Variations in bat species composition across disturbance gradients in the Long Island pine barrens using acoustic monitoring

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Fig. 1 Northern Long-Eared Bat; *Myotis septentrionalis*

Fig. 2 Little Brown Bat; *Myotis lucifungus*

Fig. 3 Tricolored Bat; *Pipistrellus subflavus*

Fig. 4 Big Brown Bat; *Eptesicus fuscus*

Fig. 5 Silver-Haired Bat; *Lasionycteris noctivagams*

Fig, 6 Hoary Bat; *Lasiurus cinereus*

Fig 7 Eastern Small-Footed Bat; *Myotis leibii*

Fig 8. Eastern Red Bat; *Lasiurus borealis*

Fig. 9 Indiana Bat; *Myotis sodalis*

Abstract:
Pine barren ecosystems, a disturbance-dependent community requires regular management to clear understory clutter and maintain the open canopy of pitch pine (*Pinus rigida*). Management in the form of mechanical treatments and prescribed fire increases necessary roosting habitat and foraging opportunities for some bat species (Order *Chiroptera*). Many bat species populations are declining from habitat loss and the deadly fungal disease, white nose syndrome (WNS; *Pseudogymnoascus destructans*). However, Atlantic coastal islands, such as Long Island may act as refugia due to a lack of the caves where WNS proliferates. To assess how different levels of disturbance in disturbance-dependent pine barrens affect bat species richness and diversity, acoustic monitors were deployed across 10 different locations at Brookhaven National Laboratory. Regardless of the various forms of disturbance bats were detected at each stand. Unfortunately, with a 90% decrease of its population, and despite being observed at BNL in the past, NLEB was not detected at any of the sites.

Introduction:
Bats (order Chiroptera), the second largest order of mammals, play important ecological roles as prey, predator, arthropod suppression seed dispersal and more[6]. While previously found across America, habitat loss and white nose syndrome (WNS; *Pseudogymnoascus destructans)* have caused many species to experience population declines. WNS, a deadly fungus, leads to physiological problems with flying, balance and thermoregulation by altering wing structure[4]. Roosting is an essential aspect of a bat's life for protection, rest while foraging, and hibernation, however bats that roost in caves are at extreme risk of getting the disease as cave climate allows WNS to rapidly proliferate. In New York the nine bat species found are seen in figures 1-9 on the left. Specifically, the northern long-eared bat (*Myotis septentrionalis;*NLEB) was listed as endangered in 2023 and the tricolored bat (*Pipistrellus subflavus;* PERSUB), and little brown bat (*Myotis lucifungus;* MYOLUC) are vulnerable.

Brookhaven National Laboratory (BNL), located in Long Island Central Pine Barrens, is a highly fire-dependent community. While the fire is beneficial to the ecosystem and studies have shown that fire creates or improves habitat for many bat species, it can physically impact the bats through smoke inhalation and burns [5+7] . Wetland presence can also increase where a bat species forages since all bats drink water[2]. The southern pine beetle (*Dendroctonus frontalis;* SPB) , a newer disturbance at BNL, accelerates the succession of the unique pitch-pine barrens causing dead trees which leads to possible roosting sites[12].

Acoustic monitoring is a non-invasive technique to obtain species presence information without the actual capturing of the animal. There are still many unknowns about the effects of different disturbance-gradients on bat presence and diversity, thus continued surveillance is important especially for endangered and threatened species. .

Methods:
•By considering the disturbance type, the presence of wetlands and the most recent United States Fish and Wildlife (USFWS) Range-Wide Indiana Bat & Northern Long-Eared Bat Survey Guidelines (May 2024 ten different study sites were chosen to deploy ultrasonic acoustic monitors.
• Per the Survey Guidelines, fourteen detector nights are required per 49.7 ha of area surveyed. Survey sites ranged from ~5.6 ha to ~52.6 ha and the number of detector nights ranged from six to sixteen (Table 1).
•Detectors (Song Meter Mini Bat, Wildlife Acoustics Inc., Maynard, Massachusetts, USA) monitors were deployed approximately 2 meters off the ground, and at least 200 meters apart from one another and tied to a tree.
•Monitors were set to record bat vocalizations using echolocation during hours when the bats are most present, beginning 30 minutes before sunset and ending 30 minutes after sunrise.
•Each monitor was deployed on a tree facing towards the area of interest with the ultrasonic microphone facing upwards.
• Using Kaleidoscope Pro® (v. 5.4.8, Wildlife Acoustics, Inc., Maynard, Massachusetts, USA) each site was individually batch-processed for cluster analysis and auto-identification of the bats.
•In Kaleidoscope, the default bat-analysis mode was used and was set for "Bats of North America 5.4.0" in the region set to "New York."

Figure 13. Deployed monitor

Figure 14. Deploying a monitor

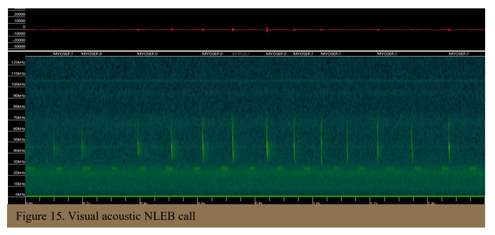

Figure 15. Visual acoustic NLEB call

Unit	Hectares	# Detector Nights	Treatment/Disturbance Type
Unit E	9.3 ha	16 nights in 2024 24 nights in 2022	Unmanaged control
Unit F	9.3 ha	16 nights in 2024 in 2022 24 nights in 2024	Prescribed burn 2022, SPB damage
Unit G+H	18.61 ha	10 nights in 2024 16 nights in 2022	Crescent Bow Fire 2012, Mechanical treatment 2022+ 2023
Unit I	9.3 ha	16 nights in 2024 in 2022	Crescent Bow Fire 2012, Mechanical treatment 2021, Prescribed burn 2023 Wildfire and Mechanical treatment by 2022 survey
Unit A	8.5 ha	16 nights in 2024 No 2022 data	Crescent Bow Fire 2012
Saddle East	5.6 ha	10 nights in 2024 10 nights in 2022	Prescribed fire 2023 Nothing done in 2022 survey
Unit C+D	15.4 ha	18 nights in 2024	Prescribed fires 2017/2018
RHIC Ring	52.6 ha	16 nights in 2024 20 nights in 2024	Wetlands, SPB presence
2nd Wildfire	10.1 ha	8 nights in 2024 8 nights in 2022	Crescent Bow Wildfire 2012, Paumanok Wildfire 2020
TS-10	30.35 ha	20 nights in 2024 No 2022 data	Man made pond

Table 1.

Acoustic Monitor Locations

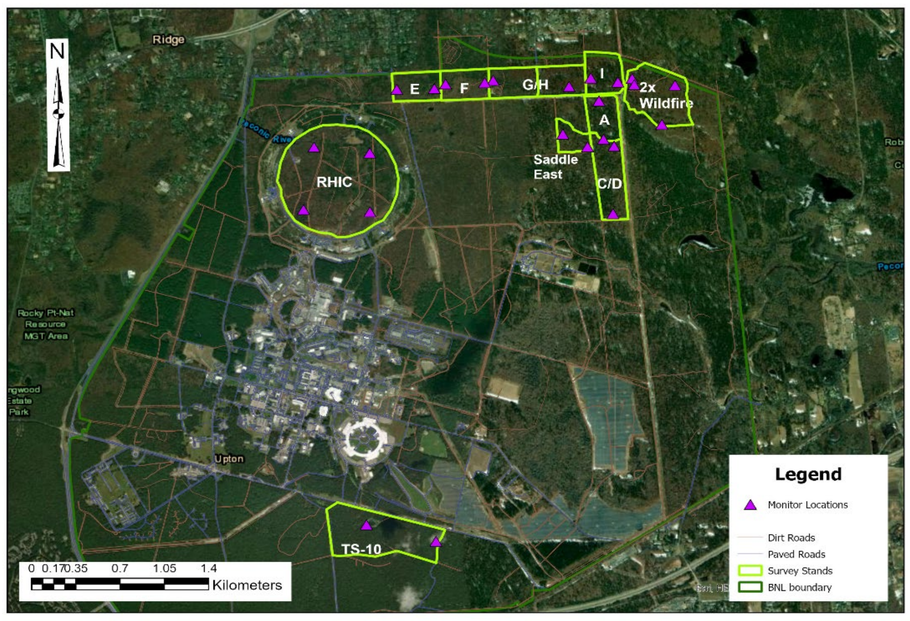

Fig. 10 Map of Brookhaven National Laboratory with blots where bat acoustic monitors were deployed.

Methods Cont'd:
• If the p-value was <.05 the species was considered present and if the value was >.05 the species was considered absent, unless vetted by an expert
• Using the significant p-values, a comparison analysis and Shannon diversity index was done between each unit to determine if bat presence was dependent on disturbance type, and time since disturbance.
• In order to increase sample size of each area and discuss differences in species richness and density acoustic survey data from 2022 done in the same areas were used. The only areas that differed were Unit T-S 10 and Unit A.
• Areas that were sampled twice in 2022 survey were also sampled twice in 2024 to increase comparison results between the two areas. Other areas of interest were still analyzed, but with smaller data sets.

Results:
- 32,000 acoustic bat calls were identified
- EPTFUS,LASBOR,LASCIN and LASNOC are the most likely to be detected at BNL, making BNL not significantly diverse
- 8/9 Species of bats were found, however only 7 of them were significant
- Wetlands didn't significantly increase bat presence
- Bat presence had either a neutral or positive response to fire, with negative effects being short lasting
- The NLEB was not significantly found
- Bat diversity tended to decrease post-management if management was done within 1 years, and after that excelled
- Bats are using areas that have extensive SPB damage
- The RHIC Ring had the most bat presence, however T-S 10 was the most diverse

Total Bat Species Found	EPTFUS	LASBOR	LASCIN	LASNOC	MYOLEI	MYOLUC	MYOSEP	MYOSOD	PERSUB
Unit G/H	982	126	398	311	0	9	0	1	2
Second Wildfire	51	23	77	26	0	5	0	0	1
RHIC Ring	5852	191	1545	1658	0	20	3	4	6
Saddle East	282	218	134	28	0	17	0	0	16
Unit E	2935	157	836	462	0	31	6	0	14
Unit F	2234	104	853	377	0	25	3	1	36
Unit C/D	1843	385	912	270	0	79	0	1	28
Unit I	2652	406	963	563	0	11	0	0	12
Unit A	989	194	376	143	0	15	1	0	35
T-S 10	525	471	597	512	0	18	0	0	7
Total	18345	2275	6691	4350	0	230	13	7	157

Table 2

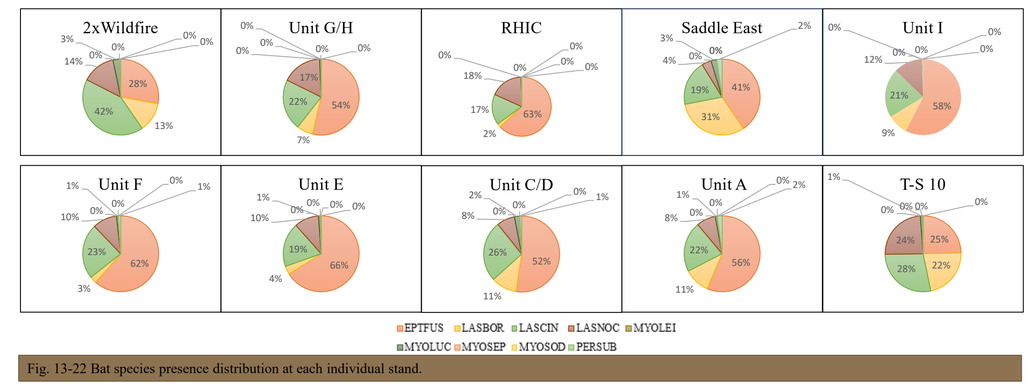

Fig. 13-22 Bat species presence distribution at each individual stand.

Fig. 11 Pie chart showing presence of bats relative to fire disturbance gradients

Diversity Over Time	2022	2024	Together
Unit G/H	H=1.21	H=1.19059	H=1.18
Second Wildfire	H=.97001	H=1.29	H=1.3
RHIC Ring	H=.805	H=1.05	H=1.0
Saddle East	H=1.2	H=1.18	H=1.35
Unit E	H=-.556	H=1.18	H=1.0
Unit F	H=.67	H=1.32	H=1.068
Unit C/D	H=.81	H=1.22	H=1.25
Unit I	H=1.06	H=1.16	H=1.14
Unit A	N/A	H=1.22	N/A
T-S 10	N/A	H=1.43	N/A

Table 3

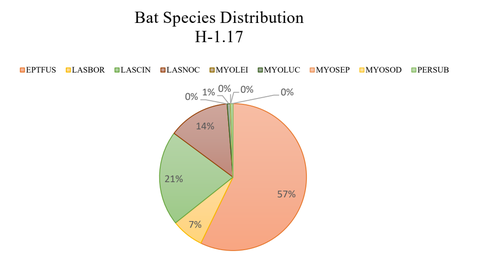

Fig. 12 Pie chart for total bat distribution across all stands

Discussion:
NLEB was not detected with significance, with 90% of the NLEB species being gone, and it not being detected or mist-netted in years, it is possible that the NLEB is no longer at BNL. Additionally, detections in the *Myotis* genus aren't reliable detections because acoustic software identification is commonly inaccurate for bats that emit high-frequency calls during foraging. Echolocation calls that are suited to being accurately identified are in areas that are uncluttered, but these small bats forage throughout cluttered areas[1]. While acoustic analysis can be a useful non-invasive strategy, it should be used with caution[11].

EPTFUS, LASBOR, LASCIN and LASNOC roost in higher populations, don't change roost sites as often, and aren't as affected by WNS. They also typically forage in open canopy, with lower frequency calls which acoustic monitors have a higher likelihood of detection[8].

When assessing how bats respond to fire gradients, there were no significant negative effects on bat species composition or diversity. Fire increases canopy gaps and insect abundance which provides far more benefit to bats than the negative impacts from the actual burning[7].

Proximity to water has been studied as an important consideration for foraging[3], while my results indicate that there was no significant correlation, increased sample size would be needed to validate these results. SPB disturbance didn't drastically affect the bats presence or absence. It is possible that since these beetles kill trees in the surrounding area, there's possible roosting habitat, but more research is needed to accurately provide that conclusion. Overall, due to the small sample size and the inaccuracies in acoustic analysis, many of the conclusions drawn from this are unknown and require a more in-depth study.

Brookhaven National Laboratory remains home to many bat species, possibly even to those that are threatened (MYOLUC and PERSUB). Bats, like fire often have negative connotations, however both are important factors of the environment that deserve to be correctly understood.

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