The bark is worse because they bite: a case study on the frequency, density, and effect of black turpentine beetles (*Dendroctonus terebrans*) in pitch pine restoration treatments at Brookhaven National Laboratory

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Abstract

Pine barrens are globally rare, fire-dependent ecosystems that only occur in extensive stands across the Atlantic Coastal Plain of the eastern US. These communities consist of an open canopy of primarily pitch pine (*Pinus rigida*) and an understory of scrub oak (*Quercus ilicifolia*), heath shrubs, and grasses. Periodic disturbance, whether biotic or abiotic, is necessary to maintain this structure and composition or become destabilized and stressed. Restoration treatments are necessary to restore and thin the barrens, however they also act as sources of immediate stress for pitch pines. The black turpentine beetle (BTB; *Dendroctonus terebrans*) is a bark beetle native to the southern and eastern US that targets and thrives on stressed pitch pines. While not an obligate tree killer of healthy pines, BTB colonization has the potential to wreak significant damage the unmanaged, overstocked, and stressed areas of the Long Island Pine Barrens, especially in tandem with other more aggressive bark infesting beetles such as the southern pine beetle (SPB; *Dendroctonus frontalis*) and *Ips* spp. The purpose of this case study was to conduct field surveys in a variety of pine barrens restoration stands, measuring the frequency and density of BTB and the characteristics of attacked trees across ten stands with a goal of expanding research on BTB presence across restoration treatments in the northeastern US. It was found that BTB were of highest density and mean count in areas with no/low management like low intensity burns. BTB were lowest in areas mechanically thinned and with histories of at least one wildfire. When BTB were present, they were more often than not found with SPB and/or *Ips* spp. The findings of this study are supported by previous research and achieves its goal of adding literature on both BTB and their presence in mid-Atlantic pine barrens. This study aligns with Brookhaven's mission to support the Department of Energy's goal of ensuring America's security and prosperity by addressing it environmental challenges. In conducting this study, I have developed a thorough understanding of bark beetle biology, ecology, and taxonomy, pine barrens' structure, ecology, and restoration treatments.

Introduction

Pine Barrens Ecology

Pine barrens are globally rare disturbance-dependent communities that can only be found in extensive stands across the Atlantic Coastal Plains on the eastern coast of the US.[2] Pine barrens consist mainly of woodlands and shrublands, though have the potential to contain a mosaic of smaller ecosystems within their boundaries such as dwarf pine communities, vernal ponds, wetlands, pine barrens lowlands, etc.[2] However, these communities consist mainly of woodlands and shrublands with an open canopy (10-60%) of pitch pine (*Pinus rigida*) and various understory communities that can include scrub oak (*Quercus ilicifolia*), several blueberry species (*Vaccinium* spp.) and sweet fern (*Comptonia peregina*).[7] Pine barrens have evolved to depend on disturbance, mainly fire, to maintain this composition of vegetation and structure of an open canopy and an early successional, low understory.[4]

Pines Barrens at BNL

The Long Island Pine Barrens (LIPB) is one of the four extensive pine barrens in the US, containing one of the three dwarf pine communities.[3] The area is roughly 42,492 ha (105,000 ac) and located in east-central Long Island in Suffolk County, NY.[3] Brookhaven National Lab is located in the heart of the pine barrens and manages approximately 2,130 ha (5,265 ac) of the area using prescribed burns, mechanical treatments, and areas with no management/ interference.[10] However, the property and surrounding forests has a long history of fire suppression that has resulted in the buildup of excessive understory growth, the disruption of nutrient cycling, and the steady transition of pine barrens to oak/hardwood forests.[7,10] The lack of management and fire suppression has resulted in an environment that overly stresses pitch pines, weakening and overstocking them, and attracting organisms that benefit from and thrive on weakened trees.

The southern pine beetle (SPB; *Dendroctonus frontalis*), is considered one of the most destructive insect pests in the country.[10] Since its discovery in the fall of 2014, LI has experienced significant and rapid pitch pine loss due to the lack of active management and fire suppression, high density of trees, and SPB's ability to successfully colonize healthy trees as well as weakened ones.[1,10] The arrival of SPB into this region, where it had previously been a nonissue, has the potential to wreak further havoc by allowing less aggressive pine colonizers, like pine engravers (*Ips* spp.) and black turpentine beetles, to further stress the pine barrens.

The Black Turpentine Beetle

The black turpentine beetle (BTB; *Dendroctonus terebrans*), is the largest pine-infesting bark beetle native to the southern and eastern US.[9] BTB can colonize all species of pine (*Pinus* spp.) within their range, attacking mainly freshly cut stumps and weakened trees affected by abiotic or biotic factors such as logging, construction, disease, hurricanes, wildfire, lightning strike, etc.[9] BTB flight activity occurs mainly from March through October with at least three overlapping generations.[5] However, due to warming temperatures, BTB have the potential to expand their range northward and extend their flight and breeding seasons and the number of overlapping generations[9].

BTB are often found colonizing trees also being attacked by SPB, and/or *Ips* spp.[11] BTB presence can be differentiated from other bark beetles by characteristic large, clumpy, reddish-brown to pinkish-white pitch tubes composed of a mixture of resin, dust, and frass that typically occur from the lower bole to the roots of a tree (Figure 1).[11]

Figure 1. BTB caught in pitch resin.

BTB are not obligate tree killers and rarely cause extensive tree mortality, however, BTB presence has the potential to attract more bark infesting beetles like SPB and *Ips* spp. which can lead to much more severe ramifications on a much larger scale.[8] Their presence in large droves can also be telling of a more serious problem within stands as they only truly attack weakened/stressed trees. Preventative management techniques are preferred over direct methods of control and include the thinning of overstocked stands, the removal of weakened or dead trees, and the reduction of competition among vegetation.[9]

Project Objective

Restoration treatments are necessary to maintain and protect pitch pine forests on Long Island. Treatments reduce the density of overstory trees, especially hardwoods, and allow for the increase in pitch pine regeneration in the understory. However, restoration treatments themselves are sources of immediate stress, influencing the frequency and density of bark beetles present in restoration stands.

The purpose of this case study was to conduct field surveys in pine barrens stands with a variety of restoration treatments on the BNL property, measuring the frequency and density of BTB across stands and the characteristics of attacked trees. Little literature and less research focused on BTB in the northeastern US exist. Response of BTB along different management gradients or how their presence/density might influence other bark beetle species is currently unknown. This study aims to provide ample description of stand history, BTB density in trees, and the characteristics of pitch pines that have been colonized by BTB. The results of this study aim to allow for a more thorough understanding of the effects different restoration treatments can have on pine barrens communities in relation to BTB and other bark beetle presence and influence.

Methods & Materials

Study Areas

Areas investigated for this survey were concentrated in the restoration stands on the northeast portion of the BNL property with the exception of one stand. Surveys were completed over the course of 4 weeks in the summer of 2024. Ten stands total were surveyed with varying of management/natural disturbance types including: wildfire, SPB damage, mechanical treatments, prescribed burns, and no management/disturbance. Within these individual treatments there is much overlap in treatment types; specifics on stand history and size are listed in Table 1 and can be seen in Figure 2.

Stand	Treatment history	Size (ha)
East A	Crescent Bow Wildfire 2012	8.66
East CD	Prescribed burn 2017 & 2018	15.3
North E	No management (control)	9.06
North F	Low intensity prescribed burn 2022	9.45
North G	Crescent Bow Wildfire 2012, mechanically treated 2022	9.55
North H	Crescent Bow Wildfire 2012, mechanically treated 2023	9.43
North I	Crescent Bow Wildfire 2012, mechanically treated 2021, prescribed burn 2023	9.51
Saddle East	Prescribed burn 2023	5.54
RHIC Ring	Significant SPB damage	52.61
East Z	Crescent Bow Wildfire 2012, Paumanok Wildfire 2020	10.12

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

Figure 2. Map of investigated BNL restoration stands

Field Surveys

Six plots were established for each stand with a fixed radius of 11.3 m, a minimum of 20 m separating each plot, and an edge buffer of 10 m (Figure 3).

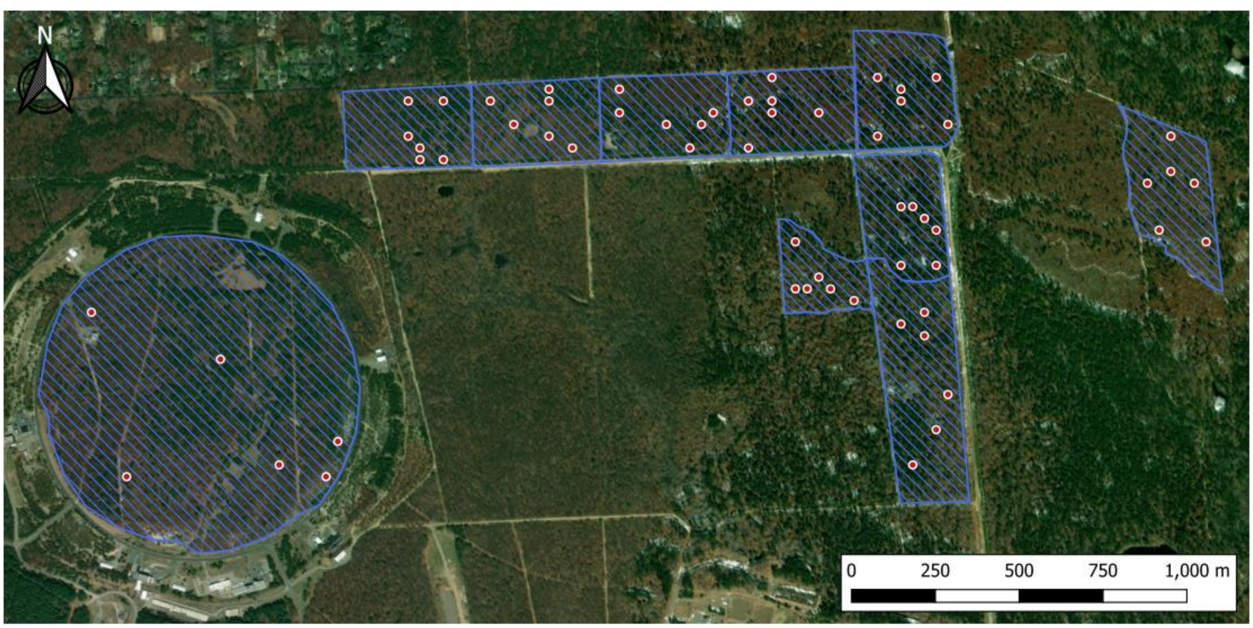
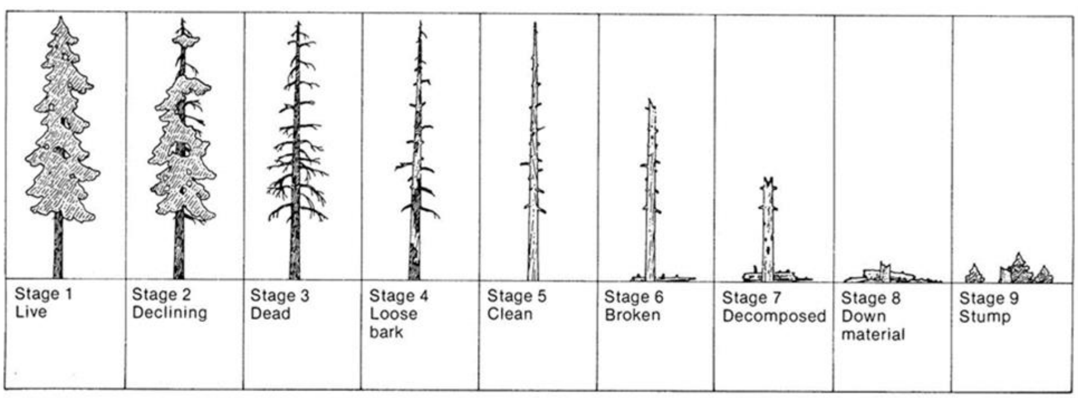


Figure 3. Map of BNL restoration stands with surveyed plots

Data on overstory pitch pines were collected for each individual within or touching plot radii for each stand. Plot radii were measured using a Haglof hypsometer. Tree characteristics were measured in order to gain an understanding of overall stand health, pitch pine concentration, and bark beetle presence/effect. Characteristics measured included: diameter at breast height (DBH) with a minimum DBH of 10 cm, canopy class as defined by comparing individuals with other trees in the same plot, living/decay stage (Figure 4), and BTB presence. If BTB were present then additional measurements and characteristics were taken including: height of highest and lowest attack from ground (cm), BTB attack site count, using a small knife to mark resin tubes and a clicker to count, and the presence of *Ips* spp. and/or SPB.



Healthy tree, no observable sign of decline	Crown fade evident, branch dieback, presence of insects or disease	Fine twigs present in crown, bark still tight on bole	Most small twigs absent, larger branches still present, loose bark	Most large branches gone, bark mostly gone	Bole only, broken	Bole only, soft wood, more advance decay evident	Short stump, majority of remaining bole on ground decaying	Stump only

Figure 4. Living/decay stage diagram

Trees were examined for characteristic BTB resin tubes. They differ from *Ips* spp. and SPB by size, texture, and location on the tree. BTB resin tubes are clumpy, pink-maroon, and about 2-5 cm wide and occur on the lower bole of the tree.[8] Older resin tubes had the same clumpy consistency and size, but with a much more muted purple-whitish color (Figure 5). SPB infestations typically occur around mid-bole and produce smaller, more drippy or globular, reddish-orange-white tubes[6] (Figure 6). *Ips* spp. can occur anywhere on the tree, but do not produce significant resin flow, instead their colonization results in characteristic red or tan wood dust (Figure 7).

Figure 5. Evidence of BTB. Fresh/recent resin tubes (left), older resin tubes (right).

Figure 6. Evidence of SPB resin tubes.

Figure 7. Evidence of *Ips* spp. dust.

Data Analysis

Several analyses were conducted with the goal of summarizing overstory composition from surveyed plots and expanded to per hectare estimates for each stand. Analyses were not run across stands, only between plots within each stand. Average tree diameter, basal area, breakout of canopy class, breakout of living/decay stage, trees per ha, and number of trees per ha with BTB provides ample description of stand condition, structure, and composition. These same analyses were run focusing on trees with BTB and other bark beetles present to create two datasets.

Results

In total 243 pitch pines were sampled across the 10 restoration stands surveyed. With the data from these 10 stands the overall stand composition and condition were evaluated and can be seen in Tables 2 and 3. These tables are meant to provide a general idea of stand health at the time surveys were conducted (mid-June to early-July 2024).

Overall Composition	**Stand**									
Variable	EA	CD	NE	NF	NG	NH	NI	RR	SE	EZ
No. of trees sampled	14	19	18	41	9	17	29	76	8	12
No. of trees per ha	1.62	1.24	1.99	4.34	0.94	1.8	3.05	1.44	1.44	1.19
Avg. DBH (cm)	40.98	37.05	35.79	27.48	33.64	33.03	29.84	25.42	33.47	34.02
Total basal area (m^2/ha)	8.28	8.59	7.88	**11.47**	**3.97**	7.9	9.03	**18.94**	**3.1**	4.77
Live tree basal area (m^2/ha)	6.82	4.28	4.11	**0.98**	**3.97**	6.97	6.98	**1.29**	**3.1**	3.92
Dead tree basal area (m^2/ha)	1.46	4.31	3.77	**10.49**	**0**	0.93	2.05	**17.65**	**0**	0.85

Table 2. Overall composition of each stand, displaying total number of sampled trees, number of trees per hectare, average diameter, and live and dead basal area for surveyed stands.

The most notable characteristics are total, live, and dead basal areas. These show the overall density of each stand along with the density of live and dead pitch pines. Stands NG and SE had the highest proportion of live to dead trees along with the lowest total basal areas out of all surveyed stands. Stands NF, and RR had the highest proportion of dead to live trees along with the highest total basal areas out of all surveyed stands.

Stand Condition	**Stand**									
Variable (%)	EA	CD	NE	NF	NG	NH	NI	RR	SE	EZ
Dominant	7.1	0	0	0	0	0	0	0	0	0
Codominant	71.4	78.9	100	70.7	100	64.7	89.7	44.7	100	83.3
Intermediate	0	21.1	0	22	0	17.6	6.9	51.3	0	16.7
Suppressed	21.4	0	0	7.3	0	17.6	3.4	3.9	0	0
Green	78.6	52.6	55.6	7.3	100	82.4	72.4	5.3	100	75
Red	0	0	0	0	0	5.9	0	0	0	0
Bare	21.4	47.4	44.4	92.7	0	11.8	27.6	94.7	0	25
Living	57.1	52.6	44.4	**4.88**	**100**	82.4	48.3	**2.6**	**87.5**	75
Declining	21.4	0	11.1	**4.88**	**0**	0	24.1	**2.6**	**12.5**	0
Dead	21.4	47.4	44.4	**90.24**	**0**	17.6	27.6	**94.7**	**0**	25

Table 3. Stand condition, containing crown class, crown color, and living/decay stage in percent for surveyed stands.

Stand condition is shown using Table 2 and Figures 8 and 9. The most notable characteristic from this table is percent living/decay stage for each stand. Stands NF and RR have the highest percentage of dead and declining trees to live trees. Stands NG and SE have the highest percentage of live trees to dead and declining ones. These findings support those of the previous table. Figures 8 and 9 are modeled to visualize the overstory composition of stands, with a majority of codominant trees in every stand save RR and living/decay in each stand.

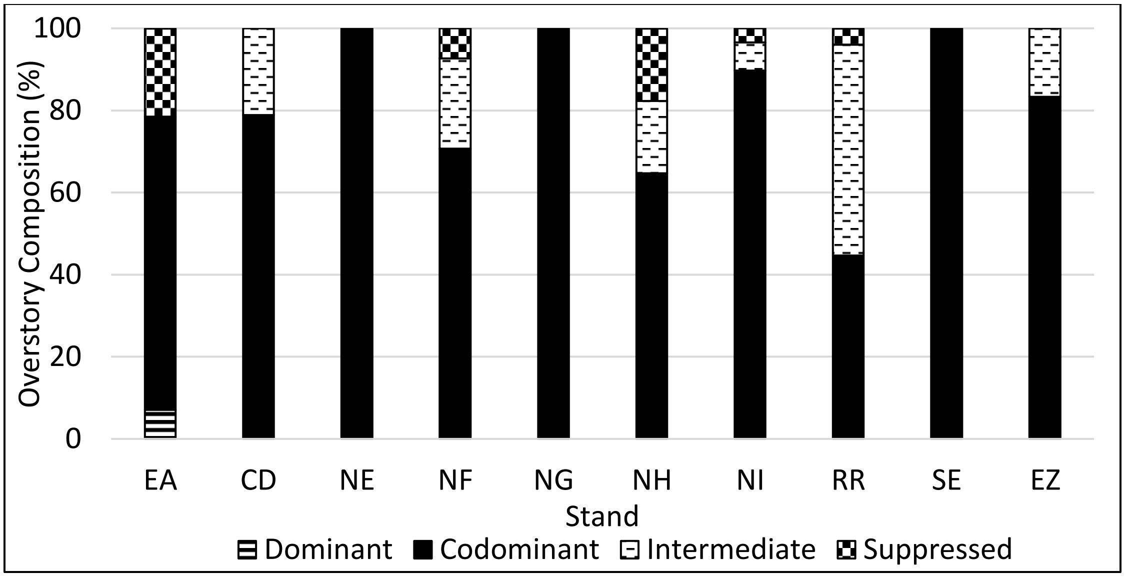


Figure 8. Overstory composition by crown class percentage of surveyed stands

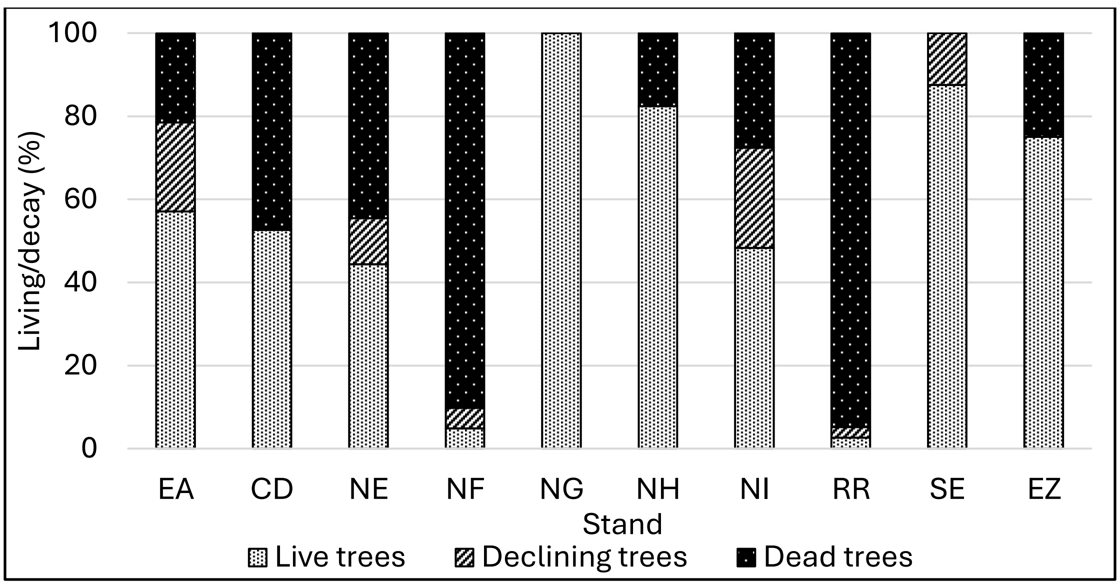


Figure 9. Living/decay stage by percentage of surveyed stands. All stages after "Stage 3 Dead" were combined to create the category of "Dead trees".

BTB Frequency & Density

In total, 8 out of the 10 stands surveyed were found to have BTB resin tubes present at the time stands were surveyed with 58 out of the 243 sampled trees containing tubes. The most notable are NG and EZ which had 0 BTB resin tubes on any trees within the radii of their plots. NE and NF were found to have had the highest mean BTB presence across sampled trees along with the highest BTB basal area and number of trees per ha with BTB present (Table 4).

Trees w/ BTB	**Stand**									
Variable	EA	CD	NE	NF	NG	NH	NI	RR	SE	EZ
No. of trees w/ BTB	2	6	**7**	**20**	**0**	5	10	7	1	**0**
Total BTB count	16	156	**251**	**509**	**0**	143	129	265	12	**0**
No. of trees per ha w/ BTB	0.23	0.39	**0.77**	**2.12**	**0**	0.53	1.05	0.13	0.18	**0**
BTB basal area (m^2/ha)	1.35	3.59	**3.88**	**7.17**	**0**	0.44	3.65	3.14	0.05	**0**
Mean BTB per tree	1.14	8.21	**13.94**	**12.41**	**0**	8.4	4.45	3.5	1.5	**0**
Standard error	0.88	4.3	**6.39**	**2.77**	**0**	5.09	1.7	1.63	1.5	**0**

Table 4. Data and analysis in relation to trees sampled with BTB within surveyed stands. This data includes total number of BTB trees, total BTB count, number of BTB trees per hectare, BTB basal area, and mean BTB per infested tree with standard error.

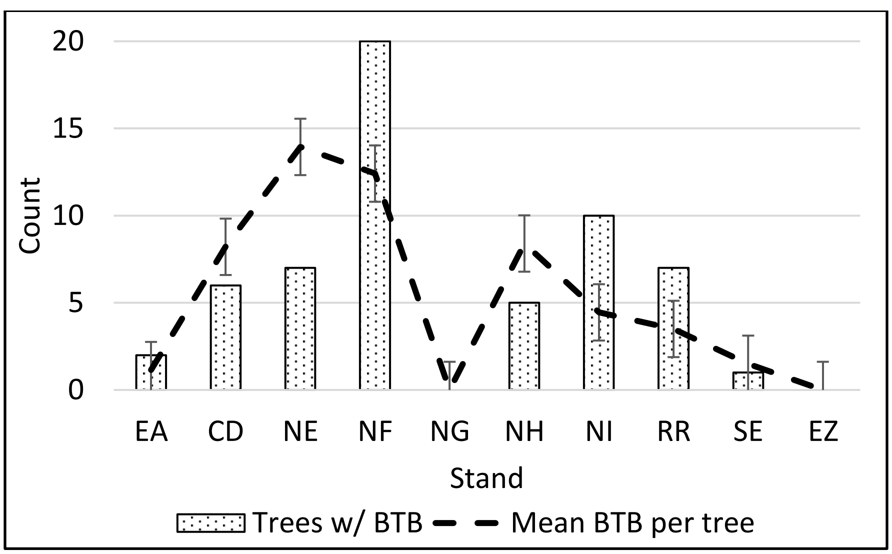


Figure 10. Displays total number of BTB trees with the mean and standard error of BTB per infested tree to show trends between the number of trees infested and count per surveyed stand.

BTB were consistently found with SPB and/or *Ips* spp. throughout most sampled stands at the time surveys were conducted (Table 5). However, while not a recorded or measured variable, SPB and/or *Ips* spp. presence was found to not be indicative of BTB presence through observation.

BTB w/ Other Beetles	**Stand**									
Variable	EA	CD	NE	NF	NG	NH	NI	RR	SE	EZ
Trees w/ BTB	2	6	7	20	0	5	10	7	1	0
Trees w/ BTB & SPB	0	2	6	15	0	1	6	7	0	0
Trees w/ BTB & Ips	0	2	3	11	0	2	5	3	0	0
Trees w/ BTB, SPB, & Ips	0	2	3	10	0	0	2	3	0	0

Table 5. Data on the presence of SPB and *Ips* spp. when BTB are present in surveyed stands.

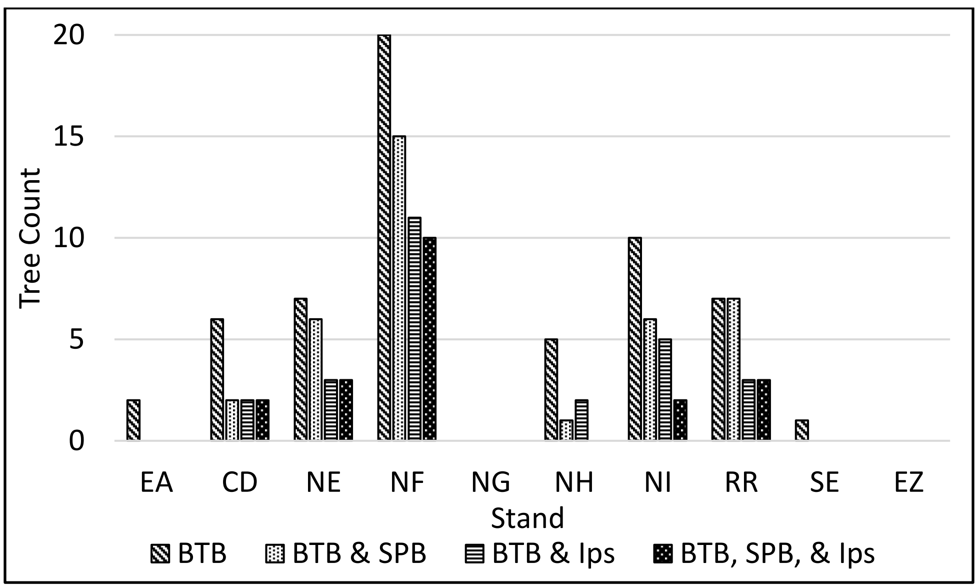


Figure 11. Shows the relationship between BTB presence and other bark beetle presence within surveyed stands.

Discussion & Conclusion

BTB were found in almost every stand regardless of treatment type, history, and size. Stands with no/low management (NE, NF) saw the highest mean BTB (Table 2, Figure 10). They were observed to have high hardwood and SPB presence. Stands with histories of mechanical treatment and multiple wildfires (NG, EZ) saw the lowest mean BTB (Table 2, Figure 10). They also had the lowest BAs (Table 1) meaning lots of open canopy and space between pitch pines, along with lowest observed quantity of overstory oaks.

These findings support previous literature on BTB behavior and the importance of open canopies and a pitch pine dominant overstory in pine barrens ecosystems. They stress the importance of thinning and disturbance as a means of management. There is a trend within this study where areas with solely mechanical thinning and at least one wildfire had lowest BTB count, BTB mean, other beetle presence, and dead basal area in comparison to those also treated with prescribed fire. Mechanical thinning was conducted to remove dead standing trees as well as mow the coppiced oak, which would account for the low dead basal area and sparse overstory oak content. An area with history of wildfire, mechanical treatment, and prescribed fire (NI) is an example of this trend. This stand had a higher percentage of dead/declining trees, higher number of trees with BTB, and a higher dead basal area than other mechanically treated stands. It is important to note that prior to burning NI, there were no dead standing trees as they were all mechanically removed. The high dead basal area is due in part to the moderate intensity prescribed fire that occurred one year after this mechanical treatment.

Of the trees recorded, BTB was found to infest a majority of dead or declining trees in all stands except stands with histories of fire and mechanical treatment (SE & NH) where the majority of BTB invested trees were alive. This supports previous studies and research that suggest BTB attack already trees weakened or stressed by other means.[7] Very similar to previously mentioned areas with low BTB presence, these stands were observed to have great open canopy and low dead basal areas (Table 2) with low live oak presence. One due to the mechanical removal of dead standing trees and overstory oaks (NH) and the other due to a higher intensity prescribed burn (SE) which had a greater observed quantity of dead oaks than other investigated stands.

When present BTB were found often with other SPB and/or *Ips* spp., however the opposite was often not true (Figure 11). Though not recorded or measured, *Ips* spp. and SPB were often observed to be found in surveyed pitch pines without BTB present. The best example of this occurred in the RHIC Ring where almost every tree in some plots had SPB present and no BTB. In this stand, SPB were found to have been more likely to be accompanied by *Ips* spp. than BTB.

These trends support previous research conducted on the behavior of BTB in their host selection being weakened trees whether by overstocked stands, heavy oak presence, other beetle damage, etc. They also suggest that low intensity prescribed burns are not effective management options as they do not burn at a heat high enough to kill overstory oaks, resulting in inadequate thinning of the stand and further weakening of pitch pines treated with fire.

Trends show that mechanical thinning and high intensity prescribed burns are preferred to reduce oak density and remove dead standing trees over low intensity burns as management techniques. These suggested practices in turn result in healthier pitch pines that are more likely to resist BTB density and frequency in pine barrens restoration stands. However, more research with a larger sample size is needed for this conclusion to be more definitive.

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