by point counts in young forest. We suspect many canopy or mature forest species captured by mist nets in the young forest were likely non-territorial floaters, or mature forest breeders coming from nearby territories to forage in the young forest (Pagen et al. 2000). As a result, Red-eyed Vireos were detected with point counts most often in the habitats where they were captured the least, and were captured with nets most often in habitats where they were detected with point counts the least.

Indigo Buntings and Northern Cardinals were detected in mature riparian forest more often with point counts, whereas mist nets indicated they were most abundant in 3- and 9-yr old cuts. Northern Cardinals and Indigo Buntings both nest in shrubs and often sing from high perches (Payne 1991; Halkin and Linville 1999), which may cause them to be missed by nets in habitats with a tall canopy and subcanopy, such as mature riparian forest. Ground-nesting species, such as the Kentucky Warbler and the Worm-eating Warbler, showed similar patterns in abundance by both methods across the four habitats (Table 2).

The season × method interaction was significant for 6 species (Table 1) largely because there was a greater decrease from breeding to post-breeding season in mist-net captures than among point-count detections. We had predicted point-count detections should be higher during the breeding season than the post-breeding season. We did not expect, however, that mist-net detections of adult songbirds might also decrease during the post-breeding period. Mist-net detections might have decreased because adults that were not provisioning nestlings were less active. Also, adults of many species undergo a complete pre-basic molt during the post-breeding period (Pyle et al. 1987; Ralph et al. 1993), which may hinder their ability to fly (Rimmer 1988; Vega Rivera et al. 1998) and, in turn, encounter nets.

Two species had a significant habitat × season × method interaction. The three-way interaction for Yellow-billed Cuckoo could have

Table 2. Mean (SE) abundance of songbirds detected by point counts and by mist-netting during the breeding and post-breeding season in 3- to 4-yr-old upland forest (3-yr old), 9- to 10-yr-old upland forest (9-yr old), mature upland forest (Upland), and mature riparian forest (Riparian) in the Missouri Ozarks, 1998.

		Point-count detections (detections/point)				*Mist-net captures (captures/100 net h)*			
Species	Season	3-yr old	9-yr old	Upland	Riparian	3-yr old	9-yr old	Upland	Riparian
Yellow-billed Cuckoo	Breeding	0.29(0.04)	0.25(0.07)	0.21(0.15)	0.21(0.08)	0.00(0.00)	0.53(0.53)	0.00(0.00)	0.00(0.00)
	Post-breeding	0.00(0.00)	0.50(0.13)	0.33(0.11)	0.21(0.15)	0.26(0.26)	0.53(0.53)	0.00(0.00)	0.00(0.00)
Eastern Wood-Pewee	Breeding	0.00(0.00)	0.04(0.04)	0.17(0.04)	0.00(0.00)	0.54(0.27)	0.25(0.25)	0.28(0.28)	0.00(0.00)
	Post-breeding	0.13(0.13)	0.08(0.04)	0.54(0.27)	0.00(0.00)	1.34(0.71)	0.54(0.27)	0.54(0.54)	0.00(0.00)
Acadian Flycatcher	Breeding	0.00(0.00)	0.00(0.00)	0.04(0.04)	0.50(0.22)	0.27(0.27)	1.56(0.45)	0.00(0.00)	0.76(0.44)
	Post-breeding	0.00(0.00)	0.00(0.00)	0.08(0.08)	0.38(0.13)	0.53(0.26)	1.02(0.67)	0.00(0.00)	0.00(0.00)
White-eyed Vireo	Breeding	0.63(0.13)	0.25(0.07)	0.00(0.00)	0.00(0.00)	4.59(1.02)	3.14(0.96)	0.00(0.00)	0.00(0.00)
	Post-breeding	0.46(0.17)	0.13(0.07)	0.00(0.00)	0.00(0.00)	4.23(1.09)	1.84(1.48)	0.00(0.00)	0.00(0.00)
Red-eyed Vireo	Breeding	0.00(0.00)	0.13(0.07)	0.71(0.23)	0.42(0.04)	2.16(0.97)	4.45(0.78)	1.77(1.10)	0.25(0.25)
	Post-breeding	0.00(0.00)	0.50(0.26)	0.71(0.25)	0.29(0.23)	7.50(3.17)	4.69(1.83)	0.51(0.51)	0.00(0.00)
Blue-gray Gnatcatcher	Breeding	0.38(0.07)	0.33(0.27)	0.38(0.07)	0.13(0.07)	0.27(0.27)	0.26(0.26)	0.00(0.00)	0.00(0.00)
	Post-breeding	0.25(0.07)	0.21(0.08)	0.33(0.21)	0.04(0.04)	1.90(1.52)	0.26(0.26)	0.00(0.00)	0.00(0.00)
Blue-winged Warbler	Breeding	0.17(0.04)	0.29(0.17)	0.00(0.00)	0.08(0.04)	4.88(0.85)	1.86(1.50)	0.00(0.00)	0.00(0.00)
	Post-breeding	0.00(0.00)	0.04(0.04)	0.00(0.00)	0.00(0.00)	2.97(1.21)	0.76(0.76)	0.00(0.00)	0.00(0.00)
Prairie Warbler	Breeding	0.58(0.29)	0.04(0.04)	0.00(0.00)	0.00(0.00)	11.59(5.30)	0.77(0.77)	0.00(0.00)	0.00(0.00)
	Post-breeding	0.08(0.04)	0.00(0.00)	0.00(0.00)	0.00(0.00)	3.83(1.20)	0.00(0.00)	0.00(0.00)	0.00(0.00)
Black-and-white Warbler	Breeding	0.21(0.11)	0.25(0.14)	0.00(0.00)	0.00(0.00)	1.61(0.81)	2.40(1.42)	0.25(0.25)	0.00(0.00)
	Post-breeding	0.21(0.04)	0.04(0.04)	0.00(0.00)	0.00(0.00)	0.28(0.28)	1.58(0.05)	0.00(0.00)	0.00(0.00)
Worm-eating Warbler	Breeding	0.04(0.04)	0.04(0.04)	0.08(0.08)	0.04(0.04)	1.59(1.21)	2.94(1.80)	0.76(0.76)	0.00(0.00)
	Post-breeding	0.17(0.11)	0.13(0.07)	0.04(0.04)	0.13(0.00)	0.82(0.82)	0.51(0.51)	0.00(0.00)	0.26(0.26)
Ovenbird	Breeding	0.00(0.00)	0.29(0.29)	0.21(0.15)	0.00(0.00)	0.27(0.27)	4.34(2.80)	0.76(0.44)	0.00(0.00)
	Post-breeding	0.04(0.04)	0.04(0.04)	0.13(0.13)	0.00(0.00)	0.28(0.28)	0.76(0.76)	0.00(0.00)	0.00(0.00)
Kentucky Warbler	Breeding	0.08(0.04)	0.17(0.08)	0.00(0.00)	0.08(0.04)	2.66(1.61)	2.85(1.23)	0.25(0.25)	1.77(0.91)
	Post-breeding	0.13(0.07)	0.13(0.07)	0.00(0.00)	0.25(0.07)	0.37(0.37)	1.01(1.01)	0.00(0.00)	0.00(0.00)
Yellow-breasted Chat	Breeding	1.38(0.14)	0.17(0.11)	0.00(0.00)	0.00(0.00)	11.01(0.67)	1.36(0.73)	0.00(0.00)	0.00(0.00)
	Post-breeding	0.92(0.22)	0.00(0.00)	0.00(0.00)	0.00(0.00)	4.28(0.63)	0.28(0.28)	0.00(0.00)	0.00(0.00)
Summer Tanager	Breeding	0.17(0.11)	0.21(0.11)	0.00(0.00)	0.00(0.00)	0.27(0.27)	0.25(0.25)	1.04(0.28)	0.00(0.00)
	Post-breeding	0.12(0.07)	0.21(0.11)	0.04(0.04)	0.00(0.00)	0.00(0.00)	0.00(0.00)	0.00(0.00)	0.00(0.00)
Northern Cardinal	Breeding	0.04(0.04)	0.21(0.04)	0.00(0.00)	0.29(0.15)	0.81(0.02)	1.30(0.52)	0.00(0.00)	0.51(0.51)
	Post-breeding	0.29(0.11)	0.50(0.07)	0.04(0.04)	0.50(0.14)	1.21(0.25)	2.07(1.14)	0.26(0.26)	0.25(0.25)
Indigo Bunting	Breeding	1.21(0.04)	0.25(0.07)	0.17(0.11)	1.00(0.19)	10.96(2.76)	3.94(1.72)	0.28(0.28)	6.06(0.76)
	Post-breeding	0.79(0.04)	0.21(0.15)	0.13(0.13)	1.13(0.29)	2.50(0.77)	0.51(0.25)	0.00(0.00)	0.76(0.76)

resulted because mist nets detected birds better in young forest, point counts detected birds better during the breeding than post-breeding season, and habitat use by post-breeding or non-breeding individuals differed from breeding individuals (Pagen et al. 2000).

Interaction effects with survey method were apparently exacerbated by differences in behavior among different segments of a population. Paired territorial males, unpaired territorial males, females, non-breeding floaters and post-breeding individuals behave differently, and therefore may have different probabilities of detection by both point counts and mist-netting. For example, unpaired territorial males sing more than paired territorial males (Best 1981; Gibbs and Faaborg 1990) and were likely detected by point counts more often. Females, non-breeding floaters, and post-breeding individuals vocalize infrequently and were likely detected by point counts less frequently than singing males. Mist-netting will also detect these groups differently. For example, floaters and post-breeding individuals of some species may move to different habitats than those used by breeders (Anders et al. 1998; Pagen et al. 2000). Because non-breeding floaters can often be a substantial part of the breeding-season population (Stewart and Aldrich 1951) and post-breeding birds can be difficult to detect (Faaborg et al. 1996), determining an effective way to estimate abundance of non-breeding floaters and post-breeding birds may be essential to understanding habitat use and population dynamics.

Since we did not know the actual number of birds on any of our sites, we do not know which survey method was most accurate. We did determine that patterns in abundance among habitats and between seasons varied by survey method, indicating biases in the survey methods. Individuals planning bird surveys should recognize these biases and select the method that best samples the segment of the community they are surveying and that is least likely to confound any treatment effects. Often this may require using multiple survey methods, as in this study and Pagen et al. (2000).

ACKNOWLEDGMENTS

We thank Dan Walton and Esther Board for their assistance with field work and John Faaborg for providing comments that greatly improved the manuscript. This research was funded by the USDA Forest Service North Central Forest Experiment Station and is a contribution from the Missouri Cooperative Fish and Wildlife Research Unit (Biological Resources Division, U.S. Geological Survey; Missouri Department of Conservation; University of Missouri; and Wildlife Management Institute cooperating).

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