Comparing vegetative fuel loading and developing custom fuel models for Brookhaven National Laboratory

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Abstract

Where fire occurs, it shapes the form and function of ecosystems; however, as a method of ecosystem maintenance, fire has largely been suppressed. This study was conducted to collect and analyze fuel loading data in Brookhaven National Laboratory (BNL) and to assess potential fire behavior. Our study was focused on two stands (D and A) in the eastern complex of the northeastern corner of BNL. Vegetative surveys were conducted in 2006 and 2016, and the resulting fuel loading data was entered into BehavePlus 5.0.5 to create custom fuel models of the stands. The results showed that Stand D had a 17%, 77%, and 44% decrease in 1-, 10-, and 100-hour dead fuels respectively, and a 227% increase in live woody fuel from 2006 to 2016. Stand A had a 29% and 73% decrease in 1 and 10-hour dead fuels respectively, and a 2,886% increase in 100-hour dead fuels from 2006 to 2016. We believe that the herbivory of the orange striped oakworm (*Anisota senatoria*) and the gypsy moth (*Lymantria dispar*), in Stand D opened the canopy and increased live woody fuel values, thereby increasing rate of spread and flame length values. We also believe that the moderate-to-high intensity fire that top-killed many oaks in Stand A, in 2012, caused the increase in the number of 100-h dead fuels and the decrease in the 1- and 10- h dead fuels. The decrease in these fine fuels in Stand A would explain the lower predicted rate of spread and flame length values in 2016 as compared to 2006.

I. Introduction

Fire, from an ecological perspective, is a human induced or naturally occurring phenomenon that deals with the combustion and conversion of complex organic compounds (oxygenated fuels) to mineral and organic products.[1] It has shaped modern day landscape characteristics such as flora and fauna species composition, natural appearance, soil drainage categorizations, and trophic levels for centuries; [2] but, wildfires, or any non-structure fire other than prescribed fire that occurs in wildlands, [3] now pose serious risks to the man-dominated environment including smoke introduction in to the atmosphere and jeopardizing human assets (land, home or business).

Wildfires are causal agents for ecosystems to adapt to or be altered by, and wildfires that aid in forest health are being suppressed due to human development protection.[2] As a limiting factor in forest succession and woody fuels on the forest floor, suppression shifts ecosystem species composition indefinitely. Long Island, New York, specifically has been suppressing fire for over 50 years due to large population increases and industrial development in the tri-state area.[4] The continual suppression of fire on Long Island has many social and ecological implications. The extent of fire suppression directly correlates to the accretion of fine and coarse woody fuel; therefore, increases in forest fuels pose an elevated risk for a larger, more intense, and more severe fire as opposed to letting natural fire initiate and end uninterrupted.[5]

By analyzing specific fuel complexes, we aim to quantify the risk of fire suppression and showcase the direct impacts on Brookhaven National Laboratory (BNL) land. Our specific objectives were to:

1. Collect vegetation fuel loading data in the northeast corner of BNL land.
2. Interpret the current fuel loading in the study site, and to compare the current data to the previous inventory conducted in 2006.
3. Create custom fuel models in BehavePlus 5.0.5, [6] and to analyze the predicted fire behavior between study site areas with different fire suppression histories.

II. Methods

A. Study Site

Our research was conducted on BNL, located in Upton, New York. BNL rests on 2,153.33 hectares (5321 acres) that are positioned within Long Island's Central Pine Barrens ecosystem and the Peconic River watershed.[7] The Central Pine Barrens primarily consists of pitch pine (*Pinus rigida*), scarlet oak (*Quercus coccinea*), black oak (*Q. velutina*), white oak (*Q. alba*), and ericaceous shrubs. The soils for these areas were formed from the recession of glaciers less than 12,000 years ago, are medium to coarsely textured, and are well to excessively-well drained.[8] Our research sites were specifically located in the northeastern corner of BNL that is divided into two subunits; north and east. The north complex consists of 45 hectares and the east complex consists of 23.88 hectares.[9] Our specific analysis focused on stands D and A within the eastern complex that contained 5 and 6 plot points respectively. The southern 3.40 hectares of Stand D experienced a low intensity prescribed burn in 2006, and Stand A experienced a low intensity prescribed burn in 2011 and a moderate-to-high intensity wildfire in April 2012.[9] These stands were chosen to be the focus of our research project because of the differing time periods in which fire was absent from the two sites. This allowed us to compare fuel loading between a stand 10 years without fire and a stand 4 years without fire.

B. Sampling Design.

Ninety-three points, each associated with unique GPS coordinates, were established across the northern and eastern complexes using ArcGIS® (10.0). The fishnet tool was used to generate a grid of equally spaced points that were at least 22.86 meters from any edge and 30.48 meters from any other point. Each point was assigned a number, and a random number generator was used to pick the 93 points from that grid. A GPS unit was used to navigate to each point, a plot center was randomly chosen by throwing an object over the collectors shoulder. A modified Brown's transect [10-11] was used to inventory downed woody fuels, and a variable radius plot was used to assess the basal area and volume [12] at each plot center. Another object was randomly thrown from plot center, and at that point a 40x40cm^2 harvest plot was completed to measure the live and dead fuels including herbaceous. Sampling was done in accordance with vegetation and fuel monitoring protocols for the Long Island Pine Barrens Fire Management Demonstration Site Project adapted from the University of Massachusetts Project "Managing Fuels in Northeastern Barrens" [11] in order to assess the fuel loading of the two complexes by collecting a representative sample of fuel information. Data was collected starting June 2016.

C. Data Analysis.

Our data was recorded into macro-enabled Windows® Microsoft Excel (2007) spreadsheets provided by the University of Massachusetts website.[11] The data was then entered into BehavePlus 5.0.5 [6] to create custom fuel models for Stand D and A to compare the predicted fire behavior over time and between the two stands. The custom fuel models for stands D and A yielded predicted surface rate of spread (maximum) (m/min) and flame length (m) values for every 1-h moisture (%) value between 4-18% at midflame wind speeds (upslope) (km/h) between 3.218688 and 38.624256 in intervals of 3.218688. The moisture values of 4% to 18% were chosen because the BNL Prescribed Fire Plan [9] requires the 1-h fuel moisture to be 6-18% inclusive for a burn to occur. The results of the BehavePlus 5.0.5 [6] runs were recorded and reorganized in Windows® Microsoft Excel (2007).

III. Results

The vegetation inventory yielded the fuel complex information for stands D and A, and the fuel complex information that was recorded for stands D and A, in 2006, was included for comparison. Stand D had a 17% decrease in dead 1-h fuel, a 77% decrease in dead 10-h fuel, a 44% decrease in dead 100-h fuel, and a 100% decrease in herbaceous fuel from 2006 to 2016. The live woody fuel load, however, increased by 227%, and the fuel bed depth increased by 125% from 2006 to 2016. Stand A had a 29% decrease in dead 1-h fuel, and a 73% decrease in dead 10-h fuel, but the dead 100-h fuel increased by 2,886%, the herbaceous fuel increased by 286%, the live woody fuel increased by 135%, and the fuel bed depth increased by 25%. In 2016, Stand D has more dead 1-h and 10-h fuels (31% and 34% more respectively), 39% more live woody fuel, and a 44% increase in the fuel bed depth than Stand A, while Stand A had 282% more dead 100hr fuel and 139% more herbaceous fuel than Stand D (Table 1).

Table 1. Table representing the fuel loading (tonne/ha) for two stands in the east block of Brookhaven National Laboratory, Upton, NY.

		Stand D 2006	**Stand D 2016**	**Stand A 2006**	**Stand A 2016**
1hr fuel load (dead)	tonne/ha	16.34	13.55	13.22	9.33
10hr fuel load (dead)	tonne/ha	1.28	0.29	0.7168	0.19
100hr fuel load (dead)	tonne/ha	3.09	1.72	0.22	6.57
Live Herbaceous fuel load	tonne/ha	0.52	0	0.36	1.39
Live Woody fuel load	tonne/ha	1.82	5.96	1.55	3.65
Fuel bed depth	m	0.12	0.27	0.12	0.15

The BehavePlus 5.0.5 [6] outputs indicated that the rate of spread (maximum) (m/min) and flame length (m) values for Stand D, in 2016, (Tables 3a and 3b) were more than double the values for Stand D in 2006 (Tables 2a and 2b) at every 1-h fuel moisture value. Stand A had similar predicted rate of spread and flame length values in 2006 and 2016; however, predicted fire behavior, in the 2016 outputs, (Tables 5a and 5b) was consistently less than the 2006 outputs (Tables 4a and 4b). The rates of spread for Stand A, in 2006, increased at a faster rate than Stand A in 2016. Stand D, in 2016, had considerably higher (more than double) rate of spread values and flame lengths, at each moisture value, than Stand A in 2016.

Table 2a. Table representing the surface rate of spread (maximum) (m/min) for Stand D, in 2006, in the east complex of Brookhaven National Laboratory, Upton, NY.

1-h Moisture	Midflame Wind Speed (upslope) km/h											
%	3.218688	6.437376	9.656064	12.874752	16.093444	19.312128	22.530816	25.749504	28.968192	32.18688	35.405568	38.624256
4	1.1	2.5	4.2	6.3	8.7	11.3	14.2	17.4	20.7	24.2	27.9	31.8
5	1	2.3	3.9	5.8	8	10.5	13.2	16	19.1	22.3	25.8	29.4
6	1	2.1	3.6	5.4	7.5	9.8	12.3	15	17.8	20.9	24	27.4
7	0.9	2	3.4	5.1	7.1	9.2	11.6	14.1	16.8	19.6	22.7	25.8
8	0.9	1.9	3.3	4.9	6.7	8.8	11	13.4	16	18.7	21.5	24.5
9	0.8	1.8	3.1	4.7	6.4	8.4	10.5	12.8	15.3	17.9	20.6	23.5
10	0.8	1.7	3	4.5	6.2	8.1	10.1	12.4	14.7	17.2	19.9	22.6
11	0.8	1.7	2.9	4.3	6	7.8	9.8	12	14.2	16.7	19.2	21.9
12	0.7	1.6	2.8	4.2	5.8	7.6	9.5	11.6	13.8	16.2	18.7	21.3
13	0.7	1.6	2.7	4.1	5.6	7.4	9.2	11.3	13.4	15.7	18.1	20.6
14	0.7	1.5	2.6	4	5.5	7.1	8.9	10.9	13	15.2	17.5	20
15	0.7	1.5	2.6	3.8	5.3	6.9	8.6	10.5	12.5	14.7	16.9	19.3
16	0.6	1.4	2.4	3.7	5.1	6.6	8.3	10.1	12	14.1	16.2	18.5
17	0.6	1.4	2.3	3.5	4.8	6.3	7.9	9.6	11.4	13.3	15.4	17.5
18	0.6	1.3	2.2	3.3	4.5	5.9	7.4	9	10.7	12.5	14.4	16.4

Table 2b. Table representing the flame length (m) for Stand D, in 2006, in the east complex of Brookhaven National Laboratory, Upton, NY.

1-h Moisture	Midflame Wind Speed (upslope) km/h											
%	3.218688	6.437376	9.656064	12.874752	16.09344	19.312128	22.530816	25.749504	28.968192	32.18688	35.405568	38.624256
4	0.9	1.4	1.7	2.1	2.4	2.7	3	3.3	3.6	3.9	4.1	4.4
5	0.9	1.3	1.6	2	2.3	2.6	2.9	3.1	3.4	3.6	3.9	4.1
6	0.8	1.2	1.5	1.9	2.2	2.4	2.7	3	3.2	3.5	3.7	3.9
7	0.8	1.2	1.5	1.8	2.1	2.3	2.6	2.8	3.1	3.3	3.5	3.8
8	0.8	1.1	1.4	1.7	2	2.3	2.5	2.7	3	3.2	3.4	3.6
9	0.7	1.1	1.4	1.7	1.9	2.2	2.4	2.7	2.9	3.1	3.3	3.5
10	0.7	1.1	1.4	1.6	1.9	2.1	2.4	2.6	2.8	3	3.2	3.4
11	0.7	1	1.3	1.6	1.9	2.1	2.3	2.5	2.8	3	3.2	3.4
12	0.7	1	1.3	1.6	1.8	2.1	2.3	2.5	2.7	2.9	3.1	3.3
13	0.7	1	1.3	1.5	1.8	2	2.2	2.5	2.7	2.9	3.1	3.2
14	0.7	1	1.3	1.5	1.7	2	2.2	2.4	2.6	2.8	3	3.2
15	0.7	1	1.2	1.5	1.7	1.9	2.1	2.3	2.5	2.7	2.9	3.1
16	0.6	0.9	1.2	1.4	1.7	1.9	2.1	2.3	2.5	2.7	2.8	3
17	0.6	0.9	1.1	1.4	1.6	1.8	2	2.2	2.4	2.6	2.7	2.9
18	0.6	0.8	1.1	1.3	1.5	1.7	1.9	2.1	2.3	2.4	2.6	2.7

Table 3a. Table representing the surface rate of spread (maximum) (m/min) for Stand D, in 2016, in the east complex of Brookhaven National Laboratory, Upton, NY.

1-h Moisture	Midflame Wind Speed (upslope) km/h											
%	3.218688	6.437376	9.656064	12.874752	16.09344	19.312128	22.530816	25.749504	28.968192	32.18688	35.405568	38.624256
4	2.4	5.6	9.6	14.3	19.6	25.5	31.8	38.6	45.8	53.4	61.4	69.7
5	2.3	5.2	9	13.4	18.4	23.9	29.9	36.3	43	50.2	57.7	65.5
6	2.2	5	8.5	12.7	17.4	22.6	28.3	34.3	40.7	47.5	54.6	62
7	2.1	4.7	8.1	12.1	16.6	21.6	27	32.7	38.8	45.3	52	59.1
8	2	4.5	7.8	11.6	15.9	20.7	25.9	31.4	37.2	43.4	49.9	56.7
9	1.9	4.4	7.5	11.2	15.4	20	25	30.3	35.9	41.9	48.1	54.7
10	1.9	4.2	7.3	10.9	14.9	19.4	24.2	29.3	34.8	40.6	46.6	53
11	1.8	4.1	7.1	10.6	14.5	18.8	23.5	28.5	33.8	39.4	45.3	51.5
12	1.8	4	6.9	10.3	14.1	18.3	22.9	27.7	32.9	38.4	44.1	50.1
13	1.7	3.9	6.7	10	13.7	17.8	22.2	27	32	37.3	42.9	48.7
14	1.7	3.8	6.5	9.7	13.3	17.3	21.6	26.2	31.1	36.3	41.7	47.3
15	1.6	3.7	6.3	9.4	12.9	16.8	20.9	25.4	30.1	35.1	40.4	45.8
16	1.5	3.5	6.1	9.1	12.4	16.1	20.2	24.5	29	33.9	38.9	44.2
17	1.5	3.4	5.8	8.7	11.9	15.5	19.3	23.4	27.8	32.4	37.3	42.3
18	1.4	3.2	5.5	8.2	11.3	14.7	18.3	22.2	26.4	30.8	35.4	40.2

Table 3b. Table representing the flame length (m) for Stand D, in 2016, in the east complex of Brookhaven National Laboratory, Upton, NY.

1-h Moisture	Midflame Wind Speed (upslope) km/h											
%	3.218688	6.437376	9.656064	12.874752	16.09344	19.312128	22.530816	25.749504	28.968192	32.18688	35.405568	38.624256
4	1.9	2.8	3.7	4.4	5.1	5.7	6.3	6.9	7.5	8.1	8.6	9.1
5	1.9	2.7	3.5	4.2	4.8	5.4	6	6.6	7.1	7.7	8.2	8.7
6	1.8	2.6	3.3	4	4.6	5.2	5.8	6.3	6.8	7.3	7.8	8.3
7	1.7	2.5	3.2	3.8	4.5	5	5.6	6.1	6.6	7.1	7.5	8
8	1.7	2.4	3.1	3.7	4.3	4.9	5.4	5.9	6.4	6.8	7.3	7.7
9	1.6	2.4	3	3.6	4.2	4.7	5.2	5.7	6.2	6.7	7.1	7.5
10	1.6	2.3	3	3.6	4.1	4.6	5.1	5.6	6.1	6.5	6.9	7.4
11	1.5	2.3	2.9	3.5	4	4.5	5	5.5	5.9	6.4	6.8	7.2
12	1.5	2.2	2.8	3.4	3.9	4.5	4.9	5.4	5.8	6.3	6.7	7.1
13	1.5	2.2	2.8	3.4	3.9	4.4	4.8	5.3	5.7	6.1	6.5	6.9
14	1.5	2.1	2.7	3.3	3.8	4.3	4.7	5.2	5.6	6	6.4	6.8
15	1.4	2.1	2.7	3.2	3.7	4.2	4.6	5.1	5.5	5.9	6.3	6.6
16	1.4	2	2.6	3.1	3.6	4.1	4.5	4.9	5.3	5.7	6.1	6.5
17	1.3	2	2.5	3	3.5	3.9	4.4	4.8	5.1	5.5	5.9	6.2
18	1.3	1.9	2.4	2.9	3.3	3.8	4.2	4.6	4.9	5.3	5.6	6

Table 4a. Table representing the surface rate of spread (maximum) (m/min) for Stand A, in 2006, in the east complex of Brookhaven National Laboratory, Upton, NY.

1-h Moisture	Midflame Wind Speed (upslope) km/h											
%	3.218688	6.437376	9.656064	12.874752	16.09344	19.312128	22.530816	25.749504	28.968192	32.18688	35.405568	38.624256
4	1.4	3.1	5.3	8	11	14.4	18.1	22.1	26.3	30.8	35.6	40.5
5	1.3	2.8	4.9	7.4	10.2	13.3	16.7	20.4	24.3	28.5	32.8	37.4
6	1.2	2.7	4.6	6.9	9.5	12.4	15.6	19	22.7	26.6	30.6	34.9
7	1.1	2.5	4.3	6.5	9	11.7	14.7	17.9	21.4	25	28.9	32.9
8	1.1	2.4	4.1	6.2	8.5	11.1	14	17	20.3	23.8	27.4	31.2
9	1	2.3	3.9	5.9	8.2	10.7	13.4	16.3	19.4	22.8	26.3	29.9
10	1	2.2	3.8	5.7	7.9	10.3	12.9	15.7	18.7	21.9	25.3	28.8
11	0.9	2.1	3.7	5.5	7.6	9.9	12.5	15.2	18.1	21.2	24.5	27.9
12	0.9	2.1	3.6	5.3	7.4	9.6	12.1	14.8	17.6	20.6	23.7	27.1
13	0.9	2	3.4	5.2	7.2	9.3	11.7	14.3	17.1	20	23	26.3
14	0.9	1.9	3.3	5	6.9	9.1	11.4	13.9	16.5	19.3	22.3	25.4
15	0.8	1.9	3.2	4.8	6.7	8.7	11	13.4	15.9	18.7	21.5	24.5
16	0.8	1.8	3.1	4.6	6.4	8.4	10.5	12.8	15.3	17.9	20.6	23.5
17	0.7	1.7	2.9	4.4	6.1	7.9	10	12.2	14.5	17	19.6	22.3
18	0.7	1.6	2.7	4.1	5.7	7.4	9.3	11.4	13.6	15.9	18.3	20.9

Table 4b. Table representing the flame length (m) for Stand A, in 2006, in the east complex of Brookhaven National Laboratory, Upton, NY.

1-h Moisture	Midflame Wind Speed (upslope) km/h											
%	3.218688	6.437376	9.656064	12.874752	16.09344	19.312128	22.530816	25.749504	28.968192	32.18688	35.405568	38.624256
4	1.1	1.6	2.1	2.5	2.9	3.3	3.6	4	4.3	4.6	4.9	5.2
5	1	1.5	1.9	2.3	2.7	3.1	3.4	3.7	4	4.3	4.6	4.9
6	1	1.4	1.8	2.2	2.6	2.9	3.2	3.5	3.8	4.1	4.4	4.7
7	0.9	1.4	1.8	2.1	2.5	2.8	3.1	3.4	3.7	3.9	4.2	4.5
8	0.9	1.3	1.7	2	2.4	2.7	3	3.3	3.5	3.8	4	4.3
9	0.9	1.3	1.6	2	2.3	2.6	2.9	3.2	3.4	3.7	3.9	4.2
10	0.9	1.2	1.6	1.9	2.2	2.5	2.8	3.1	3.3	3.6	3.8	4.1
11	0.8	1.2	1.6	1.9	2.2	2.5	2.8	3	3.3	3.5	3.8	4
12	0.8	1.2	1.5	1.9	2.2	2.4	2.7	3	3.2	3.5	3.7	3.9
13	0.8	1.2	1.5	1.8	2.1	2.4	2.7	2.9	3.2	3.4	3.6	3.8
14	0.8	1.2	1.5	1.8	2.1	2.3	2.6	2.9	3.1	3.3	3.6	3.8
15	0.8	1.1	1.4	1.7	2	2.3	2.5	2.8	3	3.2	3.5	3.7
16	0.8	1.1	1.4	1.7	2	2.2	2.5	2.7	2.9	3.1	3.4	3.6
17	0.7	1	1.3	1.6	1.9	2.1	2.4	2.6	2.8	3	3.2	3.4
18	0.7	1	1.3	1.5	1.8	2	2.3	2.5	2.7	2.9	3.1	3.3

Table 5a. Table representing the surface rate of spread (maximum) (m/min) for Stand A, in 2016, in the east complex of Brookhaven National Laboratory, Upton, NY.

1-h Moisture	Midflame Wind Speed (upslope) km/h											
%	3.218688	6.437376	9.656064	12.874752	16.09344	19.312128	22.530816	25.749504	28.968192	32.18688	35.405568	38.624256
4	0.8	1.9	3.2	4.8	6.6	8.6	10.8	13.1	15.6	18.3	21.1	24
5	0.8	1.7	3	4.5	6.2	8.1	10.2	12.4	14.7	17.2	19.9	22.6
6	0.7	1.7	2.9	4.3	5.9	7.7	9.6	11.7	14	16.4	18.8	21.5
7	0.7	1.6	2.7	4.1	5.6	7.4	9.2	11.2	13.4	15.6	18	20.5
8	0.7	1.5	2.6	3.9	5.4	7.1	8.9	10.8	12.9	15	17.3	19.7
9	0.7	1.5	2.5	3.8	5.2	6.8	8.6	10.4	12.4	14.5	16.7	19.1
10	0.6	1.4	2.5	3.7	5.1	6.6	8.3	10.1	12.1	14.1	16.3	18.5
11	0.6	1.4	2.4	3.6	5	6.5	8.1	9.9	11.7	13.7	15.8	18
12	0.6	1.4	2.3	3.5	4.8	6.3	7.9	9.6	11.5	13.4	15.4	17.6
13	0.6	1.3	2.3	3.4	4.7	6.1	7.7	9.4	11.2	13.1	15.1	17.1
14	0.6	1.3	2.2	3.3	4.6	6	7.5	9.1	10.9	12.7	14.7	16.7
15	0.6	1.3	2.2	3.2	4.5	5.8	7.3	8.9	10.6	12.4	14.3	16.2
16	0.5	1.2	2.1	3.1	4.3	5.6	7.1	8.6	10.2	12	13.8	15.7
17	0.5	1.2	2	3	4.2	5.4	6.8	8.3	9.8	11.5	13.3	15.1
18	0.5	1.1	1.9	2.9	4	5.2	6.5	7.9	9.4	11	12.7	14.4

Table 5b. Table representing the flame length (m) for Stand A, in 2016, in the east complex of Brookhaven National Laboratory, Upton, NY.

1-h Moisture	Midflame Wind Speed (upslope) km/h											
%	3.218688	6.437376	9.656064	12.874752	16.09344	19.312128	22.530816	25.749504	28.968192	32.18688	35.405568	38.624256
4	0.8	1.2	1.6	1.9	2.2	2.5	2.7	3	3.3	3.5	3.7	4
5	0.8	1.2	1.5	1.8	2.1	2.4	2.6	2.9	3.1	3.3	3.6	3.8
6	0.8	1.1	1.4	1.7	2	2.3	2.5	2.7	3	3.2	3.4	3.6
7	0.7	1.1	1.4	1.7	1.9	2.2	2.4	2.7	2.9	3.1	3.3	3.5
8	0.7	1	1.3	1.6	1.9	2.1	2.3	2.6	2.8	3	3.2	3.4
9	0.7	1	1.3	1.6	1.8	2.1	2.3	2.5	2.7	2.9	3.1	3.3
10	0.7	1	1.3	1.5	1.8	2	2.2	2.5	2.7	2.9	3.1	3.2
11	0.7	1	1.3	1.5	1.8	2	2.2	2.4	2.6	2.8	3	3.2
12	0.7	1	1.2	1.5	1.7	1.9	2.2	2.4	2.6	2.8	2.9	3.1
13	0.7	0.9	1.2	1.5	1.7	1.9	2.1	2.3	2.5	2.7	2.9	3.1
14	0.6	0.9	1.2	1.4	1.7	1.9	2.1	2.3	2.5	2.7	2.8	3
15	0.6	0.9	1.2	1.4	1.6	1.8	2	2.2	2.4	2.6	2.8	2.9
16	0.6	0.9	1.1	1.4	1.6	1.8	2	2.2	2.4	2.5	2.7	2.9
17	0.6	0.9	1.1	1.3	1.5	1.7	1.9	2.1	2.3	2.5	2.6	2.8
18	0.6	0.8	1.1	1.3	1.5	1.7	1.9	2	2.2	2.4	2.5	2.7

IV. Discussion

The orange striped oakworm (*Anisota senatoria*) is a moth that tends to deposit its young (up to 500 eggs per female) onto oak leaves.[13] When the young hatch, the larvae consume the oak leaves, attacking the newest growth first for the most nitrogen, and move up the branches toward the trunk.[14] As the orange striped oakworm is a fall defoliator, oak trees (*Quercus* spp.) are preparing for winter dormancy, and the defoliation should not impact the tree as much due to reduced photosynthesis. However, the compounded stress and herbivory caused by the presence of the gypsy moth (*Lymantria dispar*) in the spring and summer, along with other stressful environmental factors, can cause oak death.[13] We believe that the aggressive herbivory, and other environmental factors that occurred over time between the vegetation inventories of 2006 and

2016, caused oak death that opened the canopy and allowed understory vegetation (as seen in the live woody fuel values) to increase dramatically.

In addition to the orange striped oakworm and the gypsy moth, the southern pine beetle (*Dendroctonus frontalis*) has recently been detected on Long Island. Though the literature is inconclusive on the exact effects of forest pests on tree mortality and fire behavior, bark beetles can cause drastic pine mortality that could add woody debris to the fuel loading.[15] The interactions between pests and forest fuel loadings have been addressed more in the western United States than the northeastern United States, with the conclusion that increased pest presence increases tree mortality and fuel accumulation.[16] Despite current policies to reduce or prevent the introduction of forest pests into the United States, their presence is increasing rapidly with a large concentration entering through the northeast.[17] This lack of certainty and lack of literature on these interactions in the northeastern United States is alarming due to their increased presence and combined contribution to the fuel load in our study site. This should be further studied to truly ascertain forest pest impacts on northeastern ecosystems and fire behavior.

The moderate-to-high intensity wildfire that passed through Stand A in 2012 top-killed a large number of oaks. The 100-h dead fuel load increased radically in Stand A because of to the number of top-killed trees, and the reduction of the shrub layer allowed herbaceous fuels to increase. Oaks preferentially store resources in their roots before their shoots, [18-19] and therefore responded well to the disturbances by resprouting.[19] Many of the oaks that were top-killed have since coppiced.

1-hour and 10-hour fuels have the greatest impact on starting and carrying fires because of their lower heat capacities required for combustion.[20] Stand D had not experienced fire for 10 years, and now has an increased live fuel load that is predicted to burn with high rate of spread and flame length values. The lack of fire is compounded by the herbivory and defoliation from the orange striped oakworm and the gypsy moth that caused tree mortality, opened the canopy, increased available sunlight to the forest floor, ultimately increasing the accumulation of live fuels. Stand D should be burned soon with increased precaution to reduce its 1and 10-h fuels. Stand A's 1 and 10-h fuel load was reduced in the fire it experience 4 years ago, and has low predicted rate of spread and flame length values. This indicates that a prescribed burn could be potentially ineffective until there is a larger accumulation of these smaller fuels.

V. Conclusion

The fire suppression of Stand D has led to a potentially dangerous accumulation of fine woody fuels that should be remedied with a more frequent prescribed fire regime. Stand A's reduction of fuels from a fire that occurred 4 years ago is a testament to the effect of a single burn. This study has produced the most up to date fuel loading data for two of the eleven total stands in the northeastern corner of Brookhaven National Laboratory. This data will prove valuable for those trying to complete a prescribed burn in these areas, and could be potentially used in further pitch pine mixed oak forest research on Long Island. Not all of the data was able to be analyzed in time for this analysis because of the drying protocol for the 40x40cm^2 harvest plots; as such, our analysis was not as comprehensive as it would have been if granted more time.

VI. References

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