Understory Vegetation Analysis in the Proposed Long Island Solar Farm of Pine Barrens Forest, NY

Natasha L. Robateau
Murty S. Kambhampati, Ph.D
Office of Science, Faculty and Student Teams
Program

Southern University at New Orleans
New Orleans, LA

Timothy Green, Ph.D
Brookhaven National Laboratory
Upton, New York

August 2, 2010

Prepared in partial fulfillment of the requirement of the Office of Science, Department of Energy's Faculty and Student Team under the direction of Dr. Timothy Green in the Environmental Protection Division at Brookhaven National Laboratory.

Participant: ____

Participant: ____

Research Advisor: ____

Table of Contents

ABSTRACT

The Conservation of renewable energy is a critical demand for the protection of the environment. In order to encourage energy efficiency through innovation of technologies, British Petroleum has proposed the installation of a solar farm on 200 acres of the Long Island Pine Barrens Forest (LIPBF). We conducted baseline observations of the pH and distribution of vegetation species within the area. A total of 12 Transects of 25m each consisting of 6 quadrats (m^2), were laid through the vegetation. In addition, 5 controls were laid in the outer area of the proposed solar farm. The vegetation distribution was identified by taking a tally of each individual species within each plot of a quadrat according to each genus and species. The heights of the species were also measured. The pH was measured by immersing an electrode of pH meter into the soil of the fourth plot of each quadrat. The variation in pH ranges from 3.2 to 5.9. The areas with a higher acidity of 3.2 to 4.8, composed of sandy soil common for the Pine Barrens Forest, were populated with more vegetation. Moreover, the areas with a lower acidity of 5 to 5.9 were covered with a moist, marshy type of soil populated with minimal vegetation. Based on the relationship between diversity in soil and vegetation, we have a reason to believe that vegetation is driven by acidic soil. Among all sites and dominant species of vegetation in Long Island Solar Farm (LISF) sites, low bush blue berry (LB) and high bush blue berry (HBB) showed the highest and lowest IVI (125.00±50.90 and 70.88±20.95, respectively). Shannon Weiner Index (H) values on plant community diversity ranged from -0.1976 in C1 to -2.0849 in T12 of S14. In conclusion, the pH and the vegetation distribution and diversity gives us the necessary baseline information needed to compare with what may return to the LIPBF in the future, after the installation of the solar farm.

INTRODUCTION

The environment is affected by the subsequent widespread of changes that occur in the ecosystem. There is an essential need to protect the hydrological and ecological integrity of the Long Island Pine Barrens Forest (LIPBF), while conserving energy on Long Island. Consequently, British Petroleum (BP) has proposed the installation of a solar farm on 200 acres of the LIPBF to encourage energy efficiency and renewable energy on Long Island. Solar cells are photovoltaic solid-state semiconductor devices that convert light directly into electricity. They are usually made of silicon with traces of other elements. Individual photovoltaic solar cells will be assembled together to form a solar module; the modules will then be mounted to a frame which forms a solar panel [1].

The Long Island Pine Barrens Forest (LIPBF) is a distinctive type of forest located in the eastern part of the United States along the Atlantic Coastal Plain. The unique features of the ecology of the LIPBF result in an unusual flora. Pine Barrens occur in well-drained coarse-textured moraines [2]. Plant and site productivity are important drivers of the forest understory [3]. The vegetation consists of a variety of shrubs, the most common of which are scrub oak and members of the heath family. The shrub and herb layers are generally dominated by ericaceous plants such as huckleberry (*Gaylussacia baccata*), blueberry (*Vaccinium pallidum*) and wintergreen (*Gaultheria procumbens*) [2]. The dominant specie is the pitch pine, *Pinus rigida*. In no other region in North America does the pitch pine cover such an extended area of the country. Natural Pine Barrens acidity is created when decaying vegetation produces an organic acid that washes down through and is absorbed by the sandy soils [4].

Soil pH is a measure of soil acidity or alkalinity [5]. Soil pH is an important factor in the regulation of vegetation changes. Plant uptake has been related to pH-level in numerous experiments [6]. The most important factors controlling vegetation types located in the LIPBF are the soil saturation and soil composition. The LIPBF is composed of deposits of sand, gravel and clay. Sediments in the LIPBF are low in organic matter, coarse, well-drained, droughty, nutrient-poor, sandy soils [7]. Soil pH has shaped the modern vegetation of the LIPBF. These acidic soils are high in iron content but low in calcium, magnesium, and potassium [4]. The survival of vegetation located in the LIPBF requires loamy highly acidic soil conditions with a pH that ranges from 3.6 to 5. These conditions limit the kinds of vegetation that can grow on these soils.

Climate conditions effect the distribution of vegetation in many ways. A biogeography model was used in the simulation of vegetation distribution under several equilibrium climate changes in a study conducted at Oregon State University [8]. Two of the most important environmental factors related to the distribution of vegetation growth are temperature and precipitation. The precipitation in the Pine Barrens averages between 40 and 48 inches per year [4].

The Density is known to impact upon many aspects of the dynamics of vegetation with direct implications, studies of vegetation density experiments were conducted at the Hydraulics Laboratory [9]. The rate of increase in forest vegetation density is constrained by its growth rate, which can lag behind climate changes. A study conducted in Oregon simulated vegetation density in virtually all locations across the United States density either increased or decreased under future climate changes.

Quantitative and qualitative analysis using quadrat and transect methods have been conducted in the New Jersey Pine Barrens Forest [10].

The goal of this research is to establish the baseline data on the vegetation located in the proposed solar farm by applying quantitative and qualitative analysis.

The specific objectives are to: (a) collect the distribution data according to diversity of the understory vegetation and (b) analyze data statistically for density, frequency, cover, and IVI to identify the evenness or diversity in LISF. Ultimately, we will compare the vegetation that presently covers the area with what may be there in the future.

MATERIALS AND METHODS

The studies on pH and vegetation distribution and diversity conditions in the Long Island Pine Barrens forest differing in their management were carried out in Long Island, N.Y. at Brookhaven National Laboratory on the proposed Long Island Solar Farm (LISF). The study sites were divided into areas according to their vegetation type as shown in figure 1.

Line Transects

The data on distribution composition were compiled from samples taken from a total of 17 line transects which included 5 controls. Each transect was 25m in length, laid out perpendicularly across the boundary of the vegetation type. Transects were measured using a 50m Keson graduated metric instrument.

Quadrats

Six quadrats ($1m^2$) were laid five meters apart along the line transect of each survey site. Each quadrat was divided into 4 plots. All the vegetation in each individual plot was counted and recorded on data sheets. The vegetation from plot 1 of quadrats 1 and 4 were clipped and bagged.

The quadrat method was used to get accuracy on how widely each species was distributed and to determine how many plant of specie were represented.

pH

The pH level was taken from the fourth plot of each quadrat. Measurements were taken using an electrode pH meter tester by Kelway Instruments (Typ-36 TEW). The measurements on the pH meter ranged from 3.5 to 8. We poured deionized water onto the soil and allowed the soil to become fully saturated beyond the organic layer. We then inserted the pH meter into the soil just below the organic layer (3-6") and allowed it to sit for ten minutes. After the readings get stabilized on the meter, we removed the meter from the soil and cleaned it using pH meter film. This process was repeated for each quadrat.

Statistical Analysis

Descriptive statistics were computed from individual measurements of each attribute and then averaged by sample and site. The mean variance, standard deviation, standard error, and cover value were computed for continuous data using Microsoft Excel Statistical software. We used the Shannon Wiener Index to determine the ratio of diversity in present vegetation.

Vegetation analysis (Quantitative and qualitative)

Quantitative and qualitative analysis were used to classify species, count them, and construct charts in an attempt to explain what was observed in different sites of LISF.

Frequency

Frequency is the vegetation attribute that describes the probability of finding a species with a particular area. The probability is based on the variation of occurrence of that species in a series of sample unites.

$$\frac{\text{Numbers of plots in which species occur}}{\text{Total number of plots}} \times 100$$

Relative frequency (RF)

$$\frac{\text{Frequency of a species}}{\text{Total frequency of all species}} \times 100$$

Density

The density is closely related to abundance but more useful in estimating the importance of species. It is defined as the number of plants of a certain species per unit area.

$$\frac{\text{Number of plants of a certain species}}{\text{Total area sampled}} \times 100$$

Relative density (RD)

$$\frac{\text{Density of a species}}{\text{Total area sampled}} \times 100$$

Cover

Cover attributes to the amount of species covering an area in a given unit.

$$\frac{\text{Total area covered by a species}}{\text{Total area sampled}} \times 100$$

Relative cover (RC)

$$\frac{\text{Cover for a species}}{\text{Total cover for all species}} \times 100$$

IVI = RF + RD + RC

The important value index represents index number which is the ratio of the value of all species in a given period to the value of all species in the base period. It consisted of the sum of relative frequency, relative density, and relative cover.

RESULTS

The graph configurations of the vegetation reflect an uneven distribution of vegetation throughout all study sites. Distribution was greater in some sites and less other site as shown in figures. Of all the sites studied, the Shannon wiener index vegetation diversity ratio was greater in transects of S14.

Among the different plant species identified at S13, White Pine Seedlings were dominated. Site 13 had the highest distribution and the least amount of diversity. Site 18 had the most diversity and the least amount of distribution. Distribution and dominance of different species in experimental sites were summarized in figures 3-6.

Through careful observation, the vegetation analysis conducted in the LISF of site 13 had the species with the highest IVI value, White Pine Seedling. The soil pH for site 13 was the lowest of all the pH levels from the study sites at a level of 5. We observed that the lower the soil pH in each individual site the higher the distribution. Site 18 had the most diversity of vegetation and the second highest distribution, Low Bush Blueberry (figure 5). According to the Shannon Index site 13 had a ratio of 1.10, site 18 had a ratio of 1.85 and site 17 had a ratio of 1.75. It is more likely for a new species to appear in site 13 because there isn't much diversity.

DISCUSSION AND CONCLUSION

Pine Barrens forest with a high level of acidity cover a distinctive proportion of land. Among the Pine Barrens, shrubs and other heath vegetation are well represented. As a result of the Pine Barren studies, based on the standard deviation, density, frequency, and statistical analysis confirmed that the distribution of species studied under this investigation in majority of the sites were not evenly distributed.

Location has a significant effect on the growth of vegetation distribution. Because certain vegetation types such as Early Low Bush blueberry and Late Low Bush blueberry grow in limited areas, potential changes are expected in vegetation distribution under historical conditions and across a wide gradient of future temperature changes to look for consistencies and trends among many future scenarios. The pH and vegetation distribution and diversity temperature, precipitation, are key factors; they have shaped the modern vegetation of the Long Island Pine Barrens Forest.

Based on current investigations, the conditions under the vegetation is presently growing, we came up with a testable hypothesis that LISF of LIPBF may expand under some moderate conditions but decline under more severe climatic conditions. The lack of overstory canopy contributes to the decline in understory. Further studies are needed to conduct a year round basis to see trends based on seasonal variations. These types of studies will help us to draw meaningful conclusions and to validate our hypothesis.

ACKNOWLEDGEMENTS

This work was supported by NSF (grant # HRD-0928797 and DUE-0806894) for financial support and DOE/BNL for facilities. We also thank Noel Blackburn (FaST Program Manager), Jennifer Higbie (GIS), OEP staff and fellow student interns for their help and support at various stages of the project.

REFERENCES

[1] http://www.bp.com/sectiongenericarticle.do?catergoryId=9071&contentId=7038231 retrieved 2010.

[2] http://web4msue.msu.edu/mnfi/connunities/communit.cfm?id=10692 retrieved 2010.

[3] S. Royer-Tardif, R.L. Bradley and W.F.J. Parsons, "Evidence that plant diversity and site productivity confer stability to forest floor microbial biomass", *Soil Biology and Biochemistry*, vol. 42, pp. 813-821, 2010.

[4] H.P. Boyd, *Afield Guide To The Pine Barrens of New Jersey*, Plexus Publishing, Inc. 1991.

[5] http://en.wikipedia.org/wiki/soil_pH retrieved 2010.

[6] J.E. Eriksson, "The influence of pH, soil type and time on adsorption and uptake by plants of cd added to the soil", *Water, Air, and Soil Pollution*, vol. 48, pp. 317-335, 1989.

[7] http://pb.sate.ny.us/cpb_plan_vol2/vol2_chapter01.htm retrieved 2010.

[8] "Repeatability of Riparian Vegetation Sampling Methods: How Useful Are These Techniques for Broad – Scale, Long-Term Monitoring?", U.S. Department of Agriculture, Forest Service, Tech Rep 2004.

[9] D. Poggi, A. Porporato and L. Ridolfl, The effect of vegetation density on canopy sub-layer turbulence, *Boundary-Layer Meteorology*, vol. 111, pp. 565-587, 2004.

[10] E. Ashby and W.L. Stevens, "The quantitative analysis of vegetation", *Annals of Botany*, vol. 49, pp. 779-802, 1935.

TABLES AND GRAPHS

The following graph is a representation of the proposed LISF; it includes the sites where transects where laid as shown in figure 1.

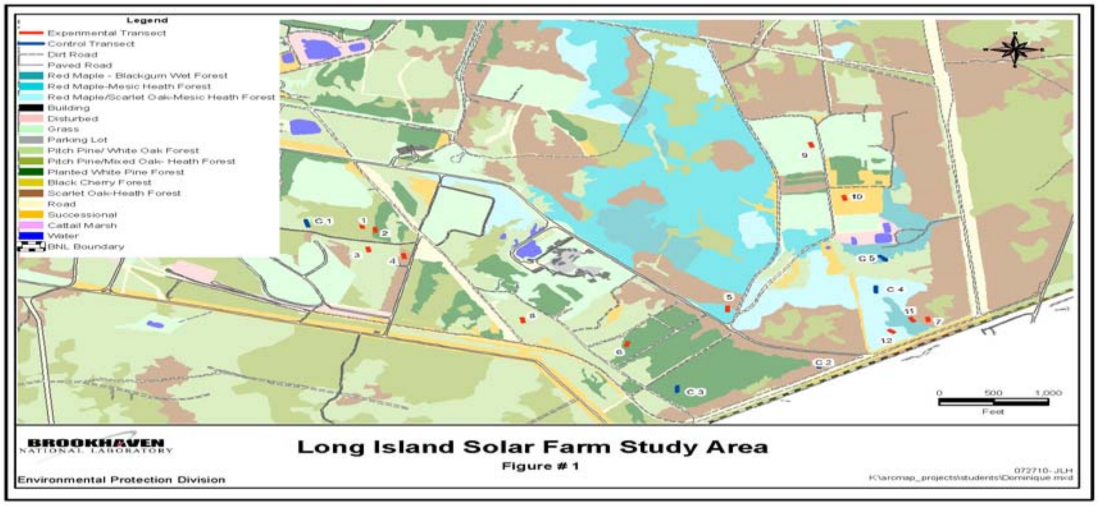


Figure 1

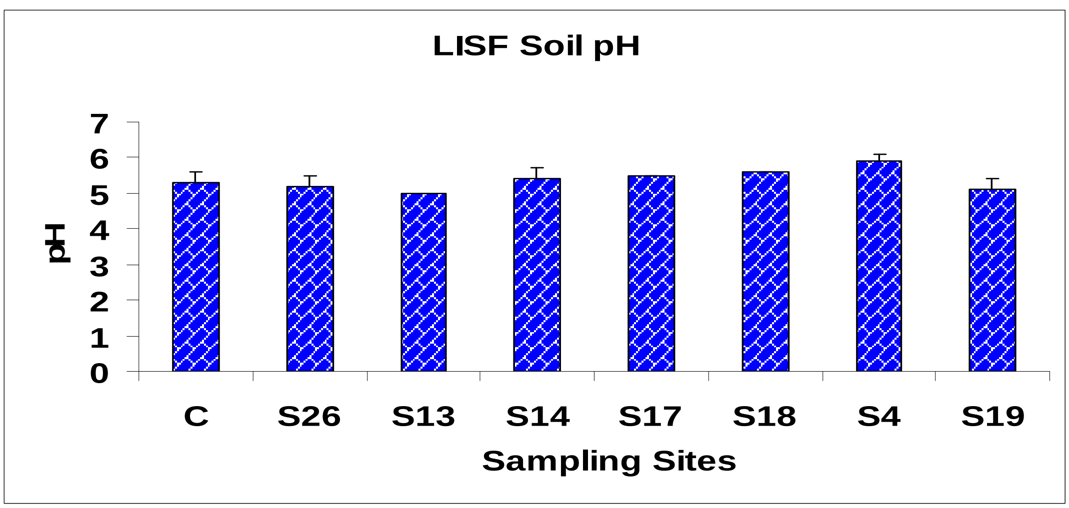
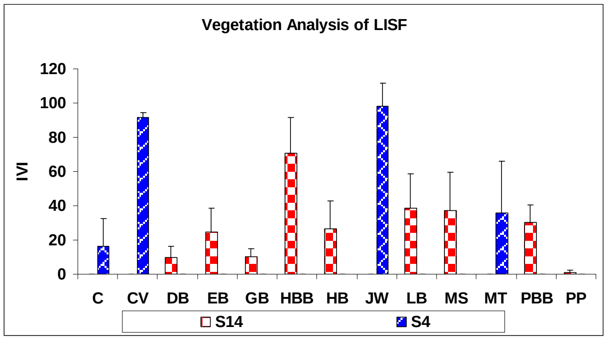


Figure 2



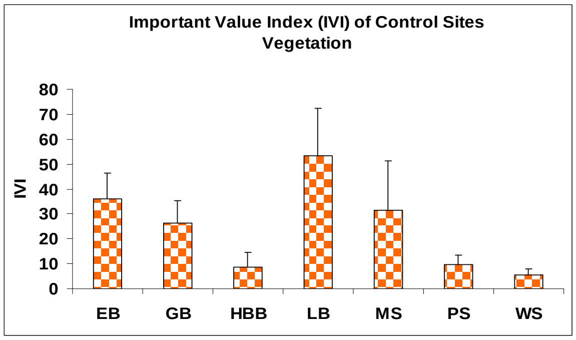
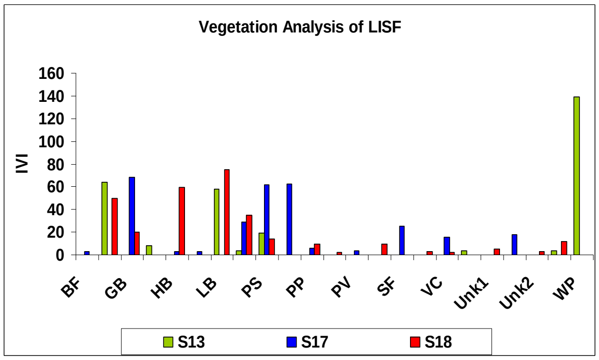


Figure 3

Figure 4



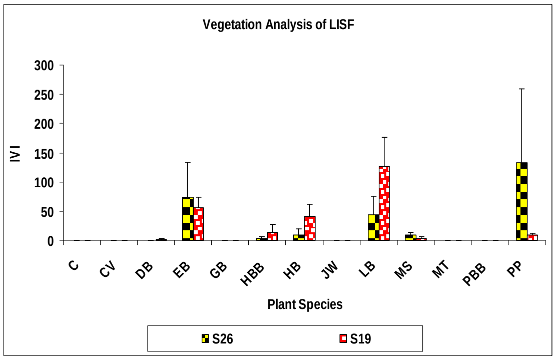


Figure 5

Figure 6