Short term effects of a prescribed burn on the fuel loads in pine barrens ecosystem at

Brookhaven National Laboratory

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ABSTRACT

Fire is an essential aspect of many ecosystems, especially Atlantic coastal pine barrens, which require fire to maintain a healthy forest. Burning, whether by prescription or wildfire, has often been suppressed in recent decades despite fire's importance in reducing built-up fuel loads and supporting fire-adapted species. This study was conducted to better understand fuel load dynamics after prescribed burns in the northeastern corner of Brookhaven National Laboratory and to determine which objectives of the burn were met. Stand D was burned in June of 2017. Pre-burn fuels surveys were conducted in 2016, and these surveys were repeated post-burn to determine the amount and types of fuels consumed. In both cases, modified Brown's transects, variable radius plots, and biomass plots were used to ascertain fuel loading and a Composite Burn Index assessment was conducted to determine burn severity. A comparison of these data were used to determine if the following objectives of the prescribed burn were met: (1) reduce existing litter, i.e. 1- and 10-hour fuels, by 50-90%, (2) top kill 30 - 90% of the shrub component of the understory, and (3) expose 20 - 50% of bare mineral soil sites over the unit area. Stand D experienced a 63.2% reduction in existing litter and a 100% reduction of live woody shrubs. The CBI determined there was no change in soil and rock cover. Therefore, objectives (1) and (2) were met and objective (3) was not. The results of this burn demonstrate the benefits of incorporating regular prescribed burns into the natural resource management strategies of the Lab. Future monitoring is needed to determine how long the immediate impacts of a prescribed burn last, if the objectives of the burn plans are attainable or should be revised, and how often future treatments will be needed to maintain lower fuel loads.

I. INTRODUCTION

Recurring wildfire has the potential to maintain and even restore the environments that are adapted to it. In the absence of this disturbance over several years, fire-dependent communities, such as Atlantic coastal pine barrens, are often replaced by fire-sensitive and shade-tolerant competitors in a process termed "mesophication".[1] This creates a positive feedback loop, in which the suppression of fire encourages further fire resistance. This includes canopy closure, which increases shade-tolerant understory species, moist microclimates, and moisture-holding fuels that are not readily combustible.[1] Fire is also discouraged by reduced wind speeds beneath the canopy which normally dry fuels or drive wildfire and in turn, fire-sensitive species begin to dominate and change the habitat.[1] When disturbance regimes are altered, succession can shift habitat composition and dominance to favor hardwood forests instead of pine barrens.[2,3] To disturb this cycle, fire is needed to reduce fuel levels, reduce canopy density to favor barrens, and expose bare mineral soil to encourage new pitch pine (*Pinus rigida*) germination.[4]

With the expansion of urban development and roads, fires have largely been suppressed on Long Island, New York for over 50 years.[3] Suppression over long periods of time, however, directly leads to a build-up of coarse woody fuels, which can result in a higher fire hazard than when habitats are regularly burned.[5]

This study will focus on the first-order fire effects of a prescribed burn on Brookhaven National Laboratory (BNL). These are the effects that occur during and immediately after a fire (in this case within a few days after) and include fuels consumption, smoke production, and death or injury of organisms.[21] Species like black huckleberry (*Gaylussacia baccata*) and blueberry species (*Vaccinium* spp.) are often top-killed in fires and soon sprout from rhizomes with more vigor than before.[6] This study focuses on surface fuels because a lack of ladder fuels presents a lower risk of crown fire in a prescribed burn. When fuels consumption is measured, they are classified into size categories based on fuel moisture dynamics and how long it takes them to lose ~66% of their moisture. Woody fuels up to .635 cm in diameter, which lose ~66% of their moisture in 1 hour, are considered 1-hour fuels, 0.635 to 2.54 cm diameter fuels are 10-hour fuels, 2.54 to 7.62 cm diameter are 100-hour fuels, and 7.62 to 15.24 cm diameter are 1,000-hour fuels.[7]

By comparing the fuel loads of stand D before and after a prescribed burn and determining which of the objectives of the burn were met, we will have a better understanding of the land management practices that work best on the Lab. As we continue to monitor and learn from management efforts, our strategies can become more adaptive, leading to informed decision-making.[8] Our specific objectives for this prescribed burn were to:

1. Reduce existing litter, i.e. 1- and 10-hour fuels, by 50-90%,

2. Top kill 30 - 90% of the shrub component of the understory, and

3. Expose 20 - 50% of bare mineral soil sites over the unit area.

II. MATERIALS AND METHODS

A. Site Description

This research project was performed on BNL in Upton, NY. BNL's 2,153.3 ha campus is situated within the pine barrens of Long Island and in the watershed of the Peconic River.[9] This particular type of barrens ecosystem, Atlantic coastal pine barrens, is one of only three such habitat types identified in the world.[10] The soils at BNL are typically indicative of pine barrens and are quick-drying, consisting of 80-96% sand, low in organic matter, acidic, and nutrient-poor.[10] About 1,394 ha of BNL consists of pine barrens habitat, which primarily includes plant species such as pitch pine and multiple oak species (*Quercus coccinea*, *Q. rubra*, *Q. alba*, *Q. velutina*, *Q. ilicifolia*) and a variety of ericaceous (heath) shrubs like black huckleberry, blueberry species, bearberry (*Arctostaphylos uva-ursi*), and wintergreen (*Gaultheria procumbens*), bracken fern (*Pteridium aquilinum*), little bluestem (*Schizachyrium scoparium*), and Pennsylvania sedge (*Carex pensylvanica*).[10]

The primary site used in this study was stand D in the East Complex of BNL's campus, in which 5 randomly chosen plots were established. The last large wildfire to move through stand D occurred in the 1930s.[11] Prior to the June 2017 prescribed fire, fuels monitoring was conducted in 2006. The southern-most 3.4 ha of stand D was burned with a very low-intensity prescribed fire in October of 2006.[12] Stand D also experienced significant defoliation from the orange striped oakworm (*Anisota senatoria*) and the gypsy moth (*Lymantria dispar*) in the early 2000's, which resulted in high oak mortality and a reduction in basal area to ~70 ft^2/acre. Fuel monitoring conducted in 2016 found that live fuels increased by over 400% in 10 years (Kathy Schwager, personal communication, July 31, 2017). This large increase in fuels from 2006 to 2016 may be attributed to the earlier oak mortality. The site was then burned in June of 2017.

B. Burn Conditions

The prescription for the June 2017 burn can be found in Table 1.[12] During the burn the highest temperature reached was 92˚F, the relative humidity bottomed out at 36%, and the minimum 1-hour fuel

Characteristic	Lower Value	Upper Value
Wind Direction	all	all
Wind Speed	2 mph	10mph
Wind Gusts	0 mph	15 mph
Temperature	30˚ F	95˚ F
Relative Humdity	30%	70%
1-Hour Fuel Moisture	6%	18%
KBDI	0	250

Table 1. Characteristic factors of the environmental prescription for the prescribed burn

moisture was 5%. The Keetch-Byram Drought Index (KBDI) is an index that represents the effects of evapotranspiration and precipitation on the flammability of organic matter on the ground.[13] The KBDI value for this burn was 126 and the 10-hour fuel moisture was 13%.

C. Sampling Design

Five plots, which had been randomly selected using ArcGIS® for the collection of pre-burn data, were used again for this study. A GPS unit was utilized to find each point, a modified Brown's transect[14, 15] was conducted to record downed woody fuels and a variable radius plot was used to quantify the basal area[16] at each plot point. The Brown's transect was modified to not include a count of 1- and 10-hour fuel intersections because 1- and 10-hour fuels, live and dead, were collected from a randomly placed 40x40 cm^2 harvest plot.[15] These fuel samples were then dried in an oven at 70˚C for up to 48 hours before being processed and weighed. A Composite Burn Index (CBI) assessment was also conducted to determine the severity of the burn. Fire severity is defined as the "magnitude of environmental change caused by fire".[17] The CBI is designed to provide a field sampling protocol to assess severity by deriving index values to summarize multiple fire effects for each stratum.[17] Fuels monitoring was conducted in 2016, and in June of 2017 fuels monitoring for the post-burn data was taken immediately following the burn.

D. Data Analysis

Data were recorded in Microsoft Excel (2010) macro-enabled spreadsheets developed by the University of Massachusetts.[15] The data for stand D from 2016 and 2017 were compiled and compared within Excel to determine changes in fuel loading in tonne/ha.

III. RESULTS

From 2016 until immediately after the 2017 prescribed burn, stand D had a 73.1% reduction in 1-hour fuels, a 52.0% increase in 10-hour fuels, and a 54.5% increase in 100-hour fuels. However when 1- and 10-hour fuels, i.e. litter, are combined, in 2016 the load was 15.06 tonne/ha, in 2017 it was 5.54 tonne/ha, and there was a 63.2% reduction. For live woody fuels, a reduction of 100% was observed. The total fuel load was reduced by 68.7% (Figure 1). Overall fuel bed depth was reduced by 91.4% (Figure 2).

FIG. 1. Bar graph representing fuel loading (tonne/ha) by fuel type for stand D in 2016 and 2017 in the east complex burn units of Brookhaven National Laboratory, Upton, NY.

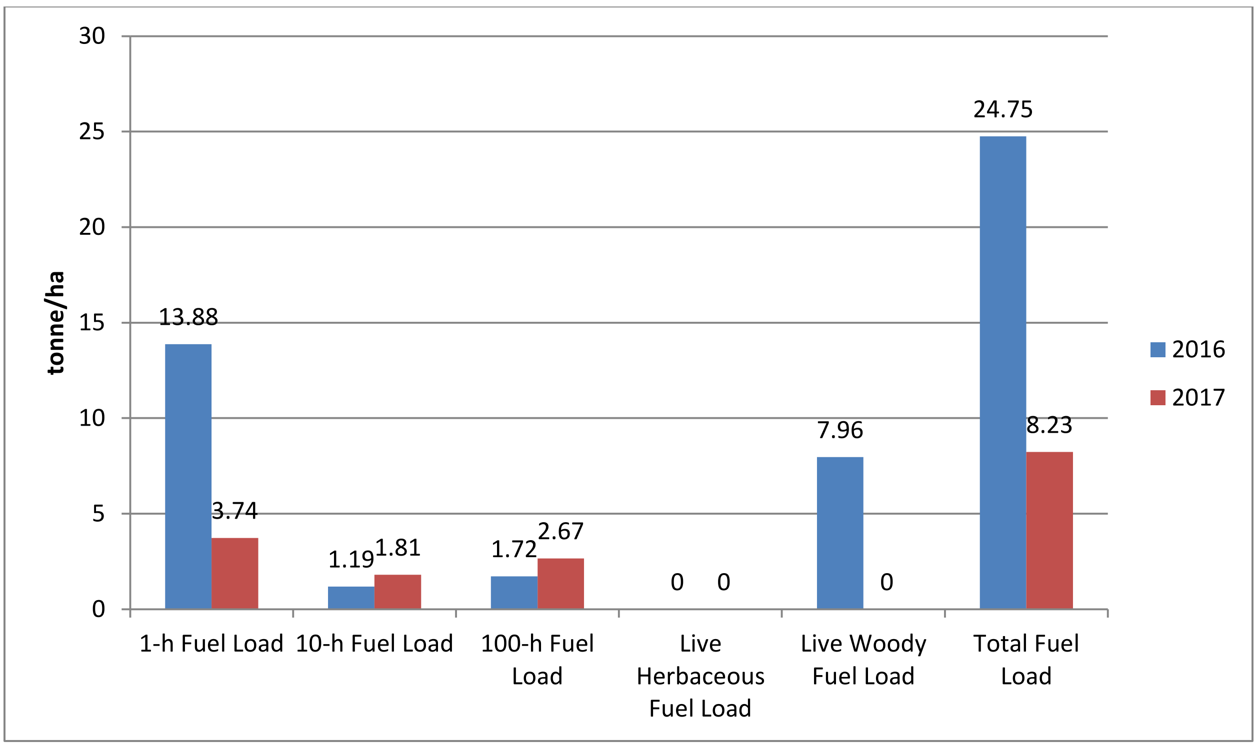
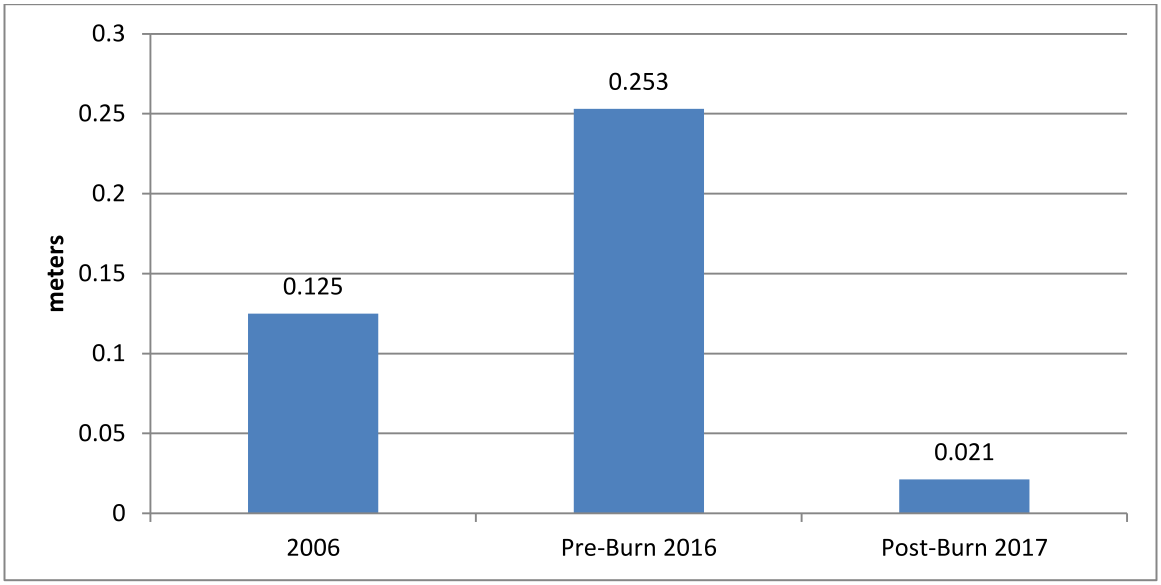


FIG. 2. Bar graph representing the average fuel bed depth (meters) of stand D in the east complex of Brookhaven National Laboratory, Upton, NY.



The average overall CBI value for the burn on stand D was 1.5, or moderate severity. For the substrates it was 0.6, or low severity. Specifically, the CBI value for the amount of litter consumed was 1.1, meaning ~50% consumed, and the value for soil and rock cover was 0.0 meaning there was no change in cover. Vegetation <1 m in height had a CBI that was 2.6, or high severity indicating ~80% of the foliage was altered and less than 20% was still living. And for vegetation 1-5 m in height it was 2.2, or moderate severity meaning ~95% of the foliage was altered.

The first objective of the prescribed burn, which was to reduce the existing litter load, or 1- and 10-hour fuels, by 50-90% and the second objective to top kill 30 - 90% of the shrub component of the understory were both met because of the observed reduction in both litter and shrub load. The third objective, to expose 20 - 50% of bare mineral soil sites over the unit area, was not met as indicated by the low CBI values for the substrates of stand D reveal that the soil and rock cover was unchanged.

IV. DISCUSSION

Habitat restoration can be a difficult task. For fire-dependent communities, prolonged fire suppression has the potential to change the ecosystem to a point of no return.[1] Vegetation condition class, the level to which current vegetation differs from the historical vegetation conditions, can be assessed to determine how far the habitat has diverged from the original.[18] Even when restoration is possible, much more energy, such as fire or mechanical treatments, is needed to return to the original habitat.[1] We believe that the pine barrens ecosystem at Brookhaven National Laboratory is in need and capable of restoration. Finding an appropriate fire return interval that maintains the early-successional habitat and accounts for urban impacts in the surrounding area will be needed in order to accomplish this restoration.[4]

The June 2017 burn did not consume enough of the built-up organic matter in order to expose the characteristic mineral soil of pine barrens habitat, but this should not be expected with only one burn after years of fire suppression. The increase in dead 10-hour fuels can be attributed to the top-killing of all of the live shrubs, but the fire did not consume the fuels completely. There is no clear reason for the increase in 100-hour fuels after the burn. Further management and monitoring will help to reveal if this is a common outcome and why it happens.

Early successional habitat like pine barrens ecosystems are vitally important for many wildlife and plant species, yet there is very little left in the northeast. Shrubland birds such as the prairie warbler now largely depend on early-successional habitat conservation efforts because they rely heavily on these areas.[19] Plant species such as scrub oak, pitch pine, black huckleberry, and blueberry species are indicative of pine barrens and decline when the disturbance of fire is removed from the ecosystem.[2, 4] Pitch pine needs recurring fire to germinate and establish itself, specifically because some of the trees bear serotinous cones and seeds require bare mineral soil for germination and an open canopy to grow.[20] Atlantic coastal pine barrens are especially rare, therefore, restoration and maintenance efforts are crucial to the species that are found in them.[2]

Continued monitoring and assessment of prescribed burn objectives will increase the Lab's ability to manage its resources adaptively. There are still many management questions that we can focus on answering such as: What fire return interval length is best during restoration? Will different fuel management objectives require different intervals based on location within the Lab? Is there a different interval length for when we reach restoration and only need to maintain current conditions? What basal area is ideal and will this differ based on management objectives? Should mechanical treatment be combined with prescribed burning? All of these questions and more can be answered with time and assessment of our efforts. What we can learn from these management efforts will continuously reduce the amount of uncertainty in making informed management decisions.[8]

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