The effects of anthropogenic disturbance on the bird community at Brookhaven National Laboratory

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Abstract:

Brookhaven National Laboratory (BNL), Upton, NY, a multi-disciplinary national laboratory and a user facility owned by the Department of Energy, contains very large facilities for conducting scientific research. Since 2000, the Environmental Protection Division has used the point count method to survey birds. Bird counts can be used to estimate population size, detect changes in the population or in diversity of species, and possibly determine the cause of any changes. The goal of this project is to analyze the data statistically to determine if the construction of the solar farm has had any significant impact on the populations of birds on site. During 2010 and 2011, the construction of a solar facility removed some of the vegetation (81 hectares) and natural habitat along the Biology Fields' Transect, located along the western side of the northern section of the solar facility. Now, several years after the installation of solar panels the vegetation has recovered. We can examine the long-term effects that the solar

facility has had on the variety of bird species. All the data collected via point count surveys from April through August annually has been organized into tables in Microsoft Excel. The data were refined and normalized to be relevant for this project and then imported into R; statistical computing software, for analysis. Using ANOVA, it was determined that there was a significant change ($p=1.04e-06$) in birds present each year from 2008-2017. Then, a Least Significant Difference (LSD) Test was conducted to conclude which years were significantly different from the others. This study helps BNL to understand the impacts of operation, if any, on bird populations found on the BNL Site, and more specifically whether the construction of the solar farm had any continuing impacts.

Background/Introduction:

Brookhaven National Laboratory (BNL), a multi-disciplinary national laboratory and a user facility, one of 10 laboratories, sponsored by the US Department of Energy (DOE) Office of Science, contains very large facilities for conducting scientific research. Since 2000, the Environmental Protection Division has used the point count method to survey birds. Bird counts can be used to estimate population size, detect changes in the population or in diversity of species, and possibly determine the cause of any changes. During 2010 and 2011, a solar facility was built, and removed some of the vegetation and natural habitat along the Biology Fields' Transect, located along the western fence of the solar facility. Now that several years have passed and the vegetation has recovered, we can examine the long-term effects that the solar facility has had on the various species identified during surveys. For surveying birds, the point count method is used in all types of projects.[1] Point counts are used to record as many different species of birds based on visual and call identification. Point count surveys are conducted from

April to August during the last week of each month. BNL has 7 permanent transects that are monitored over a period of several days to determine how many species and numbers of individuals of each species are in an area. To improve accuracy of the surveys, the quantity of point counts and the number of days a point count is repeated can be increased.

Ornithology is the scientific study of birds. "The history of ornithology is a rich one, populated by interesting characters, adventure, intrigue and discoveries that guided the development of many aspects of biology. Some have argued that the study of birds has contributed as much to the development of biology as has research on virtually any other group of animals or plants, especially with respect to behavior, ecology, speciation, sexual selection, physiology and systematics."[2]

As one of the most commonly used methods of recording bird populations (148 papers in 10 journals over 10 years)[3], point counts are defined as "a period of time during which an observer records the auditory and visual signals of the individuals on predetermined sites. This method is used to study bird population trends examine bird–environment relationships and evaluate the responses of populations to environmental changes."[3] It has been found that "it is not necessary to carry out point counts longer than 5 min for common species in a temperate landscape when using presence–absence data"[3], which is the duration that is used in the surveys at BNL.

Monitoring projects may not start with direct questions about the systems being studied. However, the results can often be used to generate questions that are answered by conducting additional research. In fact, point count surveys are used in many academic

programs. Participants can look at conclusions and form hypotheses about why differences occur between the sites of interest. "For example, one might find that woodpeckers visit Homeowner A's yard but not Homeowner B's yard. One can visit each of the homeowner's yards and look for habitat differences between the two yards. Unique hypotheses could be developed and tested. This may lead to recommendations for ways to improve Homeowner B's yard to attract woodpeckers."[1]

One can also evaluate the success of environmental changes that have been made at a location by conducting surveys before the changes are made, and continuing to take point count surveys over several years, you would be able to compare the original number of species to the number of species after to see if the changes had a significant impact on the number of birds in that location.

In most cases, point counts are used to compare bird differences between sites. They can be used to observe changes in bird populations when an area is altered. They also can be used to study annual and seasonal variations in bird populations.

From October 2010 to November 2011, the construction of a 32 megawatt solar facility was undertaken in the southeast portion of BNL (Figure 1). When constructed it was the largest solar photovoltaic power plant in the eastern United States, and it generates enough clean solar energy to power approximately 4,500 homes for the local utility.[4] It also provides research opportunities for BNL such as ecological studies, inverter technologies, smart grid predictions, and power supply studies. The construction of the solar facility changed the vegetation inside from forest or grassland to grassland and disturbed. The fences surrounding the solar facility

are large enough to provide protection for the ground nesting and the intermediate canopy nesting bird species, by preventing white-tailed deer from interfering with the environment within. Point count bird surveys conducted at BNL can provide ecological evidence and data used to study the impact on bird diversity.

The goal of this project is to determine if the construction of the solar facility at BNL has made a significant impact on the diversity and population of birds on site. The objectives of this project include: a) compile of data (2008 – 2017) taken from point-count surveys into a table to be analyzed, b) refine data to normalize and focus on years relevant to study, c) organize data into periods of time around the construction of solar facility, d) transfer data into statistical programming software for analysis, and e) run tests to determine if population changes within the data are significant. We hypothesized that the construction of the solar facility caused a significant change in the diversity and population of birds on site. The ecological significance of this project is that we can use this data to determine how many species of birds are affected by disturbance in their habitats and how long it may take for their habitats to be recovered enough for the area to be restored to its former state.

The available literature search yielded no peer reviewed publications on anthropogenic disturbances by building solar array regions and their effects on bird community in northeast regions of the United States of America. The uniqueness of this original scientific article based on empirical data is to contribute new knowledgebase to the scientific community on anthropogenic disturbance and its effects on bird populations and its recovery period in solar array regions on Long Island, NY.

Materials and Methods:

The Environmental Protection Division at BNL has been conducting bird surveys via the point count method to monitor the populations every year since 2000. During 2000 and 2001, the surveys took place at five transects: Biology Fields (BF), East Trenches (ET), North Transect (NT), Peconic River (PRB), and South Transect (ST). Each transect contained between three and eight stations where the counts were taken, added up to 20 stations. In 2002, the Z-Path (ZP) transect was added, bringing the number of transects up to 6 and points to 28. Then, in 2010, after the construction of the solar facility began, the Solar Farm (SF) transect was added, increased to a total of 31 stations within 7 transects, which can all be seen in Figure 1. These transects encompass various habitats including dry forest, white pine, the Peconic River, and wet/forest farm field, the diverse forest surrounding the ZP transect, and the now recovering environment within the SF transect.

Bird surveys are now taken at the end of the month from April to August. The data were normalized to only include the last 2 survey dates from May to August between 2008 and 2017 for this project. The radius of every observation station is approximately 150 m to ensure that there is enough space for observation. All birds seen or heard during 5-minute observation time were recorded. For environmental data, The Kestrel 4000 pocket weather meter was used during the survey. This data includes start and stop time, start and stop temperature, dew point, relative humidity, wind speed, and wind direction.

All survey data were recorded into a Microsoft Excel® spreadsheet for analysis. All statistical analysis was performed using R (version 3.5.1). Statistical tests performed include ANOVA, correlations, and LSD.

Results:

The data were analyzed to examine the interrelationships between bird counts, habitat (various transects), and environmental factors such as wind speed, humidity, and temperature that were collected each year from 2008 to 2017. The following bird species were included in the analysis due to the presence in all years: American Robin (*Turdus migratorius*), Baltimore Oriole (*Icterus galbula*), Black-capped Chickadee (*Poecile atricapillus*), Blue Jay (*Cyannocitta cristata*), Brown-headed Cowbird (*Molothrus ater*), Chipping Sparrow (*Spizella passerina*), Common Grackle (*Quiscalus quiscula*), Eastern Towhee (*Pipilo erythrophthalmus*), Eastern Wood Peewee (*Contopus virens*), Goldfinch (*Carduelis tristis*), Great-Crested Flycatcher (*Myiarchus crinitus*), Grey Catbird (*Dumetella carolinensis*), House Wren (*Troglodytes aedon*), Ovenbird (*Seiurus aurocapillus*), Pine Warbler (*Dendroica pinus*), Red-bellied Woodpecker (*Melanerpes carolinus*), and Red-eyed Vireo (*Vireo olivaceus*). The years 2008 to 2010 are identified as pre-construction years, prior to the solar facility being built. 2011 to 2013 were years that the vegetation within the solar facility that was disturbed due to the clearing of vegetation. 2014 to 2017 are considered years that the vegetation has recovered. The original habitat in the area included, Red Maple - Black gum Wet Forest, Red Maple-Mesic Heath Forest, Red Maple/Scarlet Oak-Mesic Heath Forest, Pitch Pine/ White Oak Forest, Pitch Pine/Mixed Oak- Heath Forest, Planted White Pine Forest.

Putting the data into a box and whisker plot, it can be observed that the population was different from pre-construction to post-construction to the recovery period. After running an ANOVA test, it was proven that there was a significant difference in bird population from 2008 to 2017 ($p = 1.04e-06$). An LSD test was run to determine which individual years are significantly

different from each other. The results concluded that using a confidence interval of 95% (α = 0.05), 2008 to 2013 ($p = 0.0088$) and 2013 to 2017 ($p = 0.0052$) bird counts were significantly different. To make sure that this trend was exclusive to this area and not possibly due to another factor, data from the ZP transect was plotted using the same 17 bird species and years. Comparing the summary tables 1 & 2 and two graphs (Figures 2 & 3), it is shown that the decline in bird population only occurred in the BF Transect. The average temperature was also taken from each year for both transects. An ANOVA test concluded that there was no significant difference in temperature between years, and the trend of trend of average temperatures does not correlate to average bird count, seen in Figures 4&5. Since all other factors have not proven to be the cause of the decline in bird population, we can assume that the construction of the solar facility was the cause.

The removal of vegetation caused a decline in bird population for about two years before returning to the normal count. This is useful information because it proves that although this type of disturbance causes a decline in bird population, they will make a return once the vegetation has grown back. If more studies are done, monitoring bird species before and after disturbance, it would be possible to determine what types of disturbance may be permanently detrimental to bird populations in that area, or have the potential to have the community restored given enough time.

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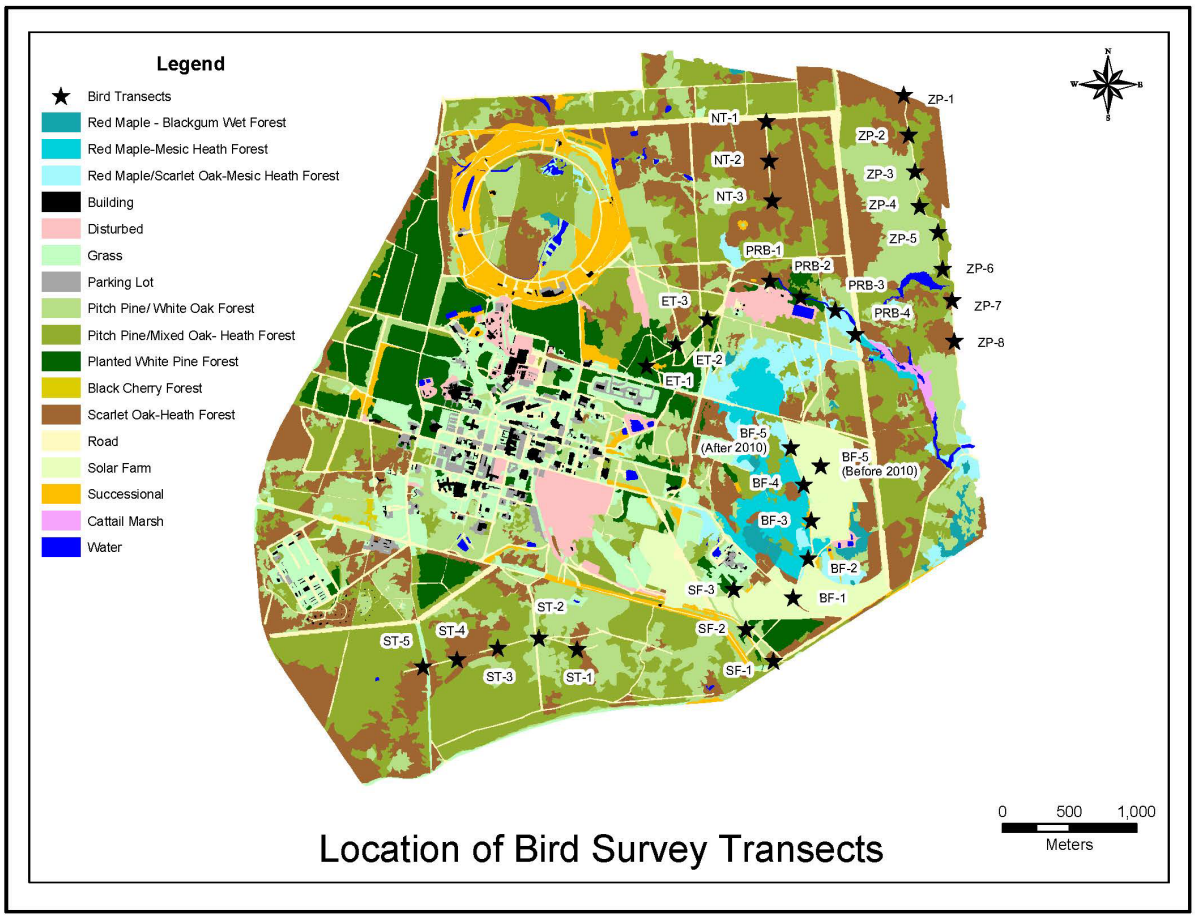
[2]“History of Ornithology.” *History of Ornithology*, amornithhistory.org/.

[3]Bonthoux, Sébastien, and Gérard Balent. "Point Count Duration: Five Minutes Are Usually Sufficient to Model the Distribution of Bird Species and to Study the Structure of Communities for a French Landscape." *Journal of Ornithology*153, no. 2 (2011): 491-504. doi:10.1007/s10336-011-0766-2.

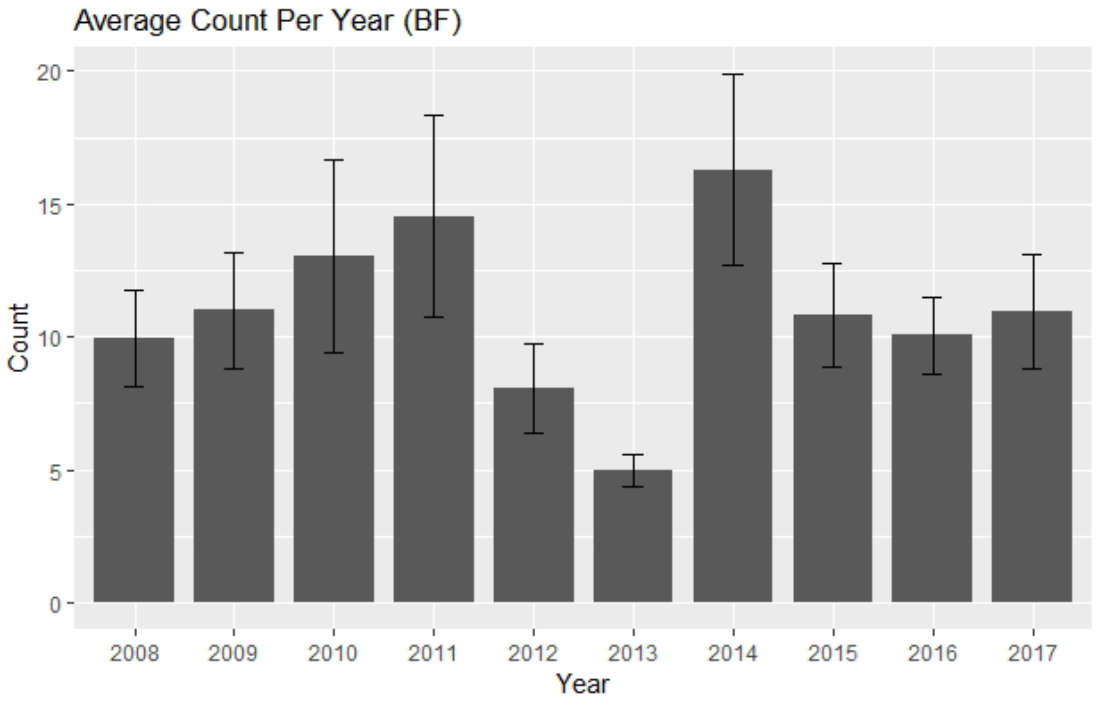
[4]Looney, P.J. Sustainable Energy Technologies Department, Brookhaven Science Associates. Brookhaven National Laboratory, Upton, New York.

Figures:

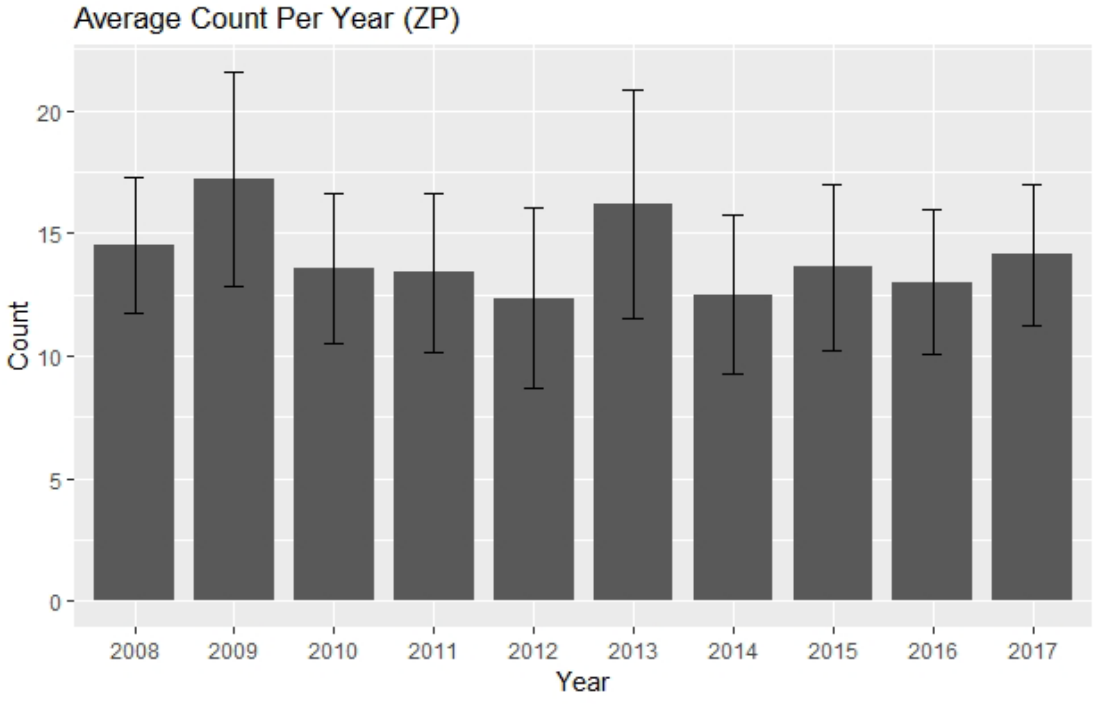
1. This map outlines the location of bird survey transect location after 2010. It shows distribution of various types of vegetation within the Brookhaven National Laboratory



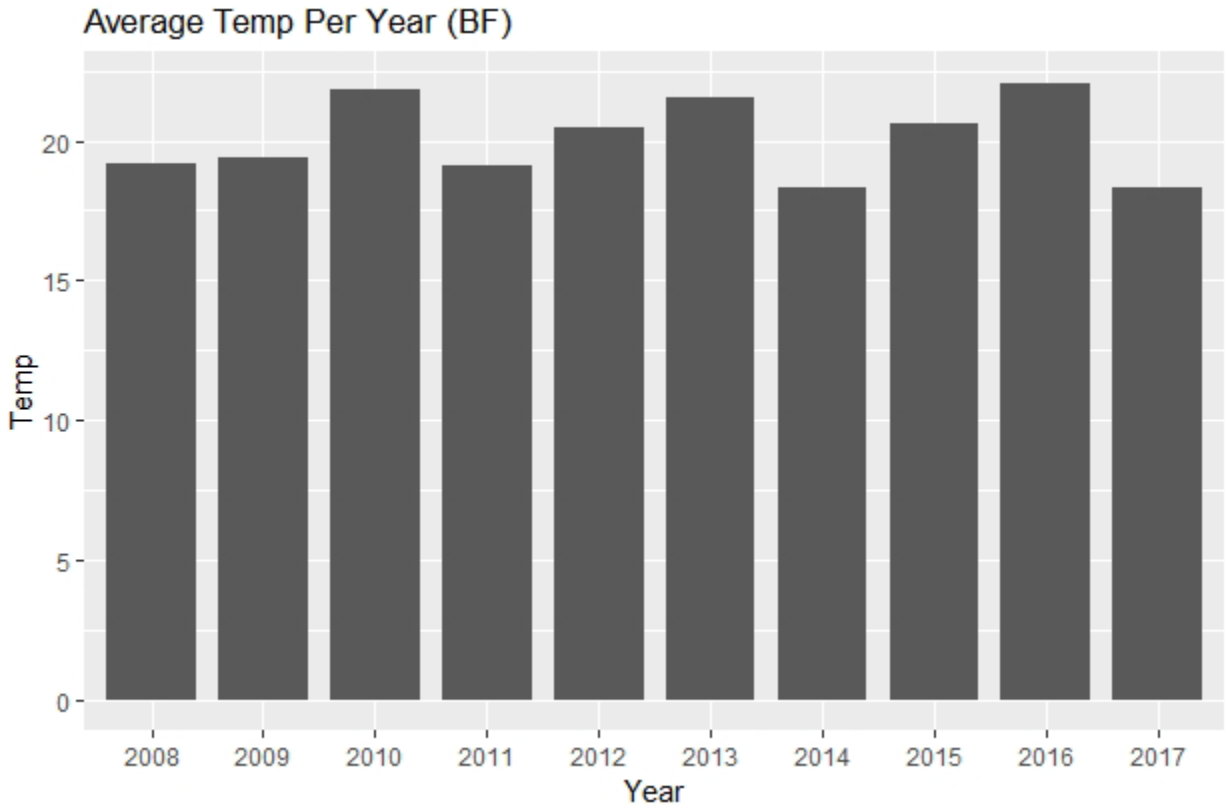
2. Shows average bird counts for the only 17 species present each year from 2008-2017 in the BF Transect.



3. Shows average bird counts for the same 17 species from 2008-2017 in the ZP Transect stations 4-8.



4. Average Temperatures from 2008-2017 in the BF Transect (Celsius).



5. Average Temperatures from 2008-2017 in the ZP Transect (Celsius).