2024

Salem State University

Lead Mills Conservation Area

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Introduction

The site we chose for our project was the Lead Mills Conservation Area on the Salem/Marblehead, Massachusetts border. Our primary focus is on studying how healthy the native vegetation is. The area was healthy when the group was there, and native plants were green and lush, but with the current drought, the area could have vulnerabilities due to many bare spots in the area that are void. The area is also host to invasive species, native wildflowers, and a few small trees. Since 2020, the Marblehead Conservancy has been planting native plants and wildflowers along the road to increase aesthetics and throughout the Lead Mills Conservation Area to increase biodiversity. Multiple fields and meadows are new or in the process of being sowed. This research is particularly vital now, as we are experiencing a significant drought and have had little rainfall under these conditions. Understanding how the affected plant life reacts is crucial for developing effective strategies to mitigate the adverse effects of these environmental changes. All four seasons in this area are essential, but the end of the summer and beginning of the fall season have seen unusually high temperatures and wildfires in recent years. Since this summer has been one of the hottest on record, analyzing how these plants adapt can provide valuable insights into their resilience. Also, this project will help with weed control and areas that require more plant life and vegetation. We flew two drone flights on September 10th and on October 17th, 2024. While the drought was already beginning in September, it increased throughout the Fall. Our results should be taken into context that in the Fall, many of these plants begin to turn brown and die back as part of their natural life cycle. Without data from previous years, it will be difficult to isolate the impacts of the drought this Fall.

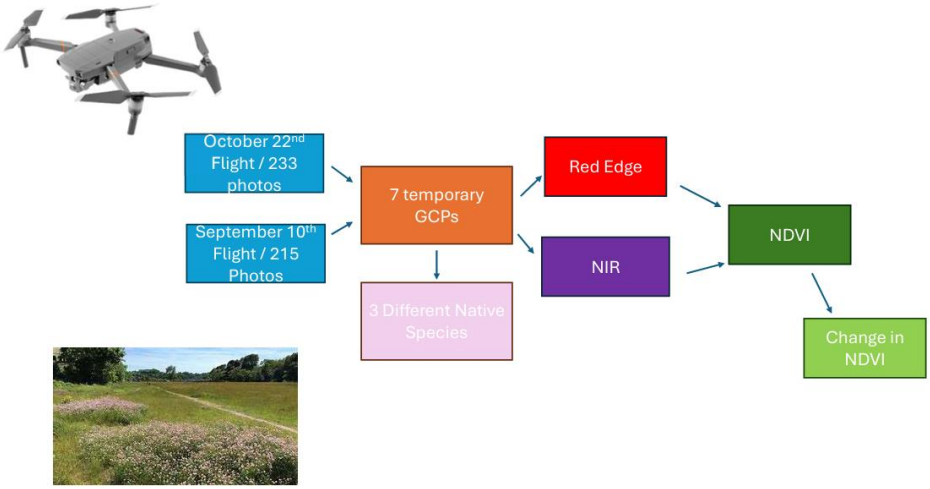
By observing the native wildflowers and lead mills' vegetation responses to drought, this study will shed light on how local plant life is coping with rapid environmental shift conditions. We may be able to apply those insights to enhance the resilience and biodiversity of other species. Also, this observation will show how to properly deal with non-native plant species in lead mills, such as the invasive species problem that this area faces. This study will uncover how to ensure this area maintains its diversity and eliminates the non-native species in this area. Wildflowers are being planted to bring new life to this former industrial site of the 18th and 19th centuries, but future climate patterns could affect the health of the native wildflowers.Ultimately, we hope our findings will contribute to broader conservation strategies and research that can enable us to predict and address potential challenges for plant life and wildlife in the area.

As a baseline for this report, it is essential to note the characteristics of each of these native plants and how they should respond seasonally and naturally. The purple love grass is a fine textured grass that will be entirely green in the spring and the summer. These plants will grow a cloud of purple plumage in late spring and early fall. These plants require very little care and are very tolerant of droughts. Goldenrods are tall plants that enjoy a dryer soil area. Goldenrods will bloom in the late summer and will have flowers into the late fall. These plants being in full sun will produce the best results for the overall health of the vegetation. Milkweeds are plants that require full sun to thrive and prefer well-drained soil. They do best with higher moisture content in the soil.

Our research questions will provide an overall outlook on native plant life interactions with environmental factors.

1. Can the drone be effective at mapping individual plant species?
2. What is the health of native plants – Goldenrods, Milkweed, and Purple Lovegrass – in September and October?
3. How has the health of native plants changed over time?

Methods/Flight Information



The model above is the methods utilized throughout the project to gather the data needed. Both NDVI and NDRE were calculated, but in the end, only NDVI was used as the NDRE data was impacted by shadow. NDVI is a vegetation index that uses the near-infrared and red bands in the electromagnetic spectrum to create a ratio from 1 to -1 that provides an indication of plant health. Chlorophyll is especially reflective in the near-infrared and absorbs red light at high levels. Plants with less chlorophyll will have lower values so plants that are stressed or changing colors due to the seasons will be affected. We started with seven temporary ground control points and yellow vests, but a few were displaced throughout the flight due to outside forces acting on them. That lapse could have created some of the weird image phenomena seen in the images within the results section, such as bizarre splicing of the images and unexplainable dark spots.

Date	Drone max height	Time	Temp GCPs	Cloud Cover	Wind speed	Air Qual.	Temp	Humidity	Air Pres.	Flight time	Photo count
09/10/24	200ft	11:44 AM	5	0-10%	0-10 MPH	24	73	51%	30.03 inHG	8 min	215
10/22/24	200ft	4:06 PM	7	0-10%	0-10 MPH	41	65	65%	30.24 inHG	8 min 30 sec.	253

Scene Model

Scene Model

	Drone	Scene/Feature	Good fit? (Yes/No)
Spatial Extent	2 square kilometers	4.5 acres	Yes
Spatial Resolution (Individual)	2cm	3m	Yes
Important Sensor Bands/Products	Infrared, red edge	Infrared, red edge	Yes
Temporal Resolution	Fall	All seasons except winter	No
Necessary Accuracy	Both	Relative	Yes

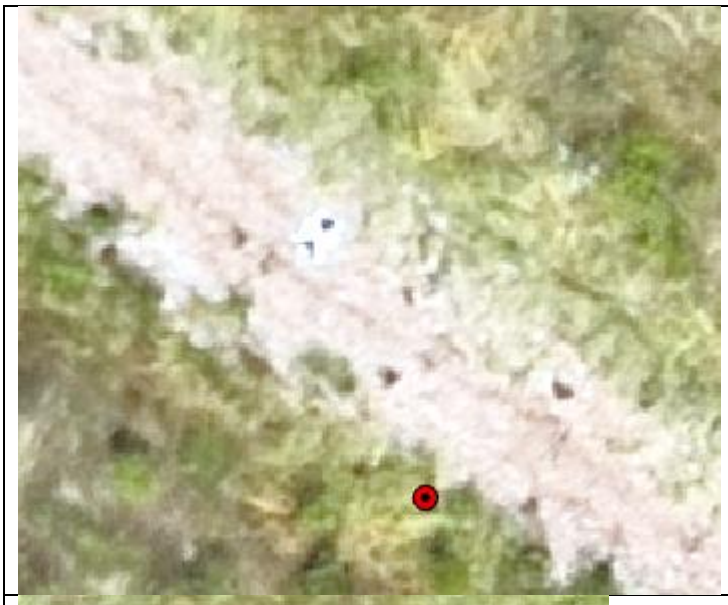
The table compares the suitability of our drone over the Lead Mills Conservation Area. The spatial extent of the drone covers 2 square kilometers, while the scene is limited to 4.5 acres. The spatial resolution is also different as the drone is highly accurate with a resolution of up to 2 cm, while the scene shows a 3m resolution. We used infrared and red edges, which was a good fit; we used these bands to identify the needed vegetation data. Many of the factors we used were a good fit except for Temporal Resolution because we only flew during one of the seasons when it would have been more beneficial to fly all year round except for winter, as there would be no data to collect.

Ground Control Points (GCPs)

A total of 10 usable Ground Control Points are in the lead mills final report, four during the September flight and six during the October flight. At first, we put out ten ground control points in our September flight, but only four were usable. During our October flight, six out of seven GCPs were usable. The GCPs were interfered with by unforeseen circumstances such as dog walkers, a middle school track team, and people walking. There was a vast improvement in the accuracy of the control points from September to October despite not having the original GCPs from the September flight. There was improvement from the September to October flight regarding the distribution of the GCPs and the accuracy of the GCPs. This was due to the placement of the GCP on the grass instead of the path, as shown in the screenshots. Also, the September flight GCP points yielded less accurate results than the October flight because the four GCPs were clustered compared to the six GCPs that were more spread out.

In the below tables for the September and October flight you can see the accuracy of the GCPs by examining the distance of the red dot from the GCP in the image. In September, the GCPs are black and

white cardboard. In October, they are yellow vests. When using the cardboard, we placed the GPS point at the center of the cardboard. When using the yellow vests, we oriented the vest so it was pointing towards the ocean and placed the GPS point at the side closest to the ocean or the top.

	This GCP is somewhat visible, although the control point could be closer to the GCP. The September GCPs are further away than the October flights. This was our second time doing the GCP points.
	In terms of clarity this GCP is one of our most visible and the control point is within the vicinity of the GCP

	This GCP was somewhat problematic because of its location in a shaded area, the GCP would have been clearer if placed under the sun.

GCP for October flight

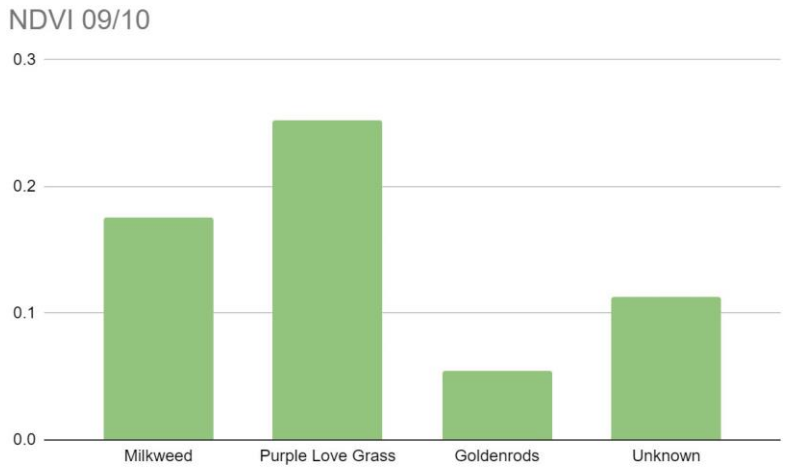
	This GCP came out fairly well and the GCP and the control point are close to each other and the GCP is clear

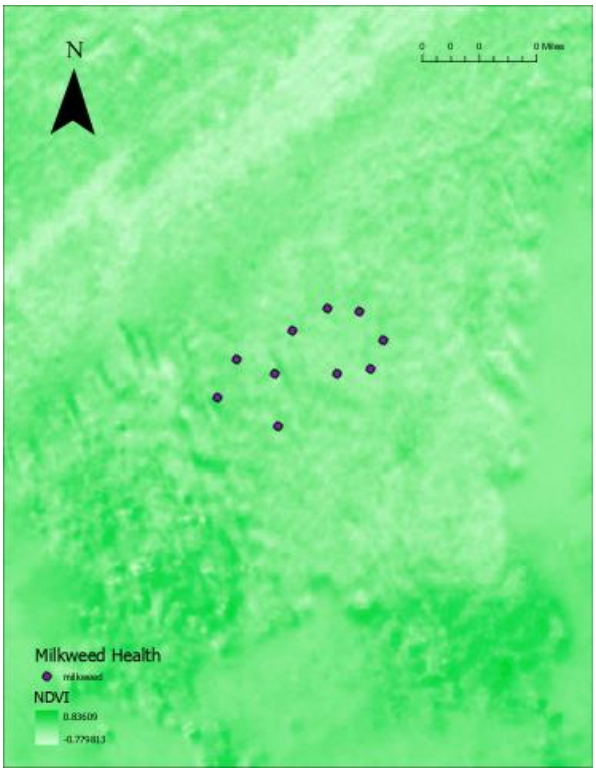
	While shade could have been an issue with this GCP, it ended up being very accurate.
	The accuracy of this GCP was the best – the red dot is exactly where it should be. This GCP was located in full sun, near vegetation.

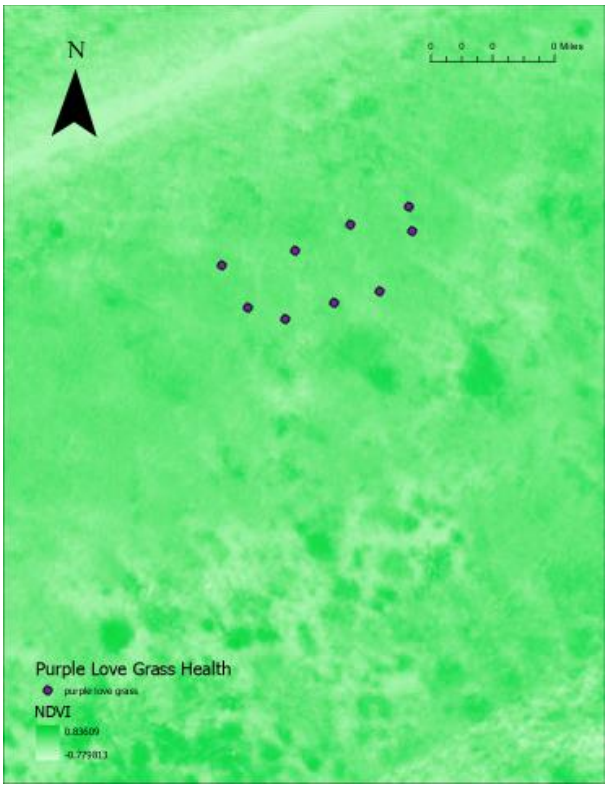
Results

September:

The chart below shows the vegetation health recorded from the September flight, which took place on the 10th. These results show that purple love grass had the highest NDVI average out of any plant species recorded. As a reminder, NDVI is a ratio using the near-infrared and red bands that measures the amount of chlorophyll molecules which is vital for photosynthesis. Milkweed with a close second while goldenrods fall behind. In September, we were a month into a drought, which could have affected the goldenrod's health, as those are less resilient to the drought than purple love grass and milkweed. In the imagery from the September flights, it should be noted that some of the golden rods were located in a shaded area, further affecting the health of that plant. It should be noted that all plants had lower values of NDVI than expected. Healthy vegetation is typically measured around .5 to .8 in our experience in other locations. This could be a sign of the impact of the drought in September as many of these plants were still very green on the surface.



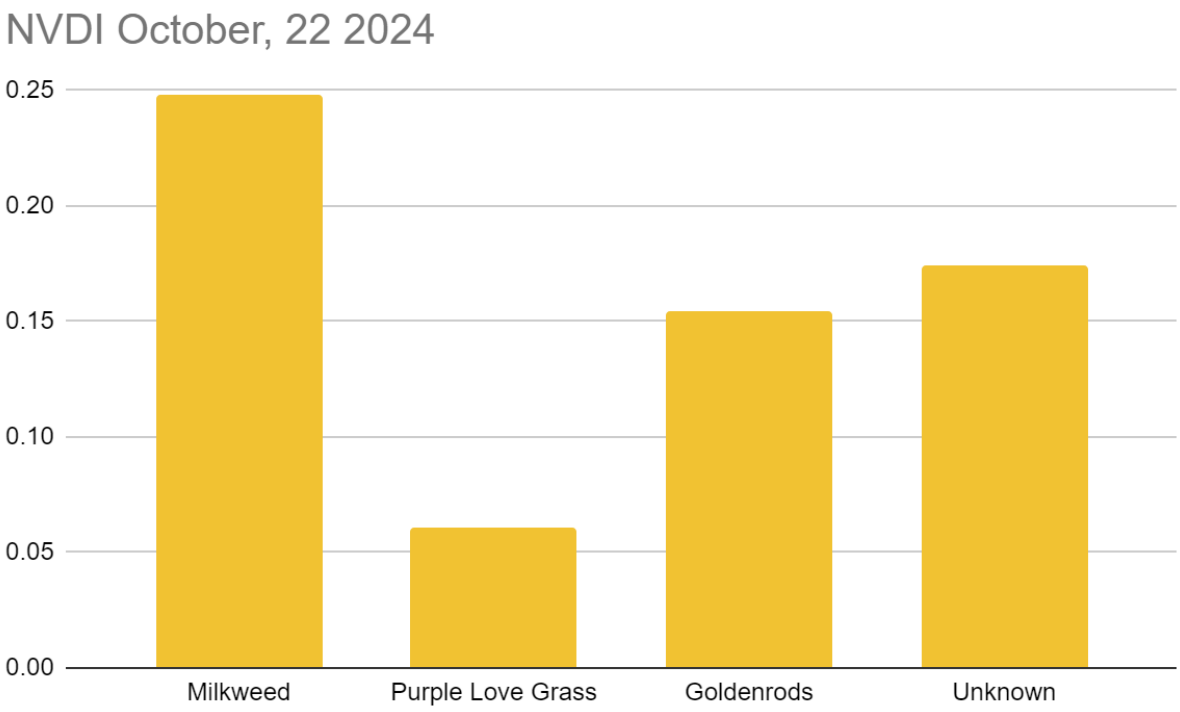


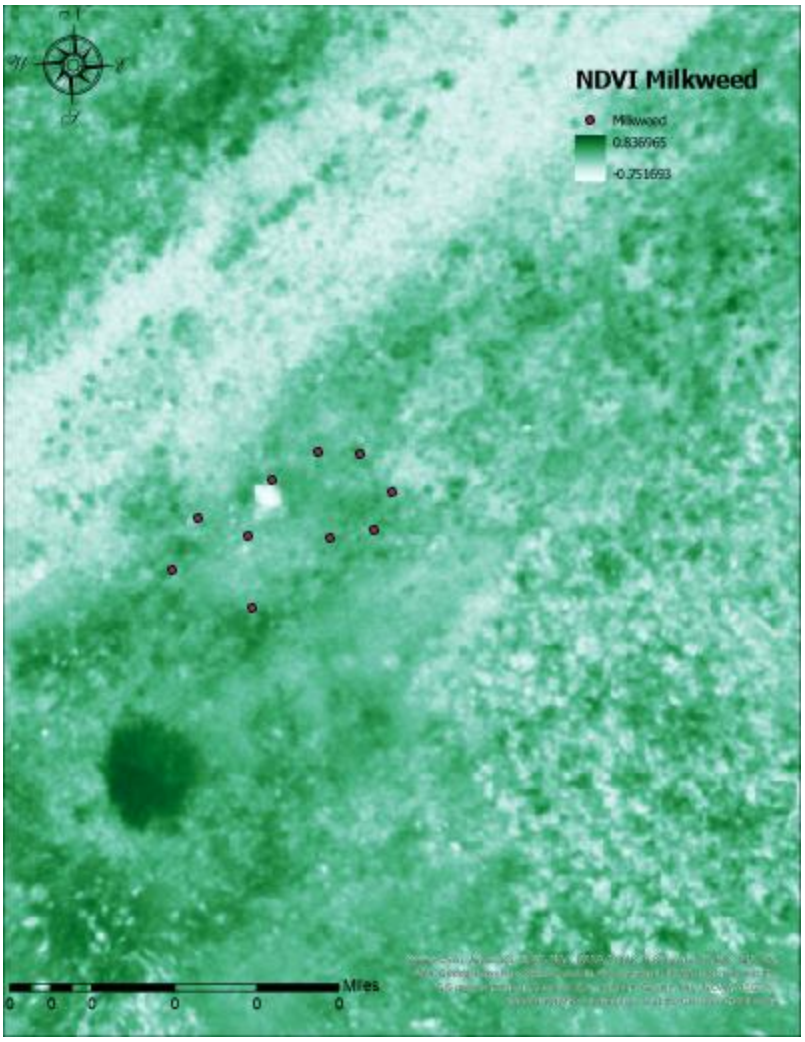


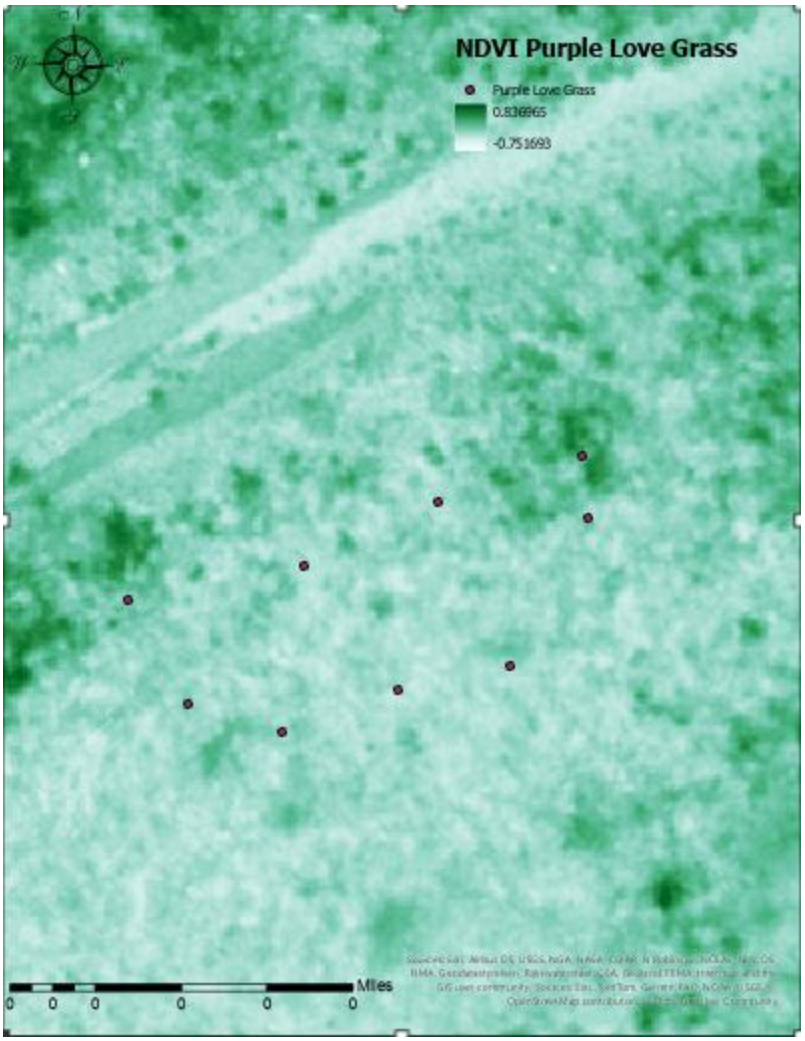
The two NDVI close ups above show the NDVI values for the milkweed and the purple love grass. Note that the scale goes from 0.8 to -0.7 so greener areas are closer to the high values and white areas are closer to the negative values.

October

Our results from October yielded interesting results shown in the October, 22, 2024 NDVI charts. Milkweed was the highest in NDVI followed by Goldenrod, and Unknown. Milkweed was slightly lower than the September results. The Goldenrod had slightly higher values of NDVI in October which is an interesting result and could indicate a change in water but could also be a source of error. When examining the difference images, it seems as if the Goldenrod might have been replaced by grass. The patches of Goldenrod are visible with very low NDVI values. Purple Love Grass was the least healthy vegetation out of the four. This contrasted sharply with our results in September. Monarch butterfly migration is affected by, "the decrease in available host plants (Milkweed) and colder temperatures(Masshort.org)." The monarchs are leaving by October and only a super generation of monarchs are around this time of the year. Our results were in line with how healthy the vegetation should be in this area of Massachusetts. You can tell the Milkweed health in NDVI because of the fact that most of the vegetation around the control points is a healthy lush green color.


NVDI October, 22 2024
0.25
0.20
0.15
0.10
0.05
0.00
Milkweed
Purple Love Grass
Goldenrods
Unknown


NDVI Milkweed
Milkweed
0.836965
-0.751693
Miles



The two NDVI close ups above show the NDVI values for the milkweed and the purple love grass. Note that the scale goes from 0.8 to -0.7 so greener areas are closer to the high values and white areas are closer to the negative values. The shade of green is different than the NDVI maps from September.

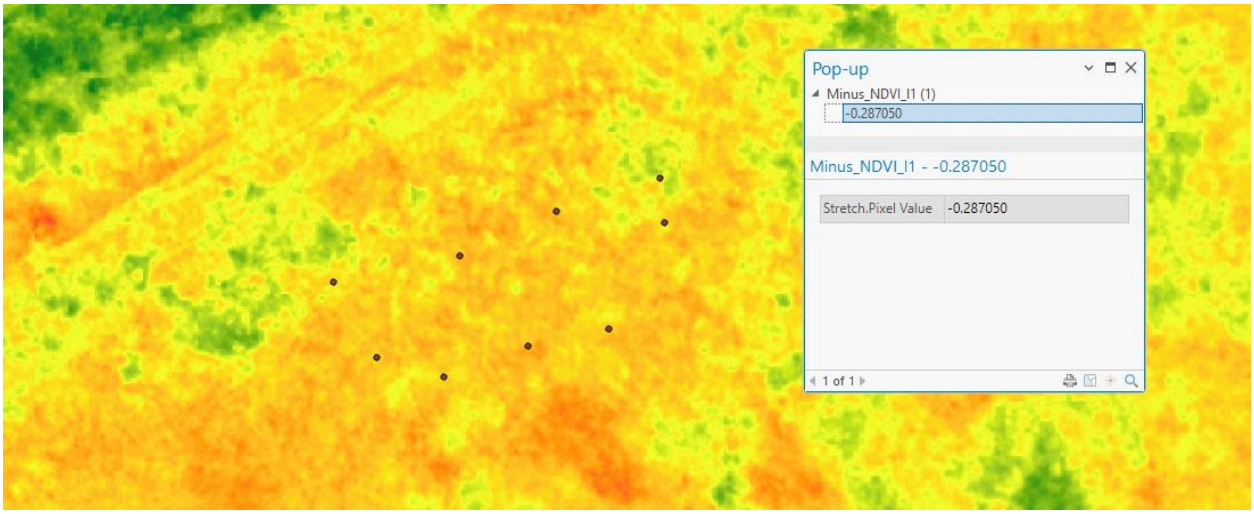
This is the true color orthomosaic image from October. Notice the amount of shade throughout the image that could have impacted some of our results for the Goldenrod.

Change Analysis

We subtracted October NDVI values from the September NDVI values to create difference maps of plant health over time. These maps show red values as areas where NDVI is decreasing so these plants are less healthy. The green values show where plants are becoming more healthy.

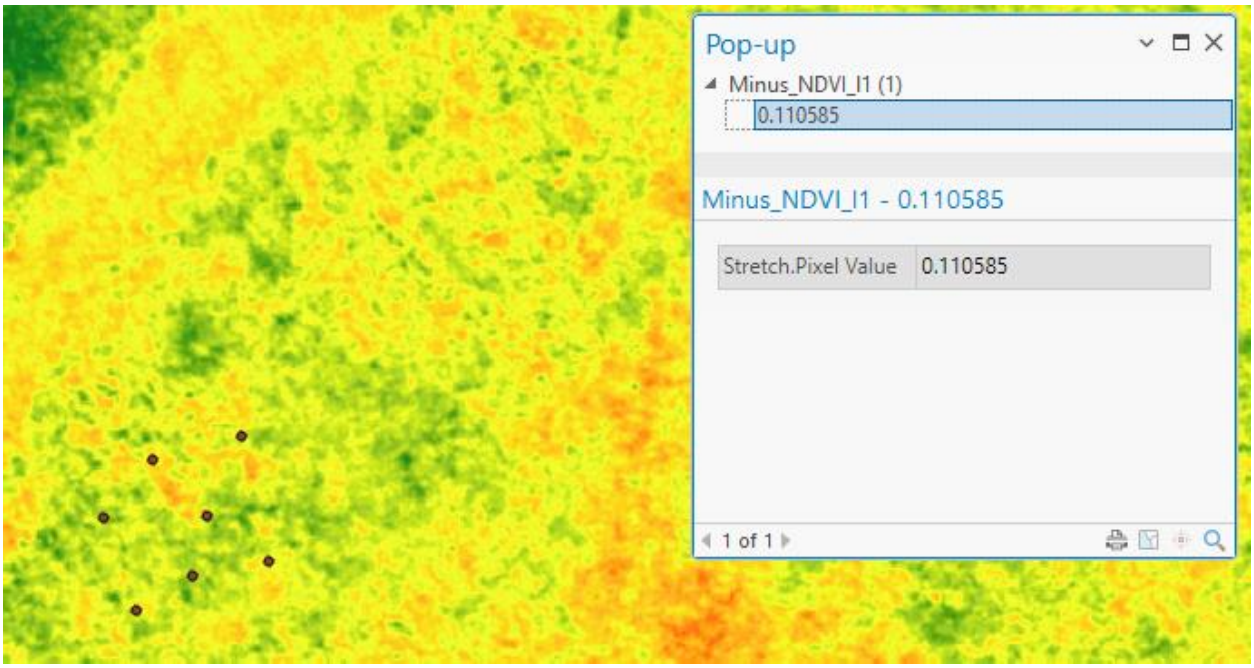
The points were created using the true color orthomosaic. In September we recorded where patches of native plants were. Then we placed 7 to 10 points in each patch to measure vegetation health.

Purple Love Grass:

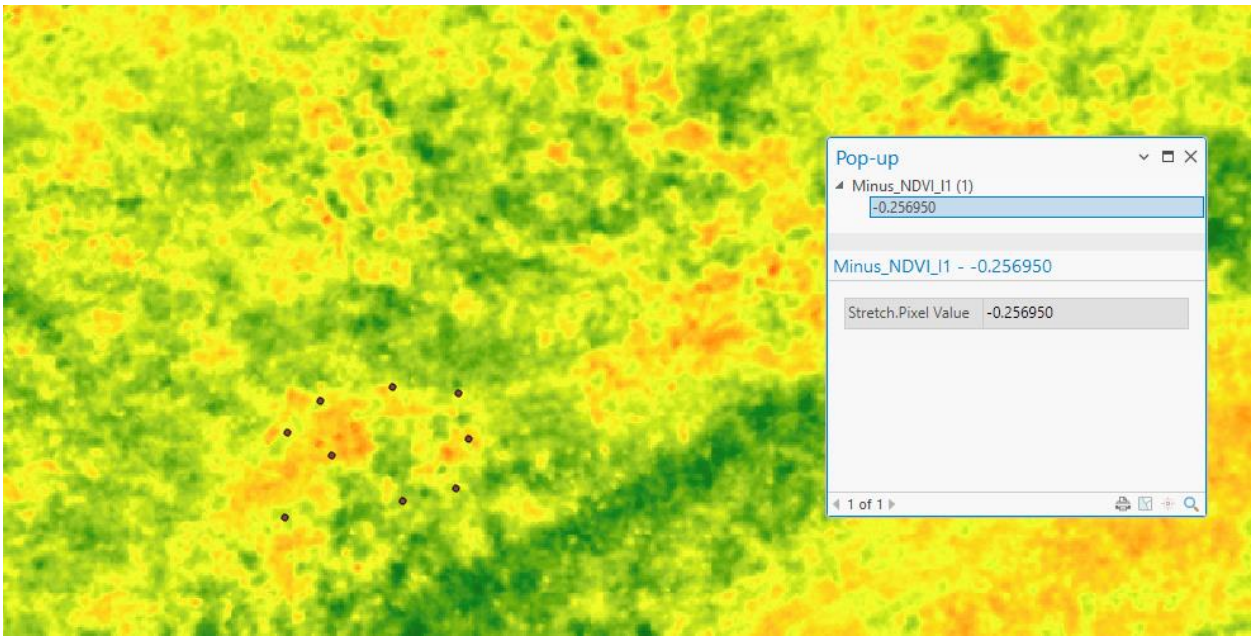


Goldenrod

Notice the points are placed in many patches of green which could be grass being revealed under the Goldenrod. The large patches of green in the top left corner is grass.



Milkweed



Discussion

The Goldenrod mostly stayed green from September to October, but a few patches started to show more red. The green we think could be grass replacing goldenrod. The first patch of Milkweed plants we observed showed more red in a surprisingly green area. Again this patch of Milkweed was surrounded by grass. The Purple Love Grass experienced a lot of red over the change from September to October. This was the largest most homogenous patch of vegetation and so it is easiest to highlight the specific species. Overall the changes from September to October were considered surprising because many of the plants did not experience as many red levels on the maps as I would have thought when considering the drought. This shows the plant's resilience to changes in conditions such as drought.

The drone was effective at isolating individual plants and measuring the health. However, there was not a clear methodology in how to connect the drone imagery to the specific plant species on the ground. Accurate plant ID and GPS points are important as well as taking the time to put points exactly on the top of plants. In the case of this analysis, too many points were place randomly in the patch of plants leading to our results being impacted by surrounding vegetation such as grass.

The weather conditions during the Fall made this study an interesting first step in using the drone to measure native vegetation and wildflowers. Having baseline summer imagery or monthly imagery throughout the year will help put the results from the Fall into context. Are these plants experiencing drought conditions or are they simply following their Fall life cycle? These questions will be able to be answered with more drone flights and better ground data.