Fire effects on box turtle spatial ecology using opportunistic capture

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Abstract

Existing literature regarding prescribed burn treatment in forests and its effects on the eastern box turtle (*Terrapene carolina carolina*) focuses largely on turtle mortality rates. Turtle grazing habits and habitat use are most likely affected by this forest management strategy, as burns both destroy and facilitate vegetation growth. Fire history and opportunistic turtle capture data collected by the Environmental Protection Division at Brookhaven National Laboratory were used with the ArcGIS® program and RStudio® statistical analysis program to plot and visualize trends. Most of the data used consisted of turtles whose home ranges overlap pine barren burn plots and other areas affected by wildfire. Over the course of the data analysis, turtles found in the field during other studies were captured, processed, and entered into a database before being released. More turtles were observed and captured around more frequently burned plots than around less frequently burned plots. More turtles were observed and captured around plots that had been burned less recently than other plots. Fire history had no significant effect on turtle health, quantified by average mass. The data used was opportunistic, meaning further standardization could lead to more significant results. This study is consistent with Brookhaven National Lab's mission to protect the natural environment and ecosystems that persist throughout the property. The work done also proves relevance to Brookhaven National Laboratory and the Department of Energy as it serves to pursue the shared ideas of environmental research and protection. My experience and skills I've learned from this study have helped me greatly in my goals of becoming a great researcher and scientist. Getting hands on research experience has helped me immensely in formulating methodology and has increased my familiarity with the research process.

I. Intro

Background:

Fire ecology and management has been an increasingly important topic within environmental conservation and ecology discussion for years, with parties both supporting and opposing the management strategy. A lack of management along with climatic changes have been found to increase wildland fires which destroy both developed and undeveloped areas, decreasing resource availability, air quality, ecosystem quality, and the overall safety of humans and wildlife alike (Vander Yacht et. al. 2024). After large wildfires in the pine barrens devastated eastern Long Island in 1995, prescribed burns became both a more restricted and a more studied management strategy across the island, with increasing support and practice since the incident (Landis et al. 2005, Jordan et al. 2003). The continuing urbanization of Long Island and the substantial loss of natural ecosystems consequential to that development incentivizes an increasing effort to conserve remaining undeveloped land, especially within the Central Pine Barrens Region (Sohl & Sohl 2012, Kurczewski & Boyle 2000).

Approximately 21,250 ha of land has been set aside through legislation of the Long Island Pine Barrens Preservation Act of 1995 to aid in the protection and conservation of the Central Pine Barrens (Jung 1995). While this effort is successful against urban development, human management of the land is still brought into debate. Many private landowners remain hesitant to support prescribed fire implementation, due to the presence of many values at risk in the wildland-urban interface that is magnified by the lack of available resources to mitigate the risk (Blanchard & Ryan 2007, Ryan 2012). Even those familiar with prescribed fire are dissuaded from practicing due to the difficulties of using prescribed fire themselves, requiring governmental permission and control over the practice (Knapick et al., 2022., McCaffrey & Olsen, 2012). With a recent rise in discussion surrounding the benefits of prescribed fire across the northeast's forests, studies have continued to assess the impacts the strategy has on the local wildlife present in these burning areas.

One notable species, the eastern box turtle (*Terrapene carolina carolina*), has been largely used for mortality assessments due to the inefficiency of their stress response to escape instances of fire (Preston et al., 2020). This species is crucial to the balance of the ecosystems they inhabit through their predatory and herbivorous behaviors, necessitating an understanding of how prescribed burns could affect their ecology for a wider understanding of ecosystem stability. Eastern box turtles are seed dispersers, eating herbaceous material and excreting the seeds in their waste (Moll & Jansen, 1995, Conant & Collins 1991, Jensen 2008). As an omnivorous species, these turtles prey on small invertebrates including a wide variety of insects, small salamander species, and even exhibit some scavenging behaviors (Conant & Collins 1991, Jensen 2008, Figueras et al., 2021). Box turtles also act as surrogate and indicator species for the health of an ecosystem due to their susceptibility to diseases, small habitat range, and long life spans (Brown et al. 2003, Russell et al. 2004).

While ectotherms like the eastern box turtle are heavily associated with thermoregulation, most frequently exhibited through habitat selection and behavioral thermoregulation, the species has been found to select habitat based on more biological and geographical factors, with temperature ranges being a surprisingly more variable restriction (Parlin et al., 2017, Harris et al., 2020) . Both Ohioan (Parlin et al., 2017) and West Virginian (Weiss, 2009) populations of eastern box turtles were observed more frequently within habitats suited better for grazing habits and shelter availability, with temperature gradients having a wider range of diversity. These habitats include those with shrubs and fleshy fruits, along with abundant canopy cover and leaf litter. Additionally, eastern box turtles have the ability to overwinter in temperate climates, allowing them to persist during the colder months (Savva et al., 2010, Currylow et al., 2012). This ability provides stronger evidence of their tolerance of relatively variable temperature ranges. There is little evidence to suggest that individual behavior is significantly impacted by lower temperatures besides breeding and growth capabilities, along with further evidence to suggest that home ranges are affected little by overall climatic temperatures as long as basking areas are present. Some studies suggest warming temperatures in the northeast due to global climatic change could be beneficial to this species, as it would alleviate a restriction to reproductive and developmental capabilities of populations, as well as alleviate overwintering complications (Savva et al. 2010) . Other studies oppose this and hypothesize a decline due to changes in hatchling survival rates in warming climates (McCallum et al. 2009), as well as those which hypothesize warmer climates to be worse for any species living in areas.

Purpose and Objectives:

Brookhaven National Laboratory sits within the Long Island Central Pine Barrens, one of three Atlantic coastal pine barrens in the world. As fire-adapted ecosystems, many of the species present on the property are fire adapted and require periodic fire to survive. Pitch pine (*Pinus rigida*), one of the most fire-adapted species, dominate the landscape along with multiple species of oak (*Quercus* spp.) and heath species such as blueberry (*Vaccinium* spp.), and huckleberry (*Gaylussacia* spp.) (Landis et al. 2005, Jordan et al. 2003). With this study, we aim to better understand the impacts of prescribed burning and wildfires on the ecology of local eastern box turtles by studying those inhabiting the pine barrens woodlands of the lab property. The majority of studies investigating eastern box turtles and prescribed fire focus mainly on turtle death rates and probabilities due to their freeze stress response strategy. Many individuals will die when their home range is set ablaze, as they will most likely not attempt to flee the fire and instinctively hide within their hinged shell (Laarman et al. 2018, Lay 2016). While single front fires with ample refugia are believed to greatly increase the chance of survival for these turtles, this claim is still understudied and only supported through implicative findings (Melvin & Roloff, 2018).

By analyzing how burning affects vegetation and ecosystem development across different species, we can better implement management strategies to both maintain and restore ecosystems. Box turtle ecology in response to fire use and its aftermath is understudied, and our goal is to begin to fill this gap in available literature. Assuming the presence of nearby refugia, we hypothesize that a greater number of box turtle home ranges of 6.96 ha (Madden, 1975) will overlap with infrequently burned habitats than with frequently burned habitats. We hypothesize that a greater number of box turtle home ranges will overlap with habitats burned 11-15 years prior to capture than with habitats burned more recently. We hypothesize turtles whose home ranges overlap with infrequently burned habitats will weigh more on average than turtles whose home ranges overlap frequently burned habitats. We hypothesize turtles whose home ranges overlap with habitats burned 11-15 years prior to capture will weigh more on average than turtles whose home ranges overlap with habitats burned more recently.

Habitats with frequent disturbance can be described through assessing vegetation makeup, as frequent fires will facilitate a greater presence of pitch pine and scrub oak than larger oak trees (Jordan et al., 2003). Areas of less frequent or sporadic disturbance should allow for a greater buildup of leaf litter and duff which is crucial for box turtle burrowing and thermoregulation. These plots should also contain enough understory vegetation to allow for abundant food such as berries and small invertebrate species as well as ample cover for thermoregulation and cover from stressors such as excessive solar radiation and predators (Jordan et al., 2003, Moll & Jansen, 1995, Figueras et al., 2021). Refugia can be described as nearby, accessible areas with suitable habitat unaffected or affected substantially less than the current area the turtle is in at the time of disturbance (Dodd et al. 2006, Currylow et al., 2012) When these features are present, turtles have a higher chance of being present in a non-burning area, surviving prescribed burns, and taking refuge within an unburned section of their home range as new vegetation emerges from the newly burned habitat (Melvin & Roloff, 2018, M. Flannigan et al., 2000, M. D. Flannigan et al., 2006). For this study we will define a frequently burned plot as being burned once within 15 years prior to the most recent burn, as long as the most recent burn was also within 15 years prior to the turtle's capture (Jordan et al. 2003, Jamison et al. 2023). The terms "eastern box turtle(s)", "box turtle(s)", "turtle(s)", and "individual(s)" will be used interchangeably throughout the following material.

II. Materials and Methods

Site Description:

In the northeastern section of the Brookhaven National Lab, Upton NY property there are 188 acres separated into 10 central pine barren burn plots (Fig. 1). Each of these burn plots are used for prescribed burns and studies regarding prescribed burn effects such as this one. The plots are all classified as pine barren stands and contain the standard vegetation at varying growth stages based on burn history. Many of the turtles found were captured while crossing dirt or paved roads used as firebreaks bordering the plots.

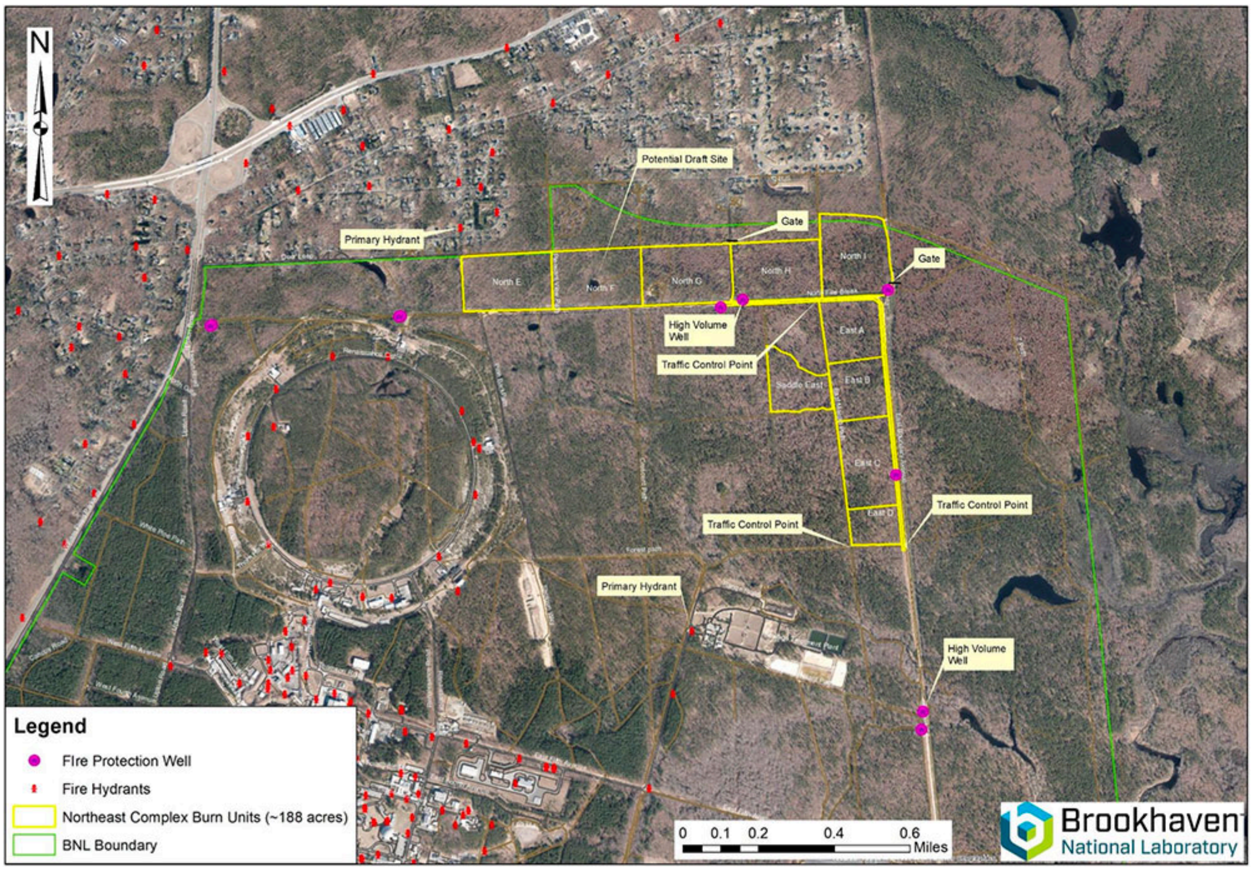

Figure 1: Map of burn units established part of the BNL burn plan. Each of the ten burn units are between 8 and 23 acres (Roedel 2023)

Existing Data:

The majority of data used for this study were provided by Dr. Timothy Green, Natural Resource Manager in the Environmental Protection Division. The massive collection of data contains data collected from 700+ individual eastern box turtles over 21 years of opportunistic capture by interns and faculty across the lab's property. Any individuals weighing equal to or less than 180g were not included in mass analyses, as these turtles are most likely not mature and would fail to produce accurate trends (dePersio & Allender, 2019). The data was organized and reformatted to match the most recent data collected. Some data required coordinate correction and inferencing, as many of the old entries had only approximate locations recorded. Burn history data in the form of a shape file of the lab's property was also used, provided by Kathy Schwager, Prescribed Fire Program Manager in the BNL Environmental Protection Division and by Sam Gilvarg of SUNY of Environmental Science and Forestry.

Turtle Processing:

When a turtle was encountered in the field, date, time, and location were recorded as well as the age and sex of the individual. The straight carapace length was taken with a caliper from the anterior point at the midline to the posterior notch at midline. Then the cumulative plastron length and plastron width at the widest point were measured using similar procedures. The turtle's mass was recorded using a hanging scale attached to a bag which the turtle is placed in. All data is recorded in a notebook and later entered into Excel®. After all data was recorded, each individual received a unique combination of notches filed into the shell for identification if ever recaptured. Individuals with existing notches had their codes recorded within their data entry before being released. Most of these processing instances were done in the field, allowing individuals to be released where they were found.

Mapping and Statistical Analysis:

After the data was corrected to the fullest extent and converted to UTM, the coordinates were brought into the ArcGIS® program to map within proximity to the fire history data. A 148.84m radius buffer was added to each turtle coordinate to observe a projected home range of 6.96 ha, which will be further referred to as either "projected home range(s)" or "home range(s)". All turtles whose projected home ranges intersected with established burn plots or previously burned areas (Fig. 2) were assigned the disturbance plot/area with the greatest amount of overlap as their habitat as well as the state of that plot at the time of capture (eg. "Frequent" or "Infrequent") based on fire history data (App. A). All turtles whose projected home ranges fell completely outside of the burned areas were removed from the data set. Each datum was also labeled with the number of years since the most recent fire disturbance and type of disturbance (e.g. prescribed fire or wildfire). Data was then reorganized and reformatted for statistical analysis through RStudio®.

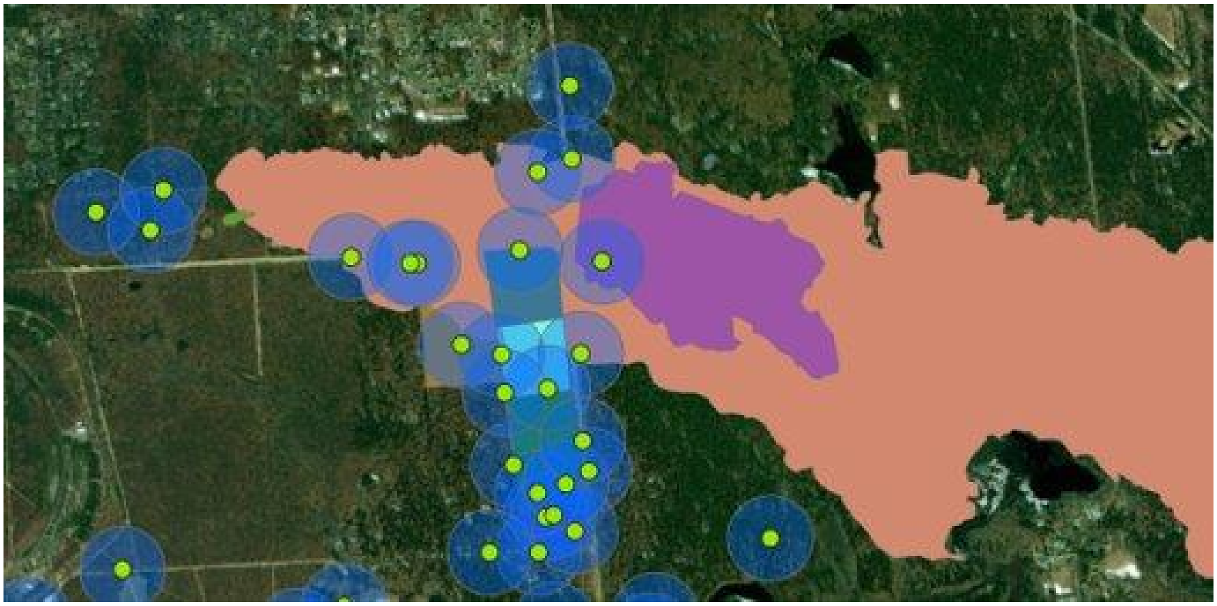

Figure 2: Locations of burn plots and burned areas represented by polygons. Coordinates where turtles were found represented by points with 6.96 ha projected home ranges represented by semi-transparent radii. Fire history data is mapped through multicolored polygons present in the northeastern area of Brookhaven National Laboratory property.

Standardization of opportunistic data was attempted through the removal of time and area differences affecting turtle capture probability between habitat types (App. B). To ensure the area of the burn plots were not double counted, the area of each assigned habitat was calculated and sums were sorted into one of the following categories: “0-5 years since last burn” , “6-10 years since last burn”, “11-15 years since last burn”, “frequent”, or “infrequent” based on a single presence of that habitat as well as the category in any capture datum. After the areas of each category were calculated, the number of turtles per year of that category was divided by the respective area value to calculate turtles per year per hectare (N/yr/ha). Average masses of turtles found in each category were also calculated to quantify average health of turtle populations and compared to observe possible trends between habitat types. A Welch two sample t-test was performed on turtle mass data to calculate statistical significance between “frequent” and “infrequent” habitat data sets (App. C). A Kruskal-Wallis chi-squared test was performed on turtle mass data to calculate statistical significance between “0-5”, “6-10”, and “11-15” years since las burn data sets (App. D).

III. Results

Turtle Capture Count Comparison:

A greater number of turtles were captured per year per hectare with home ranges overlapping “Frequent” habitats (~0.021 N/yr/ha) than turtles captured per year per hectare with home ranges overlapping “Infrequent” habitats (~0.009 N/yr/ha) (Fig. 3). A greater number of turtles were captured per year per hectare with home ranges overlapping habitats burned between 11-15 years prior to capture (~0.011 N/yr/ha) than turtles captured per year per hectare with home ranges overlapping habitats burned between 0-5 and 6-10 years prior to capture (~0.004 N/yr/ha and ~0.005 N/yr/ha respectively) (Fig. 4).

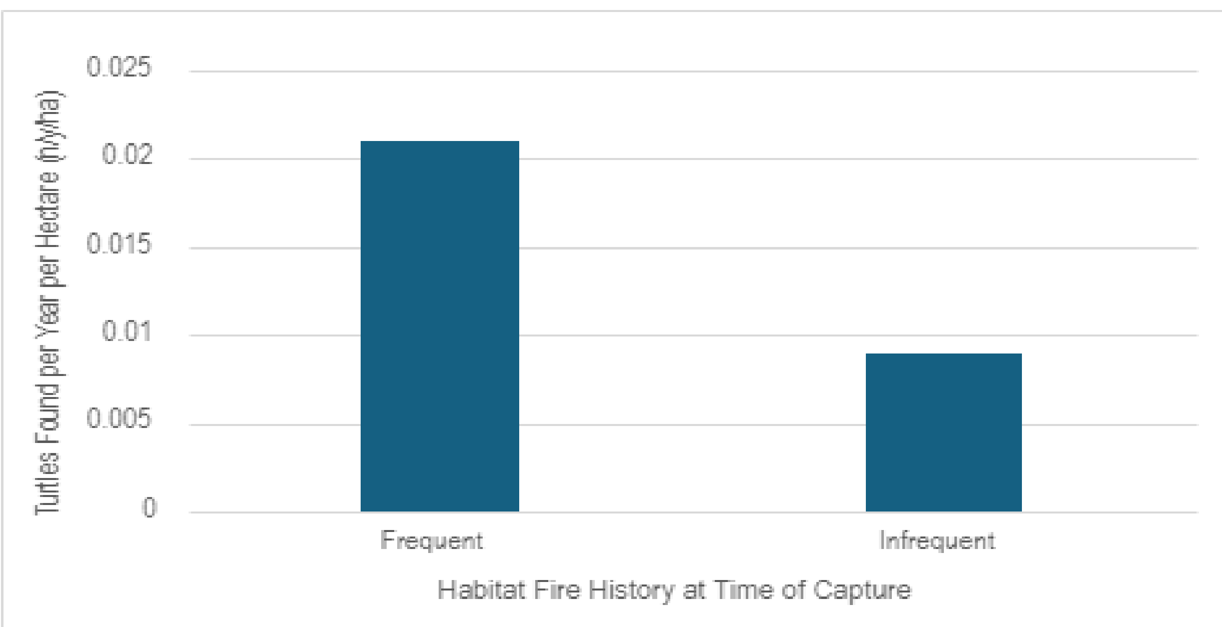

Figure 3. Turtles found per year per ha near frequently burned areas and infrequently burned areas. A greater number of turtles were found per year per hectare near frequently burned areas (~0.021 N/yr/ha) than near infrequently burned areas (~0.009 N/yr/ha).

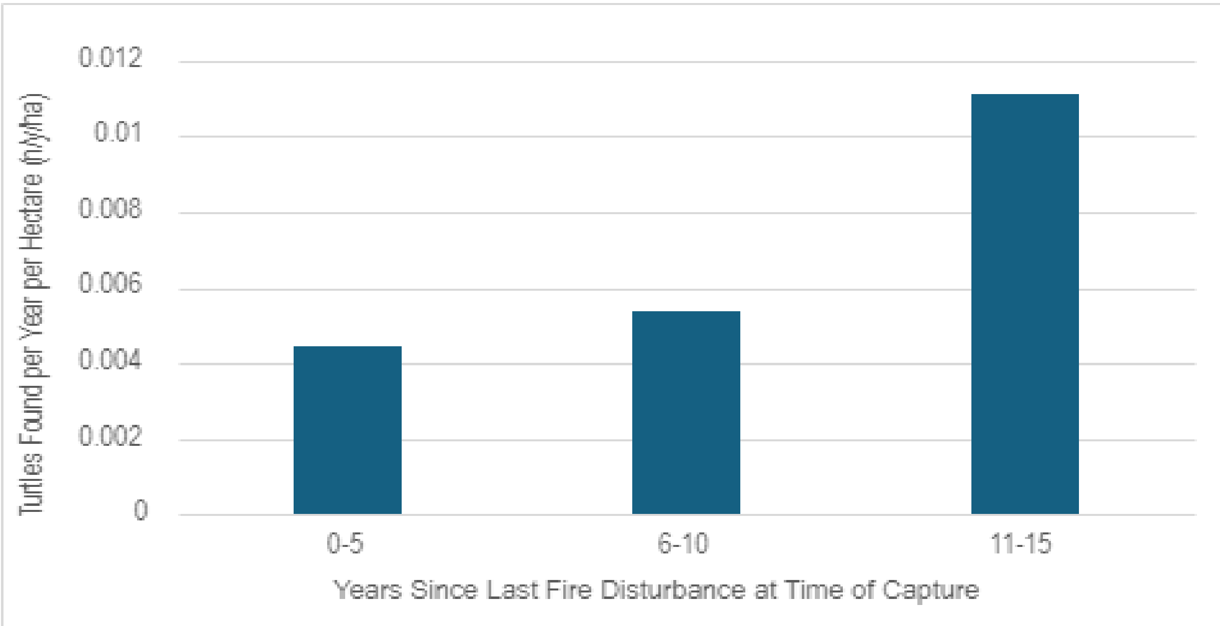

Figure 4. Turtles found per year per ha near areas burned between 0-5, 6-10, and 11-15 years prior to capture. A greater number of turtles were found per year per hectare near areas burned between 11-15 years prior to capture (~0.011 N/yr/ha) than near areas burned between 0-5 and 6-10 years prior to capture (~0.004 N/yr/ha and ~0.005 N/yr/ha respectively).

Turtle Mass Comparison:

There was no significant difference in average mass found between turtles with home ranges overlapping “Frequent” habitats (487.5g ± ~1.55) and turtles with home ranges overlapping “Infrequent” habitats (~509.9 ± ~0.69) (Fig. 5). P-value = 0.4549, failed to reject the null hypothesis. There was no significant difference in average mass found between turtles with home ranges overlapping habitats burned 11-15 years prior to capture (~512.3g ± ~1.21) and turtles with home ranges overlapping habitats burned 0-5 or 6-10 years prior to capture (~510.7g ± ~0.95 and ~478.6g ± ~1.12 respectively) (Fig. 6). P-value = 0.2974, failed to reject the null hypothesis.

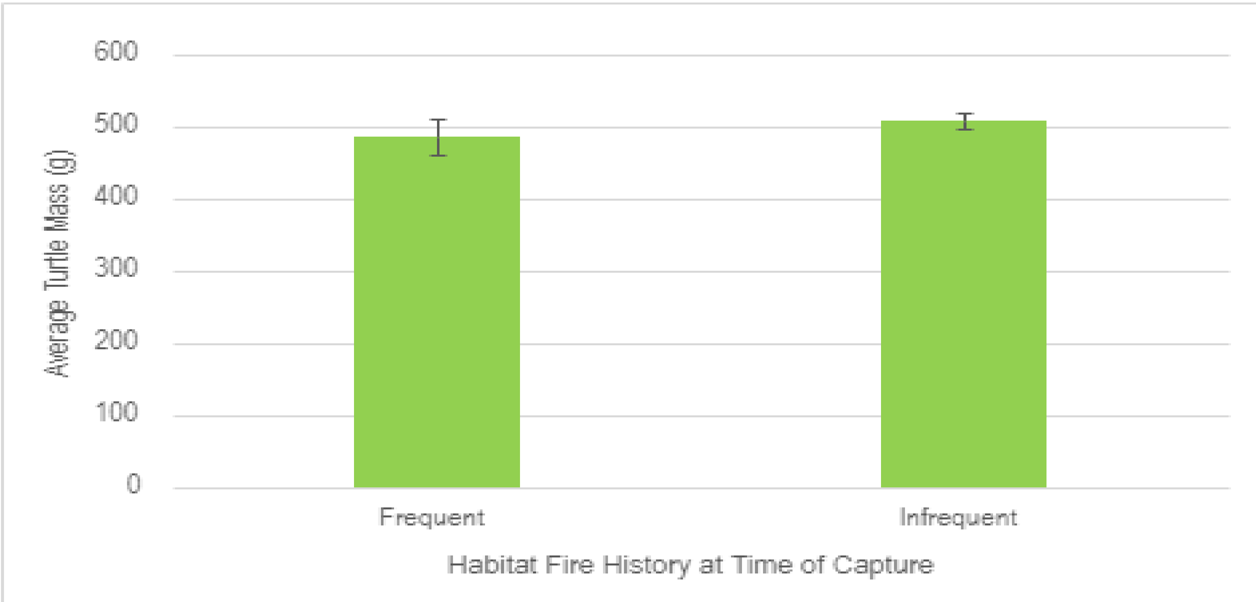

Figure 5. Average mass of turtles found near frequently burned areas (487.5g ± ~1.55) and infrequently burned areas (~509.9 ± ~0.69). No significant difference in mass was found between fire histories. P-value = 0.4549, failed to reject the null hypothesis.

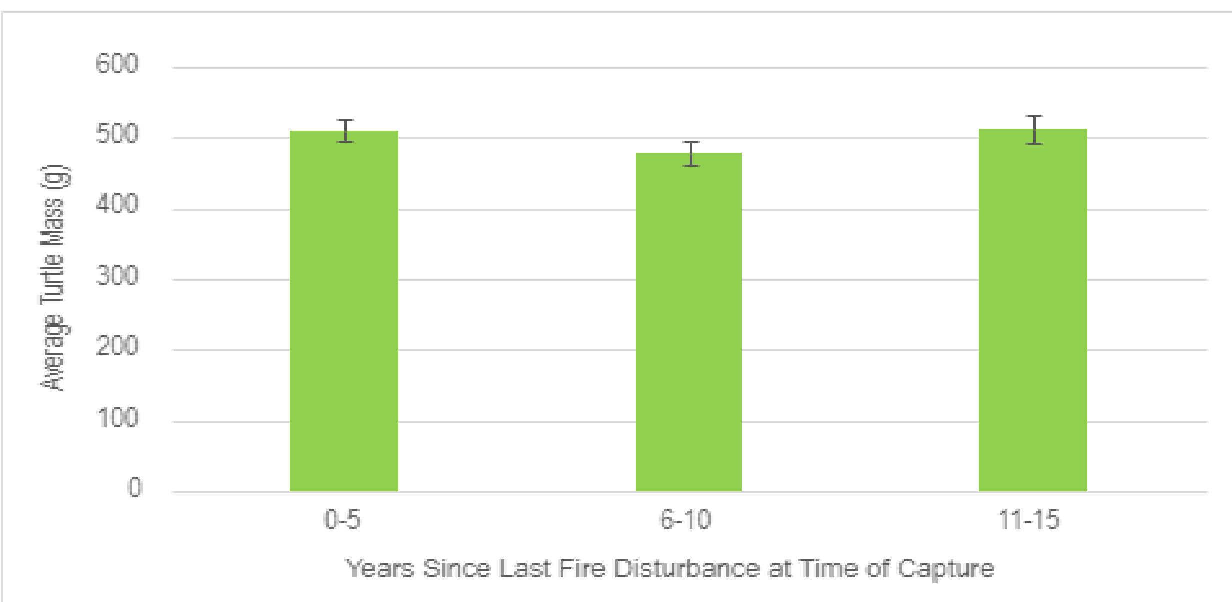

Figure 6. Average mass of turtles found near areas burned between 0-5 years prior to capture (~510.7g ± ~0.95), 6-10 years prior to capture (~478.6g ± ~1.12), and 11-15 years prior to capture (~512.3g ± ~1.21). No significant difference in average mass was found between fire histories. P-value = 0.2974, failed to reject the null hypothesis.

IV. Discussion & Conclusion

Turtle Capture Count Findings and Implications:

"Frequent" habitats had a capture rate 2.35 times greater than that of "Infrequent" habitats, whereas habitats burned 11-15 years prior to turtle capture had a capture rate ~2.49 times greater than habitats burned 0-5 years prior to turtle capture and ~2.07 times greater than habitats burned 6-10 years prior to turtle capture. These drastic differences could imply a similar trend in turtle abundance within these habitats, likely explained by vegetation presence and regeneration rates. Habitats that are frequently burned characteristically lack dense overstories which block sunlight and siphon nutrients away from developing understory vegetation. The lack of large and oppressive vegetation allows for more understory growth with greater biodiversity, most likely facilitating abundant food sources for box turtles such as heath species and leafy greens (Landis et al. 2005, Jordan et al. 2003, Moll & Jansen, 1995, Conant & Collins 1991,). The understory growth should also provide ample cover for box turtles to both thermoregulate and escape/hide from predators (Preston et al., 2020). Less recently burned habitats are more likely to have these beneficial species than more recently burned habitats, as the beneficial vegetation takes time to regenerate (Jamison et al. 2023). Habitats given greater time to regenerate also provide copious leaf litter and dense understories which allow box turtles to burrow and outlast unfavorable conditions such as colder temperatures and instances of fire

(Parlin et al., 2017, Savva et al. 2010). The abundance of box turtles in fire affected habitats could help indicate the habitat's stage of succession through capture probability and presence assessments. This finding supports their role as a possible indicator species and further proves their importance within the pine barren habitat.

Turtle Mass Findings and Implications:

Fire history was found to have no significant effect or correlation on average turtle mass. Averages calculated for both "Frequent" and "Infrequent" habitats were statistically identical to each other. Averages calculated for habitats burned 0-5, 6-10, and 11-15 years prior to turtle capture were also statistically identical. The failure to reject the null hypothesis is most likely due to the presence of nearby refugia along with instances of inconsistent individual mass (Melvin & Roloff, 2018, M. Flannigan et al., 2000). The practice of small-scale prescribed burns here at Brookhaven National Laboratory could explain the lack of significant difference, as many of the captured individuals' home ranges overlapped with control areas. These areas most likely provide resources to individuals present in less favorable habitats and correct possible differences. The probability of individuals carrying eggs, laying eggs, various shell shapes and sizes, and seasonal diets could all cause inconsistencies within an individual's mass and affect population averages (dePersio & Allender, 2019).

Opportunistic Data Issues:

The opportunistic nature of the data used caused a multitude of issues during the organization and analysis processes. The lack of standardization throughout the data's collection and the 20+ year time frame led to inconsistent formatting, requiring frequent censorship of data as the study continued. Data with incorrect coordinates, mixing up individual notch codes, failure to record weight and specific locations in earlier entries, and corrupted data were just a few of the many frustrations met when working with the data we had been provided. All data required a person to “stumble upon” individuals in specific areas of the lab, meaning strong biases of human presence and intention exist across the entirety of the study area. Additionally, the data was organized and processed through extensive standardization attempts which significantly aided our ability to correctly interpret trends, yet some biases and inconsistencies still exist and affect the outcome of our analysis.

Future Studies:

The trends found can act as foundations for further research investigating similar questions. A more standardized and consistent study could aid in both our understanding of box turtle ecology in relation to fire, and our understanding of opportunistic data and its restrictions. Future studies using this same data can use similar standardization methods, or develop new strategies to further correct the opportunistic data such as temporally isolating exact instances of available habitat area, estimating the probability of human presence in specific areas at specific times, or even estimating the probabilities of turtle locomotion between habitat types.

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VIII. Acknowledgements

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Not export controlled

IX. Appendixes

turtle	plot	plot type	plot type at capture	years time since last burn	time of capture	Mass	Time Since Category
3R12R	east d	i	infreqent (wild)	2	6/13/2006	417	0-5
3R3L11R	east d	i	infreqent (wild)	9	6/12/2013	70	6-10
9R3L8L	east d	i	infreqent (wild)	9	7/2/2013	535	6-10
11R3L4L	east d	i	infreqent (wild)	9	7/15/2013	490	6-10
1R8L11L	2012 fire share	i	infreqent (wild)	3	5/28/2015	530	0-5
1R8L12L	East C	i	infrequent	10	5/28/2015	480	6-10
8R8L12R	East d	i	Infrequent wild	11	7/1/2015	630	11-15
8R8L12L	East D	i	infrequent	10	7/10/2015	485	6-10
1R9L9R	East d	i	infreqent (wild)	11	8/14/2015	505	11-15
2R9L3R	East d	i	Infrequent wild	11	9/9/2015	550	11-15
1R10L3R	East d	i	infrequent wild	11	9/19/2015	560	11-15
2R10L3R	2012 fire share	i	infreqent (wild)	3	9/26/2015	510	0-5
2R9L12R	East C	i	infrequent	11	6/17/2016	495	11-15
3R9L10L	East D	i	infrequent	11	6/28/2016	498	11-15
4R9L9R	east d	i	infreqent (wild)	12	7/6/2016	585	11-15
11R9L12R	october 2011 rx	f	frequent	4	7/14/2016	435	0-5
8R9L10L	2012 fire share	i	infrequent	4	7/22/2016	490	0-5
9R9L11L	East d	i	infreqent (wild)	12	7/28/2016	495	11-15
12R4L8L	2012 fire share	i	infrequent	5	5/12/2017	525	0-5
4R1L2L	East D	f	frequent	0	6/15/2017	540	0-5
10R1L12R	east d	i	infreqent (wild)	13	9/14/2017	435	11-15
9R9L11L (recapture)	East d	i	infreqent (wild)	13	9/27/2017	N/A	11-15
4R2L12L	2020 wildfire	i	frequent (wild)	3	6/20/2023	515	0-5
8R10L10R	2012 fire share	i	infreqent (wild)	11	6/23/2023	500	11-15
1R11L10R(F)	North F	f	infrequent	1	7/12/2023	585	0-5
8R10L12L	East C	f	frequent	6	7/13/2023	535	6-10
2R3L4L	East C	f	frequent	7	4/8/2024	N/A	6-10
12R4L9L	2012 fire share	i	infreqent (wild)	12	6/6/2024	360	11-15
12R4L11L	2012 fire share	i	infreqent (wild)	12	6/7/2024	535	11-15
9R10L11R (Recapture)	North F	f	infrequent	2	6/13/2024	522.5	0-5
9R10L12R	North F	f	infrequent	2	6/21/2024	520	0-5
R2L2R4(bruh)	East D	f	frequent	0	6/26/2024	615	0-5
10R10L11R	EastB	f	frequent	6	7/2/2024	400	6-10
1R11L3R	saddle east	f	frequent	1	7/3/2024	435	0-5
1R11L9R(M)	East C	f	frequent	7	7/10/2024	425	6-10

Appendix A: Turtle coordinate data after mapping and organization through ArcGIS®. Notch codes are listed under "turtle" to label individuals. Labels assigned to habitat polygons are listed under "plot", assigned by selecting the polygon most overlapped with that individual's projected home range. Fire history category is listed under "plot type" and was determined through criteria listed in the "Purpose and Objectives" section of the Introduction. "Plot type at capture" is identical to "plot type" aside from the additional listing of "(wild)" if fire was unintentional. Time between turtle capture and most recent fire disturbance of their assigned habitat was calculated and listed under "years time since last burn". Date of turtle capture was listed under "time of capture". Record turtle mass was listed under "Mass". Three categories were assigned to each turtle based on the amount of years between turtle capture and the most recent fire disturbance of their assigned habitat, listed under "Time Since Category".

Plot Type (PT)	Turtles Found (n)	Years sampling (T)	Turtles Found per Year	Area of Plot Types (ha)	Turtles Found per Year per Hectare	xt
Frequent	9	7.994520548	1.125771076	53.63319643	0.020990192	0.020990192
Infrequent	26	18.03561644	1.441591979	161.1493085	0.008945691	0.008945691

Plot Type	Turtles Found (n)	Average turtle Mass (Grams)	Standard Deviation	Standard Error
Frequent	8	487.5	69.91065727	24.71714992
Infrequent	25	492.3	54.65764264	10.93152853

Years Since Last Burn (T)	Turtles Found (n)	Years sampling (T)	Turtles Found per Year	Area of Plot Types (ha)	Turtles Found per Year per Hectare	xt
0-5	13	18.06849315	0.719484458	161.1493085	0.004464707	0.004464707
6-10	9	11.08493151	0.811913	151.7011765	0.005352055	0.005352055
11-15	13	8.942465753	1.453737745	130.9283715	0.011103306	0.011103306

Years Since Last Burn (T)	Turtles Found (n)	Average turtle Mass (Grams)	Standard Deviation	Standard Error
0-5	13	510.7307692	54.59522922	15.14199218
6-10	7	478.5714286	47.18612733	17.83467975
11-15	12	512.3333333	66.78863842	19.28021919

Appendix B: Calculations made with information outlined in the above table (App. A). "Turtles Found" values were standardized by dividing by the amount of years between the least recent and most recent capture instances and by the calculated retroactive area across that time period which fell into the specific habitat category.

```
Welch Two Sample t-test

data:  Mass by Habitat
t = -0.77826, df = 9.7441, p-value = 0.4549
alternative hypothesis: true difference in means between group frequent and
group infrequent is not equal to 0
95 percent confidence interval:
 -86.74355  41.95188
sample estimates:
  mean in group frequent mean in group infrequent
                487.5000                 509.8958
```

Appendix C: Welch two sample t-test performed on Mass/Habitat data comparing average turtle mass data to "frequent" and "infrequent" habitats.

```
Kruskal-Wallis rank sum test

data:  Mass by Years
Kruskal-Wallis chi-squared = 2.4254, df = 2, p-value = 0.2974
```

Appendix D: Kurskal-Wallis rank sum test performed on mass data in relation to time since last burn disturbances categorized into "0-5", "6-10", and "11-15" years.