Soil carbon accumulation and ecosystem drivers in Youngs Bay and Tillamook Bay, Oregon, USA

Columbia River Estuary Conference
April 10, 2018

Presented by:
Laura Brophy
brophyonline@gmail.com

Director, Estuary Technical Group
Institute for Applied Ecology
and
Marine Resource Management Program,
College of Earth, Ocean and Atmos. Sciences
Oregon State University
Corvallis, Oregon, USA

Our team:
Laura Brophy[1,2], Erin Peck[2], Scott Bailey[3], Craig Cornu[1], Robert Wheatcroft[2], Stan van de Wetering[4], Laura Brown[4], and Michael Ewald[5]

[1] Estuary Technical Group, Institute for Applied Ecology
[2] College of Earth, Ocean, and Atmospheric Sciences, Oregon State University
[3] Tillamook Estuaries Partnership
[4] Confederated Tribes of Siletz Indians
[5] GeomaticsResearch LLC

Full project reports available at:
http://appliedeco.org/program/estuary-technical-group/?post_types=report

Funded by the Bonneville Power Administration, Lower Columbia Estuary Partnership, U.S. Fish and Wildlife Service, and the Oregon Watershed Enhancement Board

Great thanks to:

- The Cowlitz Indian Tribe: Rudy Salakory (site access, input and support)
- The Columbia River Estuary Study Taskforce: April Silva, Narayan Elasmar (boat and field assistance)
- Oregon Department of Fish and Wildlife: Ron Rehn, Chris Knutsen (boat and field assistance)
- U.S. Environmental Protection Agency: Ted DeWitt, T Chris Mochon-Collura (loan of cryocore and RTK-GPS equipment)
- Amy Horstman, Chad Allen, Catherine Corbett, Matthew Schwartz, Greg Hublou, David Beugli, Sarah Kidd, Guy Banner, Patrick Hayden, Jake Turner, Ian Rodger, Anne Matthews, Philip Matthews, Issac Kentta, Dillon Blacketer, Susanna Pearlstein, Julie Brown

Take-home messages

1. Mean sediment accretion rates (SARs) exceeded past sea level rise: wetlands are “keeping pace.”
2. Low marsh sites showed very high SARs, suggesting resilience to future sea level rise.
3. Carbon sequestration rates equaled or exceeded global averages.
4. Large amounts of carbon are expected to be stored at the restoration sites.
5. Ecosystem driver measurements provided vital support for interpreting results.

Full project reports available at:
http://appliedeco.org/program/estuary-technical-group/?post_types=report

"Blue carbon" study at Youngs Bay and Tillamook Bay is part of a larger project

- Additional funding from Oregon Sea Grant
- Project web page: http://seagrant.oregonstate.edu/research/current-research/blue-carbon-sequestration-oregon-salt-marshes
- Publications to date:
  - Erin Peck's Master's thesis: http://ir.library.oregonstate.edu/xmlui/handle/1957/61372
  - Peck, Wheatcroft and Brophy (in press), *Estuaries and Coasts,* Manuscript ESCO-D-17-00255R1
- 7 Oregon estuaries sampled: Columbia (Youngs Bay), Nehalem, Tillamook, Netarts, Salmon, Alsea, Coquille
- Focus is on relationships between sediment supply, relative sea level rise, and carbon sequestration at reference sites

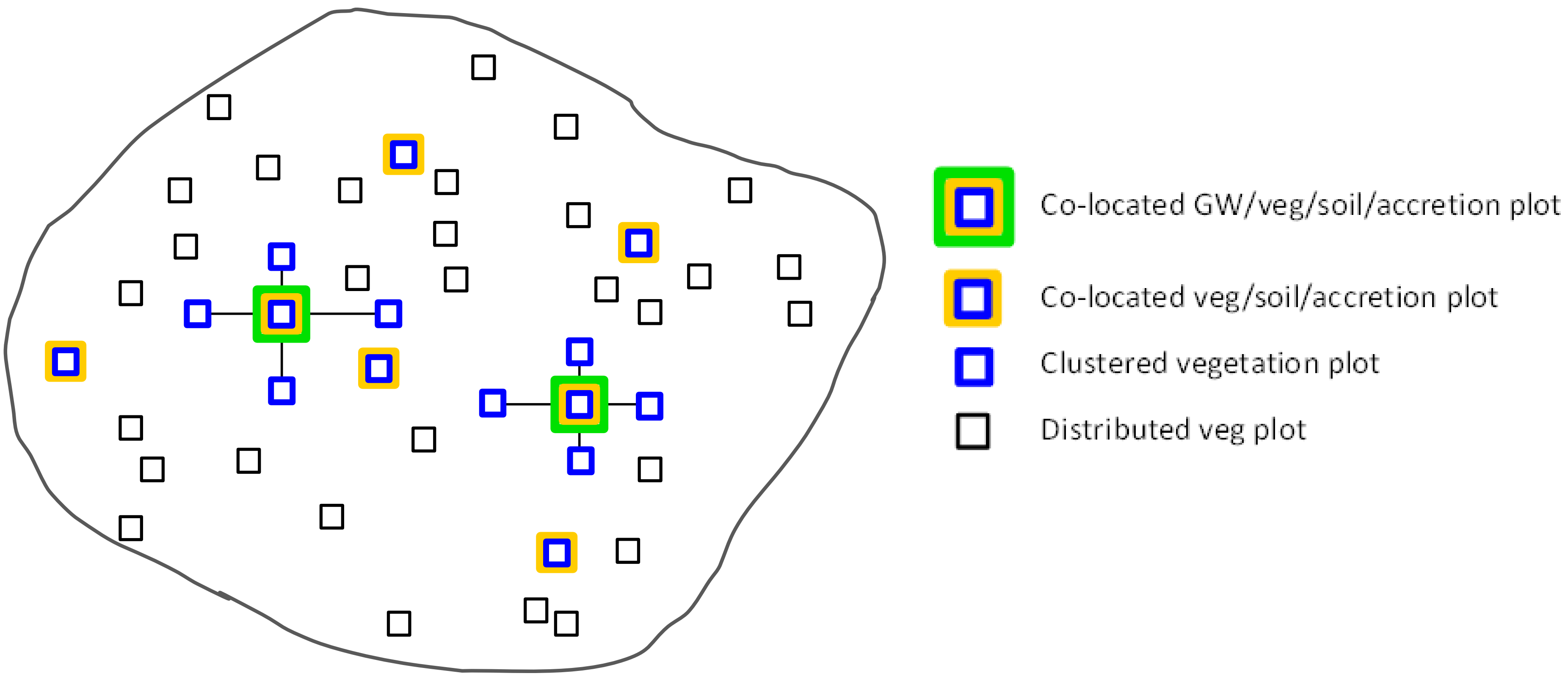
Project goals

1. Larger monitoring project: Evaluate restoration effectiveness
   - Before-After-Control-Impact approach (“BACI”)
   - Parameters reflect project goals
2. Quantify carbon stocks and sequestration rates
3. Estimate carbon losses after diking, and potential future carbon storage after restoration
4. Gain preliminary understanding of potential wetland resilience to sea level rise
5. Characterize the physical and biotic environment that supports carbon sequestration functions

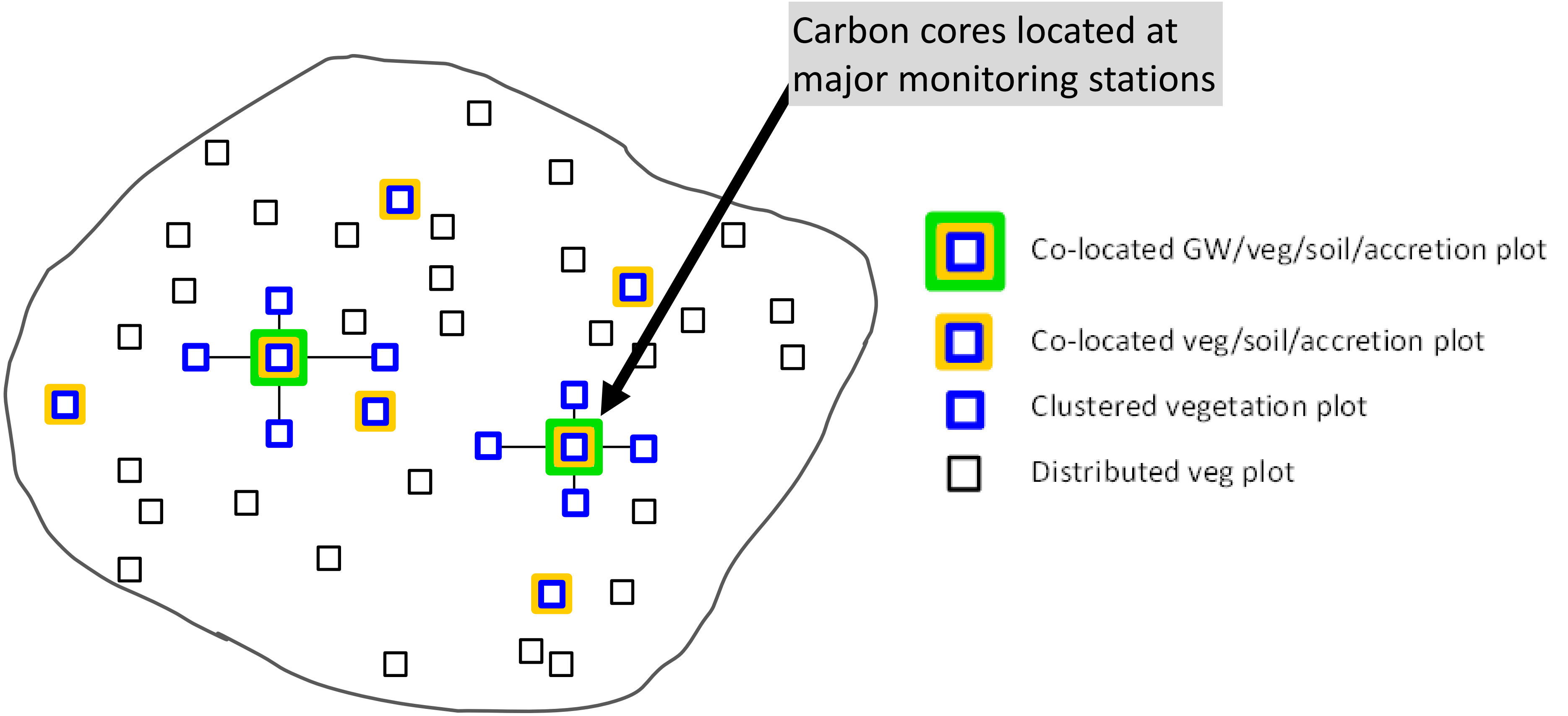
“Blue carbon” core locations

- 7 sites -- 3 in Youngs Bay, 4 in Tillamook Bay
- 1 restoration site per estuary, plus a suite of least-disturbed reference sites
- At each site, sampling stratified by habitat class, land use history
- Habitat classes: diked pasture, low marsh, high marsh, scrub-shrub tidal wetland
- Cores located at multi-parameter monitoring stations:
  - Groundwater level and GW salinity, soils, vegetation, accretion
- Channel stations: water level and salinity
- Tillamook: Greenhouse gas flux during 2017-2018 (NOAA-funded)

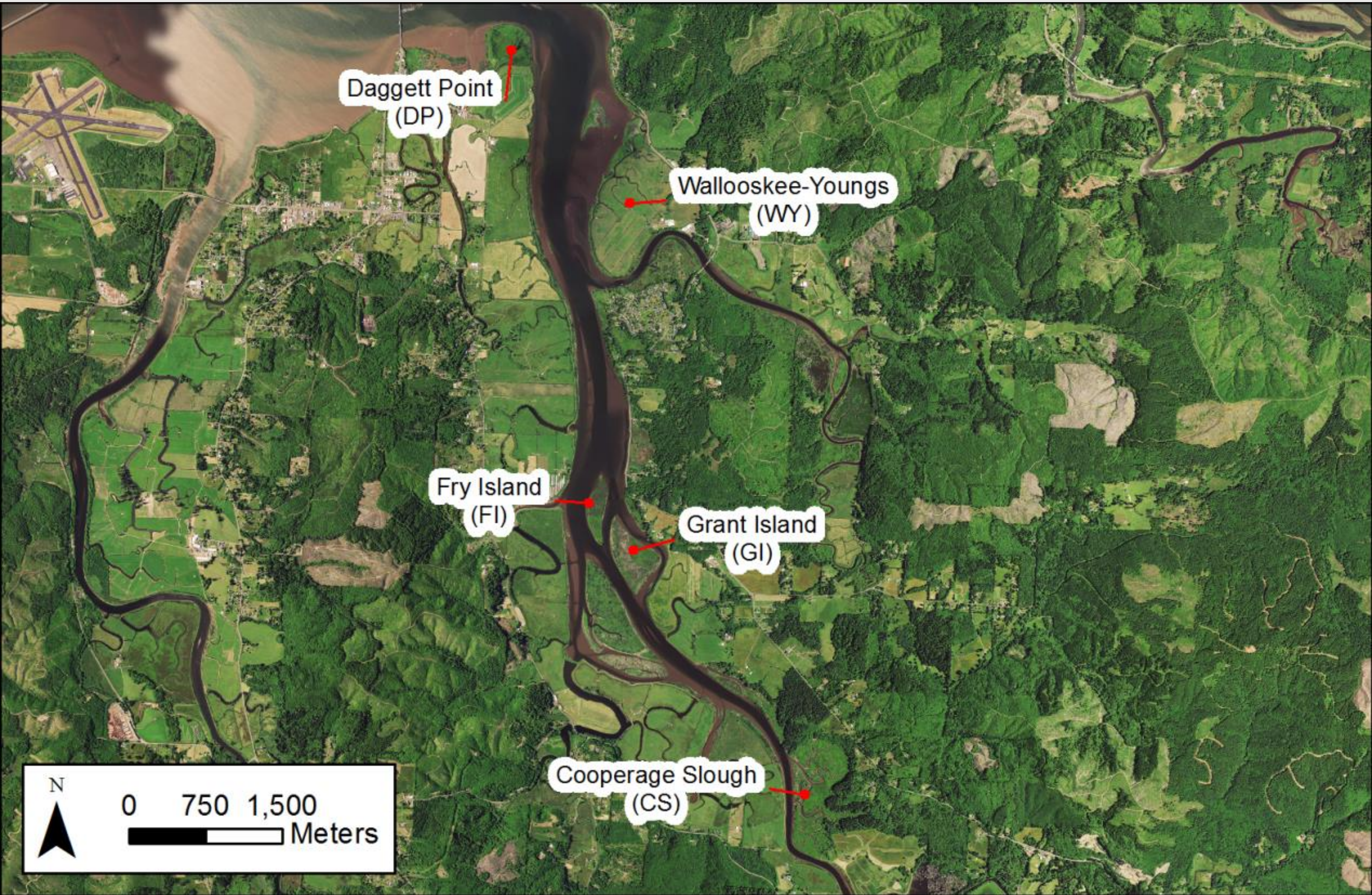
Monitoring stations



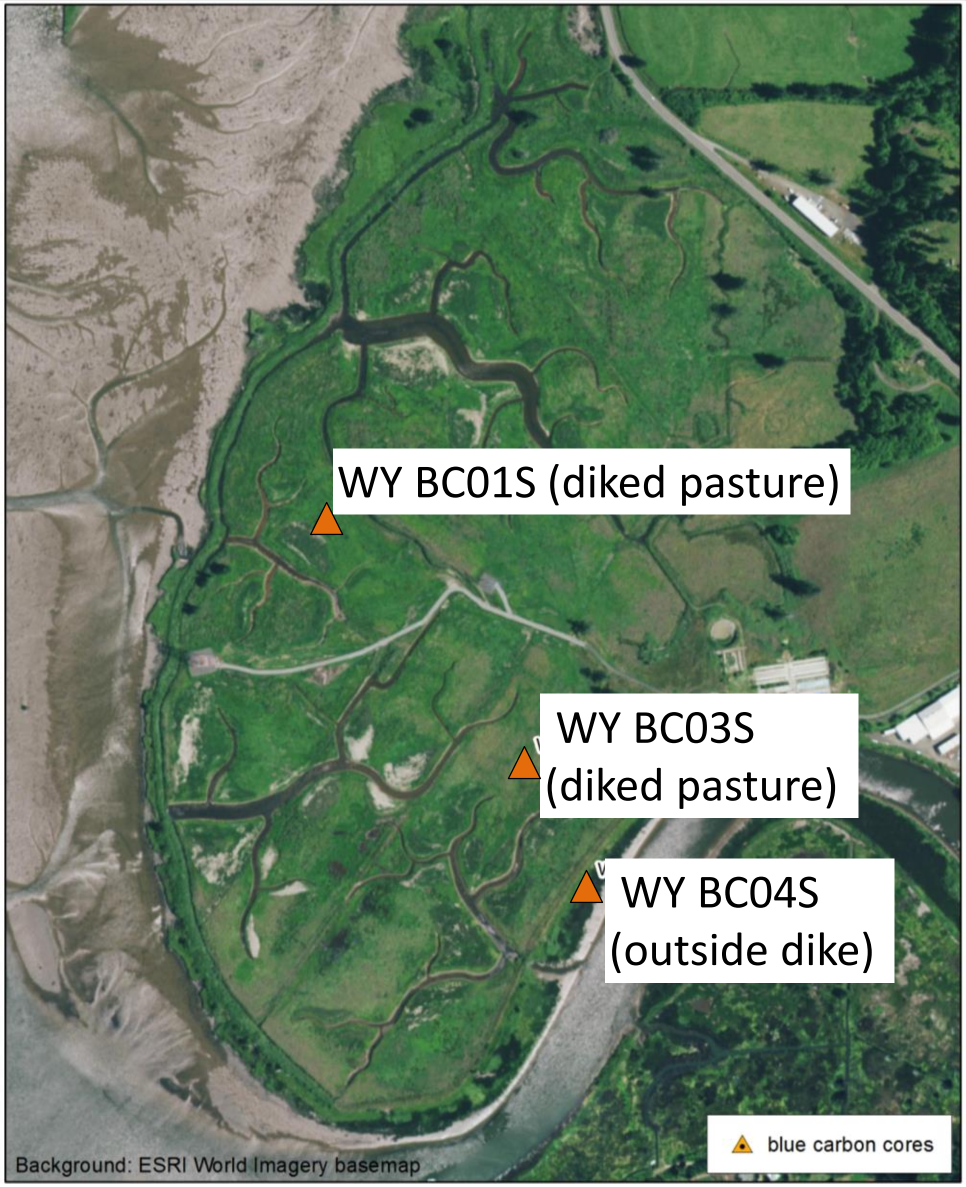
Monitoring stations



Youngs Bay study sites



“Blue carbon” cores
Wallooskee-Youngs restoration site, Youngs Bay



Blue carbon core

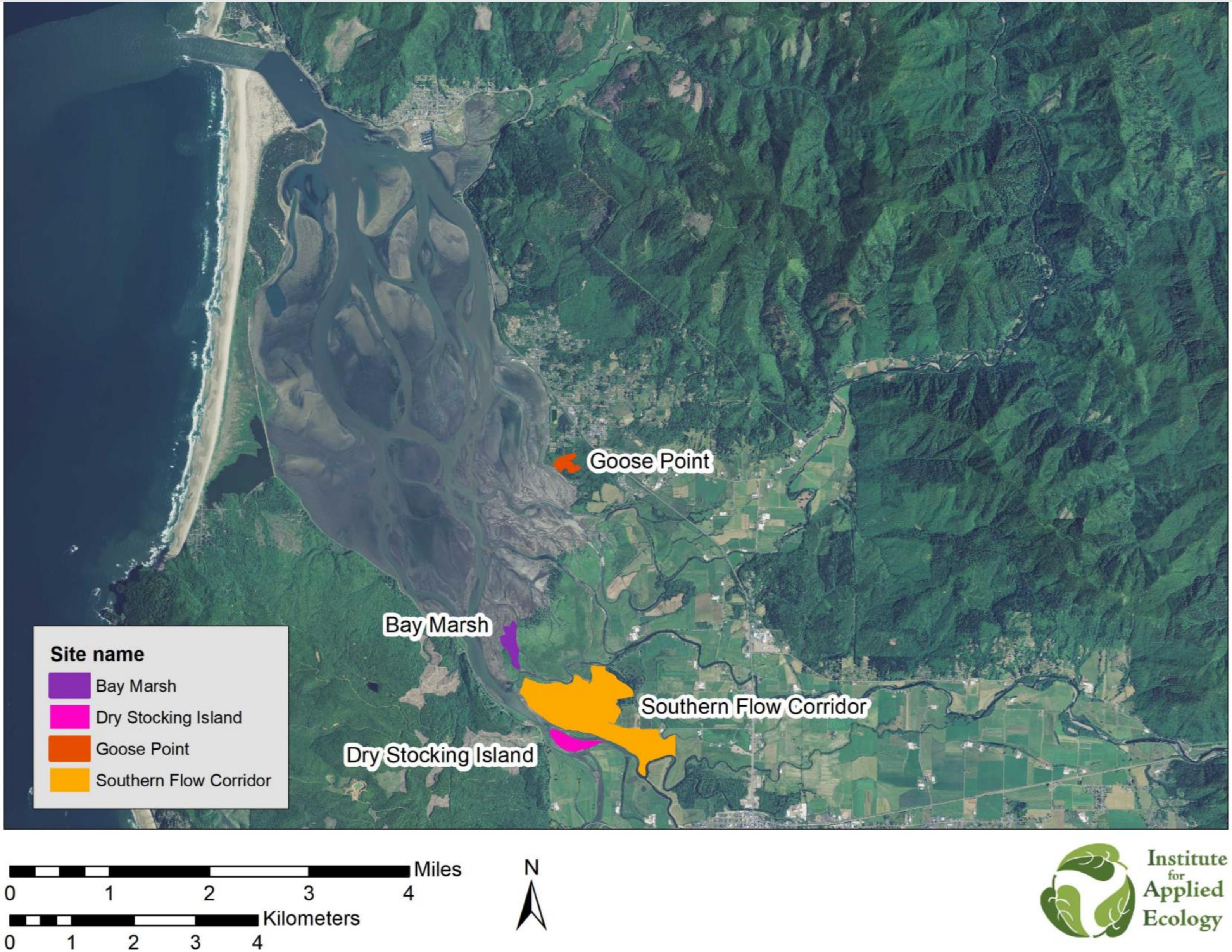
Monitoring stations
Wallooskee-Youngs restoration site, Youngs Bay

Monitoring stations are at same locations as blue carbon cores

Monitoring station

Water level and salinity dataloggers

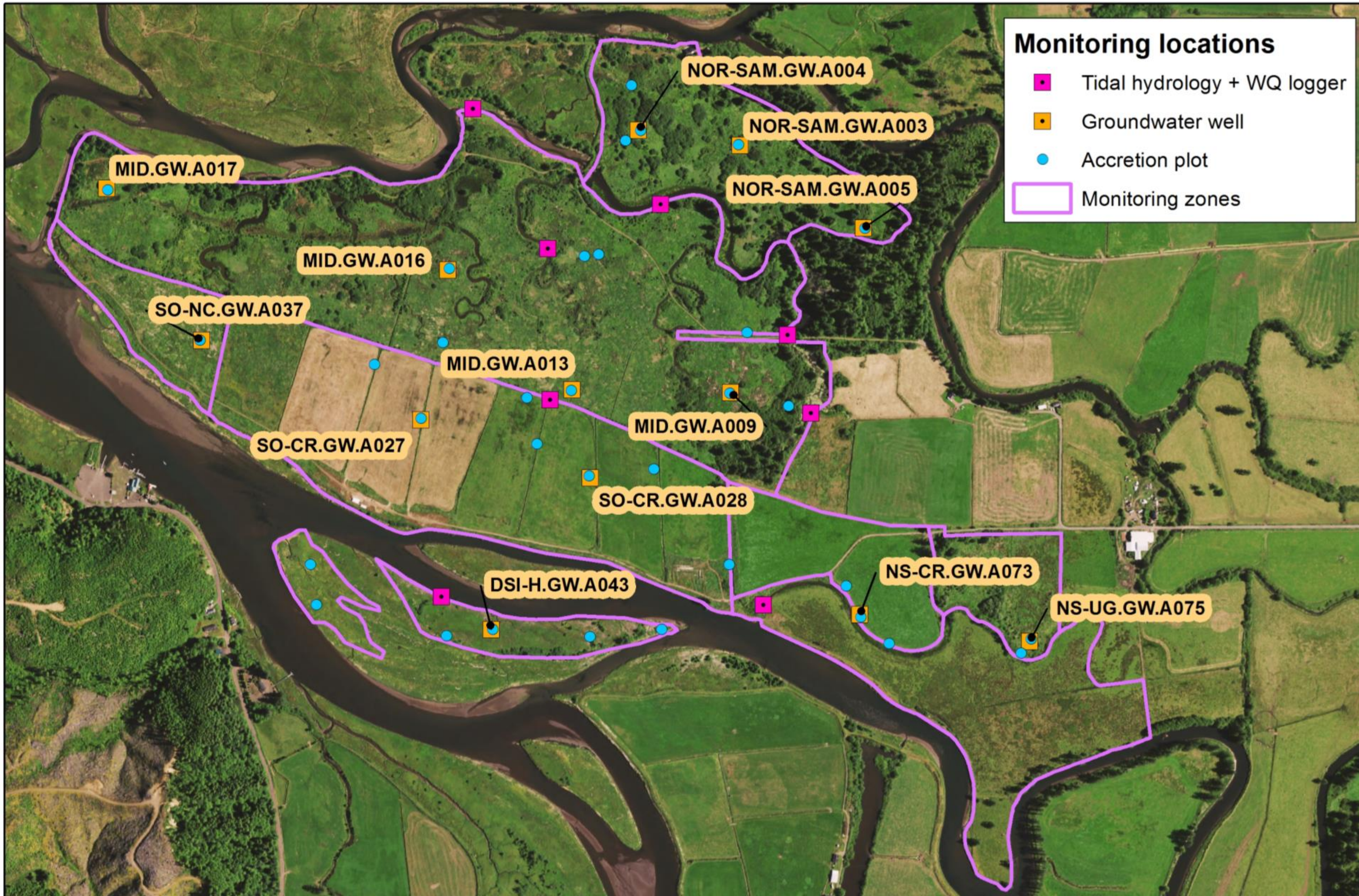
Tillamook Bay Estuary study sites



Institute for Applied Ecology

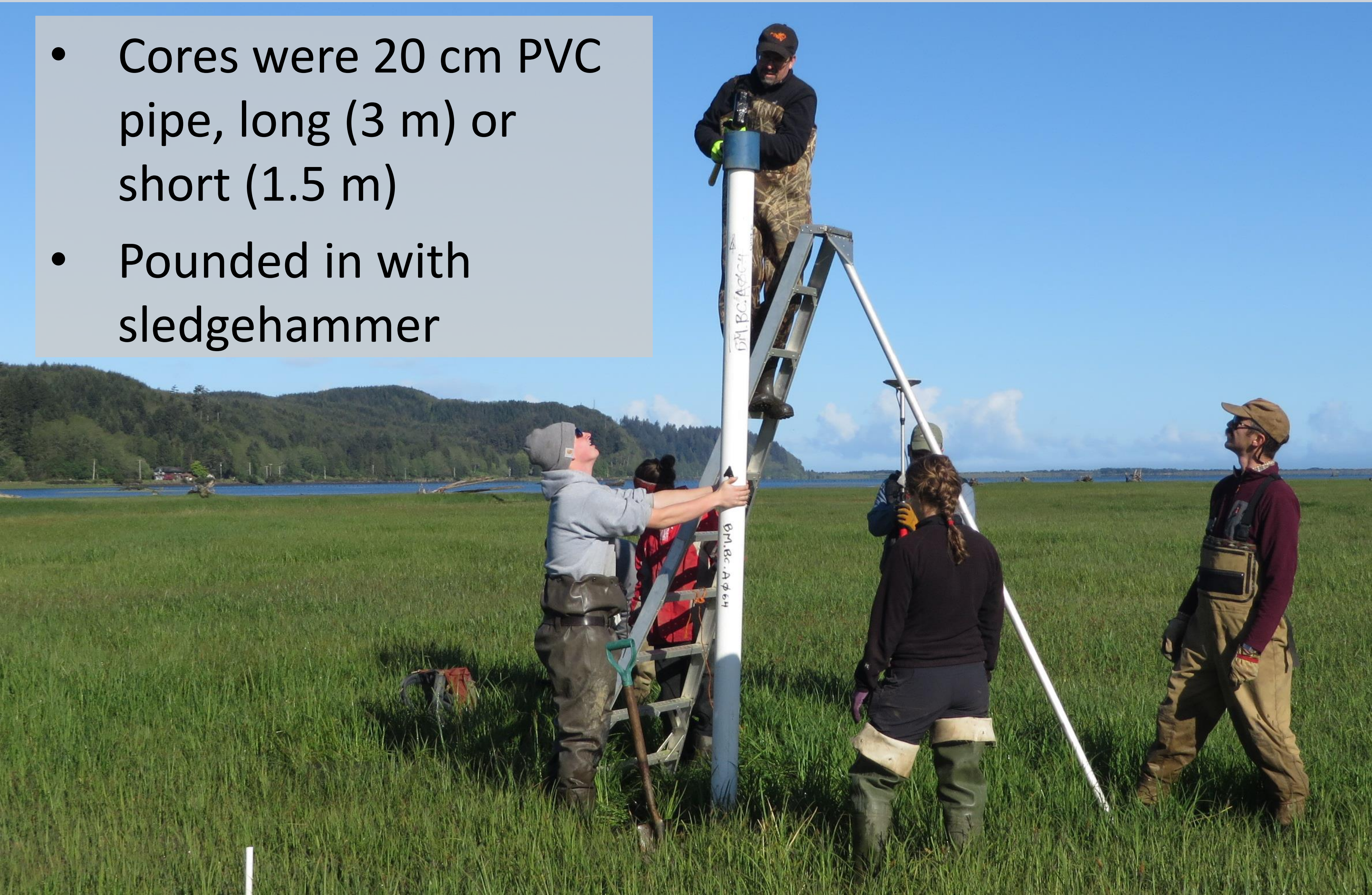
“Blue carbon” cores, SFC restoration site and Dry Stocking Island reference site, Tillamook Bay

Monitoring stations, SFC restoration site and Dry Stocking Island reference site, Tillamook Bay

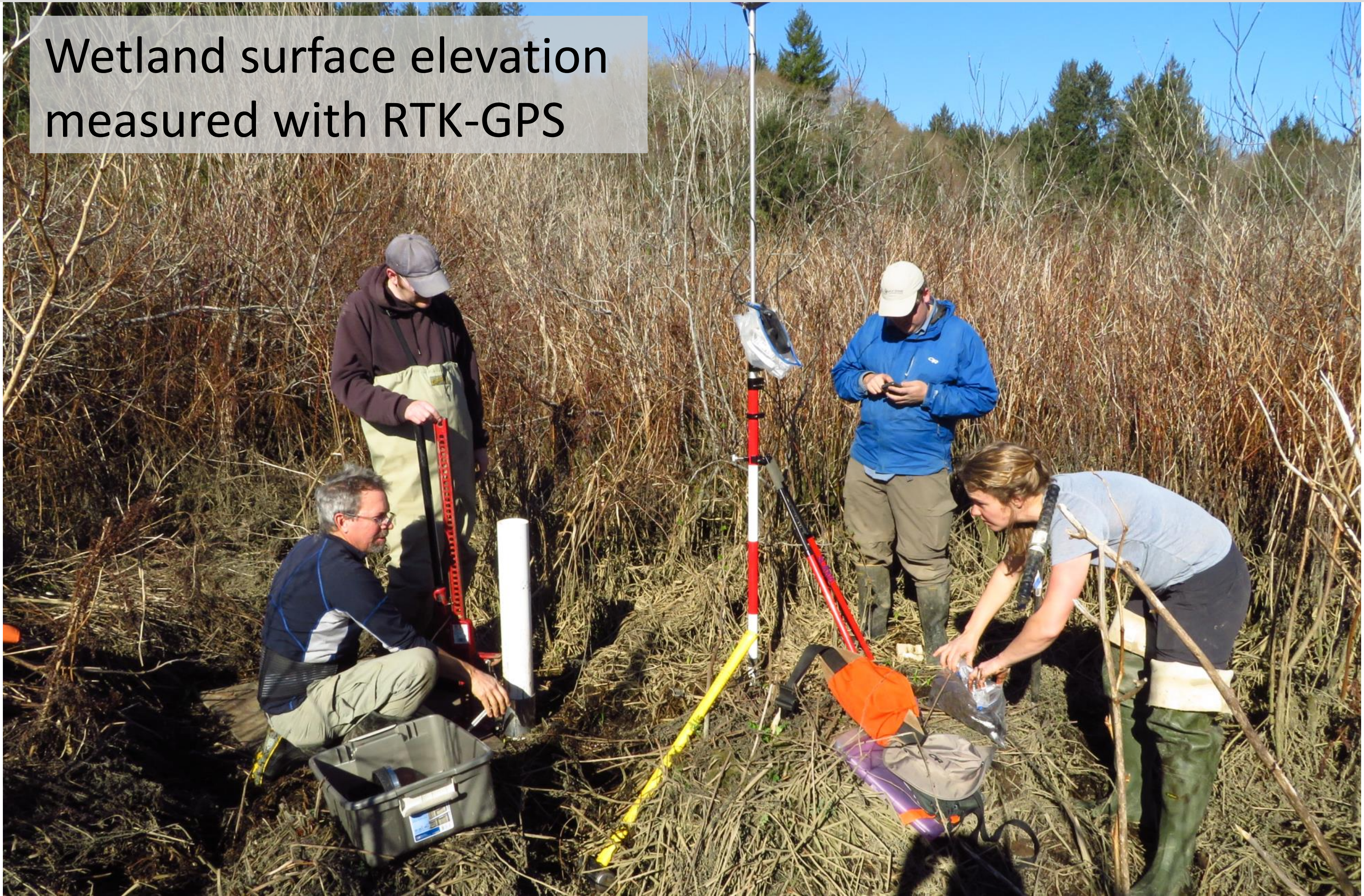


“Blue carbon” cores: Field methods

- Cores were 20 cm PVC pipe, long (3 m) or short (1.5 m)
- Pounded in with sledgehammer



“Blue carbon” cores: Field methods



“Blue carbon” cores: Field methods

Cores pulled with a truck jack

“Blue carbon” cores: Field methods

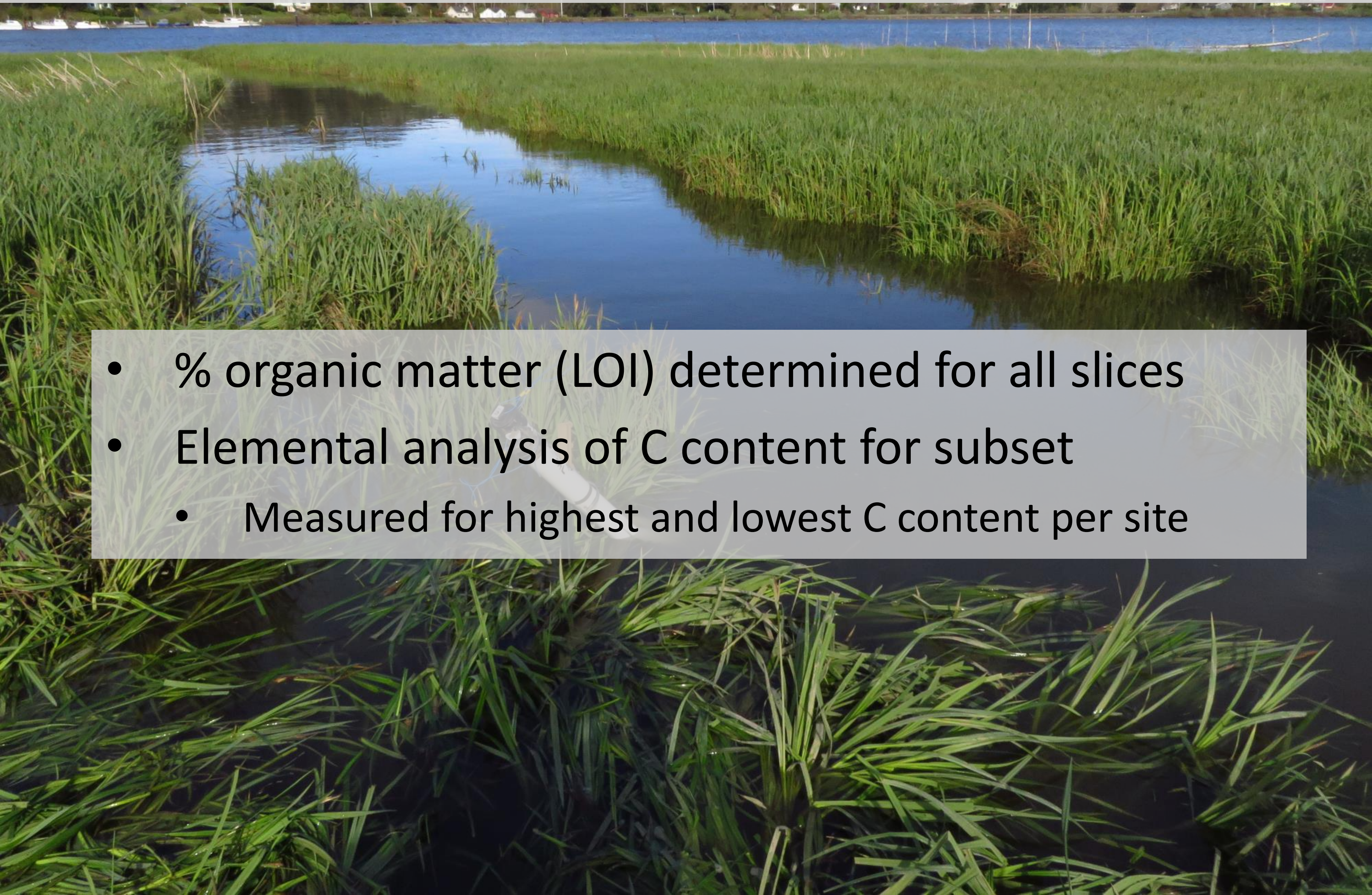
Cores (and associated equipment) carried to the car/boat

“Blue carbon” cores: Field methods

"Blue carbon" methods: Lab

- Computerized Tomography (CT) scans
- 2 cm slices freeze-dried 48 hr
- Bulk density determined volumetrically for top 50 cm (25 slices)
- Samples ground and subsamples extracted
- ^{210}Pb, ^{214}Pb, ^{137}Cs measured on gamma detectors
- Isotope profiles show the rate of sediment accumulation

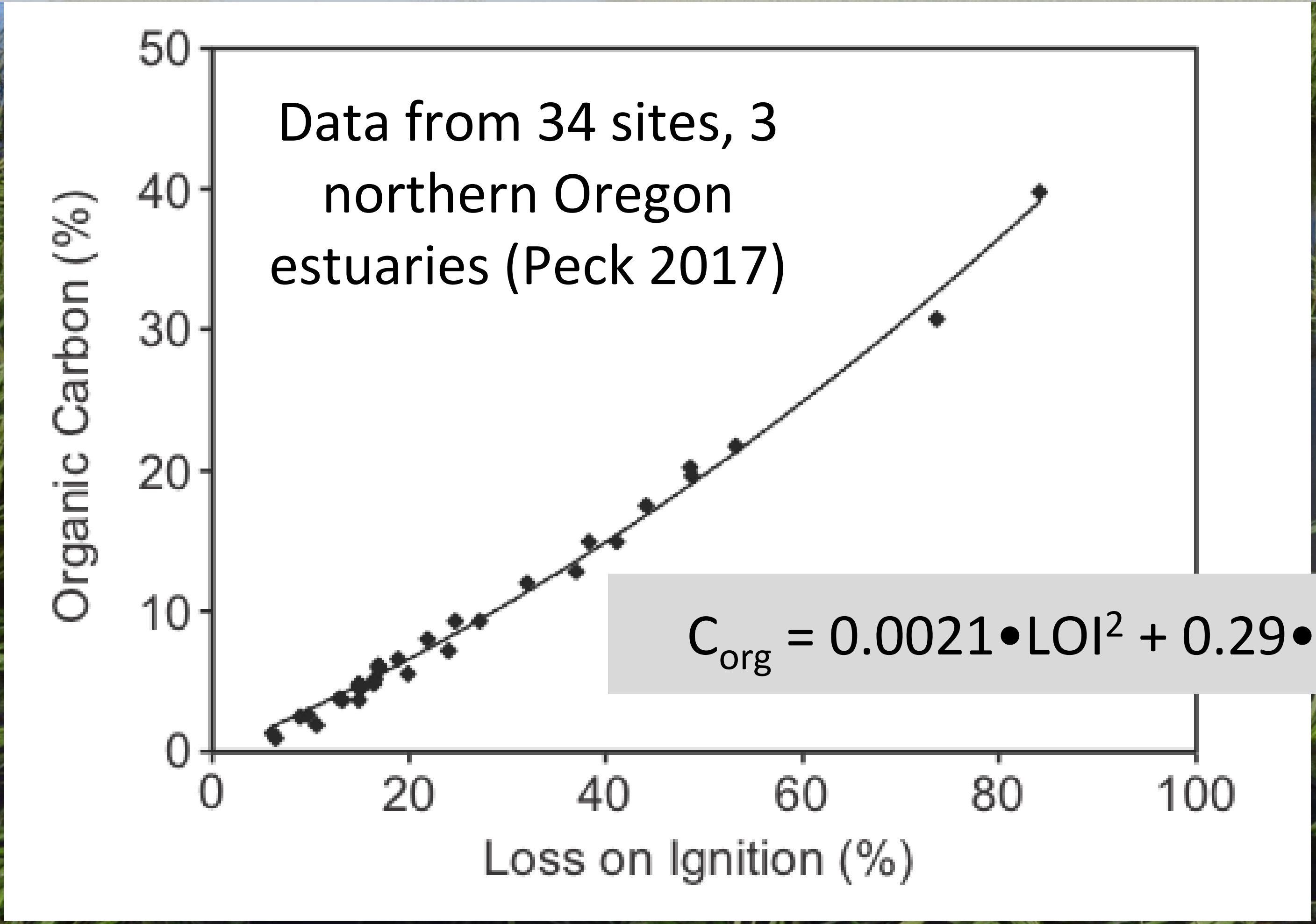
“Blue carbon” methods: Lab



- % organic matter (LOI) determined for all slices
- Elemental analysis of C content for subset
    - Measured for highest and lowest C content per site

"Blue carbon" methods: Lab

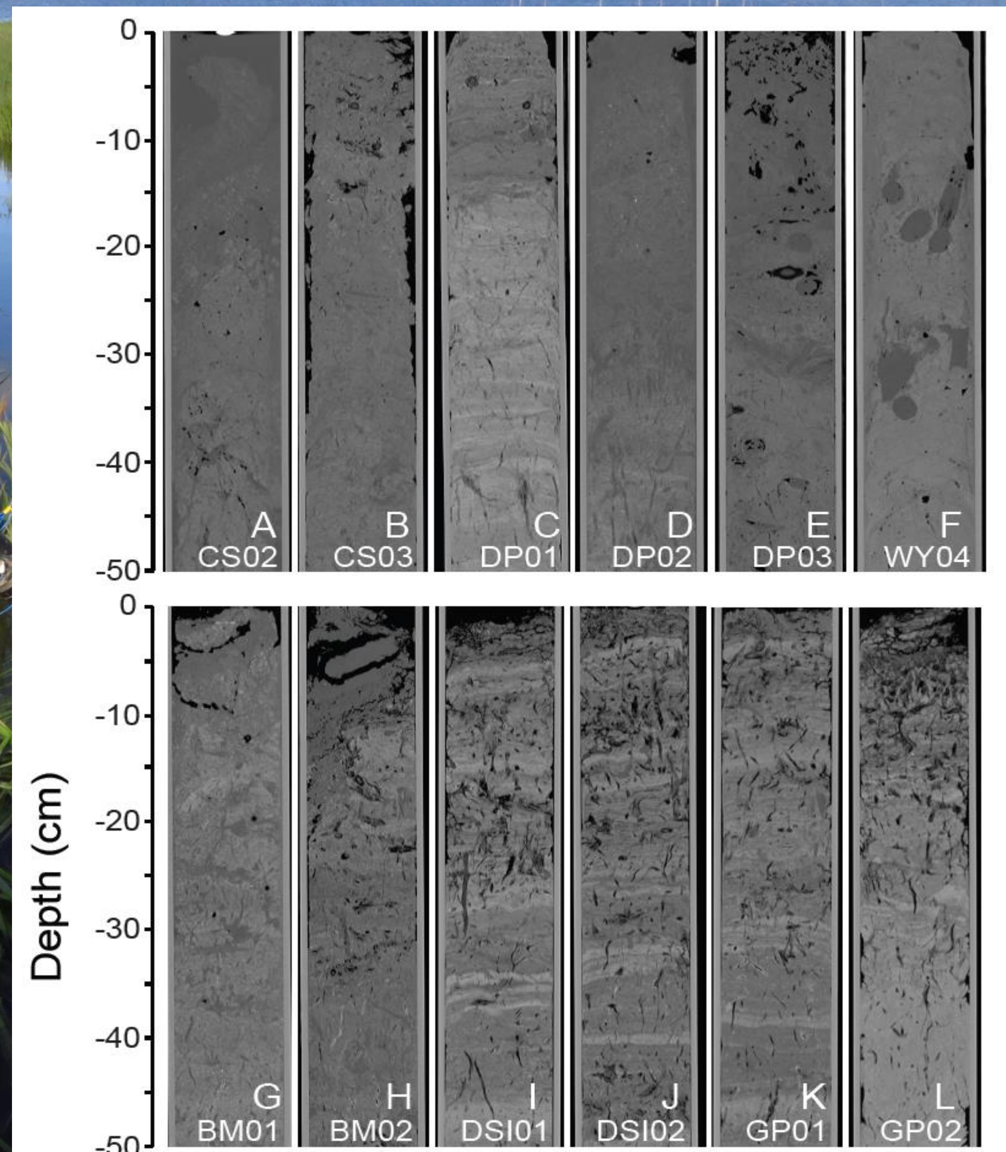
Carbon content determined using relationship between LOI and C content from elemental analysis



$$C_{org} = 0.0021 \bullet LOI^2 + 0.29 \bullet LOI$$

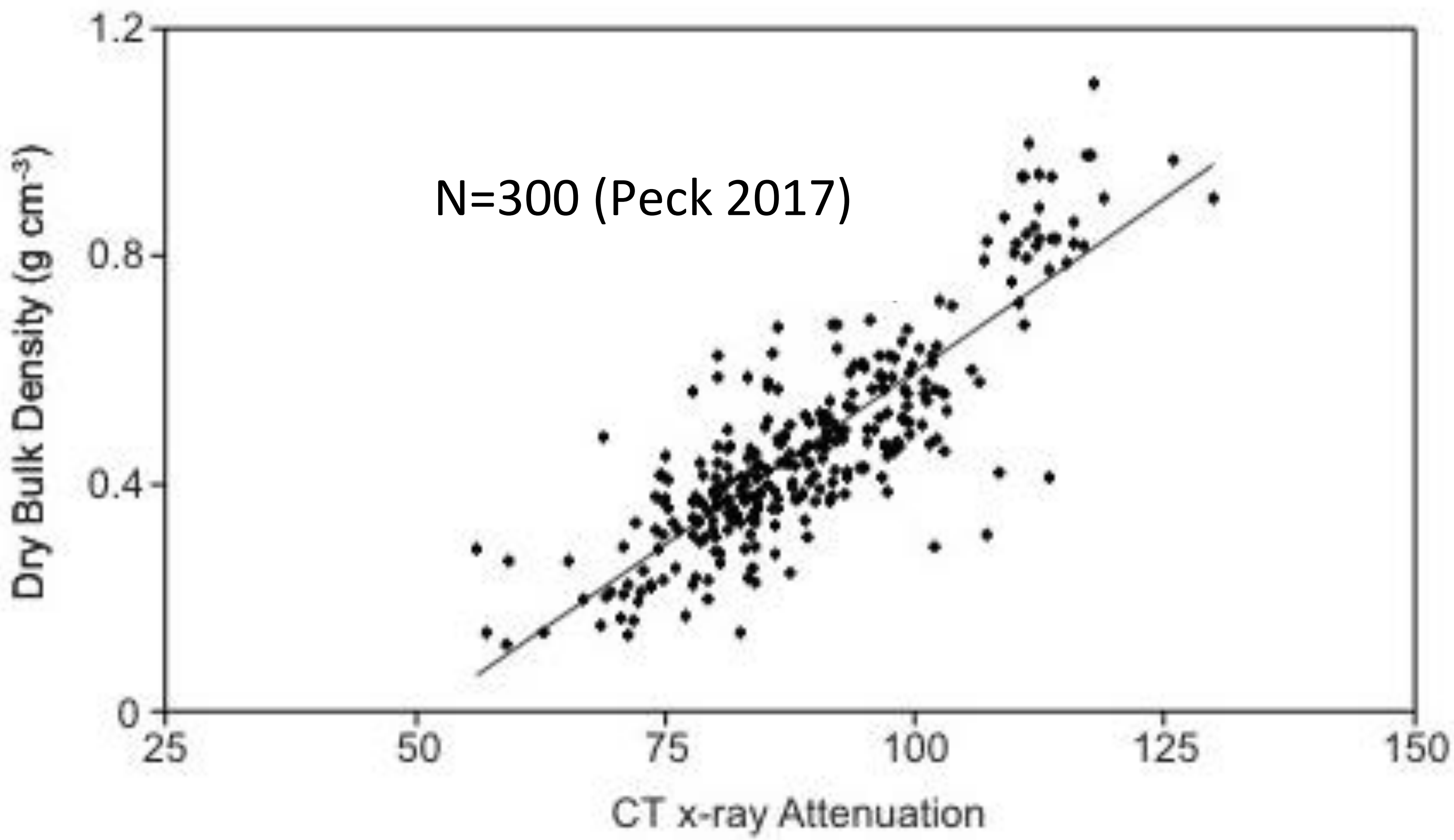
“Blue carbon” methods: Lab

Image processing to obtain grayscale data and remove large roots

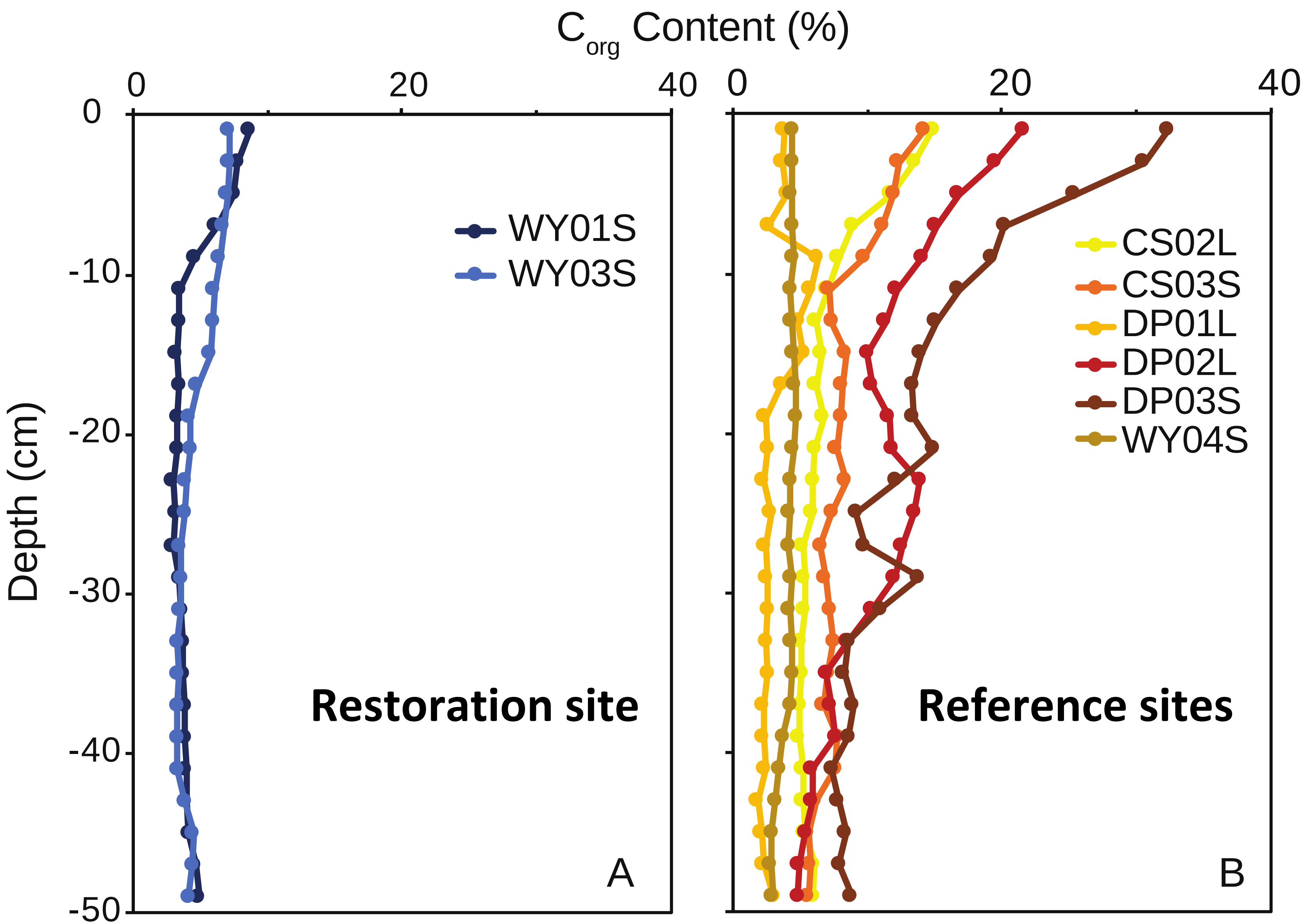


“Blue carbon” methods: Data analysis

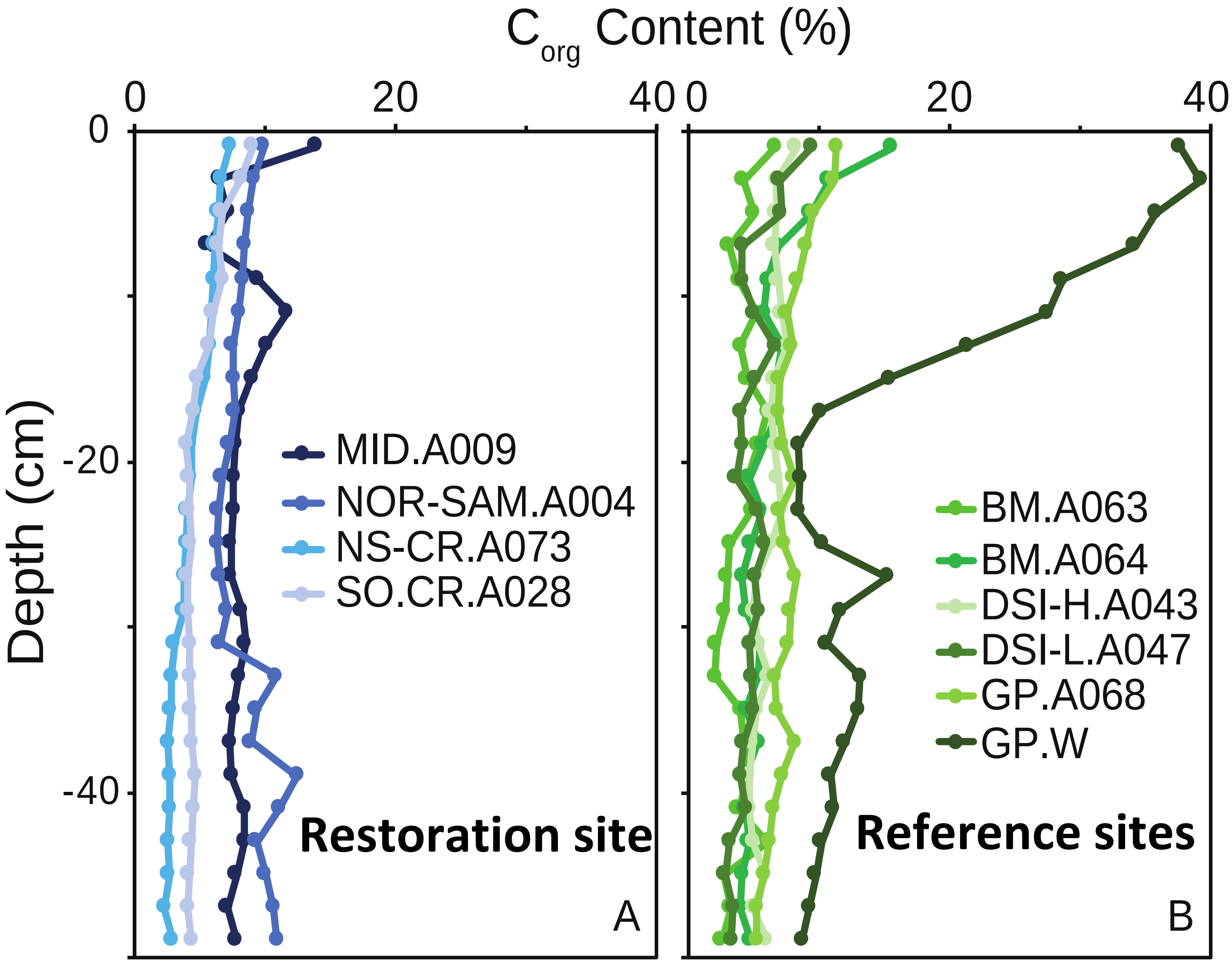
Bulk density for each slice was determined using the CT scan grayscale data (based on relationship for top 25 slices at reference sites)



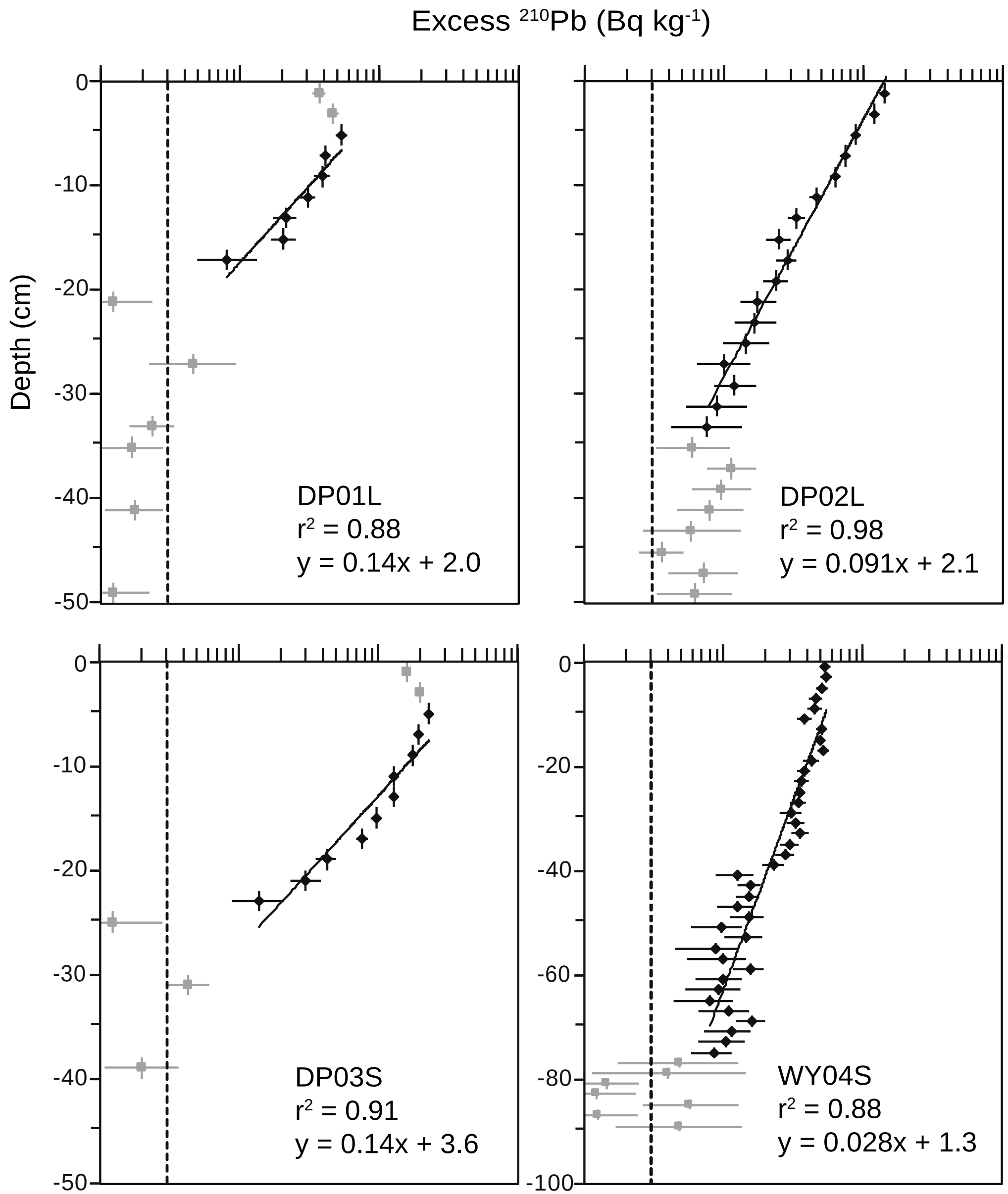
Carbon profiles – Youngs Bay



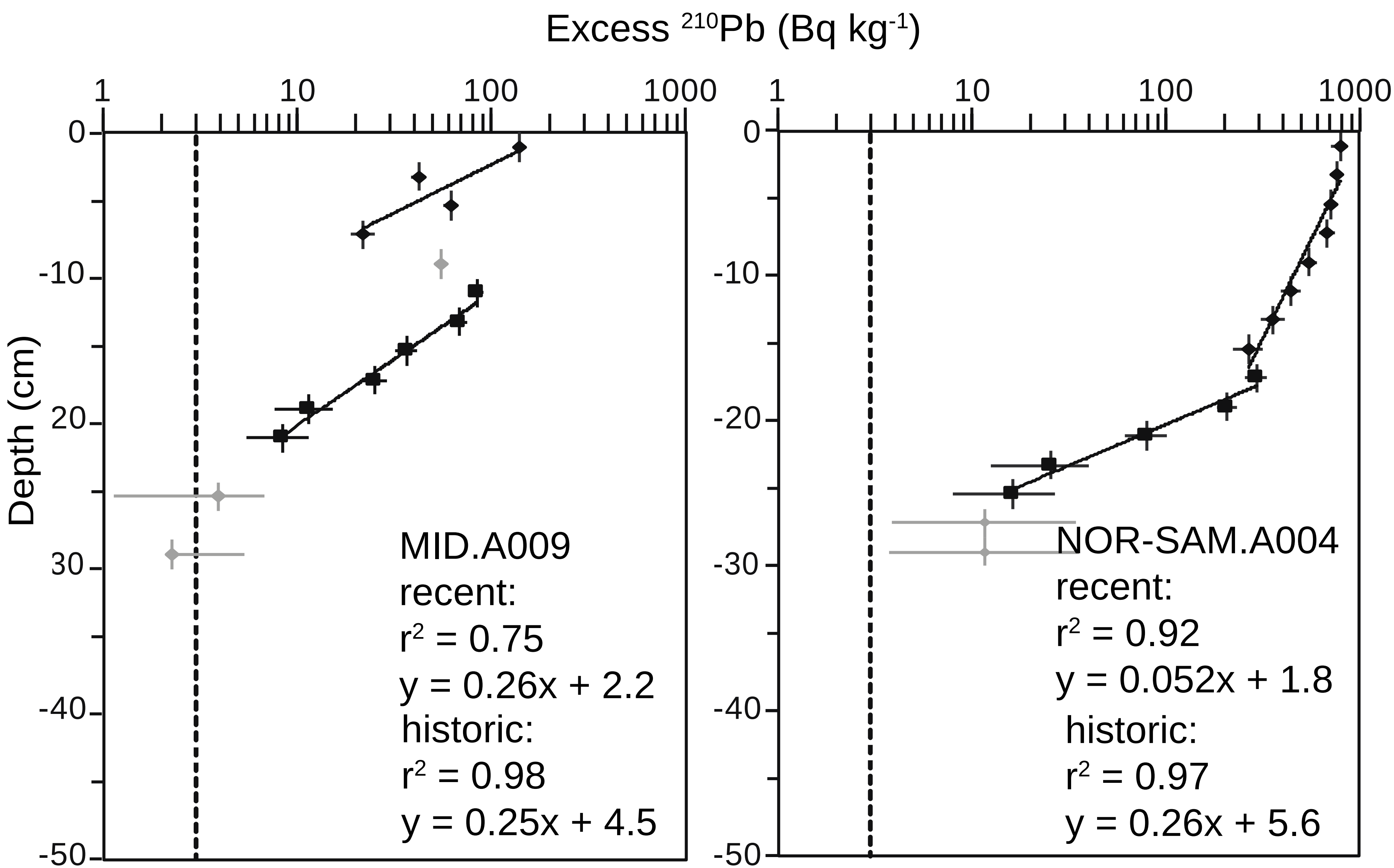
Carbon profiles – Tillamook Bay



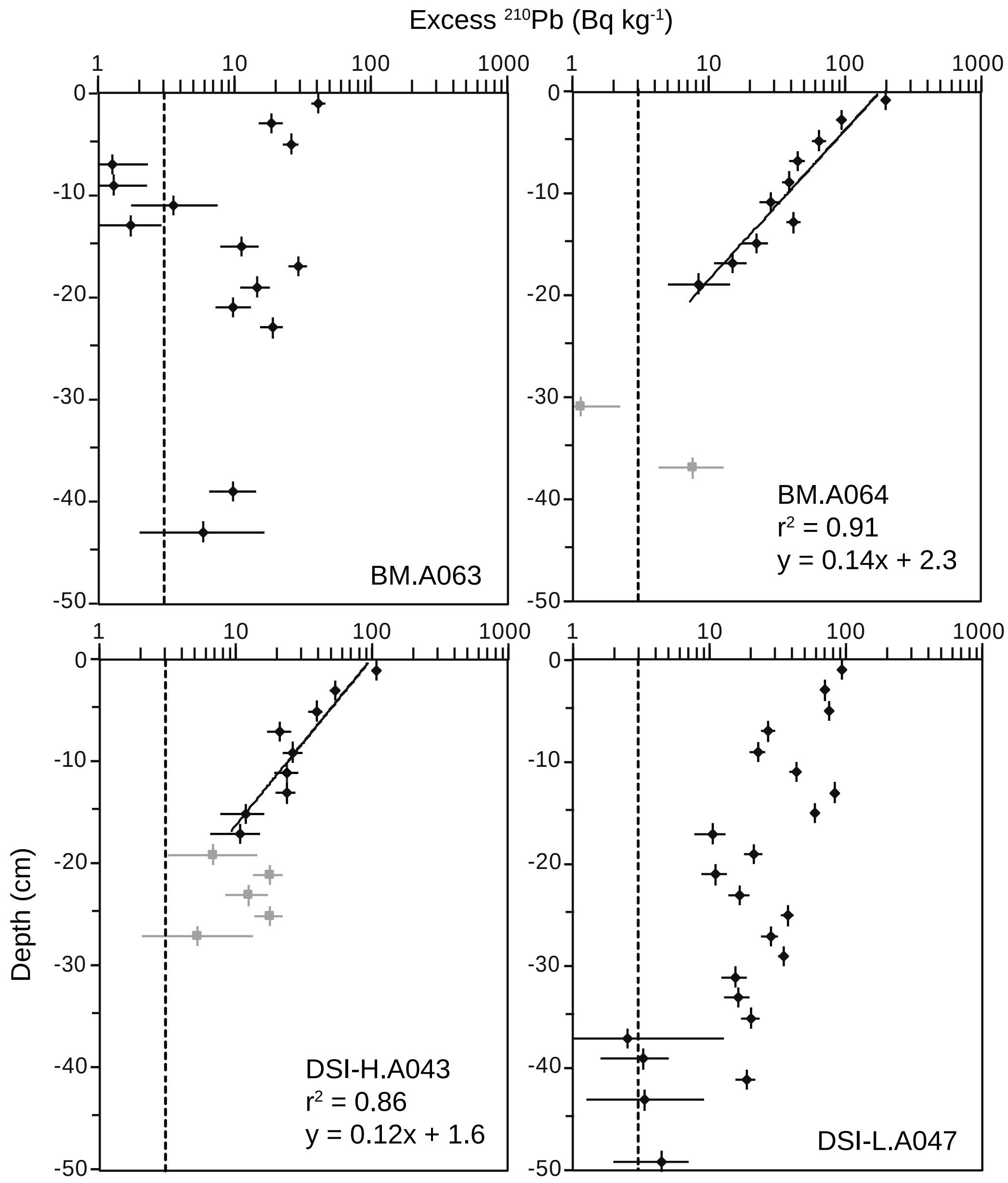
Radioisotope profiles – Youngs Bay reference sites (examples)



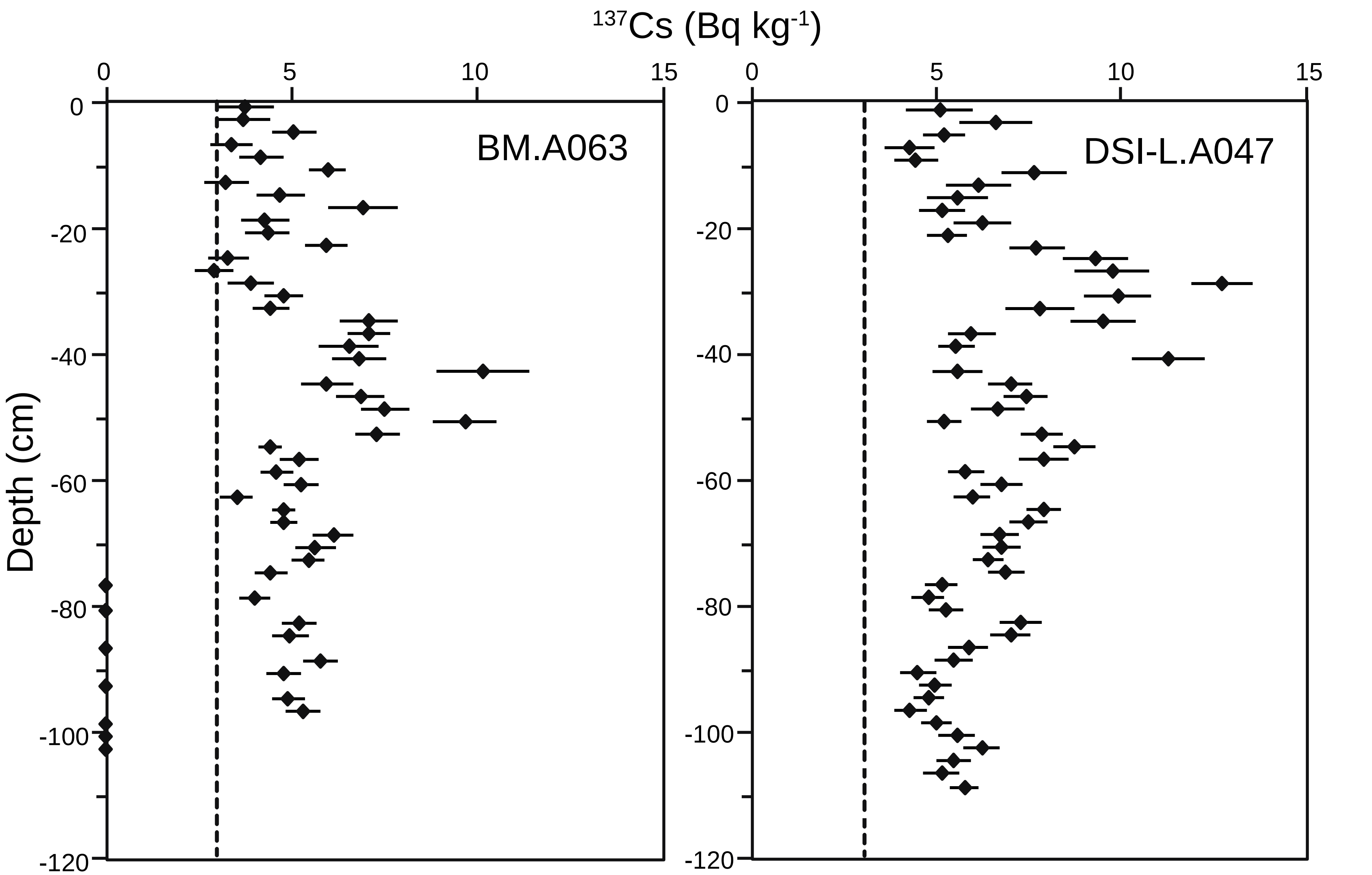
Radioisotope profiles – Tillamook SFC restoration site



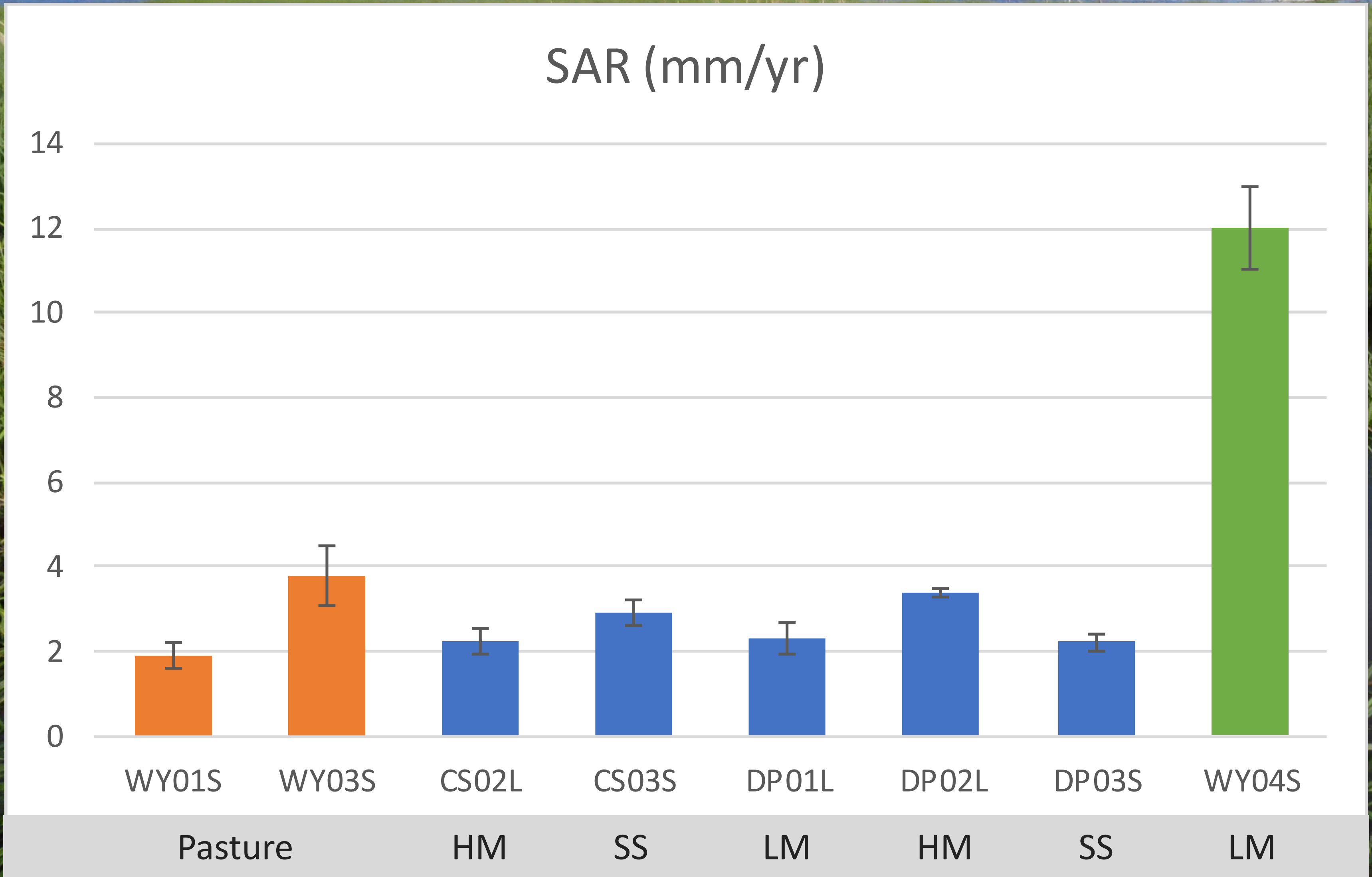
Radioisotope profiles – Tillamook Bay reference sites (examples)



Radioisotope profiles – Tillamook Bay reference sites (examples)

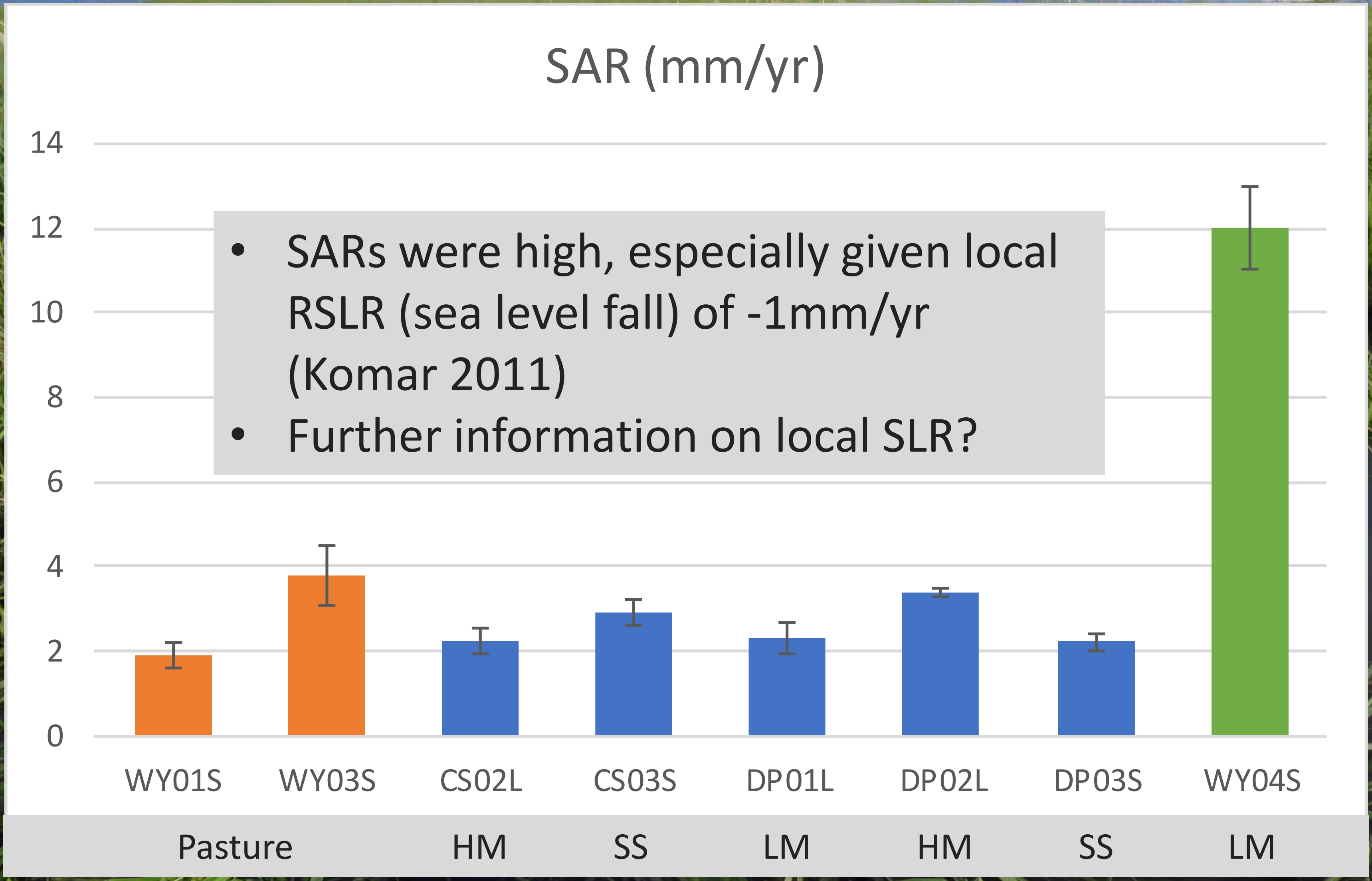


Sediment accretion rates (carbon cores): Youngs Bay

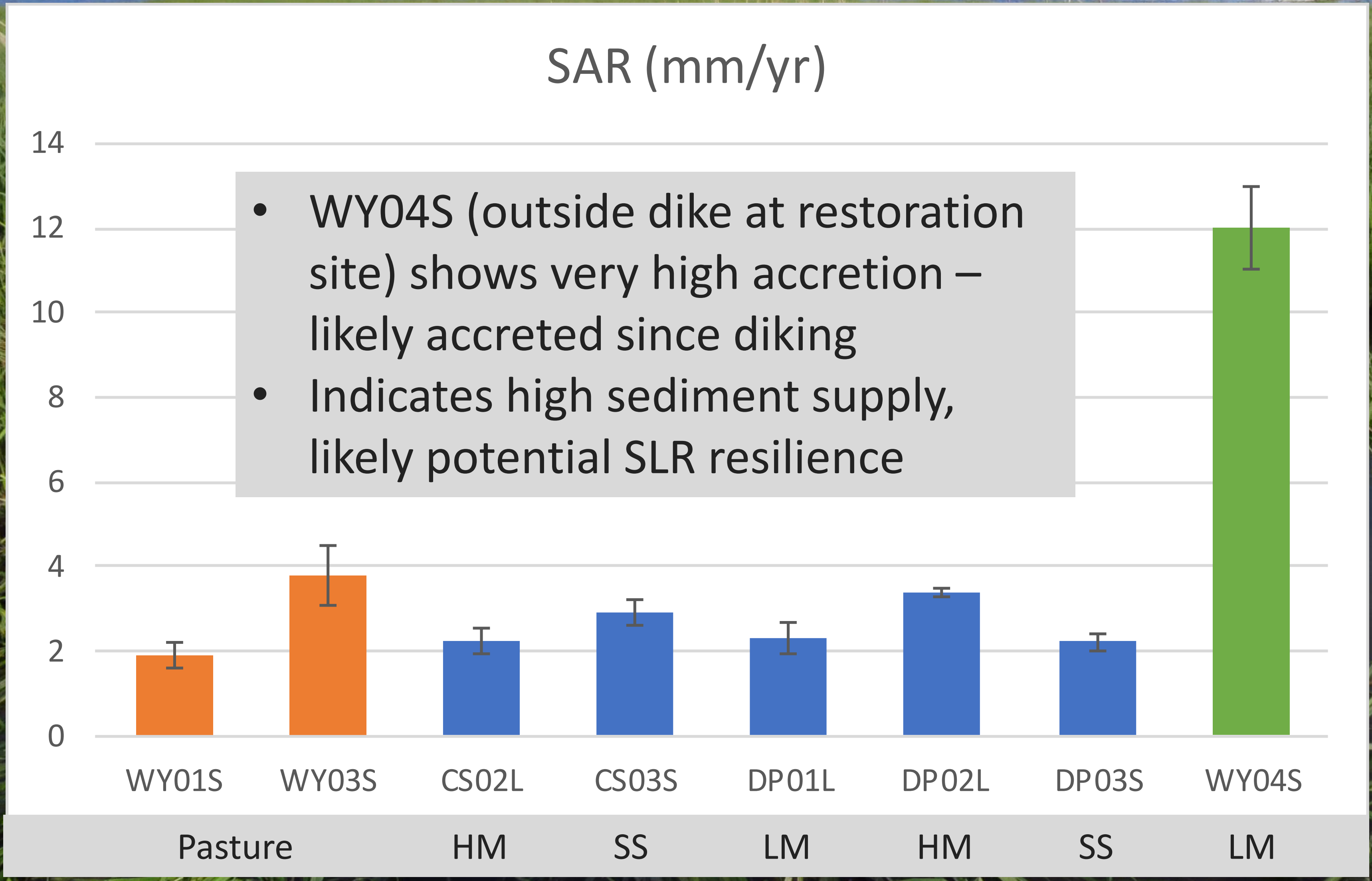


Sediment accretion rates (carbon cores): Youngs Bay

- SARs were high, especially given local RSLR (sea level fall) of -1mm/yr (Komar 2011)
- Further information on local SLR?

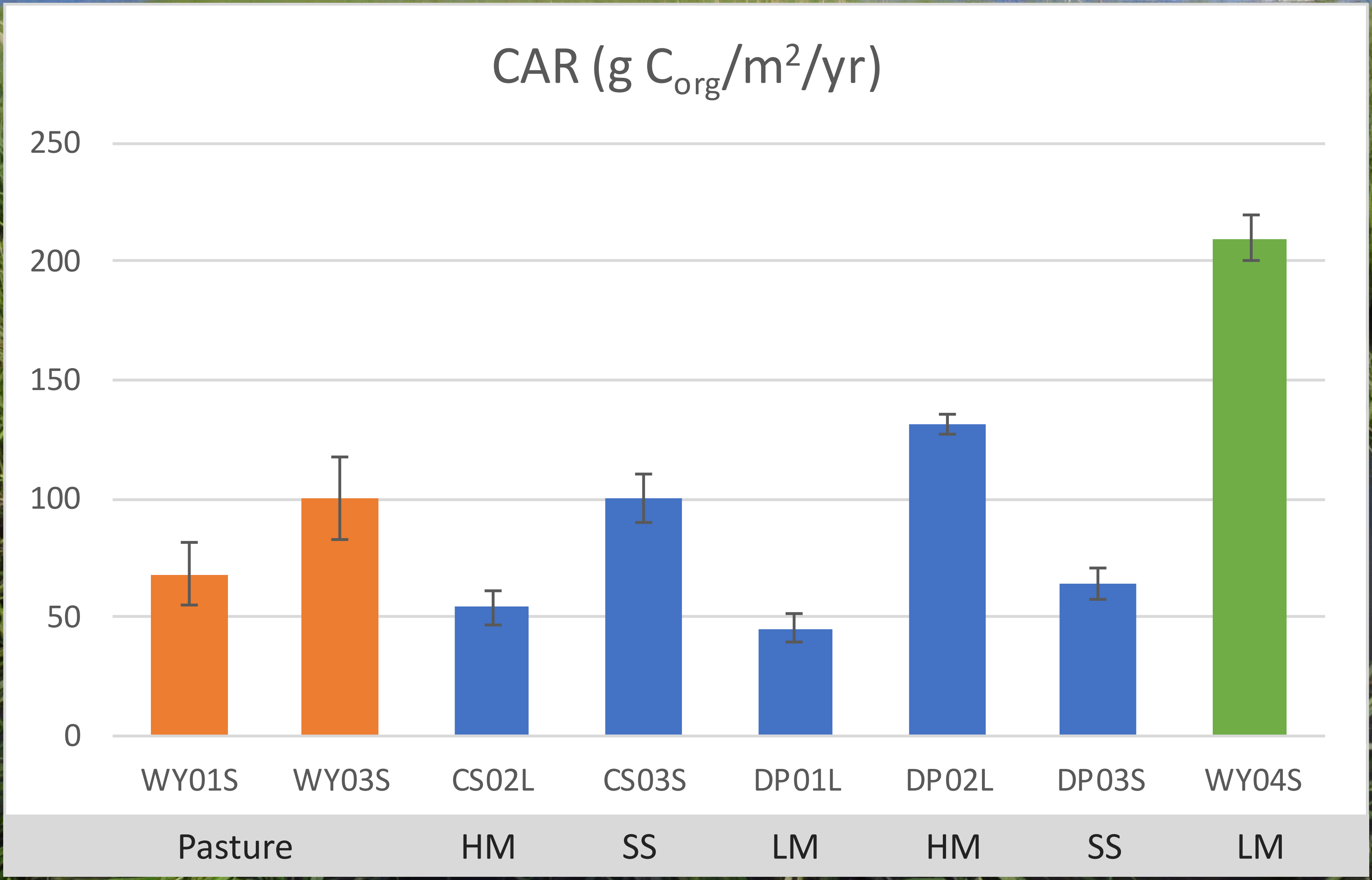


Sediment accretion rates (carbon cores): Youngs Bay



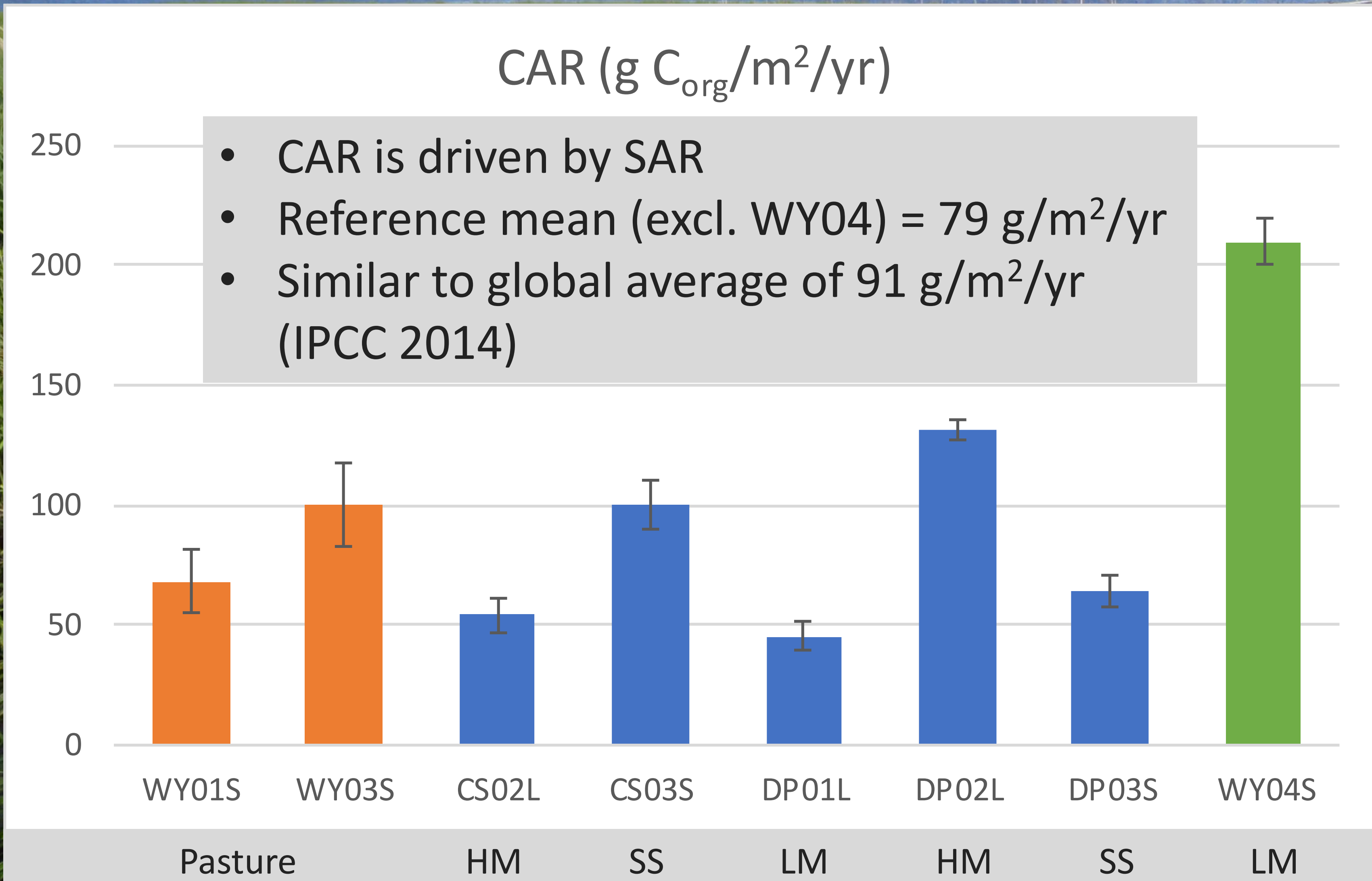
- WY04S (outside dike at restoration site) shows very high accretion – likely accreted since diking
- Indicates high sediment supply, likely potential SLR resilience

Carbon accumulation rates: Youngs Bay

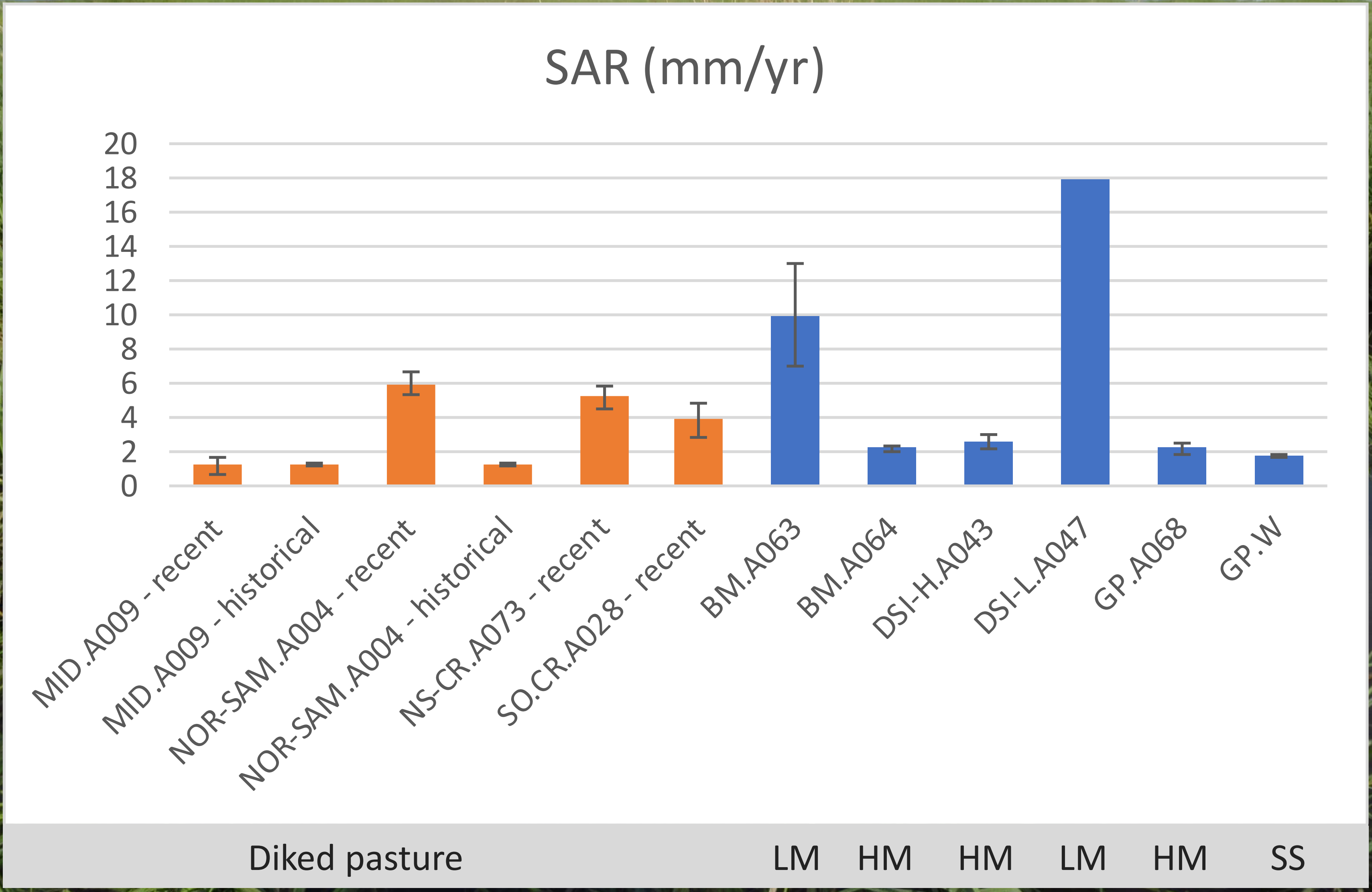


Carbon accumulation rates: Youngs Bay

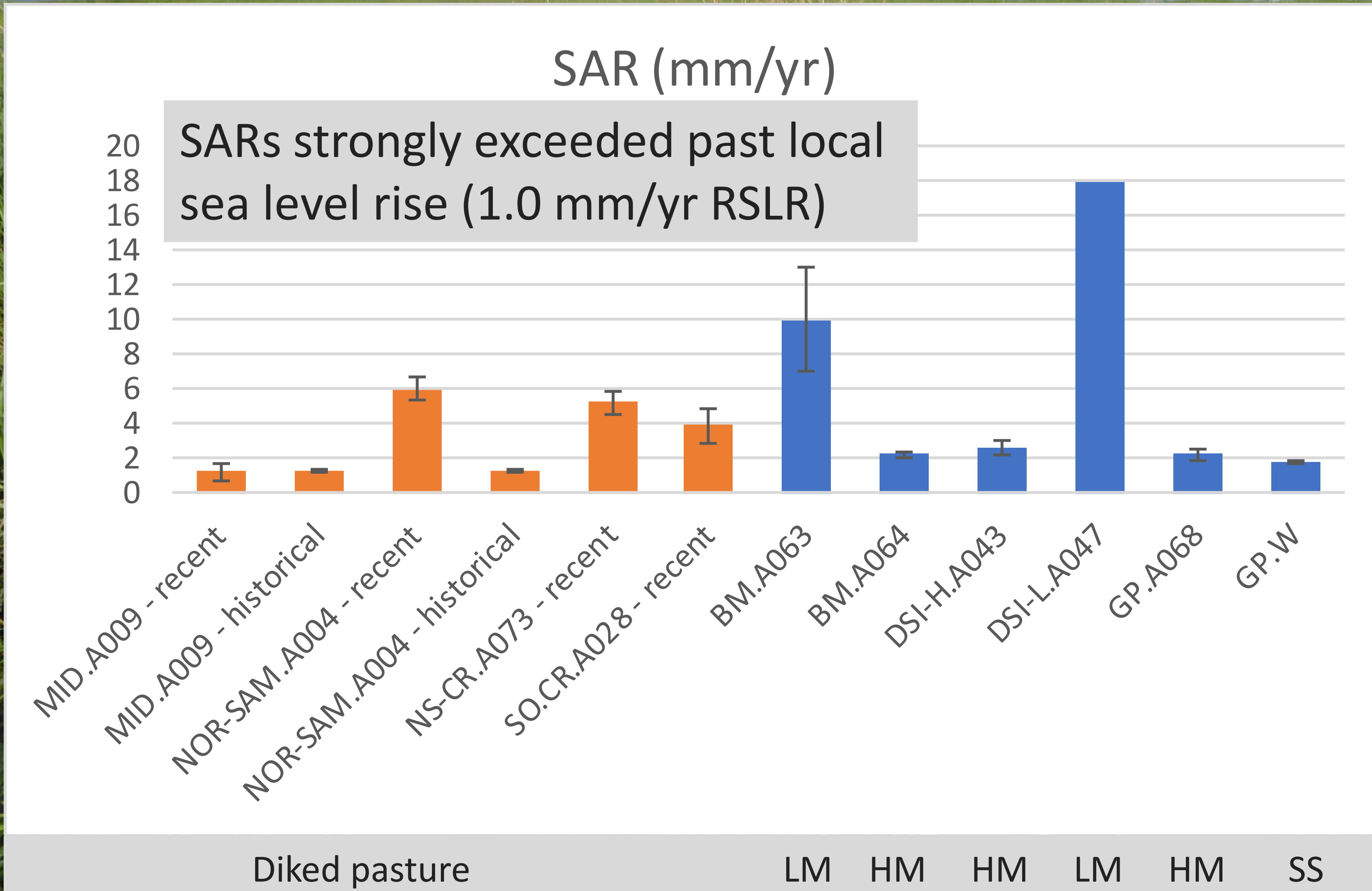
- CAR is driven by SAR
- Reference mean (excl. WY04) = 79 $g/m^2/yr$
- Similar to global average of 91 $g/m^2/yr$ (IPCC 2014)



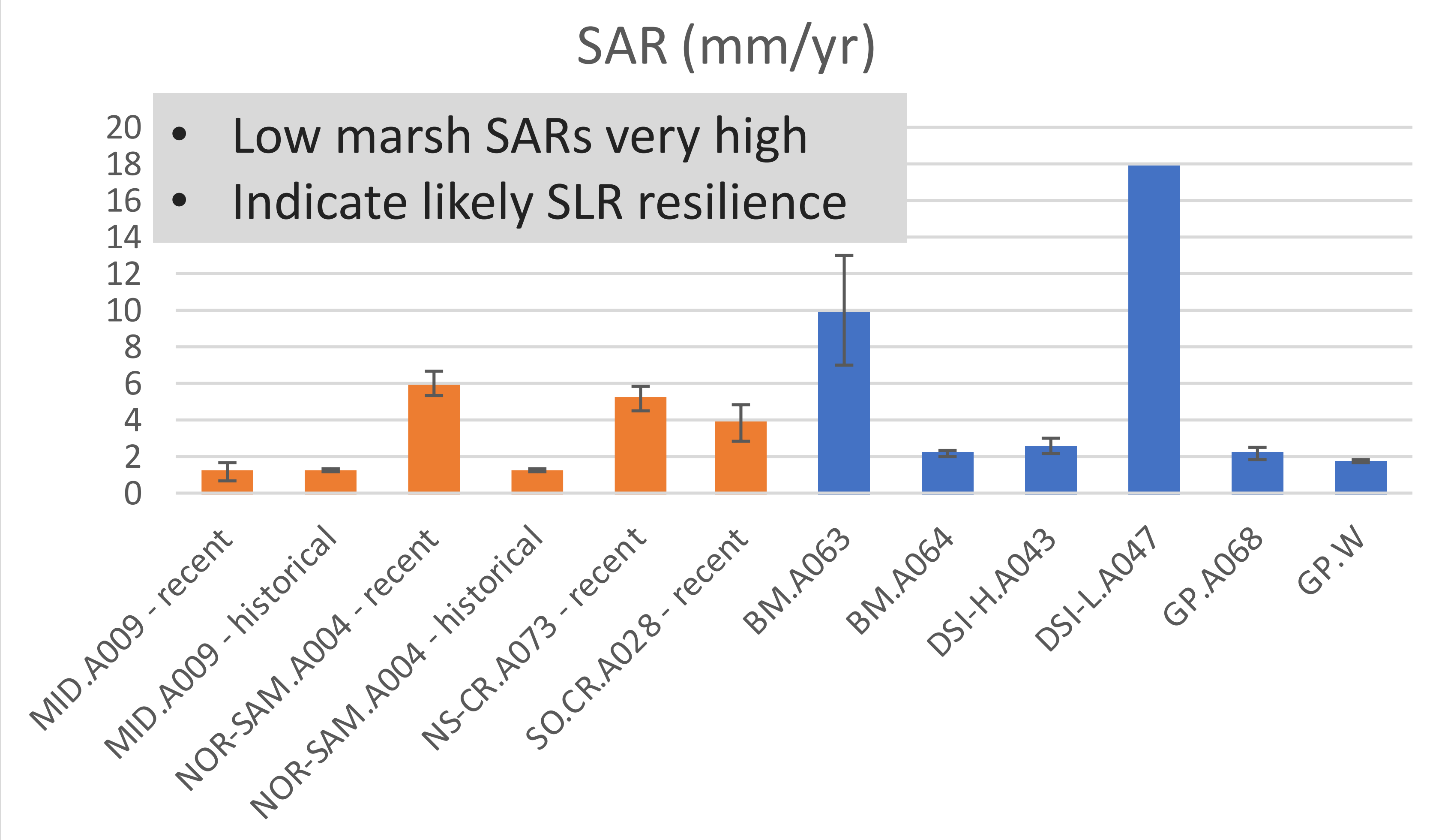
Sediment accretion rates (carbon cores): Tillamook



Sediment accretion rates (carbon cores): Tillamook



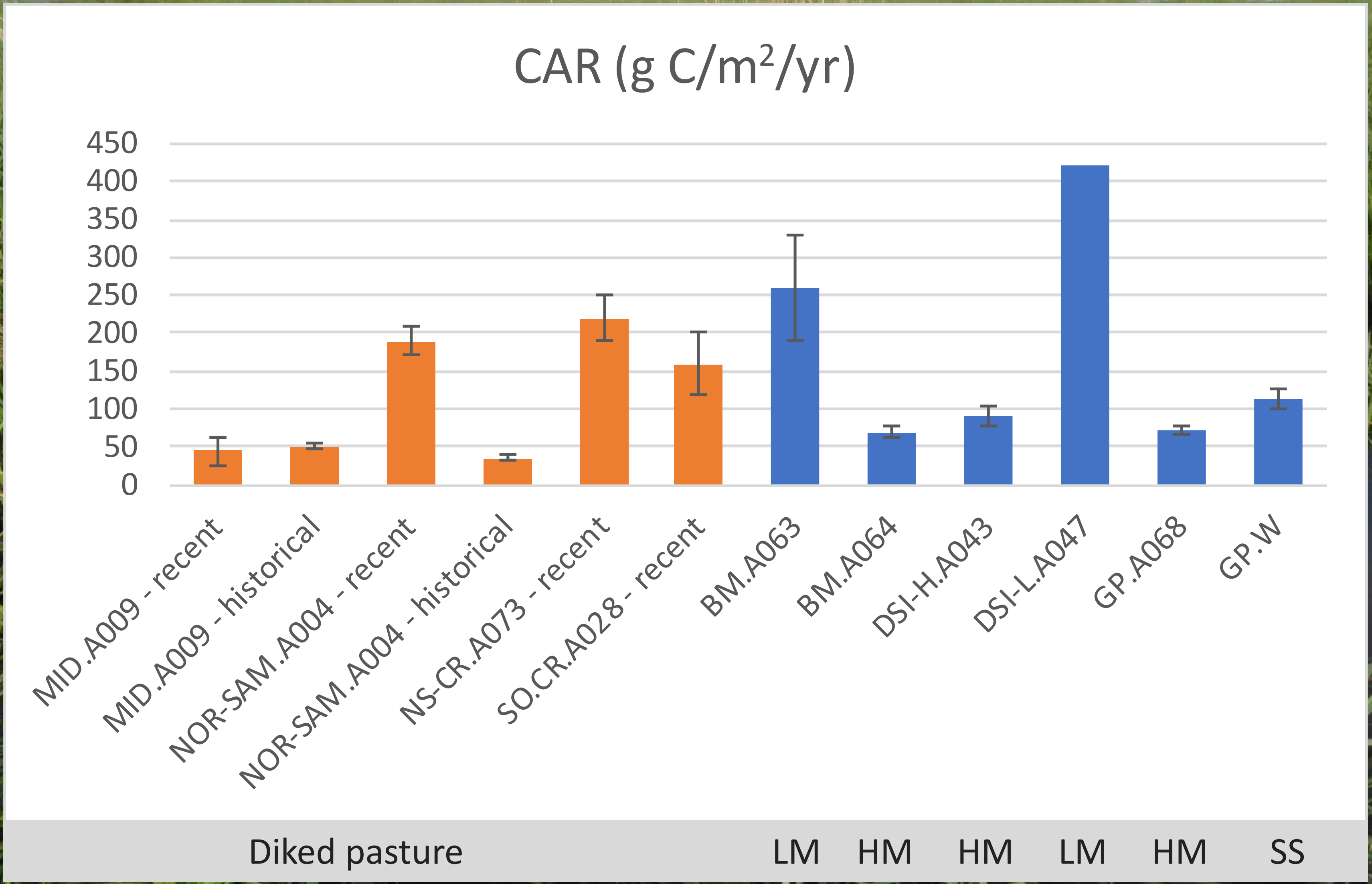
Sediment accretion rates (carbon cores): Tillamook



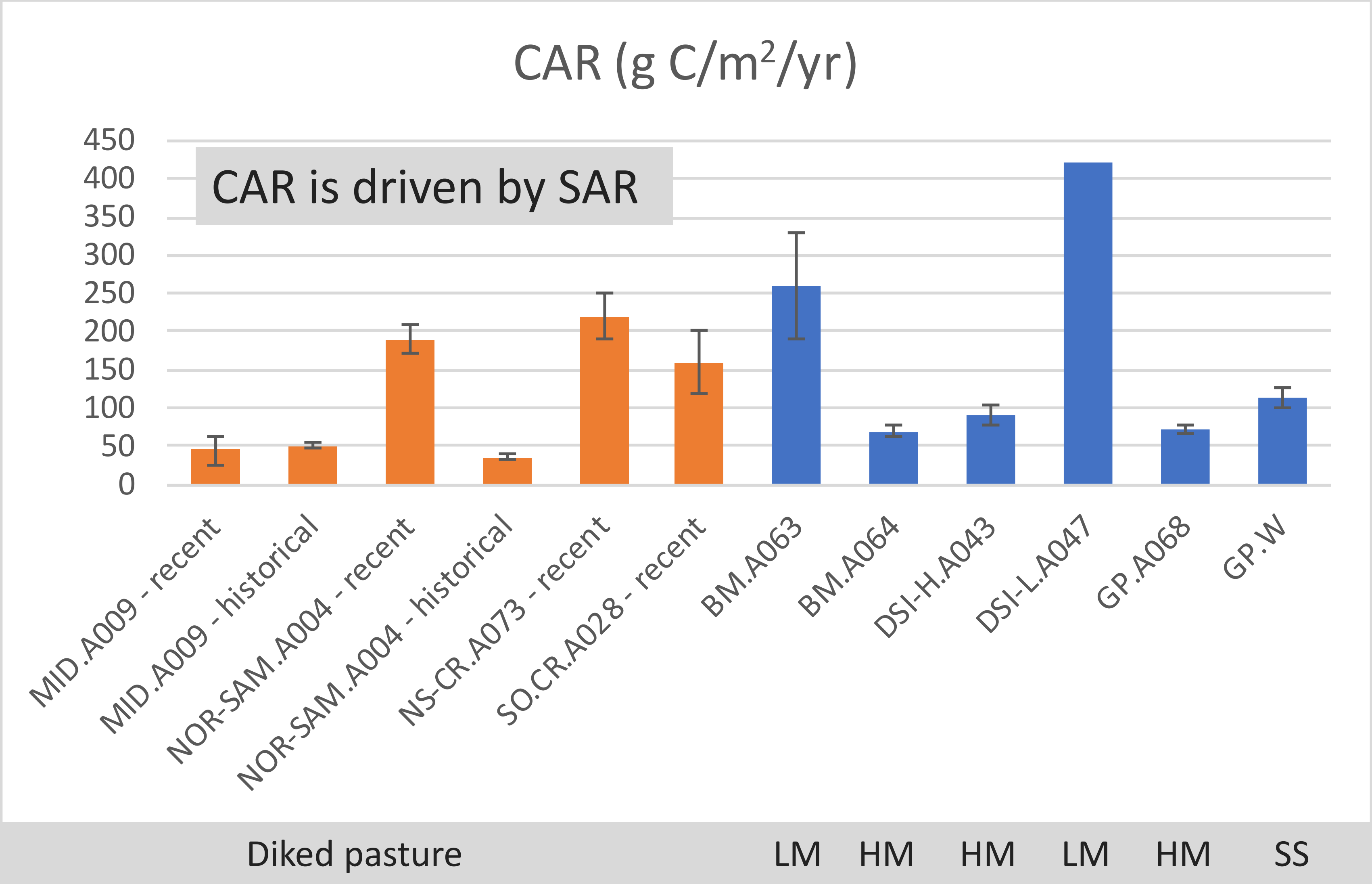
- Low marsh SARs very high
- Indicate likely SLR resilience

Diked pasture LM HM HM LM HM SS

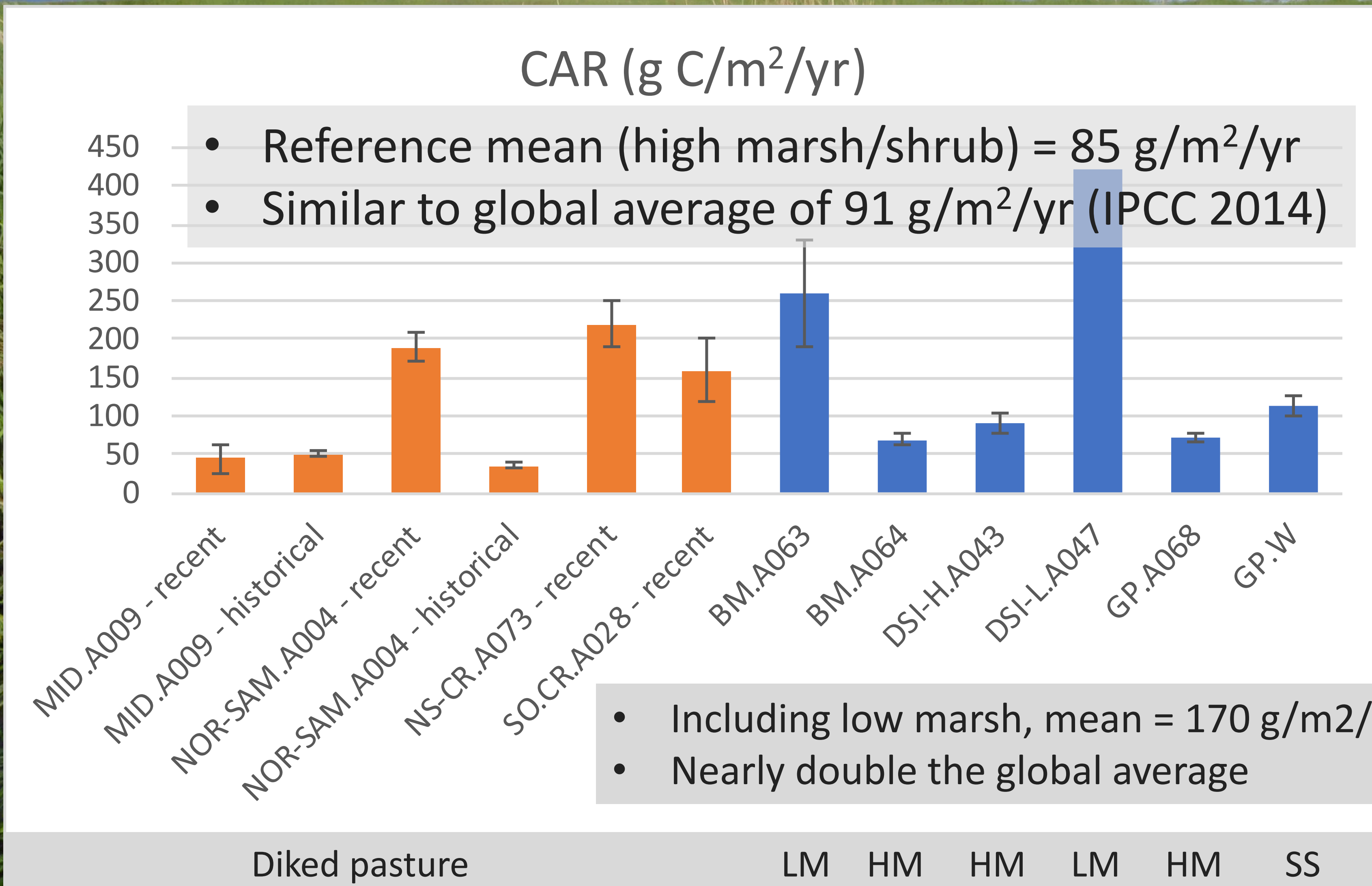
Carbon accumulation rates: Tillamook



Carbon accumulation rates: Tillamook



Carbon accumulation rates: Tillamook



- Reference mean (high marsh/shrub) = 85 g/m²/yr
- Similar to global average of 91 g/m²/yr (IPCC 2014)

- Including low marsh, mean = 170 g/m2/yr
- Nearly double the global average

Estimates of carbon losses and potential storage

- Determined using elevations of adjacent reference site vs. restoration site (from RTK-GPS), plus carbon density data
- Typical subsidence determined by site (Wallooskee) or zone (Southern Flow Corridor)
- Assumption: site will equilibrate to reference elevation
- Past carbon loss = potential future carbon storage

Carbon storage potential: Wallooskee-Youngs restoration site

Across ~71 ha site:

- Potential to store 490 t/ha carbon (34,000 tons total)
- Equivalent to 27,000 cars driven for 1 yr

Carbon storage potential: Southern Flow Corridor restoration site

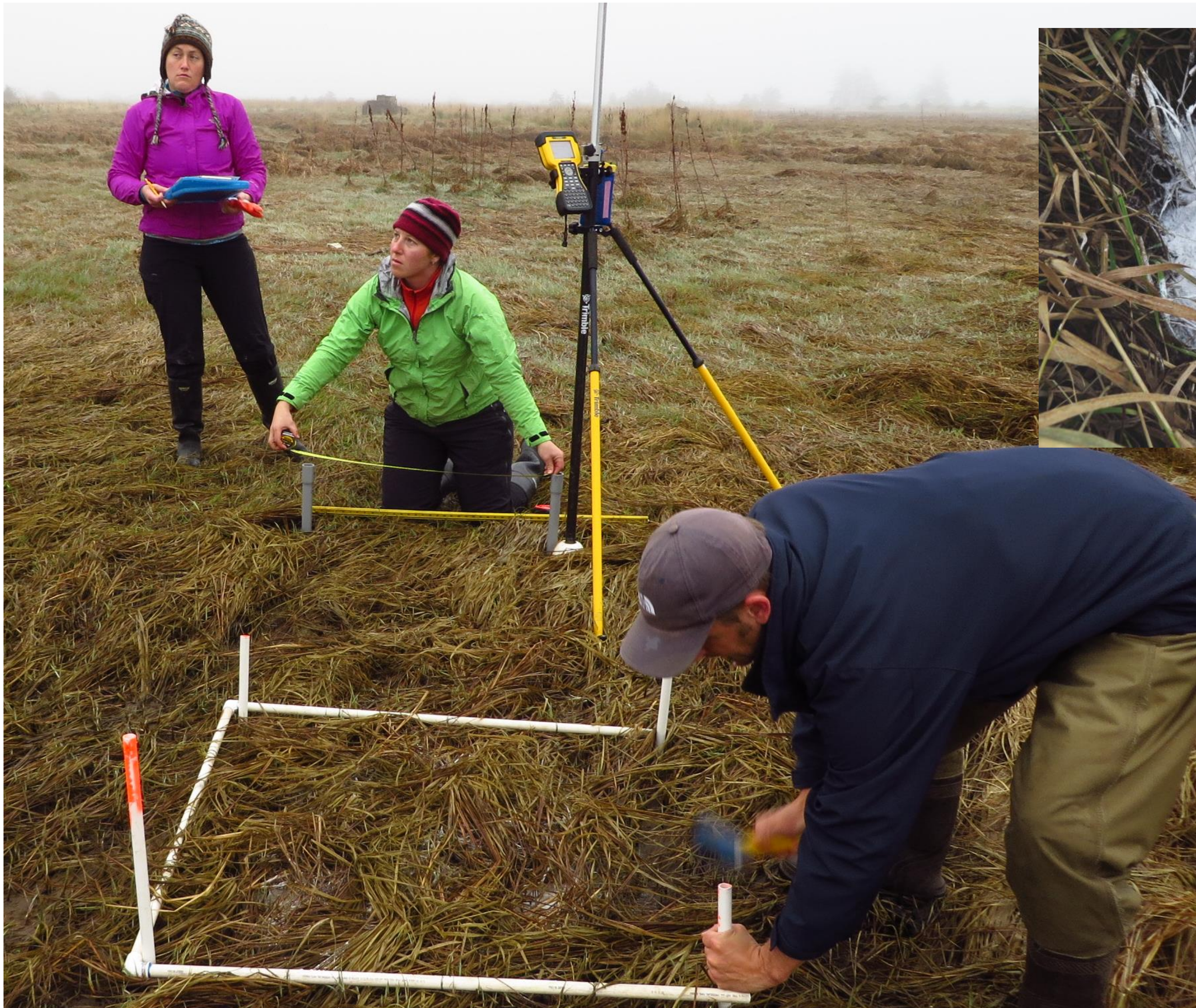
Across ~139 ha study area:

- Potential to store 200 t/ha carbon (27,000 tons total)
- Equivalent to 21,000 cars driven for 1 yr

Short-term sediment accretion -- feldspar plots (Tillamook Bay only)

- Pre- vs. post-restoration accretion comparison possible
- Higher spatial resolution (37 plots in Tillamook Bay)
- More likely to be event-driven
- Doesn’t account for gravitational compaction

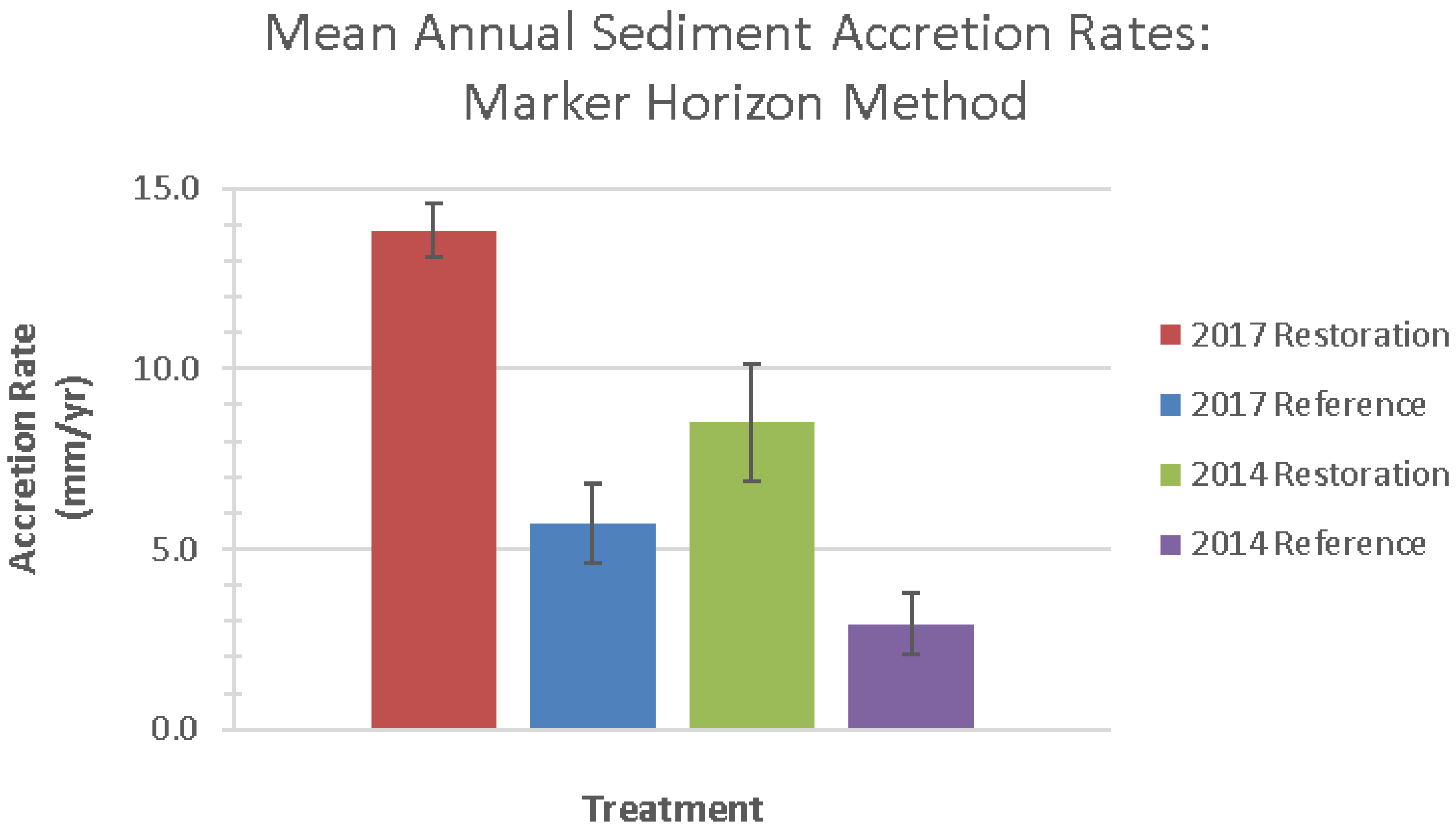
Short-term sediment accretion -- feldspar plots: Field methods (Tillamook Bay only)



Short-term sediment accretion -- feldspar plots: Field methods

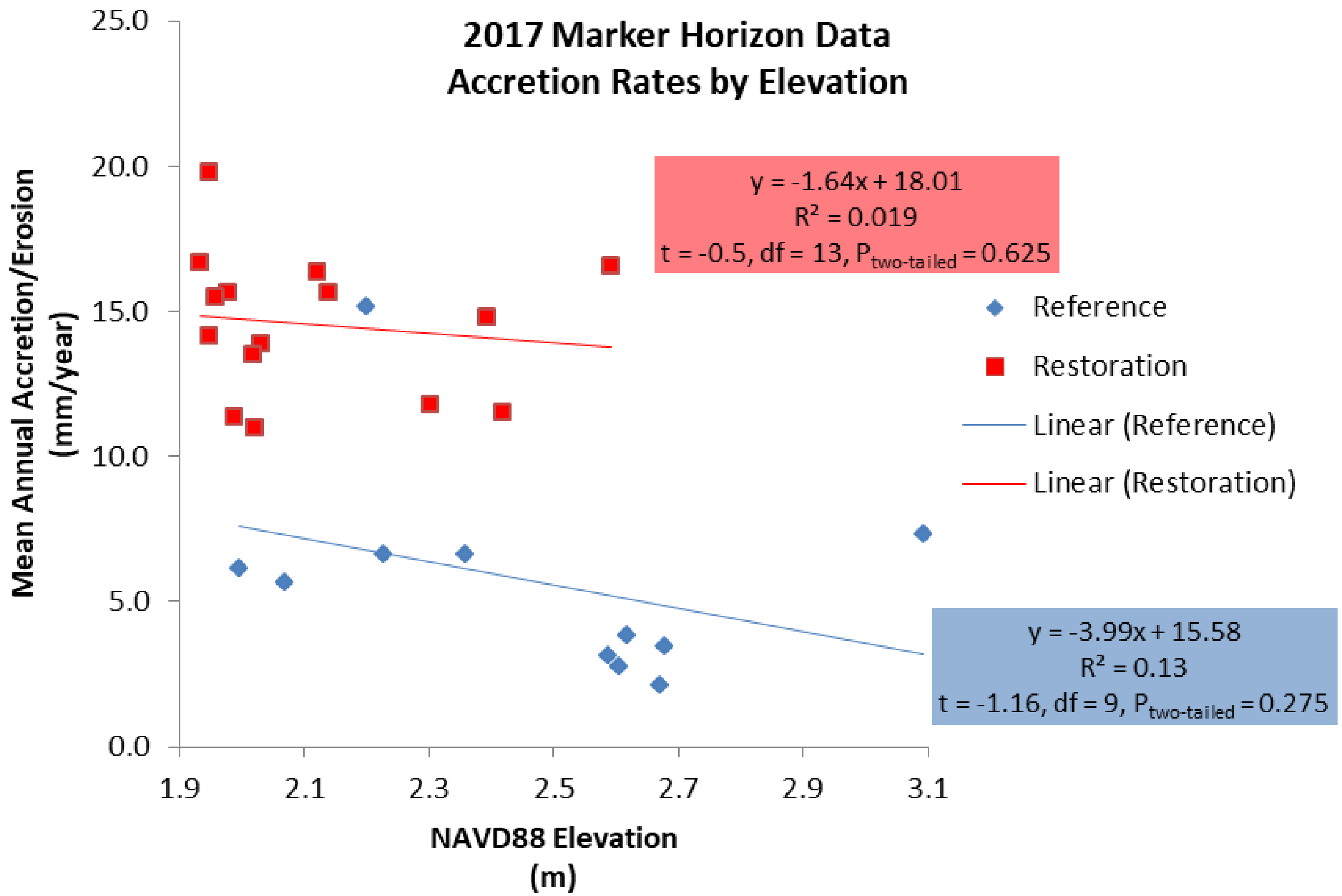
Short-term sediment accretion -- feldspar plots: Field methods

Short-term sediment accretion -- feldspar plots: Results, Tillamook Bay



- Accretion at restoration site was higher in 2017 vs. 2014 ($t=3.3$, $df = 33$, $p = 0.002$)
- Accretion at reference sites did not differ significantly between 2014 and 2017 ($t=2.01$, $df = 18$, $p=0.06$)

Sediment accretion -- feldspar plots: Results Tillamook Bay

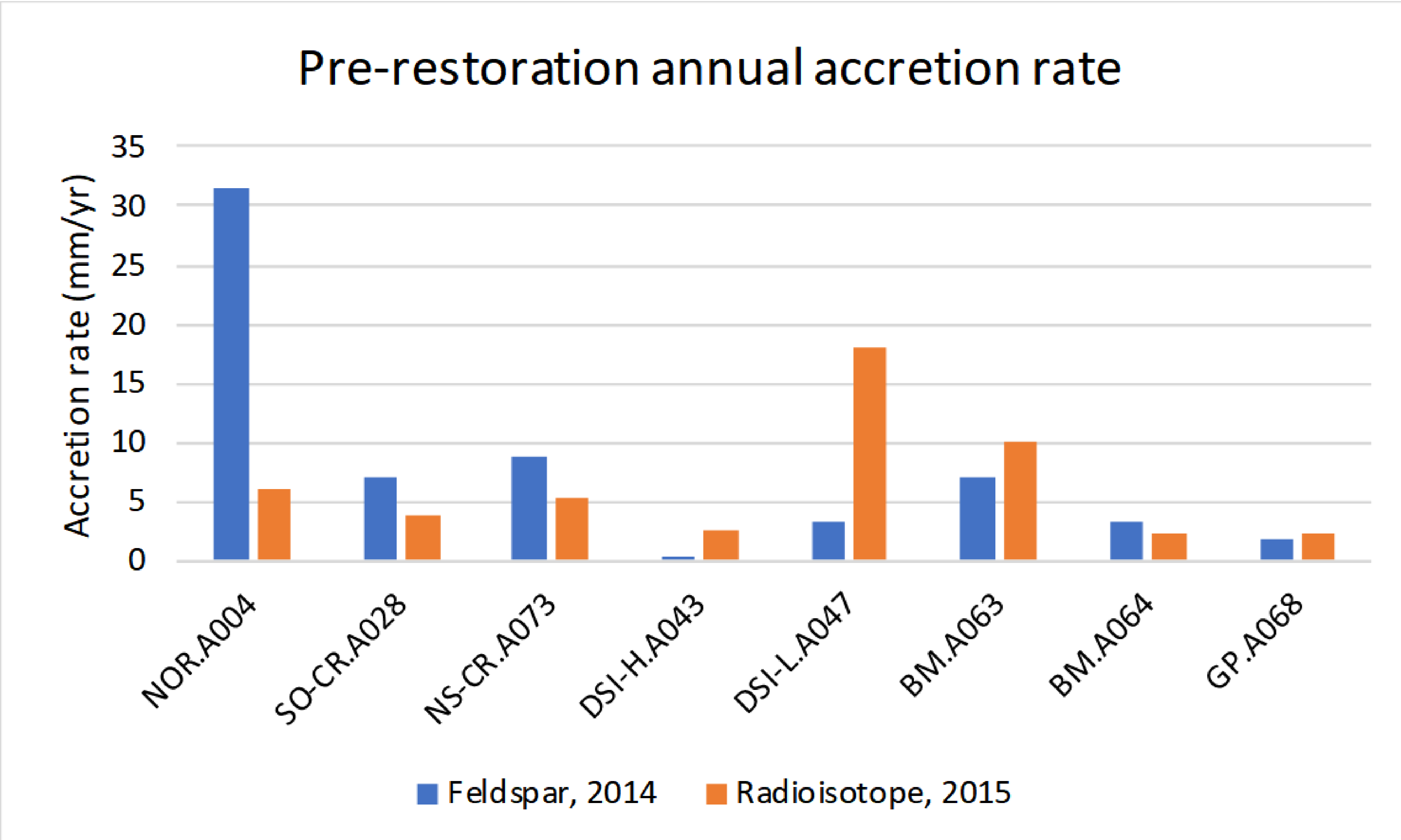


- Although regressions were not significant, ANOVA showed low marsh accretion was significantly higher ($F=15.7$, $p = 0.0006$).
- Restoration site mean higher than reference site mean, likely due to elevation

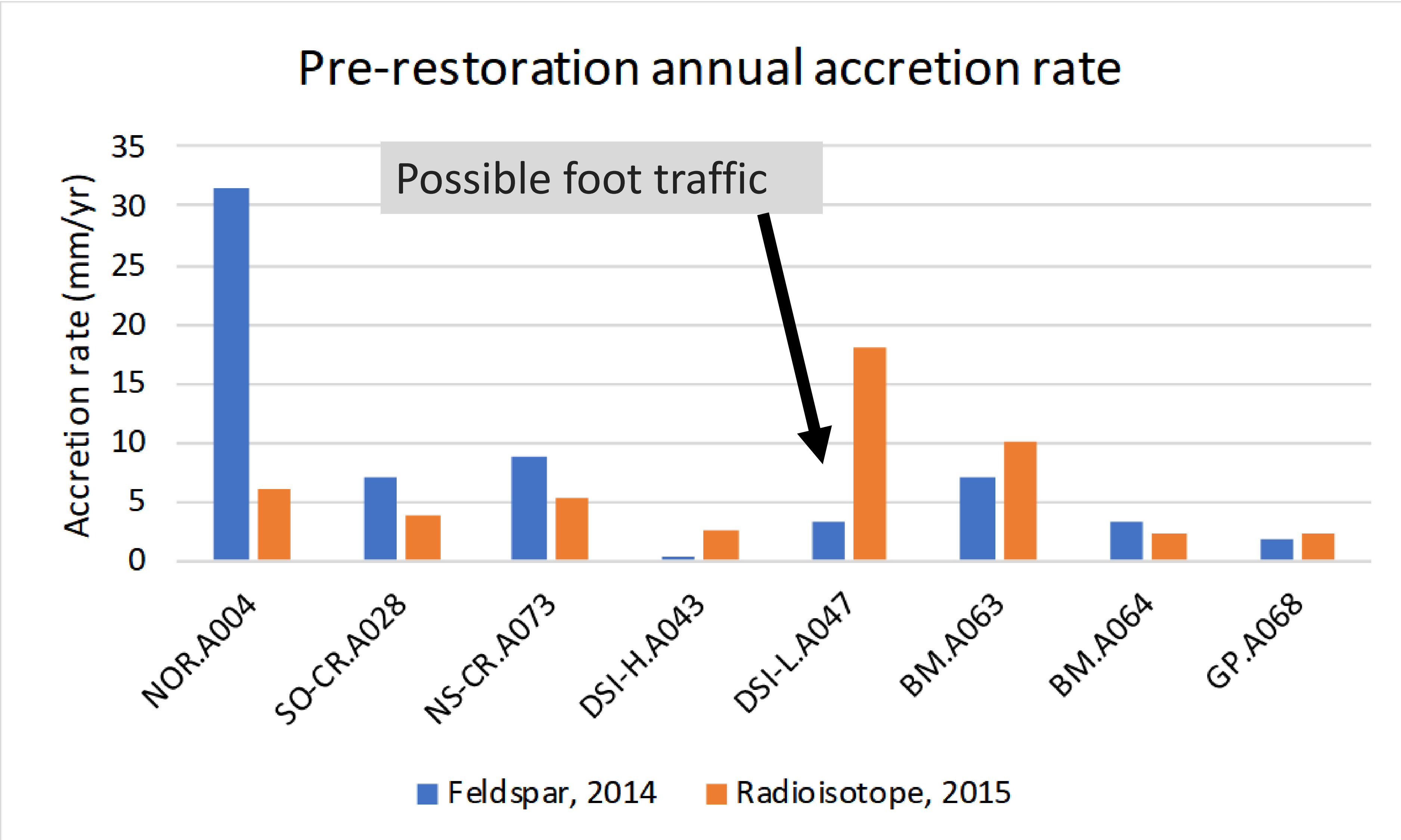
Sediment accretion rates (feldspar plots): Conclusions

- Higher accretion after restoration at SFC
- Higher accretion at lower elevations (SFC > ref, low marsh > high marsh)
- Other results similar to carbon core data, though higher in absolute terms (as expected)

Feldspar results vs. carbon core results



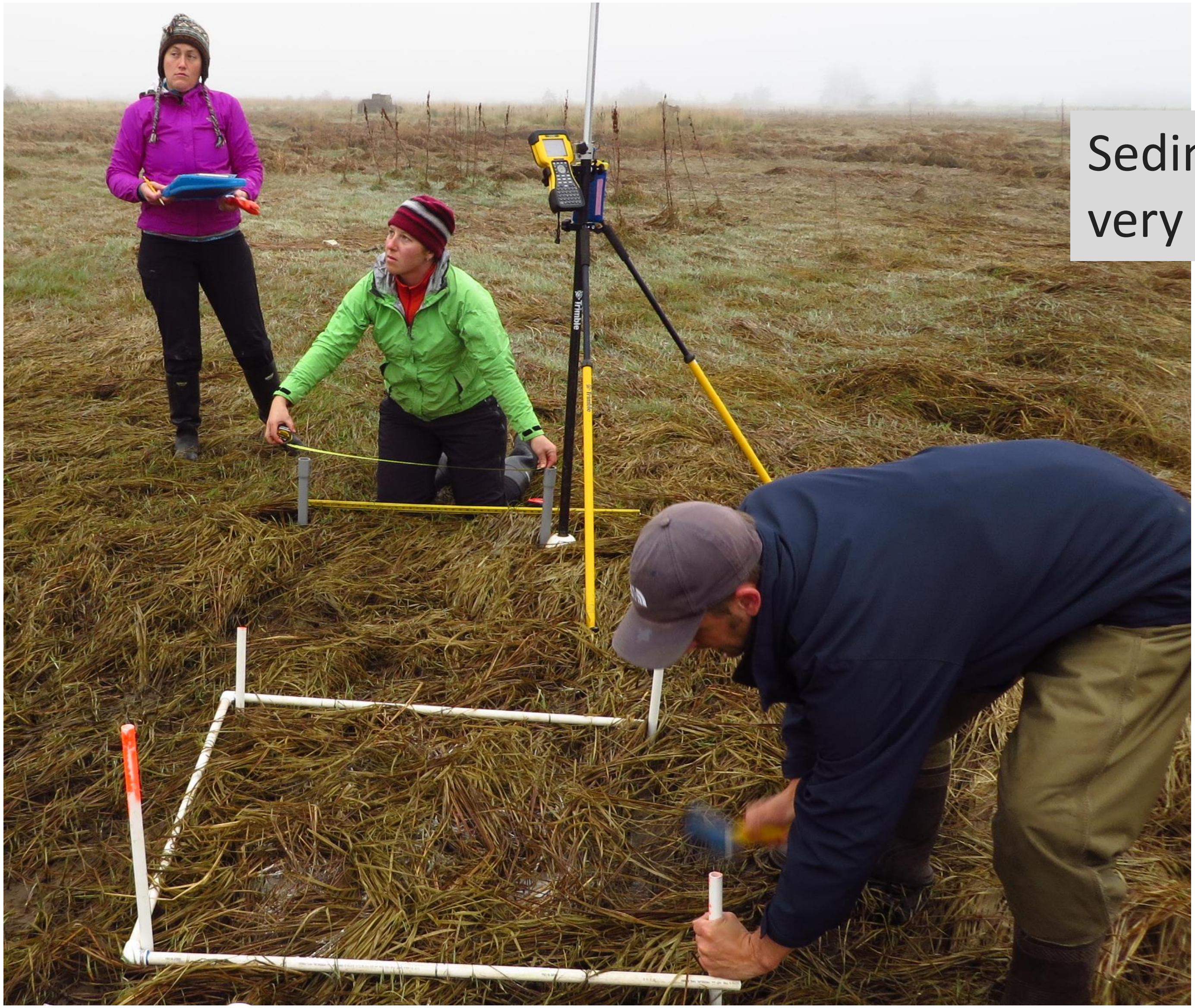
Feldspar results vs. carbon core results



Short-term sediment accretion -- feldspar plots: Challenges

Reed canarygrass root mat results in a discontinuous feldspar layer

Short-term sediment accretion -- feldspar plots: Challenges



Sediment stake data very noisy, discarded

Ecosystem drivers

Ecosystem driver measurements common to Youngs Bay and Tillamook Bay

Parameter	WY	SFC	Method	Locations	Sample unit
Tidal hydrology	X	X	Datalogger	Channels	Location
Channel temperature	X	X	Datalogger	Channels	Location
Channel salinity	X	X	Datalogger	Channels	Location
Shallow groundwater level	X	X	Datalogger	ED stations	Location
Shallow groundwater salinity	X	X*	Datalogger	ED stations	Location

* SFC project: groundwater salinity monitored only after restoration

Ecosystem drivers

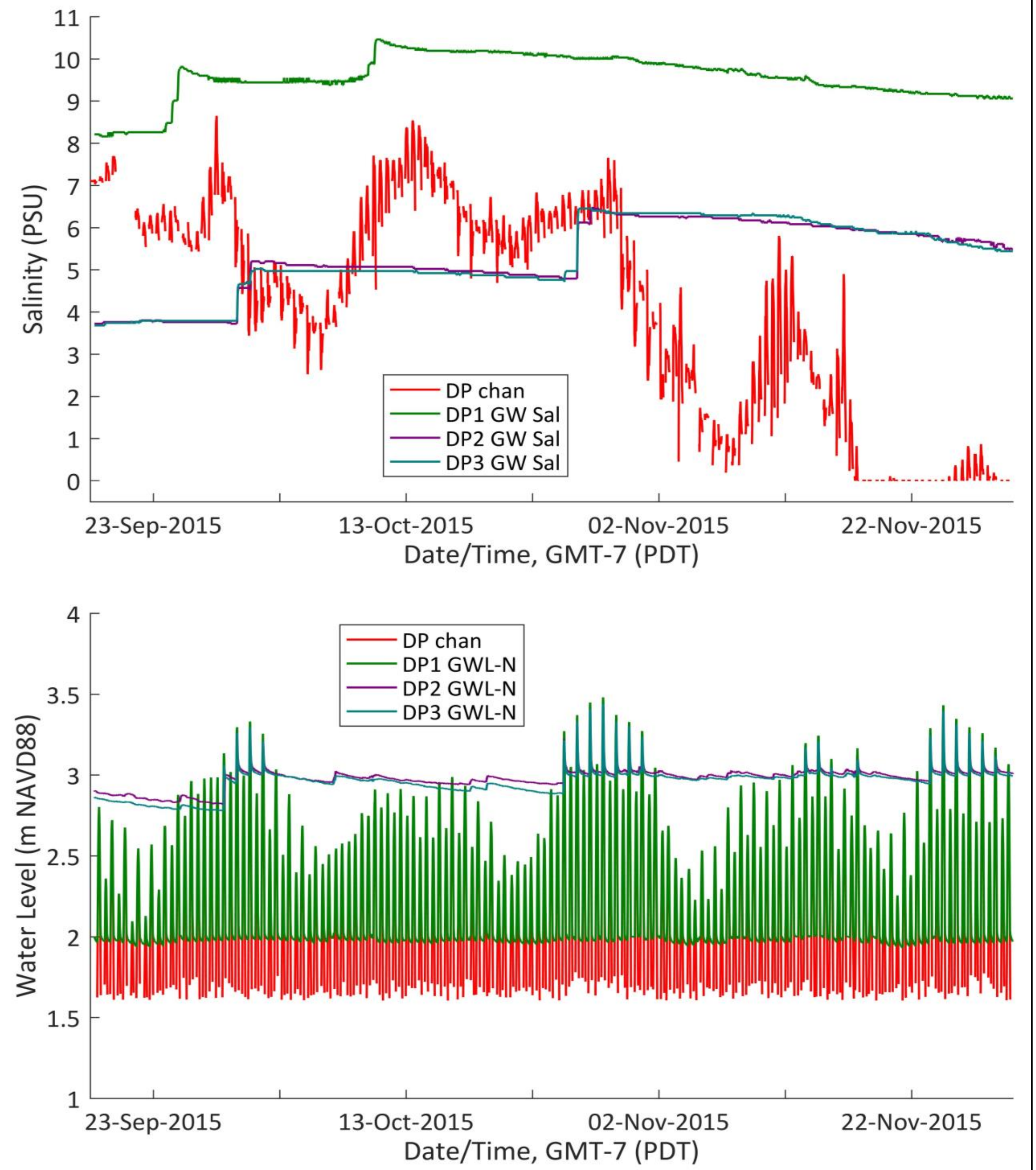
- Used throughout project for interpretation of biotic data
- Key to interpretation of carbon sequestration, greenhouse gas flux
- Post-restoration monitoring in progress at Tillamook Bay sites
- Groundwater salinity may be a better predictor of vegetation, greenhouse gas flux compared to channel salinity

Daggett Point channel vs. groundwater salinity

DP1 = low marsh

DP2 = high marsh

DP3 = scrub-shrub

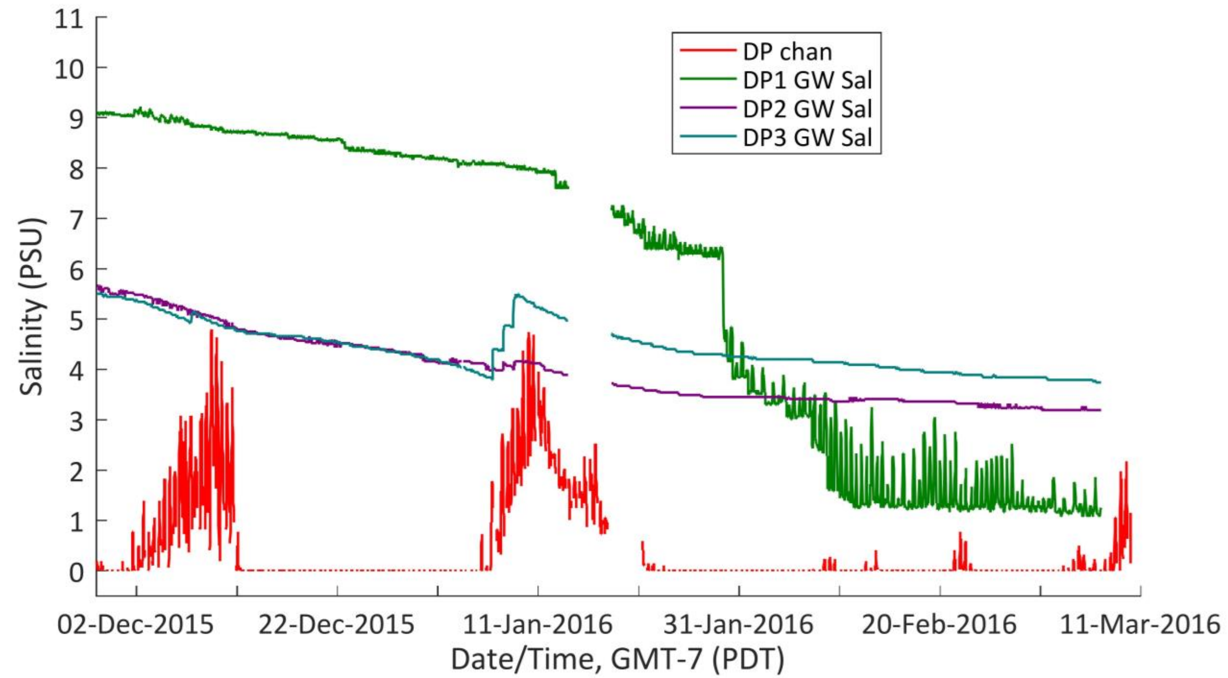


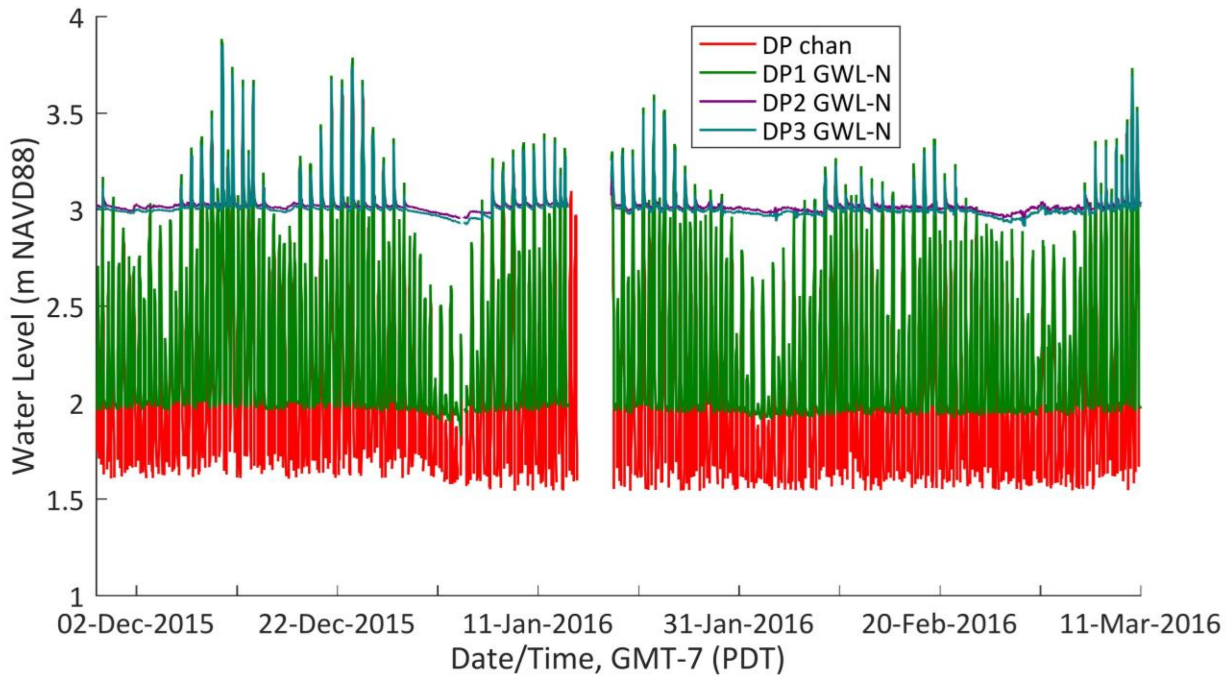
Daggett Point channel vs. groundwater salinity

DP1 = low marsh

DP2 = high marsh

DP3 = scrub-shrub





Take-home messages

1. Mean sediment accretion rates (SARs) exceeded past sea level rise: wetlands are "keeping pace."
2. Low marsh sites showed very high SARs, suggesting resilience to future sea level rise.
3. Carbon sequestration rates equaled or exceeded global averages.
4. Large amounts of carbon are expected to be stored at the restoration sites.
5. Ecosystem driver measurements provided vital support for interpreting results.

Check out our reports!

Additional “blue carbon” results here:

Peck, E.K. 2017. Competing roles of sea level rise and sediment supply on sediment accretion and carbon burial in tidal wetlands; Northern Oregon, U.S.A. M.S. Thesis, Oregon State University. Accessed 3/25/18 at http://ir.library.oregonstate.edu/xmlui/handle/1957/61372.

Peck, E.K., R.A. Wheatcroft, and L.S. Brophy. [*in review*]. Sediment accretion and carbon burial in three tidal wetlands in northern Oregon, U.S.A. Estuaries and Coasts, Manuscript ESCO-D-17-00255R1.

Full project reports available at:
http://appliedeco.org/program/estuary-technical-group/?post_types=report

Thank you for listening! Questions?

Presenter: Laura Brophy

brophyonline@gmail.com

Director, Estuary Technical Group
Institute for Applied Ecology, Corvallis, Oregon, USA
and
Marine Resource Management Program
College of Earth, Ocean and Atmospheric Sciences
Oregon State University, Corvallis, Oregon, USA

Full project reports available at:
http://appliedeco.org/program/estuary-technical-group/?post_types=report