J. Field Ornithol., 64(1):55–70

EVALUATION OF TWO SURVEY METHODS IN UPLAND AVIAN BREEDING COMMUNITIES

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Abstract.—Ten sites in the Appalachian Oak Forest community of Northern Virginia were examined using mist nets and song counts. Each site was mist-netted once, and visited three times for song counts during June and early July 1991. Mist nets provided an assessment of the understory bird community that was similar to that of the song count in terms of overall species richness, but quite different with regard to species abundance; song counts generally underestimated numbers, occasionally by an order of magnitude. Song counts also failed to accurately predict understory species composition for seven of 10 sites surveyed. The use of song counts appears to be inappropriate for determination of detailed information on breeding population dynamics. A combination of mist nets and song counts, however, can be used to determine presence/absence.

EVALUACIÓN DE DOS MÉTODOS DE CENSOS EN COMUNIDADES DE AVES MONTANAS

Sinopsis.—Se examinaron 10 localidades en las comunidades de Bosques de Roble de las Apalachias en el norte de Virginia, utilizando redes y conteos de cantos. Cada localidad fue estudiada con redes en una ocasión y visitada en tres ocasiones para conteos de cantos durante junio y julio de 1991. Las redes proveyeron una evaluación de la comunidad de aves en el sotobosque que fue similar a la obtenida con los cantos de las aves en términos de la riqueza de especies, pero diferente con respecto a la abundancia de éstas. Los censos a través de cantos generalmente subestiman los números de aves en ocasiones por una orden de magnitud. Los censos de cantos también fallaron en predecir con exactitud la composición de especies del sotobosque en siete de las diez comunidades estudiadas. El uso de cantos parece inadecuado para obtener información detallada sobre la dinámica de poblaciones en plena época de reproducción. No obstante, una combinación de ambos métodos puede usarse para determinar la presencia/ausencia de aves.

Knowledge of population size is the basis for practical and theoretical studies of demographics and community dynamics. Literature on the topic has emphasized the importance of this maxim in a number of avian community studies (Ralph and Scott 1981). Too often, however, the accuracy of an estimation methodology is not established because time, funding or availability of trained assistants are limited.

The most commonly used methods to determine species composition and abundance use bird song. Most variations on these procedures involve the following. 1) Selection of a series of points within a specified habitat type, 2) waiting for a specified period of time, 3) recording total number of individuals heard (and seen, though observed birds are generally a small percentage of the total) within a given area and 4) extrapolation to total number of breeding individuals within the population (usually double the number of singing birds heard per unit area) (International Bird Census Committee 1970, Ralph and Scott 1981, Robbins et al. 1989).

In a recent study of the effects of White-tailed Deer (*Odocoileus vir-*

ginianus) on the vertebrate and plant communities of Appalachian Oak forest, we initiated a project to compare bird use of sites affected by deer versus those from which deer have been excluded. As part of this study, we compared mist-netting and song counts as methods for arriving at an accurate measurement of avian populations on our study sites.

Our objectives were to address the following questions. 1) Can counts based on song alone produce a reliable estimate of species presence/absence? 2) Do song counts provide an accurate estimate of species abundance at a given site?

METHODS

The study sites were located in the Appalachian Mountains of northern Virginia from 300–1500 m elevation (Fig. 1). The aboriginal habitat of this region is deciduous forest (Wofford 1989). Up until the early 1900s, the dominant tree of this community was the American Chestnut (*Castanea dentata*); currently, the forest is dominated by several species of oak (*Quercus rubra, Q. alba, Q. prinus*), Tulip Poplar (*Liriodendron tulipifera*), Red Maple (*Acer rubrum*, and Beech (*Fagus grandiflora*) in the overstory, and Spice Bush (*Lindera benzoin*), dogwoods (*Cornus* spp.), and Striped Maple (*Acer pensylvanium*) in the understory. The study sites chosen for this work were all forested with stands >50 but <100 yr of age.

Ten sites were selected at random from a pool of 25 possible sites located in one of three protected areas: the Conservation and Research Center, Blandy Experimental Farm of the University of Virginia, and Shenandoah National Park (Fig. 1). The number of sites in the pool was limited by logistical and administrative constraints. Each site represented at least 4 ha (200 × 200 m) of continuous oak forest. Crane and Blandy were isolated wood lots of 4 and 10 ha, respectively. The other sites were located in blocks of continuous forest of several thousand ha, and were situated at least 1 km apart.

Exclosures were constructed between 1 Oct. 1990 and 1 Jun. 1991 on Posey, Keyser, Dump, and Hilltop. Each exclosure was a square, 200 m on a side surrounded by wire mesh fencing (10 × 10 cm mesh) to 1.5 m, with high tensile wire placed above the mesh at 15-cm intervals to a height of 2.5 m. We assume that presence or absence of the exclosures did not affect the relationship between mist net captures and song counts with regard to estimation of avian community composition.

On each site, we established a grid with one point every 20 m. Mist nets (12 × 2.6 m × 36 mm mesh) were placed 20 m from the edge of the grid and 40 m apart. Five nets were placed in five rows for a total of 25 nets/grid. The nets were run from dawn to dusk for 1500 net h (1 net open for 1 h = 1 net h), roughly 4.5 days. All 10 sites were netted between 1 Jun. and 4 Jul. 1991.

Each captive was removed from the net, banded with a U.S.F.W.S. band, sexed, aged (using plumage and skull pneumatization), checked for molt, subcutaneous fat, and reproductive condition (brood patch or cloacal

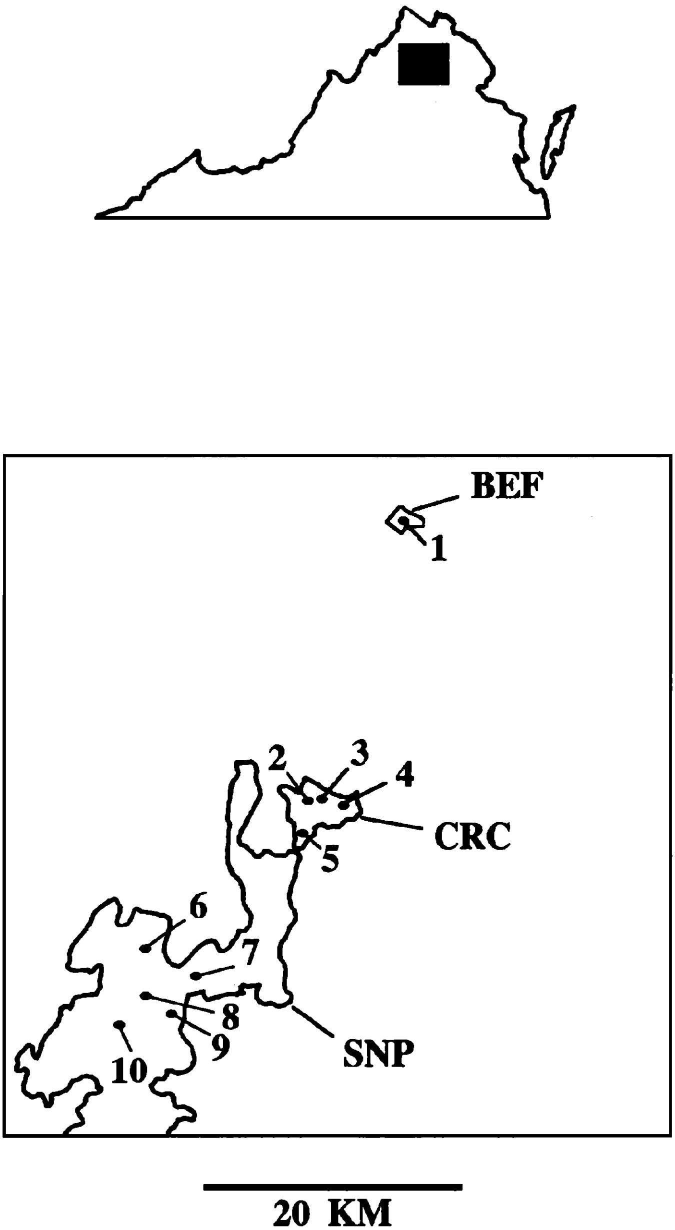

FIGURE 1. Map of Virginia with inset (black box) showing study sites in Northern Virginia: BEF = Blandy Experimental Farm of the University of Virginia; CRC = Conservation and Research Center of the Smithsonian Institution; SNP = Shenandoah National Park. The study sites are numbered: 1 = Blandy, 2 = Crane, 3 = Posey, 4 = Bear, 5 = North, 6 = Dump, 7 = Keyser, 8 = Hilltop, 9 = Range View, 10 = Elk Wallow.

protuberance) and released. For this analysis, we present data only on numbers of adult birds.

Song counts were conducted on the same 10 sites as the mist-netting over the same 1-mo period (1–30 Jun. 1991). The sites were visited three times each at a minimum interval of 1 wk between visits, from 0600–1000 hours, avoiding sites on which mist-netting was underway to minimize effects of human disturbance. The same person (JHR) did all of the song counts to eliminate inter-observer error. Procedures involved stopping for 2 min at each point with 40 m between stops for a total of 36 points on a 4-ha grid. The observer mapped the location of all singing or observed males recorded within the confines of the plot. A summary map combining the results of all three visits was made for each species. The number of territorial males on a site was determined by grouping all map locations from the three separate visits located within 20 m of each other and separated by 40 m from a neighbor as a single territorial male unless otherwise noted (i.e., when two or more birds were seen or heard simultaneously, these were noted as separate individuals regardless of their separation distance).

RESULTS

A total of 49 species was seen, heard or captured on one or more of the 10 sites (Appendix 1). Of these, 44 species were captured in nets. Thirty-seven species were seen or heard during the song counts.

We limited our song count samples to the period 1–30 Jun. to reduce variation due to song intensity for different parts of the breeding cycle. Despite this effort, we were not successful in eliminating this problem. We found that the average number of singing individuals/site for late-breeding, long distance migrants declined significantly ($t = 2.3$, $n = 74$, $P < 0.05$) from 2.1 for early June visits, to 1.7 during mid-June, and finally 1.2 during late June.

The relationship that we assumed to exist between an accurate point count and adult birds that occur in the community volume sampled by mist nets (0–2.6 m above ground) is illustrated by the Acadian Flycatcher (*Empidonax virescens*) data. Each singing male presumably represents one pair of birds, so if two males are heard on a site, four adult individuals are presumed present and should be captured in mist nets. At Bear Hollow, two individuals were heard, and four captured; at Elk Wallow, one individual was heard and two were captured, etc. Overall, 18 were heard at the 10 sites and 35 were captured. Unfortunately, the song count results do not coincide with the mist net results for most other species. Nevertheless, song count estimates appear reconcilable with mist net captures for some of the mid- or upper-level foraging species. For instance, for the Eastern Wood Pewee (*Contopus virens*), a total of 23 males was heard (presumed 46 individuals), and 27 adult birds were captured; the difference here presumably is due to the fact that the normal foraging height for pewees is above mist net height. Scarlet Tanagers (*Piranga olivacea*) (24 heard, 23 caught), Red-eyed Vireos (*Vireo olivaceous*) (21

TABLE 1. Difference between mean number (±SE) of adult birds captured and mean number (±SE) estimated by song count (number heard × 2) for 13 forest understory species.

Species	Estimate of population size		
	Mist net	Song count	Difference
Black-billed Cuckoo	0.5 (±0.5)	1.0 (±1.0)	−0.5
Yellow-billed Cuckoo	0.0 (±0.0)	4.0 (±2.0)	−4.0
Acadian Flycatcher	4.4 (±1.4)	4.5 (±0.6)	−0.5
Veery	3.0 (±1.0)	0.0 (±0.0)	+3.0
Swainson's Thrush	1.0 (—)	0.0 (—)	+1.0
Wood Thrush	8.9 (±2.4)	4.2 (±0.9)	+4.7*
Gray Catbird	15.0 (±14.0)	3.0 (±1.0)	+12.0
Worm-eating Warbler	2.3 (±0.9)	0.0 (±0.0)	+2.3
Ovenbird	7.5 (±3.2)	4.3 (±1.1)	+3.2
Louisiana Waterthrush	1.2 (±0.2)	0.0 (±0.0)	+1.2*
Hooded Warbler	1.3 (±0.8)	2.0 (±0.0)	−0.8
Northern Cardinal	2.2 (±0.8)	2.7 (±0.7)	−0.5
Rufous-sided Towhee	1.9 (±0.5)	3.7 (±0.6)	−1.9*
Total for 13 species	4.1 (±0.8)	2.8 (±0.3)	+1.4*
Total for all species	2.5 (±0.26)	2.8 (±0.15)	−0.4

* Paired *t*-test, $P < 0.05$.

heard, 21 caught), and American Redstarts (*Setophaga ruticilla*) (14 heard, 17 captured) fit this interpretation as well.

The number of adult birds captured is not readily reconcilable with the number of birds heard or seen for most species. For 17 species, more birds were captured than predicted using the song count data. This result is particularly striking for some of the 13, late-breeding understory species (Table 1) in which an average of 1.35 more adult individuals was captured than predicted by doubling the number of birds heard on the song counts ($\bar{x}$ = 4.1 and 2.8, respectively, Paired *t*-test = 2.0, $n = 60$, $P < 0.05$).

The majority of this difference is due to capture of more adult males than predicted based on the number of singing males heard or seen. Large variations in this figure occur, however, between species, and, in some species, many more females were captured at a site than was predicted by the song count estimates. For instance, two territorial male Gray Catbirds (*Dumetella carolinensis*) were estimated based on the three visits to the Blandy site; 19 adult males were captured at the site along with seven females. Similarly, four Wood Thrushes (*Hylocichla mustelina*) were heard at Bear Hollow; 15 males were captured along with six females. Nevertheless, there is a significant, positive correlation between number of individuals heard vs. number captured ($r = 0.51$, $n = 60$, $P < 0.001$).

Using averages dilutes the magnitude of the differences between the two methods, as some species, such as Rufous-sided Towhees (*Pipilo erythrophthalmus*), were captured less often than predicted by song counts, whereas other species, such as Wood Thrushes, were captured more often than predicted by song counts (Table 1). For a single species, comparisons

TABLE 2. Most often missed species by each technique. Number of plots missed in parentheses.

Missed by song count	Missed by mist net
Louisiana Waterthrush (6)	White-breasted Nuthatch (5)
Ruby-throated Hummingbird (5)	Cerulean Warbler (5)
Downy Woodpecker (5)	Yellow-throated Vireo (4)
Carolina Wren (4)	Northern Flicker (4)
Hairy Woodpecker (4)	Pileated Woodpecker (3)
Indigo Bunting (3)	Eastern Tufted Titmouse (3)
Veery (3)	Eastern Wood Pewee (3)
Eastern Phoebe (3)	Brown-headed Cowbird (3)
Worm-eating Warbler (3)	Great Crested Flycatcher (3)

between grids also showed marked variation in estimates based on the two techniques. For Wood Thrushes, the number captured was greater than three times the number estimated by song on two of the grids, relatively similar on five of the grids, and markedly less on one grid (Appendix 1). The variability in population density was larger when sampled with mist nets than with song counts, whether you examine either the entire bird community ($F' = 2.73$; df = 234, 234; $P < 0.0001$) or just the understory species ($F' = 5.99$; df = 59, 59; $P < 0.0001$) (Table 1).

Both song counts and mist nets missed the presence of many species (Table 2). Whereas in 102 instances a species was both detected on a song count and captured at the 10 plots, there were 70 instances when a species was heard, but not captured, and 65 instances when a species was captured, but not heard. The two techniques should coincide most when looking at understory species, and for these species mist net samples and song counts did not agree 22 times: on eight occasions we heard a species that we did not catch, and 18 times we caught a species that was not heard.

For both techniques, the ability to detect a species improved as the size of the population increased, but even common species were occasionally missed (Table 2). Some were missed for obvious reasons. Those with large home ranges (woodpeckers) or limited vocalization (Ruby-throated Hummingbird *Archilochus colubris*) were often missed by the song counts (Table 3). Some species (e.g., Veery *Catharus fuscescens,* Louisiana Waterthrush *Seiurus motacilla*) were missed for no obvious reason.

For understory birds, we examined the correlation between the number of species detected by mist nets with those detected by song counts (Table 4). This sample represents 13 species at 30 sample points (10 sites visited 3 times). Of the 30 song counts conducted, only seven predicted the species captured at the 0.05 level of significance. The results improve slightly when all song counts are combined for a given site, with three of 10 counts accurately predicting presence/absence based on mist net captures (Table 4).

TABLE 3. The frequency of species missed by song count or mist nets, based on the species abundance as determined by the other technique. Misses for the 10 study plots are summed, with estimates from song counts = 2 × number heard.

Species abundance (# of individuals captured or heard)	Missed during sampling	
	Mist nets	Song counts
1	—	36[1]
2	46	17
3	—	3
4	17	3
5	—	2
6	6	0
7	—	2
>7	1	2

DISCUSSION

A major difficulty of all sampling methods is that we do not know with absolute certainty what the actual number of species and individuals is in the community. As a result, we are always left with a comparison of different sampling techniques to determine which method most accurately estimates these unknown quantities.

Our goal was to determine the number of species and estimate the abundance of each species within our study plots. Neither method alone recorded all the species that were heard or captured at the plots.

The comparison between the two techniques showed a marked disagreement in species abundance, not only for birds not well sampled by either technique, but for species, such as understory birds, that should be well documented by the techniques used. We suggest three possible explanations for the different results: 1) the greater "effort" put into mist nets dictated that technique would record more individuals; 2) the song

TABLE 4. For each study plot, the correlation between song count estimates of species presence/absence and mist net results for 13 understory species.

Study site	Correlation value (r)[1]
Blandy	0.84*
Crane	0.41
Posey	0.78*
Bear	0.62
North	0.69*
Dump	−0.18
Keyser	0.62
Hilltop	0.56
Range View	0.22
Elk Wallow	0.50

[1] Pearson correlation coefficient.
* $P < 0.05$.

counts failed to detect breeding and non-breeding birds resident on the plot; or 3) the mist nets sampled the population of floaters, which were not resident on the area.

A procedural basis for the differences reported is rejected based on the variation observed between species from one plot to another. For understory birds, some species were captured more often, and some species were captured less often than predicted by the song counts. For each understory species, some plots showed close agreement between the two techniques, others showed no agreement. Much of the variability between plots as recorded by mist nets was not reflected in the song count data. Differences based on effort presumably would show a consistently higher population density using mist net techniques, not the extreme variability observed.

A second possible explanation addresses the assumptions of song count surveys. Song count accuracy rests on three fundamental assumptions: 1) the observer is able to detect, identify and properly plot all territorial birds based on their songs, 2) each singing bird represents a male/female pair of adult, breeding individuals, and 3) all males that are paired sing at the same rate.

The first assumption is not true, even for experienced observers, because other factors affect the observer's ability to detect singing birds, primarily weather and timing of the annual cycle. Wind, rain and other less obvious site- or date-specific factors are known to depress song frequency (LaPerriere and Haugen 1972, Waechtler 1977). More serious are the constraints caused by the bird's annual cycle. The difficulty arises in attempting to sample the community when: 1) all breeding members are present, 2) no transient members are present, 3) all members are singing regularly. In northern Virginia, all breeding members are not present until mid-May, but late transients are still singing as they pass through in late May. By 1 June, all community members are present, and nearly all transients have passed. By this time, however, most residents and short distance migrants are late in their breeding cycle, and seldom vocalize. By July, even the late breeders have quit singing on a regular basis.

The assumption that all singing males represent a male/female pair of adult, breeding individuals does not hold for many species (Rappole and Waggerman 1986) because males sing regardless of their pair status. In fact unpaired males have been observed to sing as much or more than paired individuals (Armbruster et al. 1978, Baskett et al. 1978, Frankel and Baskett 1961, Krebs 1971, Morton 1992, Nice 1964, Nolan 1978, Sayre et al. 1980, Stone 1966, Swanson 1989).

The third assumption, that all paired males sing at the same rate throughout the sampling period, has been found to be untrue in a number of life history studies. Song frequency varies according to the phase of the nesting cycle (Baskett et al. 1978, Cohen et al. 1960, Irby 1964). We found this phenomenon in our community; as the breeding season progressed, counts of singing males declined.

A further problem is that song rate is affected by population density.

At low population densities, calling rate is often lower per bird, or even absent, than at higher densities (LaPerriere and Haugen 1972); at very low densities or isolation, playback may be required to elicit vocalization by paired males (V. F. Cogar, unpubl. data; Marion 1974, Sorola 1984).

The large numbers of individuals in breeding condition, mostly males, captured on some of our study sites is an intriguing phenomenon. These birds may be floaters (i.e., non-paired individuals) searching for mates, territories or extra-pair copulations; or they could represent males from neighboring territories; or both. We tend toward the floater interpretation because two of the sites in which large numbers of evidently unpaired individuals occurred were small (4 and 10 ha) and isolated by a minimum distance of 500 m of open ground from the nearest continuous forest. The occurrence of floater males is a well-known phenomenon, abundantly documented in the literature (Darwin 1871, von Haartman 1971, Hensley and Cope 1951, Rappole et al. 1977), but their ecology is little understood.

Not all of the excess individuals captured were males. More females were captured on sites than predicted by song counts for the Wood Thrush, Gray Catbird, and Ovenbird (*Seiurus aurocapillus*). Floater females, though less common than floater males (perhaps because they move less) are also well-documented (Hensley and Cope 1951, Rappole et al. 1977). As in the case of the extra males we do not know the source of these females. Studies have shown, however, that the number of mated females in a population can vary dramatically from year to year based on availability of resources for reproduction (Jarvinen and Vaisanen 1984, Lack 1973, Swanson 1989) and that a certain variable percentage of the population in many normally monogamous species practice serial polygyny (Lack 1968, Rappole et al. 1977).

Whether the birds captured in mist nets are silent breeders or floaters, they represent a sizable portion of the forest community sampled. The presence of apparently excess males and females in reproductive condition on many sites, both isolated and in continuous forest, raises doubts concerning the suitability of audio-visual methods to determine population parameters. Certainly, identification of "source" versus "sink" populations (Robinson 1992), i.e., those in which reproduction is occurring as opposed to those in which it is not, cannot be accomplished using song count methodology.

The use of song counts to monitor bird populations is the most economical way to sample large areas during a short period. Interpretation of this information may be compromised, however, by the inability to document the dynamics of the silent majority of birds occurring within sampled habitats. This information can only be obtained with intensive studies at fewer sites, as opposed to rapid, economical surveys of many sites.

ACKNOWLEDGMENTS

We thank C. Wemmer, Associate Director for Conservation of the National Zoological Park, D. Haskell of Shenandoah National Park, and E. F. Connor of Blandy Experimental

Farm, University of Virginia, for permission to work on properties under their supervision. We thank Earthwatch Foundation, the Friends of the National Zoo, St. Lawrence University, Shenandoah National Park, and John Karish of the Northeast Region of the National Park Service for financial support. Volunteers who provided invaluable time and effort to the project included Grace Burford, Kathy Hartman, Rebecca Scholl, Dave Condoulis, Lisa Hartman and Wendy Nufer.

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Received 22 Oct. 1991; accepted 16 Mar. 1992.

APPENDIX 1. A comparison of the number of individuals heard (H) and captured (C) for each species at each of the 10 plots sampled during 3 spot counts and 1500 net hours in June 1991.

Species	Study sites[1]																			
	BE		BL		CR		DU		EW		HT		KR		NH		PH		RV	
	H	C	H	C	H	C	H	C	H	C	H	C	H	C	H	C	H	C	H	C
Sharp-shinned Hawk *Accipiter striatus*	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Mourning Dove *Zenaida macroura*	0	0	1	0	1	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Black-billed Cuckoo *Coccyzus erthropthalmus*	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
Yellow-billed Cuckoo *Coccyzus americanus*	0	0	0	0	0	0	0	0	1	0	0	0	0	0	3	0	0	0	0	0
Ruby-throated Hummingbird *Archilochus colubris*	0	0	0	0	0	1	0	3	0	1	0	1	0	7	0	0	0	0	1	3
Red-headed Woodpecker *Melanerpes erythrocephalus*	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Red-bellied Woodpecker *Melanerpes carolinus*	2	3	4	3	0	0	1	0	0	0	0	0	0	0	3	1	1	0	0	0
Downy Woodpecker *Picoides pubescens*	2	5	2	1	0	3	0	5	0	1	1	3	0	2	2	0	0	2	1	0
Hairy Woodpecker *Picoides villosus*	0	2	0	0	0	0	0	1	0	0	0	2	1	2	0	0	0	2	0	0
Northern Flicker *Colaptes auratus*	1	0	3	7	1	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0
Pileated Woodpecker *Dryocopus pileatus*	1	0	2	0	0	1	0	0	0	1	1	0	1	0	1	1	0	0	0	0

APPENDIX 1. Continued.

Species	Study sites[1]																			
	BE		BL		CR		DU		EW		HT		KR		NH		PH		RV	
	H	C	H	C	H	C	H	C	H	C	H	C	H	C	H	C	H	C	H	C
Eastern Wood-Pewee *Contopus virens*	2	5	2	1	1	2	4	6	2	0	4	3	3	7	2	0	2	3	1	0
Acadian Flycatcher *Empidonax virescens*	2	4	0	0	0	0	2	0	1	2	2	0	2	6	2	4	3	7	4	12
Eastern Phoebe *Sayornis phoebe*	0	0	0	1	0	0	0	2	0	2	0	0	0	0	0	0	0	0	0	0
Great Crested Flycatcher *Myiarchus crinitus*	2	0	2	3	1	0	0	5	2	2	0	0	1	1	1	0	1	1	0	0
Blue Jay *Cyanocitta cristata*	1	0	2	5	0	0	1	0	0	0	0	0	0	0	1	2	1	1	0	0
American Crow *Corvus brachyrhynchos*	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Common Raven *Corvus corax*	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0
Carolina Chickadee *Parus carolinensis*	0	2	2	7	2	2	3	0	2	2	1	0	0	2	2	1	0	0	1	0
Tufted Titmouse *Parus bicolor*	0	0	0	7	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0
White-breasted Nuthatch *Sitta carolinensis*	2	3	2	6	0	3	2	0	2	0	2	0	1	1	2	0	2	0	2	0
Carolina Wren *Thryothorus ludovicianus*	0	0	2	6	1	1	2	4	0	1	0	1	0	1	1	1	0	0	0	1

APPENDIX 1. Continued.

Species	Study sites[1]																			
	BE		BL		CR		DU		EW		HT		KR		NH		PH		RV	
	H	C	H	C	H	C	H	C	H	C	H	C	H	C	H	C	H	C	H	C
Blue-gray Gnatcatcher *Polioptila caerulea*	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Eastern Bluebird *Sialia sialis*	0	0	0	0	2	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Veery *Catharus fuscescens*	0	0	0	0	0	0	0	4	0	0	0	0	0	1	0	0	0	0	0	4
Swainson's Thrush *Catharus ustulatus*	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wood Thrush *Hylocichla mustelina*	4	21	2	16	0	1	2	5	0	0	0	1	2	12	3	8	3	10	3	11
American Robin *Turdus migratorius*	0	1	2	5	0	0	2	1	0	0	0	0	0	0	0	0	0	0	0	0
Gray Catbird *Dumetella carolinensis*	0	0	2	29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Cedar Waxwing *Bombycilla cedrorum*	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Solitary Vireo *Vireo solitarius*	1	0	0	0	0	0	1	2	0	0	0	0	1	0	0	0	0	0	0	0
Yellow-throated Vireo *Vireo flavifrons*	0	0	0	0	0	0	0	0	3	0	2	0	0	0	0	0	1	0	1	0
Red-eyed Vireo *Vireo olivaceus*	1	2	0	0	2	1	3	2	1	3	5	2	2	4	3	4	3	3	1	0
Chestnut-sided Warbler *Dendroica pensylvanica*	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0

APPENDIX 1. Continued.

Species	Study sites[1]																			
	BE		BL		CR		DU		EW		HT		KR		NH		PH		RV	
	H	C	H	C	H	C	H	C	H	C	H	C	H	C	H	C	H	C	H	C
Cerulean Warbler *Dendroica cerulea*	0	2	0	0	1	1	1	0	0	0	4	0	0	0	1	0	0	0	3	0
American Redstart *Setophaga ruticilla*	0	0	0	0	0	0	4	5	2	4	3	5	1	1	0	0	0	0	4	2
Worm-eating Warbler *Helmitheros vermivorus*	0	4	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0
Ovenbird *Seiurus aurocapillus*	1	3	0	0	0	0	0	2	3	3	3	7	3	20	0	0	0	0	3	7
Louisiana Waterthrush *Seiurus motacilla*	0	1	0	0	0	0	0	1	0	1	0	0	0	1	0	0	0	2	0	1
Hooded Warbler *Wilsonia citrina*	2	0	1	0	0	0	0	0	0	0	0	0	1	3	0	0	0	0	1	0
Scarlet Tanager *Piranga olivacea*	3	6	1	0	0	0	5	1	3	6	2	4	2	2	3	2	3	0	2	2
Northern Cardinal *Cardinalis cardinalis*	0	2	2	6	2	2	0	0	0	1	0	0	0	0	2	1	0	0	1	0
Rose-breasted Grosbeak *Pheucticus ludovicianus*	2	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0
Indigo Bunting *Passerina cyanea*	0	1	0	0	0	8	1	2	1	2	3	11	0	2	0	1	0	0	1	3
Rufous-sided Towhee *Pipilo erythrophthalmus*	0	0	3	3	2	2	1	2	1	1	3	2	2	3	1	0	0	0	2	3
Chipping Sparrow *Spizella passerina*	0	0	0	0	0	0	4	3	1	8	2	4	0	0	0	0	0	0	0	1

APPENDIX 1. Continued.

Species	Study sites[1]																			
	BE		BL		CR		DU		EW		HT		KR		NH		PH		RV	
	H	C	H	C	H	C	H	C	H	C	H	C	H	C	H	C	H	C	H	C
Field Sparrow *Spizella pusilla*	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Common Grackle *Quiscalus quiscula*	0	0	0	19	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0
Brown-headed Cowbird *Molothrus ater*	1	3	0	2	2	2	3	3	1	0	2	1	1	3	1	0	0	0	3	0
Northern Oriole *Icterus galbula*	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
American Goldfinch *Carduelis tristis*	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0

[1] Abbreviations used for study sites: BE = Bear Hollow, BL = Blandy, CR = Crane, DU = Dump, EW = Elk Wallow, HT = Hilltop, KR = Keyser Run, NH = North Hollow, PH = Posey Hollow, RV = Range View.