UAV Round Table Discussion

LCEP: Sarah Kidd, Sneha Rao, Paul Kolp, & Tiffany Thio

Acknowledgements: Narayan Elasmar, Matthew Schwartz

LCEP Overview

Current Drone Use

- Our Equipment & Software
- Research Goals
- Example Project: MCNA

Best Practices

- Field Data Collection
- Pix4D data processing

Our Equipment & Software

Drone and Sensors

Multispectral Drone Set-up

- DJI Phantom 4 & Standard RGB Sensor
- With Sentera DJI NDVI/NIR Senor Upgrade

Software

Flight Mapping

- Pix4D and MapsMadeEasy

Processing

- Pix4D

Analysis

- R, R Studio
- ArcGIS

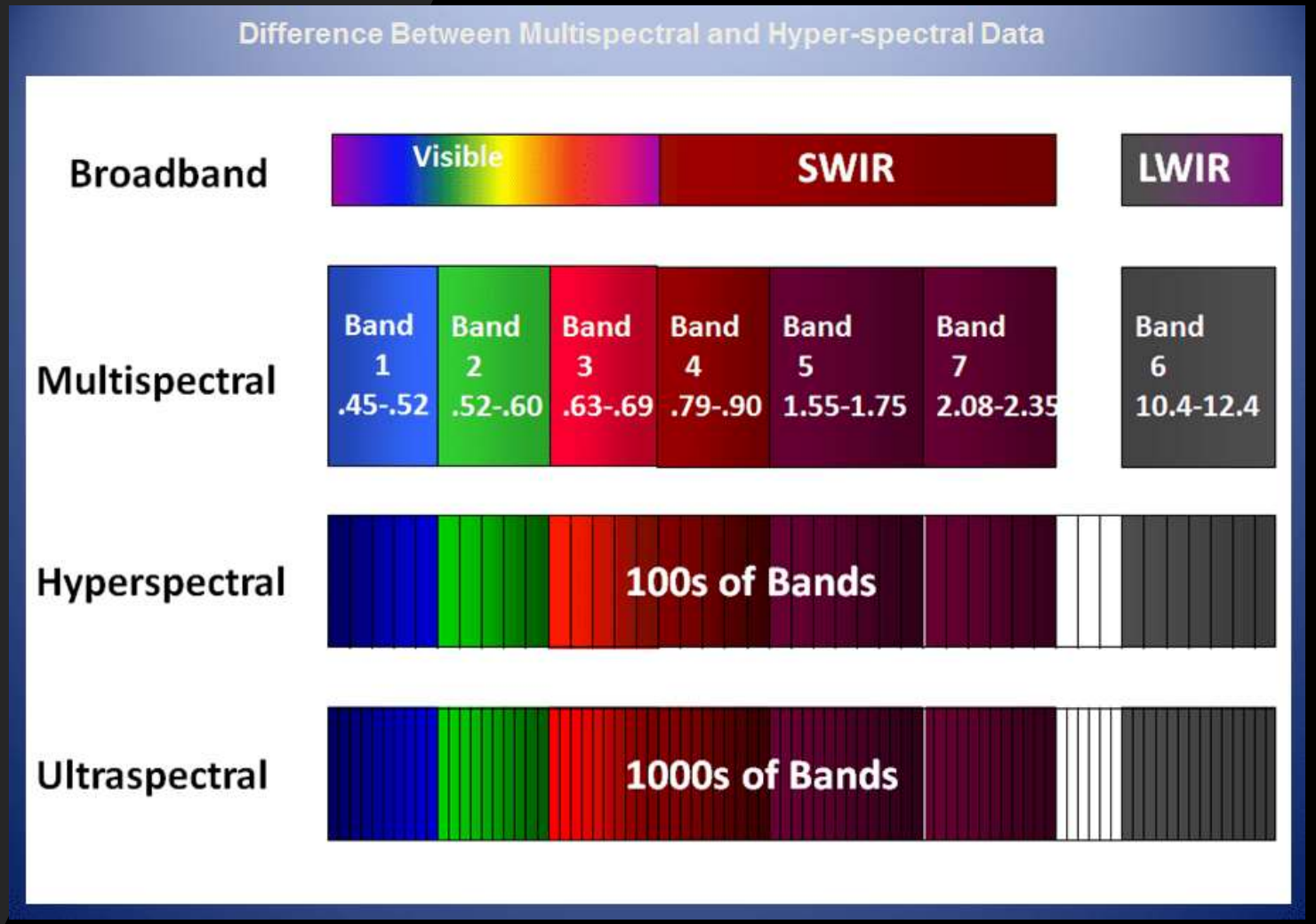
Understanding the Difference in Sensors

We use Multispectral Sensors

- **Very targeted data bands:** Visible Bands (RBG) & NIR Range (0.75-1.4 µm)
- **Final Resolution:** Dominant Plant Species (>30% cover, 0.25 m2 resolution, ~95% accuracy)
- **Equipment Cost:** 4K+ (Drone & Sensors)

Compared to Hyperspectral

- 100s of bands = lots of data
- **Final Resolution:** Plant Species at the scale of cm^2 resolution, high accuracy
- **Equipment Cost: 80-100K+** (Drone & Sensor)



Research Goals

- Create digital terrain models of:
  - Wetlands
  - Channels
  - Tributaries
  - Potential restoration sites
- Accurately map dominant plant communities

Research Applications

- Track changes in site conditions over-time:
  - *Native and Non-native Plant Community Distributions*
  - *Above Plant Ground Biomass*
  - *Channel Development*
  - *Topographic Changes*
- Assist in restoration planning, design, and adaptive management

Example: Multnomah Channel Natural Area (MCNA) UAV Mapping Dominant Plant Communities

Research Question:

What are the dominant plant communities and their extent across the site?

Results:

- Final Mapping Resolution 0.25 m^2
- 95% Accuracy for dominant plant communities (>30% cover)
  - →Validated by over 100 plant community and elevation data points collected by field crew on the ground

Example Analysis – (Post-Pix4D Processing)

Combine final sensor raster files in ArcGIS

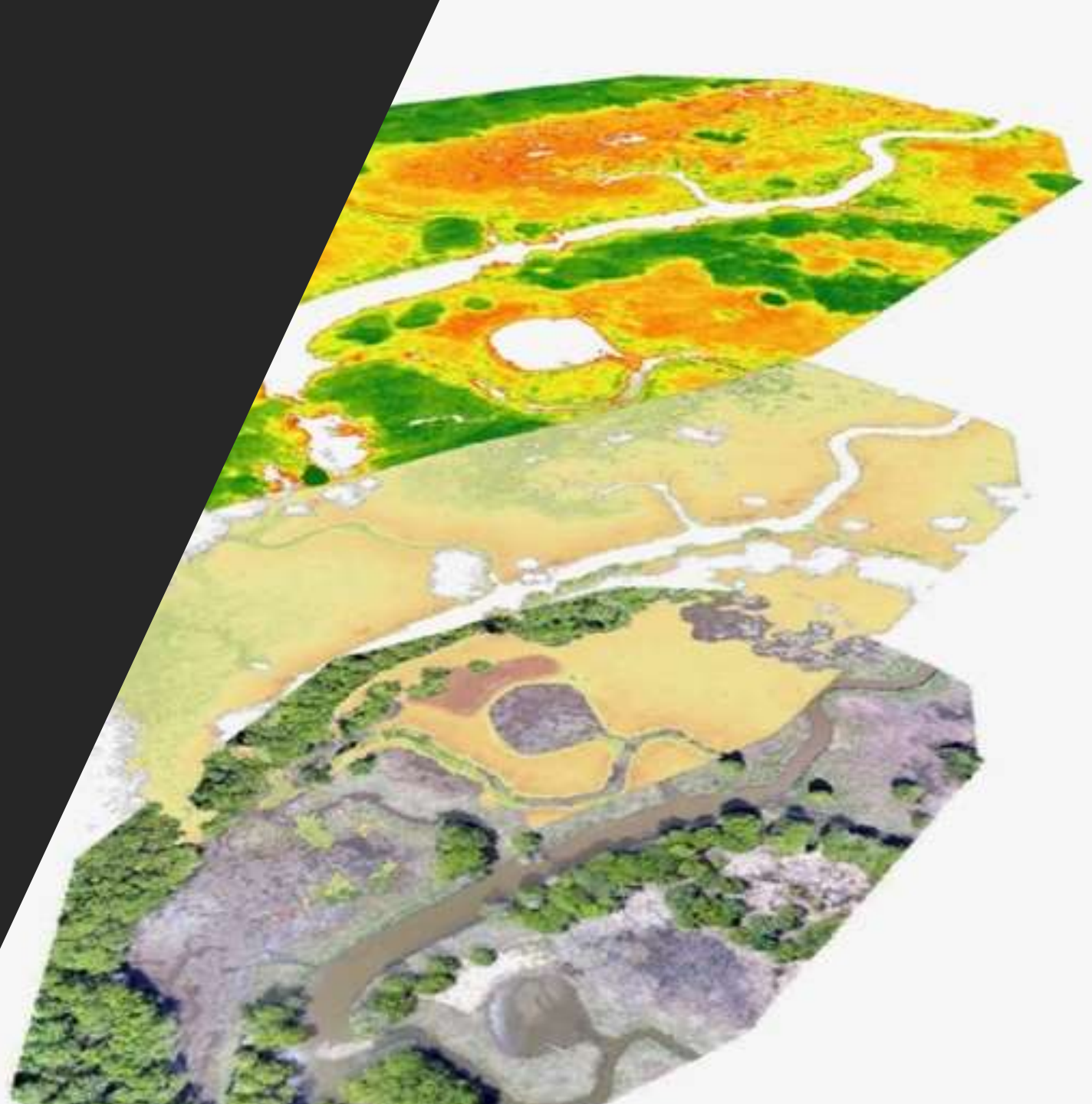
- Combine overlapping field data and multispectral data

Find signatures

- Processing data in R

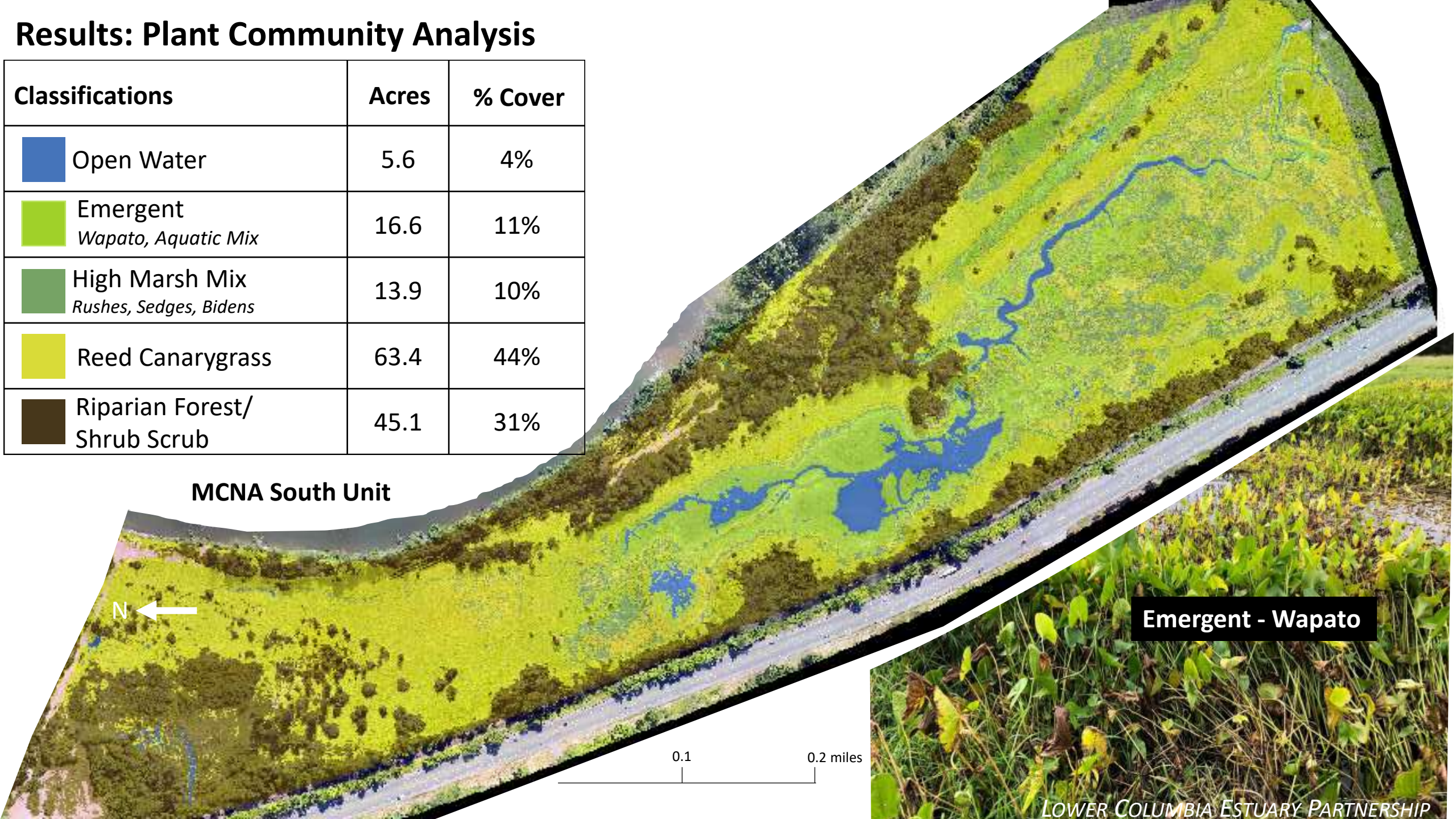
Classify plant communities in ArcGIS

- Based on R analysis outputs
- Validate with field data, make corrections where needed

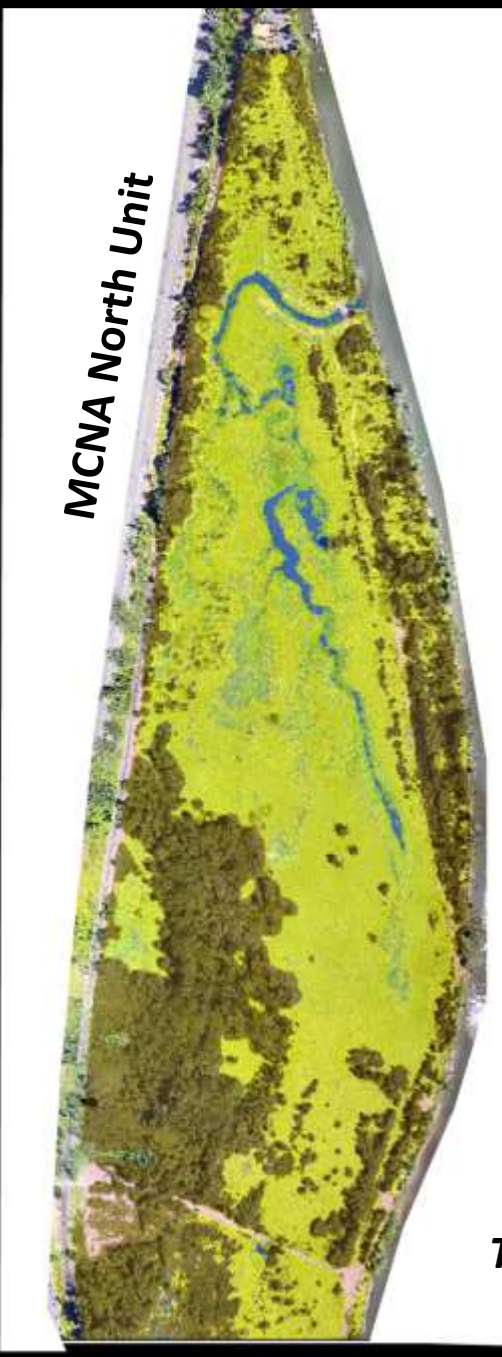


Results: Plant Community Analysis

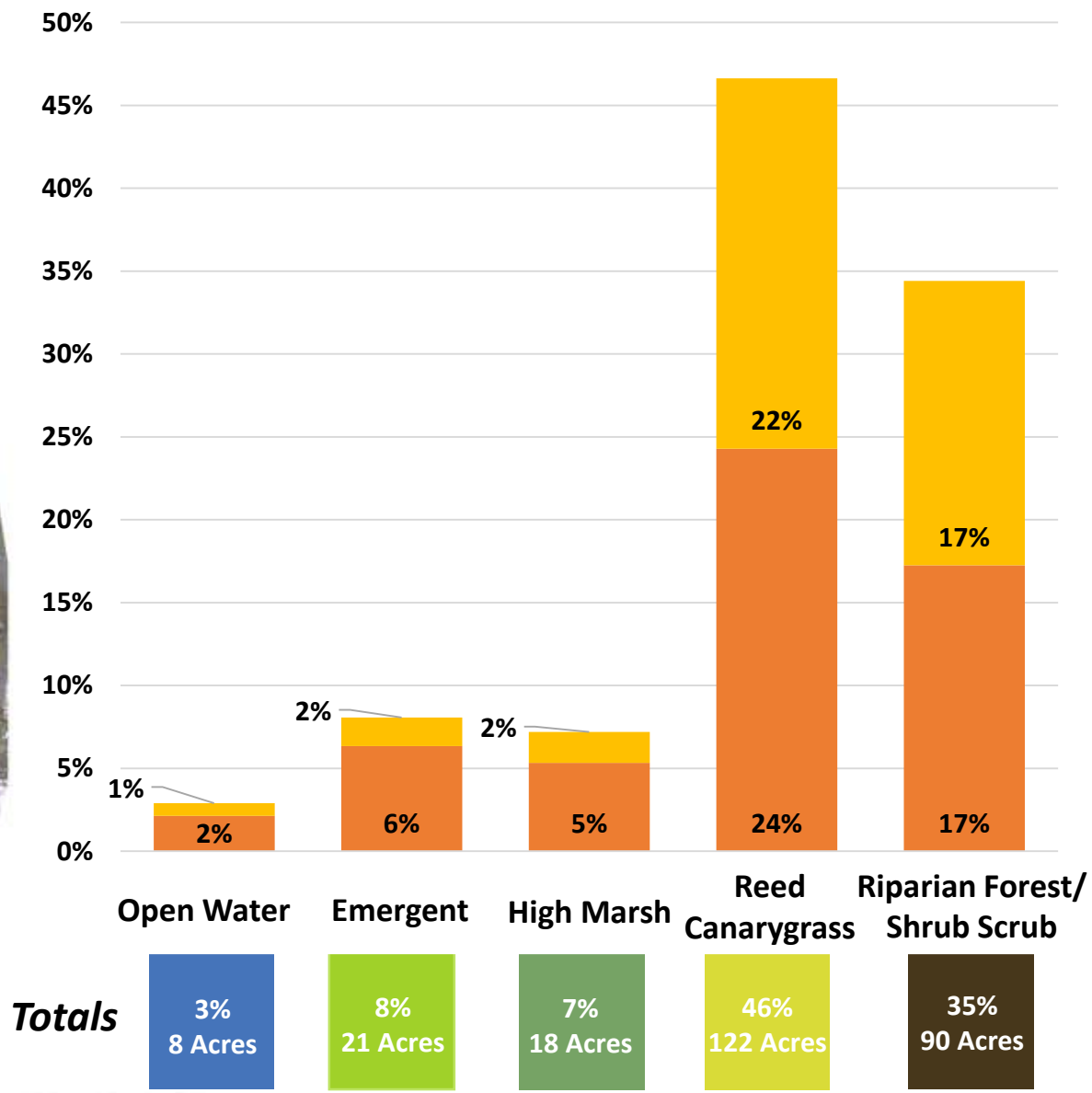
Classifications	Acres	% Cover
Open Water	5.6	4%
Emergent *Wapato, Aquatic Mix*	16.6	11%
High Marsh Mix *Rushes, Sedges, Bidens*	13.9	10%
Reed Canarygrass	63.4	44%
Riparian Forest/ Shrub Scrub	45.1	31%



This graph was created using about 4 million data points, with our mapping resolution of 0.25 m²

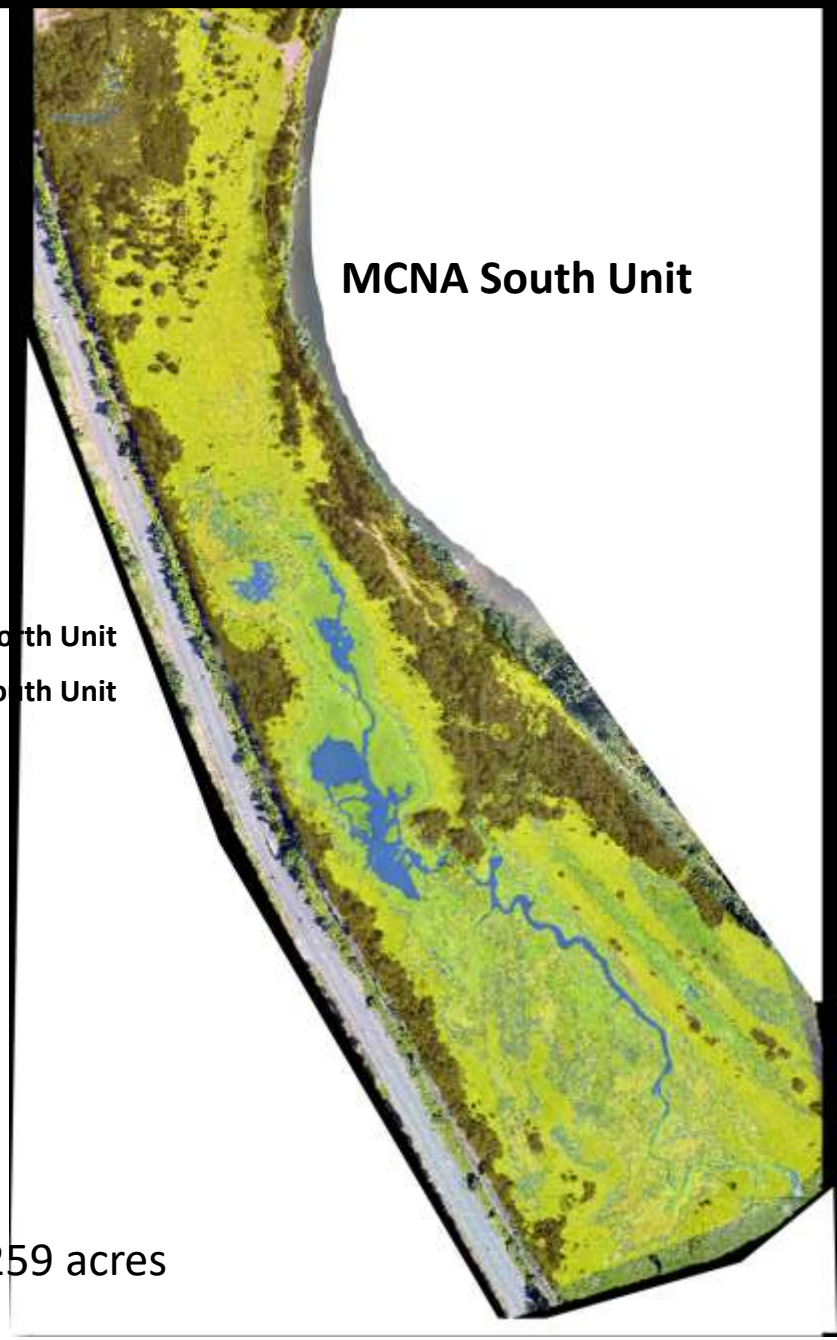


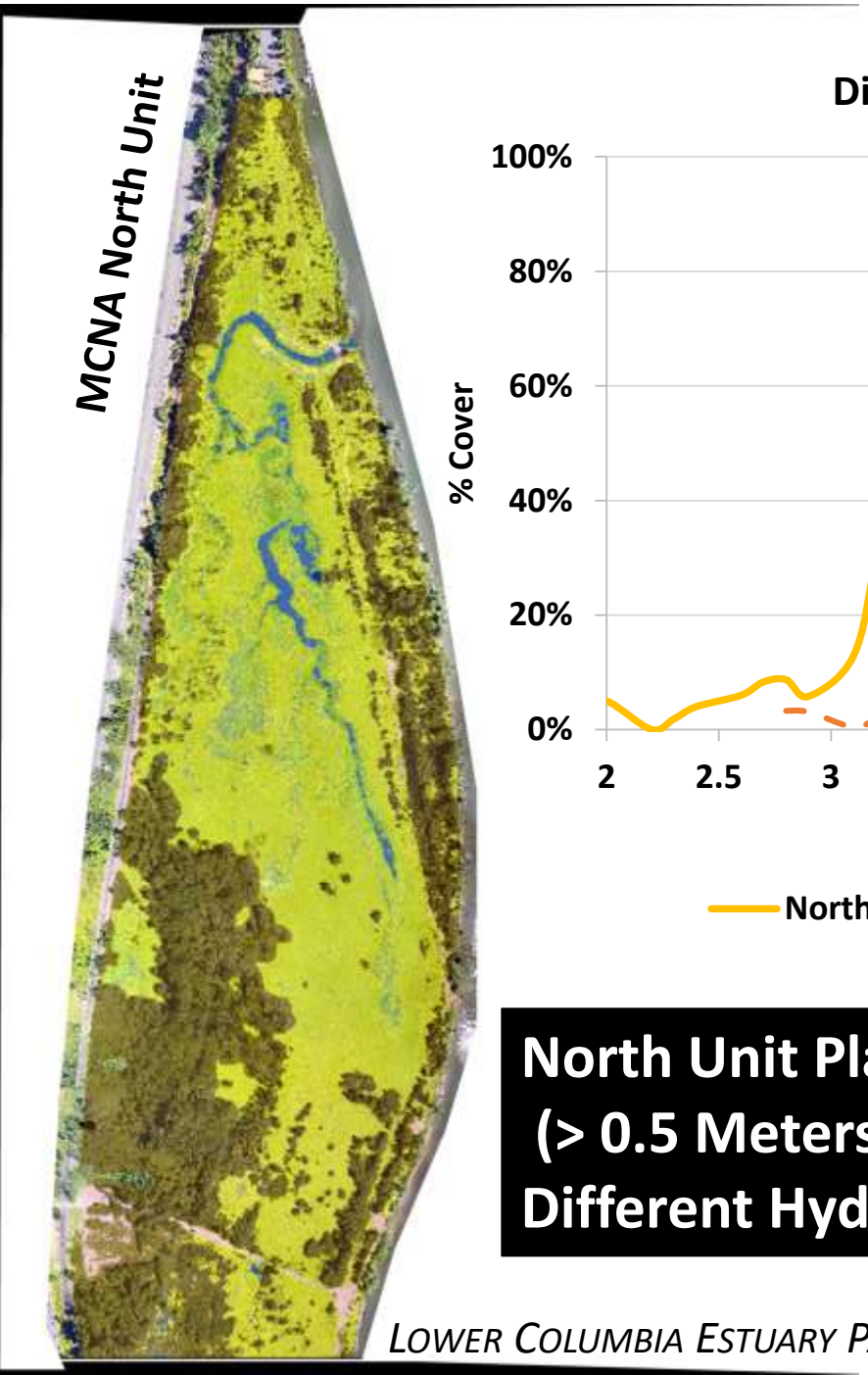
MCNA: Overall % Cover of Major Plant Communities

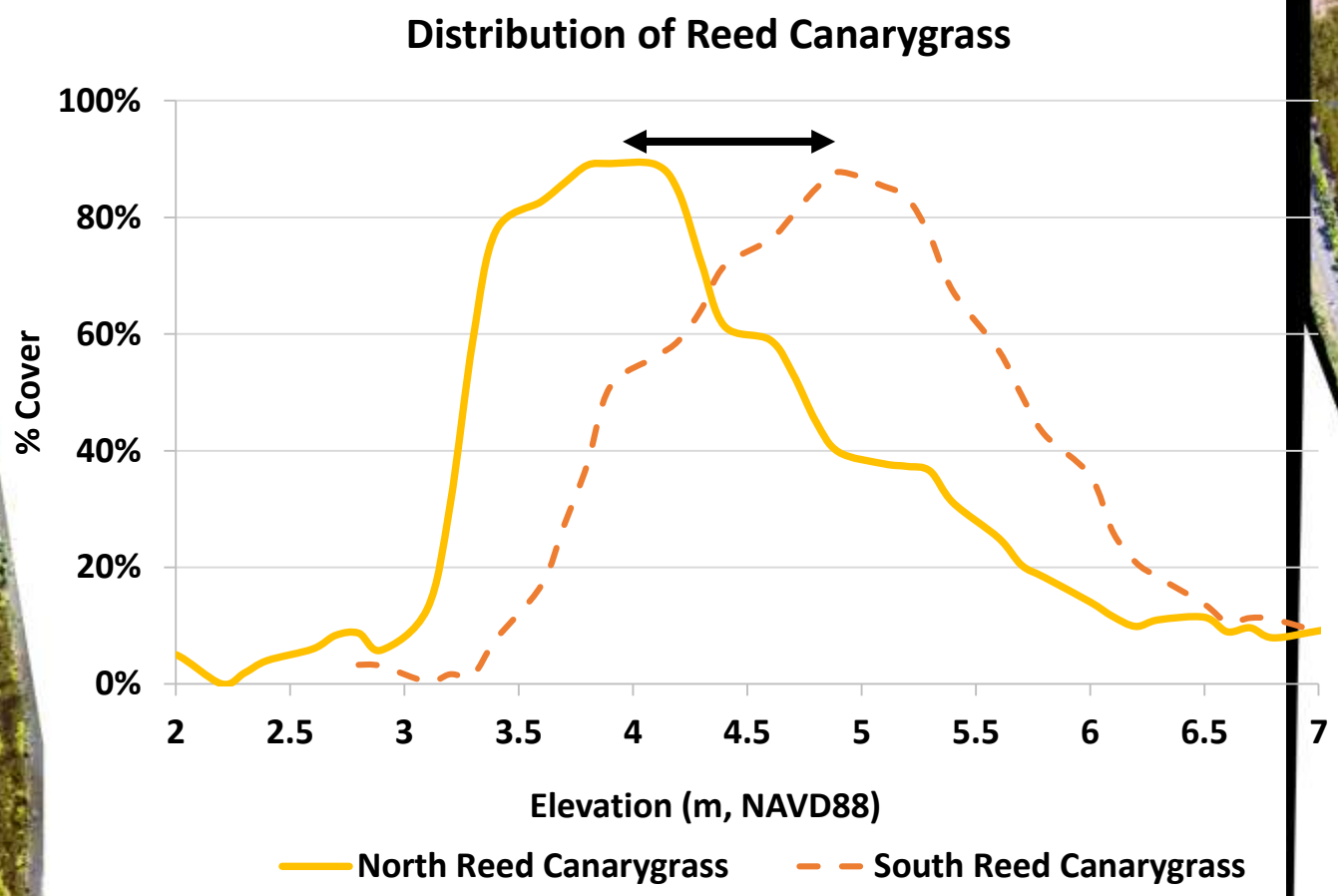


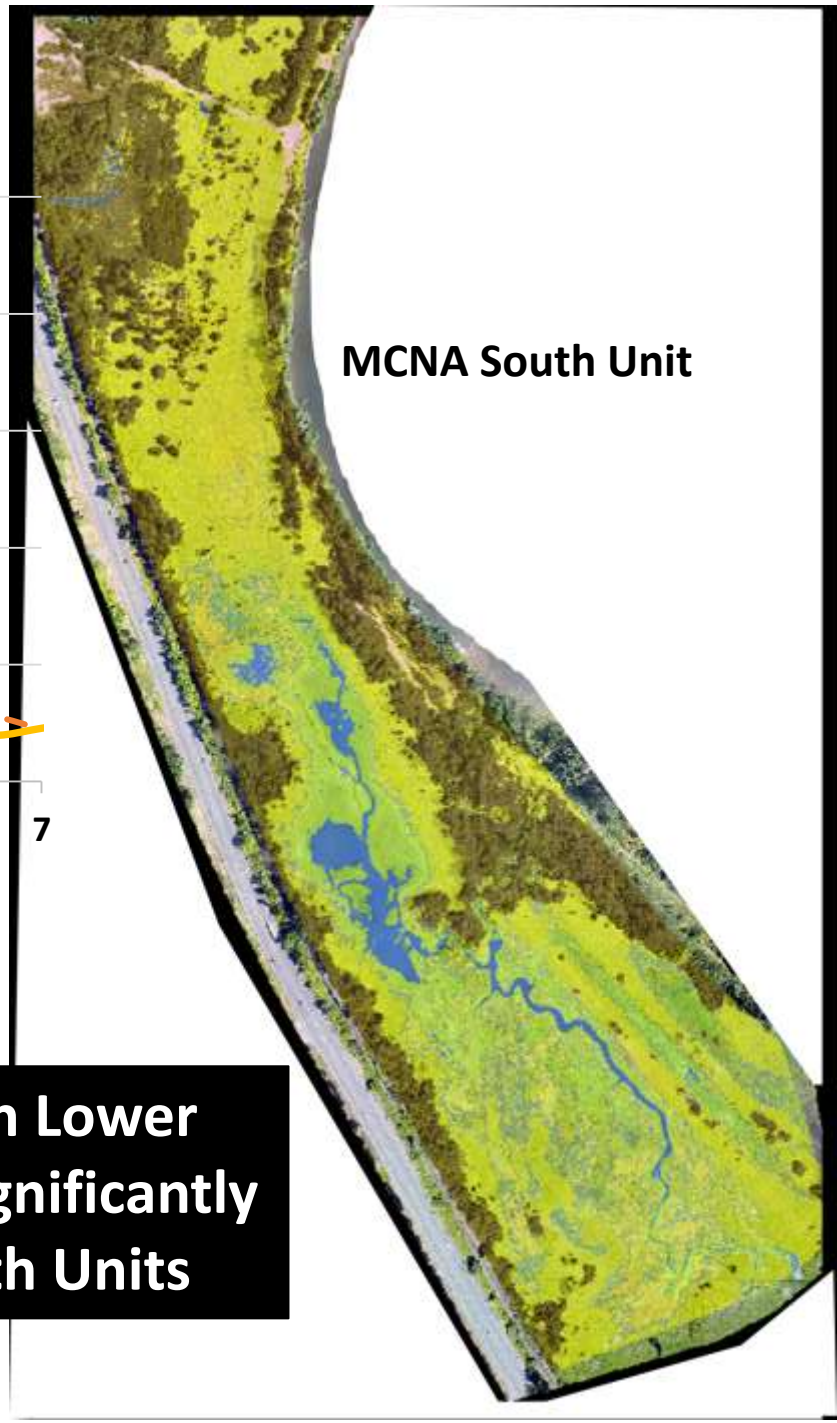
	Open Water	Emergent	High Marsh	Reed Canarygrass	Riparian Forest/ Shrub Scrub
Totals	3% 8 Acres	8% 21 Acres	7% 18 Acres	46% 122 Acres	35% 90 Acres

= 259 acres









North Unit Plant Community Elevations Much Lower (> 0.5 Meters) than South Unit, Indicating Significantly Different Hydrology Between North and South Units

Research Applications (Summary)

Pre-restoration can be used:

- When combined with hydrologic model scenarios these data can be used to predict shifts in habitat conditions across the entire site

Our research plan is to also include

- Tracking channel & over all site topographic development
- Evaluate above ground biomass (carbon stocks)
- Thermal sensing

Tiffany Thio, LCEP and Rikeem Sholes, USFW

Best Practices

- Field Data Collection

We are still working through our first season of intensive drone data collection and processing, but we have learned a few tips and trick along the way we can share

Best Practices: Field Data

In the office

1. Determine type of data you need to answer your questions
2. Flight plan and determine the number of ground controls you need (more topographic complexity = more GCPs)
   - 80% fore and side lap
   - 275-300 ft altitude
   - Mind your edges, distortion can be an issue
3. Check for software and equipment updates

Best Practices: Field Data

In The Field

1. Time of day matters, try for solar noon or overcast to reduce shadows
2. Pre-deploying GCPs or having multiple teams can reduce overall field delays during flights
3. Collect photos, plant community notes, and RTK points at each GCP and the surrounding area
4. Be sure to pack all the extra batteries and SD cards needed

Paige Suniga and Sneha Rao, Lower Columbia Estuary Partnership

Image Processing – Pix4D mapper v 4.4

- Initial Processing
- Generation of outputs

Image Processing – Pix4D mapper v 4.4

Image Acquisition

- Planning drone flight in Pix4D Capture: Selecting the flight location, deciding the overlap of the images to be taken and selecting the Flight altitude which determines Ground Sampling Distance (GSD)
- In the Field: Lay down Ground Control Points (GCPs), collect RTK Elevation data of the GCPs.
- Collect RTK Elevation data of dominant plant communities

Project Set-up

- Create a new project in Pix4D and import images.
- Read EXIF data, geolocate imported images and run initial processing to generate a quality report and previews of the desired outputs
- Also generates 3D point cloud

IMAGE PROCESSING – PIX4D MAPPER V 4.4

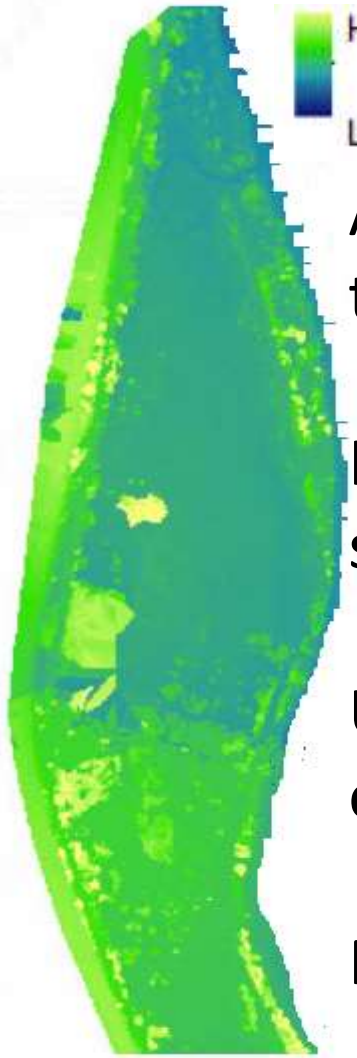
Image orientation and matching

- Importing elevation data of GCPs to georeferenced the project.
- Optimization to improve accuracy the 3D point cloud
- Select image scales for additional point generation that will be used to generate outputs

Output Generation

- The corrected point cloud is subjected to different algorithm to generate a Digital Surface Model (DSM) of the site
- The DSM is used to create a composite, 2D map of the site called an Orthomosaic
- The DSM is also used to create a 2D map of reflectance indices for Multispectral Images

Digital Surface Model (DSM)

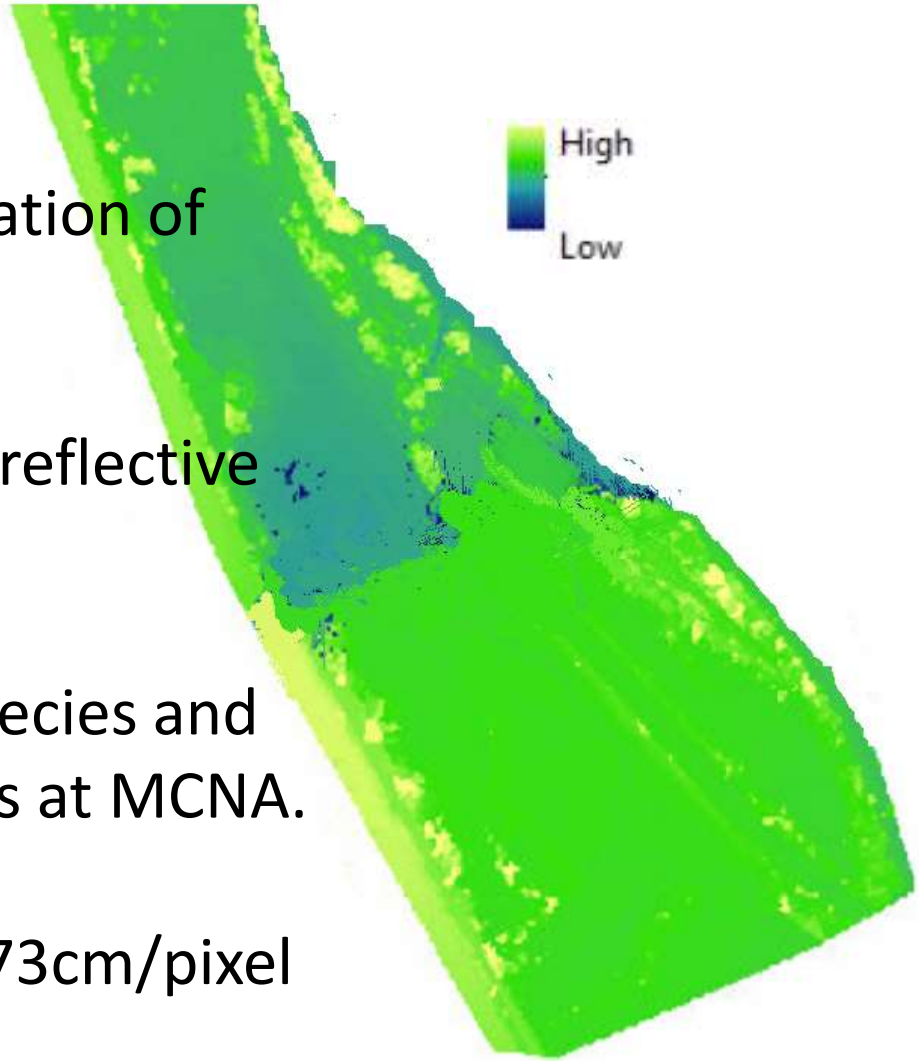


A Digital Surface Model is a digital representation of the physical features at a site.

It provides the Mean Sea Level elevations of reflective surfaces above Bare Earth

Used to extract plant heights of dominant species and establish emergent zones and riparian forests at MCNA.

Resolution of DSM (2019) for RGB band is 3.73cm/pixel



MCNA North Unit

MCNA South Unit

ORTHOMOSAIC

A detailed, accurate photo representation of an area, created out of many photos that have been stitched together and geometrically corrected.

An Orthomosaic has the accuracy of a high-resolution map. Individual Images are corrected or "Ortho-rectified" for:

- ❖ Camera Perspective
- ❖ Topographic relief

Orthorectified images are then edge-matched and color balanced to produce a seamless Orthomosaic.

ORTHOMOSAIC

This Orthomosaic is accurate to a specified map scale accuracy and can be used to make measurements as well as generate and update GIS feature class layers.

Orthomosaics of MCNA obtained over yearly flights to compare progress of plant community establishment over time. It provides textural and color information of dominant plant communities.

A total of 1916 RGB images were used to create the pictured Orthomosaic.

Normalized Difference Vegetation Index (NDVI)

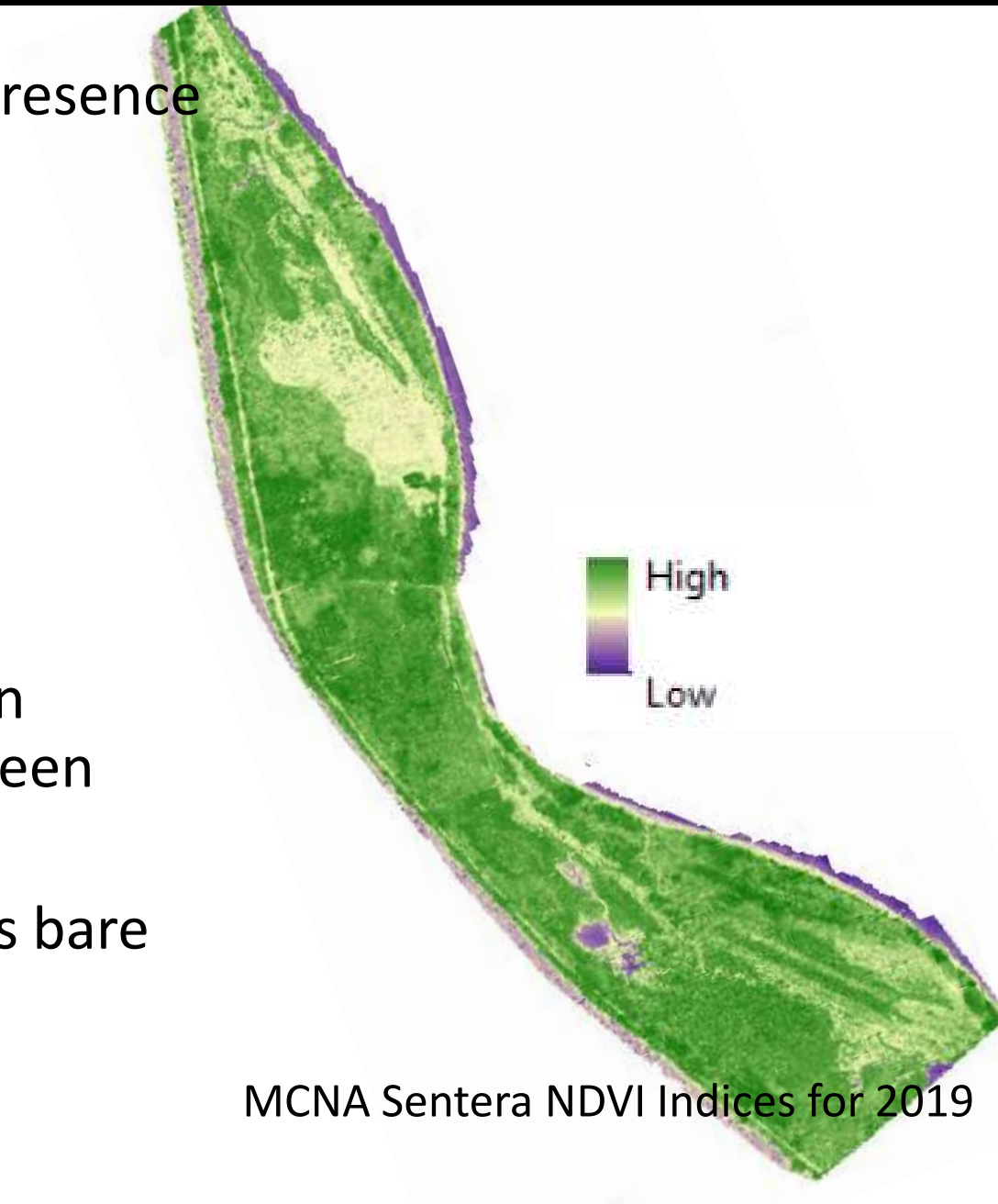
The NDVI is a well-established indicator for the presence and condition.

NDVI is calculated from the visible and NIR light reflected by vegetation:

$$NDVI = \frac{NIR - VIS}{NIR + VIS}$$

Values of the NDVI range from −1.0 (*i.e.*, no green biomass detected) to 1.0 (*i.e.*, vigorous, dense green biomass).

Open water bodies yield negative values whereas bare ground areas yield values close to zero.



MCNA Sentera NDVI Indices for 2019

Normalized Difference Vegetation Index (NDVI)

The sentera upgrade on the DJI phantom 4 captures near infrared (NIR) images of the site.

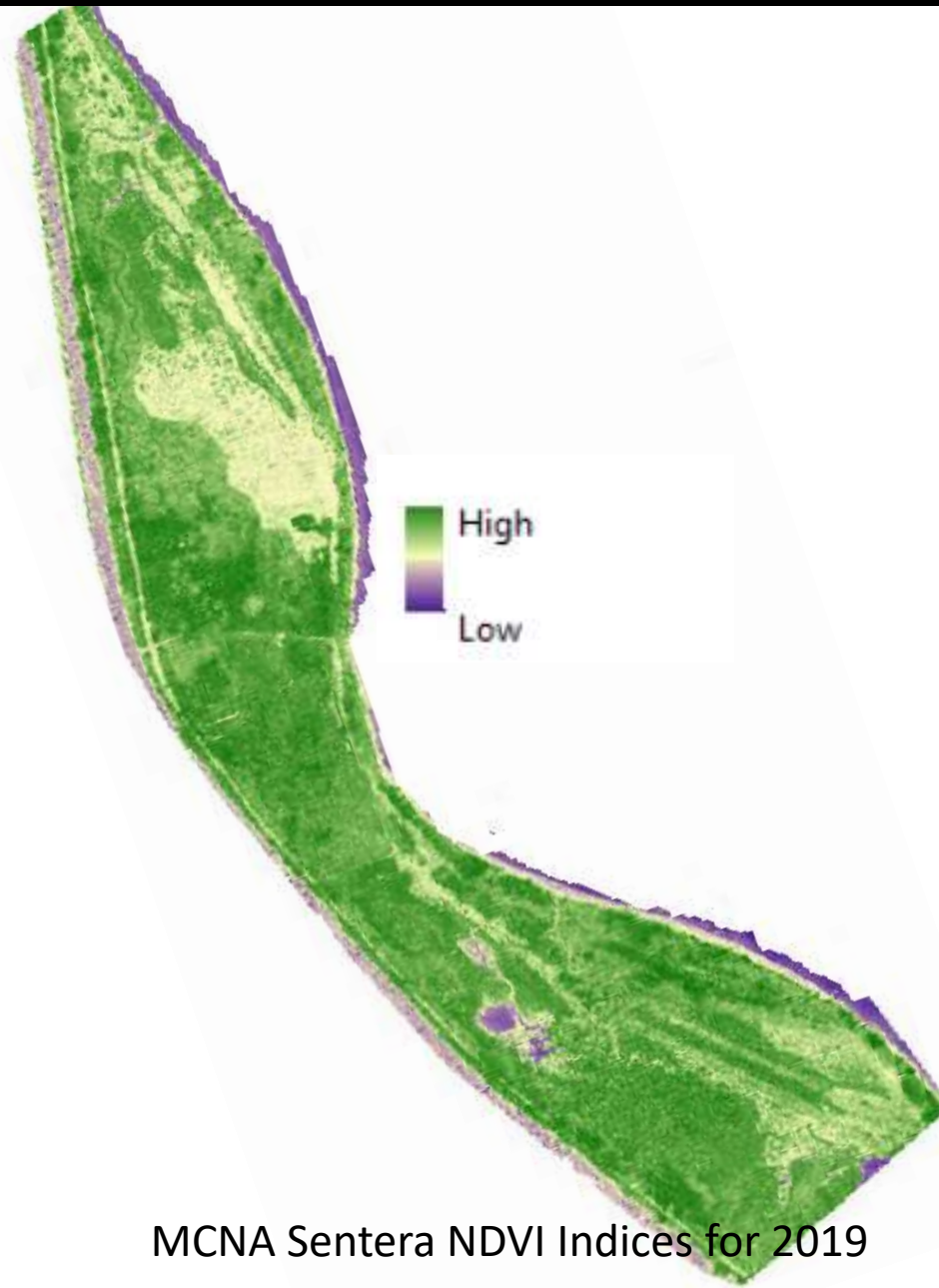
Image processing in Pix4d follows the same procedure, but, due to a different spectral band, must be considered a separate project.

GSD for NIR images vary from RGB images.

Critical piece of Multispectral data for vegetation mapping, which often varies with flights depending on:

- ❖ Time of day
- ❖Natural Light and cloud cover

Resolution of 2019 NIR flight was 7.98cm/pixel



MCNA Sentera NDVI Indices for 2019

Best Practices: Data processing

1. Ensure full image scale processing for point cloud generation to have maximum number of key-point matches.
2. Imported GCPs must be in the same plane as the point cloud. Failure to do so results in faulty DSM and Orthomosaic.
3. Images of different spectral bands cannot be merged into the same project.
4. Reoptimize whenever changes are made to the point cloud.
5. Pix4D cannot process projects that have over 3000 images, so larger projects must be processed in separate blocks.

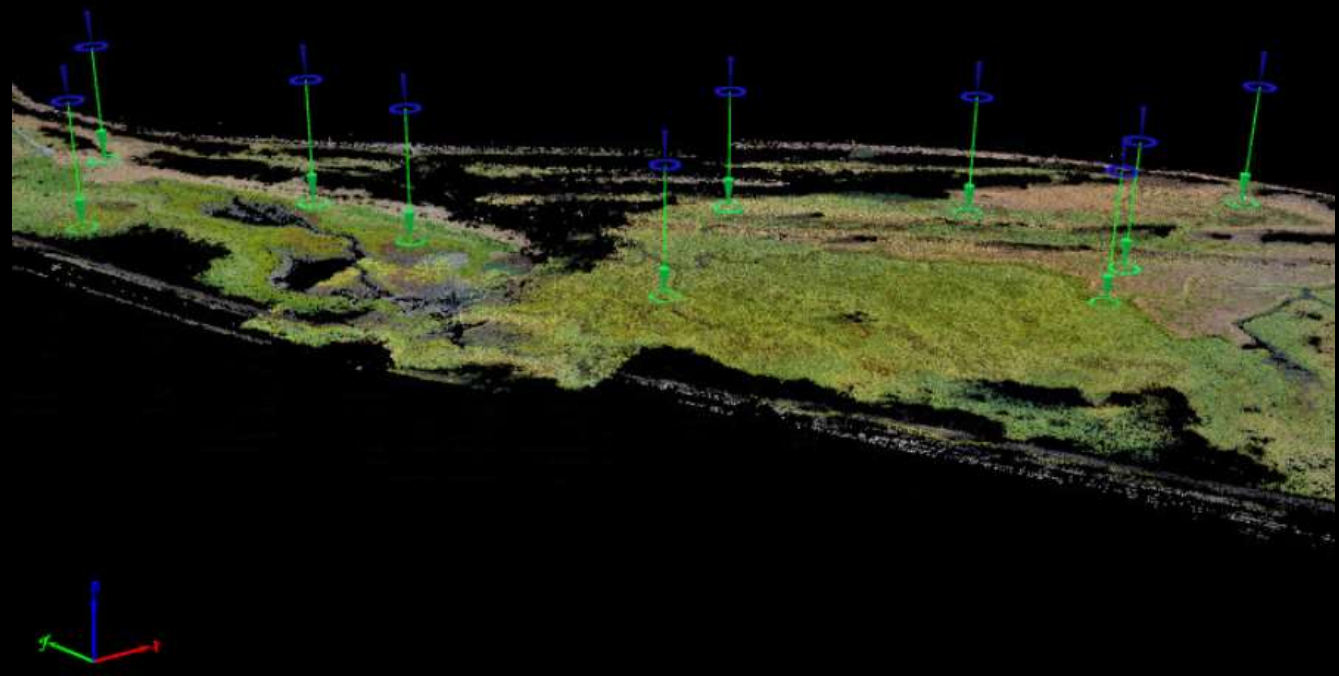


IMAGE SHOWING ELEVATION DISTORTION IN POINT CLOUD