The use of data obtained from Christmas Bird Counts
A Primer

Butcher et al. (1990) have described the National Audubon Society's Christmas Bird Counts as the oldest and largest wildlife survey in the world. The use of these survey data in an accurate and acceptable manner is difficult, however. First, the sheer size of the data base presents practical problems in its use and, second, uncontrolled variables such as weather or observer skill, may make conclusions drawn from analyses unreliable (Bock and Smith 1971). Substantial progress has been made in recent decades in computerization of the Christmas Bird Count (CBC) data and, in this respect, access to the data is no longer the daunting problem it once was. However, how the data are used remains a concern and care must be taken in any analysis of the data (Bock and Root 1981a, Butcher 1990, Butcher and McCulloch 1990, Sauer et al. 1996).

Published analyses that use CBC data generally falls into two categories. In the first category, the focus is on population trends for individual species over geographic areas of varying extent and, in the second category, the focus is on the distribution of species over large geographical areas. Once beyond these two basic categories the data have also been used for insightful investigations of less easily classified topics. In addition, there has been much investigation into the validity of various approaches for analysing the data.

Population Trends

Bock and Smith (1971) reported an early study of CBC data that was based on the development of a computerized data base. They examined the population trends of 20 species in Colorado covering the period 1940–1970. To normalize the data, they divided the number of birds counted by the number of party-hours. For the period examined they concluded that populations of most species were stable. However, they did note a dramatic increase in the population of Canada Geese, starting in the mid-1960s, an increase in the European Starling population, and a decline in the population of Northern Flicker. Although they used data from 1940 on, they concluded that there were too few counts between 1940 and 1950 and that the data from this period were therefore not suitable. They saw the need to have count data from the same count circle over a long period of time as a basis for the analysis of population trends.

Brown examined the long term population trends of a number of raptor species for the period from 1950 to about 1970. For the Red-shouldered Hawk he grouped the CBC data to roughly match the subspecific range of three of the five subspecies and plotted these populations separately (Brown 1971). He normalized the data by party-miles and plotted a five-year moving average to smooth out year-to-year variation. Although data analysis showed that the California populations were stable, the analysis indicated a decline in populations of the northeastern (*Buteo lineatus lineatus*) and the southeastern (*B. l. alleni*) subspecies. Interestingly, he grouped the data by clear and cloudy days to see if the weather conditions influenced the trends. In general, the trends were the same although there was a general tendency for fewer birds to be seen on cloudy days. Brown (1973) used the same approach for Northern Harrier, Sharp-shinned Hawk, and Cooper's Hawk and noted a decline for all three species, based on the CBC data. For this study he augmented these results by comparing two adjacent 5-year periods and, on a map of the United States, he showed all of the states that had an increase or decrease of more than 5%. In a similar study of populations of the Bald Eagle, Brown (1975) analyzed both the number of eagles as well as the number of eagles normalized by party-hours. An initial decline was observed from 1955 to 1963 and after that time, an increase. However, the increase noted was the result of new counts being included in the data base which had unusually large concentrations of Bald Eagles. If population trends were examined only for counts with continuous coverage for the period 1955–1970, then a continuous decline was apparent. These results indicate that population trend data may be unreliable for species that can concentrate in only a limited number of count circles. This is a problem that has come to be known as the “roost effect.” The problem with intermittent counts and roosts was examined again for winter populations of Black and Turkey vultures (Brown 1976). Although a general decline was noted from the early 1960s on, considerable caution is required for species such as these that may concentrate in particular count circles, particularly if the count circle is not covered each year or the roost moves into or out of a count circle.

DeHaven (1973) used CBC data to examine the invasion of European Starlings in California. Figure 1, taken from this study, shows the invasion through 1971 and the exponential

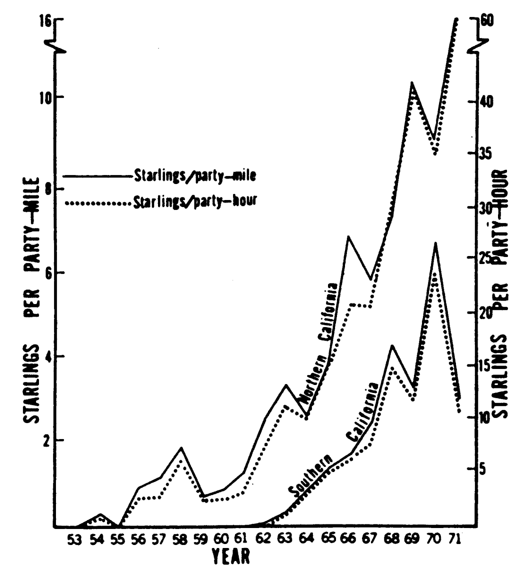

Figure 1. Population trends for European Starling in California, 1951–1971 (DeHaven 1973).

growth in the number of birds present in the early winter period is clearly seen. The data were normalized by both party-miles and party-hours and the two approaches show equivalent results. It is interesting to note that the invasion occurred first in northern California and the numbers there have always been larger than in southern California. DeHaven excluded two northern California counts because of extreme fluctuation in the numbers, suggesting the intermittent occurrence of a roost within the count circles.

Florida has numerous CBC circles located along the coast of the state and Schreiber and Schreiber (1973) used the coastal counts to examine Brown Pelican populations. They grouped the data geographically based on ongoing color-marking studies that indicated separate populations. As in the Colorado studies of Bock and Smith (1971), they noted large fluctuations in the pre-1950 data. In general their analysis showed stable populations for this species in Florida. However, when broken down by sub-region it was clear that the population wintering in the Florida Panhandle had been extirpated by the late 1950s. This wintering population breeds in Louisiana and its collapse is related to the well-known failure of the Louisiana population on its nesting grounds caused by DDT concentrating in the food chain.

Raynor (1975) examined populations trends for one central Long Island count and made a detailed evaluation of various analytical approaches for judging population changes. He looked at about 20 species and documented local increases in Tufted Titmouse, Northern Mockingbird, Northern Cardinal, and House Finch.

Stahlecker (1975) examined trends in nine raptors using Colorado CBC data. He noted the large variance in all of these populations, but concluded that there had been no significant population changes from 1953 to 1972.

Once Bock and his students had entered large portions of CBC data into a computer data base, they broadened their studies and some of these are discussed in the Avian Distribution section below. They also continued to examine population trends for individual species as well. In the case of the Cattle Egret (Bock and Lepthien 1976a) they found a population increase of about 21% a year with a coefficient of determination of 0.69 (the square of the correlation coefficient, *r*). Figure 2, from their study, shows this increase and some qualitative explanations for some of the intermediate downturns in the populations. “L” and “F” refer to significant cold periods in Louisiana and Florida respectively. They also examined the population growth of the House Finch in the eastern United States (Bock and Lepthien 1976b) and recorded a growth of 23% a year with a coefficient of determination of 0.91. The growth of both the Cattle Egret and House Finch are of interest as they are species apparently filling unoccupied ecological niches.

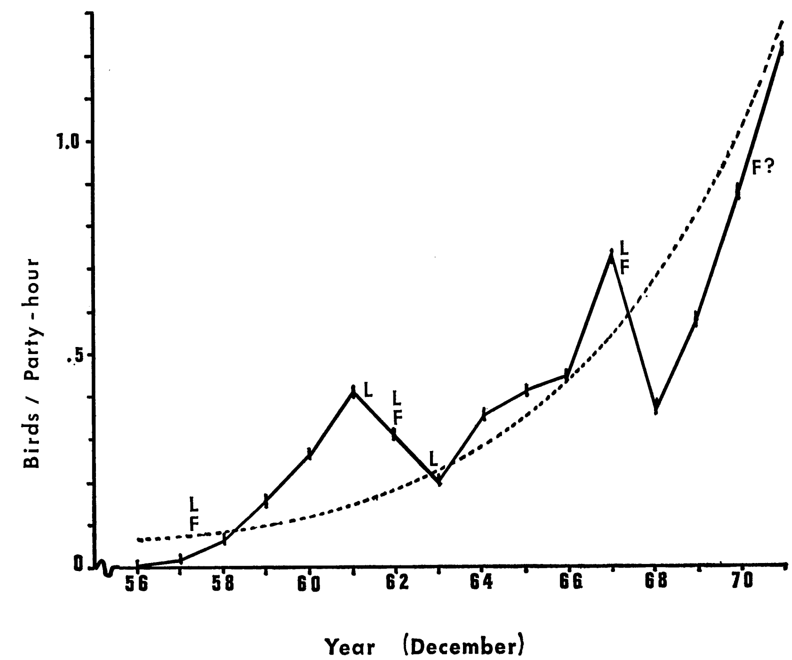

Figure 2. Cattle Egret population trend in eastern United States (Bock and Lepthien 1976b).

Morrison and Slack (1977) examined populations of Olivaceous and Double-crested cormorants in Texas for the years from 1949 to 1975. They found no correlation between numbers of birds and levels of effort and therefore there was no advantage in normalizing the data. Moreover, they pointed out that for most CBCs the location of cormorants is well known and the vast majority of birds will be counted regardless of observer effort. Their data show significant population increases in recent years and these data agree approximately with the Texas Cooperative Fish-eating Bird Surveys that were in place over the last half of the study period. They noted that estimating population trends for these species is difficult in part because of the shifting of nest sites in to and out of CBC count circles.

The recovery of White-tailed Kite populations in the United States in the last half of the 20th century was examined by Larson (1980) and Pruett-Jones et al. (1980). Larson, using the methods developed by Bock and his students grouped kite data in six five-degree latitude/longitude blocks for the period 1944–1979. A log-regression fit shows a growth in population of 8.3% a year with a coefficient of determination of 0.64. She then examined the California and Texas populations separately and computed increases of 9.0% a year in California ($r^2 = 0.73$) and 15.7% a year in Texas ($r^2 = 0.51$), with the increase in California leading that in Texas by about a decade. Pruett-Jones et al. examined White-tailed Kite populations for the period 1964–1978 for California and Texas, as was done by Larson, but also looked at population changes in Oregon, Mexico, and Central America. They noted no significant increase in the California populations for this more recent time period. They pointed out that the winter invasion of Oregon coincides with the period when the California population started to level off. Also of interest, Pruett-Jones et al. (1980) examined the year-to-year variation of the California populations as a function of mean precipitation and found a weak relationship ($r = 0.52$).

Raynor (1980) made a detailed study of Bobwhite populations on Long Island from 1959 to 1978 and also included data from other sources: a Summer Bird Count (SBC), Breeding Bird Survey (BBS) routes, hunter counts, and his own field notes. For comparative purposes he made estimates of population density for each of these sources and showed reasonable agreement between all of them. All of these approaches indicated a population showing substantial fluctuations with a noticeable decline in the last five years of the study period.

Rosahn (1980) studied Bobwhite population trends for only a 10-year period, but over the entire range of the species. She excluded all counts that did not cover the entire period. She found no correlation with any measure of effort and, therefore, used only the number of birds observed in the analysis. The results showed large variance in the populations and, when the data were grouped by state, the variance between states was sometimes in parallel and sometimes compensatory.

Kricher (1981) used Massachusetts CBC data to examine the increase of Tufted Titmice in that state. His analysis showed that the numbers of Tufted Titmice have increased exponentially from 1958–1978, but that there is no related decline of the Black-capped Chickadee, which is still the more common species.

Morrison (1981) examined populations of Loggerhead Shrike in five geographical regions and noted that over a 20-year period populations have undergone a fairly steep decline in the southeastern United States, but are stable or only declining only slightly in the rest of the country.

Kricher (1983) provided a comparative examination of population trends of both House Finches and House Sparrows in the eastern United States. The House Finch is, of course, increasing rapidly in the east, while the House Sparrow is in decline. Results presented show that the House Sparrow decline is faster in states with an expanding House Finch population, than in states where the House Finch has not yet invaded.

Morrison and Morrison (1983) made a large scale examination of nine species of woodpecker in the western United States. Although they noted a number of local increases and declines they did not find any significant regional changes except, possibly, an increase in Nuttall's Woodpecker in California.

Previous examinations of raptors have shown a large variance in winter populations in Colorado (Stahlecker 1975). Warkentin and James (1988) looked at the population of just a single raptor, the Ferruginous Hawk, but over a longer period of time (33 years) and a wider geographic area than was studied previously. They concluded that this species has been showing a general increase in its numbers and that this conclusion is not affected by the addition of new counts at the end of the period.

James and Ethier (1989) looked at Burrowing Owl population trends from 1954 to 1986 and detected no trends in North America. However, analyzed by region there is a significant decline noted in California.

Avian Distribution

The question of why birds are found in one place and not another is one of the fundamental questions of ornithology. Bock and Lepthien (1974) pointed out that it is not possible for a single individual to gather the data that is needed to allow a quantitative examination of avian diversity and they referred to this problem as one of "logistical myopia." They noted that the Audubon CBC data provides an opportunity to extend the intense small-scale studies of avian diversity that are typically done by single investigators to continent-wide investigations. They grouped CBC data by five degree blocks of latitude and longitude and used the mean number of species per CBC as a measure of diversity and the mean number of birds per party-hour per CBC as a measure of abundance. They concluded that diversity is dominated by temperature for winter populations, while abundance is more strongly influenced by local concentrating factors that attract flocking species such as waterfowl and blackbirds. A similar effect was noted by Tramer (1974) who plotted diversity measures as a function of frost-free days and found this factor was significant except in subtropical Florida. The correspondence between isocontours of diversity (Bock and Lepthien 1974) and frost-free days (Tramer 1974) is remarkable. In a related effort, Confer et al. (1979) used regression analysis as a means of predicting how many species a CBC count circle should have and this also indicated the importance of winter temperature as a controlling factor on species diversity.

Bock and Lepthien (1975) extended their examination of continental species diversity to examine summer data obtained from BBS routes. They noted that the winter species diversity correlation was better for winter climatic temperature measures as opposed to temperatures recorded on the actual counts, while the summer species diversity was best explained by summer moisture or humidity.

A number of investigators have used CBC data to map the distribution of wintering species directly (Bystrak 1971, Plaza 1978) where these maps include some measure of abundance. Root (1988) has automated this process and applied it to the majority of wintering continental birds.

Additional analysis of the distribution of wintering birds was done by Bock and Root (1981b) who looked at the relationships of 303 species of birds using cluster analysis. This analysis was used to define biogeographical regions based on avian populations. At the highest level these biogeographical regions corresponded to the well-known separation of eastern and western birds. Further subdivision or regions provided some less expected and thought-provoking results.

Spatial/Temporal Analysis

The data base obtained from CBCs can also be used to examine spatial and temporal effects together. This can be done for single species or groups of species. In general the presentation of such analyses requires multidimensional displays. Bock and Lepthien (1972) examined the winter distribution of Red-breasted Nuthatches where they used repeated maps of the United States for the count years from 1960 to 1970. On each map states were shaded if numbers were higher than normal or unshaded if less than normal. The maps show a striking two-year cycle, generally, of irruption, as is also seen in population trend data. For many species it is desirable to use running averages as a means of filtering out year-to-year scatter, but Bock and Lepthien demonstrate in this case that the most important feature of the population data for this species is the year-to-year variation.

Johnsgard and DiSilvestro (1976) examined Am. Black Duck and Mallard populations by computing their ratio for all CBCs and, then at the state level, plotting the rate of change of this ratio, comparing data from the 1970s with data from the first part of the 20th century. This plot shows the areas where Mallards are replacing Am. Black Ducks with clarity. This work also represents a case of using a reference species to compute ratios of two species as a means of compensating for varying observer effort.

Bock (1979) used five-degree blocks of latitude and longitude rather than states (Bock and Lepthien 1972) to examine temporal and geographic changes simultaneously. Figure 3 illustrates

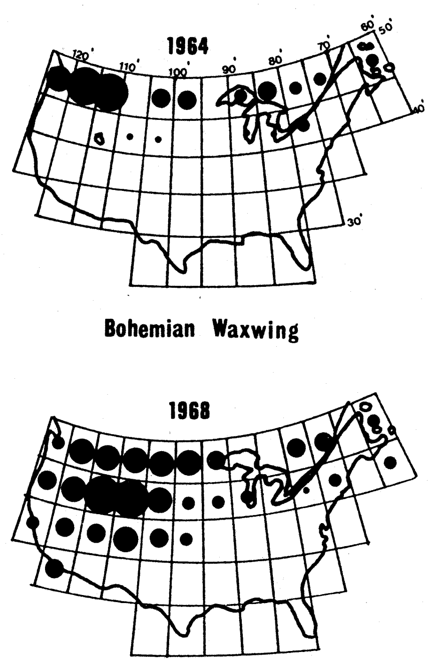

Figure 3. Winter abundance patterns for Bohemian Waxwing (Bock 1979).

the pattern seen for two different years for Bohemian Waxwing. Bock makes the point that the range of species based on known records is often of little value as there is no knowledge of abundance. He argues that "we must recognize that the 'first records' themselves almost always are biologically trivial, especially compared to the results of Christmas Bird Counts or other indices of major population changes."

As mentioned previously, Schreiber and Schreiber (1973) used CBC data to track Brown Pelican populations trends. The also attempted to show how these data segregated geographically within the state to better understand local effects. Similar approaches have been used for Red-shouldered Hawk (Brown 1971), Peregrine Falcon in the eastern United States (Bonney 1979), Barn Owl (Stewart 1980), Loggerhead Shrike (Morrison 1981), and a variety of woodpecker species in the western United States (Morrison and Morrison 1983).

Climatic Effects

Climate (as opposed to local weather conditions) has a dominant effect on the continental distribution of winter bird populations (Bock and Lepthien 1974, Tramer 1974, Confer et al. 1979). This has also been shown to be important for summer bird populations as identified from BBS data (Bock and Lepthien 1975). These effects are also seen at a reduced geographic level where Tangren (1977) has examined CBC and BBS data within California for landbird populations. At this finer scale, the correlation between winter and summer populations and climatic variables are reduced and many smaller-scale factors become important, such as the reduction of summer populations in the Lower Sonoran Life Zone and the influence of riparian habitats.

Pruett-Jones et al. (1980) have also examined climatic effects to attempt to explain variations in White-tailed Kite populations. Bock and Lepthien (1976a) have also suggested that long-term cold spells in the southern United States are the source of variance in the increasing population of Cattle Egrets.

Assessment of CBC Data Accuracy

The assessment of the accuracy of CBC data is difficult as no comparable set of data exists that can be used for comparison. However, a number of approaches have been made to look at limited portions of the data and assess how well they compare with independent measures. Morrison and Slack (1977) had a limited set of population data from the Texas Cooperative Fish-eating Bird Survey (TBS) for cormorant populations in Texas. Qualitatively these data show fair to good agreement in terms of populations changes between years although no test of significance was made.

Plaza (1978) compared the range maps for seven species of woodpeckers with the AOU checklist. Again, this was a qualitative comparison, but in general the correspondence was good.

Raynor (1980) computed population densities for Bobwhite based on five CBCs on Long Island and compared these with results from a Summer Bird Count, two BBS routes and hunter-kill counts. It is generally accepted (Stewart 1954) that the assumptions involved in computing population densities from CBC data are not reliable, nonetheless, Raynor obtained reasonable agreement from his four measures over a period of 20 years.

Warkentin and James (1988) examined Ferruginous Hawk population trends over western North America and found a generally increasing population. They noted these results contradicted a number of small-scale studies that had shown local declines. The disagreement in this case invalidates none of the studies, but simply points out the need for large-scale studies to assess population trends.

Butcher et al. (1990) selected seven species of birds that are resident east of the Mississippi River and used available BBS data as a test of CBC data. They generally selected species that met four criteria: (1) resident or short-range migrants, (2) non-flocking, (3) wellrepresented on both BBS and CBC surveys, and (4) the BBS data showed a significant population trend. Four species were selected based on these criteria: Nor. Flicker (−), Eastern Phoebe (−), Nor. Mockingbird (−), and House Finch (+). The CBC data showed significant declining trends for each of these species and thus disagreed with the House Finch trends. Moreover, the size of the population changes did not agree. Three other species were selected that did not meet the original criteria. Tufted Titmouse was selected because there was no significant trend in the BBS data and the CBC data showed the same result. Eastern Bluebird populations showed a declining trends on the BBS data and were selected because of the large variance that is seen in these population data. By comparison, the CBC data disagreed and showed an increasing trend. Cooper's Hawk was the seventh species selected as it showed a significant decline in the BBS data but the sample rate was considered too small to be trustworthy. In this case the CBC data also disagreed and showed a significant increase in the population.

The Patuxent Wildlife Research Center (Sauer et al. 1996) has done some initial work in comparing population indices for the BBS and CBC data. This work shows remarkable correspondence between winter and summer population indices for some species: Osprey, Red-shouldered Hawk, American Kestrel, Northern Flicker, Steller's Jay, and Lark Sparrow. However, unexplained differences are also seen for other species such as American Goldfinch. This work is still in process and is not ready for publication (John Sauer, pers. comm.).

Daniels (1975) and Mark (1981) have examined the ability of various CBC counts to reliably report numbers for species that are difficult to identify. This sort of assessment is very different from that of determining the accuracy of population or species diversity numbers. Daniels compared Sharp-shinned to Cooper's Hawk ratios as determined by hawk watches during the fall migration and then the subsequent ratios determined by CBC data. The agreement was poor and, based on the assumption that both measures were for the same populations, Daniels concluded that CBC trend data for this species pair is not trustworthy. Mark looked at the Thayer's/Herring Gull ratios along the west coast for five years of data and concluded that the results for these species cannot be uniformly trusted.

Data Use–Observer Effort

A properly designed population survey would use uniform sampling techniques so that results between different samples, whether temporal or spatial, can be directly compared (Butcher 1990). The CBC data do not meet this criteria and so it is necessary to determine how to compensate for different levels of observer effort. A number of investigators have examined different approaches to this problem (Raynor 1975, Morrison and Slack 1977, Falk 1979, Rosahn 1980, Morrison 1981, Morrison and Morrison 1983, Butcher and McCulloch 1990). For most species it appears that such generally used measures of efforts as number of observers, number of parties, party-hours, and party-miles give the same results and the consensus choice of a normalizing factor is to divide the number of birds recorded by the number of party-hours (Bock and Root 1981a). In part these conclusions are obtained by either examining the correlation between population numbers and levels of effort (Raynor 1975, Rosahn 1980), by comparing trend information using different normalizing factors (Morrison and Slack 1977, Morrison and Morrison 1983), or by qualitative examinations.

For specific species, however, an examination of normalizing effects suggests that their use is not justified. Raynor (1975) concluded that waterbirds, normally concentrated in just a few areas, should not be normalized. Morrison and Slack (1977) found that counts of two species of cormorants were not correlated with any measure of observer efforts and should be used by themselves. Rosahn (1980) found that for Bobwhite populations none of the measures of effort correlated with the species numbers. Morrison (1981) found tests of significance for population trends for Loggerhead Shrike were sensitive to measures of effort and this result is atypical for landbird species. Butcher and McCulloch (1990) pointed out that while Red-tailed Hawk numbers were highly correlated with observer effort, the population counts for Mallard and Bald Eagle were either independent of observer effort or inversely correlated.

Tramer (1974) has pointed out that the party-hours per party, which can be computed from the CBC data, sometimes indicate serious recording errors, that is, incorrect recording of the number of party-hours or number of parties. As daylight during the CBC is limited to 10 or 11 hours, the mean value of party-hours per party cannot exceed this value although some CBCs erroneously record higher values. Peterson (1994) has approached this problem using a trimmed mean to exclude excessive values. In his approach he assumes that the recording error is in the number of party-hours and computes a correction based on a trimmed mean. However, he notes that errors in the number of parties can also occur.

Although normalization by party-hours appears a satisfactory way to compensate for observer effort for landbirds, it is less clear which species should not be normalized. Nor is it clear how rare species or those found in very limited habitats should be treated. Butcher and McCulloch (1990) propose a nonlinear regression fit of the data to include the effects of observer effort and time as separate variables. This approach appears to be an improvement in some cases over the more simplified normalizing approach used by earlier investigators. It appears, however, that more effort is required in determining the most accurate approaches to be used for compensating for variable observer effort (Sauer et al. 1996).

Data Use–Reference Species

The use of reference species is an approach to avoiding the problem of variable observer effort and it has other advantages as well. Raynor (1975) proposed this approach and used the House Sparrow as a reference species for other sparrows in the expectation that this would remove the effects of weather as well as observer effort. However, based on a qualitative examination of the data there was no perceived benefit.

Johnsgard and DiSilvestro (1976) in their study of Am. Black Ducks used Mallard as a reference species and this allowed them to not only compensate for variable observer effort on CBCs but also to incorporate historical information from unrelated surveys.

The reference species approach has other benefits, aside from compensating for observer effort variation in the data. Just as Johnsgard and DiSilvestro (1976) used the ratio of Am. Black Ducks to Mallard to understand the effects of the latter species on the former other investigators have used these comparisons to better understand species or niche competition. Morrison and Slack (1977) compared Olivaceous and Double-crested Cormorants and found the two species' trends are independent of each other. Kricher (1981) examined possible competition between Tufted Titmice and Black-capped Chickadees in the same way and also concluded there was no relation.
Kricher (1983) also compared House Finch and House Sparrow in the eastern United States to see if the former's known increase is related to the latter's decline, but here the results were not conclusive.

More subtle effects on bird populations can be obtained using a reference species. Haney (1983) examined Red-breasted Nuthatch distribution in Tennessee and used White-breasted Nuthatch as a reference species. He noted an increase in the number of Red-breasted Nuthatches from west to east in the state and thought that this might reflect an increase in the percentage of conifers in woodlands. However, the same increase was seen for the White-breasted Nuthatch and Haney concluded that both species numbers were increasing because of the percentage increase in woodland acreage not woodland composition.

Data Use–Averaging

The year-to-year variation in numbers of birds may reflect true population fluctuations (Bock and Lepthien 1972) or a result of other variables that are not easily quantified, such as weather. Two general approaches are used to reduce the variance in year-to-year fluctuations. The first approach is to combine count data for a fixed number of years. Investigators have used both three-year intervals (Morrison and Slack 1977, Morrison 1981) and five-year intervals (Stahlecker 1975, Brown 1976, Rosahn 1980). This is particularly useful for species that are recorded in small numbers and may be missed in some years. The second approach is to use a running average which for each year replaces the number seen with the average of adjacent years. Raynor (1975) and Rosahn (1980) have used three-year running averages while Brown (1971, 1973, 1975, 1976) has used five-year running averages.

Data Use–Excluding or Omitting Data

Excluding data is an appropriate technique as long as it is applied uniformly and in an *a priori* sense. Bock and Smith (1971) noted that the year-to-year variance in counts grew as the number of counts decreased and, therefore, did not include data from the 1940s in Colorado when very few counts were made. A number of investigators have excluded data from count circles with continuous coverage below some threshold: three years for DeHaven (1973), ten years for Rosahn (1980) and Morrison (1981), and 20 years for Morrison and Morrison (1983). Stahlecker (1975), Morrison (1981), and Morrison and Morrison (1983) eliminated counts that had fewer than three parties and Stahlecker (1975) also eliminated counts with fewer than ten observers. The criterion of too few birds recorded on a count has also been used as a basis of elimination in regional studies (Schreiber and Schreiber 1973, Bonney 1979, Pruett-Jones et al. 1980, Rosahn 1980, Bock and Root 1981b, Morrison and Morrison 1983). In addition a number of investigators have excluded data that indicated a concentration based on roosts (DeHaven 1973, Brown 1975, Brown 1976).

Data Use–Weather

Christmas Bird Counts are run regardless of the weather, once they have been scheduled (Butcher 1990), and the influence of weather may have a confounding effect on the results. Brown (1971, 1973, 1974, 1976) grouped population trend data into clear and cloudy or rainy day categories and showed that in general more birds are observed on clear days, but the population trends seen in the two data sets are the same. Morrison and Slack (1977) examined the influence of weather variables on their counts of cormorants in Texas and found no measurable effect. Falk (1979) examined 15 sites in the north central United States where weather conditions can be severe and concluded that there is only a weak effect on count results caused by weather conditions, and it is more clearly seen in the number of birds than in the number of species. Smith (1979) examined the number of species for 12 counts distributed widely over the United States and saw mixed and inconsistent effects of weather. Raynor (1980) examined the effects of snow cover and temperature on Bobwhite populations and found only a weak effect.

Summary

The advantages and disadvantages of the use of Christmas Bird Count data have been extensively discussed (Bock and Smith 1971, Bock and Root 1981a, Drennan 1981, Butcher 1990, Butcher and McCulloch 1990, Sauer et al. 1996). The trade off is clearly one between the major advantage of the data set because of its size, both temporal and spatial, and problems that derive from unstandardized sampling. Perhaps Bock and Lepthien (1974) have stated this problem most succinctly "Without doubt the value of Christmas Count data lies in their quantity rather than their quality, which is highly variable."

Butcher (1990) listed a number of points that needed to be considered in the use of CBC data:

1. Consider any potential identification problems for species being examined.
2. Consider potential counting biases. These may include improvements in skill levels or equipment over long time periods.
3. Consider biases in habitat coverage. There is an emphasis on spending observer time where the best birds are rather than uniformly and this will bias the coverage.
4. Consider whether cold or wet weather will affect the count data.
5. Decide how to treat count circles that have moved between years.
6. Determine how to account for observer effort. Bock and Root (1981a) suggest normalizing by party-hours for most species, but not waterbirds.
7. Consider the use of references species where this can be accommodated.
8. Do not rely on data from one count or one year to justify conclusions.

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