

**Change in bird biodiversity trends due to environmental events at the Long Island
Central Pine Barrens**

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Abstract

The Long Island Central Pine Barrens is an ecosystem consisting of pitch pine woodlands, pine oak forests, coastal plain ponds, swamps, marshes and streams. Within the Pine Barrens is Brookhaven National Laboratory (BNL), a multi-dimensional national laboratory that provides large scale facilities for research. Point Count Bird Surveys were conducted by the Laboratory's Environmental Protection Division over the past 14 years to monitor bird species diversity. The present study examined the trends of bird species diversity during 14 years of observation along different transects at BNL. In 2010, a 200 acre Long Island Solar Farm (LISF) was added at BNL. The point count bird survey at BNL indicates that the bird species richness and diversity increased at the Long Island Solar Farm area because of the vegetation change. The bird counts of ground nesting birds such as Ovenbirds and Eastern Towhees were increasing at the Biology Fields transect, which is close to the Long Island Solar Farm. On April 9th 2012, three bird observation stations located at Z-Path transect were burned out by a top-kill, intense wildfire. Most of the oak trees and understory were wiped out at these three bird observation stations by the wildfire. The bird populations and species were subsequently found in abundance. We found that the vegetation changes due to the fire including land clearing, opening up the canopy, providing more dead standing trees and the construction of the LISF influence the bird biodiversity. The Pearson correlation was determined analyze the correlation between white-tailed deer population at BNL and bird species counted at different nesting heights. The correlation between the deer population and the ground nesting/ the intermediate canopy nesting bird species is moderately positive, which is unexpected.

1. Introduction

The Long Island Central Pine Barrens is a large preserved land which mostly remains undeveloped. The Pine Barrens overlies Long Island's fresh water aquifer and helps to purify Long Island's drinking water. Most of the Peconic River, the longest river on Long Island, is in the Central Pine Barrens. The Peconic River originates in bogs and wetlands near the Brookhaven National Laboratory (BNL). Since 2000, the Environmental Protection Division at BNL has conducted point count bird survey to monitor the bird biodiversity on site. Changes in bird diversity may provide a glance of environmental change at BNL. That would provide suggestions for making changes in the conservation policy at BNL.

From October 2010 to November 2011, the construction activity of 32 megawatts Long Island Solar Farm (LISF) was undertaken at southeast end of BNL. The LISF, the largest solar photovoltaic power plant in the eastern United States, generates enough clean solar energy to power approximately 4,500 homes for the local utility, Public Service Enterprise Group (PSEG-LI). The LISF also provides research opportunities for BNL such as ecological studies, inverter technologies, and power supply studies. The construction of the LISF has changed the vegetation inside of the LISF from forest or grassland to grassland and disturbance. Bird species diversity is related to the percentage of vegetation cover¹. After construction of LISF, fences were set up to protect the solar panels. The fences are large enough to provide protection for the ground nesting and the intermediate canopy nesting bird species, by keeping white-tailed deer outside of the LISF. Point count bird surveys conducted at BNL can provide ecological evidence and data used to study the impact on bird diversity due to the LISF.

BNL occupies more than 1000 acres of core preservation area of the Central Pine Barrens. On April 9th 2012, a top-kill, intensive wildfire wiped out four point count bird survey stations at Z-Path transect. Most of the oak tree and understory were burned. The fire changed the forest structure such as tree density, snags (dead standing tree), shrub cover, and leaf litter. This resulted in changing the relative abundance of breeding bird species and population at post-fire Z-Path transect². Comparing this to the New York State Breeding Bird Survey³ Rout 001 Westhampton and Rout 002 Manorville in post-1995 Sunrise Highway fire, the relative bird species and community shared the similarity that the relative bird species had increased.

Another disturbance to bird diversity is the large white-tailed deer population in the northeastern United States. Approximately 600 white-tailed deer live at BNL which is 2132 hectares. A high density white-tailed deer population at BNL has reduced understory vegetation, disturbed ground nesting bird species, and intermediate canopy nesting bird species⁴. The correlation between the deer population and both ground nesting and intermediate canopy nesting bird species is moderate. However, the positive correlation is unexpected. A possible explanation is migration survivability and the availability of food sources in South America, two factors that impact both bird species richness and population. Most species travel to South America for the winter. The long-distance flights can be very dangerous and consume a lot of an individual's energy. During migration, if there are not enough food sources along the route, migration survivability of a bird decreases. Due to urban development in South America, the land demand is increasing. With that, many bird habitats have been lost. This results in a decrease of food sources for migrating bird species.

2. Methods and materials

2.1 Study design

The point count method has been applied in monitoring bird populations⁵ by The Environmental Protection Division at BNL annually from 2000. From 2000 to 2001, the point count bird surveys were conducted along the original five transects, known as: Biology Fields (BF), North Transect (NT), Peconic River (PRB), and South Transect (ST). Each transect contained between three to eight sample stations for a total of 20. The Z-Path (ZP) transect was added in 2002, which brought the sampling stations up to 28. In 2010, The LISF was added to BNL, and the Solar Farm (SF) transect add three additional sample stations to the point count survey annually. Currently, there are seven transects, totaling 31 point count sampling station, established through varying habitats at BNL. The BNL transects were created to cover as diverse a community as possible. The original five transects covered dry forest, white pine, the Peconic River, and wet/forest farm field. The Z-Path added diverse forest habitat on the east side of the site representing the Upton Reserve. The Solar Farm transect was added to try to detect changes before and after construction of the LISF.

Each transect station is identified by the initials of the respective transect and a number (Figure 1). The Solar Farm transect is close to a high volume expressway, and due to the traffic noise, SF-1 was the first sample station to start the survey.

2.2 Bird sampling

Point count bird survey is conducted at BNL annually during May, June, and July. The radius of every transect sampling station is approximately 150 meters to ensure that

there is enough space for observation, but no two transect sampling stations overlap⁶. During the survey, all birds observed (seen or heard) during a five minute period were recorded by two observers. The Kestral 4000 portable weather station was used during the survey. The data recorded includes start and stop time, start and stop temperature, dew point, relative humidity, wind speed, and wind direction.

2.3 Data analysis

All survey data was recorded into a Microsoft Excel[®] spreadsheet for analysis. Statistical analysis was performed using R (Version 3.1.1). Statistical analysis is conducted from 2000 to 2013. Bird species richness, Simpson Diversity Index, and Shannon Wiener Evenness⁷ within each bird count station, or based on bird nest placement height⁸. Statistical tests performed include Shapiro-Wilk Normality Test to test if the data sets are normal. However, several data such as bird counts at sampling station fails the normality test. In these cases, non-parametric tests such as the Mann-Whitney Test and the Kruskal-Wallis test are used to compare the medians⁹.

3. Results and Discussion

We examined the bird diversity during pre-construction and post-construction of LISF transect to understand the ecological impact brought by LISF. We categorized 2009 and 2010 as the pre-construction of LISF, 2012 and 2013 as the post-construction of LISF. The bird species richness was counted at each station in Biology Fields transect (Figure 2). The Shapiro-Wilk test of normality was performed and the results indicate both pre-construction and post-construction species richness follow the normal distribution. Paired t-test was performed to analyze the difference between the birds species richness obtained in two time periods. The p-value is 0.001568 ($\alpha = 0.05$) that

reveals species richness is significantly different between the two time periods. Moreover, the result of one tail paired t test ($p = 0.0007839$, $\alpha = 0.05$, alternative=less) showed species richness obtained during post-construction of LISF was greater than pre-construction of LISF at Biology Fields transect.

Principal Component Analysis (PCA) was performed to visualize the difference of vegetation each bird count stations during pre-construction (Figure 3A) and post-construction of LISF (Figure 3B). The PCA figures and the vegetation map indicated the vegetation of station PRB-3 and PRB-4 was similar to the Biology Fields transect. Hence, we classified the bird obtained at PRB-3 and PRB-4 as the control group, and the Biology Field transect as the experimental group to analyze the biodiversity changes. Using 2009-2010 as the pre-construction of the LISF period, and 2012-2013 as the post-construction of the LISF period for both control group and the experimental group, paired t tests were performed. The bird species richness obtained at the control group (PRB-3 and PRB-4) shows no significant difference ($p=0.3024$, $\alpha=0.05$) between the two time periods. However, the bird species richness obtained from the experimental group (Biology Field transect) indicates the bird species richness obtained during post-construction of the LISF is greater ($p=0.0007839$, $\alpha=0.05$, alternative=less) than during pre-construction of LISF.

The ground nesting bird species such as Killdeer (*Charadrius vociferus*), Mallard (*Anas platyrhynchos*), and Song Sparrow (*Melospiza melodia*) were present at the experimental group (Biology Fields transect) in post-construction of the LISF, but absent in pre-construction of the LISF. The population of Chipping Sparrow (*Spizella passerina*), Eastern Towhees (*Pipilo erythrophthalmus*), Goldfinch (*Carduelis tristis*), and Ovenbird (*Seiurus aurocapillus*) counted were increasing during post-construction of LISF at the

experimental group. These bird diversity changes haven't been observed at the control group (PRB-3, PRB-4). The grass and disturbance inside the LISF attracted more ground nesting bird species and population at the Biology Fields transect.

On April 9th, 2012, a top-kill, intensive wildfire took place at three bird count stations at Z-Path transect. Due to effective public relations efforts concerning wildfire, fire has been suppressed throughout the Northeast United State in recent decades¹⁰. There were two major wildfires recorded at Long Island Central Pine Barrens. One was 1995 Sunrise Highway fire; the other one was 2012 fire. The 2012 fire cleared the understory and leaf litter, opened the canopy, and provided snags at ZP-1, ZP-2, and ZP-3. More insects went to post-fire stations. Because of opened canopy, blueberry and hackle berry grew back quickly and vigorously¹¹. That attracted the more bird species and population. We categorized the bird species richness obtained at 2010 and 2011 as the pre-fire period and at 2012 and 2013 as the post-fire period (Figure 4A, Figure 4B). Paired t tests were performed to analyze the bird species diversity difference during pre-fire and post-fire at the each station at the Z-Path transect. The statistical test conducted at ZP-1, ZP-2, and ZP-3 shows the bird species richness obtained pre-fire were significant less than post-fire ($p=0.0186$, $\alpha=0.05$, alternative=less). Conversely, the statistical test conducted at ZP-4, ZP-5, ZP-6, ZP-7, and ZP-8 shows the bird species richness obtained during two time periods is no significant difference ($p=0.865$, $\alpha=0.05$). Both of the bird species richness and population were increasing at three post-fire stations. Compared to the overall bird population obtained at 2011 at pre-fire stations, the overall bird population obtained at 2012 and 2013 at post-fire stations increased 15.9% and 32.7% respectively. However, compared to pre-fire stations, both the Simpson diversity index and the Shannon-Wiener

Evenness index were decreased at post-fire stations. It shared the similarity with data obtained at New York State Breeding Bird Survey Rout 001 Westhampton and Rout 002 Manorville at post the 1995 Sunrise Highway fire. The relative bird species and population had increased such as American Robin (*Turdus migratorius*), Chipping Sparrow (*Spizella passerina*), Common Grackle (*Quiscalus quiscula*), Great Crested Flycatcher (*Myarchus crinitus*), Pine Warbler (*Dendroica pinus*), and Red-breasted Nuthatch (*Sitta canadensis*). Eastern Kingbird (*Tyrannus tyrannus*), snags nesting species such as Red-bellied woodpecker (*Melanerpes carolinus*), and Northern Flicker (*Colaptes auratus*) presented at post-fire stations, but not at pre-fire stations. Wood Thrush (*Hylocichla mustelina*) was absence at post-fire stations probably because Veery (*Catharus fuscescens*) expanded their habitat at the post-fire stations at the Z-Path transect⁸.

BNL has a large population of white-tailed deer (Green, unpublished data). High density white-tailed deer populations reduce the understory vegetation and the rate of forest regeneration⁴. Overabundance of white-tailed deer disturbs the regrowth rate of vegetation, especially impacts bird species that nest below 6 feet⁴. The correlation between the white-tailed deer population and the species richness of the bird species nesting less than 6 feet is 0.4776298 by performing the Pearson Correlation. The correlation is moderate, but unexpected. However, there are many factors affect the bird diversity. Bird species richness and population counts are impacted by the migration survivability and the food sources available in South America during the winter. Climate change would impact at the migration locations. Migratory species are particularly fragile because they depend on success in multiple locations across the globe. Destruction of

habitat in either seasonal location lowers the survival rate and is detrimental to the bird species and population.

4. Conclusion

This paper focused on the bird diversity changes due to environmental changes at BNL inside of the Long Island Central Pine Barrens. The 2012 wildfire and existence of the Long Island Solar Farm have changed the vegetation structure. The different vegetation available at BNL was changed not only the quantitative in terms of bird species and population, but also qualitative in terms of species diversity and evenness. Our study addressed at the bird diversity trends based on 14 years observations. Construction of Long Island Solar Farm created an open disturbance for bird community without browsing by high density white-tailed deer population. That increase abundance and species richness of bird species including ground nesting species. The 2012 wildfire provides open, young-forest for bird species. The 2012 wildfire increased the relative bird species and population. However, effects of wildfire on the forest, and subsequently on bird diversity are short-term, as the oak trees and shrubs recover rapidly. Our study suggests prescribed fire can be adapted to change canopy cover and forest structure. That may lead to increase bird species richness and decrease fuel accumulated for severe wildfire over time. Overabundance of white-tailed deer population brings negative effect to manage forest vegetation and wildlife, especially songbirds¹². The influence of overabundance white-tailed deer population at BNL would need further study. Prey-Predator relationships might be an available direction for the future study.

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Figure 1

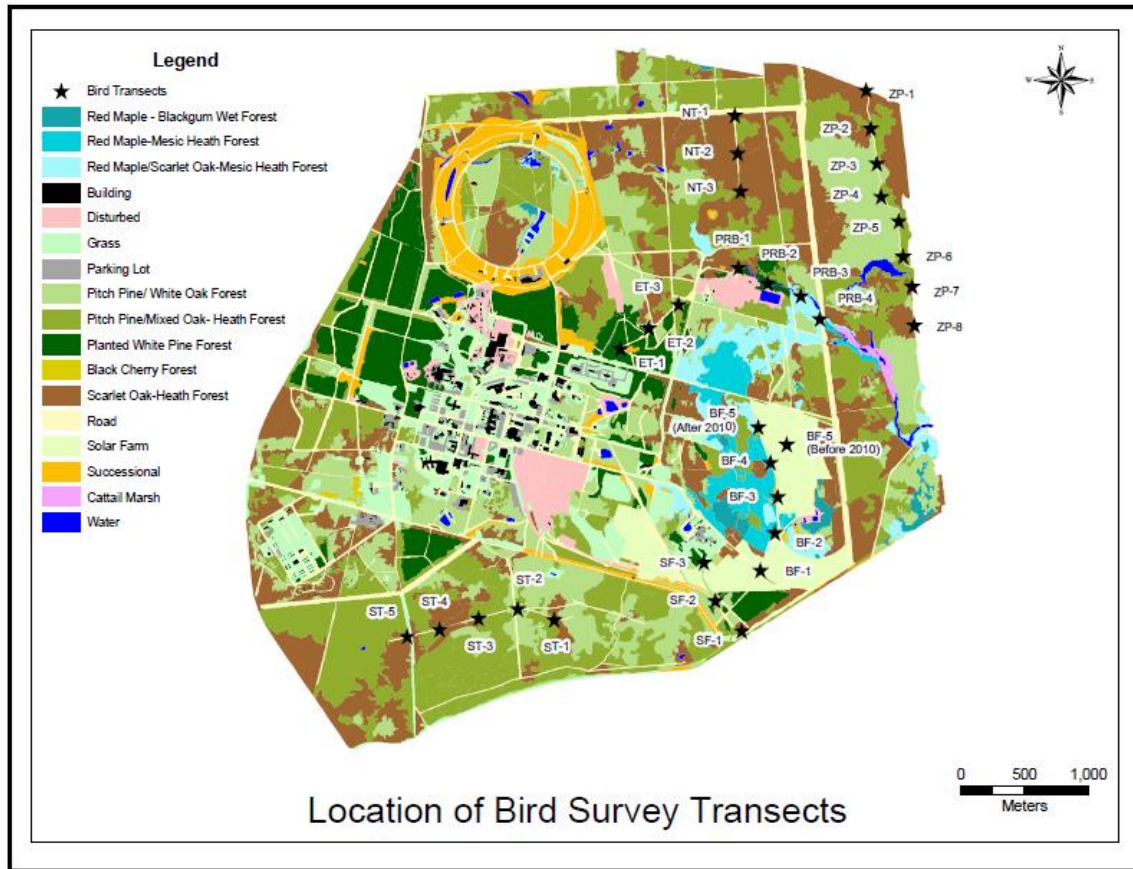


Figure 1: This map outlines the location of bird survey transect location after 2010. It shows distribution of various types of vegetation within the Brookhaven National Laboratory.

Figure 2

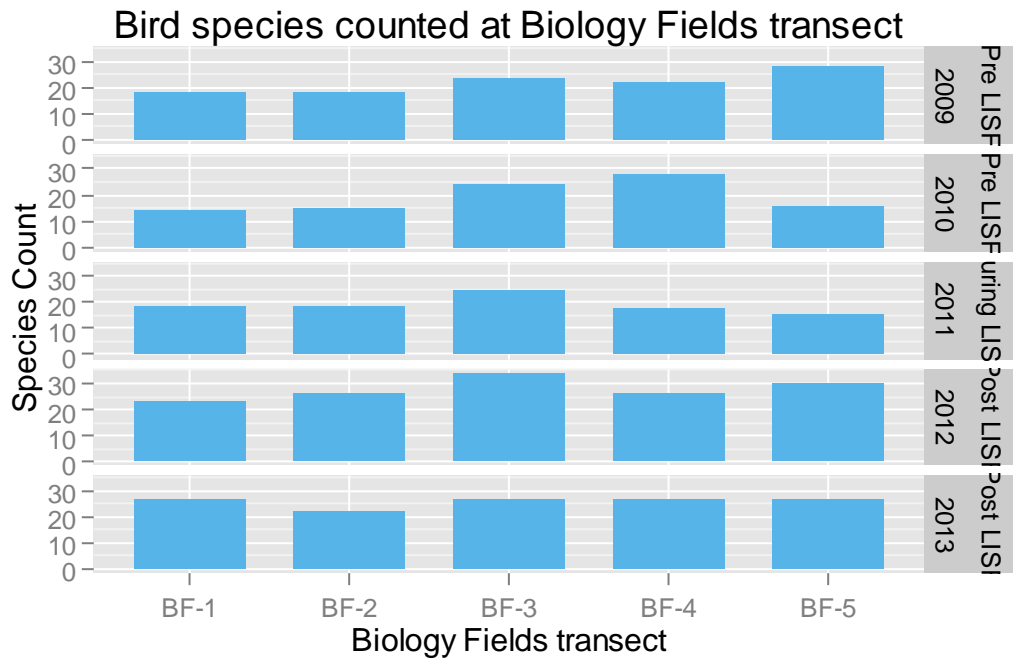


Figure 2: This bar chart shows the bird species richness obtained at each station in Biology Fields transect during pre-construction of LISF, during construction of LISF, and post-construction of LISF.

Figure 3A

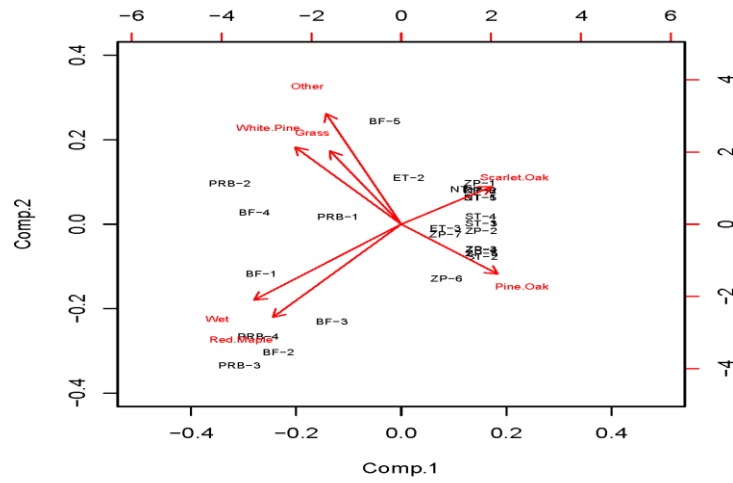


Figure 3A: The PCA graph illustrates the bird count station covered by different vegetation in pre-construction of LISF.

Figure 3B

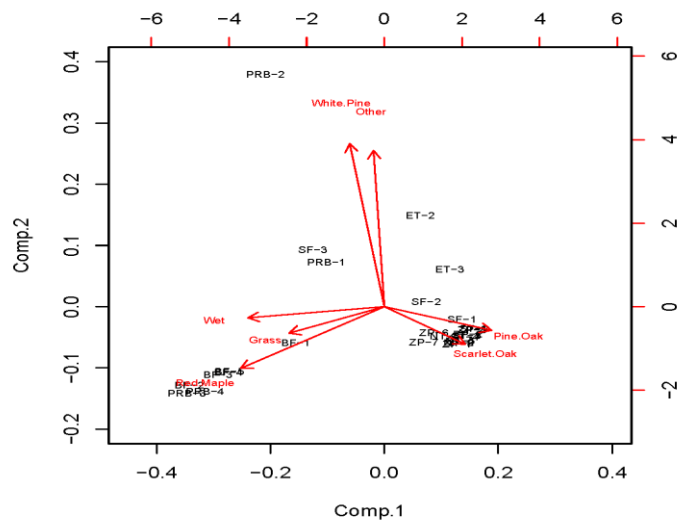


Figure 3B: The PCA graph illustrates the bird count station covered by different vegetation in post-construction of LISF.

Figure 4A

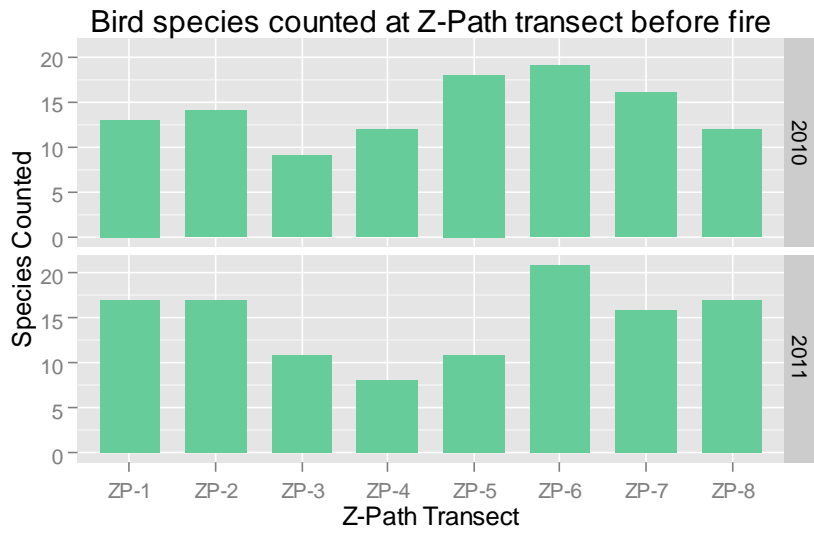


Figure 4A: The bar chart illustrates the bird species richness obtained at each station in Z-Path transect before wildfire.

Figure 4B

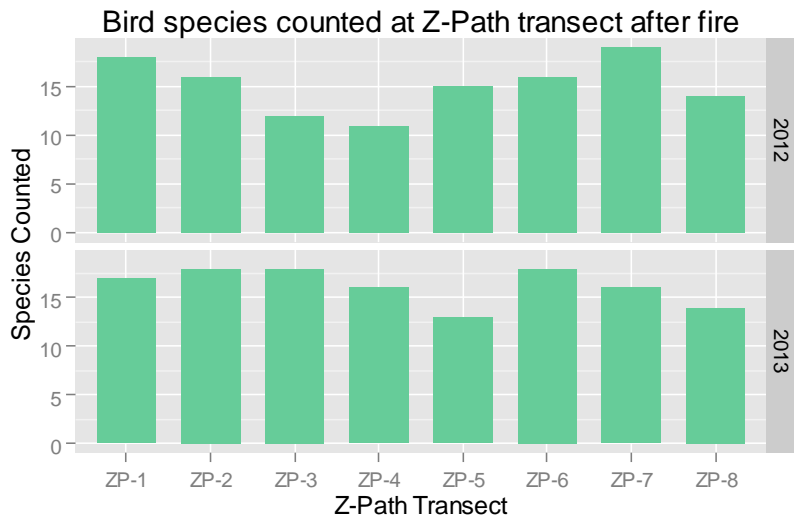


Figure 4B: The bar chart illustrates the bird species richness obtained at each station in Z-Path transect after wildfire.