Invasive Species in the Delta: Segmentation and Classification of Water Hyacinth and Primrose

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Objectives

Because of its great beauty, *Eichhornia crassipes* (Water Hyacinth), originally from South America, has been introduced to 4 continents. Furthermore, because of its genetic make-up, high versatility and resiliency, this plant has become a frightening invasive, affecting boating and shipping, farming, water quality and fishermen livelihood wherever it thrives. However, Water Hyacinth (WH) is only 1 of over 84 invasives in the California Delta, which is where we focused our study.

- Analyze photos taken along the Delta to discriminate WH from Primrose (PR)
- Determine the effectiveness of the treatment of Water Hyacinth (WH) in the Delta
- Create a map and write a literature review to make further predictions about the future of Water Hyacinth in the U.S

Figure 1. WH

Figure 2. PR

Figure 3. WH and PR

Classroom Connection

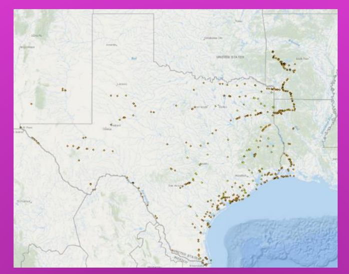

Figure 15. *Water Hyacinth in Texas.*

Invasive species like Water Hyacinth (presented in map above) are also found in my home state. This project has allowed me to bring back hands on experience to my students for the purpose of further exploration and problem solving. Students can research invasives in their home state and experiment with ways to solve the issues they incur. **Some questions that arise are:**

- Do we try to make the best of the issues that invasives bring, or do we try to restore what has been broken?
- How do invasives affect established organismal relationships?
- Should the transport of organisms across regions be banned or more strictly overseen?

Implications from Literature Review

Factors affecting Water Hyacinth Growth

- weather conditions
- Excessively modified waterways (e.g. California Delta)
- Nutrient runoff from fertilizers /Highly polluted waters

Proposals for Further Investigation

- Because of worsening weather conditions around the world, one can predict the future of not only WH, but invasive, proliferation.
- WH has been a hot topic for centuries, but the problem is not Invasives. The problem is the defacement of Earth's waterways. This is the root, how can we fix it?
- In the meantime, let's look at the benefits of WH: it is perfect for wastewater treatment and might even be advantageous to astronauts.

These maps were created to depict the extent of WH versatile growth across America. The maps indicate that WH is not just a tropical plant but has a wide range of temperatures at which it can thrive. Using the maps, one can predict that WH will begin to move further upward into the central American region, if not impeded.

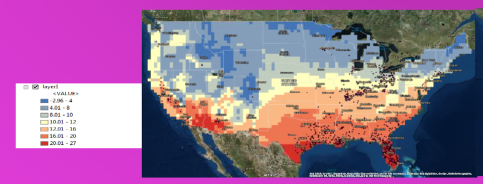

Figure 13. *Average yearly maximum temperature in degrees Celsius*

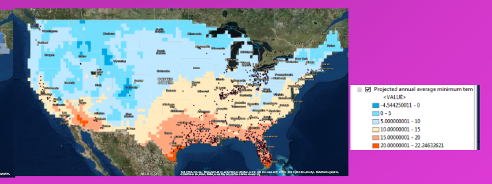

Figure 14. *Average yearly minimum temperature in degrees Celsius*

Methods

Collection
- About 90 photos were collected physically by going along the Delta. We visited recently treated areas as well as untreated areas (figure 4)

Segmentation
- Used ENVI to find best parameters for segmenting each leaf and other areas based on red green blue (RGB) band data via trial and error testing (figure 5 & 6)

Classification
- Recorded average RGB bands for these areas: WH leaves, PR leaves, water/shadow, PR flowers, and detritus.
- Calculated RGB ratios (R:G, G:B, R:B), maximum and minimum values for each area, and recorded average roundness for WH and PR to distinguish shapes.

Figure 4. *Collection* Camera set at constant height to capture same area

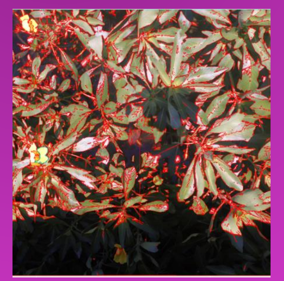

Figure 5. *ENVI Segmentation for PR* Red lines show polygons create by ENVI

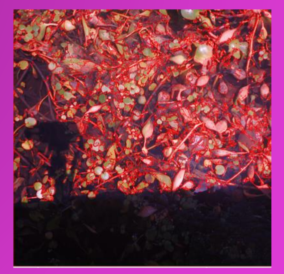

Figure 6. *ENVI Segmentation for detritus*

Results

From Collection

- Photos from treated areas had more detritus.
- More Pennywort (native Delta plant) was found in treated vs. non-treated areas

Figure 7. *Photo of Pennywort* This picture was taken, among others, at a treated site along the Delta.

From Segmentation

- We found these parameters for segmentation in ENVI to be the best only for segmenting photos consisting of one species as compared to photos with two species: segment=75, merge: 95, kernel size= 19 (figure 7).

Figure 8. *ENVI Segmentation for mixed* Blue outlines show a merged polygon of WH and PR

From Classification

- Rules were ineffective for blurry or glared pictures.
- Young PR tended to be rounder so it got mistake as WH.
- If a picture did not have a flower but had 'bright spots', those areas were mistaken as flowers.

Class 1 (Flower)	215 ≤ R ≤ 256
Class 2 (Dead or Detritus)	124 ≤ R ≤ 250 AND 0.5 ≤ G:R ≤ 0.8
Class 3 (Black/shadow/water)	R ≤ 100 AND G ≤ 65
Class 4 (Primrose)	200 ≤ R ≤ 256 AND 0.85 ≤ G:R ≤ 1.20 AND Roundness ≤ 0.35
Class 5 (Water Hyacinth)	200 ≤ R ≤ 256 AND 0.85 ≤ G:R ≤ 1.20 AND Roundness ≥ 0.35
Class 6 (Undefined)	Everything else

Figure 9. Legend and *Table for Rules* Left column shows key for figure 10 while the whole table depicts the rules chosen for classification.

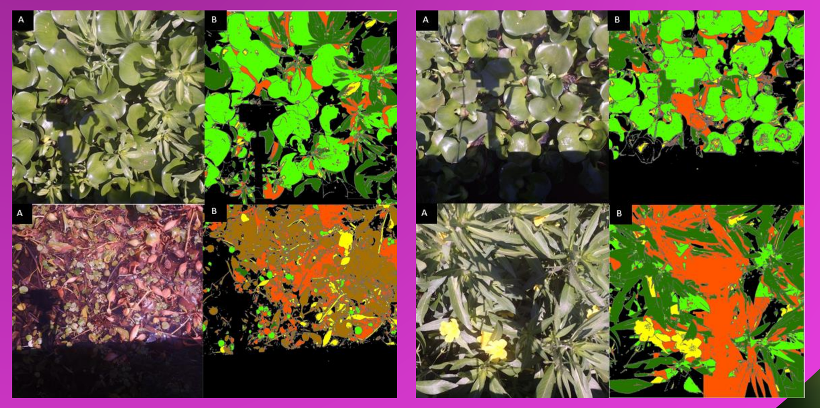

Figure 10. *Results from classification rules* A- original picture taken. B- Classification based on rules created

Conclusions

- We confirmed that the herbicidal treatment was indeed effective and was not a hindrance to the native plant, Pennywort, but a benison as Pennywort was found thriving in areas where invasive growth was controlled.
- Proper segmentation parameters for separating WH and PR within a given photo was not found, as roundness was our only discriminator and it cannot be used on JPEGs, only polygon shapefiles from ENVI.
- A more effective way to segment JPEGs is needed to enhance these findings.
- Calculated average coverage for WH and PR at each site to obtain quantitative values relating to the effectiveness of chemical treatment (figure 12).
- Future work:
  - Collect more accurate and higher quality photos using drone to allow for improved segmentation
  - Create rules without roundness that can be applied to JPEGs

Figure 11. Partial *Aerial image of Delta* .We would like to be able to apply rule to images like this one to better visualize which invasive are affecting the Delta, and to solve issues more quickly. [Image by NASA]

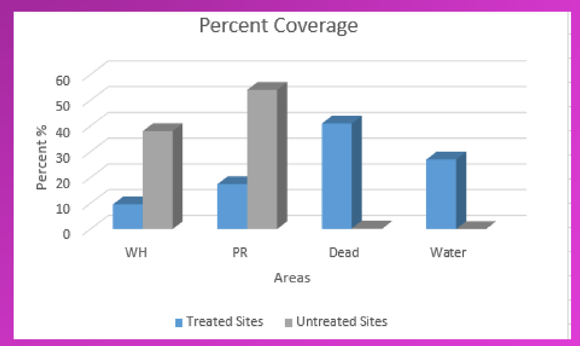

Figure 12. *Percent Coverage of Each Category* Results from our rules indicate that in the untreated site, more WH and PR was found, and less detritus and water coverage was found.

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