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Population Trends in Birds by Physiographic Strata

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Abstract

In North America the only systematic sampling program that monitors long-term population trends in land birds on a continental scale is the Breeding Bird Survey (BBS), a program run by the U.S. Fish and Wildlife Service (FWS) and the Canadian Wildlife Service. In a recent paper, the FWS argues that, although there is no evidence of overall declines in Neotropical migrant species for the full 25 years of the BBS period, 67% of the species in eastern and central North America had declining populations between 1980 and 1991. Although we have not repeated the FWS analysis, we report elsewhere a study of BBS data for wood warblers based on a method of analysis different from that used by the FWS. Because our analysis does not indicate more declining than increasing species of warblers in recent years, and because we have concerns about the FWS methods of analysis, we think the evidence that an alarming number of species of Neotropical migrant land birds have been declining is weak. There is strong evidence that birds other than Neotropical migrant land birds (some temperate migrants in grassland habitats, some ducks, some shorebirds) are in serious decline in North America. We think that the direction of research on the conservation of all North American birds needs to be reevaluated. For land birds, one way to set priorities would be to review population trends in species well sampled by the Breeding Bird Survey. Such analyses by species, undertaken at the scale of the physiographic stratum, would be appropriate. Then graphs in which trends by strata are compared can be viewed as multiple time-series designs, and they might lead to (admittedly weak) inferences about the causes of trends.

Our analysis for warblers by physiographic strata indicated that even species that were stable or increasing throughout large areas were declining

in several highland areas in the southern Appalachians, the Adirondack Mountains, and the Ouachita Mountains. This result, declines in highland areas, makes us suspect that subtle and indirect effects of atmospheric contamination, a known correlate of altitude, may be affecting bird populations in these areas. We see no reason why such effects should be confined to warblers or to Neotropical migrants, but of course much further work would be required to discover whether such a problem in fact exists.

INTRODUCTION

Neotropical migrant land birds are defined as those species that breed in the United States and Canada and migrate to wintering sites in the Caribbean or Central or South America. Some species have seriously declining populations; others have been increasing in number. The recent focus on declines in Neotropical migrant land birds has apparently been driven more by concern for loss or fragmentation of forest habitats, in both the tropics and eastern North America (Terborgh 1992), than by evidence that declining populations in this group of birds is greater than that in other groups. Forest fragmentation is associated with increased predation on nestlings (Wilcove 1985) and increased brood parasitism by brown-headed cowbirds (Molothrus ater) (Robinson 1992). However, neither predation nor brood parasitism by cowbirds has been shown actually to be regulating the sizes of populations of migrants. As Newton (1991) pointed out, even when a particular source of mortality can be shown to have a severe effect, that source is not necessarily the one that regulates the size of the population, and its control would not necessarily be the best management strategy. However logical the general link between birds and their habitats may sound, confirmation that Neotropical migrants have been declining in numbers in proportion to disturbance to forest habitat either on the breeding grounds (Sauer and Droege 1992) or in winter (Petit et al. 1992) has been elusive. One of the complicating factors, of course, is that many Neotropical migrant species do not live in forests in either season (Hutto 1980, 1988; Lynch 1989; Smith et al. 1992). As an environmental problem requiring a solution, the topic of the decline of Neotropical migrants lacks evidence of causal connections (James et al. in press).

The Breeding Bird Survey

The best source of data for the determination of widespread population trends in North American land birds is the Breeding Bird Survey (BBS), a program of roadside censuses run by the U.S. Fish and Wildlife Service (FWS) and the Canadian Wildlife Service that has now accumulated more than 25 years of data. The latest published summary statistics of the FWS (Sauer and Droege 1992) estimates that more Neotropical migrant land birds species had increasing than decreasing trends between 1966 and 1988 (56% of 100 species increasing). Another summary, which is in press (Peterjohn et al. in press), estimates that 55% of 97 species of Neotropical migrants had increasing trends from 1966 to 1991. If nothing unusual were going on, these values would be expected to be close to 50%, which they are. Analyses of BBS data by the Canadian Wildlife Service estimate that in Canada species of Neotropical migrant land birds have had more increasing than decreasing trends (Erskine et al. 1992). Even so, the FWS estimates that, in the most recent years of the BBS, there have been significantly more decreasing than increasing forest-dwelling species in eastern North America (Robbins et al. 1989), and this finding has been the justification for an interagency program in the United States (Partners in Flight) focussed on these declines. The most recent analysis on which the FWS bases its conclusion of major change in population trends in Neotropical migrants during the BBS period is that of Peterjohn and coworkers (in press). It reports more increases than decreases in the early part of the period (70% of 94 species increasing from 1966 to 1979) and more decreases recently (54% of 100 species decreasing from 1980 to 1991). The estimate of 54% of the species declining is not an alarmingly high value, but the 67% estimated for the eastern and central regions in the recent period

should be examined in more detail. We have not repeated the FWS analysis, but we have concerns about the FWS methods with regard to their criteria for the selection of routes, the model used to fit the data, and how the data were handled. Our analyses of BBS data for wood warblers (Parulinae) do not show a difference between early and recent periods, even in cases in which direct comparisons can be made with FWS results (James et al. submitted). Research on the causes of declines in the species that are in serious trouble is clearly warranted, but for Neotropical migrants in general it is premature.

It should not be surprising that there is no overall population trend in such a heterogeneous group of species as Neotropical migrant land birds. The list includes some hawks (Accipitridae), most swallows (Hirundinidae), all hummingbirds (Trochilidae) and swifts (Apodidae), most tyrant flycatchers (Tyrannidae), and most songbirds (oscines) that breed in North America. What is needed is a comprehensive analysis of what species of both land and water birds are in trouble, regardless of their migratory status, and whether there are places in North America where groups of species are declining, even though they may be doing well elsewhere. Recently Knopf (in press) has completed an analysis of BBS data that shows that grassland-nesting birds, most of which are either temperate-zone migrants or resident species, have a much higher percentage of declining species (82%) than do Neotropical migrants. Although the sampling and analysis problems are even more complex than with land birds, severe declines in waterfowl (FWS forecast for 1993-94 flight) and some species of shorebirds (Howe et al. 1989) are apparent.

Population Trends in Wood Warblers

With regard to land birds, study of BBS data by species at the level of the physiographic stratum is a logical place for analysis of population trends

to begin. Our analyses are based on nonlinear regression models (James et al. 1990, 1992, submitted). For the 26 species of wood warblers for which the best data are available, we estimate with either nonlinear nonparametric route regression or nonlinear semiparametric route regression (or both) that a few species, like the Cerulean (Dendroica cerulea), Prairie (D. discolor), and Canada Warblers (Wilsonia canadensis); Yellow-breasted Chat (Icteria virens); and Golden-winged Warbler (Vermivora chrysoptera), have had declining populations in eastern and central North America between 1966 and 1992. Others, like the Blue-winged (Vermivora pinus), Mourning (Oporornis philadelphia), Blackburnian (Dendroica fusca), and Magnolia Warblers (D. magnolia); Northern Parula (Parula americana); and Ovenbird (Seiurus aurocapillus) have been increasing during this period.

Various authors have used different ways to define population trends in BBS data. For example, when the goal was to derive one number for a trend, Knopf (in press) used the percent of routes on which the species was increasing or decreasing according to linear route regression (Geissler and Noon 1981); Peterjohn et al. (in press) used the estimated average percent change per year in the number of birds per route as determined by linear route regression; James et al. (1992) used the percent change between the average number of stops per route on which the species was recorded in a set of early and that for a set of late years. All these ways assume that the trend is best estimated by quantification of changes in time on routes on which the species occurred. The method of Knopf ignores the fact that there is variation in the geographic distribution of the routes.

Another decision to be made when defining a population trend in BBS data is whether to include in the quantification those routes on which the species

did not occur. In that case, the focus would be on the density of the population in a geographic unit, rather than on the changes in estimates for counts on routes on which the species occurred. For example, if a species declined by 10% on five routes in a physiographic stratum, and it did not occur on five other routes in that stratum, the decline would be judged to be 10% by the first methods listed above, but it would be 5% in terms of density. For maps that give the average number of birds per route or the changes in that average over time, we use data from only routes on which the species occurred. For graphs that compare nonlinear trends by geographic area, we prefer that they be based on density of birds per route averaged over all routes that meet the selection criteria. Below, these differences are illustrated with an analysis of population trends in the Blue-winged Warbler.

An Example: The Blue-winged Warbler

With nonparametric nonlinear route regression (NNRR), the Blue-winged Warbler is estimated to have increased significantly in numbers by 61% between 1970-72 and 1986-88 (James et al. submitted). Nonlinear semiparametric route regression (NSRR), which incorporates a factor to account for variation due to differing abilities of observers to detect birds, provides an estimate of a 38% increase (not statistically significant). The incorporation of observer effects into the model involves a tradeoff of decreased precision and a corresponding decrease in the ability to declare changes to be statistically significant.

Next we use the Blue-winged Warbler as an example of how the results of NSRR can be presented in maps and graphs. For routes on which the Blue-winged Warbler was recorded, the highest numbers of birds recorded recently (1986-88) occurred in Southern New England and the Ohio Hills (Figure 1a). Estimates

using NSRR indicate that the population in Southern New England had increased since 1970-72, as had populations in Northern New England, the Allegheny Plateau, and the Ozark Mountains. Populations in the Northern Piedmont and the Ohio Hills declined during this period (Figure 1b). A graph giving the major changes in density through time estimates that a precipitous decline occurred in the 1980's in the Ohio Hills (Figure 2). The combination of the maps and the graphs indicates major geographic differences in the population dynamics of the species. The declines of Blue-winged Warblers in the Ohio Hills and the Northern Piedmont are exceptions to trends toward increase in the northern and western parts of the species range and stability elsewhere.

Causes of Trends

Past cases in which causal factors regulating bird populations have been most clearly established are ones that used experiments. Examples are those of Källender (1981), who provided supplemental food to tits (Parus) in winter, and Potts and Aebischer (1991), who combined simulation modelling with experiments in studies of the Grey Partridge (Perdix perdix) and showed that density-dependent predation and shooting rather than food supply were the factors affecting equilibrium densities. When experiments are not feasible, we think that some progress can be made toward the analysis of causes by means of planned comparisons among places with different population trends and different levels of potentially causal environmental factors. We discuss the strengths and weaknesses of this procedure elsewhere (James et al. in press).

We do not know of any ecological similarities within or differences between the two groups of warblers listed above, those that are increasing and those that are declining, that might be related to their differences in population trends. Each species warrants independent causal analysis.

As a first step toward causal inference, we recommend analyses of graphs like the one for the Blue-winged Warbler (Figure 2) that compare nonlinear population trends among physiographic strata. If the different strata have different levels of environmental factors, weak causal inferences may be possible (James et al. in press). This procedure would be similar to application of the multiple time-series design of Campbell and Stanley (1963). The case of the Blue-winged Warbler is particularly interesting because it hybridizes with its sibling species, the more northerly Golden-winged Warbler (V. chrysoptera) (Confer 1992). Both species are apparently expanding their geographic ranges northward, and the Golden-winged Warbler is subject to introgressive hybridization in places such as southern Michigan and central New York where the ranges overlap (Gill 1987). Thus, the search for a cause of the decline in the Blue-winged Warbler in the Ohio hills should include factors that were present in the 1980's but not in the 1970's in this stratum or any time during the BBS period in the other two strata (Figure 2).

Multispecies Analysis of Trends in Warblers

One surprising feature of our multispecies analysis was its demonstration of a statistically significant geographic pattern in the population trends of the warblers as a set (James et al. submitted). In spite of estimates of no general declines in most species, we estimated that the average species declined in several upland and highland physiographic strata. This effect was most clear in the Cumberland Plateau, the Blue Ridge Mountains, the Adirondack Mountains, and the Ouachita Mountains. Unfortunately the number of BBS routes in these areas that met out selection criteria was small, so the conclusion is tentative. However, we suspect that subtle and indirect effects of atmospheric contamination, a known correlate of

altitude, may be affecting bird populations in these areas. Such ecosystem-level effects on birds have been documented experimentally in Europe (Graveland 1990). Similar investigations are called for in North America.

Other BBS analyses show that at least two groups of birds have far higher percentages of declining species than do Neotropical migrants. These two groups are grassland-nesting birds (most of which are temperate-zone migrants) and shrub-nesting species (Knopf, in press). Among the water birds, serious declines are well documented in many species of ducks (U.S. Fish and Wildlife Service) and some shorebirds (Howe et al. 1989). We think, for all species of land birds that nest within the area covered by the BBS, that nonlinear analyses of their geographic variation in population trends by physiographic strata can provide valuable comparative information. Structured comparisons may then help researchers make preliminary inferences about the causes of population trends and set priorities for further research.

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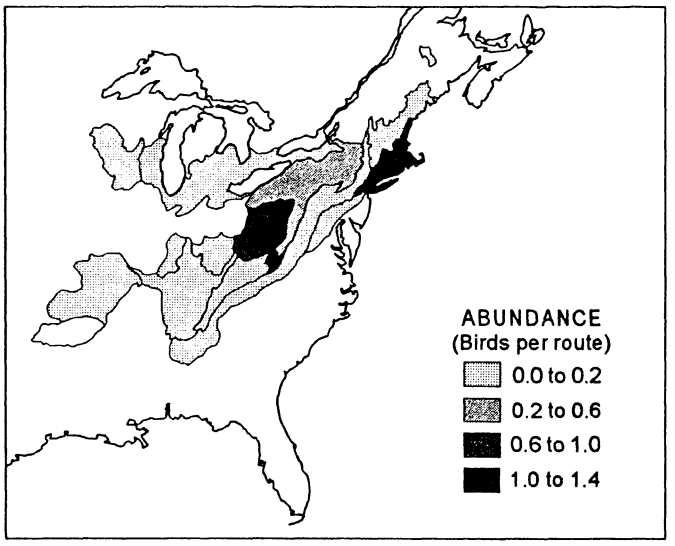
FIGURE LEGENDS

Figure 1a. Map giving the recent (1986 to 1988) abundance of the Blue-winged Warbler as estimated by birds per route (on routes on which the species occurred); Figure 1b gives the change in birds per route (since 1970 to 1972). Both are estimated by nonlinear semiparametric route regression.

Figure 2. Nonlinear trends in the Blue-winged Warbler in birds per route in the three physiographic strata with the largest populations. Values are averages for all routes in the stratum, including those on which the species was not recorded. After the early 1980's, there was a sharp decline in the Ohio Hills, but populations in the Allegheny Plateau and Southern New England continued to increase.

a. BLUE-WINGED WARBLER



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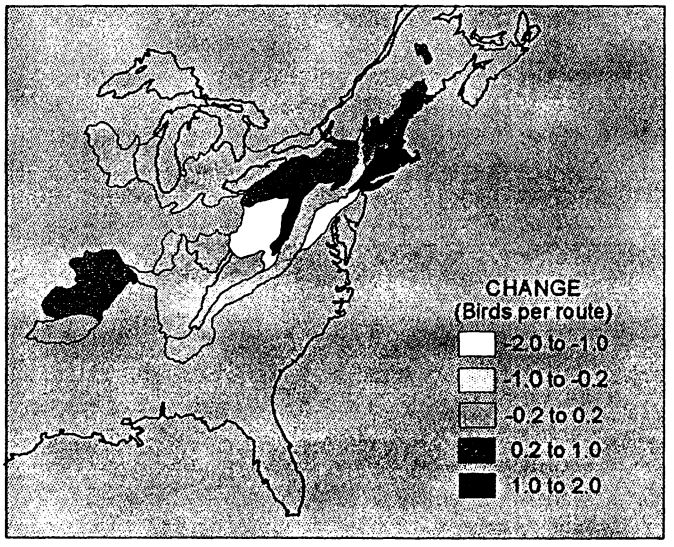

BLUE-WINGED WARBLER

EASTERN FOOTHILLS & APPALACHIAN MOUNTAINS