Statistical Analysis of Point Count Bird Surveys and Measuring Biodiversity

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American Robin

Blue Jay

Abstract

Point Count Bird Surveys have been conducted at Brookhaven National Laboratory over six different transects for thirteen years from April through September annually. Within the last two years (2010-2011), the 200 acre solar farm has been added to the landscape and an additional transect was added in 2010 to document effects of this feature on bird populations. There have been 122 different bird species identified. The large data set of more than 13,000 entries was analyzed statistically by looking at the different variations among different bird species and by identifying variation from transects to transect. By analyzing the large data set, it will allow us to find different trends by species and different trends by transect. Indices that were used to measure biodiversity were Simpsons Index and Shannon-Wiener Index. Point Count Surveys are continuing in 2012, but have been reduced to 4 months/yr (May-August) from six (April-September) to focus more on migratory species.

Introduction

Bird surveys have been conducted at Brookhaven National Laboratory to detect the various bird species present and their relative abundance at specific locations across the 5,265 acre site. Point Count Surveys were started in the year 2000 and are continuing in 2012, but have been reduced to 4 months/yr from six. Therefore, an abundance of data has been recorded over the last thirteen years. Based on a survey by U.S. Fish and Wildlife Service, 51.3 million Americans watch birds. There are about 9,865 species of birds found worldwide. At Brookhaven National Laboratory, 122 different species have been detected across seven transects (Biology Fields, Peconic River, East Trenches, North Transect, South Transect, Z-Path, and Long Island Solar Farm). Each transect varies in the number and abundance of individual species found. This allows for calculation of species diversity and specific variations within species, and within and across transects. In order to record data, one has to recognize the various bird calls of each species. The date, location, the number of birds heard or seen, the time, temperature , dew point, relative humidity, wind speed, and wind direction at the beginning and end of each transect run are also recorded.

This paper provides information and conclusions based on statistical analysis of the data. Statistical analysis was completed to understand what is occurring over time. We used multiple statistical strategies and formulas to figure out which birds have declined or increased over time; to compare year to year variations; measure biodiversity; and to compare variations between transects. Biodiversity is the main focus of this paper. Using multiple tests we were able to determine statistically significant changes in biodiversity over the 13 year period.

Materials & Methods

More than 1,956 points were sampled throughout the seven transects at Brookhaven National Laboratory. From 2000-2001, there were 20 transect points surveyed (240 points). From 2002-2009, there were 28 transect points surveyed (1,344 points), and from 2010-2011 there were 31 transect points studied (372 points). The last two years the number of transect points increased due to the addition of a 200 acre solar farm to the landscape and an additional transect was added to document effects of this feature on bird populations. The same exact points are surveyed annually over a six month period to obtain statistically sound analysis of the data. Point Count Surveys were initially conducted from March through October, but were reduced to April through September to capture mostly migrating species. Analysis conducted included calculation of the average number of birds, standard deviation, and developing a weighted average for each species. The weighted average normalizes the bird species for easier comparison of species and to help identify differences in populations, if any. To calculate the weighted average (WA),

$$WA = \left(\frac{total\ number\ entries\ in\ one\ year}{total\ number\ transect\ points\ in\ a\ specific\ year}\right) \bullet (total\ \#\ species\ detected\ per\ year)$$

These tests helped standardize the population to help identify and compare transects and individual species. Based on the large data set, two tests were conducted using the Simpson Index (D); a measurement that accounts for the richness and the percent of each species from a biodiversity sample within a zone. The index assumes that the proportion of individuals in an area indicate their importance of diversity. The first is Simpson's index (the probability that two randomly selected individuals in the zone belong to the same subspecies:

$$D = sum(P_i^2)$$

The second is Simpson's index of diversity; the probability that two randomly selected individuals in a zone belongs to different subspecies: = 1- D. Another way to measure biodiversity was to use the Shannon-Wiener index (H). The first step is to calculate for each category (transect). You then multiply this number by the log of the number. While you may use any base, the natural log is commonly used. The index is computed from the negative sum of these numbers. In other words, it is defined as:

$$H = -sum(P_i \log |P_i|)$$

Using species richness (S) and the Shannon-Wiener index (H), you can also compute a measure of evenness:

$$E = H / \log(S)$$

Evenness (E) is a measure of how similar the abundances of different species are. When there are similar proportions of all subspecies then evenness is one, but when the abundances are very dissimilar (some rare and some common species) then the value increases. (REWHC, 1999-2000)

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Discussion

Estimating abundances and trends in abundance is an objective of many wildlife monitoring programs, with point-count surveys being the most popular approach for monitoring avian populations. As an example, Thompson and La Sorte conducted Bird Count Surveys for seven years (1997-2004) in the Ozark-Ouachita Interior Highlands (OOIH). Counts at each point were conducted for 10 minutes. The birds that were consistently detected for their data collection are Acadian flycatchers, Blue-winged warblers, Ovenbirds, Prairie warblers, Red-eyed vireos, and Wood thrushes. (Thompson & La Sorte, 2008) At Brookhaven National Laboratory (BNL), we have been conducting bird count surveys for twelve years (2000-2011) and counts at each point are conducted for 5 minutes. We have found the same exact birds at our location that were found in the Interior Highlands. The results show a huge difference in the number of birds found among the different areas. In 2000, one blue-winged warbler was found at BNL, where 42 were found in OOIH. The biggest difference was comparing the red-eyed vireos. Only 28 were located at BNL, where 1,086 were found in OOIH. The biggest factor that is probably affecting such a huge difference in the results is the location that the birds are nesting. Even though the same exact birds were found at BNL and OOIH, OOIH is within the Central flyway while BNL is on the Atlantic flyway and variations in habitat and nesting areas play a key role in abundance.

The analysis completed did not take into consideration the outside environmental information that could affect bird populations. For example, in 1999, presences of the West Nile Virus began affected bird populations. West Nile Virus affected two commonly found bird species at BNL; blue jays and American crows. This could explain why these two species are decreasing over time. Other changes that have happened at BNL are the disappearance or decline of the scarlet oak trees, the over population of deer, control of fire, and clearing of approximately 165 acres within and near the Biology Fields to develop the Solar Farm. The data raise questions as to why some of the birds are increasing while others are decreasing. This initial statistical analysis, suggests the need for more research to be done to better understand the changes seen.

Results

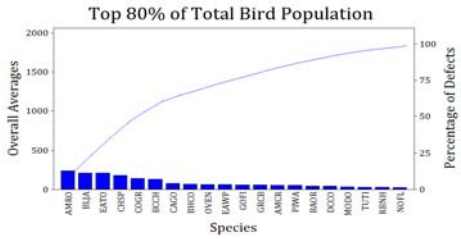


Figure 1 (left) 21 individual birds make up 80% of the population and serve as the core subset of birds. To display what is happening over time, Pareto Analysis was conducted to visually display the results (Figure 1). The scale on the right tells us the percentage of defects, which means if the AMRO (American Robin) and BLJA (Blue Jay) were combined; the two individual species make up about 25% of the total population. Overall looking at the Pareto Chart, the core subset seems to be fairly even, which means the measures of different species are relatively similar.

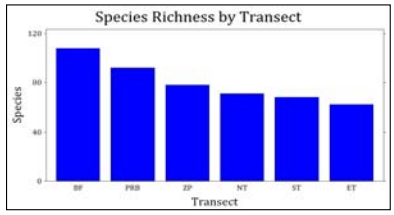
Table 1 (below): Measures of Biodiversity using Simpson's Diversity Index & Shannon-Wiener Index

Table 1 displays measures of biodiversity using Simpson's Diversity Index and Shannon-Wiener Index for the twelve years of data. Species richness is accounted for by the122 different bird species. Simpson's Index D describes the randomly selected individuals who belong to the same subspecies. Simpson's Index D calculated is closer to zero; therefore Simpson's Diversity Index (Figure 3) tells us that the individual species are independent of the others. The results for Shannon-Wiener Diversity index, the numbers calculated for evenness are closer to one which conclude that the there are similar proportions of all subspecies and tells us how similar the different species are throughout the population.

	Overall	BF	ET	ST	PRB	NT	ZP
Species Richness S	122	108	62	68	92	71	78
Simpson's Index D	0.047	0.024	0.019	0.015	0.074	0.067	0.013
Simpson's Diversity Index	95.3%	97.6%	98.1%	98.5%	92.6%	93.3%	98.7%
Shannon-Wiener Index H	3.600	4.388	4.043	4.193	3.722	3.656	4.335
Evenness	0.749	0.937	0.980	0.994	0.823	0.858	0.995

Figure 2 (right):
Species Richness (S): Total Number of Individual Species per transect (Biology Fields (BF), Peconic River (PRB), Z-Path (ZP), North Transect (NT), South Transect (ST), and East Trenches (ET))

Comparing the species richness among all transects, the number of species are very diverse. The transect with the highest diversity is the Biology Fields which also has the highest species richness.



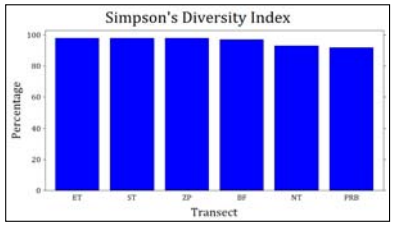
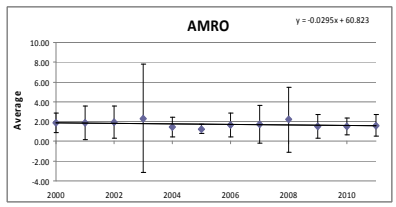


Figure 3 (left):
Simpson's Diversity index
(Simpson's Diversity Index tells us that the individual species belong to different subspecies.
The closer to 100%, the more diverse each transect is.

Figure 4 (right):
American Robin (Linear Regression)

Robins represent the most prevalent bird found on the landscape where the rate of change (slope) is -0.0295. Since the slope is closer to 0, this tells us that the population is not changing much..



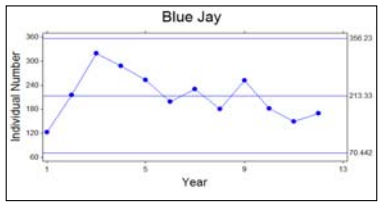


Figure 5 (left):

The figure to the left is an example control chart for individuals (I-Chart). The center represents the average. Upper Center Level (*UCL*) and Lower Center Level (*LCL*) represent the average of the moving range of two observations. Blue Jay's in control, since none of the plotted points fall outside either the *UCL* or *LCL*.