Multispectral UAV Data for Wetland Plant Community Mapping: Predicting and Evaluating Restoration Impacts

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Columbia River Estuary Conference

RESEARCH CONDUCTED BY:
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Lower Columbia Estuary Partnership

RESEARCH GOALS – PROGRAM LEVEL

## Ecosystem Monitoring Program (EMP)

- Status and trends monitoring of ecosystem condition – suite of reference sites throughout the estuary

Action Effectiveness Monitoring & Research Program (AEMR)

- Evaluation of restoration actions- if projects achieve the goals of the project, inform adaptive management

Overarching Goals

- Improve our understanding of the ecology of the estuary so we may continue to inform and improve our restoration and conservation efforts!

Lower Columbia Estuary Partnership
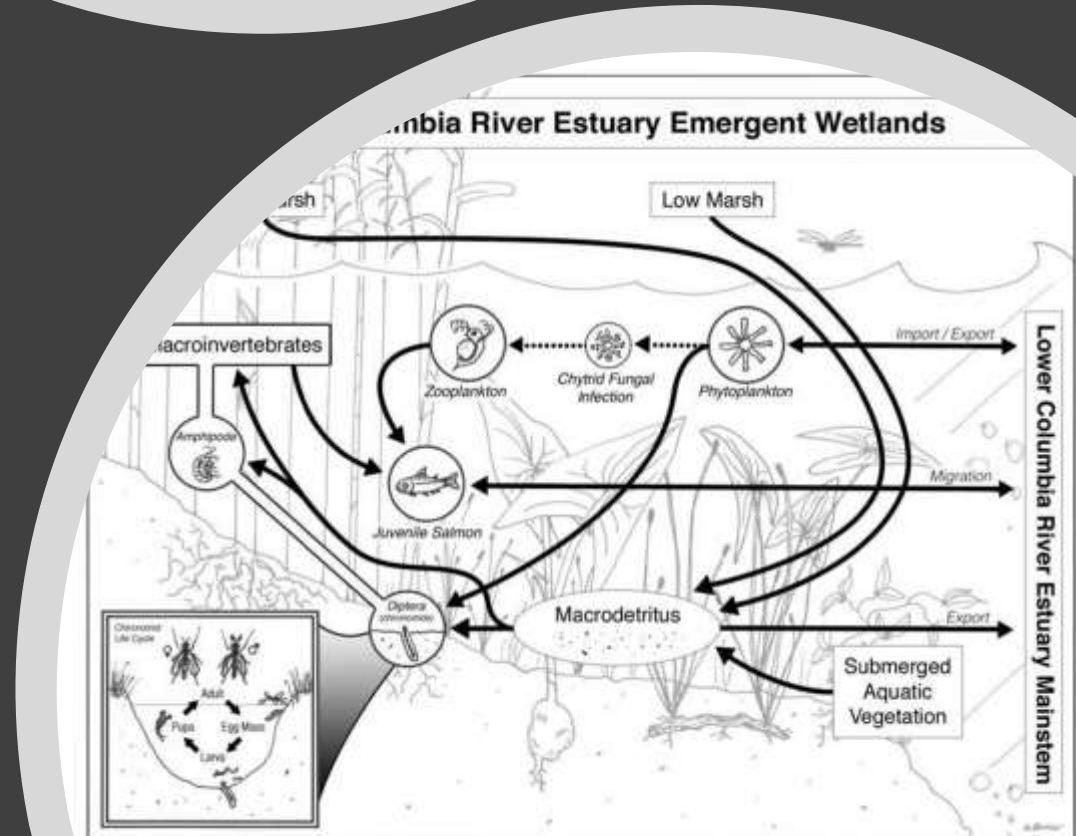
Research Goals – UAV Applications

- Accurately map dominant plant communities and site hydrology

- Create accurate summaries of **Salmonid Habitat Conditions**

- Track changes in site conditions over-time:
  - *Native and Non-native Plant Community Distributions*
  - *Above Plant Ground Biomass*
  - *Channel Development*
  - *Topographic Changes*

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

Processing

- Pix4D

Analysis

- Tableau, R, R Studio

- ArcGIS

Lower Columbia Estuary Partnership

Research Goals
UAV Applications – Wetland Plant Community

In the past we have focused on monitoring conditions using transects and 1-m^2 plot data (<1-5% of the site would be monitored)

- Model those results across the entire site using the UAV sensor data and ArcGIS image classification

- Example - **Shift from collecting data from 0.02 acres to 200 acres**

- **Track site-wide change overtime**

- **Predict shifts from SLR/Climate Change, Restoration, Management**

WALLOOSKEE, 3 YEARS (2020) POST-RESTORATION

PROJECT BACKGROUND

The Wallooskee restoration site is in Youngs Bay, near the City of Astoria in Oregon (Columbia RM 16, Reach A) .

The 200-acre tidal reconnection restoration project was funded by BPA and is currently owned and managed by the Cowlitz Indian Tribe. The overall goal for this project was to restore full tidal reconnection and provide juvenile salmonid access.

Dr. Sarah Kidd, with the Lower Columbia Estuary Partnership, has been conducting restoration effectiveness monitoring at this site in partnership with the Cowlitz Indian Tribe since 2013.
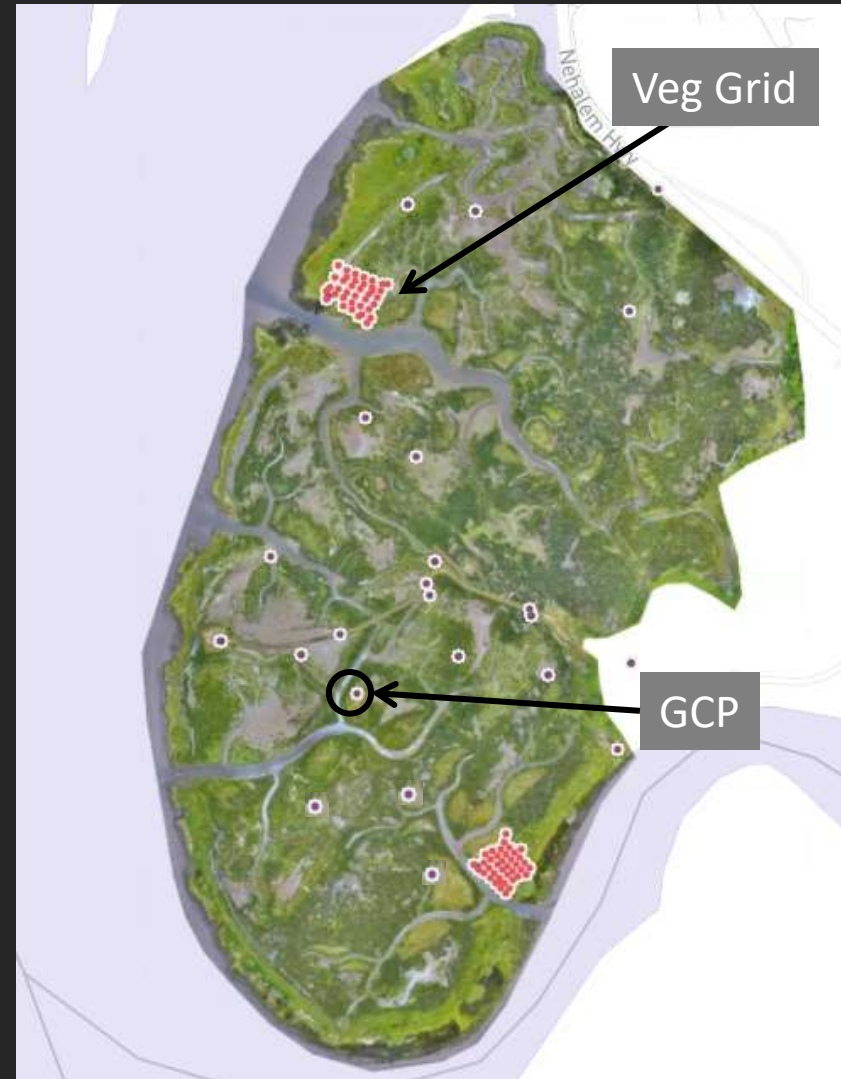
In July of 2017, tidal flooding was restored throughout the wetland through the removal and lowering of levees that bordered the site. Additional channel enhancements were conducted in areas to expand channel density and access to wetland habitat.

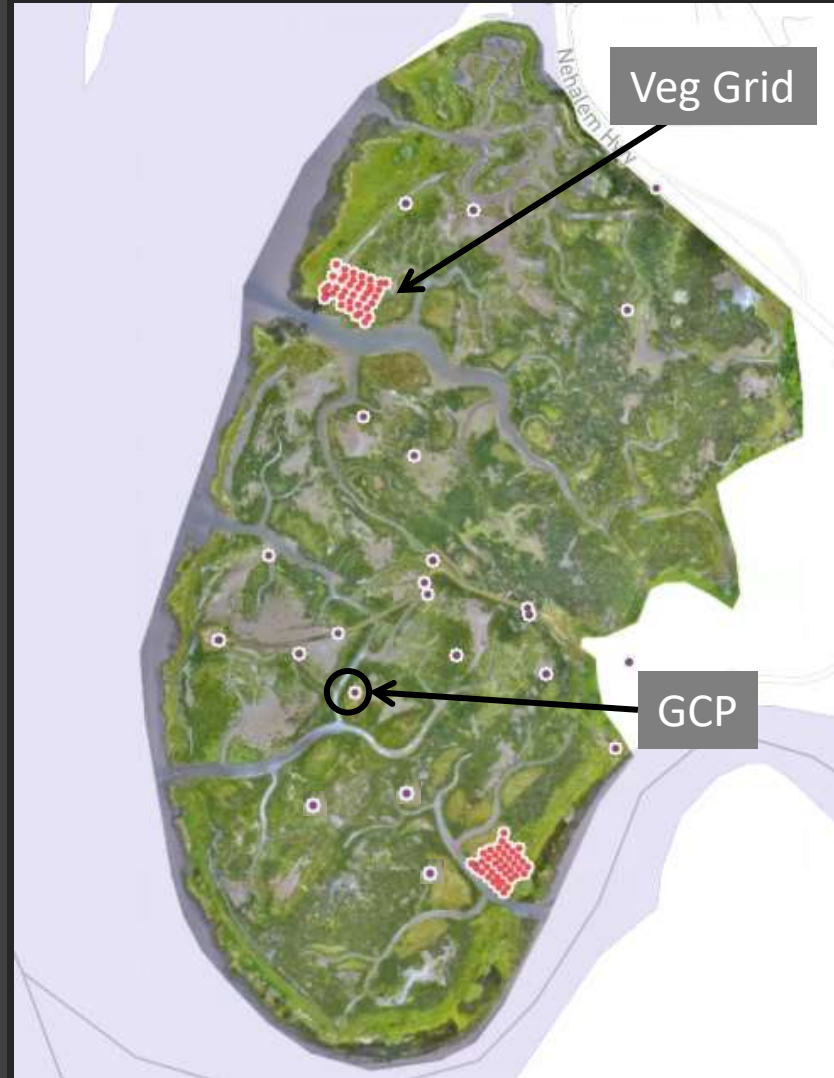# Field Data Collection and Plant Community Mapping

Wallooskee Field Survey Work

✓ Vegetation Grids – 70 plots (1 m^2) –Detailed (% cover) species data and co-located RKT data

✓ Ground Control Points (GCPS) –31 Locations - RTK, Photos Points, and Dominant Species Recorded

Wallooskee Field Survey Work

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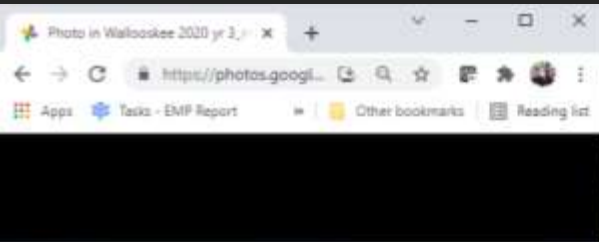

Veg Grid

GCP
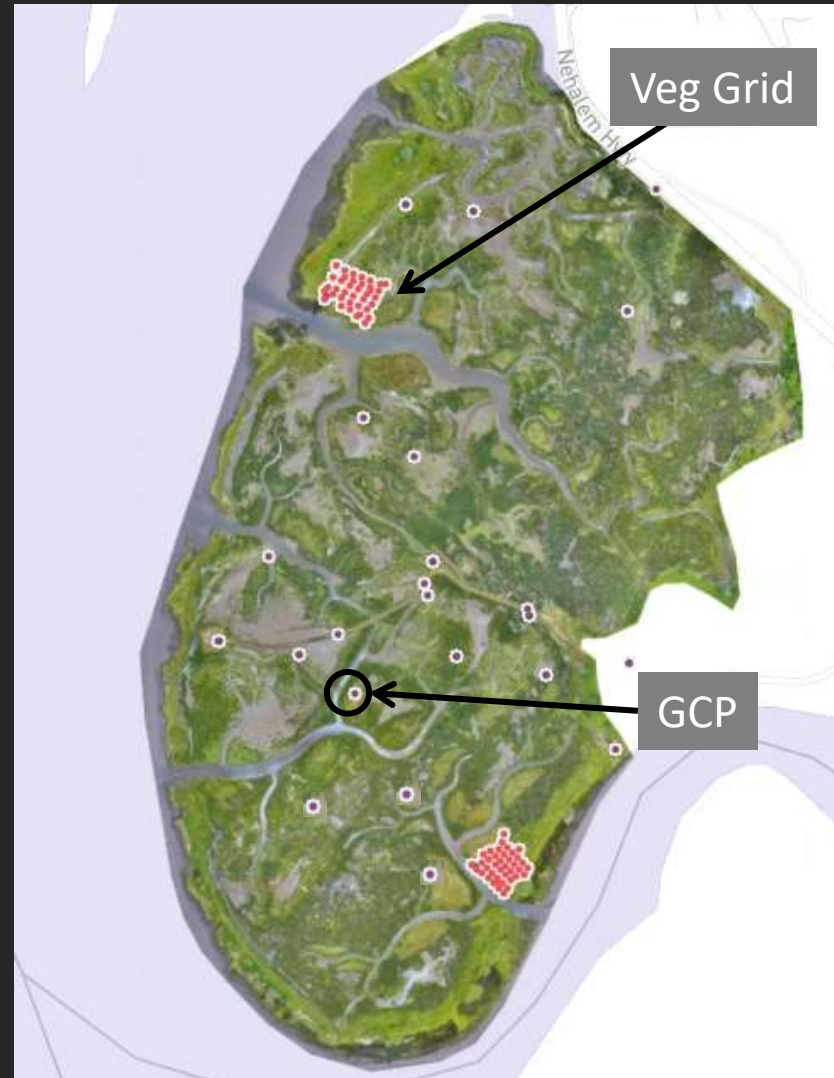
UAV Flight
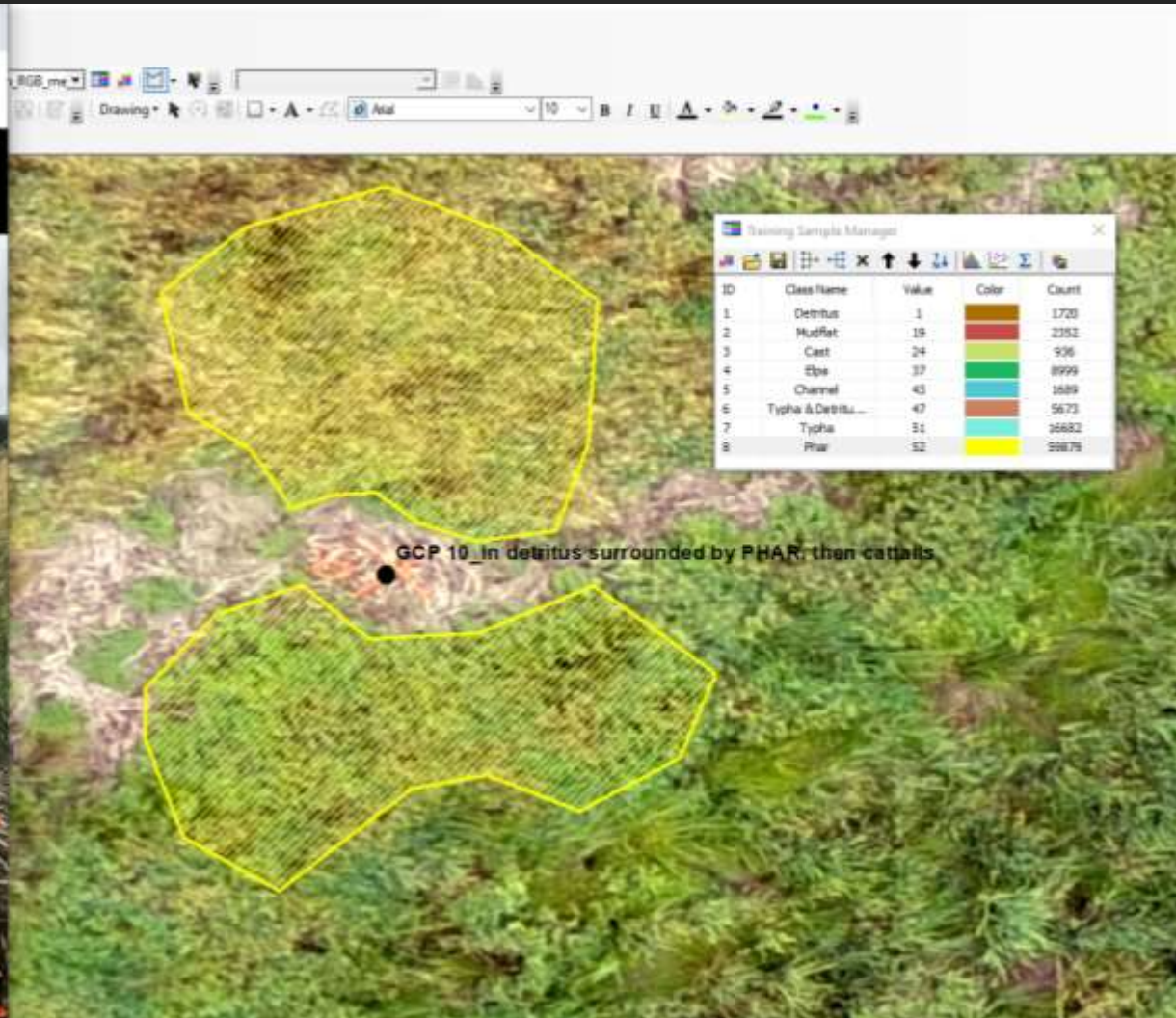- ✓ 300 ft
- ✓ 80% fore and side lap
- ✓ Flown over 2 days

Pix4D Processing Outputs: 3.73 cm ground sampling distance
- RGB – Image seen to the left
- DSM – Digital Surface Model
- DTM – Digital Terrain Model
- NIR – Near Infrared
- NDVI - Normalized Difference Vegetation Index

GCP Data Used to Inform Training Polygons

Excellent resource including how to evaluate error in your model:
Rwanga, Sophia S., and J. M. Ndambuki. 2017. "Accuracy Assessment of Land Use/Land Cover
Classification Using Remote Sensing and GIS." International Journal of Geosciences 8 (4): 611–22.
https://doi.org/10.4236/ijg.2017.84033.

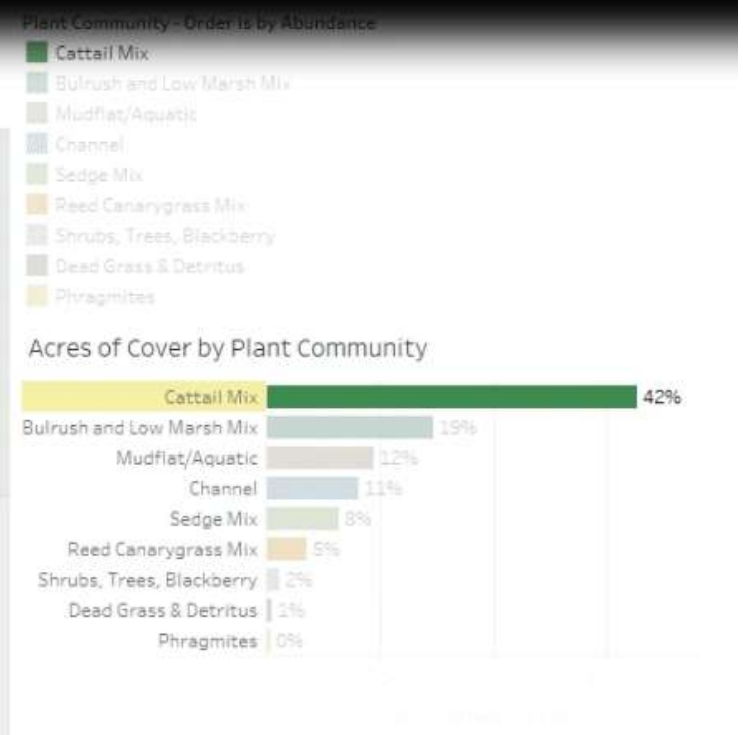## Model Building Considerations

- Clean up all raster data sets
  - ✓ Wetland boundary
  - ✓ Mask out any non-wetland areas (roads/power lines etc.)
  - ✓ Removing wet areas, channels, and riparian forest if easily classified by elevation etc.
- Iterate and take good notes
  - ✓ Adjust Training Polygons as needed
- Accuracy >95-85%, Kappa 1-0.7.
- Some areas may require clean up post-processing

Plant Community Composition

UAV Modeled From 2020 Drone Flight

Hover your mouse over the bar graph below to highlight the communities on the map.

Veg group: **Cattail Mix**

© 2022 Mapbox © OpenStreetMap

Plant Community – Order is by Abundance

- Cattail Mix
- Bulrush and Low Marsh Mix
- Mudflat/Aquatic
- Channel
- Sedge Mix
- Reed Canarygrass Mix
- Shrubs, Trees, Blackberry
- Dead Grass & Detritus
- Phragmites

Acres of Cover by Plant Community

Community	%
Cattail Mix	42%
Bulrush and Low Marsh Mix	19%
Mudflat/Aquatic	12%
Channel	11%
Sedge Mix	8%
Reed Canarygrass Mix	5%
Shrubs, Trees, Blackberry	2%
Dead Grass & Detritus	1%
Phragmites	0%

FINAL MODEL – INTERACTIVE ON TABLEAU ONLINE

Cattail Mix

Mudflat/Aquatic
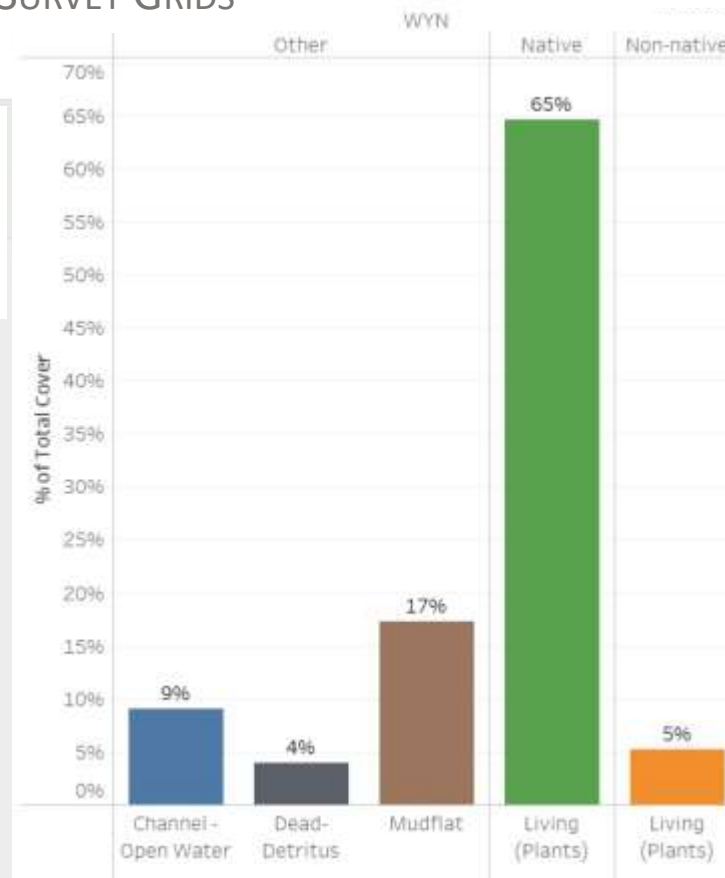
Bullrush and Low Marsh (Spike Rush)

Plant Community Composition

UAV Modeled From 2020 Drone Flight

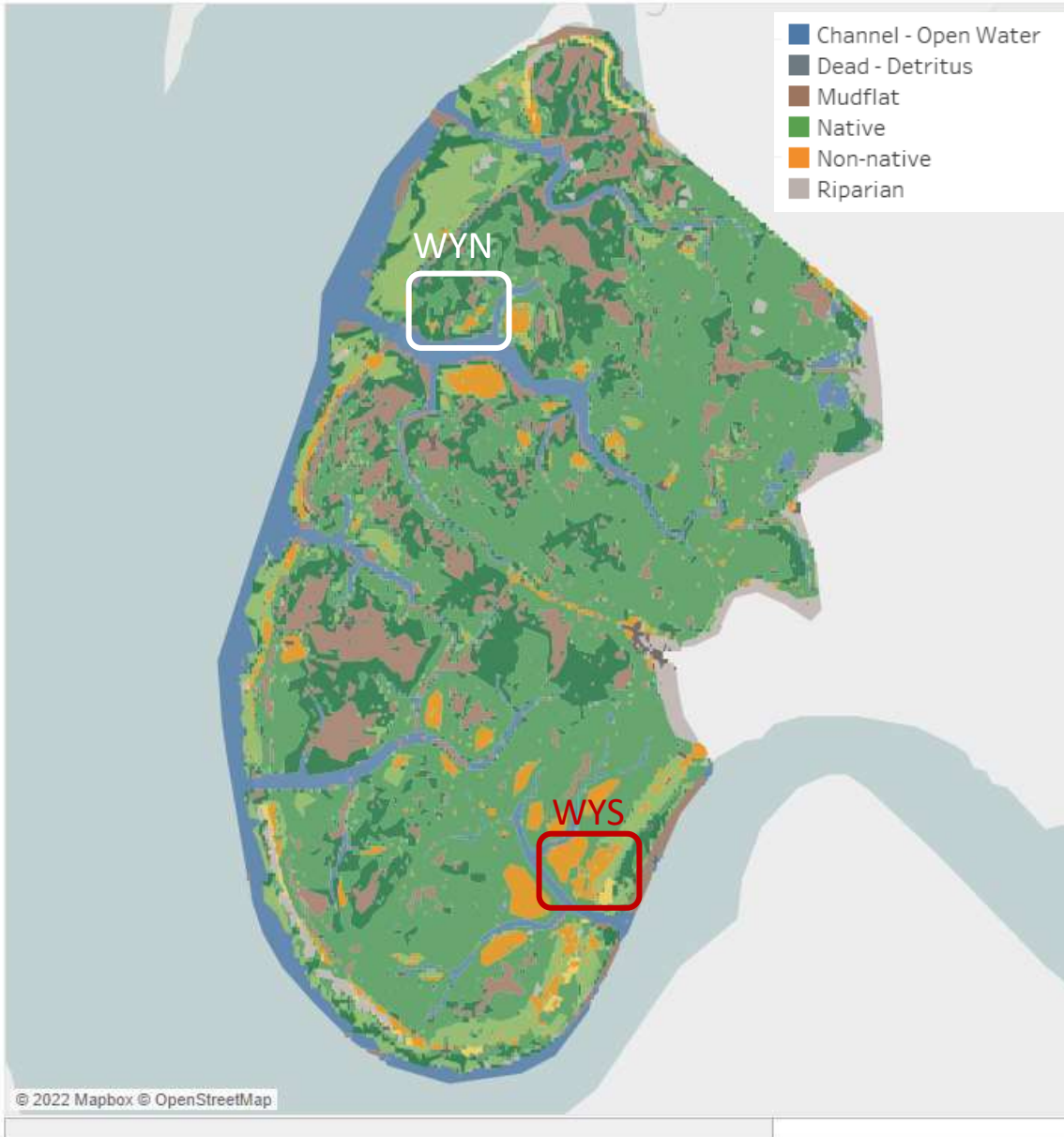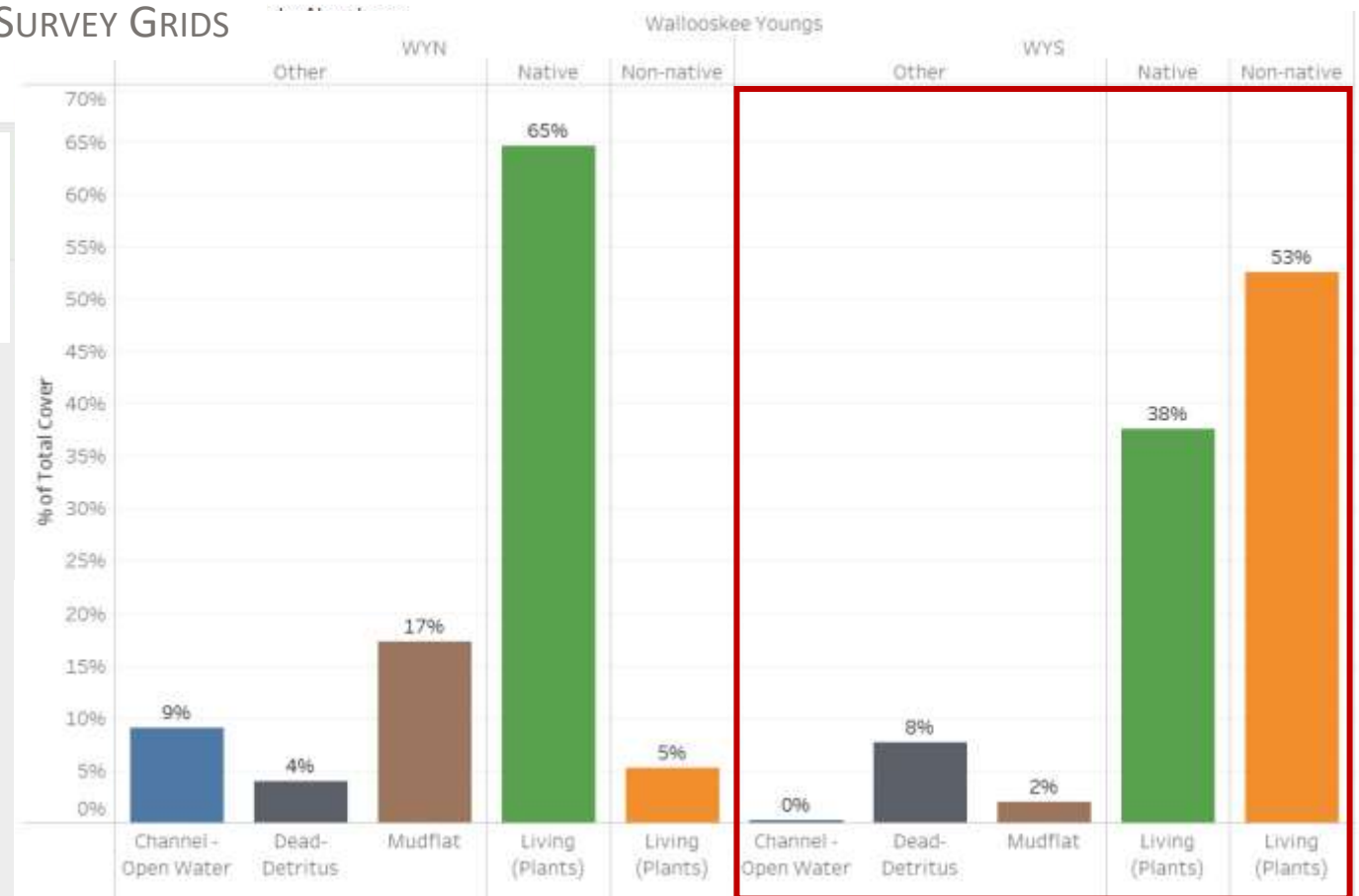*Hover your mouse over the bar graph below to highlight the communities on the map.*

Legend:
- Channel - Open Water
- Dead - Detritus
- Mudflat
- Native
- Non-native
- Riparian

WYN

© 2022 Mapbox © OpenStreetMap

WYN

	Other		Native	Non-native
Channel - Open Water	Dead-Detritus	Mudflat	Living (Plants)	Living (Plants)
9%	4%	17%	65%	5%

% of Total Cover

Plant Community Composition

UAV Modeled From 2020 Drone Flight

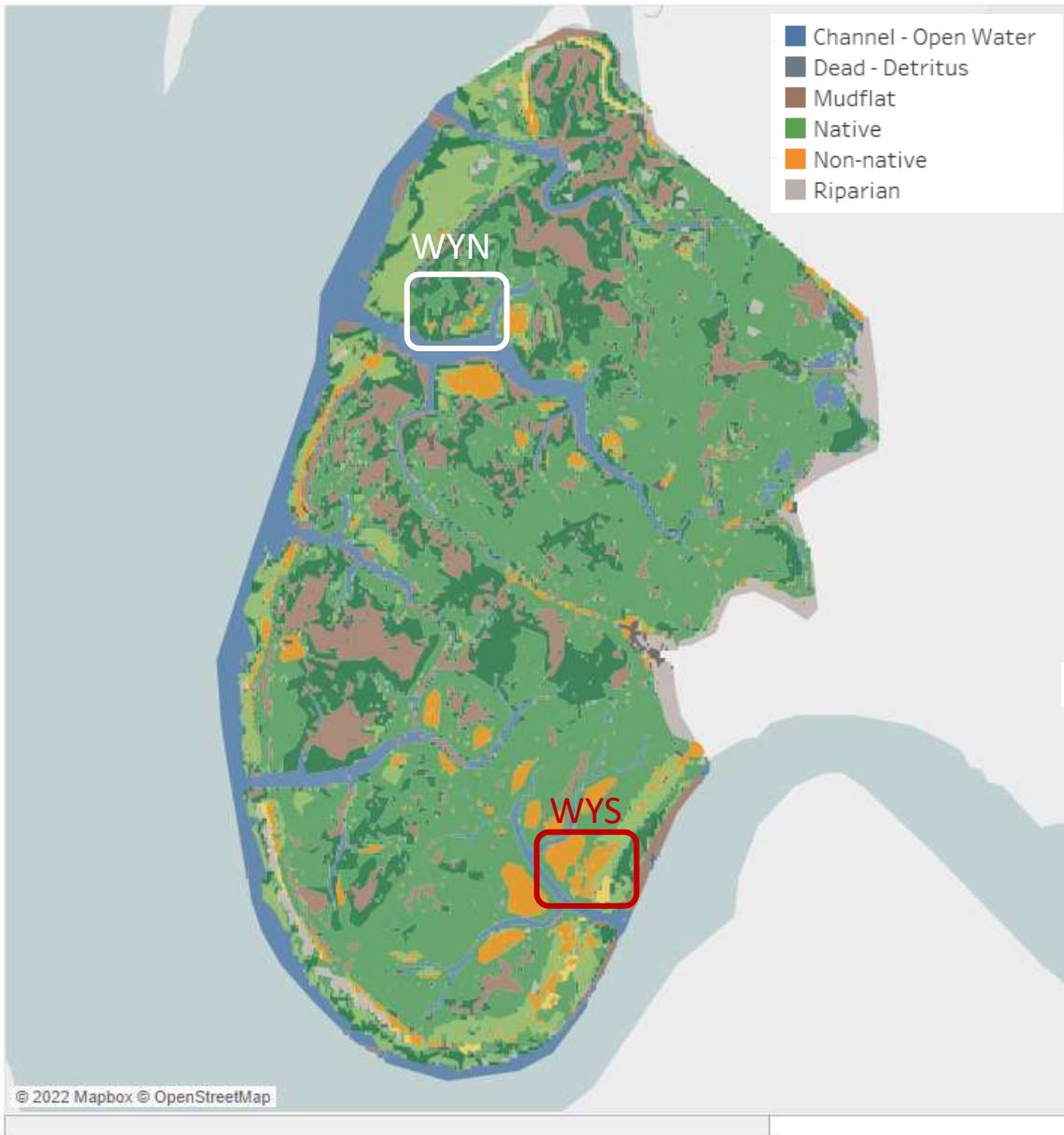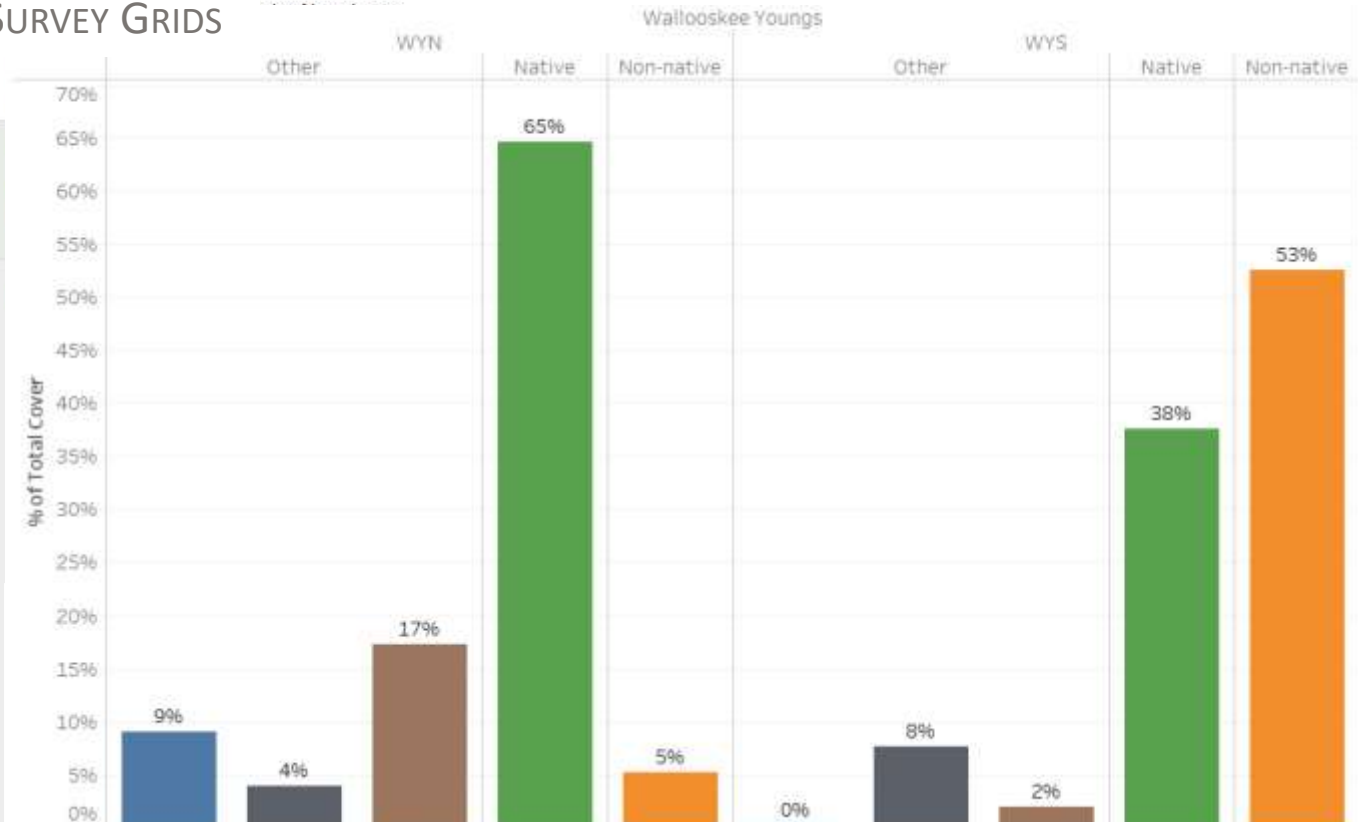*Hover your mouse over the bar graph below to highlight the communities on the map.*

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© 2022 Mapbox © OpenStreetMap

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Legend:
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- Native
- Non-native
- Riparian

WYN

WYS

© 2022 Mapbox © OpenStreetMap

VEGETATION SURVEY GRIDS

Wallooskee Youngs

WYN
- Other
- Native
- Non-native

WYS
- Other
- Native
- Non-native

% of Total Cover

9% | 4% | 17% | 65% | 5% | 0% | 8% | 2% | 38% | 53%

UAV MODELED

Percent of Total Acres

| Channel - Open Water	Dead - Detritus	Mudflat	Native	Non-native	Riparian
11%	1%	12%	70%	5%	2%
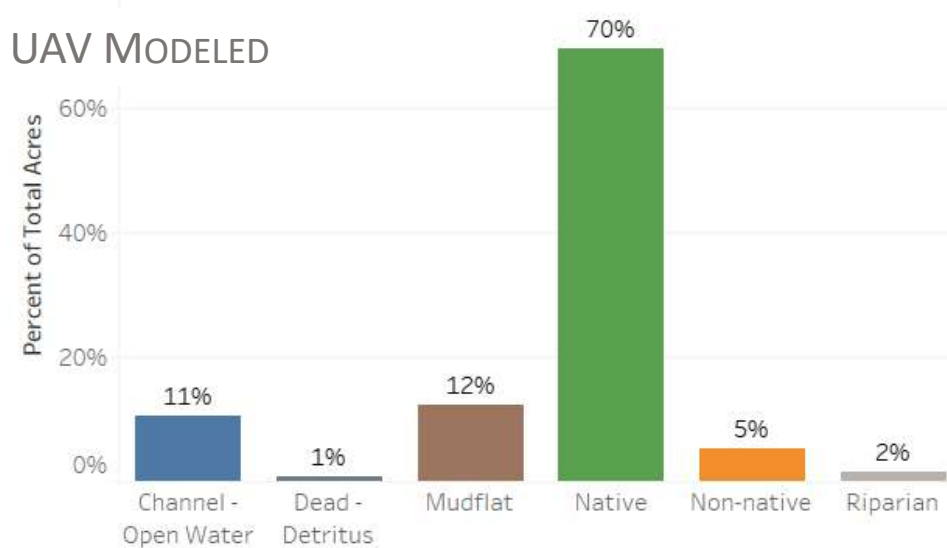
- Field Survey vs. Modeled results are informative
- Model accuracy = extremely reliable
- Scope/Extent of information about site conditions vastly improved with Modeled Data

Combining Data Sets – Modeling Habitat Conditions Site Wide

- **Where and When are habitat conditions ideal across a site?**

  - Acres of native habitat with ideal depths and temperatures for salmonid access, for % of time over the month, year, etc.

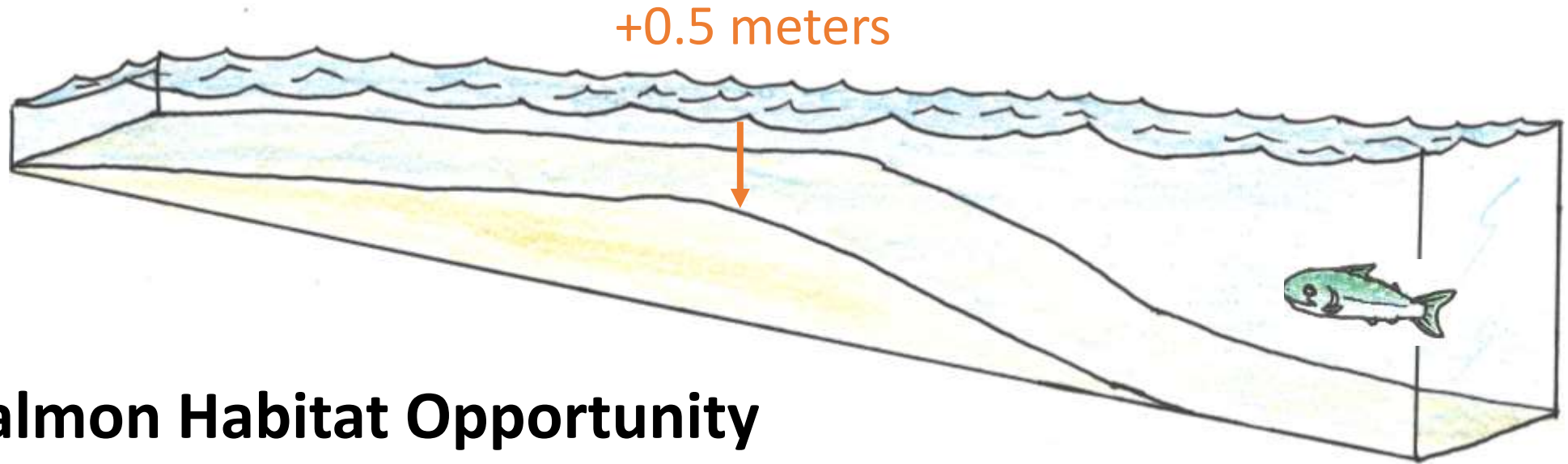- **What are the major drivers in these conditions?**
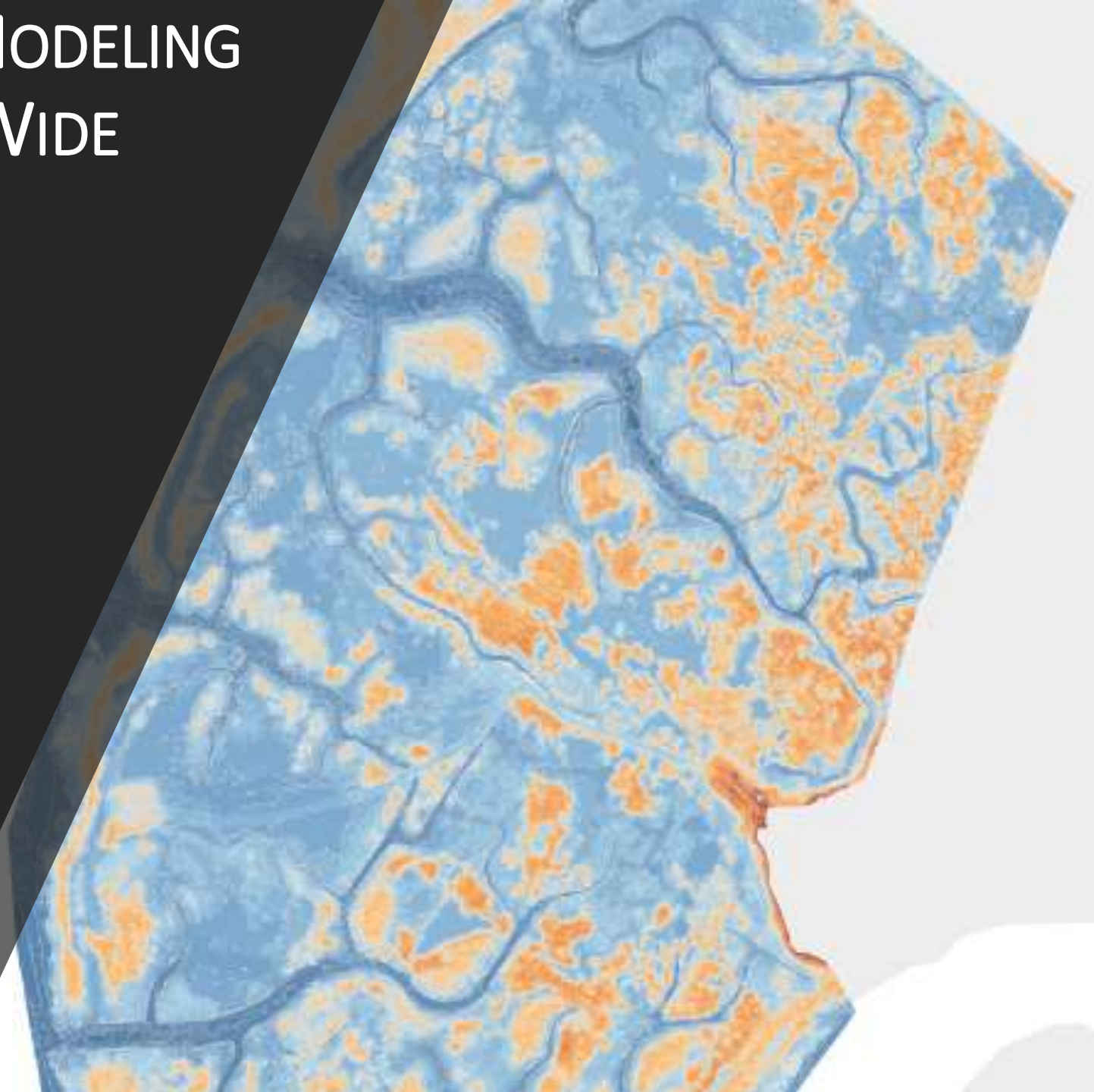
RESEARCH GOALS – UAV APPLICATIONS – HABITAT CONDITIONS

Salmon Habitat Opportunity Model

+0.5 meters

What is **Salmon Habitat Opportunity**

ACCESS DEPTH = Channel and Wetland Elevation
≥0.5 m

OPPORTUNITY TEMP = Optimal ≤ 17.5 C
Marginal 17.5-22 C

Original citation - Dan Bottom 2011 (source for metric) and now as adapted by LCEP for AEMR reports/analysis since 2018.

RESEARCH GOALS – UAV APPLICATIONS – HABITAT

Salmon Habitat Opportunity Model =

Site Hydrology and Temperature Data

↑ 2015 Construction of the southern channel network connecting to the Wallooskee River

RESEARCH GOALS – UAV APPLICATIONS – HABITAT

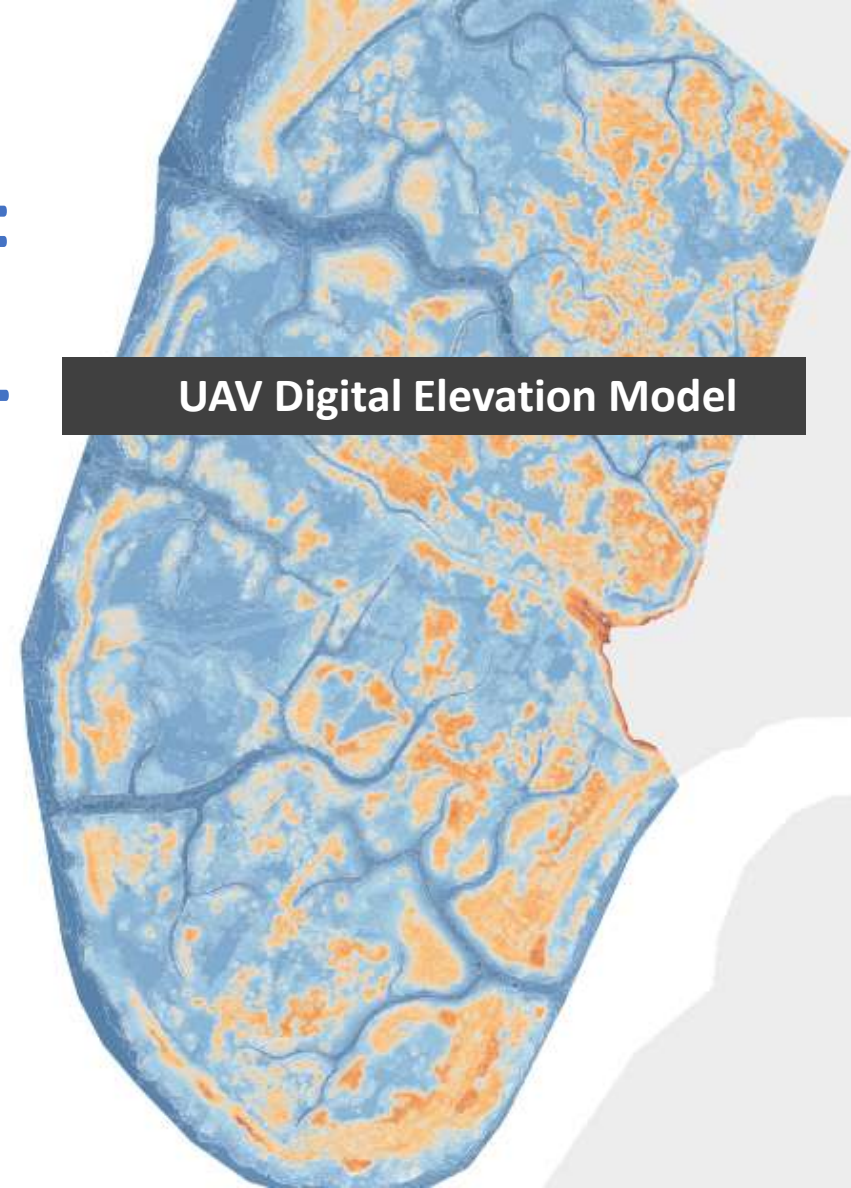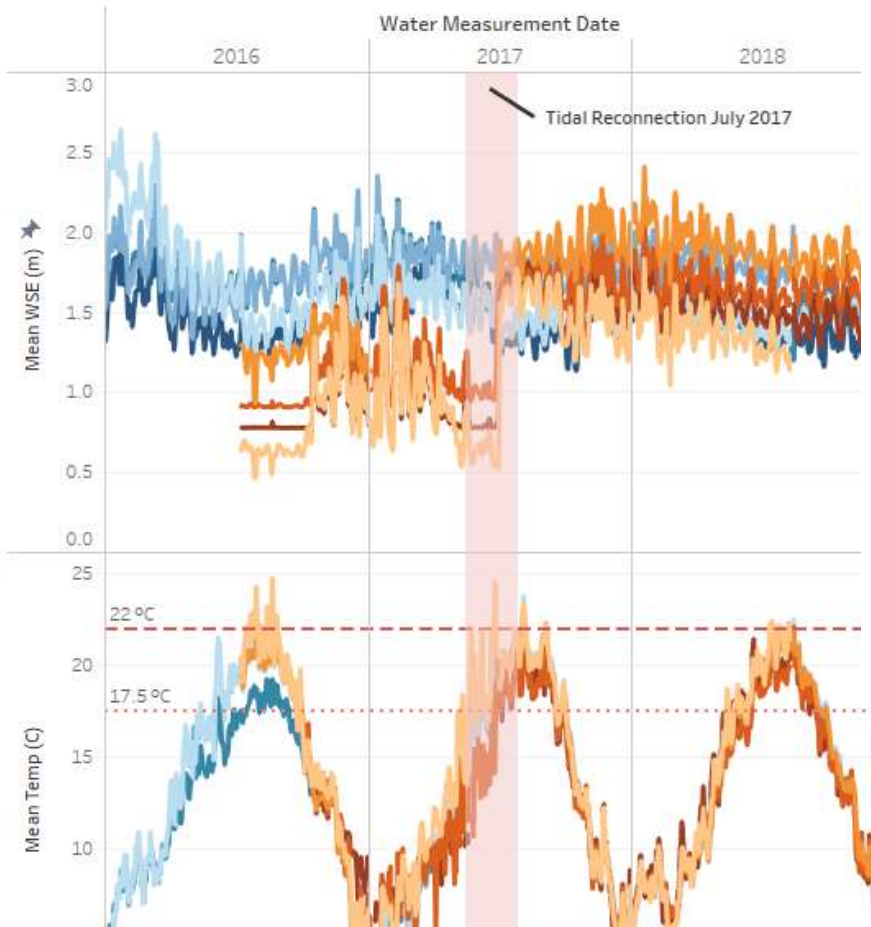**Salmon Habitat Opportunity Model** =

Site Hydrology and Temperature Data + **UAV Digital Elevation Model**

Data Logger Locations

Year
- (All)
- 2014
- 2015
- ☑ 2016
- ☑ 2017
- ☑ 2018
- 2019
- 2020
- 2021

© Mapbox © OSM

Location Information
- 2) Inner Channel - Youngs Bay Side
- 7) Inner Channel - Wallooskee Side
- 12) Inner Channel - Wallooskee Side Near Transmi...
- 13) Inner Channel - Youngs Bay Side Near Base of ..
- 3) Outer Mudflat - Youngs Bay Side
- 8) Outer Channel - Wallooskee Side
- 14) Astoria Tidal Gage (NOAA) Station #9439040
- 15) Daggett Point

Location Number
- ☑ (All)
- ☑ 2
- ☑ 3
- ☑ 7
- ☑ 8
- ☑ 12
- ☑ 13
- ☑ 14
- ☑ 15

Mean Daily Water Surface Elevation, Temperature, and Salinity

Water Measurement Date

2016   2017   2018

Tidal Reconnection July 2017

Mean WSE (m)
3.0
2.5
2.0
1.5
1.0
0.5
0.0

Mean Temp (C)
25
22 °C
20
17.5 °C
15
10

SALMONID HABITAT ACCESS (DEFINED BY WATER DEPTHS)
BASED ON MEAN MONTHLY CONDITIONS ACROSS THE SITE

JUNE-OCT 2020
Dry Season

Summer Mid-Low Tide

JUNE-OCT 2020

Dry Season

67 % (128 acres) Access
33 % (62 acres) No Access

HABITAT ACCESS

- Channel >2.5 meters *(also accessible)*
- Accessible 0.5-2.5 meters
- No Access <0.5 meters

Salmonid Habitat Access (Defined by Water Depths)
Based on mean monthly conditions across the site
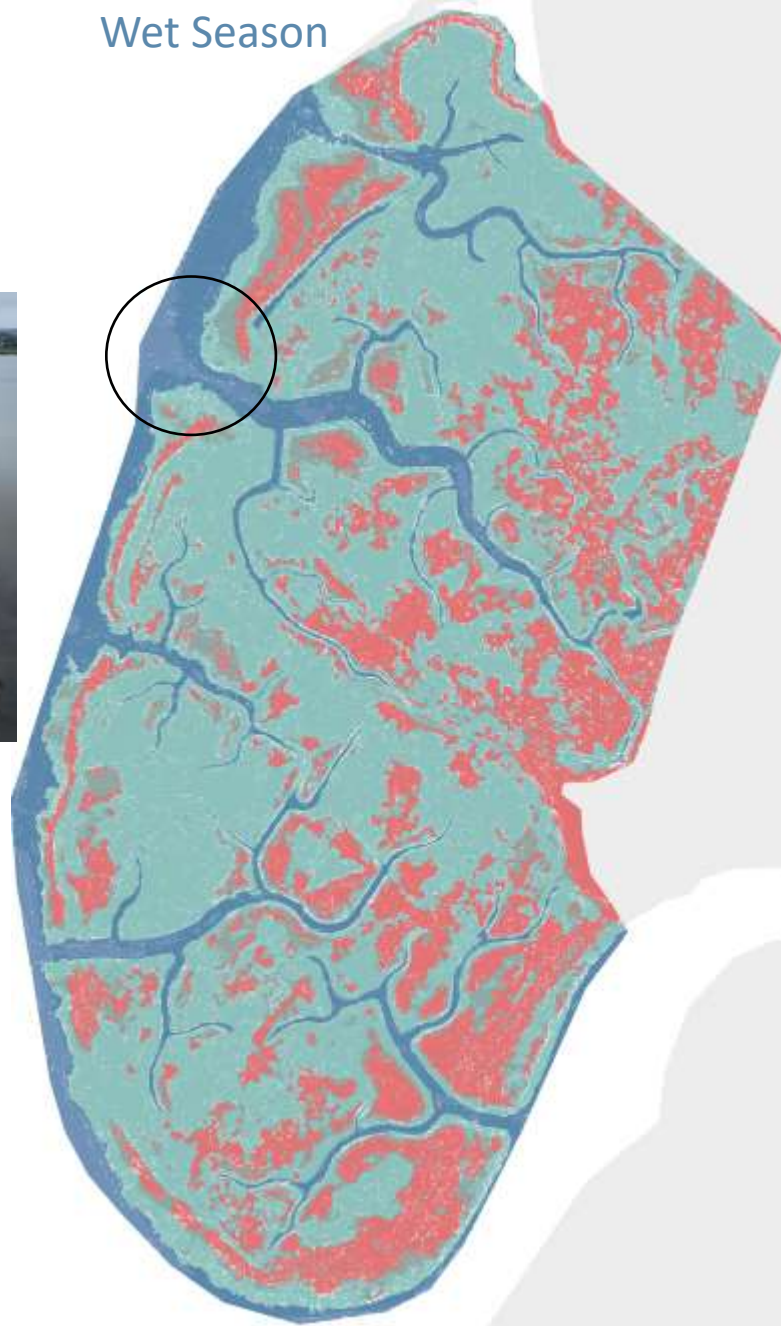
June-Oct 2020
Dry Season

Nov 2020 - May 2021
Wet Season

67 % (128 acres) Access
33 % (62 acres) No Access

Winter King High Tide

Nov 2020 - May 2021
Wet Season

72 % (137 acres) Access
28 % (53 acres) No Access

Habitat Access
- Channel >2.5 meters *(also accessible)*
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- No Access <0.5 meters
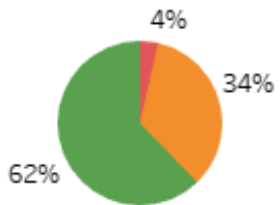
Salmonid Habitat Access & Opportunity

Habitat Opportunity
- 🟥 Inhospitable >22.5 C
- 🟧 Marginal 22- 17.5 C
- 🟩 Optimal <17.5 C

% Time (Hourly) Areas with access also have a given water temperature range

June-Oct 2020
Dry Season

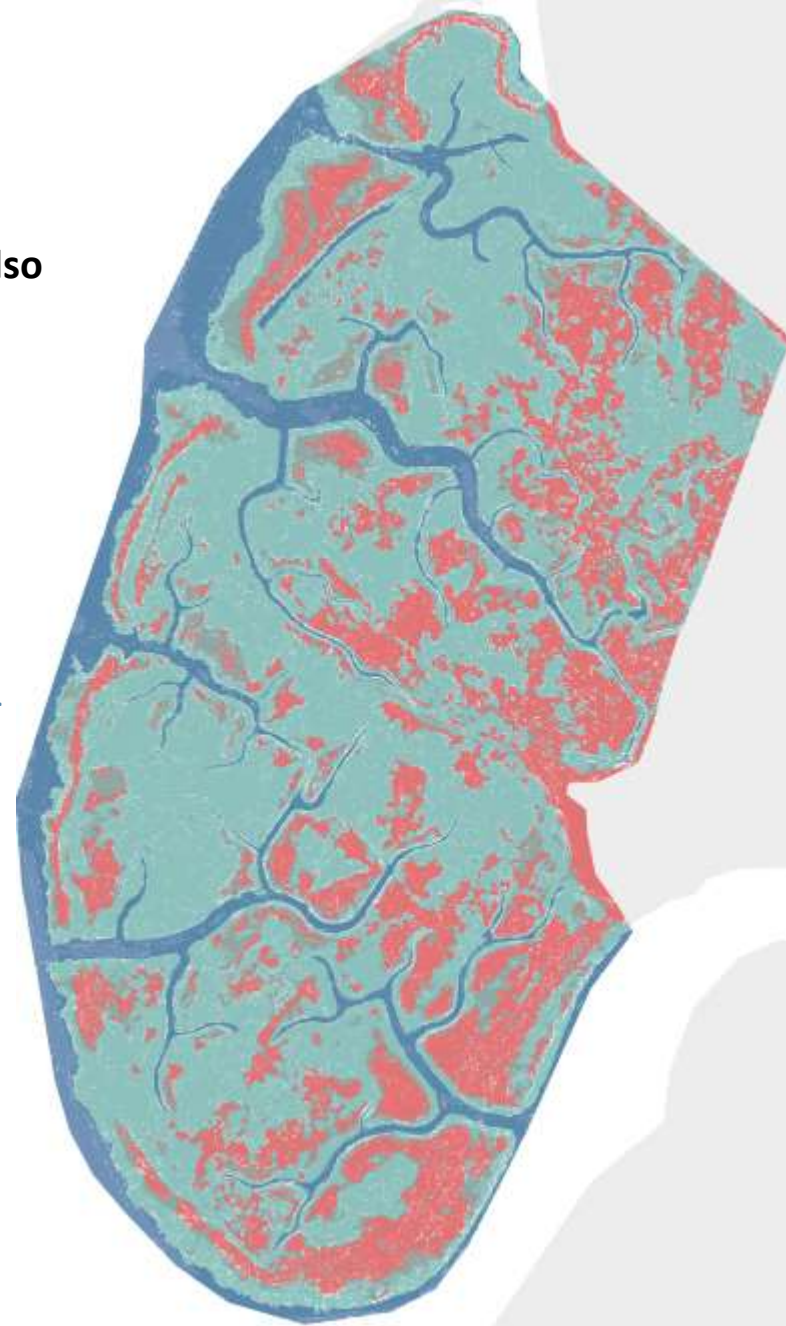67 % (128 acres) Access

4%
34%
62%

Nov 2020 - May 2021
Wet Season

72 % (137 acres) Access

1%
99%

Habitat Access
- 🟦 Channel >2.5 meters *(also accessible)*
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Combining Data Sets – Modeling Habitat Conditions Site Wide

Where and When are habitat conditions ideal across a site?

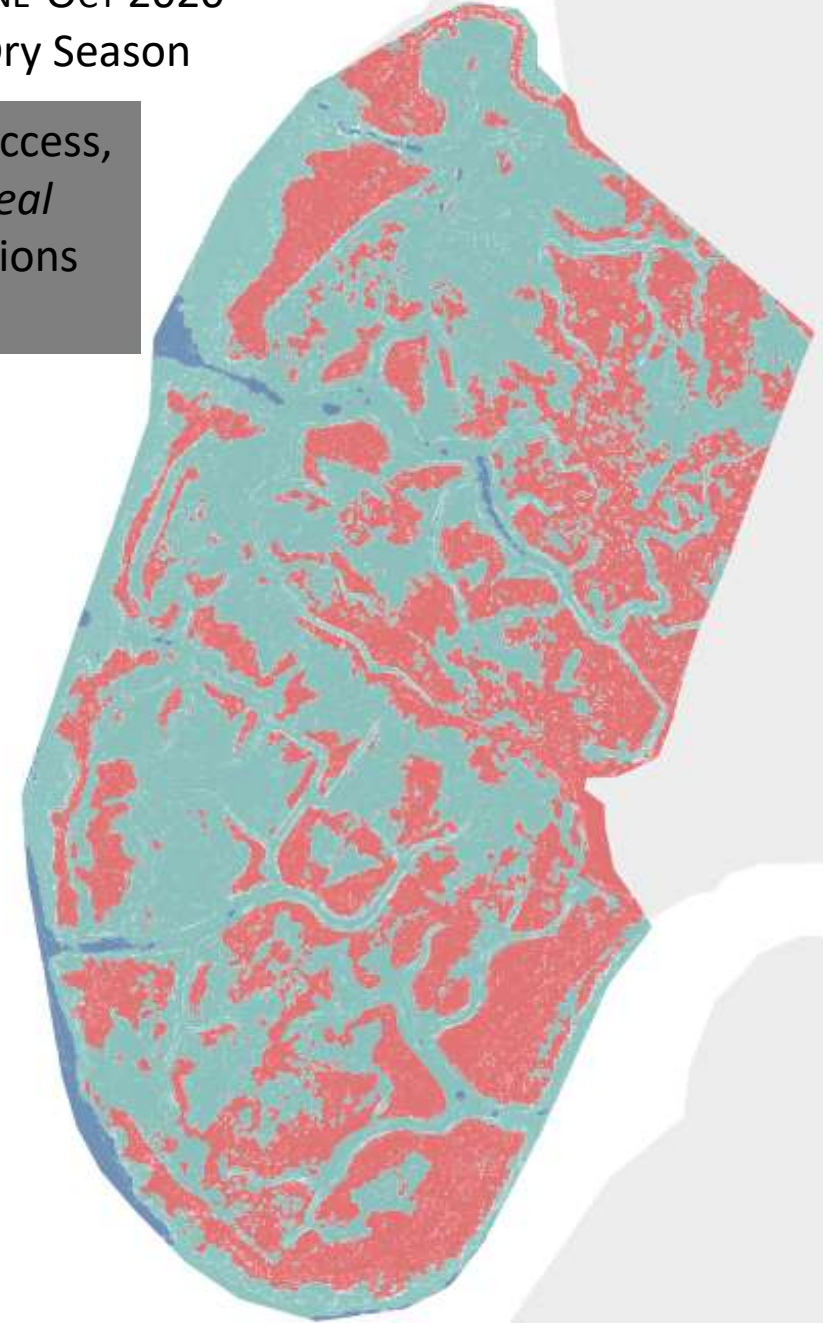Total 128 acres of Access, with *Marginal or Ideal* temperature conditions 96% of the time

Combining Data Sets – Modeling Habitat Conditions Site Wide

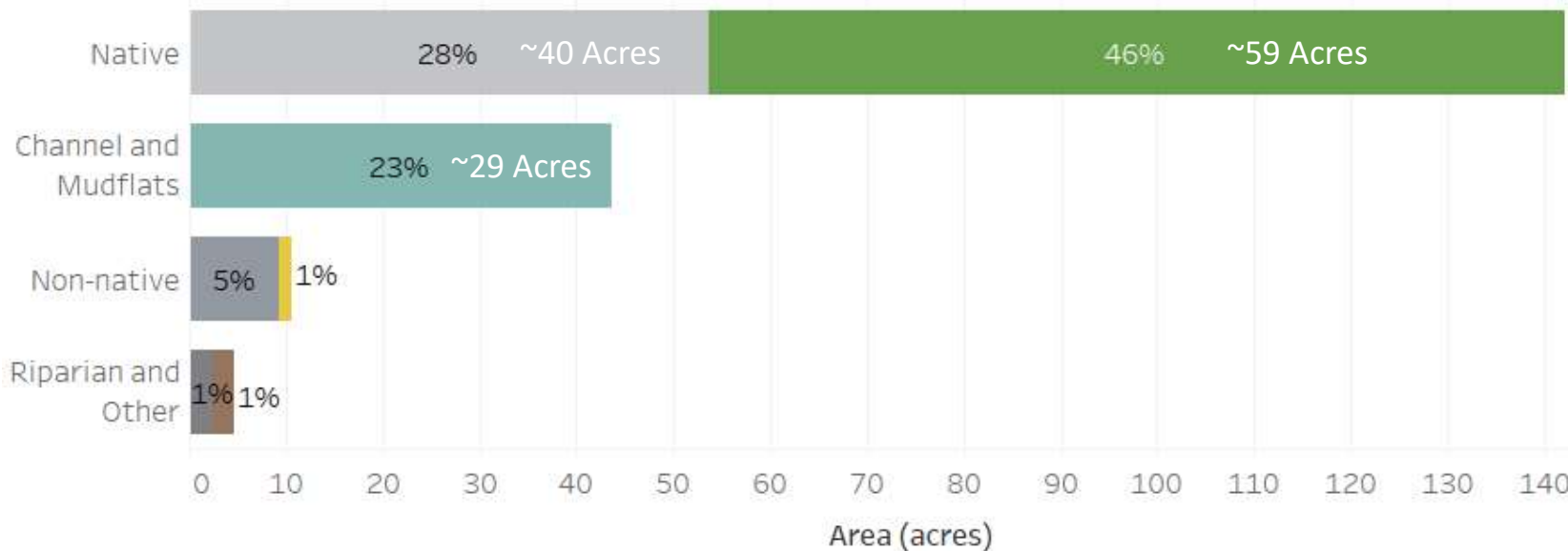Where and When are habitat conditions ideal across a site?

Total 128 acres of Access, with *Marginal and Ideal* temperature conditions 96% of the time

Habitat Accessibility by Plant Community

- Accessible Channel and Mudflats
- Accessible Native
- Accessible Non-native
- Accessible Riparian and Other

- No Access Channel and Mudflats
- No Access Native
- No Access Non-native
- No Access Riparian and Other

Accessiblity and Habitat Type

Habitat Type	No Access	Accessible
Native	28% ~40 Acres	46% ~59 Acres
Channel and Mudflats		23% ~29 Acres
Non-native	5%	1%
Riparian and Other	1%	1%

Area (acres)

COMBINING DATA SETS – MODELING HABITAT CONDITIONS SITE WIDE

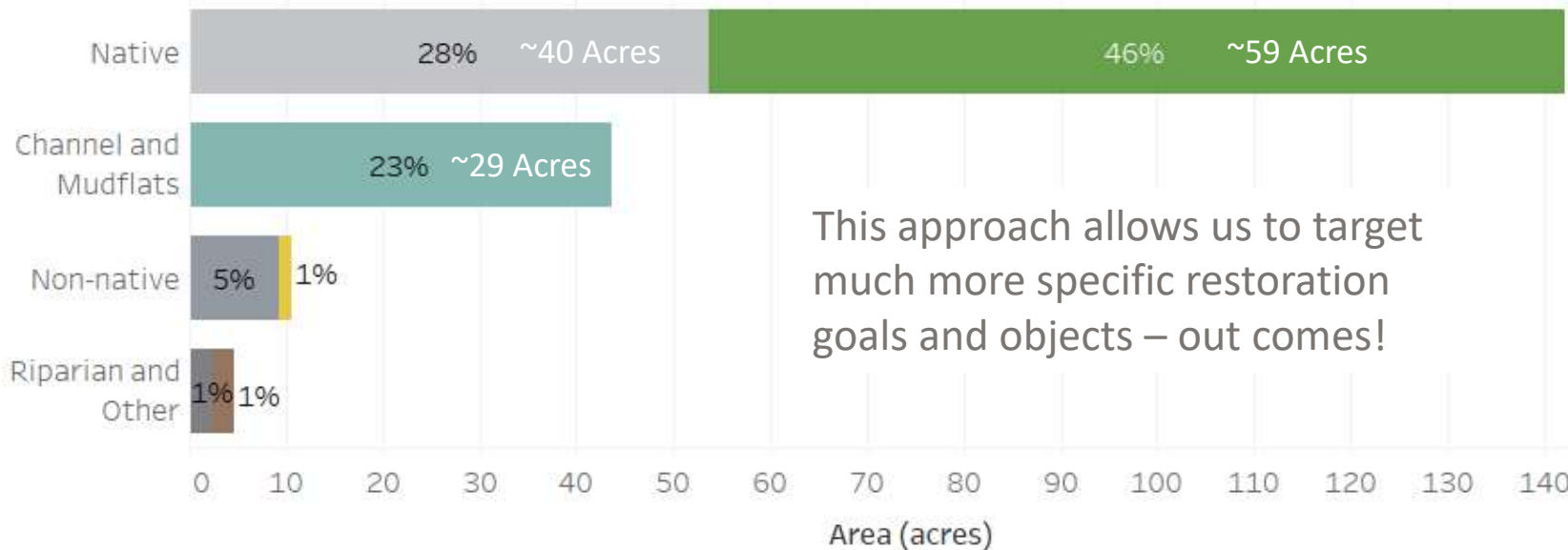Where and When are habitat conditions ideal across a site?

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Accessiblity and Habitat Type

Habitat Type		
Native	28% ~40 Acres	46% ~59 Acres
Channel and Mudflats	23% ~29 Acres	
Non-native	5% 1%	
Riparian and Other	1% 1%	

Area (acres): 0 10 20 30 40 50 60 70 80 90 100 110 120 130 140

This approach allows us to target much more specific restoration goals and objects – out comes!

Research Applications

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 (also a SLR application)

- Assist in restoration planning, design, and adaptive management

Ian Edgar and Sneha Rao, LC

THANK YOU!

Please reach out if you have any questions.

Lower Columbia
Estuary
Partnership

Sarah Kidd

skidd@estuarypartnership.org

All Data Can Be Accessed On Our Tableau Dashboard:

https://public.tableau.com/app/profile/aemr.epmonitoring/viz/WallooskeeRestorationProjectResearchDashboard/
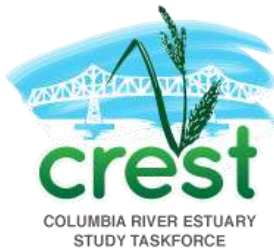
Narayan Elasmar, *CREST*

RESEARCH PARTNERS

April Silva, CREST