2024
Salem State University

Danehy Park Mini-Forest

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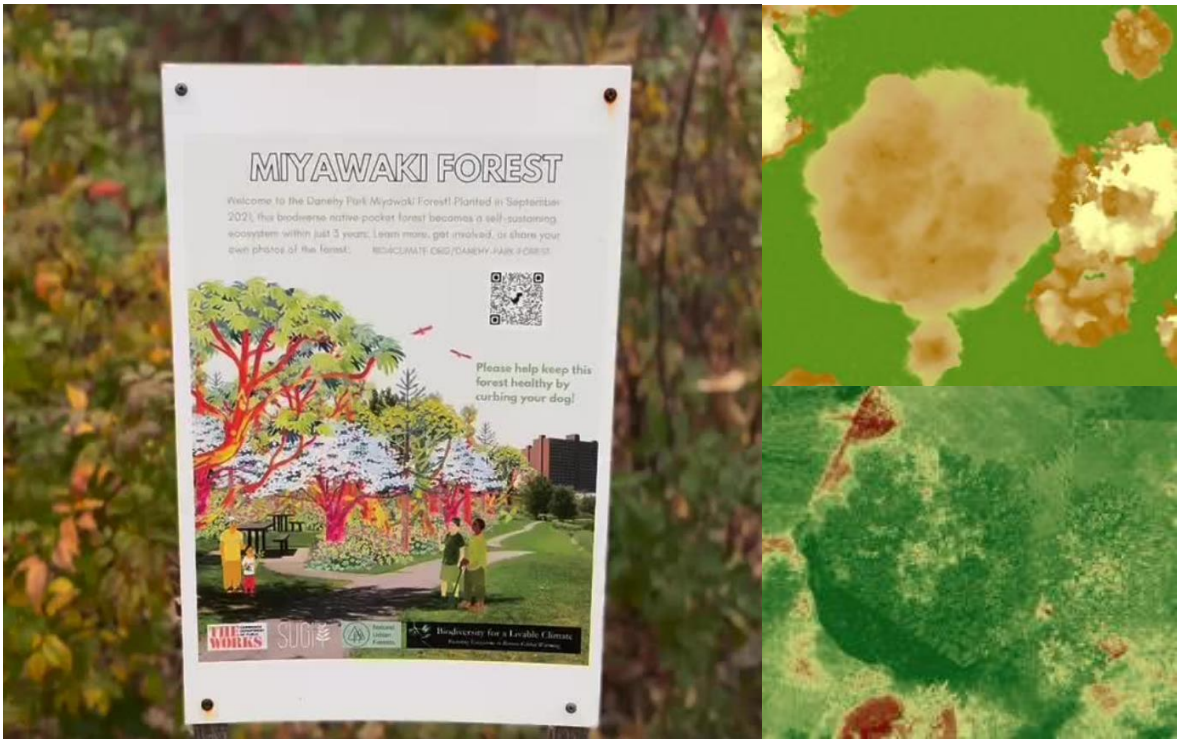
Edited by Nicholas Geron PhD



Introduction

Mayor Thomas M. Danehy Park is a 50-acre green space in Cambridge, Massachusetts, a suburb to the north of Boston across the Charles River. Historically, the site was composed primarily of clay, attracting brick manufacturers in the mid-19th century. After New England Brick Company ceased excavation in 1952, the city of Cambridge began to use the now-deep pit mine as a landfill for around two decades. Although the city ceased dumping waste in the early 1970s, it would continue to be filled, this time by sediment from excavation done by the Massachusetts Bay Transportation Authority as they extended their transit system through Cambridge. The park was developed between 1988-1990 on top of the landfill and was first opened to visitors in September of 1990.

Developed by botanist Akira Miyawaki, the Miyawaki forestry method acts as a guideline for planting small, urban forests composed entirely of native plants as determined by the "potential natural vegetation" (PNV) of a given area - what native species would constitute a climax forest had human interference not occurred - and then planting a dense forest using those native species. Because of their composition and density, Miyawaki forests are able to grow several times faster than traditionally-grown forests while also increasing local biodiversity.

The mini-forest Forest in Danehy Park was planted in the autumn of 2021 through a collaboration with the City of Cambridge and the non-profit Biodiversity for a Liveable Climate. The forest is Miyawaki inspired with a collection of high density native species that are not a climax community. The forest is 4,310 square feet and made up of 1,400 trees and shrubs from 32 species native to Massachusetts. In 2022, 12 months after planting, the survival rate of the plants was 98% and the average height of the 3 tallest trees was 2 meters. Another year later, in 2023, the survival rate was 95% and the 3 tallest trees averaged out at 5.3 meters tall.

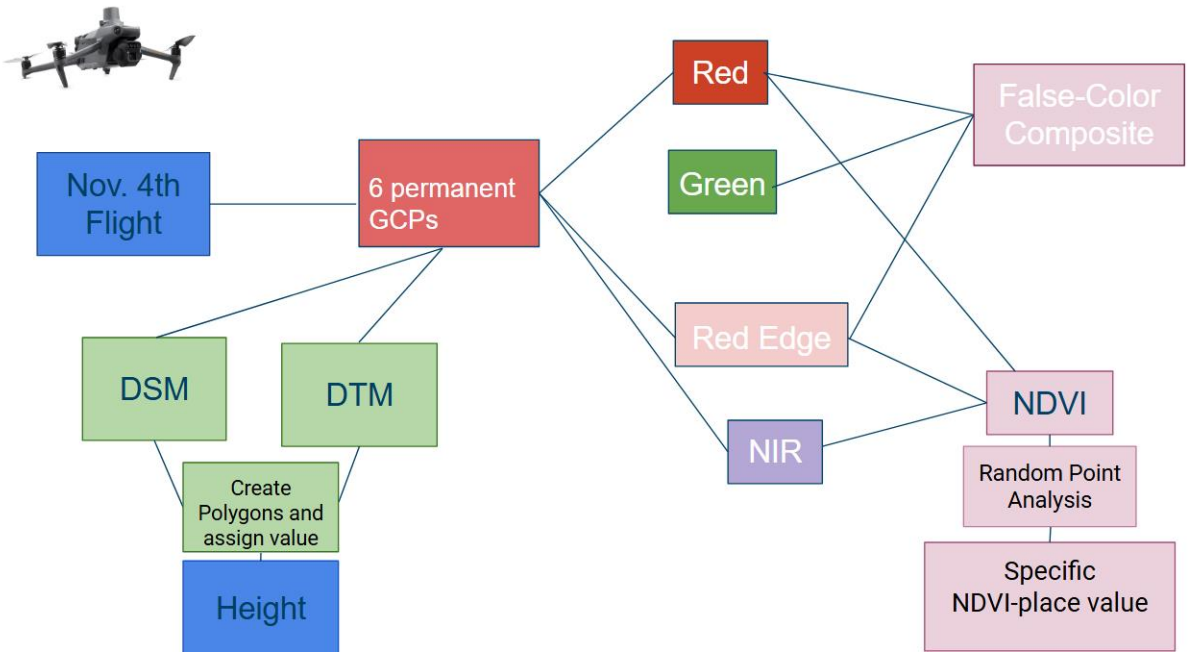
Research Questions

How did the NDVI (greenness) of the forest compare to the surrounding vegetation?

What is the height of the forest compared to the surrounding vegetation?

Based on the NDVI, are some parts of the forest healthier than others?

Methodology



Flight Information

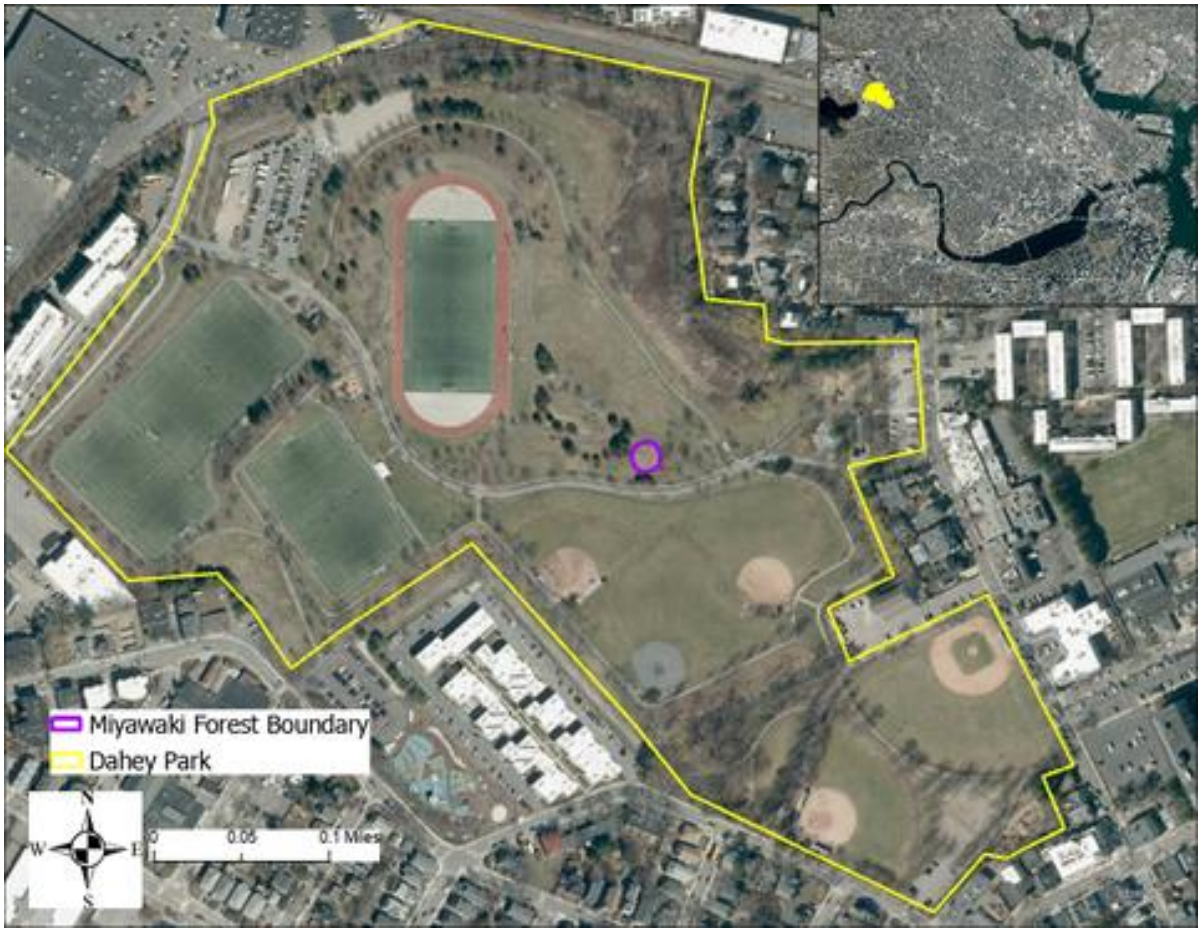
The project requires that our group fly over the Danehy Miyawaki Forest as well as parts of the surrounding area in order to observe the forest's health and species of the vegetation growing within the mini-forest. We captured 2D multispectral and recorded the DTM and DSM of the site in order to conduct our research. Potential factors for the scene that influenced the flight include a restriction on elevation which prevented the drone from exceeding 100ft, the seasonal condition of the trees within the forest,and visitors of the park that were present. The % overlap required of the images was relatively high at about 90/80 in order to measure the height of the trees within the mini-forest while flying around 100ft, with the optimal minimum pixel size being 5-15 cm in order to catch detailed imagery of the vegetation health and species.

Timestamp	Location	GCPs	Cloud Cover	Wind Speed	Wind Direction	Temperature (F)
9/2/2024 11:11:44	Danehy park	0	80-100%	0-10mph	N	72
9/2/2024 15:20:34	Danehy park	0	40-60%	0-10mph	NW	78
9/2/2024 19:06:26	Danehy park	0	40-60%	0-10mph	NW	71
11/4/2024 12:29:23	Danehy park	5	80-100%	0-10mph	S-SE	49

Drone Justification

A drone is the best way to fulfill our analyses as it will provide not only better-quality imagery of the vegetation health and species as compared to aircraft or satellite technology, but allow for images to be generated at different times of day. Aerial or satellite imagery is only gathered in the morning, but drones can be flown at any time. Furthermore, they provide access to potentially limited space due to weather or seasonal availability. However, the disadvantages of a drone compared to field work of larger aircraft is the possible ethical concerns as a result of a disruption to privacy in the park. Using a drone will demand having visual observers in order to monitor the drone, ensure it is not infringing on park patrons' privacy and safety, as well as being transparent in what our research objectives are. Furthermore, we will need to be cautious of disturbing bird populations that could interfere with the drone flight and avoid collisions with manned vehicles or other recreational activities. In order to be mindful pilots, we will establish a methodology and protocol akin to drone research, establishing that ethical codes were not infringed and proper techniques were used.

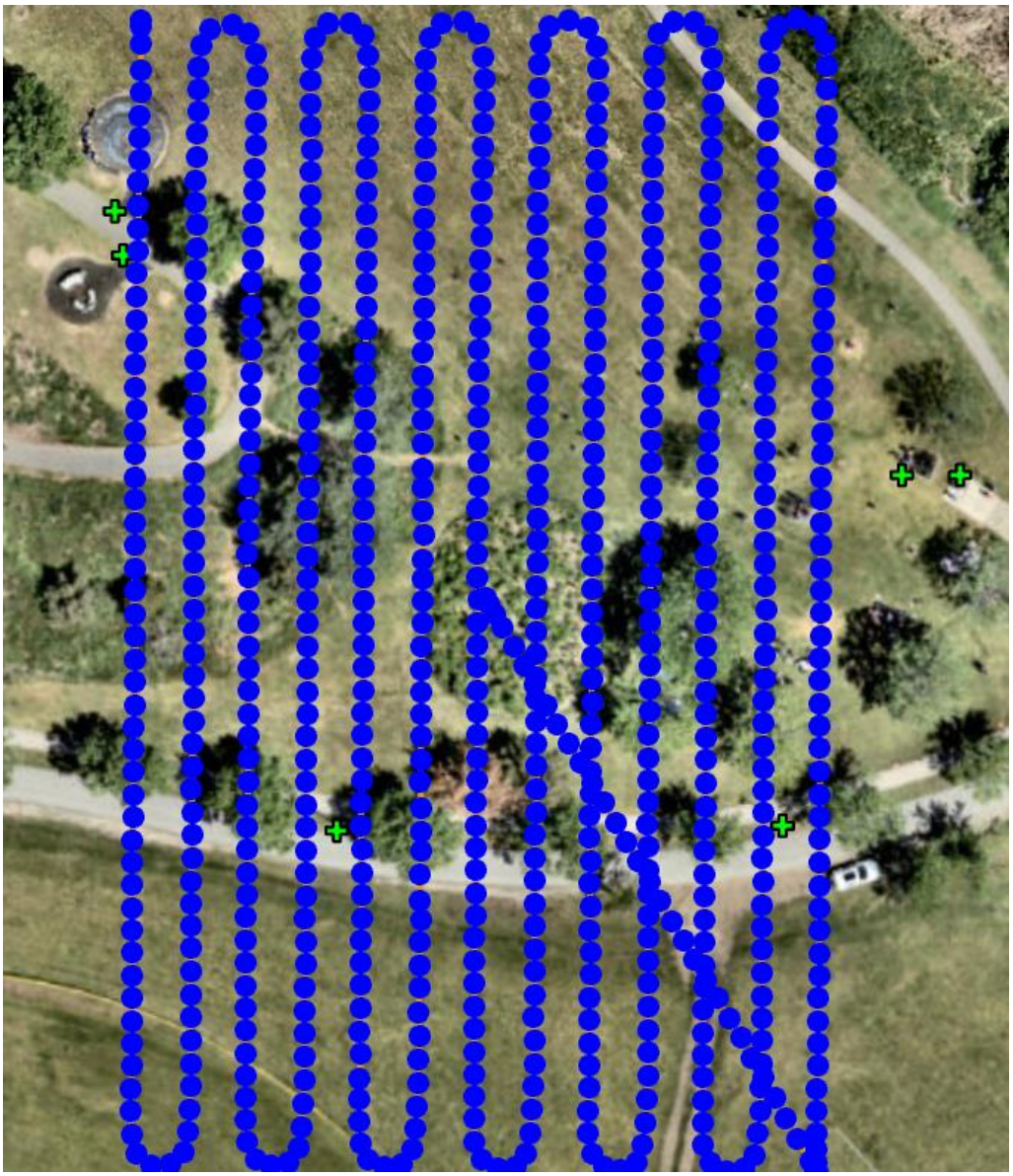
Area of Interest



Scene Model

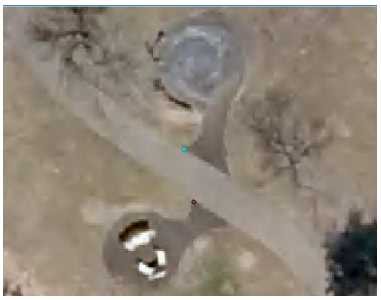
	Drone	Scene/Feature	Good fit? (Y/N)
Spatial Extent	Flying over Miyawaki forest to determine effects on heat Forest: 4,310 square feet	Miyawaki forest, taking heat of surrounding park into account Forest: 4,310 square feet Danehy Park - 50 acres	Y
Spatial Resolution (Individual)	5-15cm	Captures detailed imagery of vegetation 2-5 feet	Y
Important Sensor Bands/ Products	DSM/ DTM LST NDVI/NDRE (Red, Red Edge, NIR)	Looking at LST and tree canopy, need heat of ground and above	Y
Temporal Resolution	5 flights - For leaf area index (LAI), heat - summertime with full leaf coverage - For NDVI (red edge, near infrared) - fall when leaves are off of trees 2 Sept 2024 4 Nov 2024	To capture heat during an extremely hot day at different times of day Summer and fall leaf imagery to capture species	Y
Necessary Accuracy	Both	Relative	Y

Flight Path



Each blue dot represents an image taken over Danehy Park. Using the GCPs, shown as green ‘+’ marks, Drone2Map is able to align the imagery.

Ground Control Points

GCP Name	Image	Comments
1_right_circle_patio_topcorner		Clear, useful - USED
2_bench_patio_bottomleft		Mostly clear in thermal, less so than patio nearby - USED
3_sidewalk_fork_bottomright		Too far from study area - NOT USED
4_bare_patio_topleft		Too far from study area - NOT USED

5_left_bsbl_field_rightfield_pole		Decent point, not as good as others that were used - NOT USED
6_lightpost_left		Easier to spot than middle lightpost - USED
7_left_circle_patio_topcorner		Similarly easy to use as other circle patio - USED
8_right_bsbl_field_leftfield_pole		Incredibly difficult to spot - NOT USED
9_lightpost_middle		Useful, but difficult to spot among trees and sidewalk in thermal - USED

10_lightpost_right		Too far from study area - NOT USED
11_long_patio_topright		Very clear point, defined well in thermal - helpful point

Results

The mini-forest was overall as healthy or healthier than the surrounding vegetation. NDVI measures the ratio between the near-infrared and red bands in the electromagnetic spectrum. Chlorophyll in leaves reflects strongly in the near-infrared, meaning vegetation with high NDVI values can be assumed to be greener and healthier (Au, 2023). There are some parts of the mini-forest in the middle and north that have lower NDVI values which is an indication of stress or poor health. Nevertheless, a majority of the vegetation in the Mini Forest registered higher or similar NDVI values than the surrounding vegetation such as grass or individual trees.

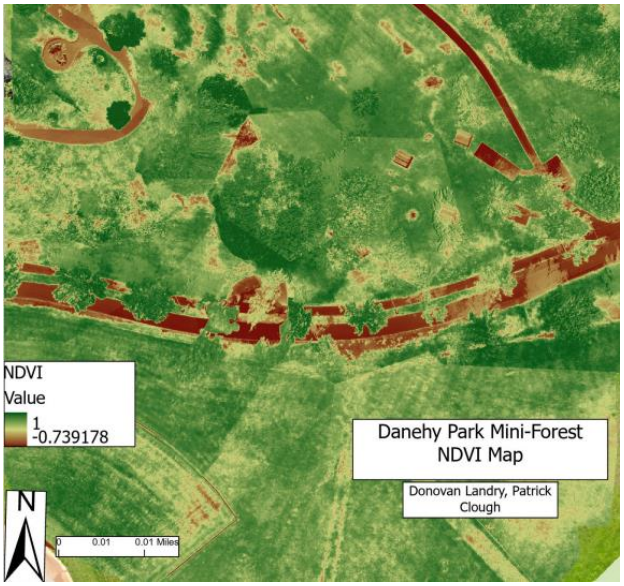
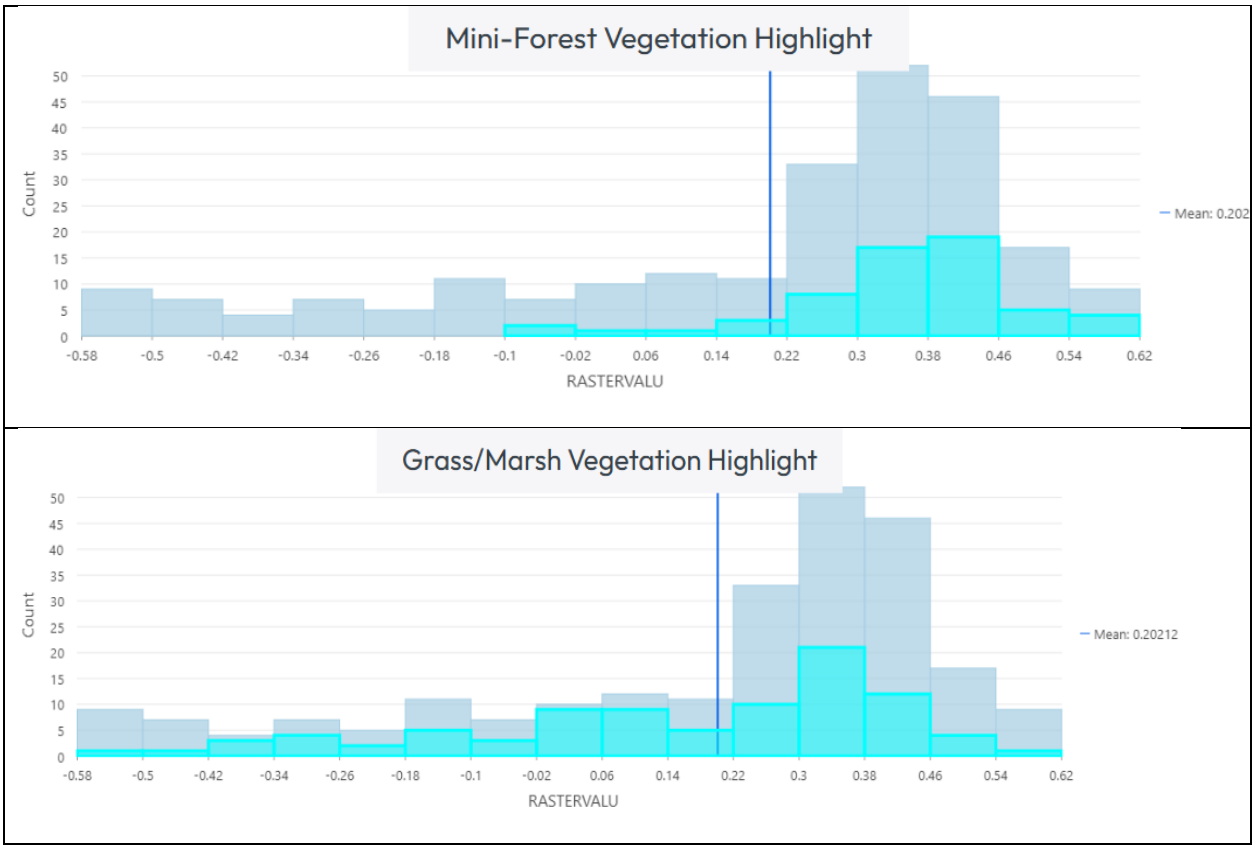


Figure 1: NDVI map of mini-forest and surrounding vegetation



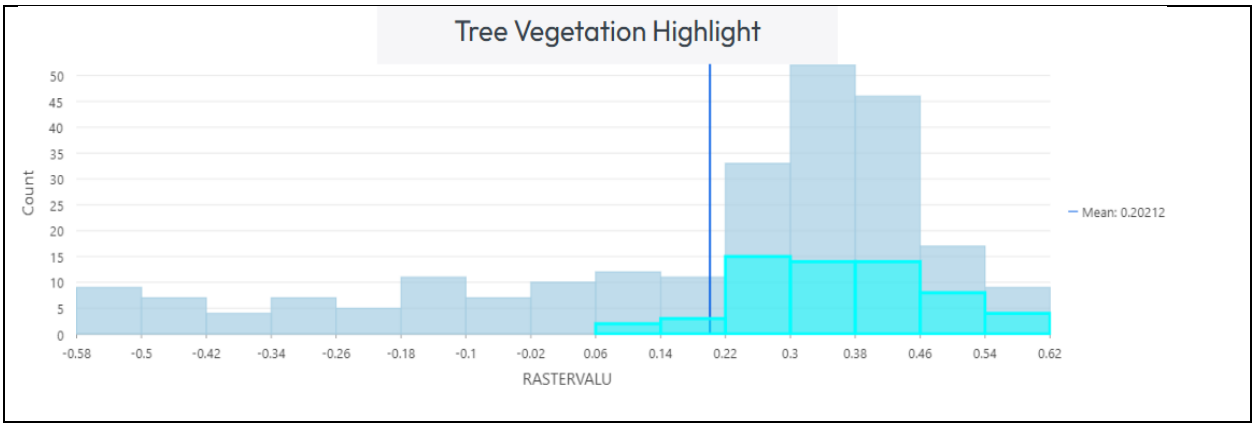


Figure 2: NDVI values at randomized points in three different types of vegetation.

These graphs illustrate the NDVI values of points located within grassy areas and nearby trees. As shown in the top graph, the NDVI of the surrounding grass varied above and below the mean, possibly indicating that some areas are able to be better maintained than others. The bottom graph shows how the majority of trees that were selected in the surrounding area are above the mean NDVI value of the total location. This indicates that, while some trees are somewhat below the mean, a majority of trees are possibly healthier than the others.

Vegetated Areas	*Mean NDVI*
Mini-Forest	0.359
Trees	0.362
Grass	0.166
Total	0.292

The height analysis found that the forest had grown rapidly since 2023. In 2023, the survival rate the 3 tallest trees averaged out at 5.3 meters tall but our measurements in 2024 found the average height is now 5 meters with the largest trees at 7 meters tall (Figure 3).

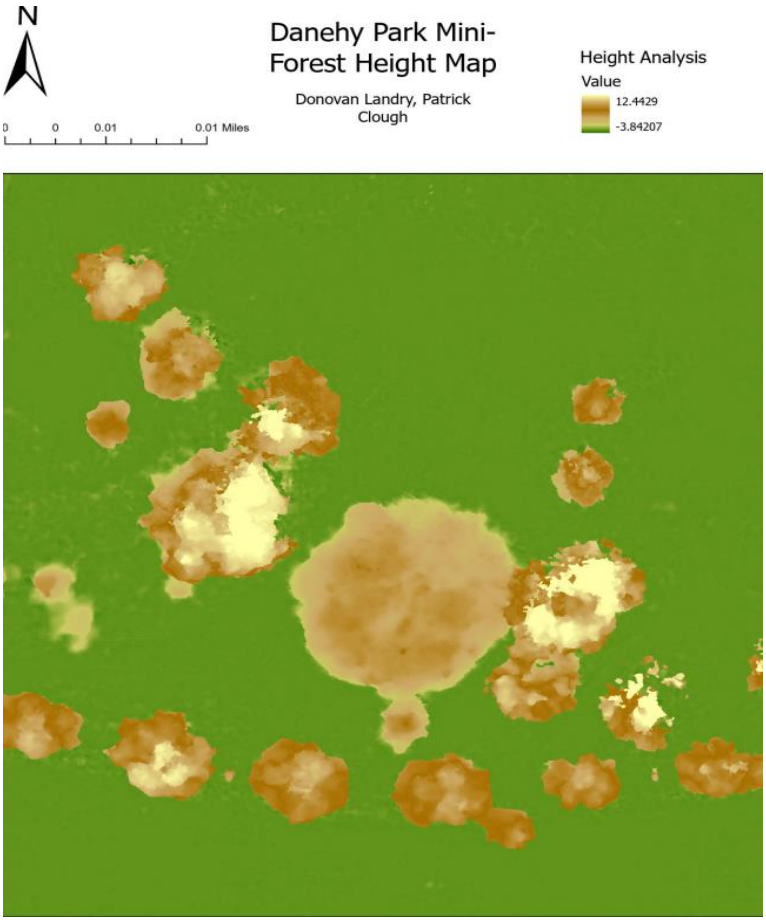


Figure 3: Height map of the mini-forest. Surrounding trees reach up to 12 meters tall.

Discussion and Conclusion

In the analysis of the Mini Forest and the surrounding area, we found that the majority of the mini-forest surpassed the surrounding area's NDVI average. Additionally, it can be seen in the map that the NDVI values for the trees directly adjacent to the mini-forest are registered lower than mini-forest. This could signify that the mini-forest's natural benefits are bolstering the performance of that area compared to the nearby control group. Nonetheless, the NDVI values for the mini-forest were specifically similar to the results from the overall surrounding trees, while performing significantly better than nearby grassy areas. Lastly, it is important to consider that a small population of the NDVI values for the mini-forest are performing worse than the

surrounding mean. This could mean that the vegetation is not as healthy or being compromised in some way, such as sumac or other species that harm the balance of biodiversity in similar mini-forest.

In addition, we found that the mini-forest within Danehy Park has grown considerably over the years that it has been active. While the heights of the surrounding trees were on average taller than the mini-forest, the mini-forest has grown since last recorded and the rate shows that it could soon match the surrounding vegetation.

Resources

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