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FEEDER COUNTS AS INDICATORS OF SPATIAL AND TEMPORAL VARIATION IN WINTER ABUNDANCE OF RESIDENT BIRDS

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Abstract.—Project FeederWatch (PFW) is a North American-wide volunteer program that has compiled weekly observations of birds at feeders throughout each winter since 1987–1988. Three population indices are calculated for each bird species: percent of feeders visited, group size (number observed per visit), and mean abundance per feeder over the entire season. For nine resident species in the northeastern United States, we tested whether PFW indices reflect spatial and temporal patterns of abundance similar to those derived from the Breeding Bird Survey (BBS). For most species, PFW indices were strongly correlated with BBS relative abundances from the same states (averaged across years). Percent of feeders visited was significantly correlated with BBS in all nine species, and mean abundance was significantly correlated in eight species, whereas average group size was correlated in only four species. However, there was poor correlation between PFW and BBS annual abundance indices (averaged across states). The range of temporal variation in PFW and BBS indices is more limited than the range of spatial variation across the northeast region, and PFW annual indices evidently do not track subtle population changes in the same manner as BBS. For two species (Carolina Wren, House Sparrow) that exhibited marked among-year changes in abundance, however, PFW tracked the same pattern of change as BBS, and annual indices from both programs were significantly correlated. We conclude from our analyses to date that winter feeder counts, if interpreted with care, accurately reflect spatial, and in some cases temporal, variation in abundance of common resident birds.

CONTAJES EN COMEDEROS COMO INDICADORES DE VARIACIONES ESPACIALES Y TEMPORALES EN LA ABUNDANCIA INVERNAL DE AVES RESIDENTES

Sinopsis.—El "Programa para Observar Comederos" (PFW) es un esfuerzo voluntario que ha compilado observaciones semanales de aves en los comederos a través de cada invierno desde el 1987–1988 a por toda Norteamérica. Se estiman tres indices poblacionales para cada

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especie: el porciento de comederos visitados, el tamaño de grupo (número observado por visita), y la abundancia promedio por comedero a través de toda la temporada. Evaluamos si los indices del PFW de nueve especies residentes al noreste de los Estados Unidos reflejan patrones de abundancia espacial y temporal similares a los derivados del "Censo de Aves en Reproducción" (BBS). Los indices del PFW estan altamente correlacionados con las abundancias relativas del BBS para los mismos estados (promediados a través de los años) para la mayoría de las especies. El porciento de visitas a comederos correlacionó significativamente con los datos del BBS para las nueve especies, y la abundancia promedio estuvo correlacionada significativamente en ocho especies, mientras que el promedio de tamaño de grupo fué correlacionado tan solo en cuatro especies. Sin embargo, hubo poca correlación entre los indices anuales de abundancia del PFW y del BBS (promediados en los estados). El alcance en variación temporal de los indices del PFW y del BBS es más limitado que el alcance de variación espacial en la región noreste, y los indices anuales del PFW evidencian no detectar cambios poblacionales sutiles como lo hace el BBS. En dos especies que mostraron cambios en abundancia marcados entre años (*Thryothorus ludovidianus* y *Passer domesticus*), el PFW tuvo el mismo patrón de cambios que el BBS, y los indices anuales de ambos programas tuvieron una correlacion significativa. Concluimos en nuestro análisis que conteos invernales en comederos, de interpretarse con cuidado, reflejan apropiadamente la variación en abundancia espacial y en ocasiones temporal, de residentes comunes.

In North America, only the Breeding Bird Survey (BBS) and Christmas Bird Counts (CBC) have traditionally been available for investigating the abundance and distribution of birds on a continent-wide scale. The former samples bird populations during the breeding season (Peterjohn and Sauer 1994), while the latter samples bird populations once in early winter (Butcher 1990). Both programs provide an annual index of abundance for the periods during which the surveys take place.

In 1987, Project FeederWatch (PFW) was initiated jointly by the Cornell Laboratory of Ornithology and the Long Point Bird Observatory. The project was modeled on the Ontario Bird Feeder Survey started in 1976 (Dunn 1986). In contrast to the one-time counts of BBS and CBC, Project FeederWatch participants collect information on bird numbers at feeders weekly from November through early April. This data set may therefore provide an additional tool for tracking spatial and temporal changes in winter bird abundance and distribution.

Although a number of studies have examined survival rates (Brittingham and Temple 1988, 1992a; Hickey and Brittingham 1991), feeding rates (Brittingham and Temple 1992b), and habitat preferences (Wilson 1995) of feeder species, the relationship between winter feeder counts and regional species abundance has yet to be demonstrated. To test whether feeder counts reflect bird abundance, we compared data from PFW with independently derived estimates from BBS for nine common, resident species in the northeastern United States. Specifically, we tested whether regional (among state) and temporal (among year) patterns of breeding-season abundance of resident species are correlated with winter feeder counts from the same region. The BBS is a standardized survey run on randomly distributed routes and therefore provides the most statistically defensible view of regional abundance and its changes over time (Peterjohn and Sauer 1994). Feeder counts could be biased by several factors, including birds using feeders more in certain weather conditions, observ-

er experience, and by an unrepresentative distribution of participants across a particular region. Our aim here is to determine whether PFW data provide scientifically valid information that can be used to track spatial and temporal variation in the abundance of winter birds.

METHODS

Data Collection.—Since 1988–1989, PFW has had between 3800 and 5500 volunteer cooperators who have returned data. Project FeederWatch data consist of counts, following a standardized protocol, of birds visiting feeders. In each of ten 2-wk periods from November through early April, all cooperators preselect two consecutive days on which they will count the birds visiting their feeders. Half of the participants are assigned to begin their bi-weekly counts in the first week of the 21-wk observation period while the other half begin in the second week, so counts are obtained for all 21 weeks of the period. During each 2-d count, observers record the maximum number of birds of each species in sight at any one time within a predefined feeding area. Maximum counts for each species are recorded, along with the date and basic weather information.

Data Editing.—Data are collected on computer-scannable bubble forms and extensively edited to identify and remove detectable errors. The first edit checks for duplicate ID numbers, zip codes that did not match the state, and other internal consistency problems. Other edits flag records with abnormally high numbers and records of species beyond their normal ranges, as determined from DeSante and Pyle (1986), Peterson (1980, 1990), and our own personal knowledge. Flagged records are reviewed manually to determine whether the problem can be corrected and approximately 0.35% of the records are removed from further analysis.

Analysis.—Because protocols used to gather and edit data were modified after 1987–1988, data from that pilot season were excluded from this analysis. To compare PFW with BBS, we used data from U.S. Fish and Wildlife Service Region 5, which includes the states of Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont, Virginia, and West Virginia, plus the District of Columbia. Participants were distributed through all these states (Fig. 1). Largest samples were from 1994–1995, with 540 observers in New York and 459 in Pennsylvania, while the smallest state sample that year was 22 (for West Virginia). Concentrations occurred around major human population centers, mostly located along the Atlantic coastal plain (Fig. 1).

The nine species considered were Red-bellied Woodpecker (*Melanerpes carolinus*), Downy Woodpecker (*Picoides pubescens*), Hairy Woodpecker (*P. villosus*), Tufted Titmouse (*Baeolophus bicolor*), Black-capped Chickadee (*Poecile atricapillus*), White-breasted Nuthatch (*Sitta carolinensis*), Carolina Wren (*Thryothorus ludovicianus*), Northern Cardinal (*Cardinalis cardinalis*), and House Sparrow (*Passer domesticus*). Besides being largely resident throughout the northeastern U.S., these species exhibit a range of winter territoriality from the highly territorial woodpeckers and Caro-

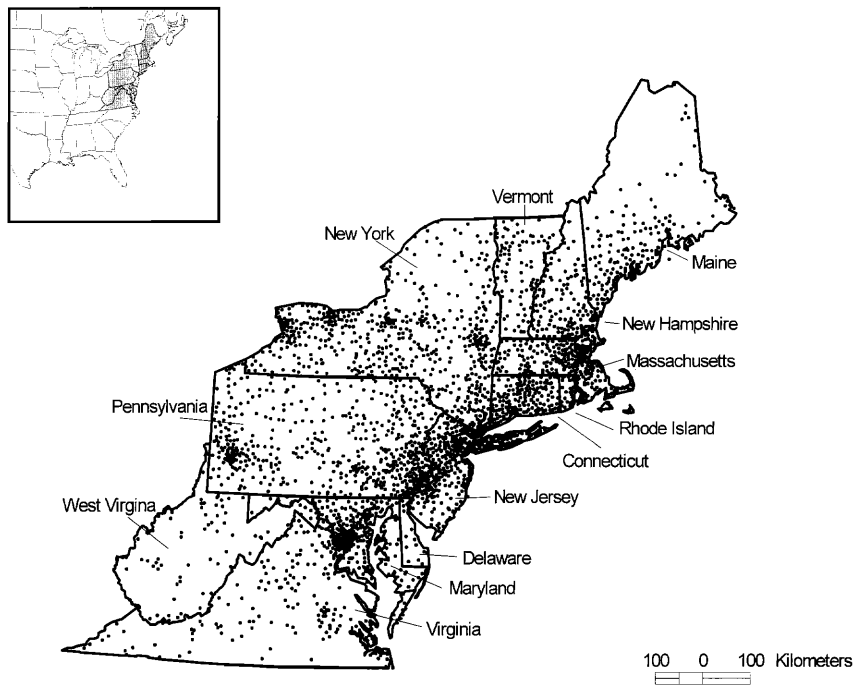

FIGURE 1. Map of the northeastern U.S. showing the distribution of Project FeederWatch participants from 1988–1994. Each dot represents a U.S. Postal Service Zip Code region where at least one participant reported data in at least one winter.

lina Wren to the flocking House Sparrow (Laskey 1944; Kilham 1963, 1965; Dow and Scott 1971; Smith 1991; Lowther and Cink 1992; Pravosudov and Grubb 1993; Grubb and Pravosudov 1994; Haggerty and Marton 1995). By concentrating on resident species we can directly compare PFW and BBS abundance in the same regions with less concern for immigration or emigration.

We examined three PFW indices of abundance: percent of feeders visited, mean abundance, and group size. Each calculation included only those observers who participated at least once in each of the three 7-wk periods of the season. Percent of feeders visited was the percent of observers in a state or region reporting the species at least once in a season. Mean abundance was the average number of the species reported across all sites, over the entire winter. Group size represented the average number of the species seen at one time, including only those sites and weeks in which the species was present. State averages were calculated for the three indices for each year as the mean of individual observer values in that state. Similarly, we calculated annual indices for Region 5 as the means of state indices, weighted by area of each state. The weighting

procedure minimized potential bias due to unequal distribution of observers among states.

BBS relative abundances for each state were obtained from Sauer and Hines (1996) for the period 1988–1994. Each value represents the average number of individuals of a species counted per 39.4-km survey route over the 7-yr period. To test whether spatial variation in abundance across states was similar in the two datasets, we compared PFW and BBS values for each of the states in Region 5 (averaged across the 7 yr).

To test whether temporal variation in abundance across years was similar in BBS and PFW data, we obtained BBS annual indices (Sauer and Geissler 1990) for Region 5 for each species from Bruce Peterjohn, Biological Resources Division, U.S. Geological Service and compared them to annual PFW indices by calculating correlation coefficients. For each year, we compared PFW data with BBS data from the preceding breeding season.

RESULTS

Spatial variation.—Our analysis of spatial variation across the 13 states showed a significant correspondence between PFW and BBS indices. Percent of feeders visited per state was significantly correlated with state BBS indices in all nine species (Table 1). PFW mean abundance and BBS state indices were significantly related in eight of nine species, with correlation coefficients close to those for the comparison of percent of feeders visited with BBS. PFW group size per state was significantly correlated with BBS indices in only four species (Table 1).

Temporal variation.—Annual PFW indices averaged across states usually were not correlated with similar BBS indices over the 7-yr period (Table 1). Annual PFW group size indices were significantly correlated with BBS abundance in four species, whereas PFW mean abundance and BBS abundance were correlated only in the House Sparrow. Annual indices of percent of feeders visited were highly correlated with BBS in the Carolina Wren and House Sparrow. In these two species, PFW and BBS tracked a similar pattern of temporal change; in the wren, both surveys detected a steady increase from 1988–1992, followed by a sharp decline, and in the sparrow both surveys detected a consistent, long-term decline in the region (Fig. 2). In several other species, the overall pattern of temporal change tracked by PFW and BBS appeared similar, even though correlations between the two measures were not significant (Fig. 2).

DISCUSSION

The strong correlations among states between BBS and PFW indices demonstrate that both surveys are measuring abundance similarly at relatively broad geographic scales. Each of the three PFW indices, however, reflect different aspects of regional abundance. PFW mean abundance reflects both percent of feeders visited and average group size; these two measures could vary independently. For example, in largely territorial species that visit feeders either singly or in pairs, larger regional popula-

TABLE 1. Spatial (among-state) and temporal (among-year) correlations between Breeding Bird Survey (BBS) and Project FeederWatch (PFW) abundance indices for nine resident bird species in the northeastern U.S.

Species	Among-state BBS vs.:			Among-year BBS vs.:		
	Percent feeders visited	Mean abund.	Group size	Percent feeders visited	Mean abund.	Group size
Red-bellied Woodpecker	0.63*[a]	0.61*	0.12	0.27	−0.30	0.11
Downy Woodpecker	0.60*	0.51	0.41	−0.03	0.53	0.82*
Hairy Woodpecker	0.89***	0.89***	0.25	−0.29	−0.02	0.82*
Tufted Titmouse	0.87***	0.88***	0.79**	0.53	−0.01	−0.49
Black-capped Chickadee	0.86***	0.88***	0.78**	0.61	−0.16	−0.39
White-breasted Nuthatch	0.76**	0.80***	0.59*	0.65	0.64	0.81*
Carolina Wren	0.77**	0.73*	0.47	0.88**	0.63	0.65
Northern Cardinal	0.85***	0.77**	0.67*	−0.28	−0.38	−0.41
House Sparrow	0.72**	0.67*	0.29	0.78*	0.78*	0.81*

[a]* = $P < 0.05$; ** = $P < 0.01$; *** = $P < 0.001$.

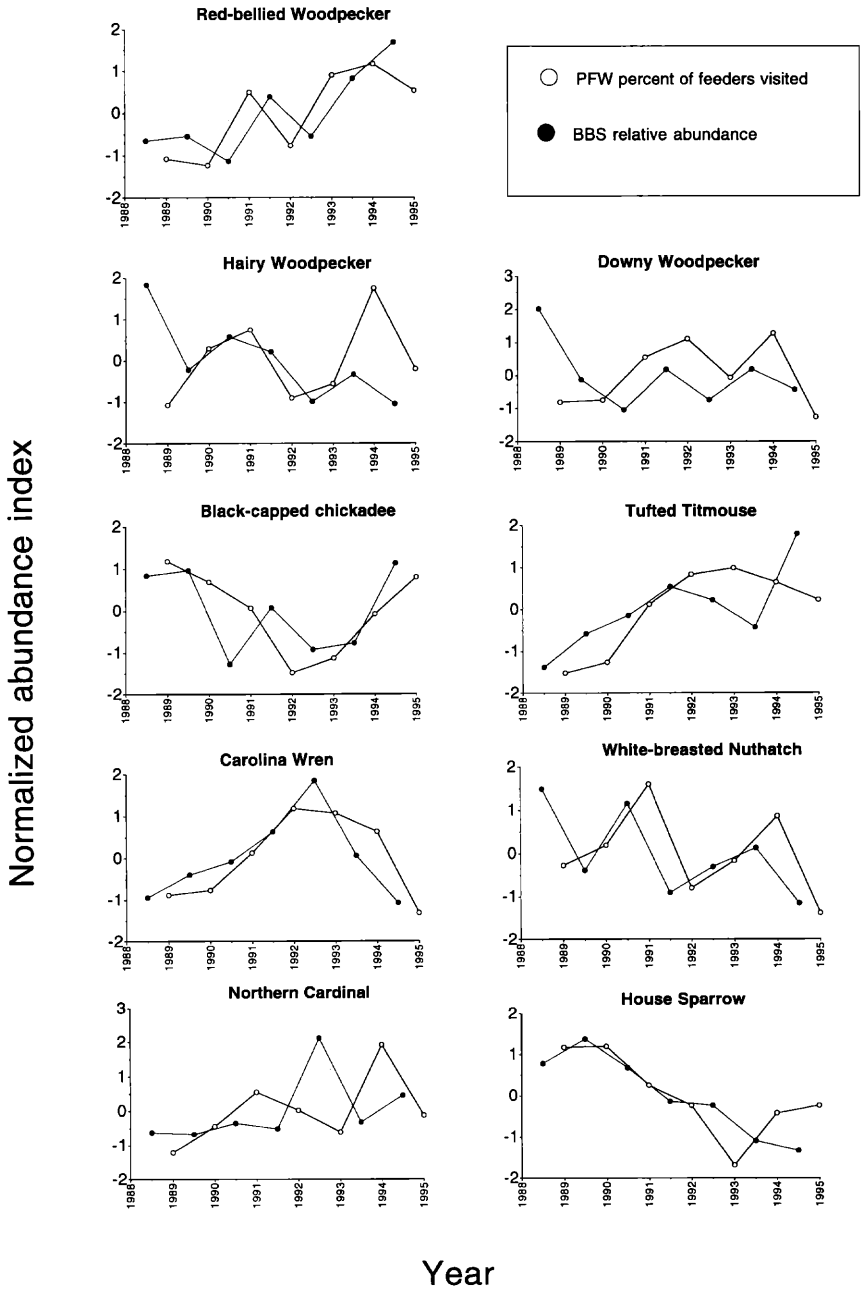

FIGURE 2. Normalized Breeding Bird Survey abundance vs. PFW percent of feeders visited from 1988 to 1994 for nine resident bird species of the northeastern U.S. BBS values are for the breeding season preceding winter PFW values. Indices were normalized by subtracting the 7-year mean from each value and dividing by the standard deviation.

tions will be reflected in more sites being occupied and, therefore, a higher value for percent of feeders visited. In contrast, group size (average number of birds per visit) in these territorial species was the least well correlated with BBS. One or two territory holders may be able to keep conspecifics away from particular feeder sites, regardless of regional population size, making this index relatively inflexible. Indeed, group size was relatively stable (close to 1.0) across states in the woodpeckers and Carolina Wren, which are among the most territorial in winter of our study species (Kilham 1963, 1965; Haggerty and Morton 1995). State group size indices did correlate significantly with state BBS abundance in four species (Tufted Titmouse, Black-capped Chickadee, White-breasted Nuthatch, and Northern Cardinal), which suggests that their group sizes at individual feeders are a reflection of statewide breeding abundance. At least three of these species are known to relax territoriality in winter and form flocks locally (Laskey 1944, Kricher 1981, Smith 1991, Grubb and Pravosudov 1994).

In contrast with our spatial comparisons, among-year variation in PFW and BBS abundance indices for the resident species in our analysis were usually not significantly correlated. This lack of correspondence may be related to several factors. For example, an increase in the number of breeders registered by the BBS might not be reflected in the following PFW season if there were higher than usual mortality or dispersal in the late summer or fall. In addition, if winter mortality determines subsequent breeding population size, PFW counts may correlate better with BBS abundance from the following rather than previous breeding season. In the Red-bellied Woodpecker, for example, percent of feeders visited was highly correlated with BBS abundance from the subsequent season ($r = 0.96$).

A lack of correlation with BBS also might be expected if neither method is detecting relatively large year-to-year population change. Among the species we examined, the strongest correspondence between PFW and BBS indices was seen in Carolina Wren. This was the only species showing large temporal changes, doubling in abundance between 1988 and 1992 and then declining 50% by 1994. For other species that exhibit large temporal variation in abundance within a region, PFW may be better able to track these changes. For example, feeder counts revealed a striking 2-yr cycle of abundance of Varied Thrush (*Ixoreus naevius*) in the Pacific Northwest, a pattern corroborated by regional CBC and BBS indices (Wells et al. 1996).

Our results indicate that winter feeder counts can detect regional variation in abundance and, in some cases, may be valuable in tracking temporal variation in species with relatively large annual fluctuations in abundance. Uncontrollable variation in weather, sampling distribution, and observer experience inherent in this volunteer-based program may limit PFW's ability to track subtle or local temporal changes in abundance. Many flocking and irruptive species exhibit levels of variation equal to or

much greater than those seen in the resident species we studied, and these may be even more amenable to tracking by PFW indices.

Future analyses of PFW data will focus on patterns of winter distribution in irruptive species and investigating within-season variation in relation to weather, geography, and timing of migration. We conclude from our analyses to date that winter feeder counts, if interpreted with care, accurately reflect spatial, and in some cases temporal, variation in abundance of common resident birds.

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