The Effect of Overstory Composition and Cover on Understory Make-up in the Long Island Solar Farm Area.

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Abstract

The Effect of Overstory Composition and Cover on Understory Make-up in the Long Island Solar Farm Area. Brittany Hernon (SUNY Geneseo, Geneseo, NY 14454), Tim Green (Brookhaven National Laboratory, Upton, NY 11973).

The construction of a two hundred acre, thirty two-megawatt, utility scale solar array, set to occur at Brookhaven National Laboratory (BNL) in August 2010, will provide a unique opportunity for BNL to research the effects of this solar array on the surrounding environment. In order to carry out this research, a baseline must be created to outline the current forest composition. For this reason, our group laid 12 twenty-five meter long transects in the various vegetation types present in the future solar array. One square meter quadrats were placed every five meters along the transect and the number, height, and percent cover of each understory species were recorded. Overstory composition and percent cover over each quadrat were also recorded. The group established five control transects in similar vegetation types in areas that will not be affected by the solar array construction. The understory composition was then analyzed based on overstory cover and composition and the results show that pine only forests produce lower biodiversity than oak-pine, mixed oak and maple areas. The pine only forests had only12 different understory species present and the grassy field area had 14 while the oak-pine had 19, mixed oak had 25 and maple had 28 understory species. The Shannon-Weiner biodiversity indices were calculated and the values are as follows: pine only 0.15, oak-pine 1.63, grassy field 1.63, mixed oak 1.76 and maple 2.11. These values revealed that as forests age and progress from pine only to a mix of maple and oak, the understory becomes more diverse. Once the panels are installed it will be interesting to see how they affect this process of maturation and diversity increase. The results also show that areas with heavy overstory cover have greater biodiversity and these will be particularly interesting to observe after the panels are put in and the overstory cover is reduced to zero between arrays and becomes close to 100% under the arrays. It appears that huckleberry, late season low bush blueberry and greenbrier will thrive in the newly cleared areas since they flourish in locations with lower overstory cover. The forest clearing for solar array construction may also have a negative effect on invasive species which could help reduce their population and allow native species to prosper. This vegetation baseline will allow scientists to study how the solar array installation will affect understory composition in the future.

Introduction

Solar energy has become a growing alternative energy source around the world, but the effects of the solar arrays have not been extensively studied. The construction of the Long Island Solar Farm (LISF) at BNL will allow scientists to pioneer studies on the environmental effects of the solar arrays. This will give researchers a chance to study aspects such as rain pooling at the base of the panels and effects of shading from solar panel installation. The proposed solar farm area is currently composed mostly of Pine Barrens forest, which needs to be cleared in order for construction to occur. The method for clearing was chosen to have minimal disruption on the understory and involves cutting the trees and then removing their stumps (1). This will reduce the overstory cover over the forest to zero allowing future research to be conducted on how this affects or changes the understory composition. In order to carry out the various solar array research, a vegetation baseline must be created to outline the current forest composition. For this reason our group has set out to estimate the understory composition of the proposed solar area and also record parameters of the surrounding environment. This baseline will not only act as a comparison for future studies but will help BNL re-vegetate the solar farm area when and if the panels need to be removed after the arranged 20 years of operation (1).

The Pine Barrens forests present in the solar farm area are in various successional stages. As areas progress from bare soil to climax forests the understory and overstory experience changes in their make-up. Newer forests are comprised mainly of softwood species, particularly pitch pine and white pine in Pine Barrens forest. As they mature more hardwood species are seen starting with oak and proceeding to a mature mix of oak, hickory, maple and pine species (4). In previous studies of the Pine Barrens it was noted that mature forests of this type exhibit a greater species diversity of shrub and herb species (4). It is expected the more mature, oak-dominated

forests of the future solar farm area will also experience a greater level of diversity, which is why my project will focus on quantifying the diversity of the understory in different forest areas so changes can be monitored in the future. Biodiversity can be used to monitor the health of the understory once the panels are installed, which will help scientists assess the benefits or dangers the panels will have. The current understory composition can be used to calculate how diverse the different forest types are prior to the construction. After tree removal, the progression of the forest to a mix of hardwoods and softwoods could be facilitated or hindered which could be seen by an increase or decrease in biodiversity.

The areas where the panels are to be installed also have varying degrees of overstory cover and therefore experience different levels of light transmittance. When the forest is first clear cut for construction, all of these areas will be forced to endure full sunlight due to tree removal. Then, once the panels are installed, the areas under the panels will experience close to 100% shading while the other areas are exposed to full sunlight. This is another parameter that will affect the growth and distribution of understory vegetation, so my project will also focus on investigating the understory make-up in areas of different percent overstory cover. This will again give future researchers baseline data to refer to, allowing changes in vegetation patterns due to solar panel shading to be tracked.

Materials and Methods

Vegetation maps of the future solar farm area were analyzed along with the solar array construction sections to determine locations where vegetation sampling was to occur. Locations were chosen so all vegetation types were represented in as much of the solar farm area as possible. Control areas were also selected outside the solar array area where similar understory and overstory vegetation were seen. Belt transects were chosen as the best way to outline the

current forest composition for solar panel research, and a length of 25 meters was selected based on previous studies in the Pine Barrens region and elsewhere in the country (4,5). Data sheets were created for our specific research task by revising ones used for health monitoring of the Long Island Pine Barrens (4).

For each location, an area was chosen that appeared to be a good representation of the understory make-up and allowed for a 25-meter transect to be placed in the N-S direction with the least interference from trees and fallen logs. The wind speed and direction, temperature, humidity and dew point were taken using a Kestrel 4000 hand held weather station to collect data on the weather conditions. For the start and end points of each transect the latitude and longitude were recorded on the data sheets and also logged into the global positioning system (GPS) unit.

Once the weather conditions and location were recorded, vegetation data was then taken along the 25-meter transect. One square meter quadrats were placed every five meters along the transect, on the 0M, 5M, 10M, 15M, 20M, and 25M marks. The number and percent leaf cover of each understory species were recorded. The heights of two stems for each species were measured so average heights could be compared. The pH of the soil was also recorded for each quadrat to see if changes occurred due to rain water pooling at one end of the solar panels. One quarter of two quadrats along a transect were clipped so biomass estimations could be made, again allowing changes in the future to be seen. Overstory composition was determined and percent cover over each quadrat was estimated to see how differences in overstory make-up affected understory composition. For the first few transects, all group members performed these estimations together to establish a uniform method. In total, 12 experimental and 5 control transects were used to get a complete representation of the vegetation for the baseline.

Overstory composition was split into five categories for data analysis: Pine only (>90% pine cover), oak-pine (>50% oak, <50% pine cover), mixed oak (>90% scarlet and white oak cover), maple (>90% maple cover) and grassy field (0% cover). Each transect was placed into one category and the location of each transect along with the category it was classified as can be seen in the map in Figure 1. Percent leaf cover by the overstory layer was also analyzed and broken down into the following categories: 1-20%, 21-40% cover, 41-60%, 61-80% and 81-100%, and each quadrat was placed into one. The quadrats that experienced 0% cover were not included in the analysis because they were comprised of a different understory composition. For each overstory composition and overstory cover category the diversity of the understory was compared by calculating the Shannon-Weiner Biodiversity Index (3). The average number of each understory species per transect was also determined for each overstory composition category to make the results comparable, since each category had a different number of transects. In the past, similar data categories have been used along with these calculations to assess the make-up and health of Pine Barrens understory (2).

Results

The data taken for each of the experimental transects provides a snapshot of the understory species present throughout the future solar farm area. For these transects there are many common species found in 10 or more of the transects as well as unique species found in only 1 or 2 of them. All of the compiled data will be retained as the baseline for future comparisons, but for analysis purposes only certain species were taken into account for the biodiversity calculations. After the data was broken down by overstory composition and overstory percent cover, species seen in only 1 or 2 categories were removed from analysis to

allow for comparison across the solar farm area. The species used for comparison can be seen in the pie charts made for each category in Figures 3 and 4.

As predicted, pine only and oak-pine forests produce lower biodiversity than the more mature mixed oak and maple areas. The pine only forests only had 12 different species present and grassy field had 14 while the oak-pine had 19, mixed oak had 25 and maple had 28. The Shannon-Weiner biodiversity indices for the overstory composition categories are as follows: pine only .15, oak-pine 1.63, grassy field 1.63, mixed oak 1.76 and mixed maple 2.11, and are recorded in Figure 2. This shows that as forests age and progress from pine only to a mix of maple and oak they become more diverse. The percent composition of each understory species was determined and Figure 3 shows pie charts of the results for each overstory composition category. As the forest type moves from pine only to a mature maple and oak mix, an increase in species such as Vaccinium corymbosum, Smilax rotundifolia, Uvularia puberula is seen. A decrease in Vaccinium pallidum, Vaccinium angustifolium, and Gaylussacia baccata was seen as forest type moves from oak-pine to a maple mix. Figure 5 shows the average number of species per transect. It can be seen that the average increased from 0.5 to 22.6 for Smilax rotundifolia and from 1.25 to 34.8 for *Vaccinium corymbosum* as forest type moved from pine only to maple mix. This provides more evidence that these species thrive in mature forest types.

The Shannon-Weiner biodiversity indices for the overstory cover categories are as follows: 1-20%: 1.52, 21-40%: 0.20, 41-60%: 2.29, 61-80%: 2.03 and 81-100%: 2.04, and can also be seen in Figure 2. This shows that the areas with greater than 41% overstory cover had greater understory diversity. The percent composition of each understory species was again determined and Figure 4 shows pie charts of the results. Species such as Smilax *rotundifolia*, *Gaylussacia baccata* and *Vaccinium angustifolium* appear to thrive in areas with lower overstory

cover while species such as *Carex pensylvanica*, *Vaccinium pallidum*, *Vaccinium corymbosum* and *Uvularia puberula* are more prevalent in areas that have greater than 41% over-story cover. **Discussion**

The understory data taken along the 12 experimental transects provides a baseline that will allow scientists to repeat the transect process after the panels have been installed to study the vegetation changes. The results show that as forests progress to mixed oak and maple mixes the biodiversity of the understory increases, which is an indication of higher forest health. The effect that the installation of solar panels has on the biodiversity of the region should be looked at to determine how they affect forest health over time. The panels could halt the progression of the forests which would prevent them from reaching a state of high biodiversity, and cause a decrease in species such as *Vaccinium corymbosum, Smilax rotundifolia, Uvularia puberula.* They could also speed up this progression by allowing for the introduction and cohabitation of different species.

The results also show that understory diversity is higher in areas that have greater than 41% overstory cover. These will be particularly interesting to observe after construction begins and the overstory cover is reduced to zero. The areas with lower overstory cover provide a guess as to which species will thrive once the area is cleared, and they currently exhibit lower biodiversity. It appears that *Smilax rotundifolia, Gaylussacia baccata* and *Vaccinium angustifolium* will prosper in the newly cleared area since they flourish in areas with lower than 20% overstory cover.

The biodiversity values show that reducing overstory cover in these areas could be detrimental, because it may lead to a reduction in diversity and decline in forest health. The clear cutting could greatly alter the composition of the understory, since the grassy field areas with 0%

overstory cover have an understory make-up which is unique. The forest clearing could also be beneficial because it will give species such as *Smilax rotundifolia, Gaylussacia baccata* and *Vaccinium angustifolium* a chance to thrive.

The results also allow us to predict the vegetation patterns that will occur once panels are installed and some areas experience full shade while others have direct sunlight. The areas that become shaded by the panels could allow species such as *Carex pensylvanica, Vaccinium pallidum, Vaccinium corymbosum* and *Uvularia puberula* to grow while the species that prefer little overstory cover grow in adjacent areas. Over time the patches of land under those panels may have a completely different vegetation make-up then those left in the open. This has the potential to increase the diversity of the solar farm area by providing a variety of growing conditions close together. Alternatively, this change in shading could shock the forest and lead to a decrease in some species. The vegetation data collected will allow scientists to catch these declines early so revival attempts can be put in place.

The construction of the LISF will have impacts on the environment other than altering the shading patterns of the forest. During construction, invasive species that exist near the edges of the forest will be cleared in an attempt to give native species a chance to spread out into that habitat (1). The solar farm area will also be completely fenced off which will prevent deer from grazing on plants, again giving native species a chance to grow. The vegetation baseline provided by this study will allow scientists to study and quantify the effects that solar arrays have on the surrounding understory vegetation and environment.

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Figure 1: Locations & Overstory Composition of the Experimental and Control Transects

Figure 2: Biodiversity Indices Based on Overstory Composition and Percent Cover

Overstory composition category	Shannon- Weiner Biodiversity Index	Overstory cover category	Shannon- Weiner Biodiversity Index
Pine Only	0.15	1-20%	1.52
Oak-Pine	1.63	21-40%	0.20
Mixed Oak	1.76	41-60%	2.29
Maple	2.11	61-80%	2.03
Grassy Field	1.63	81-100%	2.04



Figure 3: Percent Composition of Understory Species Based on Overstory Composition



Figure 4: Percent Composition of Understory Species Based on Percent Overstory Cover

Species	Pine only	Oak pine	Mixed Oak	Maple mix
Pteridium aquilinum	0	3	2	0.2
Vaccinium pallidum	44.5	189	56.67	14.8
Smilax rotundifolia	0.5	4	9	22.6
Gaylussacia baccata	2.75	42	21.67	3.4
Vaccinium corymbosum	1.25	9	19.67	34.8
Vaccinium angustifolium	50	138.67	55.67	18.6
Acer rubrum	0.5	14.33	3.67	37
Toxicodendrun radicans	0	0.33	0.67	1.8
Pinus rigida	6.25	4.67	1	1.6
Carex pensylvanica	13	31.33	255.33	180.4
Ludwigia alternifolia	0	8.67	6	0.4
Quercus coccinea	0	0.33	0.67	0.2
Parthenocissus quinquefolia	0	0.33	6.33	2.2
Quercus alba	0.5	3.33	1	0.6
Pinus strobus	805.5	0	1.33	0.2

Figure 5: Average Number of Species Per Transect for Each Overstory Composition Category