Pitch pine mortality and regeneration from southern pine beetle across restoration treatments in the Long Island Central Pine Barrens, New York.

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Abstract

Brookhaven National Laboratory (BNL) lies within the fire-adapted and globally rare Central Pine Barrens. Over the past decade, rapid spread of southern pine beetle (*Dendroctonus frontalis*; SPB) has resulted in extensive mortality of pitch pines (*Pinus rigida*) across Long Island, New York. This project determined the effects of SPB on overstory trees and regeneration across six different disturbance histories: one or two prescribed fires, a wildfire, wildfire and thinning, wildfire thinning and a prescribed fire, and unmanaged controls through reductions in pitch pine canopy cover, mortality and vigor, as well as regeneration counts. Eight stands across the six treatments, each with six plots were randomly selected at least twenty meters apart from one another. The stands range in size from five to fifty hectares. At each sampling plot center, in a variable radius from a 10 BAF prism, tree diameter, canopy density, pitch pine mortality rates and infestation presence were measured. Regeneration was then tallied within a twenty-five by two-meter belt transect from a random bearing at plot center. A total of 362 trees were surveyed, 201 were pitch pine (56%). Of the 201, 50% were dead and an additional 14% were infested. Stands that underwent multiple forms of restorative treatment methods, fire and thinning, were found to have the lowest percentages of SPB infestation (20-35%), mortality (0-5%) and highest regeneration counts (175+) of the stands surveyed. This study furthered my training as a professional in natural sciences, increasing my fluency in data collection, organization,

management, analysis, and the scientific process from hypothesis to conclusion. It aligned with BNL's climate science emphasis and may help confirm that active forest management through varied restorative treatments (prescribed fire and thinning) can be a mitigative measure to the damage done by SPB as climate change continues to solidify their habitat expansion in the northeast.

Introduction

Pine barrens are globally rare ecosystems sparingly scattered throughout the Atlantic Coastal Plain of North America. Pine barrens consist of nutrient poor, sandy mineral soils, and highly site tolerant herbaceous and tree species. (Quigley et al., 2020). These ecosystems are fire dependent; necessary for nutrient cycling leaf litter, downed woody debris and snags into the mineral soils. Fire is primarily responsible for tree regeneration within the barrens, as pitch pine *(Pinus rigida*) are shade intolerant, require bare mineral soil for seed germination, and often have serotinous cones, or cones coated in a resin that must be burned off to open for seed dispersal (Jordan, 2003). Frequent fire (three to ten years) ensure that leaf litter and duff remain at low enough levels to keep fires low intensity (Jordan, 2003). Fire intervals can range anywhere from three to forty years to maintain specific desired pine barren stands (Jordan, 2003).

The Central Pine Barrens are located within the Atlantic Coastal Pine Barren range and are a community of fire dependent pitch pines, and various oaks (*Quercus spp*.) preserved on over 100,000 acres located in Suffolk County, Long Island, New York. (Central Pine Barrens Joint Planning & Policy Commission, 2024). The pine barrens have been largely unmanaged over this past century, largely due to its' preservation status, as well as the long-standing fire suppression policies for wildland urban interface areas throughout the state. (Heuss et al., 2019, Panko, 2021, Change et al., 2018, Central Pine Barrens Joint Planning & Policy Commission, 2024).

This has led to the pine barrens becoming severely overstocked leading to closed canopy conditions that stifle future pitch pine regeneration and inhibit seedling and sapling growth. (Heuss et al., 2019, Jordan et al., 2003, Chang et al., 2018). Pitch pine dominated stands have shifted in composition to oak-pine and primarily oak stands. This successional shift under mesophication; has not only changed the forest composition but threatens to erase the entire barren ecosystem itself. (Heuss et al., 2019, Jordan et al., 2003, Palus et al., 2018).

The absence of management within the pine barrens has decreased the resiliency of the ecosystem to stressors. The barrens are being devastated by the southern pine beetle (SPB, *Dendroctonus frontalis*). First detected in 2014, SPB is a pine boring insect native to American southeastern pine forests that targets hard pines. (Heuss et al., 2019, Dodds et al.,2018) The expansion northward is due to the warming winter temperatures, as SPD is freeze-intolerant. (Panko, 2021, Huess et al., 2019). A beetle will release pheromones after discovering a suitable tree which attracts large numbers of additional beetles that overwhelm the host tree by burrowing through the phloem, for nutrition and as an egg laying location for future generations. (Dodds et al.,2018). Beetles then move onto the next suitable tree, eventually joined by the future generations boring out from the original tree. SPB can host multiple generations, around three per year in the northeast, the infestation can spread rapidly, particularly in these stressed, overstocked stands. (Dodds et al., 2018).

Active management of our lands are crucial to protect them. Pine barrens require disturbance to maintain these earlier stages of succession. (Dodds, 2018). Restorative treatments such as prescribed fires and mechanical treatments, can act as a controlled form of necessary disturbance. Mechanical treatments such as thinning have not historically been common on the island due to the lack of a local market, low valued species, employable personnel, or sawmills. (Dodds, 2018). The integration and increased frequency of multiple forms of disturbance to the barrens, land managers can attempt to mitigate current pitch pine erasure and may be able to increase resiliency against SPB. (Dodds, 2018, Clarke et al., 2016, McNichol, 2019). There is limited recent fire history within the Central Pine Barrens, but Brookhaven National Laboratory hosts portions of acreage that have been burned within the past 15 years; both prescribed and wildland. It is my hypothesis that pine stands with frequent forms of restorative treatments (fire, thinning) will have lower rates of SPB damage and higher rates of regeneration. The Central Pine Barrens are crucial to a variety of life on Long Island, including our own. SPB will continue to dramatically alter the pine barrens' forest health and structure, without intervention, the future of the Long Island pine barrens is uncertain.

Study Area and Design:

The Central Pine Barrens are in Suffolk County, Long Island, New York. The area of focus during this study is situated in Brookhaven National Laboratory (BNL), in Upton, New York. BNL hosts five percent of the Central Pine Barren's 4050 hectares. (Brookhaven National Lab, 2024). Eight stands were selected based on disturbance and management history. Land management information on each of the stands are listed in Table 1. In ArcGIS a fishnet was created over each stand, and six points were randomly selected to serve as plot center from each stand. Plots were selected with the restriction of being at least 20 meters apart from one another. There are six plots per stand, totaling forty-eight plots surveyed.

Stand	Disturbance history	Size (ha)
East A	Wildfire: 2012	8.66
East CD	Prescribed burn: 2017 & 2018	15.30
North E	No management (control)	9.06
North F	Low intensity prescribed burn: 2022	9.45
North H	Wildfire: 2012, mechanically treated: 2023	9.43
North I	Wildfire: 2012, mechanically treated: 2021, prescribed burn: 2023	9.51
Saddle East	Prescribed burn: 2023	5.54
RHIC Ring	No management (control), significant SPB damage	52.61

Table 1. Name, treatment history, and size of investigated stands

Figure 1. BNL selected stands map with plot locations

Field Methods:

At each plot a spherical densiometer was used over plot center in each of the cardinal directions to calculate an average canopy cover, dead pitch pines were not counted as canopy. A 10 BAF (Basal Area Factor) prism was used at plot center to determine which trees are within the variable radius. Trees were identified to species, the diameter at breast height (DBH) was measured, and pitch pine mortality rate was then assessed following the method presented by McNichol et al., 2019. Overall crown mortality was assessed for each tree on a scale from 1 to 5: 1 = 0% mortality; 2 = 25% dieback (red and/or fading needles); 3 = 50% dieback; 4 = 75% dieback; and 5 = dead, 100% mortality. (McNichol et al., 2019). Additionally, any signs of *Ips* spp. infestation such as frass, pitch tubes and holes appearing above 2 meters on the bole were noted. (McNichol et al., 2019).

Regeneration was also assessed at each of the plots. A 2- by 25-meter belt transect was lain out from the plot center in a randomly determined direction and any regeneration within the belt transect was identified and tallied. Regeneration includes seedlings less than half a meter and saplings in between a half to two meters tall. (Batcher et al., 2007). Averages of measurements were taken at the plot level, stand level, and treatment level. A Kruskal-Wallis-test with an alpha of 0.05 was used to validate findings as the data was not normal.

Results

In total, 362 trees were surveyed across the 48 plots. Out of this total, 201 trees were pitch pine, 50% of these were dead, 37% healthy, and 12% currently infested, a health assessment by treatment viewable in Figure 3. In the 48 regeneration transects 1,153 seedlings and saplings were counted and averaged by treatment (Figure 4). The highest rate of pitch pine infestation were 100% and lowest was 20%; average by treatment are in Figure 5. Average canopy cover ranged from 10% to 60% when rounded to the nearest 5%. The average pine diameter at breast height was 33.9 centimeters. Stand dominance averaged out to either being co-dominant or dominant. Kruskal-Wallis tests were used at a 5% level of significance when comparing average regeneration per treatment and average SPB presence per treatment. Further comparisons of the average Ips presence and average regeneration per treatment type (if fire, type of fire, and if mechanical), can be found in Appendix B and C.

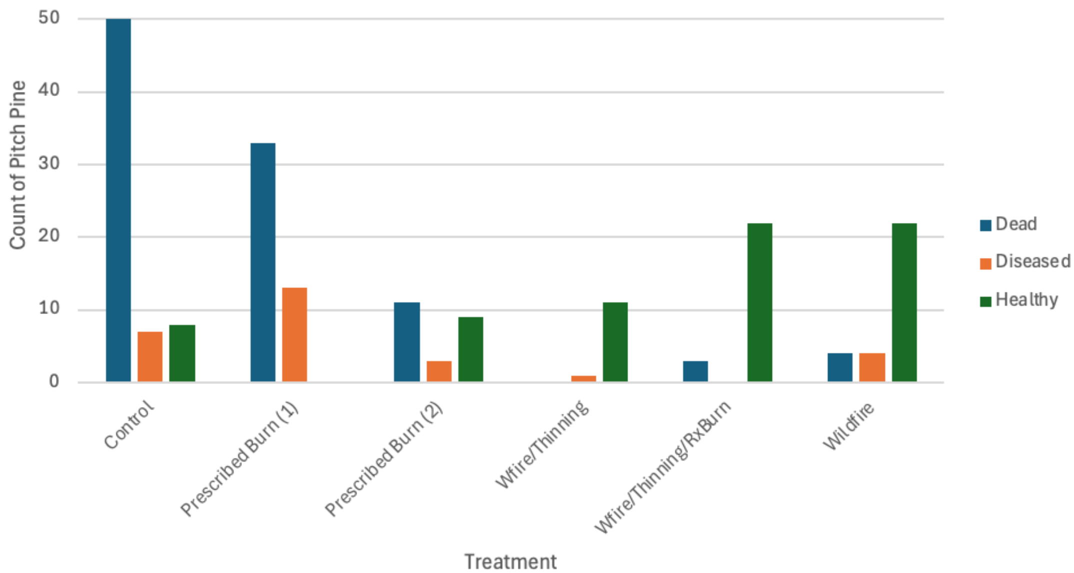

Figure 3. Pitch Pine Health Counts per Treatment

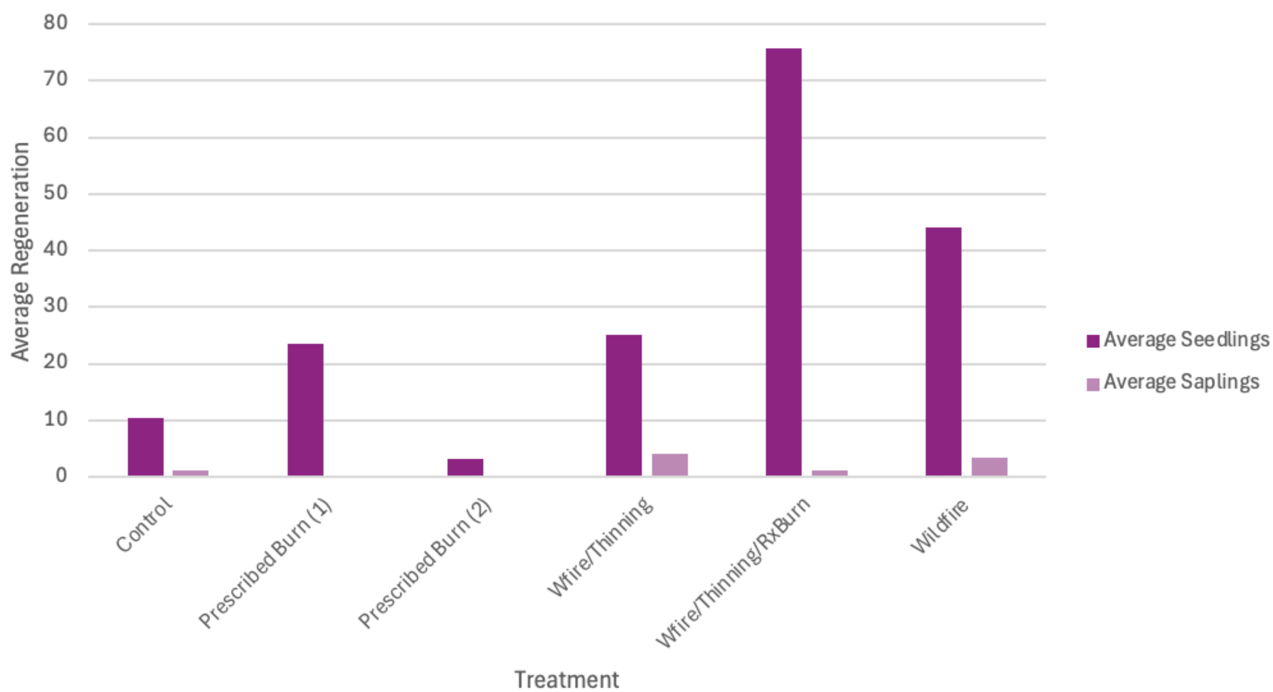

Figure 4. Average Regeneration per Treatment, Kruskal-Wallis p-value 0.0002691

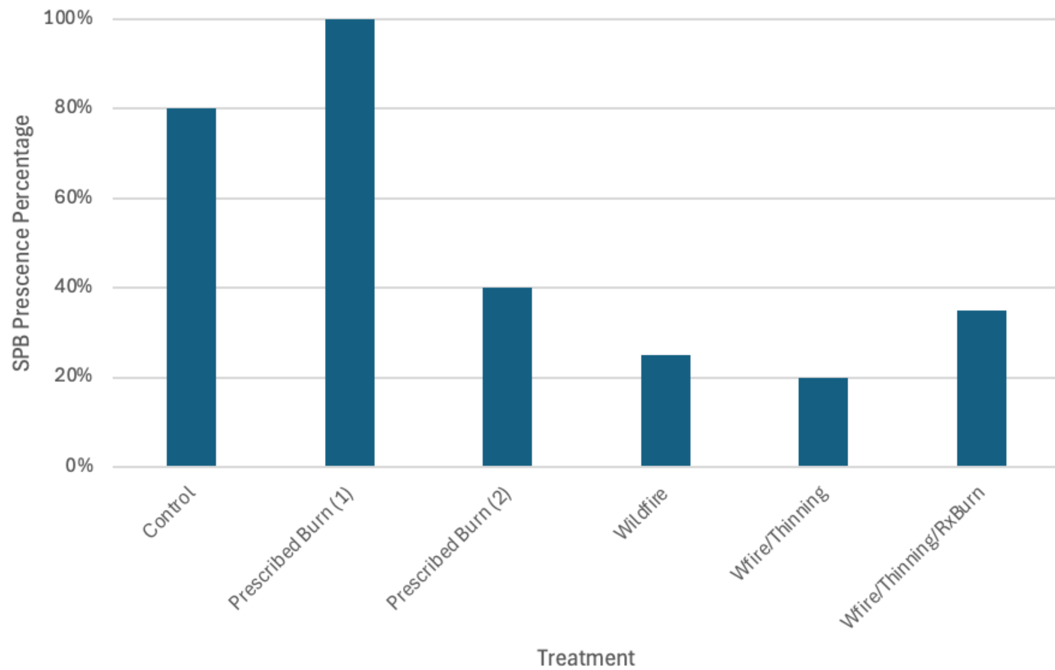

Figure 5. Average SPB Presence per Treatment, Kruskal-Wallis p-value: 0.0008526

Discussion

Based on my observations, a correlation between pitch pine resiliency from SPB and treatments was found, with the most influential treatments being those that repeated or combined methodology. Stands that had undergone multi-method treatments had both high resiliency (lower mortality and infestation rates) and regeneration. Treatments were found to align; those that promoted stand health were where high regeneration values were counted. Diameter at breast height and tree dominance rating were not found to have an interaction with mortality or infestation rates.

An inverse relationship between average canopy cover (via treatment), and regeneration values was noted, with stands with a low average canopy cover such as North H and North I had higher regeneration rates (176-461 counted) and healthier pines (0-20% infestation rates). (Lee et al., 2018). These two stands have both fire and mechanical treatment history, the low canopy cover mainly due to thinning treatments. The addition of thinning in conjunction with fire may be vital in lowering stand density which may delay or eliminate SPB's spread. There is a question if it is the various restoration methods or thinning alone that are contributing to healthier values. The mechanical treatments may provide the major benefit directly choosing which trees to keep, meaning foresters can cut out the infestation. The observations in stand North H and North I may have been influenced by this. Thinning can guarantee an open canopy as well. Research of a stand that has only been thinned is necessary to determine the validity of this, which does not exist at the BNL campus.

Control stands had the highest rates of pitch pine mortality at 77%, control stand RHIC Ring had the highest rate of pitch pine mortality per stand at 93%. A slight trend of high pitch pine health was noted in certain control plots, where oaks heavily dominated sufficiently spacing remaining pines out, but this high stand density are pines are stressed, more susceptible to SPB. This is stand mesophication: as these pines die out, the closed canopy and high oak leaf litter will inhibit any future pine germination and growth.

Stands with a single prescribed fire were found to remain overstocked and suffering the effects of SPB with high rates of mortality and 100% infestation rates among surveyed pines. And, while there were moderate seedling counts, there were no saplings; either due to fire recency (2022, and 2023) burning any regrowth, or that the stands were not disturbed enough to allow seedling maturation into saplings. Further monitoring of these stands is needed to understand if either the prescribed fires have not been intense enough to lower the density of the forest structure (as it is dense in areas and oaks still dominate portions of these stands), if increasing prescribed fire frequency would be sufficient to emulate necessary disturbance, or if prescribed fires can only act as a form of maintenance and a bigger act of restorative treatment must be used to jumpstart change, restart succession and allow for pitch pine domination within the stand. Do the low intensity prescribed fires harm the pitch pines in overstocked and infected stands by further stressing them, inadvertently promoting further SPB infestation?

A larger sample size of stands must be measured and reviewed before confirming the results found in this study. More plots within each stand would be needed to ensure statistically significant findings and would better account for any outliers found. Plots should be given the additional restriction of a minimum distance from the edge of the stand, to avoid edge effects. A few of my regeneration transects walked me back to the road, which may have shown a disproportionately higher seedling count due to more disturbed soil and less canopy cover. A long-term study of the Central Pine Barrens is needed to confirm if repeated prescribed fires along with mechanical treatments could make a stand more resilient to SPB. Time since fire, prescribed or wildland, as well as fire intensity, severity and frequency should be denoted and further studied as well. At stands such as East CD, East A, and Saddle East I observed a wider breath in pine health, but this diversity did not translate to measured trees. Beginning the regeneration assessment at seedlings starting at least at ten centimeters (as opposed to any starting size) would allow for quicker assessments, ensuring more plots would be feasible. Given more time I would have studied another stand, East Z, that has had two wildfires in ten years. Further assessment is needed to confirm if SPB is directly influencing regeneration or if it is solely due to treatment methods.

Conclusion

My results align with my initial hypothesis that pine barren stands with a frequent fire history and active management, in the form of mechanical treatments will have less death and decline from SPB and higher pitch pine regeneration values. The low p-value scores for testing infestation and regeneration allow me to reject the null hypothesis. More data and research is needed to validate findings of this study. Multimethod restorative treatments may be key to combating SPB mass death, maintaining stand health and ensuring regeneration success over time. Varied treatments may be able to emulate wildfires in a more predictable and safe manner while providing adequate disturbance to encourage the Central Pine Barrens to withstand SPB and reestablish it as a pine dominated ecosystem.

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Appendices

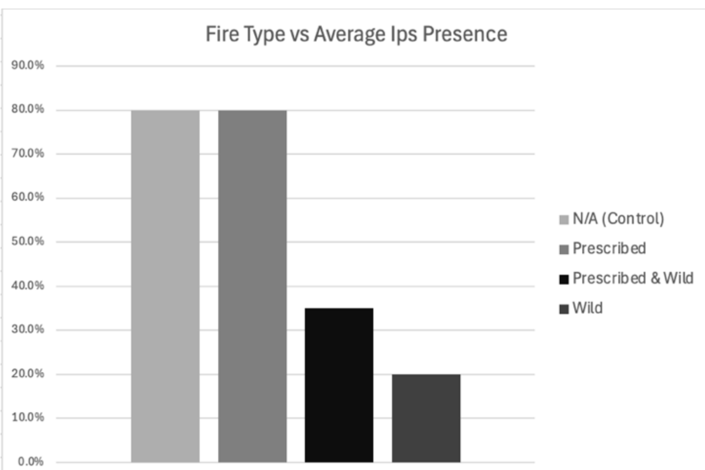
Appendix A: Stand Comparison

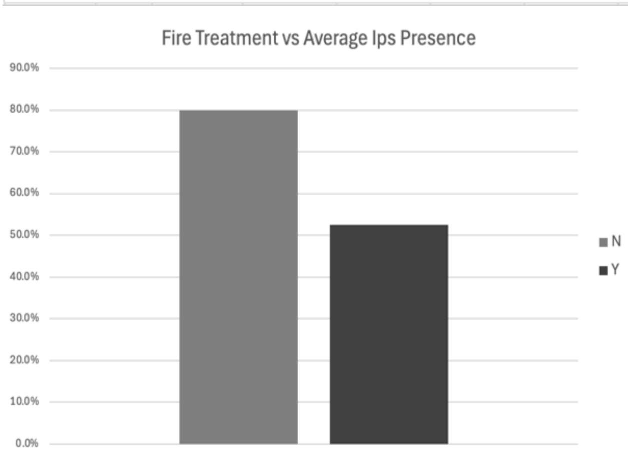
Stand North F: Summer 2017 vs. Summer 2024

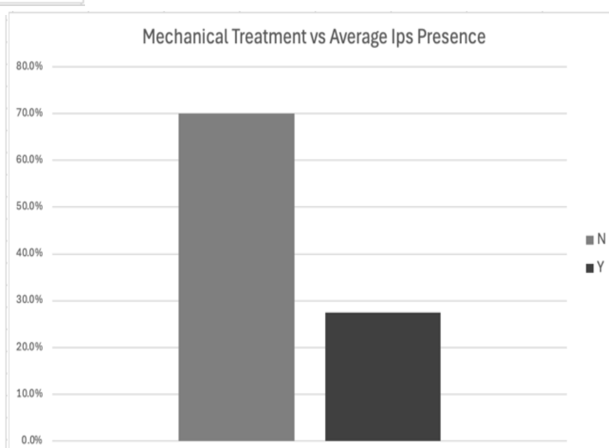
Stand RHIC Ring: Summer 2017 vs. Summer 2024

Imagery taken from Nearmap.com

Appendix B: Treatment Comparisons for SPB Infestation Rates







Appendix C: Treatment Comparisons for Average Regeneration Rates