AVIAN WINTER ABUNDANCE PATTERNS IN FARMSTEAD SHELTERBELTS: WEATHER AND TEMPORAL EFFECTS

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Shelterbelts are small, wooded habitats that often are planted near farmsteads in the Midwest to protect humans, domestic animals, and buildings from damage or heat loss caused by winds, drifting snow, and blowing soil (Hintz 1976). During periods of low temperatures and moderate to high winds in winter, properly designed shelterbelts modify the microclimate for cattle, thereby reducing excessive energetic and feed requirements imposed on cattle by high windchill (Robbins 1976). With the exception of studies by Rotzien (1963), Emmerich (1978), and May (1978), little is known regarding the importance of shelterbelts to wintering birds. Ambient temperatures and winds in winter affect foraging strategies, habitat use, and metabolism of birds (e.g., Grubb 1977, Mayer et al. 1979). Presence and density of wintering bird species in shelterbelts have been suggested to be somewhat weather dependent (Rotzien 1963). My objectives in this paper are (1) to describe avian winter abundance patterns in several shelterbelts and (2) to examine whether or not these patterns are related to weather and temporal factors during winter.

STUDY AREA AND METHODS

The study was conducted on 7 farmstead shelterbelts (total = 3.3 ha) at the Rosemount Agricultural Experiment Station, Dakota County, Minnesota. Descriptions of the shelterbelts are given elsewhere (Yahner 1980a, b). Birds occupying each shelterbelt were censused the same morning on 15 occasions from late December to early March in both 1979 and 1980 (Yahner 1980a, 1981), giving a total of 30 censuses per shelterbelt. The order in which shelterbelts were visited in a morning was randomized. Because of the width of the shelterbelts (10–27 m), all birds in each could be detected readily by slowly walking a transect positioned in the center of the shelterbelt and extending the total length (162–498 m). All birds seen or heard were noted. Data obtained from the 7 shelterbelts were pooled each census. The following bird variables were calculated to describe bird abundance patterns: density of all species combined (N), density of individual species (n_i, where i is the ith species), species richness (S = number of different species), species diversity ($H' = p_i \ln p_i$, where p_i is the proportion of individuals in the ith species), and species equitability ($J' = H'/\ln S$) (after Dickson 1978). A temporal variable (TIME), time elapsed (days) since the first day of winter (21 December), and 3 weather variables, including minimum ambient temperature (°C, TEMP), mean wind velocity (km/h, WIND), and snow depth (m, SNOW), were determined for each census. Ambient temperature and wind velocity were measured 25 m distant from the windward (north or west) side of shelterbelts, and snow depth was taken at 5 random points within non-drifted sectors of shelterbelts. The bird

variables (dependent variables) were regressed on the temporal and weather variables (independent variables) using stepwise multiple regression (BMD02R; Dixon 1973). Data from 1979 were analyzed separately from those for 1980, giving 2 data matrices consisting of 15 cases (censuses) per year. Residuals were plotted against the computed values of Y and against the 4 independent variables to visually check for autocorrelation (Draper and Smith 1966, Chatterjee and Price 1977). A multiple regression coefficient (R) was computed for each dependent variable each year; R was used to calculate the proportion of total variance explained (R^2) with all 4 independent variables in the regression models and to test for significant partial regression coefficients by inclusion of p independent variables in each regression equation (Chatterjee and Price 1977).

RESULTS AND DISCUSSION

The winter of 1979 was characterized by colder temperatures, higher winds, and greater snow depths than 1980; these differences in the relative severity of weather may, in part, account for lower mean values of S, H', and J' in 1979 compared to 1980 (Table 1) (after Kricher 1975). In contrast, mean N in 1979 was higher than in 1980 because of greater densities of House Sparrows. Large flocks of House Sparrows lowered J' in 1979, and J' was correlated to H' ($r = 0.78$, df = 13, $P < 0.01$). Kricher (1972) attributed lower values of J' in wintering bird communities to interspecific flocking, and Dickson (1978) noted a relationship between J' and H' resulting from large numbers of a few wintering species in the community. On the other hand, House Sparrows were less abundant and S was higher in the shelterbelts during the milder winter of 1980 (Table 1), and H' was correlated instead to S ($r = 0.79$, df = 13, $P < 0.01$).

Winter densities of all species combined (N, Table 1) in the 7 shelterbelts were comparable to winter densities reported for bird communities of various habitats in southern latitudes of the United States but were much higher than those of northern regions (see Dickson 1978, for discussion). The presence of spilled grain in areas adjacent to 2 of the 7 shelterbelts was a major factor in attracting large numbers of House Sparrows, Starlings, and several other granivorous species. Food supplied by man also accounted for increased densities of granivorous bird species during winter in urban environments studied by Lancaster and Rees (1979).

Four of 17 and 4 of 20 bird variables measured in 1979 and 1980, respectively, were correlated with weather and temporal factors (Table 2). No pattern, however, existed in the effects of these independent variables on the bird variables between winters. For example, Starlings were more abundant in shelterbelts in 1980 than in 1979 (Table 1); in 1979, densities of this species were related to the temporal factor but were not correlated with any independent variable the following winter. Blue Jays were less common in shelterbelts as spring approached in 1980 but did not vary seasonally in 1979 (Table 2).

TABLE 1. Mean ± SD of bird variables and weather variables determined from 15 cen-
suses of 7 farmstead shelterbelts in Minnesota during winter 1979 and 1980 (see text for
discussion of variables).

	Mean ± SD	
Variable	1979	1980
Ambient temperature (°C)	−11.63 ± 6.27	−10.26 ± 11.17
Wind velocity (km/h)	10.73 ± 8.64	5.46 ± 5.13
Snow depth (m)	0.46 ± 0.16	0.10 ± 0.05
Species richness, S	5.07 ± 1.71	5.80 ± 2.31
Species diversity, H′	0.91 ± 0.35	1.24 ± 0.34
Species equitability, J′	0.58 ± 0.20	0.73 ± 0.16
Total density, N (no./ha)	20.69 ± 9.83	16.97 ± 15.69
Species density, n (no./ha)[a]		
Ring-necked Pheasant (*Phasianus colchicus*)	1.41 ± 1.33	0.68 ± 0.68
Gray Partridge (*Perdix perdix*)	0.08 ± 0.24	NR
Mourning Dove (*Zenaida macroura*)	NR	0.04 ± 0.11
Great Horned Owl (*Bubo virginianus*)	0.04 ± 0.15	0.14 ± 0.25
Hairy Woodpecker (*Picoides villosus*)	0.06 ± 0.12	0.06 ± 0.17
Downy Woodpecker (*Picoides pubescens*)	0.06 ± 0.17	0.08 ± 0.18
Blue Jay (*Cyanocitta cristata*)	0.42 ± 0.48	0.44 ± 0.44
Common Crow (*Corvus brachyrhynchos*)	0.10 ± 0.19	0.06 ± 0.17
Black-capped Chickadee (*Parus atricapillus*)	0.14 ± 0.34	0.46 ± 0.65
Brown Creeper (*Certhia familiaris*)	NR	0.02 ± 0.08
Cedar Waxwing (*Bombycilla cedrorum*)	NR	0.24 ± 0.93
Starling (*Sturnus vulgaris*)	0.68 ± 1.30	1.87 ± 2.69
House Sparrow (*Passer domesticus*)	14.98 ± 9.10	6.65 ± 8.09
Brewer's Blackbird (*Euphagus cyanocephalus*)	0.02 ± 0.08	NR
Cardinal (*Cardinalis cardinalis*)	NR	0.02 ± 0.08
American Goldfinch (*Carduelis tristis*)	NR	1.77 ± 4.66
Dark-eyed Junco (*Junco hyemalis*)	2.35 ± 1.86	2.59 ± 2.20
Tree Sparrow (*Spizella arborea*)	0.04 ± 0.15	0.04 ± 0.15

[a] NR = not recorded in shelterbelts for that particular winter.

Mean population density of Ring-necked Pheasants in shelterbelts in
winter 1979 was nearly twice that of winter 1980 (Table 1). Differences
in density between winters may be partially due to a statewide decline
in numbers of Ring-necked Pheasants in autumn 1979 compared to
autumn 1978 in the rural sectors of southern Minnesota (A. Berner,
pers. comm.). Use of shelterbelts by this species at the Rosemount Sta-
tion was not correlated with weather or temporal factors in winter 1979,
yet snow depth was important in winter 1980 (Table 2). I suggest that
mean snow depth in 1979 (0.46 m, Table 1), plus additional depth re-
sulting from drifting in certain sectors of all shelterbelts, virtually elim-
inated access to low-lying sources of food and cover in shelterbelts dur-
ing the 1979 winter. In contrast, decreased amounts of snow in
shelterbelts during winter 1980 (0.10 m, Table 1) conceivably permitted
Ring-necked Pheasants to more easily obtain food and/or cover near
ground level and in leaf litter with reduced time-energy costs because

TABLE 2. Stepwise multiple regression based on 15 censuses of 7 farmstead shelterbelts in Minnesota during winter 1979 and 1980. Bird (dependent) variables are regressed on 4 independent variables, including a temporal variable (TIME) and 3 weather variables (TEMP, WIND, SNOW). Proportion of variance explained (R^2) is given with all 4 independent variables in the regression equations. Equations and/or independent variables are omitted from table if partial regression coefficients are not significant ($P < 0.05$; see Chatterjee and Price 1977) (see text for discussion of variables).

Dependent variable	1979		1980	
	R^2	Regression equation	R^2	Regression equation
Species richness, S	0.50	Y = 3.412 − 0.142 (TEMP)	0.56	
Species diversity, H′	0.22		0.48	
Species equitability, J′	0.07		0.24	
Total density, N	0.15		0.27	
Species density, n[a]				
Ring-necked Pheasant	0.19		0.45	Y = 1.512 − 8.457 (SNOW)
Gray Partridge	0.41		NR	
Mourning Dove	NR		0.37	
Great Horned Owl	0.50		0.72	Y = −0.012 + 0.010 (TIME) − 2.912 (SNOW)
Hairy Woodpecker	0.42		0.23	
Downy Woodpecker	0.35		0.13	
Blue Jay	0.23		0.41	Y = 0.886 − 0.011 (TIME)
Common Crow	0.59	Y = −0.081 − 0.016 (TEMP)	0.18	
Black-capped Chickadee	0.35		0.49	
Brown Creeper	NR		0.59	Y = −0.009 + 0.004 (TEMP) + 0.739 (SNOW)
Cedar Waxwing	NR		0.21	
Starling	0.48	Y = 2.751 − 0.043 (TIME)	0.22	
House Sparrow	0.12		0.29	
Brewer's Blackbird	0.28		NR	
Cardinal	NR		0.12	
American Goldfinch	NR		0.03	
Dark-eyed Junco	0.43	Y = 0.453 − 0.163 (TEMP)	0.34	
Tree Sparrow	0.28		0.12	

[a] NR = not recorded in shelterbelts for that particular winter. Scientific names as in Table 1.

a smaller proportion of shrubs and herbaceous plants were buried in snow compared to the previous winter. The influence of snow depth on relative food availability for other species, e.g., White-tailed Deer (*Odocoileus virginianus*), is well documented (Kucera 1976). Thus, in years of

reduced snow accumulation (as in winter 1980), use of shelterbelts by
Ring-necked Pheasants may be largely a function of snow depth; when
snow depths are excessive (as in winter 1979), use of shelterbelts perhaps
is contingent on other factors, such as annual fluctuations in population
densities or proximity to alternate food sources. Gates and Hale (1974)
and May (1978), for example, stressed that provision of food near shel-
terbelts for wintering Ring-necked Pheasants is critical for survival and
use of these habitats as traditional wintering areas or as daytime loafing
sites. Proper spacing of trees and shrubs planted in shelterbelts can
affect snow distribution patterns (see Scholten 1979); therefore, design
of future shelterbelts should consider the potential consequences of tree
and shrub spacing on Ring-necked Pheasant populations in winter (May
1978). Dalke (1943) concluded that increased winter use of shelterbelts
by Ring-necked Pheasants was evident when winds exceeded 40 km/h.
I have no data to support this contention because maximum wind ve-
locities never exceeded 35 km/h during my censuses.

Great Horned Owls occurred in the shelterbelts only during late win-
ter each year (Yahner 1980a, 1981), coinciding with nesting activity.
Because nesting activity began 1 week earlier in 1980 than in 1979, the
occurrence of Great Horned Owls in winter censuses and, hence, density
were greater in 1980 (Table 1). In winter 1980, sightings of Great
Horned Owls were correlated with the temporal variable and to snow
depth, which decreased in early spring (Table 2).

Lower ambient temperatures in winter 1979 were associated with in-
creases in S and densities of both Common Crows and Dark-eyed Juncos
(Table 2). As previously noted, S was lower in winter 1979 than in winter
1980 as a plausible outcome of warmer temperatures in winter 1980
(Table 1). Apparently, a greater proportion of the species comprising
the avian community at the Rosemount Station during the colder winter
of 1979 tended to seek refuge in shelterbelts in response to lower am-
bient temperatures as compared to the warmer winter of 1980. Simi-
larly, Gottfried and Franks (1975) noted that Dark-eyed Juncos seek
wooded habitats as ambient temperatures decline; they concluded that
selection of sheltered areas is adaptive by reducing metabolic costs dur-
ing periods of adverse weather conditions. Conversely, densities of
Brown Creepers, a species noted only in winter 1980 (Table 1), in-
creased directly with ambient temperatures and snow depth (Table 2).
I have no explanation for this trend.

In conclusion, the presence of most wintering bird species in farm-
stead shelterbelts is difficult to predict on the basis of short-term changes
in either season (elapsed time) or weather conditions (Table 2). Perhaps
an analysis of short-term fluctuations in weather conditions can help us
better understand the effects of weather and season on energetics and
foraging strategies (e.g., Grubb 1977, Mayer et al. 1979). Community
structure and population densities of birds in shelterbelts of a geographic
region during a given winter may likely be products of factors such
as long-term weather phenomena and/or annual fluctuations in winter

food availability, nesting success during the previous breeding season, or autumn and early winter migratory patterns. Further, an examination of weather phenomena over longer time periods, as when pooled over the entire winter (Table 1), may give valuable insight into a possible causal relationship between severity of winter weather and avian abundance patterns. For example, differences in both S and mean weather conditions between winters in this study (Table 1) may lend support to the hypothesis that weather acts, at least partially, as a regulatory mechanism of wintering bird populations (Fretwell 1972, Kricher 1975).

SUMMARY

Avian use of farmstead shelterbelts was studied for 2 winters in Minnesota. Species diversity was correlated to species equitability in the severe winter of 1979 and to species richness in the mild winter of 1980. Densities of all species combined were considerably higher than those reported for different habitats in northern latitudes. Species richness in 1979 and population densities of 7 species in either 1979 or 1980 were correlated with weather or temporal factors. Short-term changes in season (elapsed time) or weather conditions are probably not good predictors of avian abundance patterns in shelterbelts during winter.

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