Baseline Survey on Biomass Distribution in the Long Island Solar Farm

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Abstract

As electricity and natural gas consumption continues to increase on Long Island, renewable energy sources will play an important role in Long Island's energy future. To make an efficient and substantial impact on Long Island's energy crisis, a large scale commercial solar photovoltaic array of 32 MW will be constructed on approximately 200 acres at Brookhaven National Laboratory (BNL). Because no other Utility Grade solar installation has been monitored for its environmental impact and specifically on vegetation biomass, this research has established baseline scientific data for future studies of assessment on the impacts associated with construction and operation of the Long Island Solar Farm (LISF). Plant biomass, plant diversity, chlorophyll concentrations, and other measures were compared after careful quantitative examination within seven major vegetation types. The seven study sites were selected to represent the variation of plants in the 200 acre proposed solar farm area. Twenty-five meter line-transects and 1m^2 quadrats were used to measure the estimated plant population and percent ground cover. Ground vegetation samples were clipped and brought to the lab for biomass weighing and chlorophyll analysis. Among all sites, S19 has maximum % dry weight (85.5%; 42.75%C). Bracken fern showed highest values of chlorophyll and Black cherry has larger stomata compared to other species. The understory vegetation biomass throughout the LISF area is dominated by *Gaylussaicia baccata, Vaccinium pallidum, V. corymbosum, and V. angustifolium.*

Introduction

Currently, biomass energy provides 14 percent of the world's main energy consumption. It accounts for 38 percent of the primary energy used in developing countries, as compared to 4 percent for the United States. With ample land and agricultural resources, the United States can see biomass energy consumption rise as high as 20 percent within the next 20 years. Some concerns have come to light regarding the current energy crop programs taking place in developing countries as to whether food supplies will suffer as a result of biomass energy needs. Overall, the outlook for biomass energy is promising. Our present-day crisis concerning fuel and energy costs sees biomass energy production as a definite direction for the future [1].

Chlorophyll is the green molecule in plant cells that carries out the bulk of energy fixation in the process of photosynthesis. Chlorophyll makes it possible for plants to convert carbon dioxide and water, in the presence of sunlight, into oxygen and glucose. Besides its importance in photosynthesis, chlorophyll is probably the most-often used estimator of biomass [2].

Under story vegetation usually represents a relatively minor component of the whole biomass of forests. It can play an important role in the annual biomass production and hence also in the nutrient cycling of forest ecosystems[3]. The underlying objective is to have reliable estimates of living biomass and chlorophyll concentrations of these species groups expressed per known ground surface area.

The goal of this research was to establish baseline data of understory vegetation biomass for the Long Island Solar Farm (LISF). Specific objectives of this study were to: (a) determine the dry weight biomass and (b) chlorophyll concentrations and stomatal distribution in dominant species found within the proposed LISF.

Materials and Methods

A total of seven study sites were selected to represent the variation of plants in the 200 acre proposed solar farm area. Line-transects (25 m) and quadrats (1m^2) were used to estimate plant community biomass within the different study sites (Figure 1). On each quadrat, height, percent cover, and biomass were measured for each species. In addition, we have collected the understory vegetation samples randomly from two LISF sites (S13 and S17) to determine the biomass, chlorophyll concentrations, and stomatal distribution. The pH in soil of all experimental sites was measured using a field pH electrode. Plot 1 of quadrats 1 and 4 on each transect were clipped for biomass. The samples of each quadrat were stored separately in plastic bags or durable paper bags and fresh weights were taken for all clippings using the Scout Pro 200g weighing scale (0.02g accuracy). All biomass samples were oven dried in Fisher Scientific Isotemp oven. Each sample was dried for 36-48 hours or until the sample weight stabilized and then weighed dry biomass to the nearest 0.02 g at 70°C. The individual quadrat biomass values were then averaged/converted for each plot to generate an overall biomass value in % dry weight/m^2.

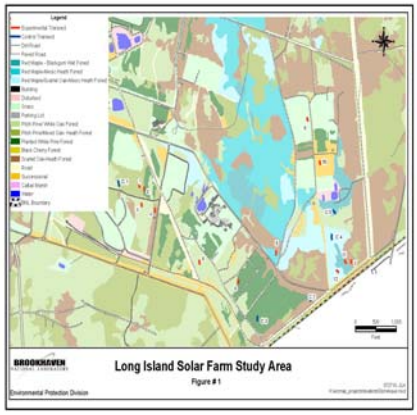
Leaf samples of dominant species found within the LISF were also collected for stomatal distribution (size and number in a field area at 40X) and for chlorophyll analysis. The chlorophyll concentration was analyzed using spectrophotometry. Fresh leaf samples of 0.02g each were measured (Scout Pro 200g Scale with 0.02g accuracy). Samples were placed in 20 mL glass bottles with 10 mL of 95% C_2H_5OH (ethanol). Samples were stored in a cool, dark place for 24 hours and analyzed for chlorophyll a and b using Spectrophotometer at 665 nm and 649 nm wavelengths. Chlorophyll concentrations were measured using the following formulae:

Chlorophyll a µg /mL = (13.70) * (A 649 nm) – (5.76) * (A649 nm)

Chlorophyll b µg /mL = (25.80) * (A 649 nm) – (7.60) * (A665 nm)

Leaves of Black Cherry (*Prunus serotina),* Late Low-bush Blueberry (*Vaccinium angustifolium*), and Huckleberry (*Gaylussacia baccata*) were brought to the lab for stomatal observations. Leaves were cut into approximately 2cm squares and put into distilled water. Because the trichome layer completely covers the ventral surface of the leaves and prevents visualization of stomata the epidermal surface and the trichome layer was peeled from each leaf. Observations were made using an Olympus BX 41 Spectra microscope.

Stomatal counting requires an extreme level of precision. Images of ventral surface of the leaf (at 40X) were captured using a Power Shot SD790 IS Digital Elph camera. Stomata were counted manually on the screen and ten individual lengths and widths of the fresh leaves were recorded to assess the accuracy and reproducibility of the method.



Common Name	Abv.	Genus	Species
Bracken Fern	BF	*Pteridium*	*aquilinum*
Black cherry	BC	*Prunus*	*serotina*
Early Lowbush Blueberry	EB	*Vaccinium*	*pallidum*
Greenbrier	GB	*Smilax*	*rotundifolia*
Highbush Blueberry	HBB	*Vaccinium*	*corymbosum*
Huckleberry	HB	*Gaylussacia*	*bacatta*
Late Lowbush Blueberry	LB	*Vaccinium*	*angustifolium*
Maple Seedling	MS	*Acer*	*rubrum*
Pine Barren Bellwort	PBB	*Uvularia*	*puberula*
Seedbox	SB	*Ludwiga*	*alemifolia*
Virginia Creeper	VC	*Parthenocis sus*	*quinquefolla*

Table 1: Understory vegetation of LISF

Results and Discussion

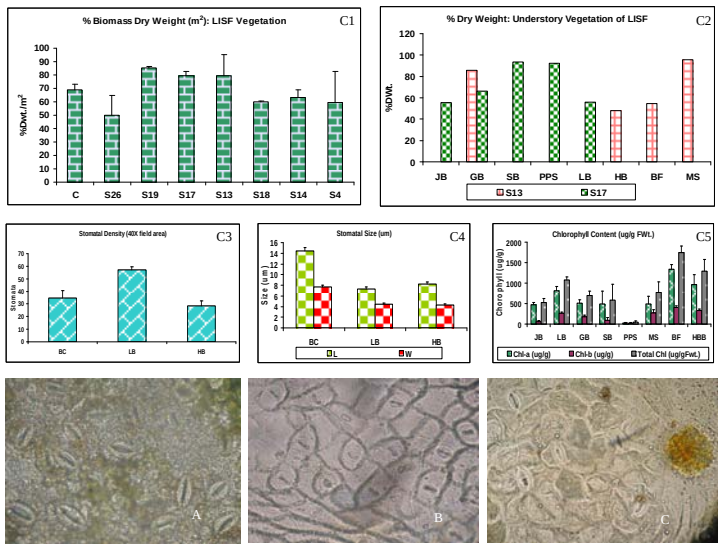


Figure 2: Stomata of: A) Black Cherry (*Prunus serotina*), B) Later Lowbush Blueberry (*Vaccinium angustifolium*), and C) Huckleberry (*Gaylussacia bacatta*).

Among all sites, S19 has maximum % dry weight (85.5%; 42.75%C) as shown in C1. Bracken fern showed highest values of chlorophyll and Black cherry has larger stomata compared to other species (C5 and Figure 2A above). The understory vegetation biomass throughout the LISF area is dominated by *Gaylussaicia baccata, Vaccinium pallidum, V. corymbosum, and V. angustifolium.* Understory vegetation represents a relative component of the whole biomass of high forests (Table 1).

Since chlorophyll content is often closely related to plant production, any reduction in leaf chlorophyll would limit net photosynthesis and thus diminish total plant growth. Stomata regulate the exchange of water vapor and CO_2 between the plant and the atmosphere, mainly through changes in the stomatal pore. Therefore, stomata play a pivotal role in controlling the balance between water loss and carbon gain. Moreover, the direct correlations between estimating biomass, chlorophyll concentration, and measuring the number and of stomata have played an important role in many studies of anatomical, physiological, ecological agricultural interests [4].

Further studies on interrelationships between stomatal density and distribution and chlorophyll concentrations on overall rate of photosynthesis and biomass production in LISF sites are warranted.

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