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BIRD ACTIVITY LEVELS RELATED TO WEATHER

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ABSTRACT.—The Breeding Bird Survey data bank serves as a primary source for studying effects of sky cover, wind speed, and temperature on bird census results. Other standardized methods, such as spot-mapping (Breeding Bird Census), point counts, banding, and the Winter Bird Survey, provide additional, but limited, means of assessing effects of weather.

Numbers of songbirds detected are generally inversely correlated with wind speed, but hawks often are seen in larger numbers on windy days. Rain greatly reduces the numbers of birds detected. Cloud cover has relatively little influence on early morning bird counts during the peak of the breeding season. Fog selectively favors auditory detections of some species. Counts of many species are correlated with temperature, but effects are minor unless temperatures are extreme.

Under marginal weather conditions, total species observed may be nearly normal, whereas number of individuals observed is reduced, as is the opportunity to record simultaneous registrations.

This paper is concerned with effects of weather on counting bird populations during the breeding and winter seasons. The effects of weather on activity during migration periods are a different subject and beyond the scope of this paper. I discuss primarily the effects of weather on bird activity, especially on singing, but reference is made to the effects on the observer and detection ability.

Bird censusers as a rule are conscientious and devoted to achieving the best estimates of the birds on their study plot(s). Close estimates of the actual populations or of an index to these populations are essential if the investigator is making comparisons between habitats or over time. Accuracy is especially important if the results are to enter the literature or data banks used for subsequent investigations.

Census workers, therefore, tend to conduct their fieldwork under the best possible environmental conditions. In particular, strong winds, rain, and excessive heat are avoided. Most instructions for the spot-mapping method (Hall 1964, International Bird Census Committee 1970, Berthold 1976) do not stipulate acceptable weather conditions, and instructions for the Common Birds Census of the British Trust for Ornithology specify only that visits should be made during favorable weather when song is not reduced by wind or heavy rain. Instructions for the Breeding Bird Survey (available from U.S. Fish and Wildlife Service) say to avoid fog, steady drizzle, prolonged rain, and winds greater than Beaufort 3 (13–19 kmph), and further state that winds of Beaufort 2 (6–12 kmph) or less are preferable.

There are few published references to measured effects of weather on bird censusing, so the inexperienced observer has no guidelines as to which conditions should be avoided. Similarly, the experienced observer has no guide on ways to compensate for counts that are unusually low (or high) because of wind, fog, rain, or of snow cover.

METHODS

The following data sources were examined for purposes of this paper.

BREEDING BIRD SURVEY

Breeding Bird Survey (BBS) data are suitable for analysis of the effects of weather on census results. The large sample size, broad geographic distribution, the large number of species sampled, and the fact that temperature, wind speed, and sky condition are recorded at both the beginning and the end of each survey make these data especially useful. For this paper I selected BBS counts from four geographic regions (Figure 1). These were selected so that within each region there would be uniformity of normal weather conditions—especially a narrow range of average minimum temperatures (13–16°C in regions 1, 2, and 4, and 7–13°C in region 3 for the week 4–10 June; Visher 1954:68). I had to be sure that differences in birds detected were a result of local temperatures during the counts rather than reflecting different parts of the range where abundance of the species was different. Altogether, BBS totals for 46 species that occur commonly in one or more of the four regions were selected for analysis.

Routes were sorted into groups according to the sky condition at the start of each route (clear, partly cloudy, overcast, fog, drizzle, and showers). Starting rather than ending sky condition was used because (1) more birds are recorded in the first half of BBS routes than in the second half, and (2) starting rather than ending conditions influence the observer's decision whether to conduct a count. Wind speed recorded in the Beaufort scale at the end of each coverage was selected for analysis because wind has a greater effect in mid-morning than near sunrise. Starting temperatures were grouped by 2.78°C categories (5°F). Mean counts (and standard errors) for the 46 species in each of the four regions were computed and plotted for each weather interval, and the data for some of these species were examined by analysis of variance to remove any geographical or route effect.

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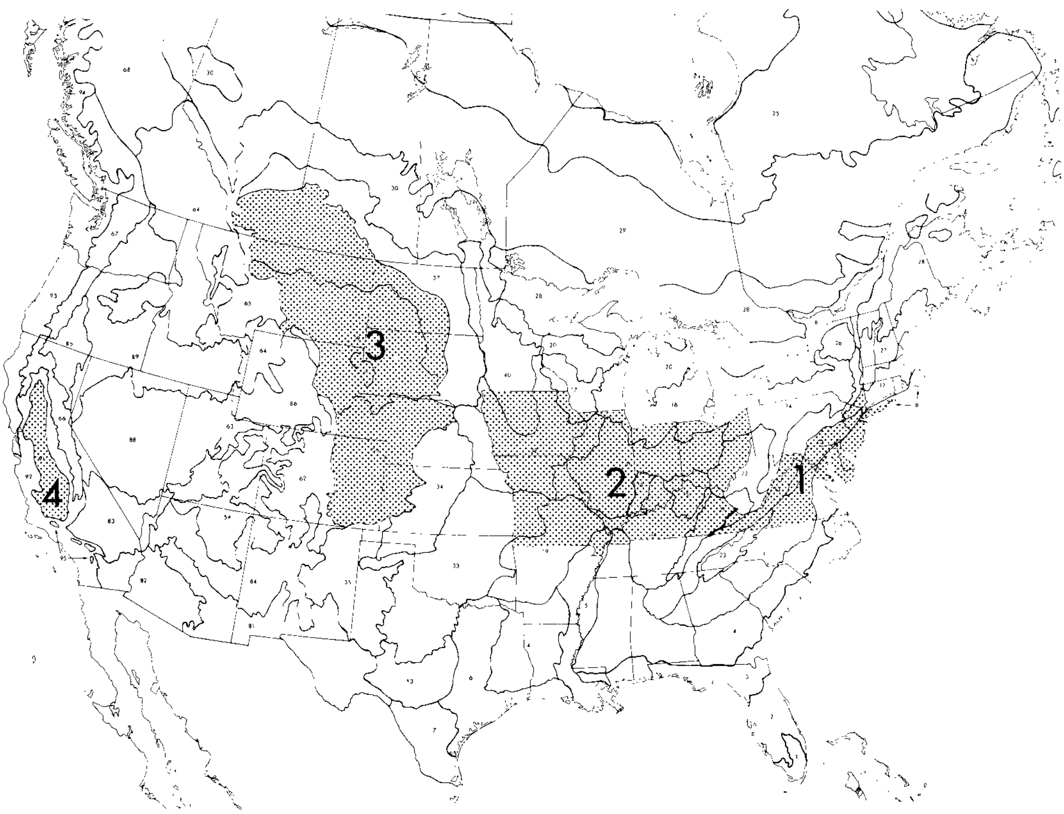

FIGURE 1. The four regions used for analysis of effect of weather conditions on BBS results.

Breeding Bird Survey Check Routes

There are several BBS routes in Maryland that have been covered numerous times in the same year by the same or different observers in the course of various types of observer tests. Two of these 50-stop routes provided an opportunity to study weather effects. Because these routes had been used to study observer bias, it was easy to eliminate observations of participants who had hearing problems. Accordingly, 58 comparable coverages of the Beltsville BBS route (46-022) and 26 of the Harmony route (46-038) were examined for effects of temperature, wind, and sky cover on 30 common bird species.

Other Breeding Season Counts

Spot-mapping.—On 8 July 1980 I took a census trip in steady light rain through an upland hardwood plot in Howard County, Maryland, that I have been censusing for eight years. Normally I would have canceled my plans, but this was an opportunity to measure the effect of light rain in comparison with a similar count I had made in good weather on the previous day.

Breeding season banding.—Results of intensive all-day banding in a floodplain study plot on the Patuxent Wildlife Research Center in Laurel, Maryland, over a period of 10 years were examined.

Point counts.—Because very little point count data were available for poor weather conditions, I conducted 20-min. point counts under marginal conditions when I had satisfactory counts available from an adjacent day for comparison.

Winter Counts

Transect counts.—Transect counts from all seasons of the year made through a variety of habitats on the Patuxent Wildlife Research Center were examined to see whether species totals were correlated with wind, temperature, or cloud cover.

Winter Bird-Population Study.—Personal records from the Audubon Winter Bird-Population Study were examined to see whether there were consistent effects of low temperatures on the birds of two woodland study plots in Howard County, Maryland.

Christmas Bird Counts.—Twenty-five years of data from three Christmas Bird Count areas on the Eastern Shore of Maryland were examined as were data from 20 years from a fourth area. Two of these areas were selected because I have been the compiler for the entire period and have personal knowledge of how the weather conditions have been recorded and how the coverage (party-miles) has been calculated. I have also participated in the other two counts, although they had been compiled by others. Five species were selected

TABLE 1
SPECIES AFFECTED BY CLOUD COVER

Species	Mean with clear sky (n = 1911)	% change when overcast (n = 917)
Bobwhite	32.4	−15.7**
Eastern Kingbird	16.8	−23.8**
Tufted Titmouse	8.0	−14.9**
Gray Catbird	7.0	+14.3**
Brown Thrasher	5.9	+12.0**
American Robin	39.4	+10.9**
Yellow Warbler	1.5	+22.0*
Eastern Meadowlark	32.2	−10.3*
Rufous-sided Towhee	8.1	+14.4*
Song Sparrow	19.4	+9.7*

* $P < 0.05$.
** $P < 0.01$.

for study and in each year the number of individuals of each of these species was divided by the number of party-hours of coverage in that year. The resulting birds per party-hour were then grouped by weather categories and examined by stepwise regression analysis to sort out year-to-year changes from changes influenced by weather conditions.

RESULTS

BREEDING BIRD SURVEY

Data from each of the four regions shown in Figure 1 were analyzed separately for each species. It soon became apparent that hundreds if not thousands of records for each species would be needed to demonstrate effects of weather conditions. One reason large samples are required is because the great majority of counts were taken in a narrow range of satisfactory conditions. Thus fog, drizzle, showers, high winds, and extreme temperatures are poorly represented in the sample. For most species in region 4, samples were too small (n = 186 route-years) to show significant effects of weather, and even in region 3 (n = 788) the results were meager. Most of the following comments, therefore, relate to the more common species that nest in both region 1 (n = 1417) and region 2 (n = 2435).

Sky condition

Cloud cover.—After finding only five significant differences ($P < 0.05$) between number of birds found on clear vs. overcast mornings in any single region, I combined regions 1 and 2, which had the most species in common. This increased the number of significant differences to 10 (Table 1), but note that it required nearly 3000 route-years of data to demonstrate these differences (without counting the days that were partly cloudy, foggy, or rainy).

Fog.—Fog has a greater effect on bird counts than overcast vs. clear skies (Table 2). With much smaller samples (173 foggy days), 18 species showed significant differences ($P < 0.05$). The pattern that emerges from Table 2 is that birds detected primarily by sight (hawks, swifts, swallows, Starlings, blackbirds) are found in smaller numbers on foggy mornings

TABLE 2
SPECIES AFFECTED BY FOG

Species	Mean with overcast sky (n = 917)	% change when foggy (n = 173)
Red-tailed Hawk (*Buteo jamaicensis*)	0.33	−42.8**
Mourning Dove (*Zenaida macroura*)	27.4	−18.5**
Chimney Swift (*Chaetura pelagica*)	13.2	−26.7**
Eastern Kingbird (*Tyrannus tyrannus*)	4.5	−34.9**
Eastern Wood Pewee (*Contopus virens*)	5.0	+17.1*
Barn Swallow (*Hirundo rustica*)	23.7	−25.5**
Tufted Titmouse (*Parus bicolor*)	7.1	+33.6**
American Robin (*Turdus migratorius*)	43.7	−13.2*
Wood Thrush (*Hylocichla mustelina*)	9.2	+64.7**
Starling (*Sturnus vulgaris*)	110.9	−19.4**
Red-eyed Vireo (*Vireo olivaceus*)	5.9	+82.9**
Ovenbird (*Seiurus aurocapillus*)	1.7	+39.8*
Red-winged Blackbird (*Agelaius phoeniceus*)	124.1	−28.0**
Brown-headed Cowbird (*Molothrus ater*)	11.2	−21.0**
Cardinal (*Cardinalis cardinalis*)	23.0	+18.3*
Indigo Bunting (*Passerina cyanea*)	22.8	+27.4**
Chipping Sparrow (*Spizella passerina*)	8.8	+31.2**
Field Sparrow (*Spizella pusilla*)	14.5	+25.7*

* $P < 0.05$.
** $P < 0.01$.

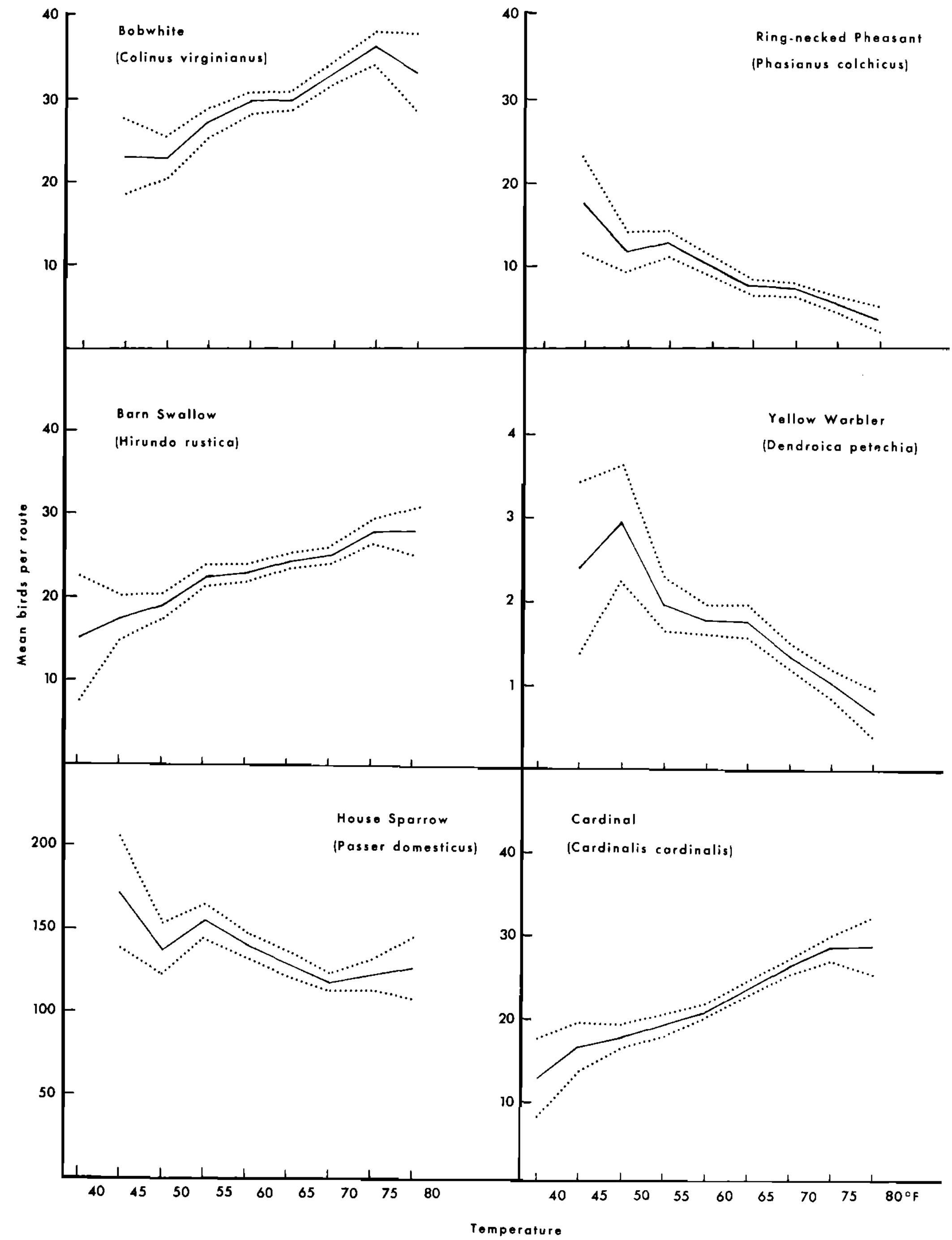

FIGURE 2. Effect of temperature on six species of breeding birds in Regions 1 and 2 based on 3852 route-years of BBS data. Temperatures (°F), taken one-half hour before sunrise, were grouped by 5° intervals for the analysis. Mean birds per 50-stop route and 95% confidence limits are shown. Note that small samples at the temperature extremes (n = 63 for the 41–45° temperature group and n = 82 for 75–80°) broaden the confidence limits.

TABLE 3
SIGNIFICANT CORRELATIONS WITH TEMPERATURE
($P < 0.05$)

Species	Areas	Correlation
Red-tailed Hawk	2, 3, 4	−
Mourning Dove	2, 3	+
Whip-poor-will	1, 2	+
Chimney Swift	1, 2	+
Eastern Kingbird	1, 2	+
Horned Lark	2, 3	−
Mockingbird	1, 2, 4	+
American Robin	1, 2, 4	−
Red-eyed Vireo	1, 2	−
Eastern Meadowlark	2, 3	+
Indigo Bunting	1, 2	+
Dickcissel[a]	3	+
Grasshopper Sparrow	1, 3	+
Vesper Sparrow	2, 3	−
Song Sparrow	1, 2	−

[a] *Spiza americana.*

TABLE 4
NUMBER OF SPECIES (FROM A SAMPLE OF 30 SPECIES) SIGNIFICANTLY CORRELATED WITH WEATHER CONDITIONS ON THE BELTSVILLE AND HARMONY BBS ROUTES

Weather variable	Number of significant correlations, $P < 0.05$	
	Positive	Negative
Temperature at start	9[a]	2[b]
Temperature at end[c]	3	0
Wind at start (Beaufort)[c]	0	1
Wind at end	3[d]	3[e]
Wind, sum of start and end	1[f]	4[g]
Wind at end vs. count at last 20 stops	2[h]	6[i]
Sky at start[c]	3	0
Sky at end	2[j]	2[k]
Sky, sum of start and end[c]	0	2
Sky at end vs. count at last 20 stops[c]	2	1

[a] Eastern Kingbird, Barn Swallow, American Robin (both routes), Eastern Meadowlark (*Sturnella magna*), Cardinal, Rufous-sided Towhee, and Grasshopper Sparrow (*Ammodramus savannarum*; both routes).
[b] Starling, Red-winged Blackbird.
[c] From a sample of 30 species on each of 2 BBS routes, 3 significant correlations with this variable would be expected from chance alone.
[d] Starling, Red-winged Blackbird, Field Sparrow.
[e] Mourning Dove, Eastern Wood Pewee, Song Sparrow.
[f] Wood Thrush (Harmony route).
[g] Barn Swallow, Wood Thrush (Beltsville route), Rufous-sided Towhee, Field Sparrow.
[h] Chimney Swift, Grasshopper Sparrow.
[i] Gray Catbird (*Dumetella carolinensis*; both routes), Brown Thrasher (*Toxostoma rufum*), House Sparrow, Cardinal, Chipping Sparrow.
[j] Red-eyed Vireo, Common Grackle (*Quiscalus quiscula*).
[k] Chimney Swift, Mockingbird.

whereas fringillids and some of the other passerines with loud songs are found in larger numbers. Fog improves ability to hear distant birds, and in addition, when an observer cannot see distant birds he naturally devotes more attention to detecting auditory cues.

Wind

Of 18 species analyzed from region 4 in California (corrected for route effect), one-third were significantly correlated with wind speed, the Red-tailed Hawk (scientific names not in the text appear in Table 2 or in footnotes of Table 4) positively, the others negatively: Horned Lark (*Eremophila alpestris*), Mockingbird (*Mimus polyglottos*), House Sparrow (*Passer domesticus*), and Red-winged Blackbird (*Agelaius phoeniceus*).

Of more practical interest than whether the numbers recorded are correlated with wind is the wind speed at which there is a significant change in the number recorded. In the following list the numbers in parentheses are the wind speeds (kmph) that correspond to the highest wind speed (originally recorded in the Beaufort scale) at which there was not a significant ($P < 0.05$) decline in registrations as compared with calm days: Bobwhite, *Colinus virginianus* (11); Mourning Dove (19); Whip-poor-will, *Caprimulgus vociferus* (11); Eastern Wood Pewee (11); Mockingbird (5); Gray Catbird, *Dumetella carolinensis* (11); Red-eyed Vireo (5); Yellow Warbler, *Dendroica petechia* (11); Ovenbird, *Seiurus aurocapillus* (11); Common Yellowthroat, *Geothlypis trichas* (11); Eastern Meadowlark, *Sturnella magna* (11); Scarlet Tanager, *Piranga olivacea* (2); Cardinal (5); Indigo Bunting (11); Rufous-sided Towhee, *Pipilo erythrophthalmus* (11); Chipping Sparrow (11); and Field Sparrow (11). These data are from region 2, which had the largest sample (n = 2435). Observations of almost all species declined more sharply at Beaufort 4 and 5, indicating that wind speeds above Beaufort 3 (13–19 kmph) should be avoided when possible.

Temperature

Effects of temperature were discernible only with large samples. In region 4, the Central Valley of California (n = 186), significant temperature trends ($P < 0.05$) were detected only after route effect was removed by analysis of variance.

Temperature trends for six species are shown in Figure 2, based on the combined results of regions 1 and 2. Some other significant correlations are listed in Table 3. Analyses for other species had to be abandoned because the large samples submitted for analysis of variance exceeded the capacity of the computer.

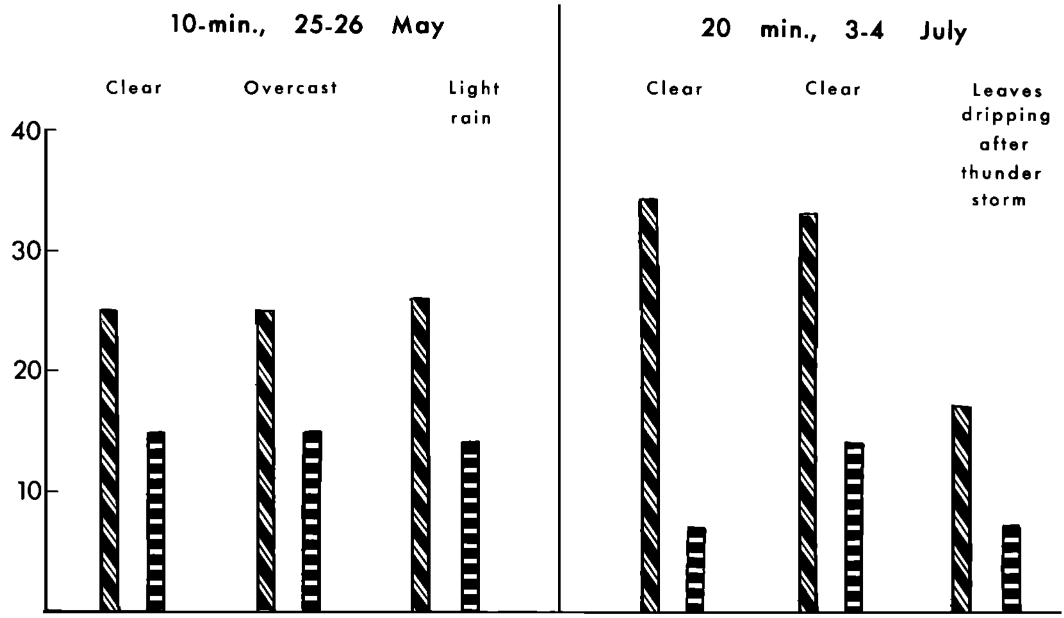

FIGURE 3. Effect of light rain and of dripping leaves on total individuals (diagonal barring) and total species (horizontal barring) recorded on IPA point counts. Although light rain did not depress singing, dripping leaves after a nocturnal thunderstorm did.

Breeding Bird Survey Check Routes

I used linear regression analyses to explain the variation in the counts of 30 species on the Beltsville and Harmony, Maryland, BBS routes. The results and independent variables used in these analyses are given in Table 4. Note that with a sample of 30 species on each of two BBS routes, three significant correlations with each weather condition variable would be expected from chance alone. It was surprising, therefore, to find that with a large sample of records from experienced observers on two BBS routes, the number of correlations with weather conditions was so low.

As an example of effects of rain that occurred on just part of a BBS route (number 46-047), the right half of Table 5 shows the percentage decline, by family, caused by rain. This route was covered on two consecutive days by the same observer. Numbers given are the 50-stop totals. On the first day, moderate rain occurred at 9 of the first 18 stops, followed by overcast skies; skies were clear when the count was repeated the next day. Although the total number of species observed was only 4 (6%) fewer on the rainy day, total individuals dropped 19% and 8 of the major families registered declines of more than 35%. On another route (46-038), where coverage was cancelled after 20 stops with rain, comparison with the first 20 stops of the rerun (under partly cloudy skies) showed a reduction of 36% in species and 61% in individuals on the rainy day.

Other Breeding Season Counts

Spot-mapping.—Although comparative data are few, they demonstrate that even light rain can have a strong effect on the numbers of birds recorded (Table 5, left half). These observations are similar to those of Hogstad (1967), who reported that the number of registrations in rainy weather drops to about half that in dry weather. The effect becomes greater as precipitation becomes heavier, and especially if precipitation is accompanied by high winds. Any sharp decrease in singing activity also reduces the likelihood of simultaneous registrations, which in turn decreases the effectiveness of a spot-mapping visit.

Breeding season banding.—Because rainy days were avoided, and because the study plot was heavily wooded and well sheltered from the wind, extreme weather conditions were not encountered. The closed canopy of the mature forest shaded the nets from the sun at all times. Lack of correlations between weather and numbers of birds netted serves as a recommendation for using banding in conjunction with other tech-

TABLE 5
EFFECT OF LIGHT RAIN ON TWO COUNT METHODS

Family	Spot mapping			BBS		
	Clear	Rain	Difference	Clear	Rain (9 stops)	Difference
Columbidae	4	4	0	13	7	−46%
Cuculidae	2	2	0	21	10	−52%
Picidae	7	3	−57%	28	15	−46%
Tyrannidae	10	6	−40%	15	17	+13%
Hirundinidae				39	31	−21%
Corvidae	0	1	+	57	44	−23%
Paridae	4	1	−75%	49	26	−47%
Troglodytidae				21	10	−52%
Mimidae	4	1	−75%	12	15	+25%
Turdidae	13	12	−8%	54	34	−37%
Sturnidae				114	96	−16%
Vireonidae	10	3	−70%	43	39	−9%
Parulidae	13	10	−23%	44	40	−9%
Ploceidae				60	33	−45%
Icteridae	4	0	−100%	176	179	+2%
Thraupidae	5	1	−80%	8	5	−38%
Fringillidae	11	6	−45%	64	63	−2%
All species	87	51	−41%			

niques in closed canopy habitats. In an open situation either sun or wind could severely reduce the catch.

Point counts.—From a sample of over 500 20-minute point counts I have selected three examples to illustrate effects of weather conditions. The first two, shown in Figure 3, illustrate different effects of rain on total adults recorded and total species recorded. The first count, taken on 25 May 1980 in deciduous woods at Laurel, Maryland, had 10 minutes of very light rain followed by 10 minutes of solid overcast. The numbers of species and individuals recorded were almost identical during and following the light rain. The count was repeated the next day under a clear sky and broken into two 10-minute segments to be comparable with the two segments of 25 May. The mean of the two segments is plotted at the left in Figure 3 and shows that in this instance the light rain had no effect on the bird count.

On the right half of Figure 3 are the results of 20-minute counts taken in another upland deciduous forest area in Maryland on 3–4 July 1980. The count shown at the right was made while water was still dripping from the leaves after a thunderstorm that occurred during the night. In comparison with this are two consecutive 20-minute counts taken at the same point on the following day. Time, temperature, and wind conditions were essentially the same both days. Although singing activity was reduced by about 50%, judged by the number of adult birds recorded, the number of species detected during the 20-minute period was not reduced.

In the third example, the effect of wind on bird activity was recorded in an upland deciduous forest in Garrett County, Maryland, on two clear days, 6–7 July 1980. The wind was estimated at Beaufort 3 (13–19 kmph) when the first 20-minute count was taken at 0915 EDT, and it was calm on the following day at the same time. The wind caused a 40% drop in total adults recorded, a 41% drop in the number of species detected, and a 54% drop in the number of singing males.

These examples, based on selected pairs of observation periods, are purely illustrative, but they indicate that counts may be seriously affected by such common environmental factors as dripping leaves and winds of about 15 kmph.

In a 13-day series of early morning 20-min. point counts made 12–24 July 1980 in deciduous forest in Laurel, Maryland, the number of species recorded was inversely correlated both with local temperatures ($r = -0.872$, $P < 0.001$) and with relative humidity recorded 30 km away at National Airport ($r = -0.781$, $P < 0.005$).

WINTER COUNTS

Transect counts.—The most consistent source of transect data was from repeated coverage of an 8-km Winter Bird Survey route on the Patuxent Wildlife Research Center in Maryland. This transect was covered at least three times each winter by each of two observers in late December or early January for 5 consecutive years. Data from counts taken on the coldest winter mornings were compared with matching data from seven warm mornings the same winter. Starting temperatures on the cold mornings ranged from −16° to −7°C; starting temperatures on the warm mornings ranged from −4° to +3°C. Because of the small sample size, birds were grouped in families for comparison. Sample sizes ranged from 66 wrens to 370 woodpeckers. No significant differences were found for any of the groups or individual species tested: woodpeckers (Picidae), titmice (Paridae), wrens (Troglodytidae), kinglets (Sylviidae), and the Cardinal. No effects of weather conditions could be detected on a series of breeding season transects either.

Winter Bird-Population Study.—Data from eight years of Audubon Winter Bird-Population Studies on two forest plots in Maryland were examined for differences between results on warm mornings compared with cold mornings in the same winters. More birds were recorded on warm mornings (starting temperatures −8° to 0°C) than on cold mornings (−27° to −14°C), but the differences were not significant ($P > 0.05$).

Christmas Bird Counts.—I selected five species (Red-bellied Woodpecker, *Melanerpes carolinus*; Carolina Chickadee, *Parus carolinensis*; Brown Creeper, *Certhia familiaris*; Hermit Thrush, *Catharus guttatus*; and Cardinal) for weather analysis using Christmas Bird Count data from the Ocean City and Southern Dorchester County, Maryland, counts. Year-to-year changes in totals of these five species on these two counts, and on two other counts from the Eastern Shore of Maryland, showed relatively little annual variation when corrected for party-hours of coverage. Of the five species examined, the Red-bellied Woodpecker was negatively correlated ($P < 0.05$) with the starting wind speed at Ocean City, the Brown Creeper was negatively correlated with the maximum wind speed at Ocean City, and the Brown Creeper was negatively correlated with the minimum temperature at Southern Dorchester County. Examination of Christmas count data for other species and for other areas, especially when there are high contrasts in weather conditions and when a large comparable sample is available, would reveal the limiting conditions beyond which counts become too variable to have comparative value.

DISCUSSION

TEMPERATURE

There is close, but not perfect, agreement among the various data sets examined. Comparing the effects of starting temperature, five of the seven species in footnote (a) of Table 4 also appear as positively correlated with temperature in Table 3 or Figure 2. The two exceptions are the Rufous-sided Towhee, whose positive correlation was not statistically significant ($P > 0.05$), and the American Robin, which was negatively correlated with temperature in regions 1 and 2. O'Connor and Hicks (1980), in a study of breeding birds on a nature reserve in southern England, found one negative and seven positive correlations with temperature based on 40 visits in the spring and summer of 1978. They had no species in common with the present study, nor any consistent temperature effects within families that can be compared with this study.

One pattern that emerges is the tendency for birds near the southern limit of their breeding range (American Robin; Vesper Sparrow, *Pooecetes gramineus*; Song Sparrow, *Melospiza melodia*) to be negatively correlated with temperature, whereas those near their northern limit (Mockingbird, Cardinal) are positively correlated with temperature (i.e., each sings more regularly at temperatures more like those at the center of its breeding range). Birds that feed on flying insects (Whip-poor-will, Chimney Swift, Barn Swallow) were positively correlated with temperature, as their prey also would be. Other species that showed a consistent trend tended to be positively correlated with temperature.

In regions 1 and 2, activity of the Mourning Dove and many other species declined when starting temperatures were above 23°C (73°F). McClure (1939:325) found that Mourning Doves did not coo much at temperatures above 25°C, and Wimmer (1961:38) said that calling was reduced above 29°C. Three of four authors cited by Baskett et al. (1978), however, stated that weather factors within the normal range encountered on call-count surveys did not significantly affect cooing of Mourning Doves.

When Mourning Dove data from 3852 route-years in areas 1 and 2 were divided into 10-stop (ca. 1-hr) intervals, temperature had no effect on activity during the hour centered at sunrise. In the second hour, however, activity increased slightly with increasing temperatures, reaching a peak near 23°C. In the third hour the increase with temperature was more pronounced, peaking again near 23°. The fourth hour was similar to the third, but with a peak at 20°. The fifth hour showed an even sharper increase to a still cooler peak at 17°. The count in each hour was lower than that of the preceding hour. Thus, counts may be variously affected by temperature, depending on when they are started and how long they continue.

I have found (unpublished data) that the number of phrases sung per minute by the Red-eyed Vireo is directly proportional to air temperature, and Curio (1959) found the same thing for the Pied Flycatcher (*Ficedula hypoleuca*). Higgins (1979) showed that there was a positive correlation between temperature and the duration of the morning song period of the Song Thrush

(*Turdus ericetorum*) in central England in December and January.

Anderson and Ohmart (1977) concluded, as we did for the Breeding Bird Survey instructions, that winds of less than 20 kmph (12½ mph) interfere very little with accurate censusing. They censused 22 transects on days when winds were from 24 to 50 kmph and compared these with the same transects on adjacent calm days. In about half of these tests they found a significant diminution of counts on windy days. Higgins (1979), summarizing work of Thorpe (1961), Armstrong (1973), and Astrom (1976), reported that onset of first song in the morning is delayed by both wind strength and cloud cover.

Sky Condition

Heavy overcast delays the dawn chorus and causes early cessation of evening activity. Whether activity continues later in the morning on an overcast day depends largely on other conditions, such as temperature and wind. Solid overcast prevents thermals and it delays or reduces soaring flight by vultures, hawks, and other large soaring birds. Dark sky and haze increase identification problems because of poor visibility. Bright sun can be a problem if the observer is looking toward it.

Although fog reduces visibility and will seriously affect visual counts of distant birds, fog tends to improve transmission of sound, and unless accompanied by wind it frequently increases the distance over which birds can be heard. Light falling snow affects visibility but may not seriously interfere with detecting calls. Because falling snow is dry and nearly silent, it has less effect than rain on the observer and his equipment.

My findings for Bobwhite disagree with those reported by Bennitt and Elder. Bennitt (1951:19–21) found no significant effect of cloudiness, and a negative correlation with temperature; and Elder (1956:650) reported that neither wind nor temperature had a significant effect. In areas 1 and 2, BBS data showed a strong positive correlation with temperature (Fig. 2), a highly significant decrease with cloud cover (Table 1), and a sharp drop with wind speeds above Beaufort 4.

Wind

O'Connor and Hicks (1980) reported that out of 27 British species tested, registrations of two, Great Tit (*Parus major*) and Blue Tit (*P. caeruleus*) were positively correlated with wind speed ($P < 0.05$), whereas two others, the Wren (*Troglodytes troglodytes*) and Chiffchaff (*Phylloscopus collybita*), were negatively correlated. In the BBS data I did not find any consistent indication that any small passerine species were found in larger numbers on a windy day, but counts for Starlings, blackbirds, and swallows, most of which were recorded by sight, were independent of wind speed.

Winter Conditions

Results from the winter analyses are far from conclusive. They have demonstrated that large samples of data collected under controlled conditions are required. On Christmas Bird Counts, where the most extreme weather conditions are apt to occur because dates are set in advance, the weather data tend to be imprecise, to apply to only one point in the 458 km^2 circle, and cannot be related to any particular time in the day; for example, the maximum wind might occur during the early morning and seriously interfere with songbird counts or, on the contrary, it might appear briefly during a thunderstorm gust or frontal passage and have little overall effect.

General Conditions

Even when counts are carefully timed, accurate measurements of local temperature, wind, and precipitation generally are not taken. Few observers are equipped to measure rainfall or wind speeds at ground level, let alone treetop level. Conditions recorded at the beginning and the end of a mapping or transect census do not necessarily apply throughout the course of the activity. Similarly, wind and temperature conditions recorded at the 50th BBS stop may not be similar to those prevailing at the 49th stop under entirely different habitat conditions.

CONCLUSIONS

A steady hard rain probably has a greater effect on bird counts than any other weather condition. This affects not only singing and other behavior of birds but also affects the observer and his equipment, including binoculars, eyeglasses, and notepaper. Part of the disturbing effect of rain is the noise created, and even the noise of dripping leaves after the rain has stopped can affect census results. Effects of light or intermittent rain at times are negligible. Drizzle, unless prolonged, will not necessarily interfere with census results; this conclusion is based on examination of 173 BBS routes started during drizzle. Effects of cloud cover are minimal.

Strong winds certainly affect bird counting. The generally accepted limit for satisfactory count results is 20 kmph (12 mph). During higher wind, singing decreases, birds tend to take shelter (keeping out of sight or concentrating in sheltered areas), and side effects, such as rustling leaves or rough water, affect detection by sound or sight. Blowing dust or drifting snow adds to the problems of high winds.

Effects of temperature are minimal within the range normally experienced by census takers, but unusually low temperatures tend to inhibit activity and unusually high temperatures in summer shorten the activity period.

Taken in combination, effects of unusual weather conditions are compounded. On the one extreme, hot calm air causes sounds to be diverted upward away from the observer so that singing birds are not detected as far away as under normal conditions, and distances are likely to be overestimated. On the other hand, a combination of low temperatures and strong wind produces a serious chill factor that will have a profound effect on the observer if not on the birds themselves.

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