CHASE GARDEN CREEK SALT MARSH Vulnerability Assessment

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Association to Preserve Cape Cod

Project funded by the Lavori Sterling Foundation

Agenda

APCC PRESENTATION

- Project Scope & Timeline
- Existing Conditions; Literature Review
- Salt Marshes: Benefits & Threats
- Results from Salt Marsh Vulnerability Assessments (2023)
    - UVVR (unvegetated to vegetated ratio) Assessment
    - Rapid Field Assessment
- Conclusions
- Questions (during pres. use chatbox)

RESTORATION OPTIONS & DISCUSSION

Scope and Timeline: 5-Year Project

- Year 1 (2023): Assess marsh integrity & human impacts (landscape-scale evaluation) and coordinate with stakeholders
- Year 2 (2024): Targeted baseline monitoring
- Year 3 (2025): Plan/design potential restoration actions; seek funding for project(s)
- Year 4 (2026): Permitting; Pre-restoration monitoring
- Year 5 (2027): Implementation; Post-restoration monitoring

Chase Garden Creek: Areas of Concern

Barrier beach, sandbars, and shoals	Erosion of Chapin Beach Sedimentation in the Creek
Salt marsh	Resiliency to sea level rise Anthropogenic history and current status
Wildlife	Tom Mathews Pond Upstream tidal restrictions

Sedimentation at Chase Garden Creek

- Chapin Beach dynamic littoral cell
- Heavily altered coastline east of Chase Garden Creek
- Sedimentation and shoal formation at the inlet

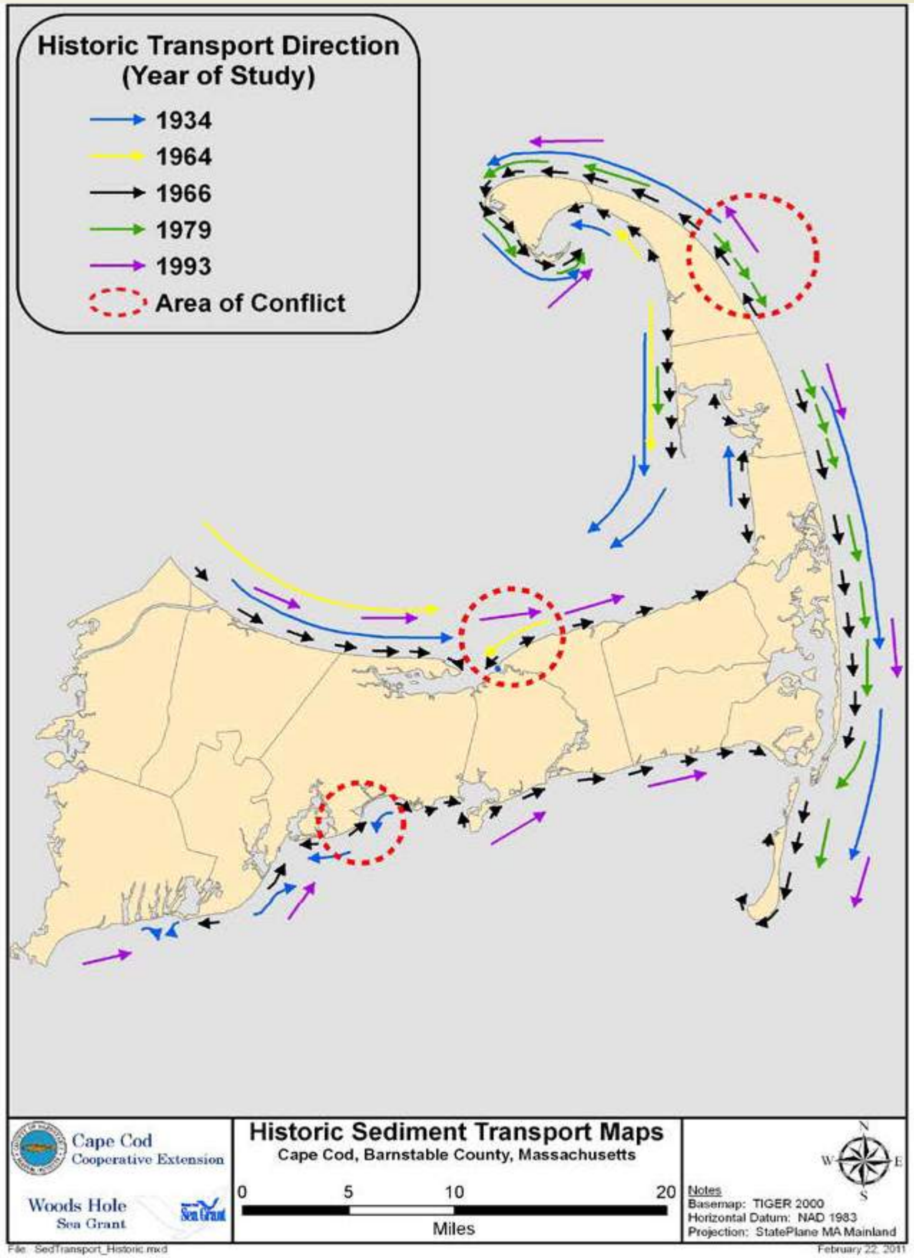

Figure 4. Composite historic transport map showing transport of sediment throughout the Cape Cod region. Each of the component maps was georeferenced and the arrows converted to vectors. The arrow length and position is depicted similarly to the original study map, except in cases where overlaps made the arrows illegible. Each study is color-coded according to the legend (Woodworth and Wigglesworth, 1934. Giese, 1964, Strahler, 1966. Fisher, 1979. FitzGerald, 1993.) Giese (1964 data) analysis based in part on previous studies (U.S. Congress, 1959 & 1960).

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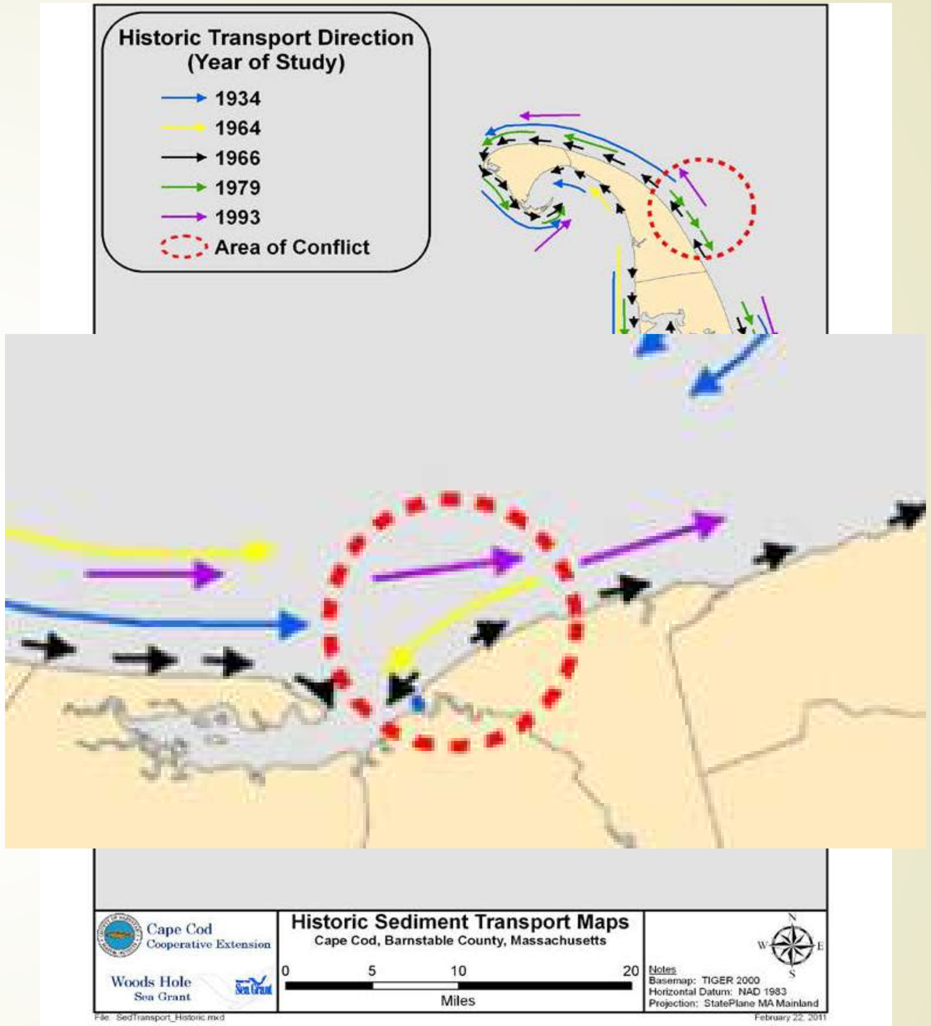

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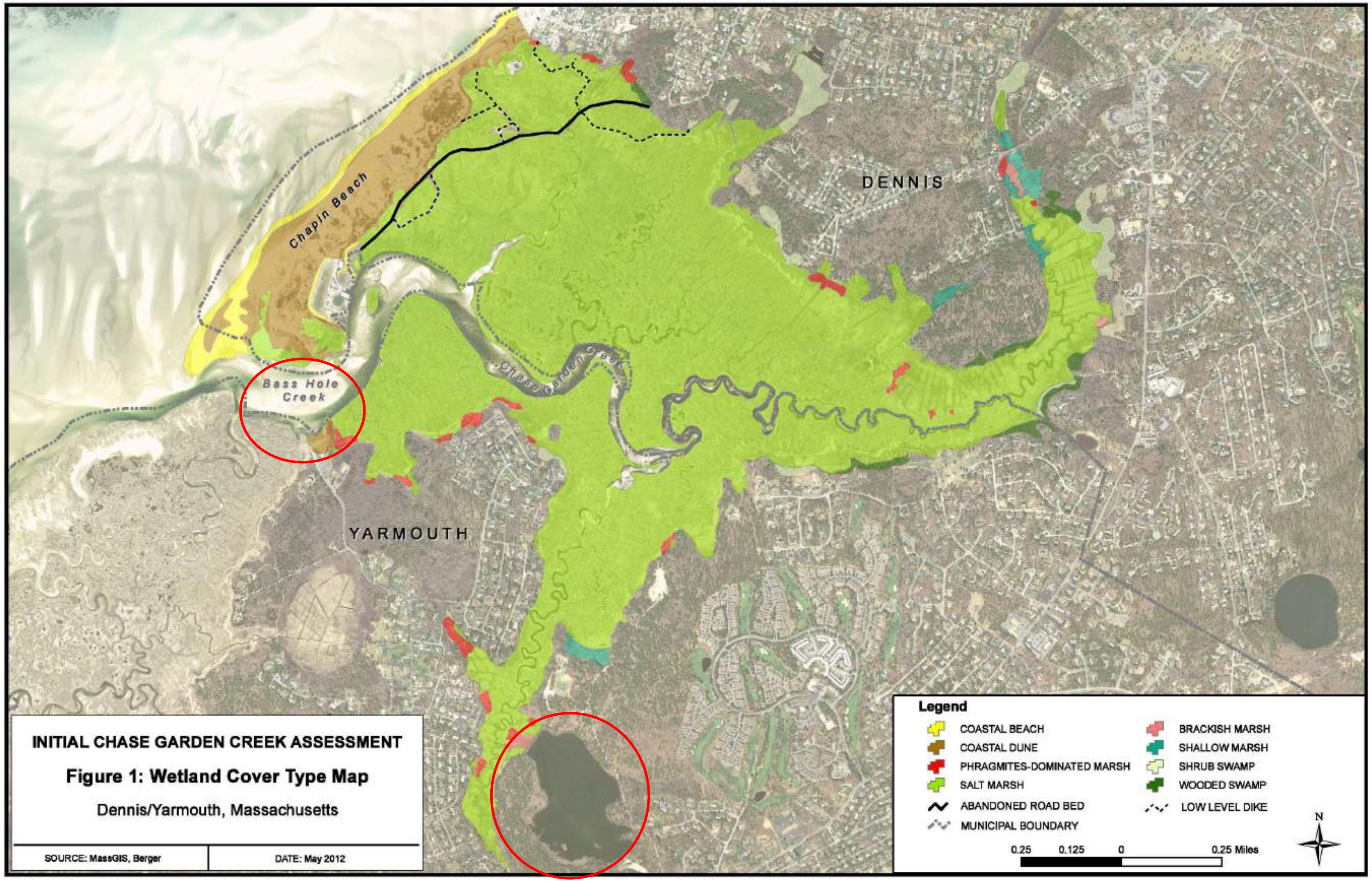
HABITATS & EXISTING CONDITIONS

- Beach, salt marsh, brackish, and freshwater vegetation
- Shoals and shellfish habitat
- Marsh characteristics
  - elevation, tide levels
- Herring run trends



From *Initial Chase Garden Creek Assessment*, Louis Berger Group 2012

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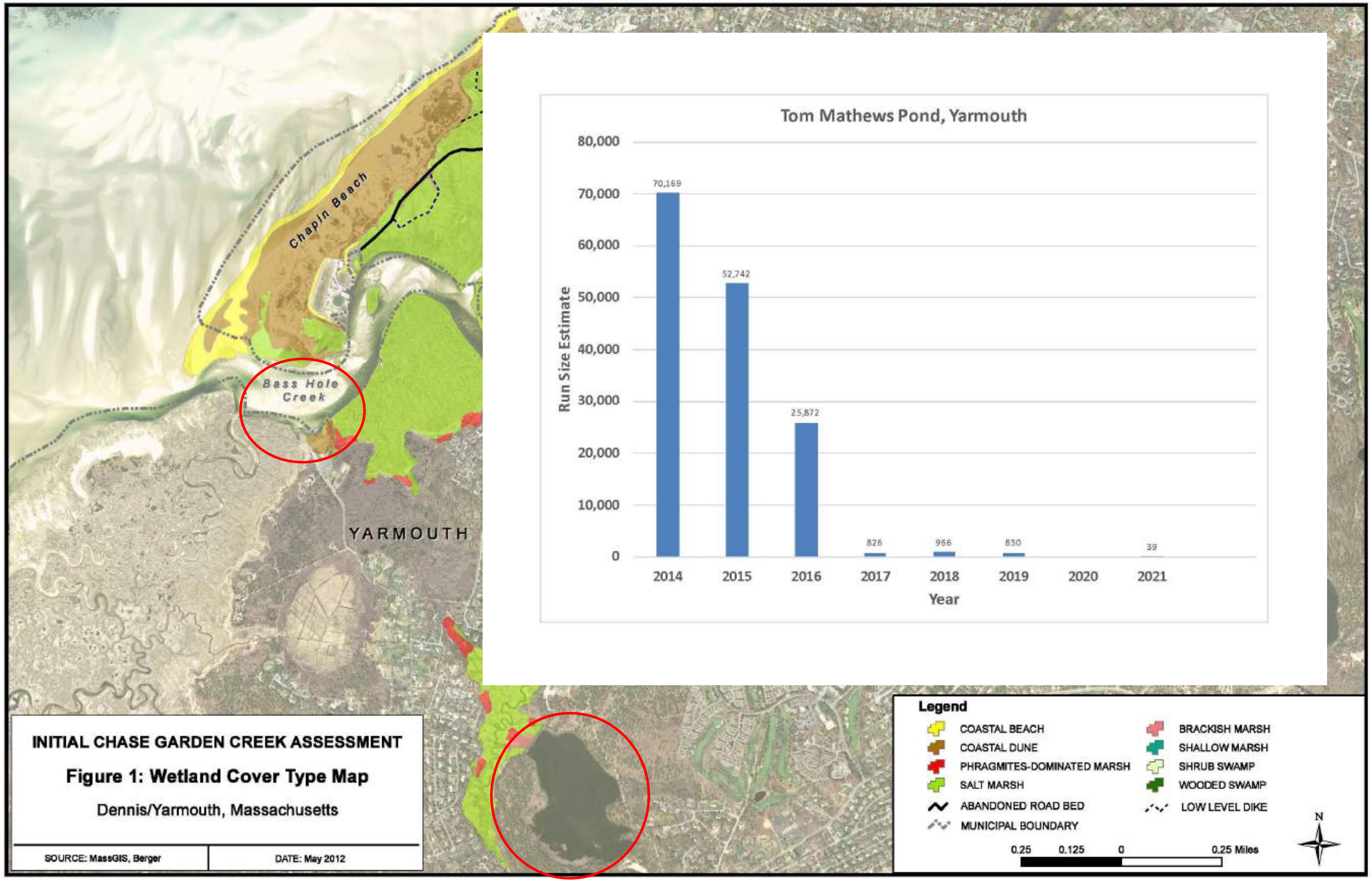

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Marsh Survey

- What the 2012 survey showed:
  - Tidal range and tidal dampening
  - Change in vegetation type (salt marsh, *Phragmites*, etc.)

- What else constitutes marsh health?
  - Change over time
  - In-depth vegetation analysis
  - Presence of man-made features

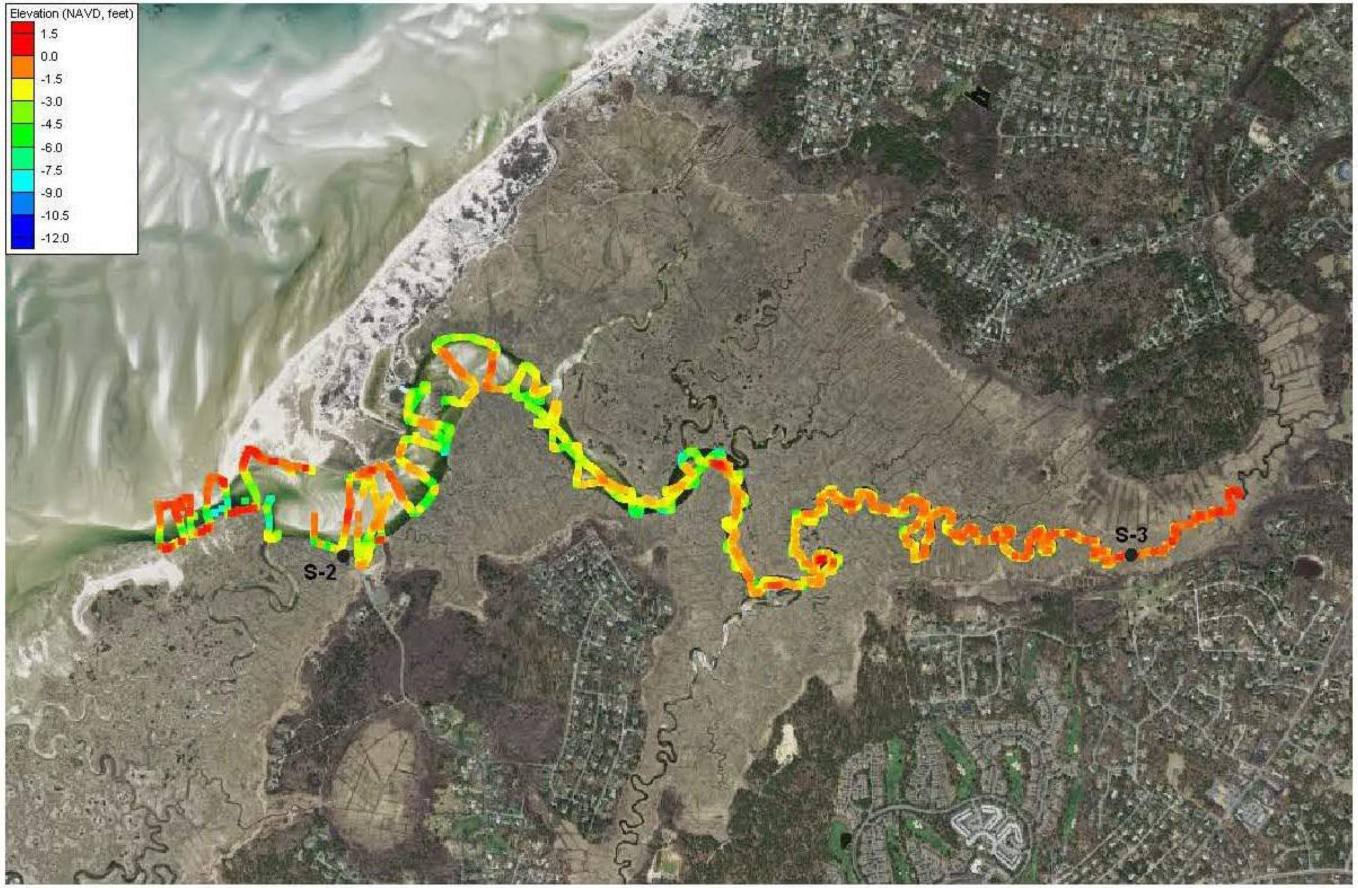

Figure 6. Bathymetric data collected November 14th and 15th, 2011. Gage locations for the dock gage (S-2) and the farm gage (S-3) are shown.

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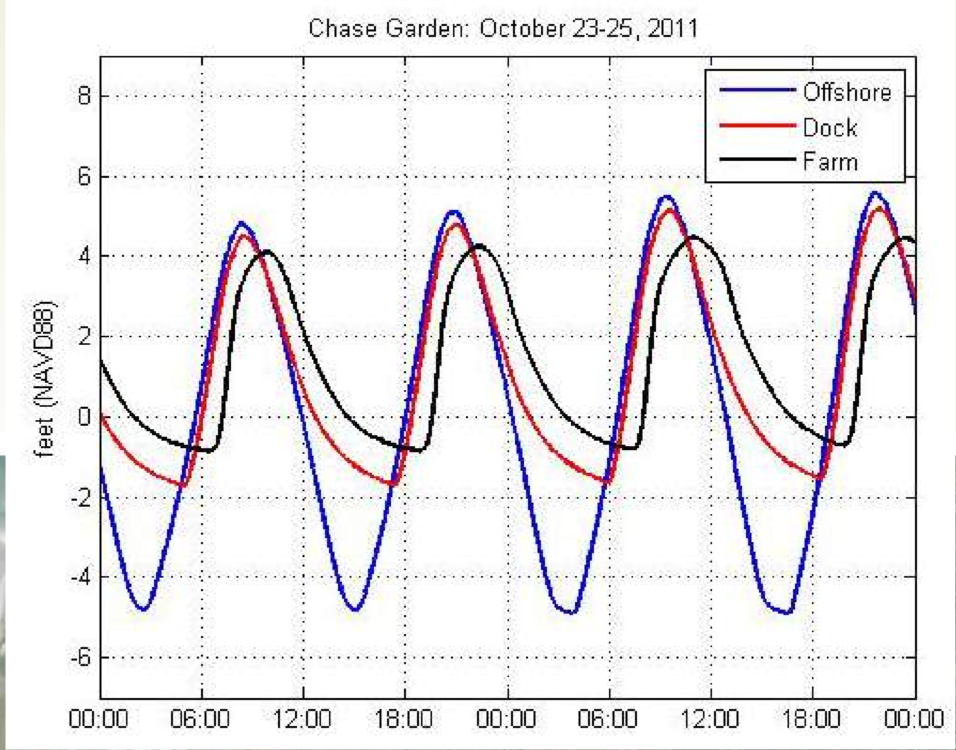

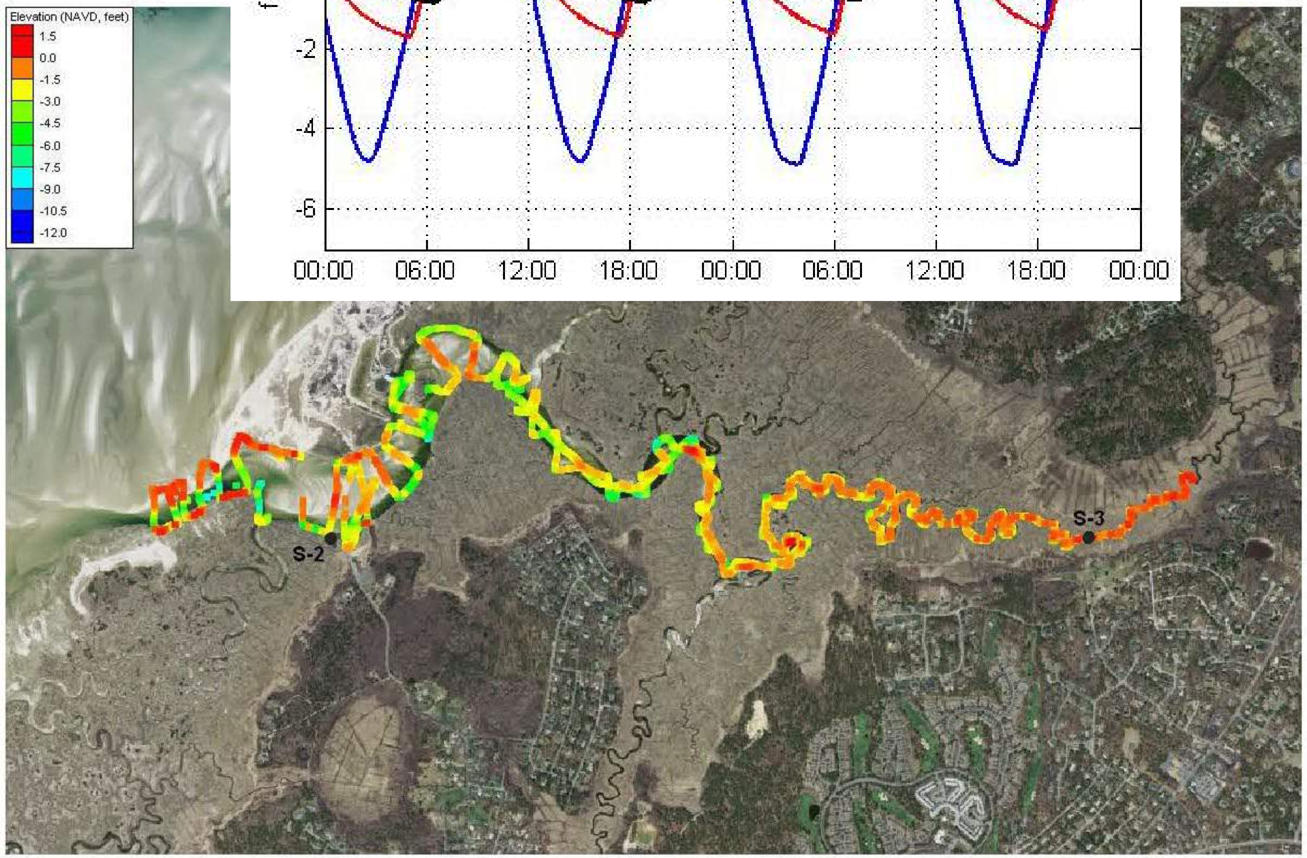

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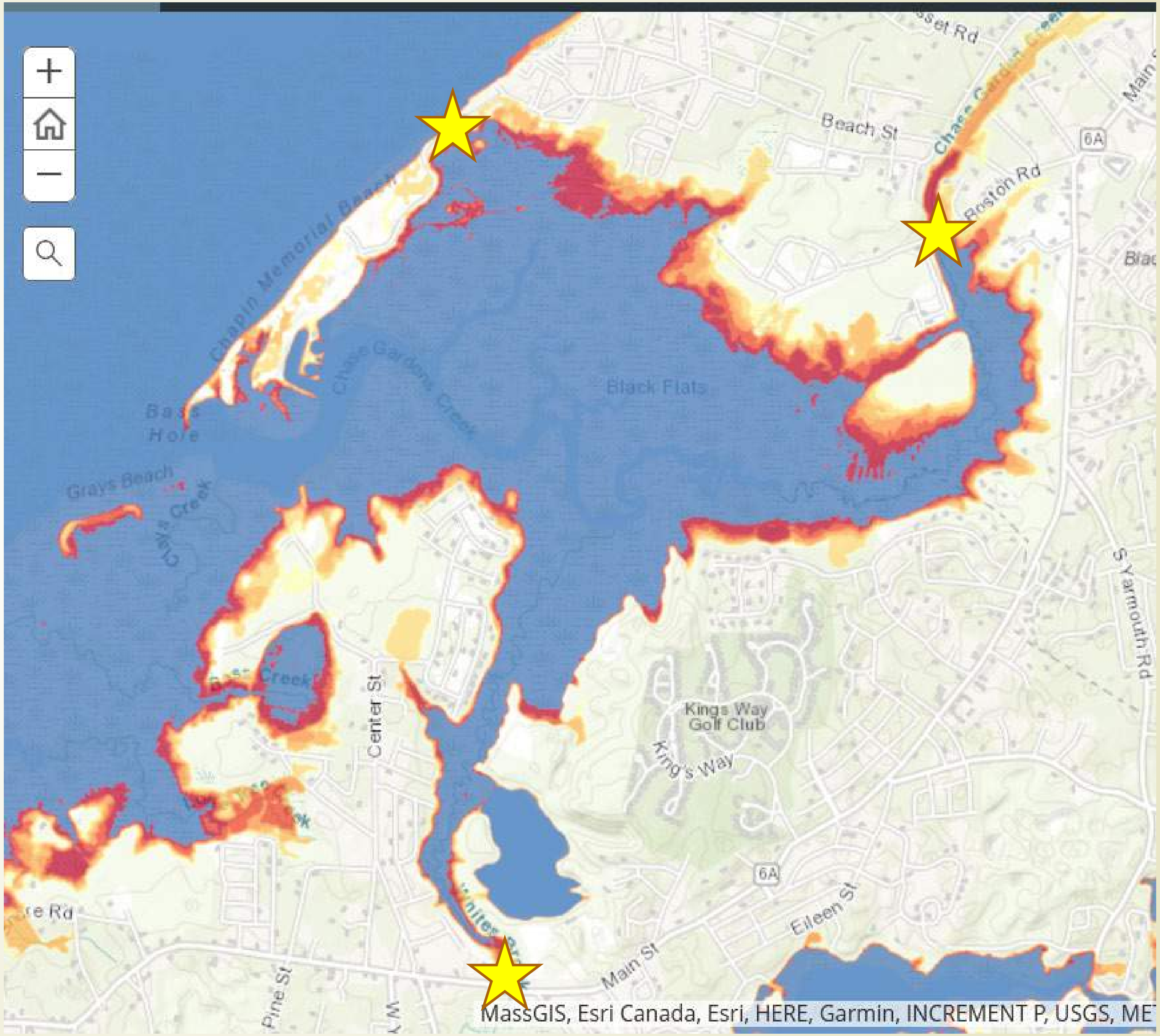
Cape Cod Commission's Low Lying Roads Project

Potential Extent of Mean Higher High Water (MHHW) with Sea Level Rise

- MHHW
- MHHW + 1 ft Sea Level Rise
- MHHW + 2 ft Sea Level Rise
- MHHW + 3 ft Sea Level Rise
- MHHW + 4 ft Sea Level Rise
- MHHW + 5 ft Sea Level Rise
- MHHW + 6 ft Sea Level Rise



Salt Marshes
Significance & Threats

Salt Marshes: Why are they important?

- Ecological Value
- Recreational Value
- Economical Value

Ecological Value of Chase Garden Creek

- Support Threatened/Endangered Species
  - Juvenile Winter Skate (Leucoraja ocellata)
  - Salt marsh sparrow (Ammodramus caudacutus)
  - Diamondback Terrapin (Malaclemys terrapin)
  - Mitchell's sedge (Carex mitchelliana)
- Improve water quality by filtering and removing pollutants



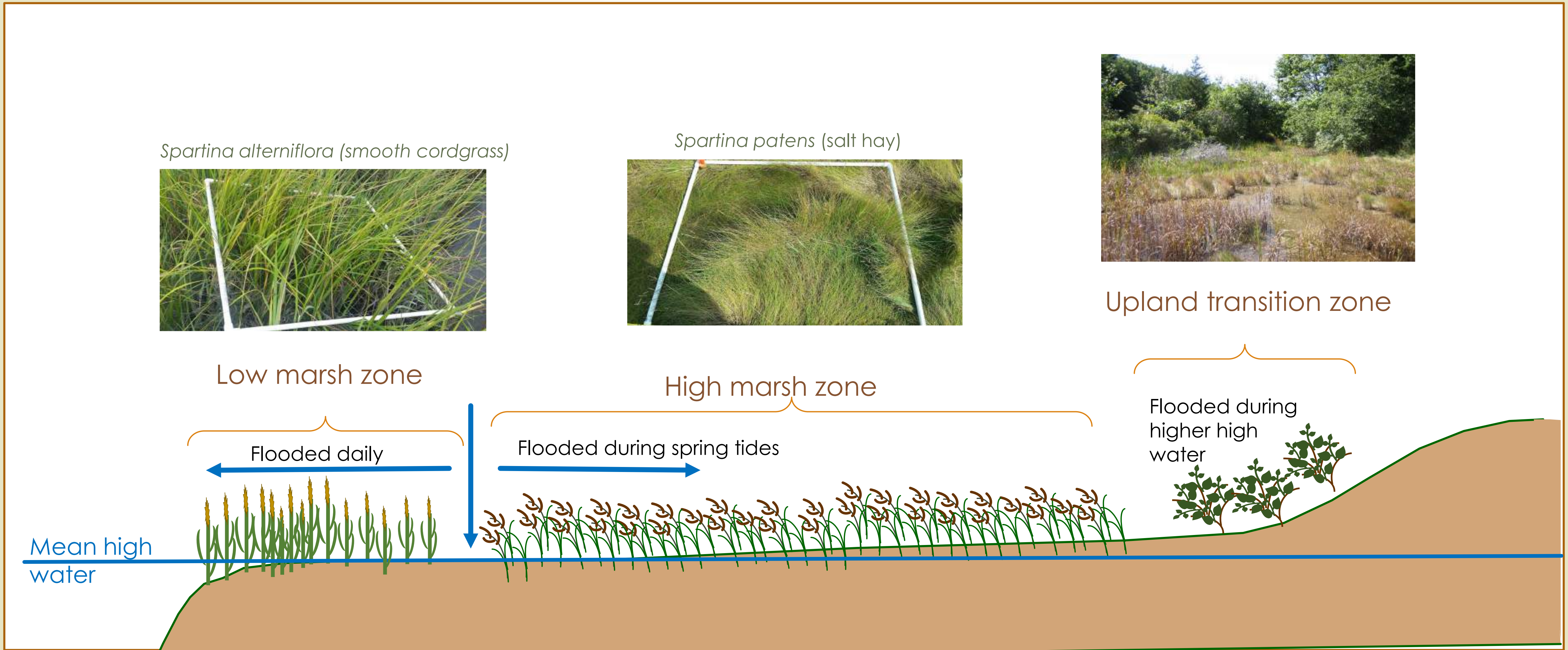
Economical value of salt marshes

- Flood and erosion protection
- Essential habitat for commercial shellfishing and fishing industry
- Carbon sequestration (mitigate climate change)

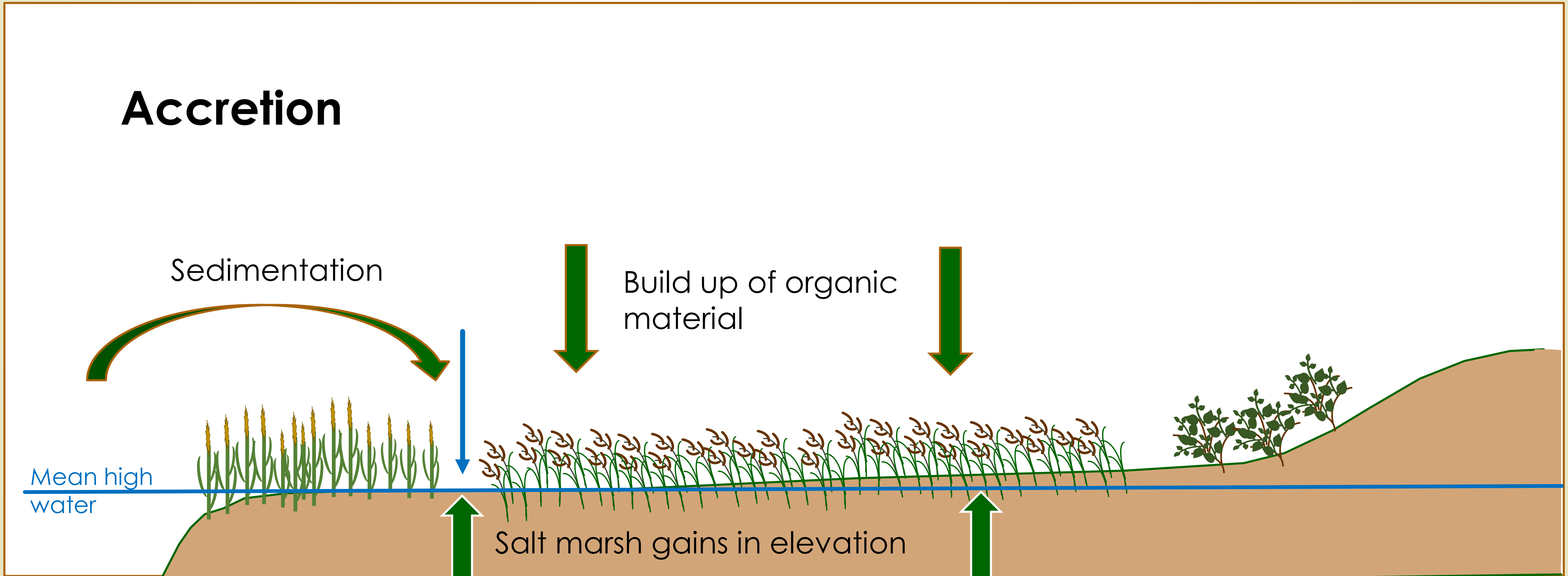
POLL QUESTION #1

- **Rate salt marsh services based on how important they are to you.**
  - Storm buffering (erosion and flooding protection)
  - Carbon sequestration
  - Wildlife habitat
  - Water quality improvements
  - Sustaining healthy aquaculture and commercial fishing industries
  - Recreation (fishing, birding, kayaking, etc.)

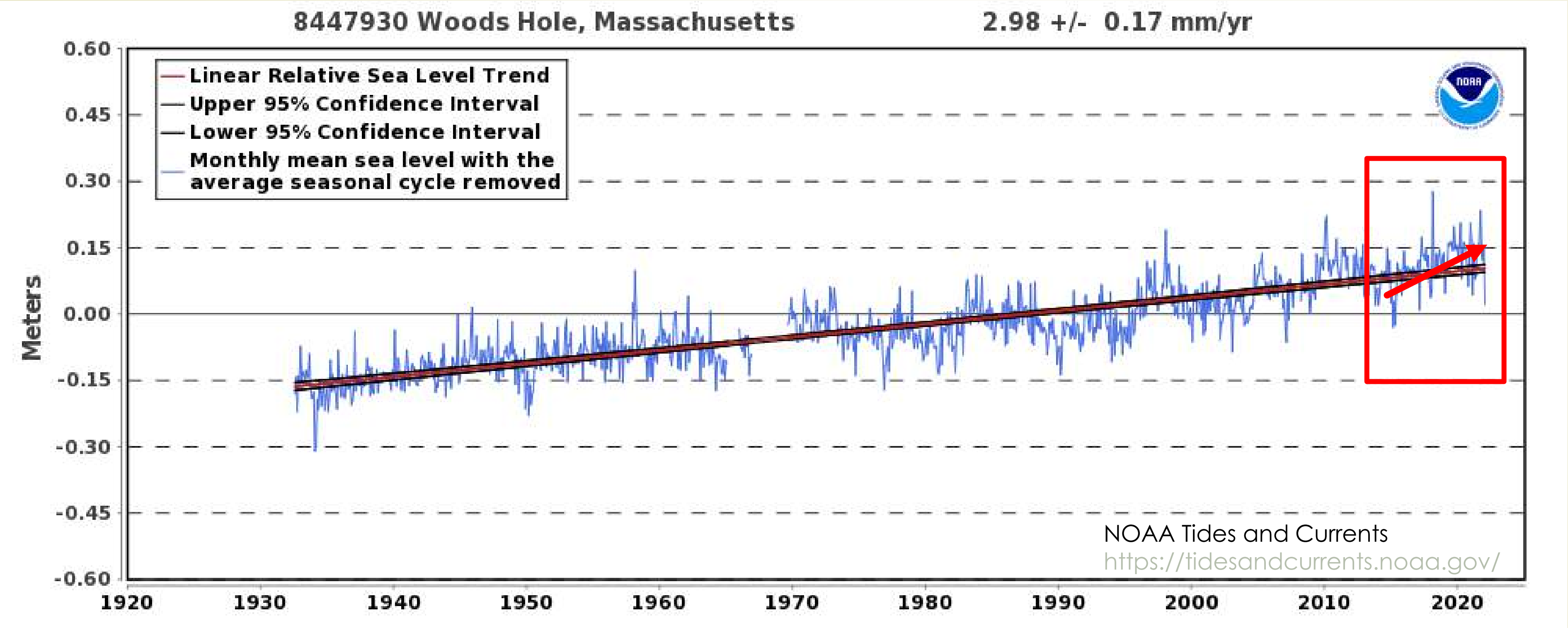
Salt Marsh – General Structure



Salt marshes naturally adjust to sea level rise



Sea Level Rise in New England



- Historic average for New England: **2.5mm/yr**
- Last 19 years for New England: **3-4mm/yr (extreme high water: 4-6mm/yr)**

Watson et al. 2017

What threatens a salt marsh?

Threats to Salt Marshes

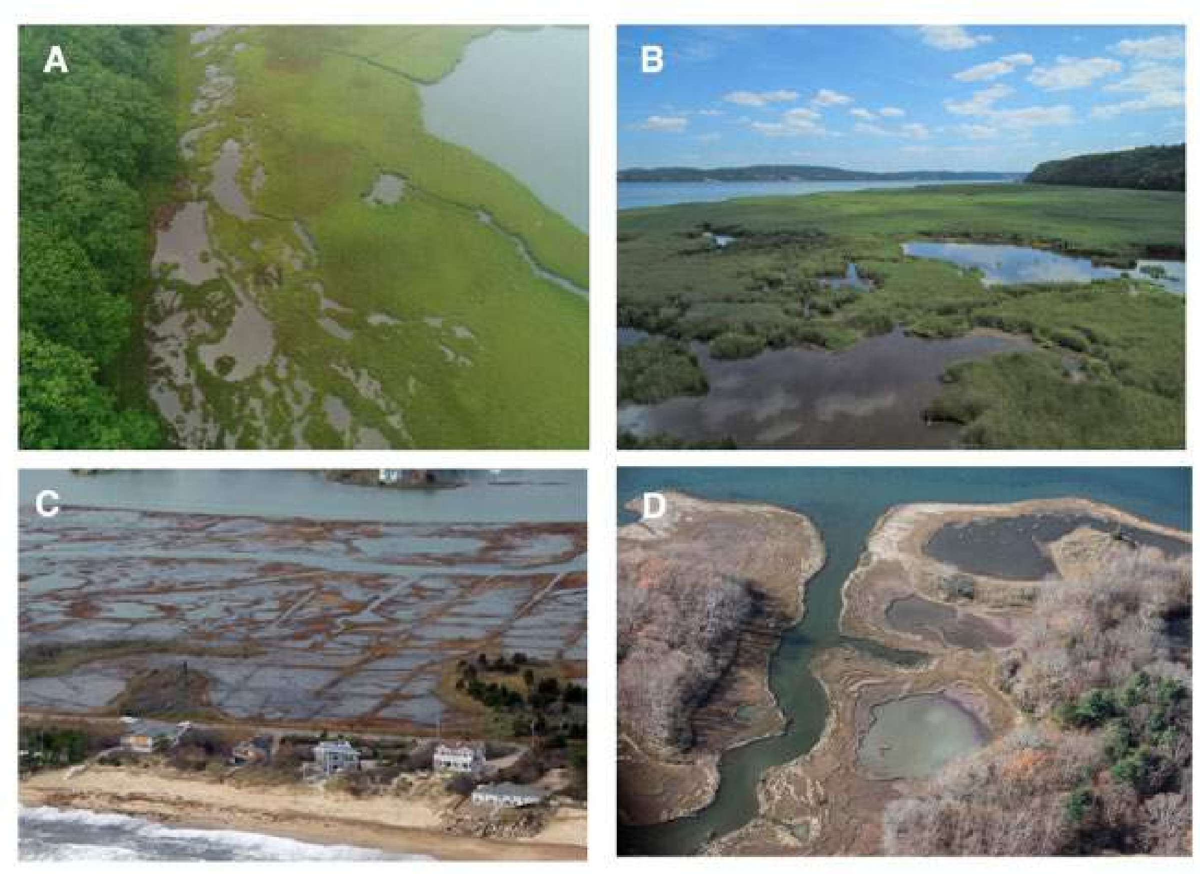
- Land reclamation (filling)
- Ditching (agricultural & mosquito control)
- Restricted tidal flow (e.g., undersized culverts & dikes)
- Physical barriers to landward migration
- Invasive species

Première Terres Acadiennes by Azor Vienneau

41% of Massachusetts' and 38% of Cape Cod's salt marshes already lost

Waterlogged Subsidence Trajectory (mega-pools)

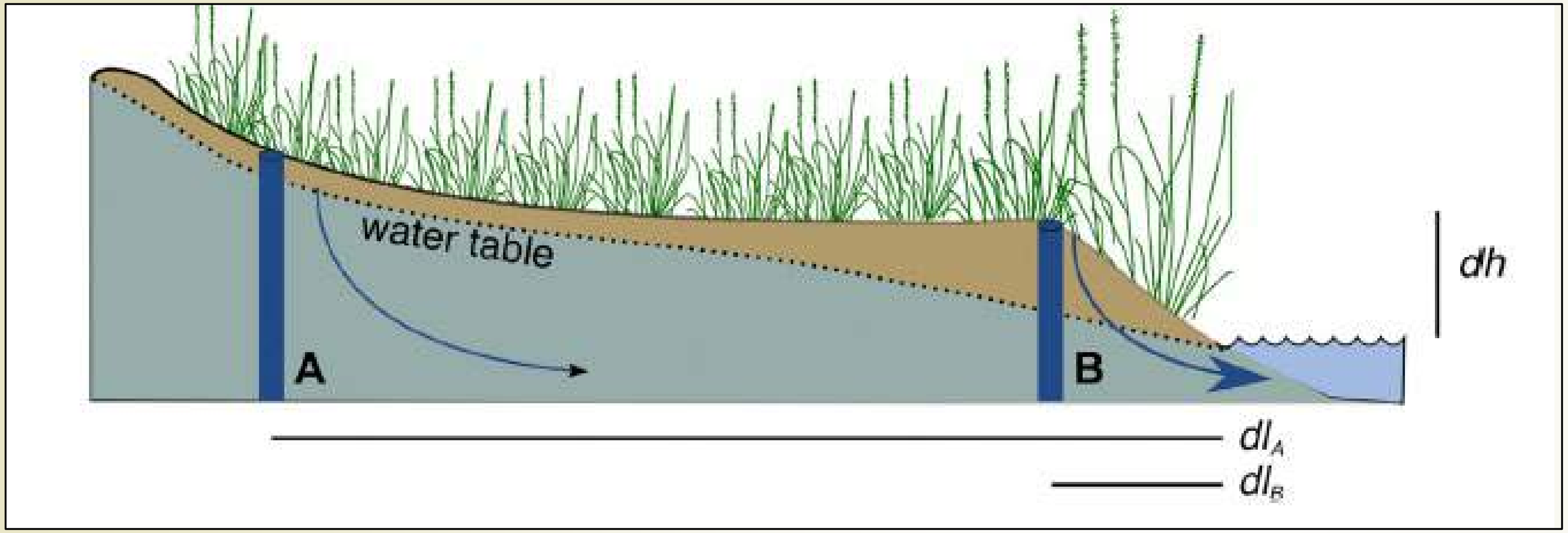
- Poor drainage from embankments cause dieback of vegetation and root collapse



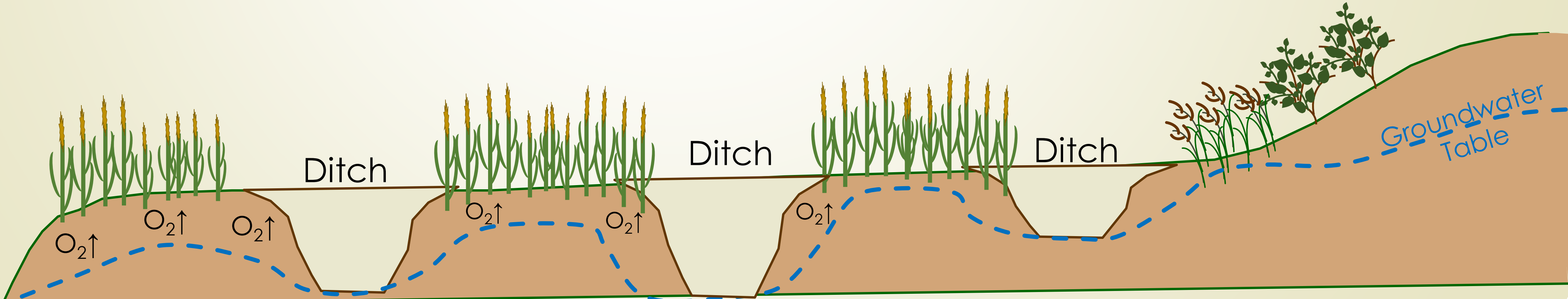
Watson et al. 2022

Oxidation Subsidence Trajectory

- Aeration of root zone and increased decomposition



Watson et al. 2022



Vulnerability Assessment METHODS

1. Unvegetated to Vegetated Ratio (UVVR)
   - **2016 & 2021**
2. Rapid salt marsh assessment method (MarshRAM)
   - **Summer 2023**

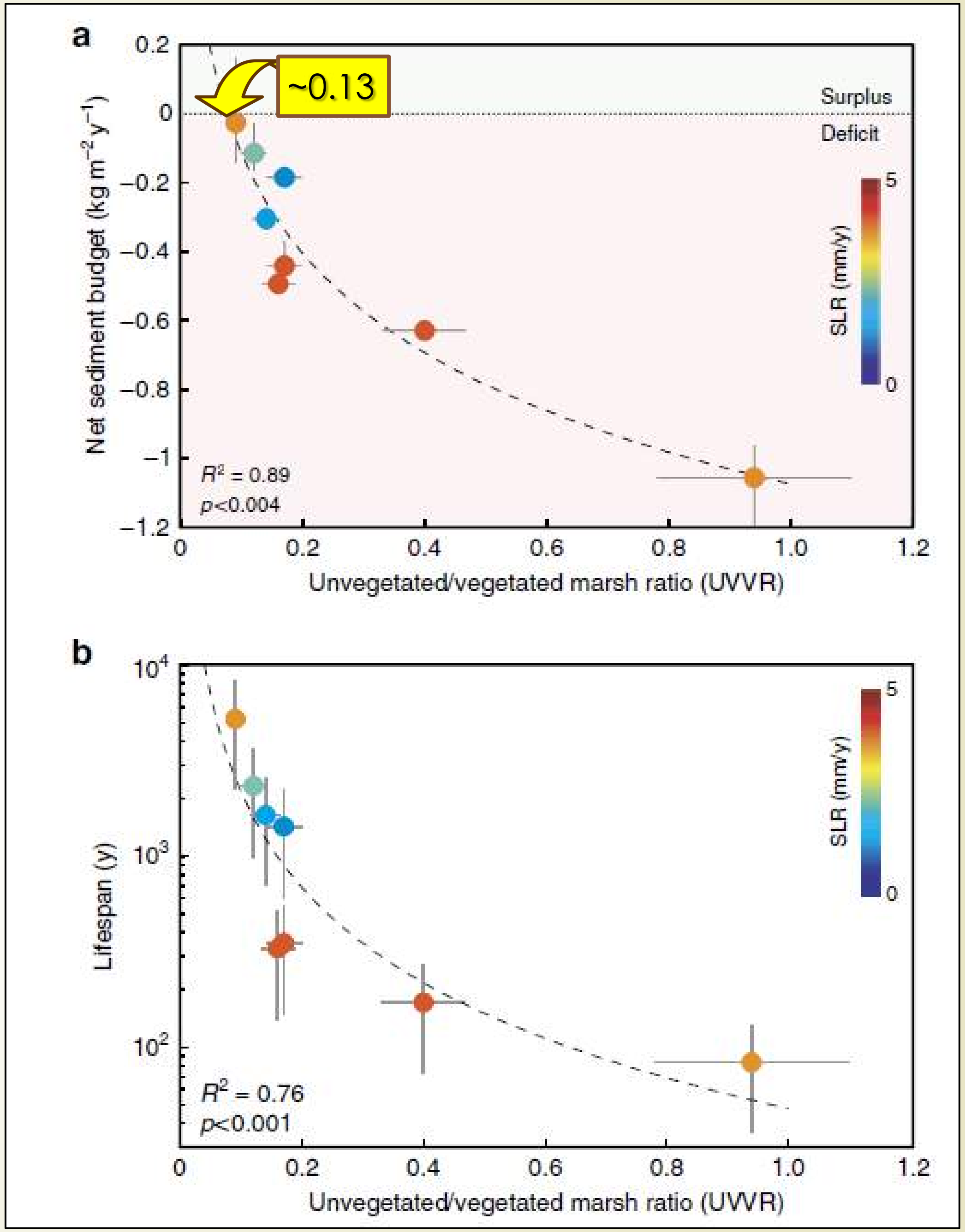
POLL QUESTION #2

- **How familiar are you with UVVR?**
  - Very – ask me anything!
  - Somewhat – I get the gist.
  - A little – I've heard of it.
  - Not at all – what's UVVR?

Unvegetated to Vegetated Ratio (UVVR)

Ganju et al. 2017

- Effective predictor for salt marsh lifespan based on net sediment budget
- sediment surplus = vertical growth and/or expansion
- sediment deficit = drowning and/or contraction



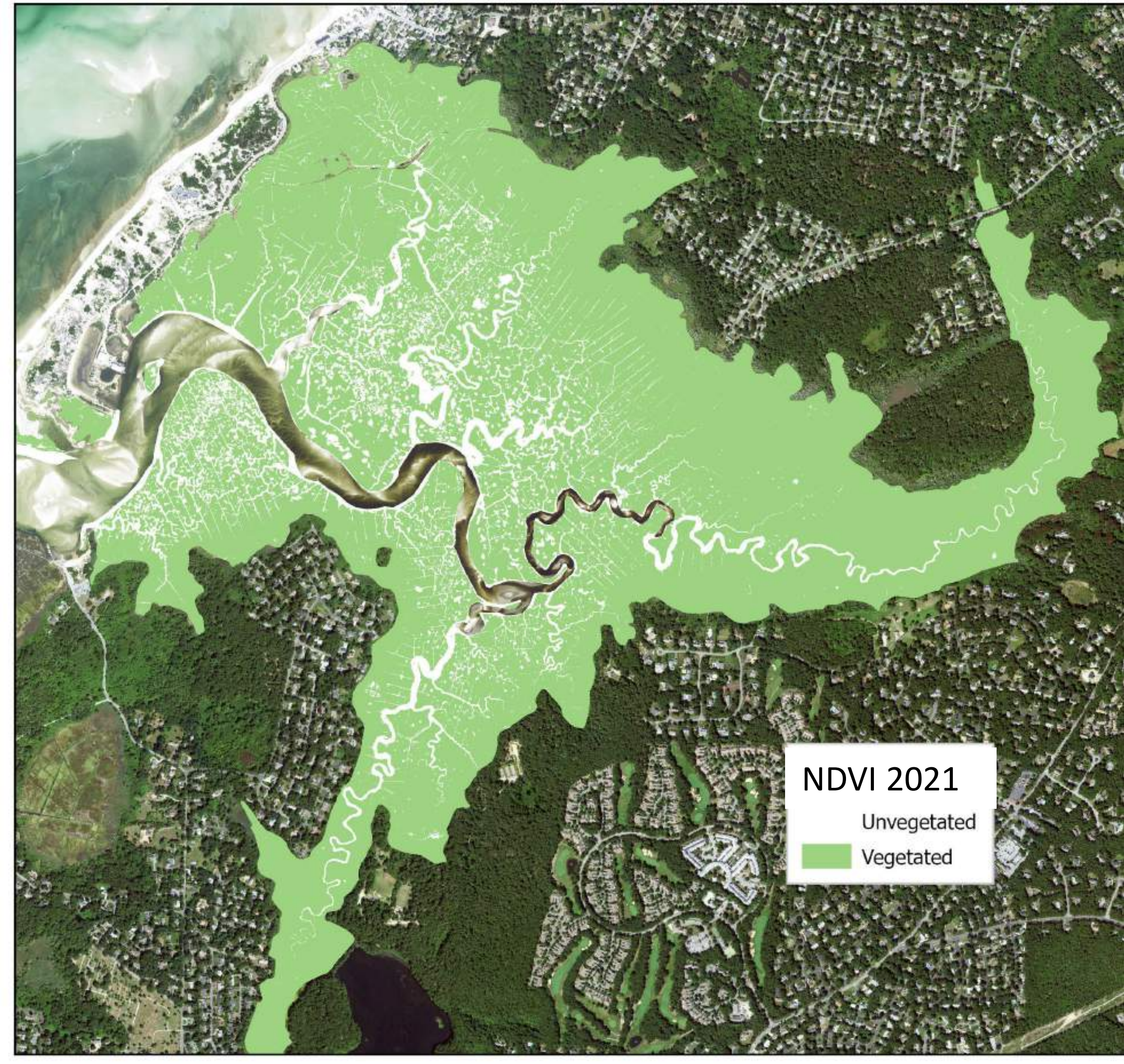
METHODS: Unvegetated to Vegetated Ratio (UVVR)

Using ArcPro, followed steps provided by David Burdick & Grant McKown (Jackson Estuarine Laboratory, University of New Hampshire)

1. Acquisition of aerial imagery from the National Agricultural Imagery Program

   USGS 2021Tidesheds

2. Calculation of the Normalized Difference Vegetated Index (NDVI)
3. Classification of pixels of the NDVI imagery into 'vegetated' or 'unvegetated'
4. Calculation of unvegetated-vegetated ratio (UVVR)
5. Accuracy Assessment



Classification Wizard – Training Polygons

Accuracy Assessment

Using **Accuracy Assessments Tool** in ArcPro
- Generates randomized points
- Calculates confusion matrix (kappa coefficient)

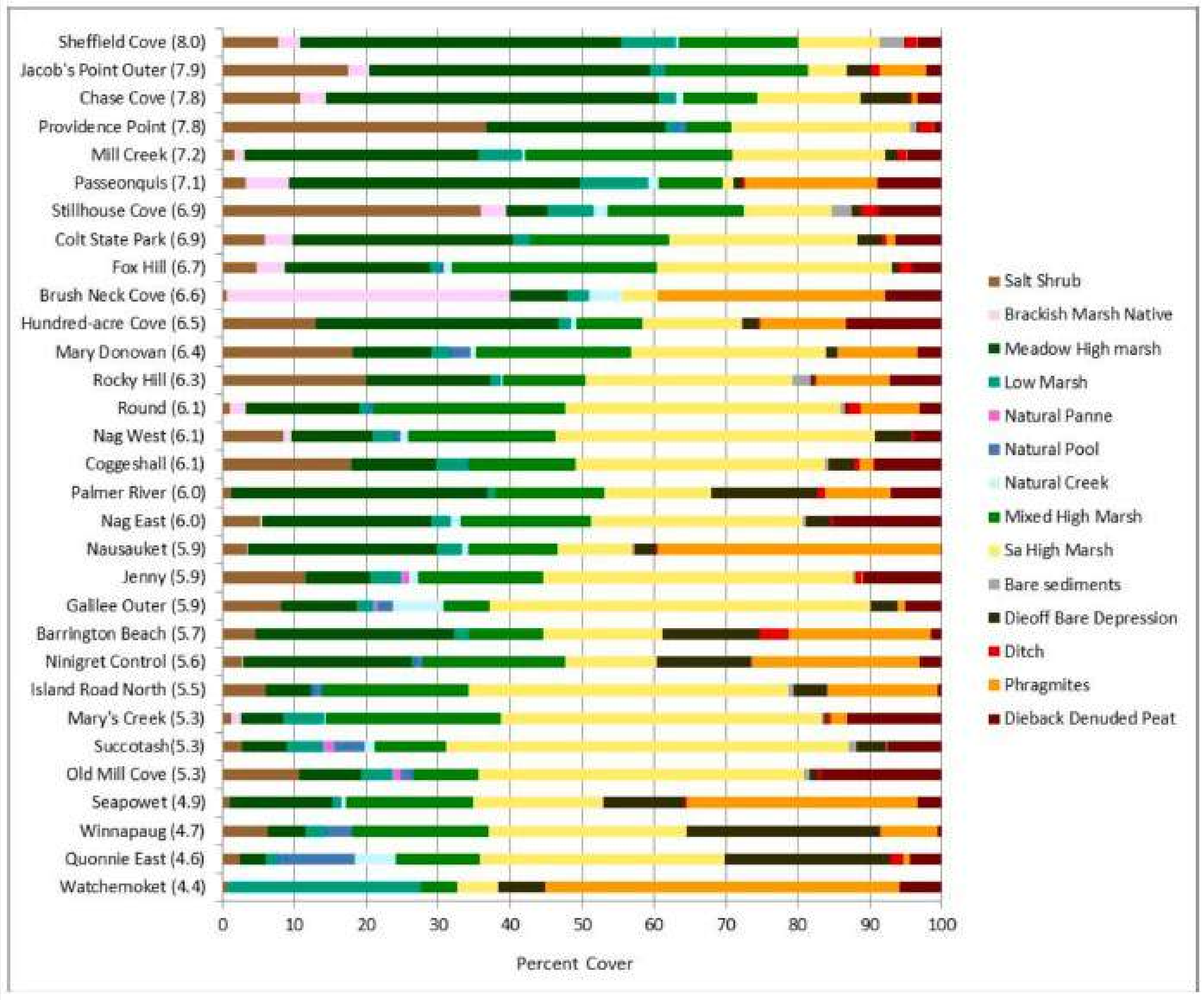
Interpretation of Kappa Coefficient		
Kappa Value	**Level of Agreement**	**% Data is Reliable**
0 - 0.20	None	0 - 4
0.21 - 0.39	Minimal	5 - 14
0.40 - 0.59	Weak	15 - 35
0.60 - 0.79	Moderate	35 - 63
0.80 - 0.90	Strong	64 - 81
0.90 - 1.0	Almost Perfect	82 - 100

METHODS: Rapid assessment method (MarshRAM)

Kutcher et al. 2022

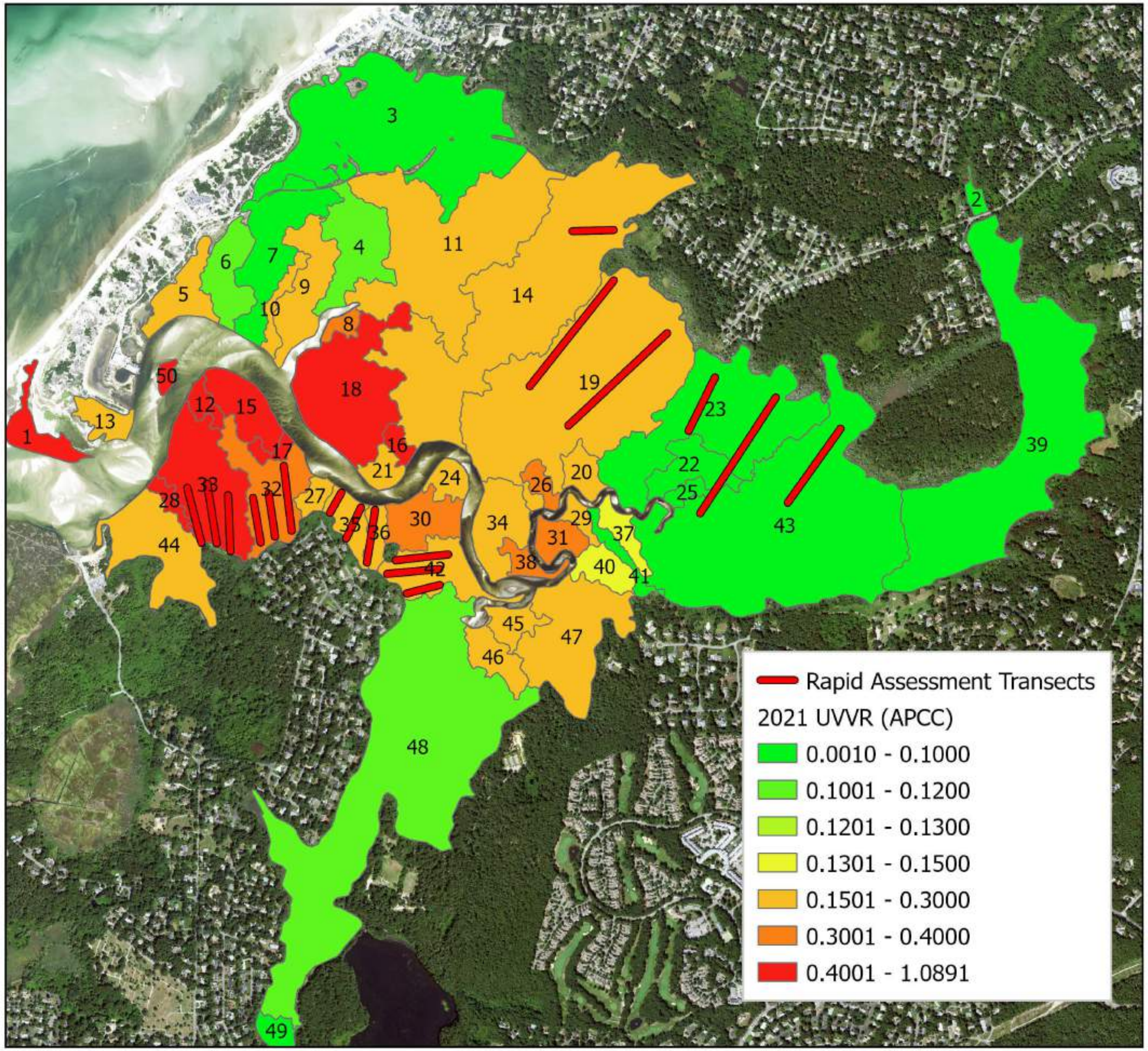
Table 3
MarshRAM community types and their mean cover across 31 RI salt marshes, sorted by Pearson correlation coefficients (r), indicating the relative influence of each type on IMI values across the marshes; i.e., the highest (+) and lowest (−) r coefficients indicate cover types that most strongly increase (+) or decrease (−) IMI scores.

MarshRAM Community	% Cover	IMI	
		r	P
Meadow High marsh	19.3	0.73	<0.01
Salt Shrub	8.7	0.46	0.01
Bare sediments	0.5	0.32	0.08
Ditch	0.8	0.24	0.19
Brackish Marsh Native	2.4	0.23	0.22
Mixed High Marsh	15.4	0.08	0.66
Dieback Denuded Peat	6	−0.11	0.54
Natural Creek	1.1	−0.11	0.54
Low Marsh	3.9	−0.18	0.32
Natural Panne	0.1	−0.24	0.18
Phragmites	9.8	−0.37	0.04
Sa High Marsh	25.7	−0.38	0.04
Natural Pool	1.1	−0.43	0.02
Dieoff Bare Depression	5.2	−0.53	<0.01



Rapid Assessment Transects

- Stratified randomized placement of upland end point
  - Three transects per UVVR ranking bracket
  - 6 northern transects (cross tidesheds)
  - 12 southern transects (three per tideshed)
- Walked transect until reached impassable creek



Vulnerability Assessment RESULTS

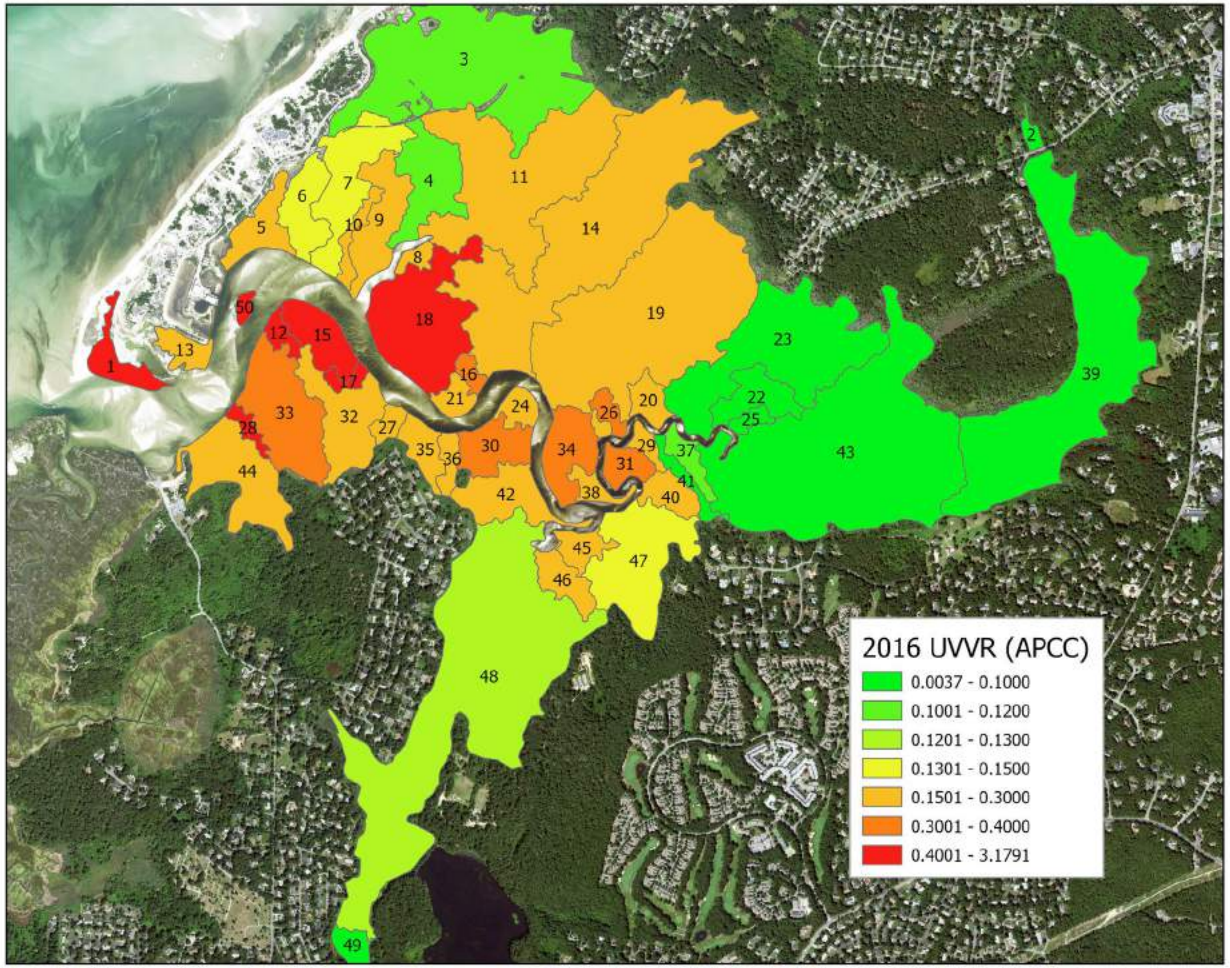
Unvegetated to Vegetated Ratio (UVVR)

- 2016 & 2021

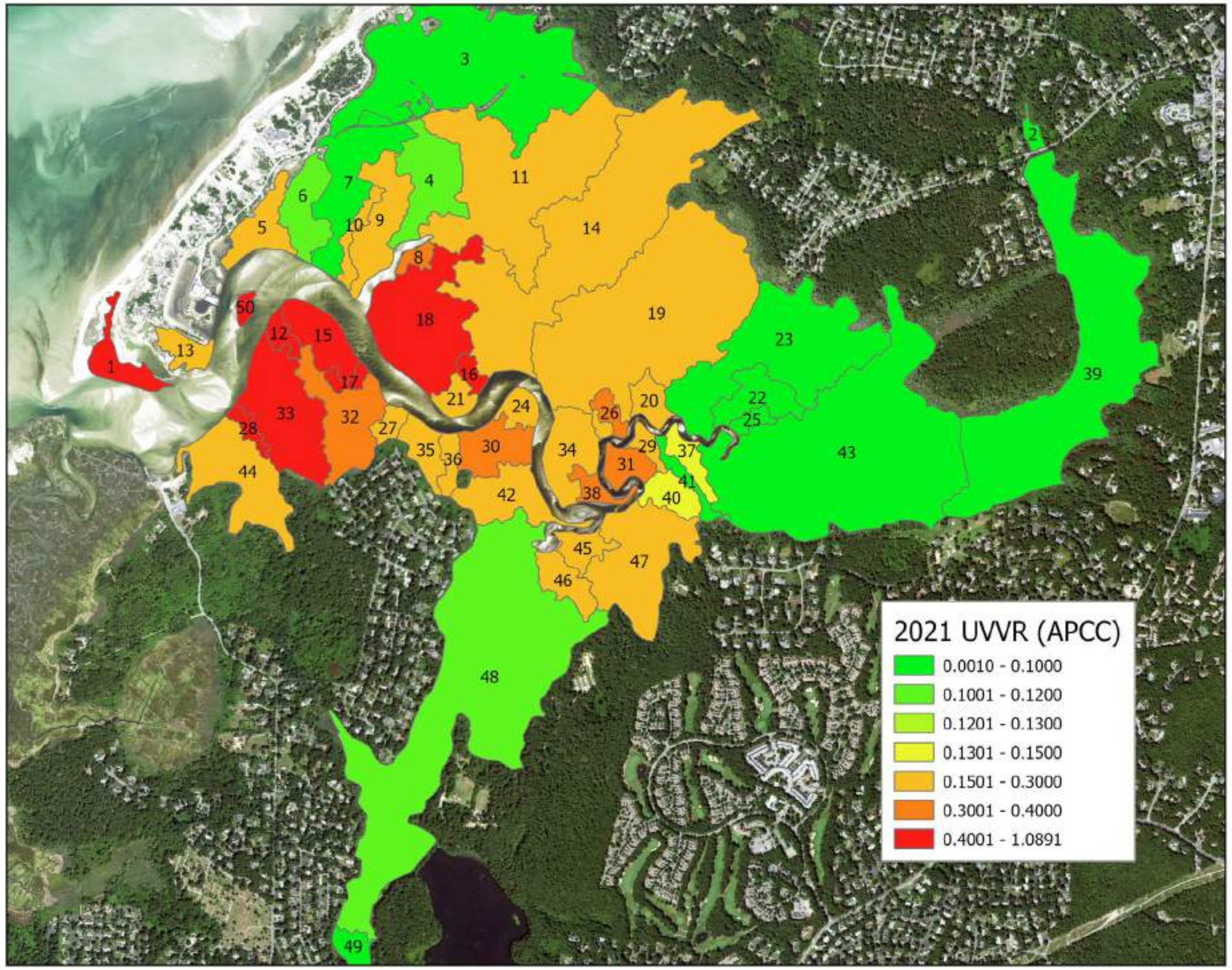
UVVR Results: Higher UVVR => more vulnerable to SLR

<0.13 = stable; >0.13 unstable

2016



2021



Confusion Matrix Results

2021 (APCC)					
ClassValue	C_0	C_1	Total	User Accuracy	Kappa
C_0	40	3	43	0.930233	0
C_1	2	8	10	0.8	0
Total	42	11	53	0	0
Producer_Accuracy	0.952381	0.727273	0	0.90566	0
Kappa	0	0	0	0	**0.703247**
2016 (APCC)					
C_0	41	1	42	0.97619	0
C_1	0	10	10	1	0
Total	41	11	52	0	0
P_Accuracy	1	0.909091	0	0.980769	0
Kappa	0	0	0	0	**0.940367**
				Average Kappa:	**0.821807**

Interpretation of Kappa Coefficient		
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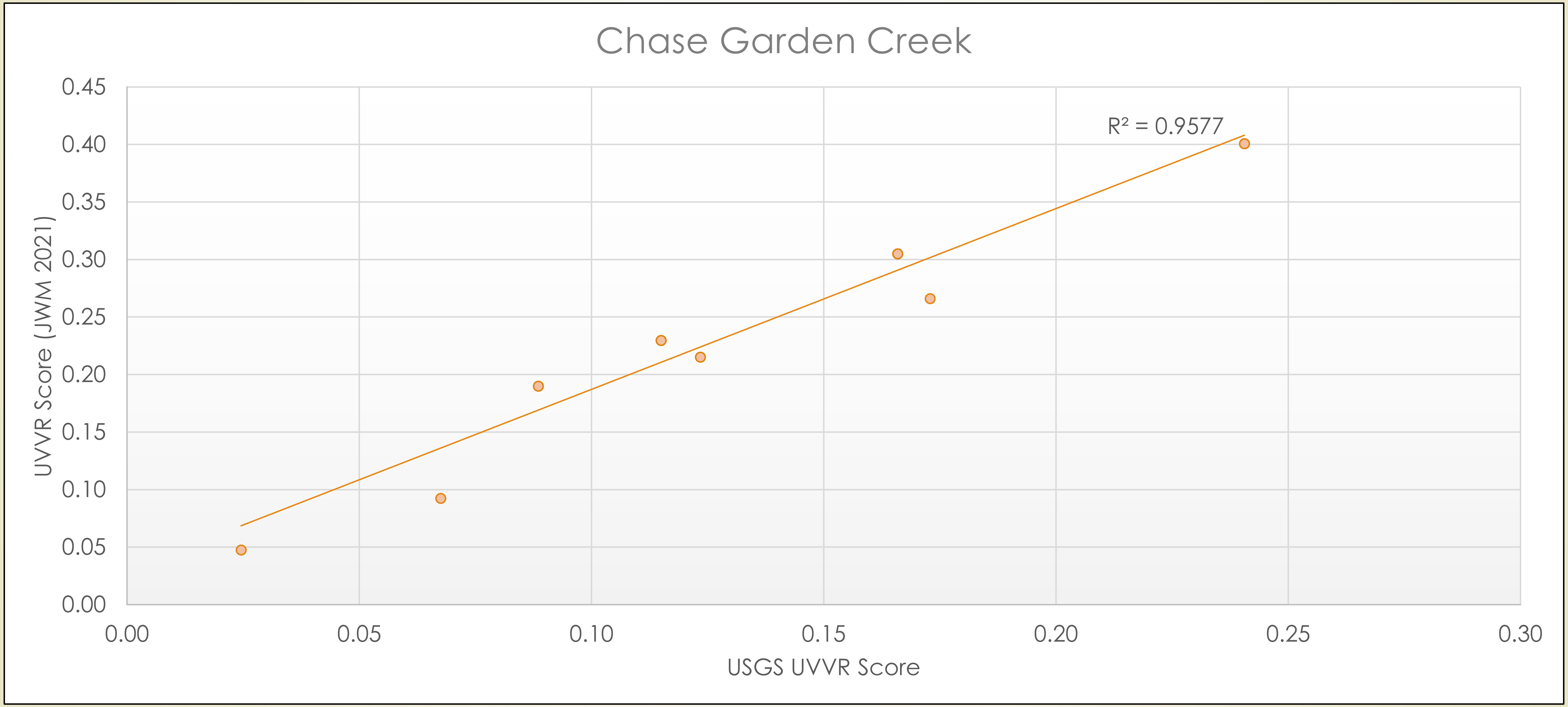
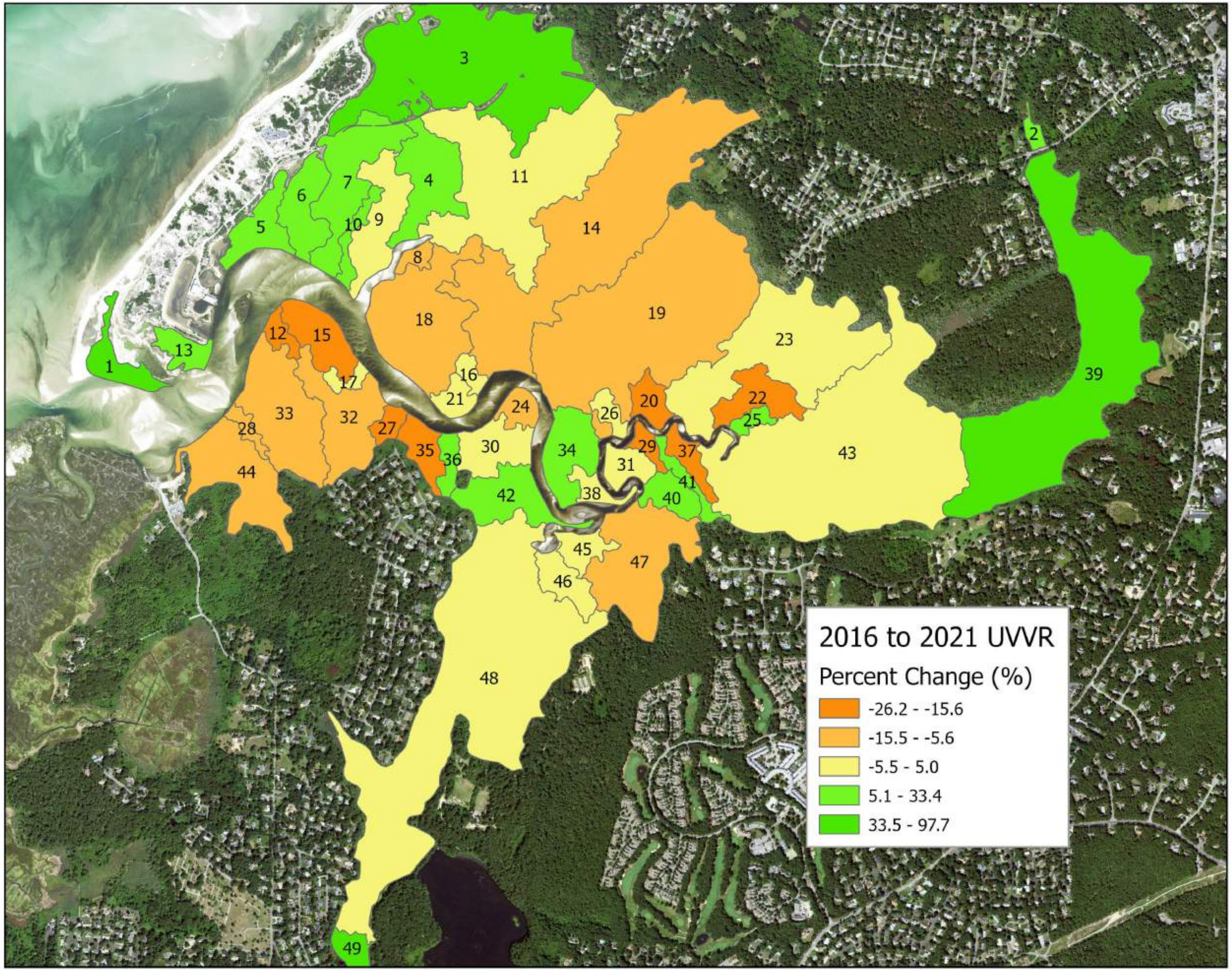
Checking Accuracy of 2021



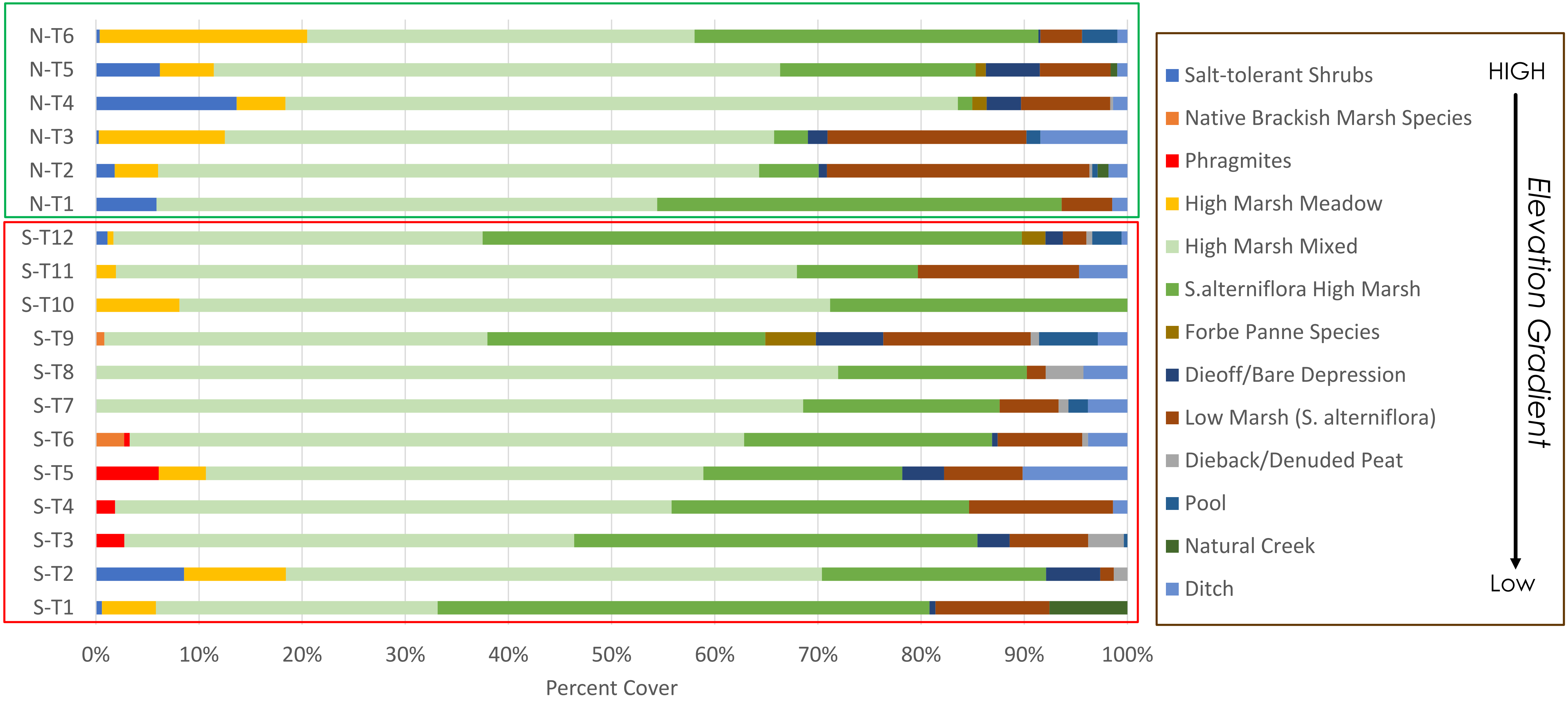
Percent Change Overtime



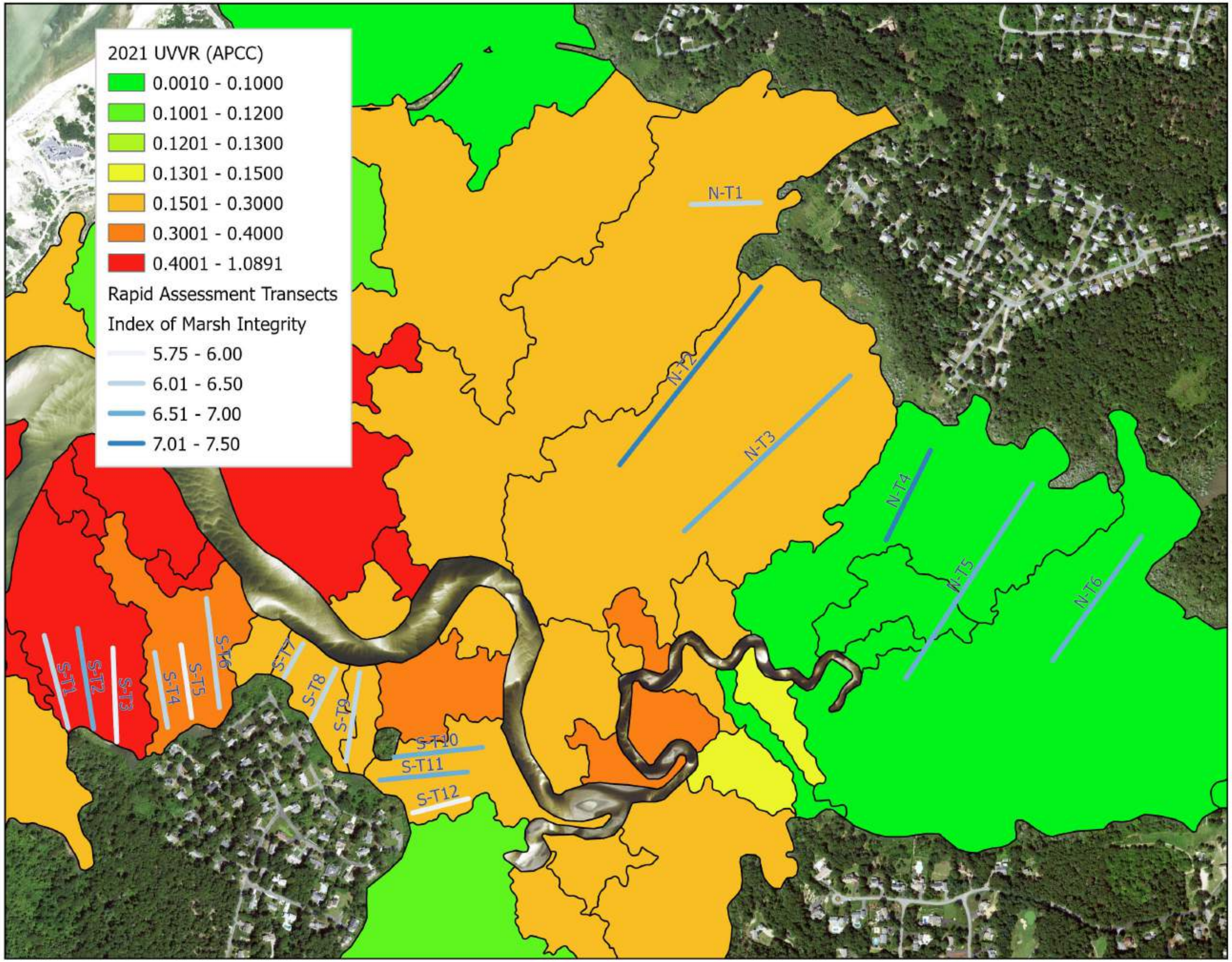
Vulnerability Assessment RESULTS

Rapid salt marsh assessment method (MarshRAM)

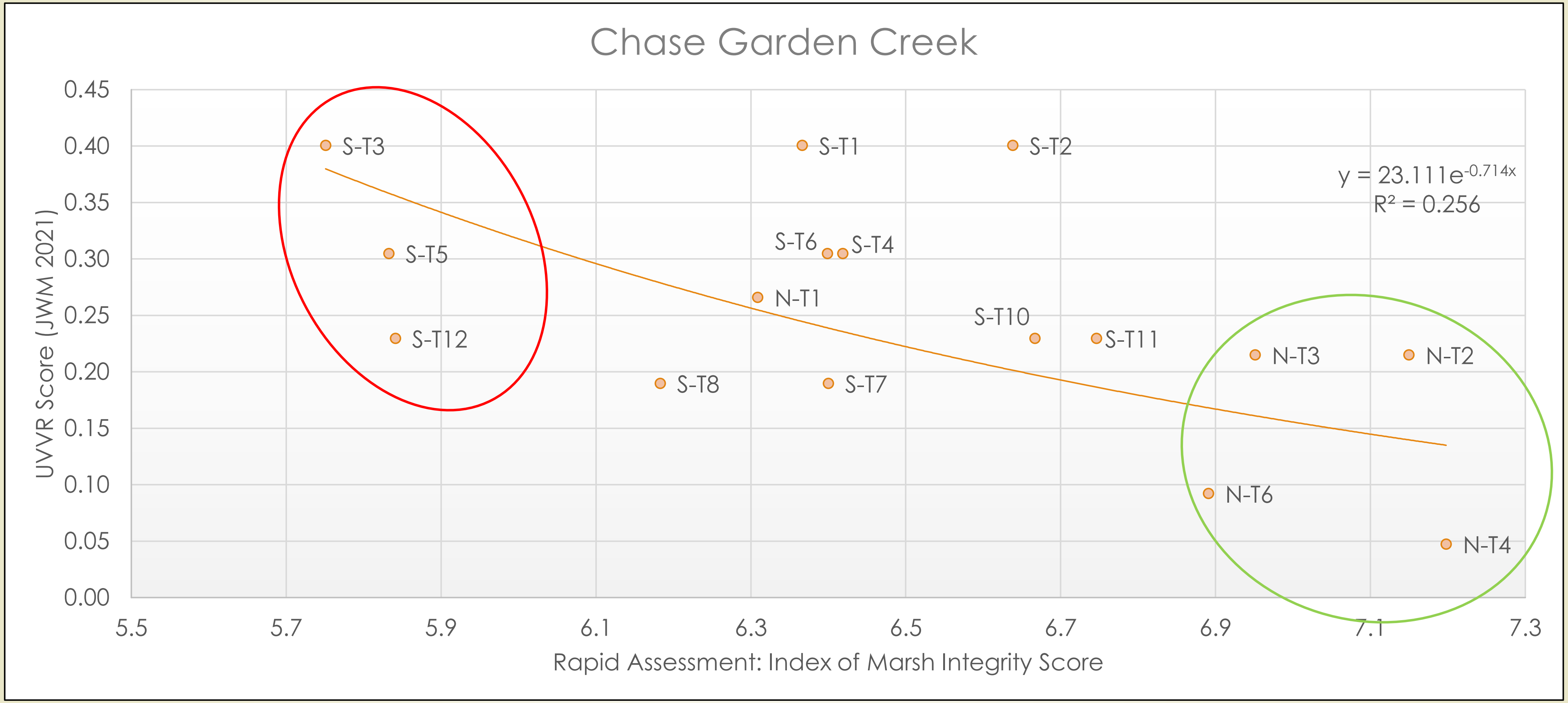
- Summer 2023



N-T6
N-T5
N-T4
N-T3
N-T2
N-T1
S-T12
S-T11
S-T10
S-T9
S-T8
S-T7
S-T6
S-T5
S-T4
S-T3
S-T2
S-T1
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent Cover
Salt-tolerant Shrubs
Native Brackish Marsh Species
Phragmites
High Marsh Meadow
High Marsh Mixed
S.alterniflora High Marsh
Forbe Panne Species
Dieoff/Bare Depression
Low Marsh (S. alterniflora)
Dieback/Denuded Peat
Pool
Natural Creek
Ditch
HIGH
Elevation Gradient
Low


2021 UVVR (APCC)
0.0010 - 0.1000
0.1001 - 0.1200
0.1201 - 0.1300
0.1301 - 0.1500
0.1501 - 0.3000
0.3001 - 0.4000
0.4001 - 1.0891
Rapid Assessment Transects
Index of Marsh Integrity
5.75 - 6.00
6.01 - 6.50
6.51 - 7.00
7.01 - 7.50
N-T1
N-T2
N-T3
N-T4
N-T5
N-T6
S-T1
S-T2
S-T3
S-T4
S-T5
S-T6
S-T7
S-T8
S-T9
S-T10
S-T11
S-T12

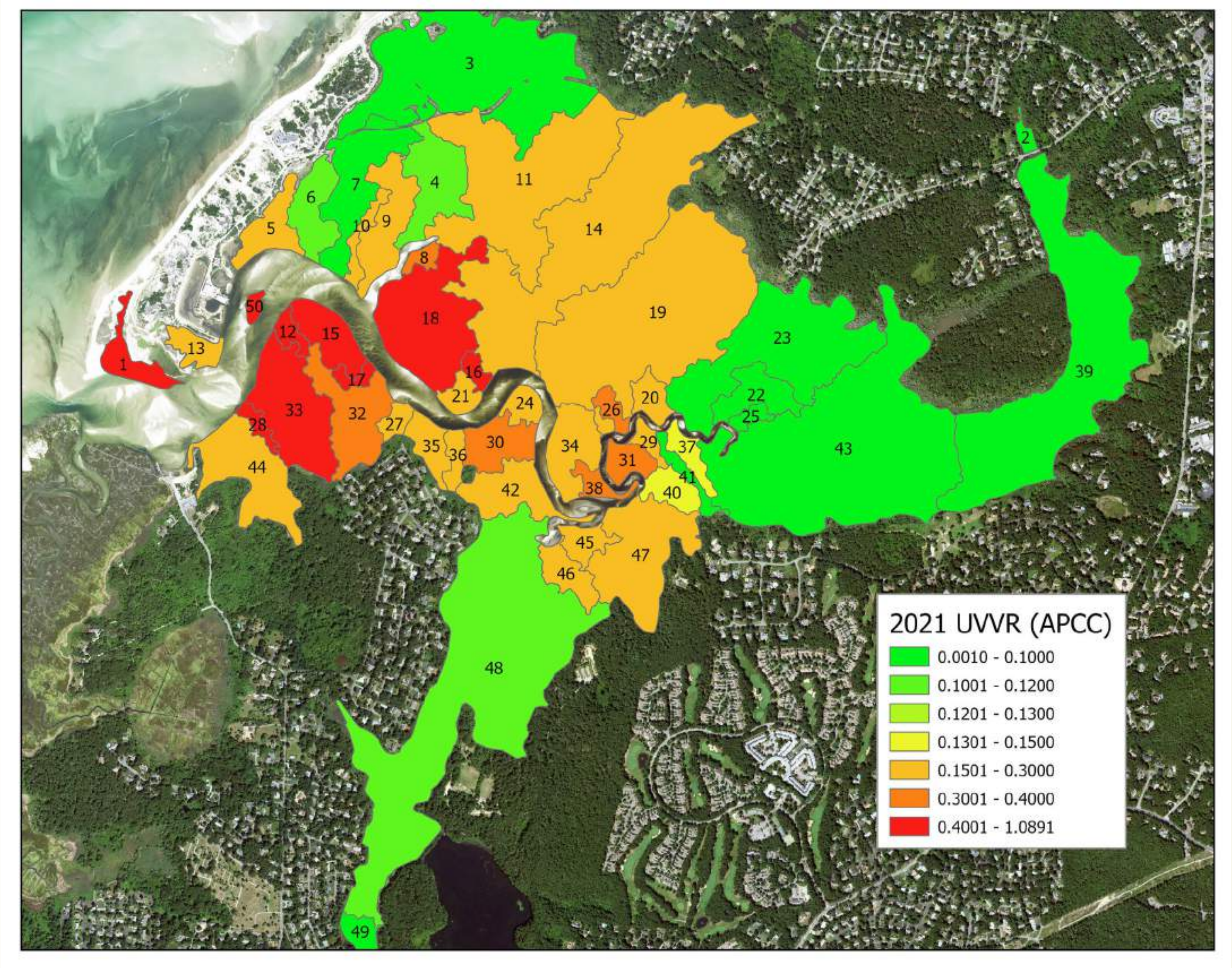
UVVR and MarshRAM comparison



Vulnerability Assessment CONCLUSIONS

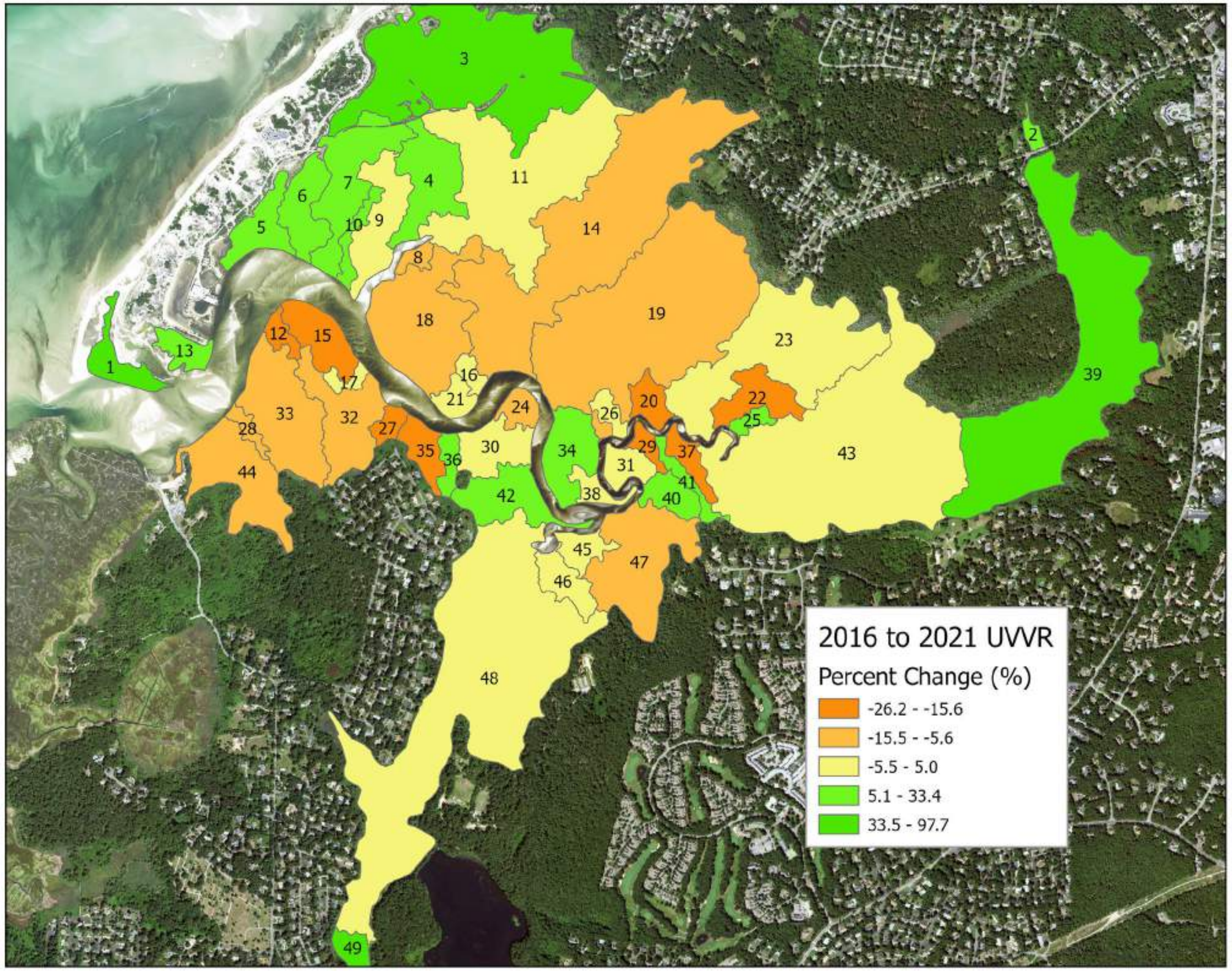
UVVR (2021)

- Based on the 2021 UVVR results (APCC), the **central part** of the Chase Garden Creek marsh has the lowest relative vegetated cover making it **most at risk for sea level rise.**
  - Of that area, **bare areas are most prevalent near the creek edge**
- The marsh surrounding **the eastern and southern tributaries are the most stable** with higher relative vegetated cover.

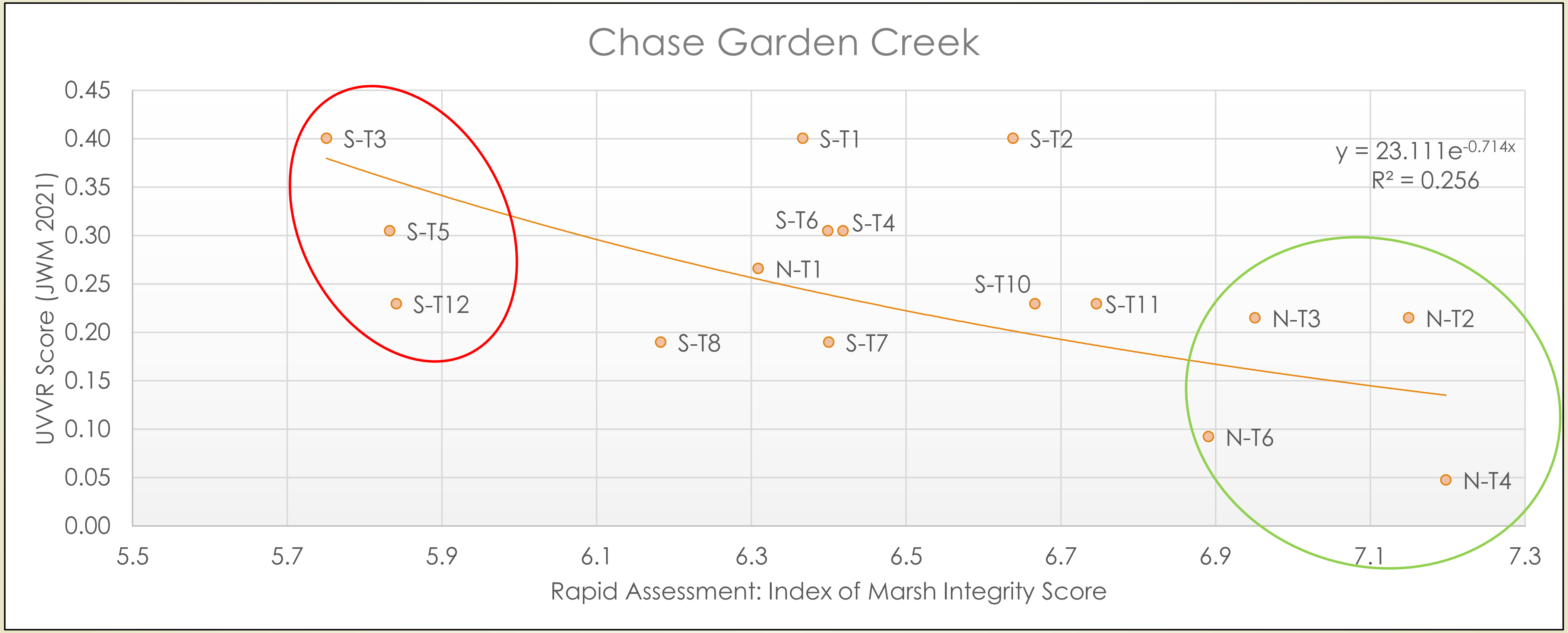


UVVR: 2016 vs. 2021

- By comparing UVVR in 2016 vs. 2021, the data indicate that the areas experiencing **the highest rate of change is occurring at the center of the marsh nearest the creek**
  - The 8 tidesheds experiencing the most vegetation loss border the creek (tidesheds: #12, 15, 27, 35, 29, 20, 37, 22)
  - Of those 8, six are located on the southern (Yarmouth) section of the marsh, and only two are in Dennis

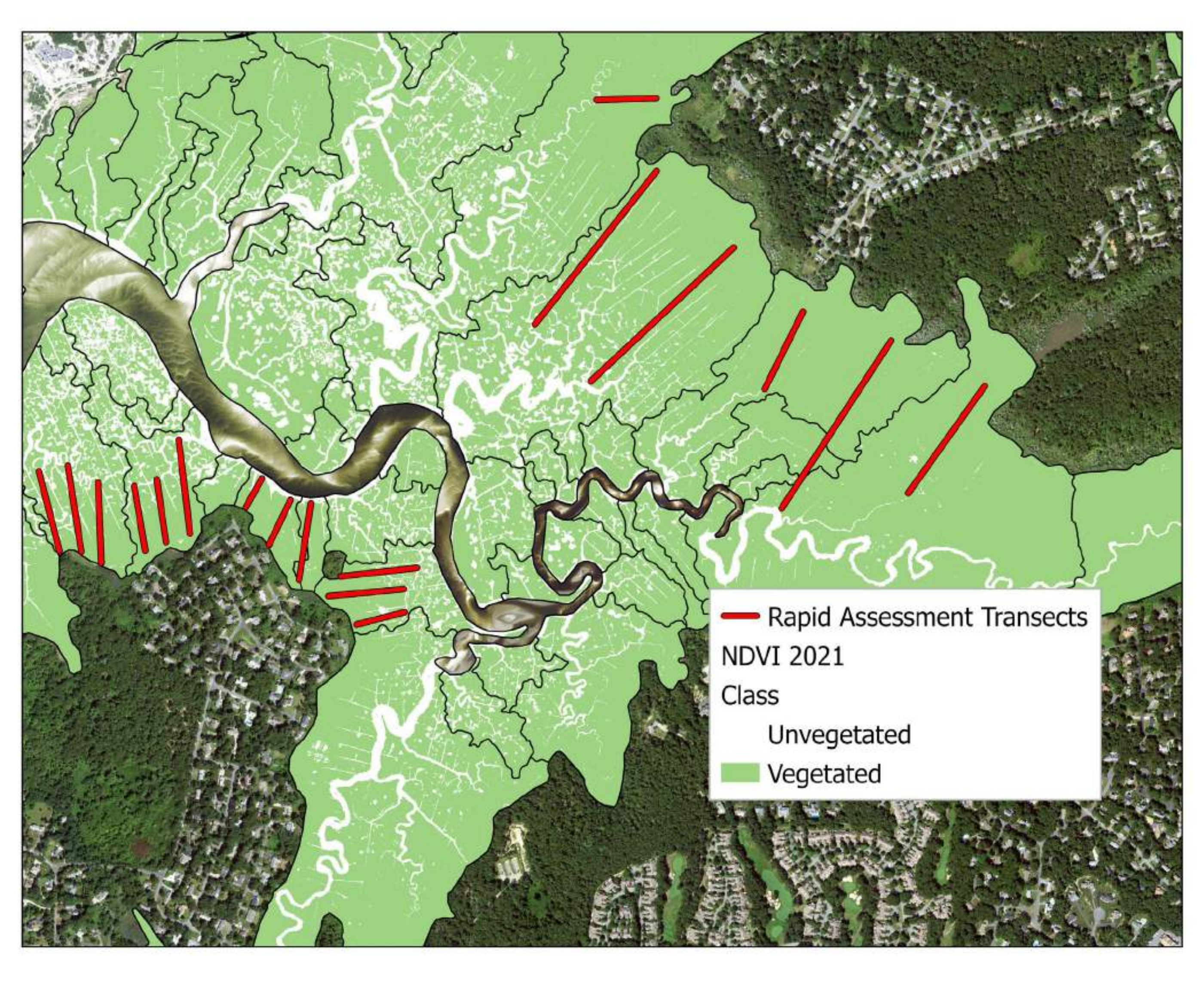


UVVR vs. MarshRAM

- In general, the rapid assessment method corroborated the UVVR findings: **areas with higher marsh integrity scores were also generally areas of lower UVVRs.**
- 

UVVR vs. MarshRAM

- In general, the rapid assessment method corroborated the UVVR findings: **areas with higher marsh integrity scores were also generally areas of lower UVVRs.**
- However, the **size of the tidesheds and the challenges in accessing sections of the marsh limited the strength of the correlation.**
  - **Recommend using smaller tidesheds for future analyses.**



Take home!

- Results indicate that vegetation cover is relatively low at the center and near the creek edge .
  - When vegetation cover is low, accretion mechanisms are impaired.
    - In other words, sediment deposition and the accumulation of organic matter is limited.
  - Combined with high rates of sea level rise, these factors can lead to erosion of creek edges and formation of pools, exacerbating the problem.

Questions?

Thank you!

Visit the project website:
https://apcc.org/our-work/science/chase-garden-creek/

Potential Restoration
Goals & Actions

Overarching Restoration Goals

- **Halt subsidence trajectories by bolstering natural accretion mechanisms**
- **Promote native salt marsh plants to recover habitat for threatened/endangered species**

Step by Step Goals

- Restore tidal regime
- Enhance sediment deposition
- Increase plant productivity by improving drainage in waterlogged/oversaturated areas
- Raise groundwater table to reduce decomposition rates (restore low oxygen conditions in soil)
- Create conditions (microtopography) to encourage high marsh plants

DISCUSSION QUESTION

- **Are there other restoration goals that we haven't considered?**

Step by Step Goals For Reference

- *Restore tidal regime*
- *Enhance sediment deposition*
- *Increase plant productivity by improving drainage in waterlogged/oversaturated areas*
- *Raise groundwater table to reduce decomposition rates (restore low oxygen conditions in soil)*
- *Create conditions (microtopography) to encourage high marsh plants*

Possible methods for restoring degraded marsh platform

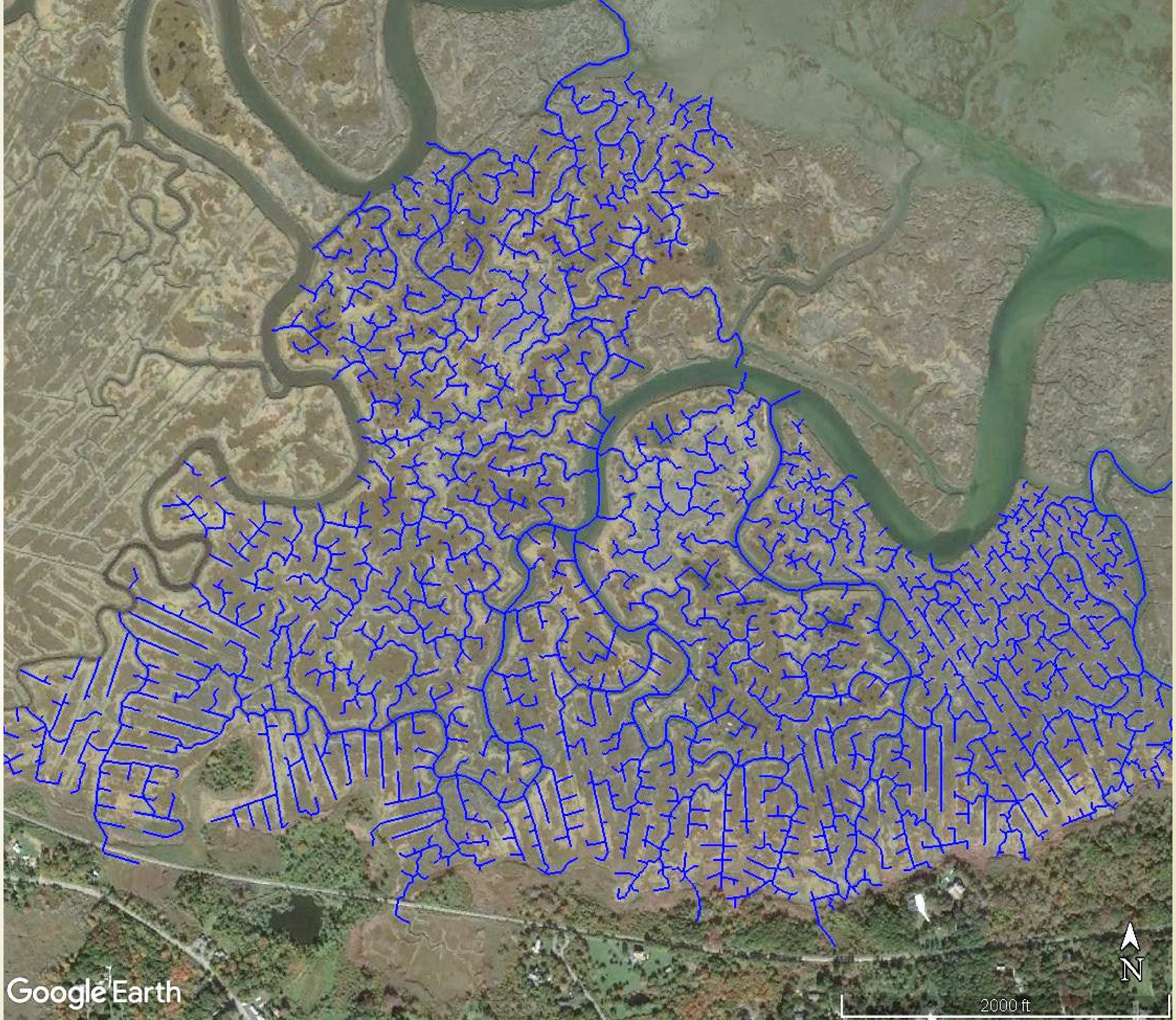
1. Establish single channel hydrology
   1. Runnels
   2. Ditch remediation (i.e., ditch plugging)
2. Thin Layer Placement

POLL QUESTION #3

- **How familiar are you with the concepts of runneling and ditch remediation as strategies for marsh restoration?**
  - Very – ask me anything!
  - Somewhat - I get the gist of it.
  - A little – I've heard of it.
  - Not at all - Say what?

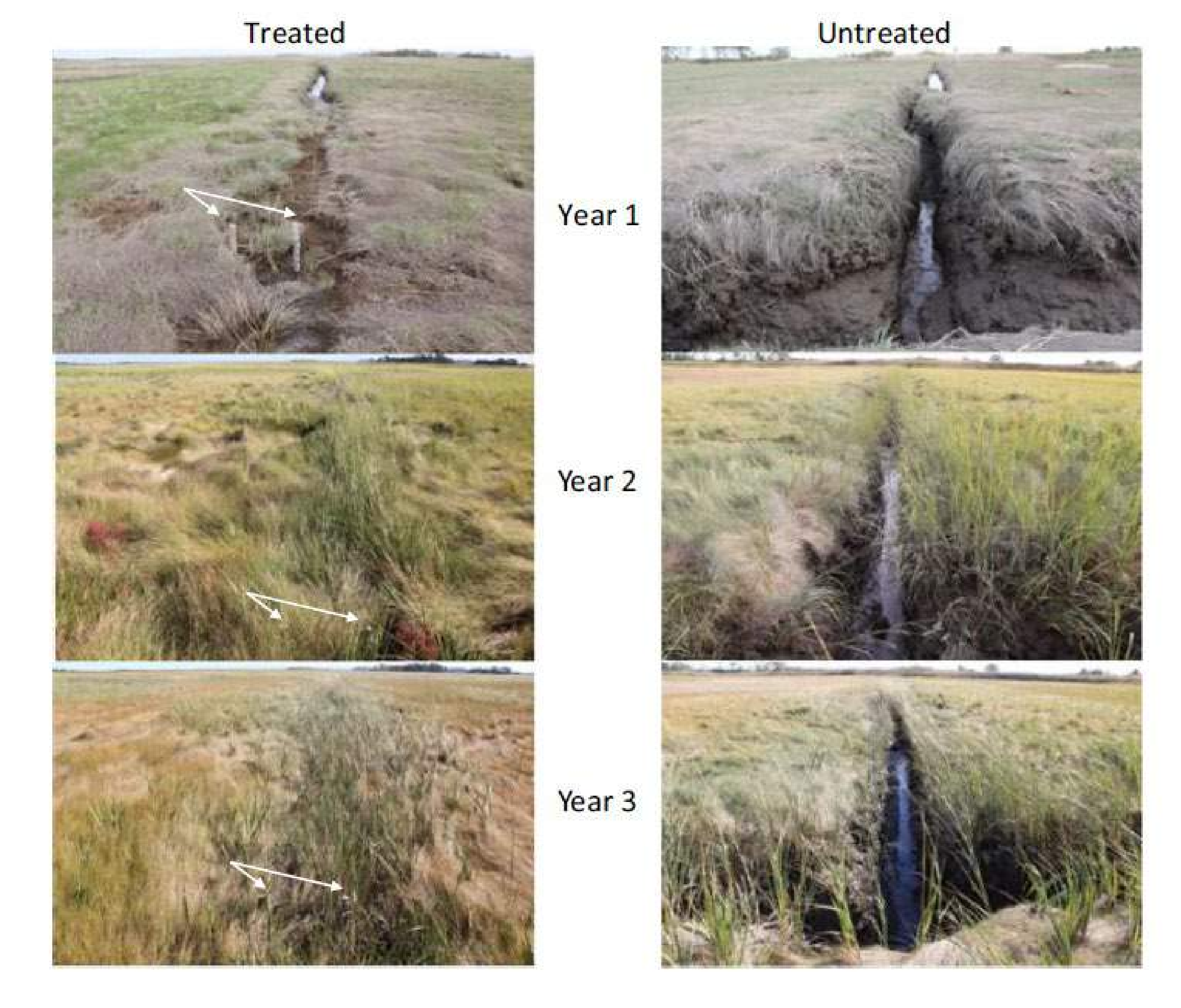
Single Channel Hydrology Restoration

- Barnstable Great Marsh
  - Mass Audubon and U.S. Fish & Wildlife SMARTeams)



Achieving Single Channel Hydrology

- **Ditch remediation**
  - Mow salt marsh perennial grasses from one or both sides of the treatment ditch
  - Allow hay to air dry for 24 h prior to loosely braiding
  - Fill ditch with 15–20 cm hay layer
  - Lightly compact by foot
  - Secure to the ditch bottom with twine and softwood grade stakes



Burdick et al. 2020

Achieving Single Channel Hydrology

- **Runneling**
  - Small channel (generally ≤ 30 cm wide and deep) that drains standing water on the marsh surface
  - Constructed using hand-digging and/or low-ground_pressure excavators or ditchers
  - Vegetation recover within 3-5 years (Perry et al. 2021)

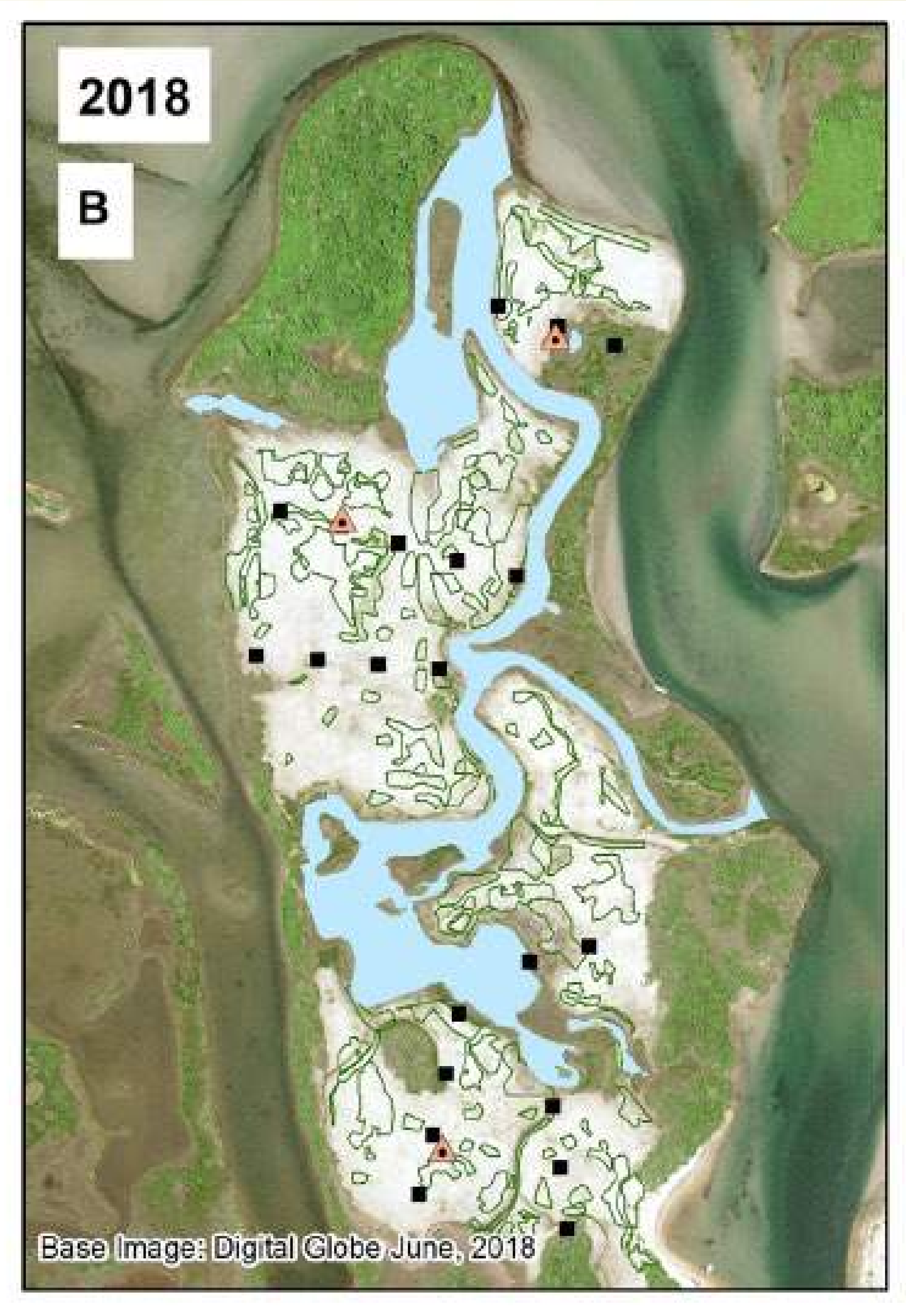
Maher et al. 2022

POLL QUESTION #4

- **How familiar are you with the concept thin layer placement as a strategy for marsh restoration?**
  - Very – ask me anything!
  - Somewhat - I get the gist of it.
  - A little – I've heard of it.
  - Not at all - Say what?

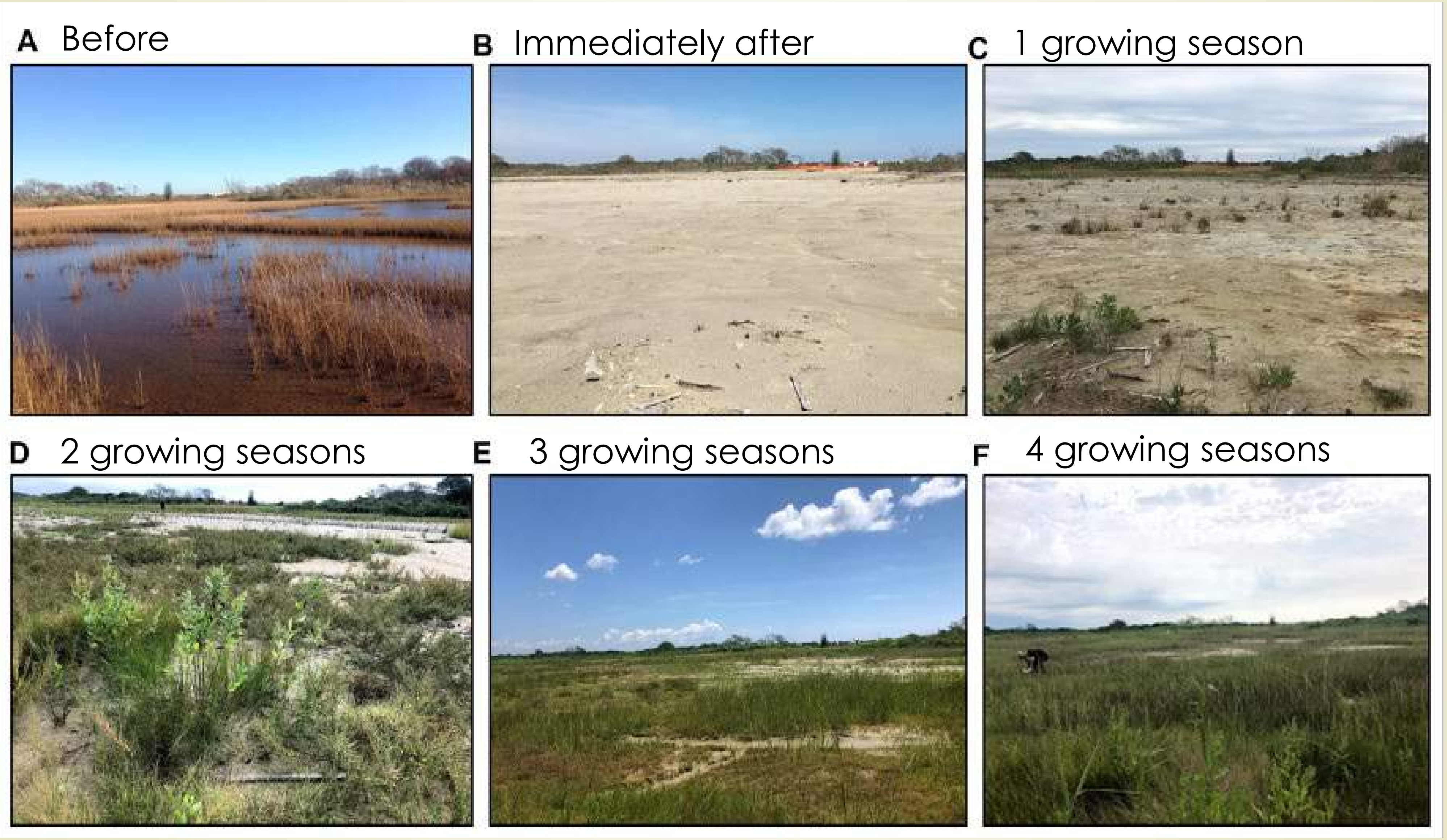
Thin Layer Placement
(Ninigret Marsh Example)

- Goal: quickly build elevation capital and enhance declining high marsh plant species
- Methods:
  - Applied a thick (10–48 cm) layer of sandy dredged material
  - Sediment was moved using two hydraulic dredges and discharged via 20-cm pipe onto the existing marsh surface.
  - Placed sediment was then graded by low ground-pressure bulldozers to target elevations



Raposa et al. 2022

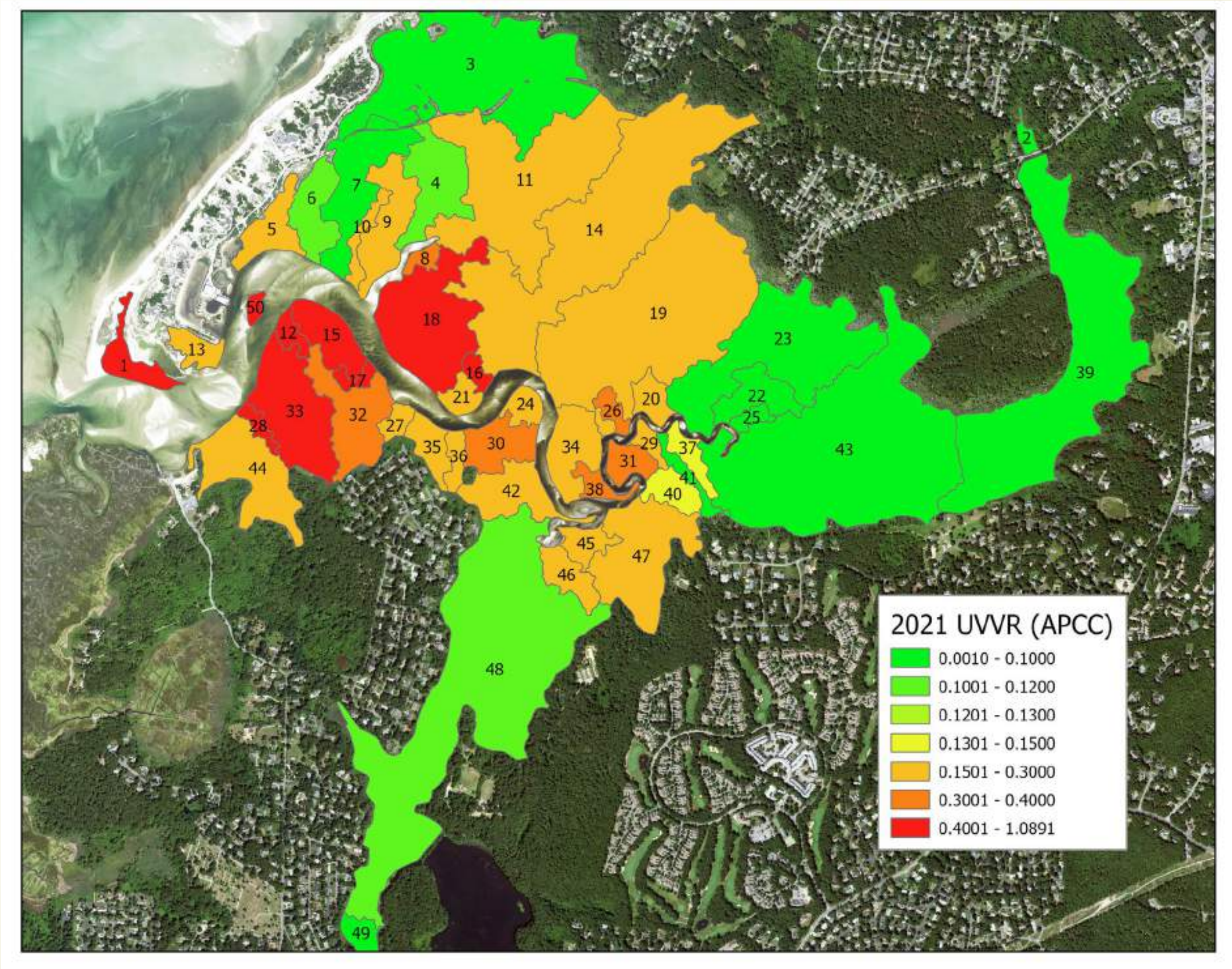
Thin Layer Placement (Ninigret Marsh Example)



Raposa et al. 2022

POLL QUESTION #5

- **Which tidesheds do you think are the highest priority for restoration?**
  - Stable
    (<0.13 UVVR; green)
  - Moderately vulnerable
    (0.14-0.30 UVVR; yellow/orange)
  - Extremely vulnerable
    (>0.30 UVVR; dark orange/red)



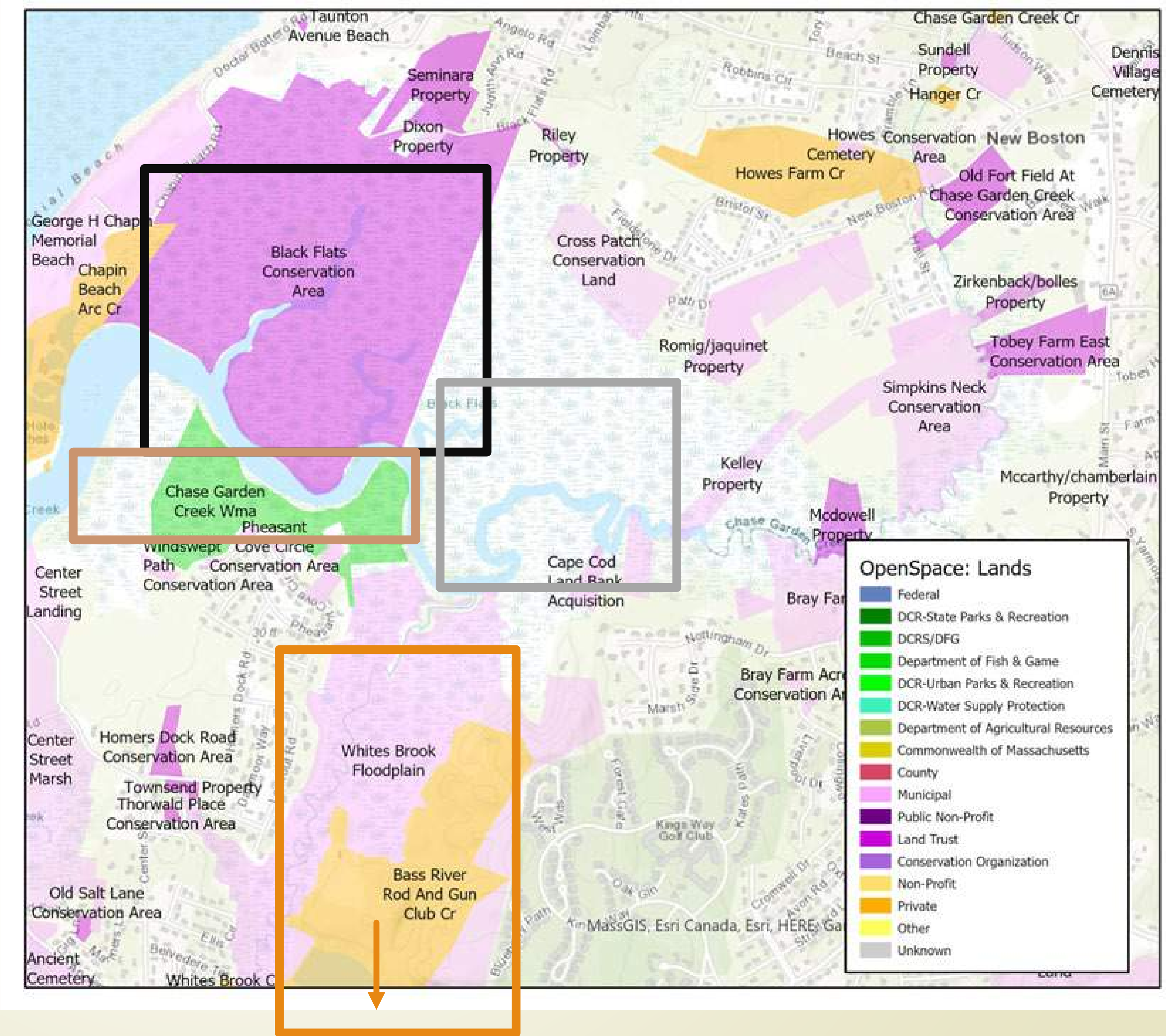
2 POLL QUESTIONS (#6 & #7)

- **In your opinion, which restoration technique do you think the salt marsh platform would benefit from most?**
  - Thin Layer Placement
  - Single Channel Hydrology (ditch remediation and runneling)
  - Neither
  - Other (please share during discussion)

- **Which restoration technique do you think would be most feasible at the Chase Garden Creek salt marsh?**
  - Thin Layer Placement
  - Single Channel Hydrology (ditch remediation and runneling)
  - Neither
  - Other (please share during discussion)

POLL QUESTION #8

- **What areas of Chase Garden Creek are most accessible for further survey <u>and</u> potential restoration action?**



Wrap – Up & Next Steps

- Please fill out the survey provided in the chat box to help us plan next steps.

- February 1, 2024: Final report due
- Spring 2024: Planning meeting
- Summer 2024: Additional marsh monitoring
- TBD: Public Meeting

https://apcc.org/our-work/science/chase-garden-creek/

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