Framework to Conduct Ecological Estimate Transfers: A Case Study of Seagrass Blue Carbon

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Using Existing Information to Fill Knowledge Gaps

When primary data is unavailable for a location of interest it may be desirable to instead use or transfer data from studied locations. This demand may be greater for data-intensive but research-poor areas such as ecosystem services. The importance of similar contexts, such as geographic, temporal, and ecological similarity is not well defined for ecological estimate transfers. Here, we investigate the role of contextual variables in selecting reliable estimates for transfer in ecosystem service assessment and modelling using seagrass Blue Carbon as a case study.

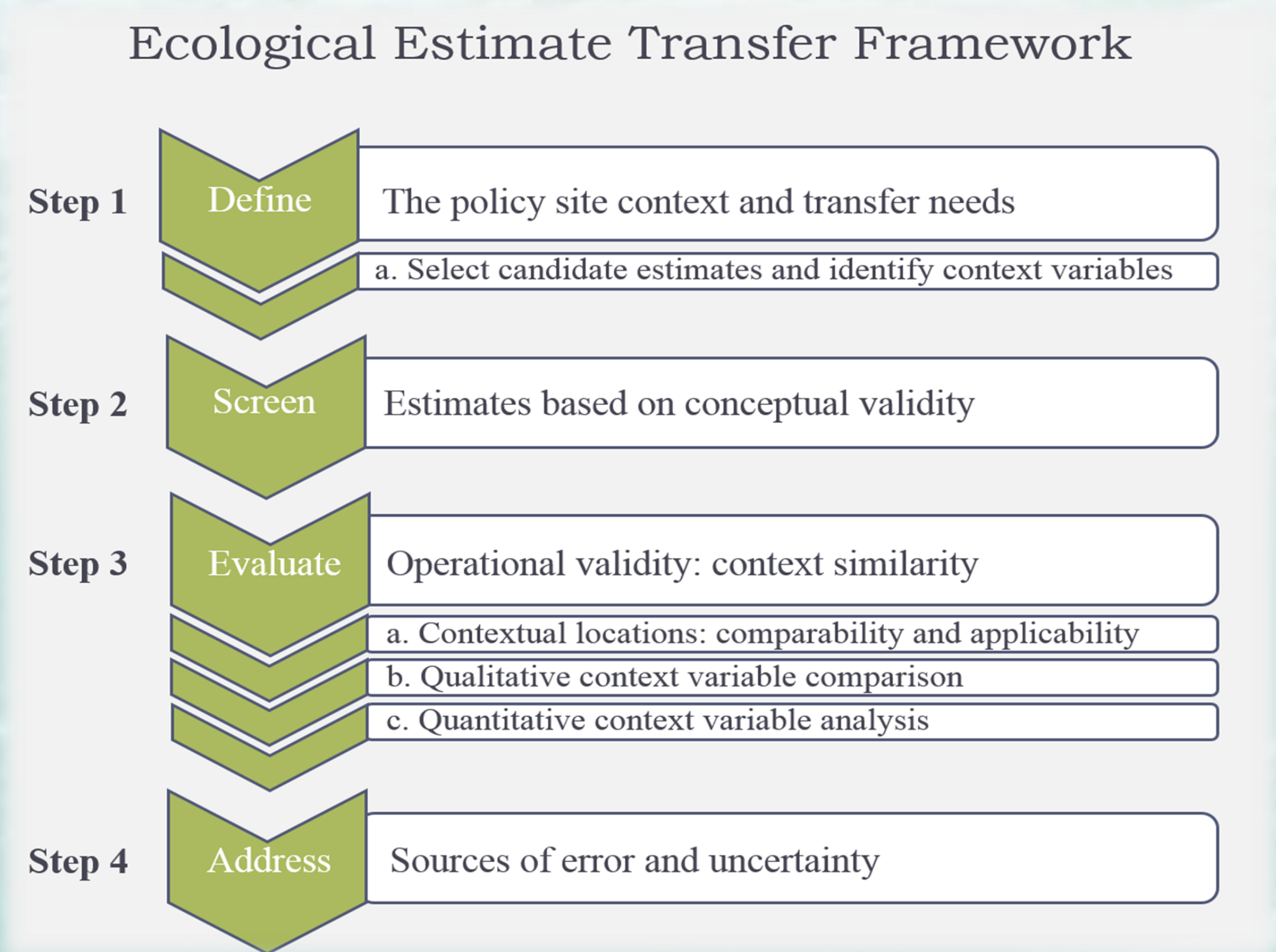
What is Blue Carbon?

The ability of ecosystems to sequester carbon, or store carbon in the soil for long periods of time, is an ecosystem service. Carbon sequestration in marine and coastal environments is called “Blue Carbon”. Tidal marshes, mangroves, and seagrasses are most commonly associated with estimates and discussions of blue carbon. There are over 60 species of seagrass, a globally distributed submerged aquatic vegetation.

So What?

Transferability is important for policy and research spanning economics and environmental science. While the foundations of economic benefit transfer are well founded, there is little guiding principle for biophysical and ecological value transfer. This case study demonstrates a framework created by Errend (2015) (Figure 1). **We hope to: 1). Demonstrate the applicability and logic of this framework and 2). Improve the ways in which seagrass blue carbon transfers are made.**

Framework to Assess the Transferability of Ecological Estimates



Ecological Estimate Transfer Framework

Step 1 Define — The policy site context and transfer needs
- a. Select candidate estimates and identify context variables

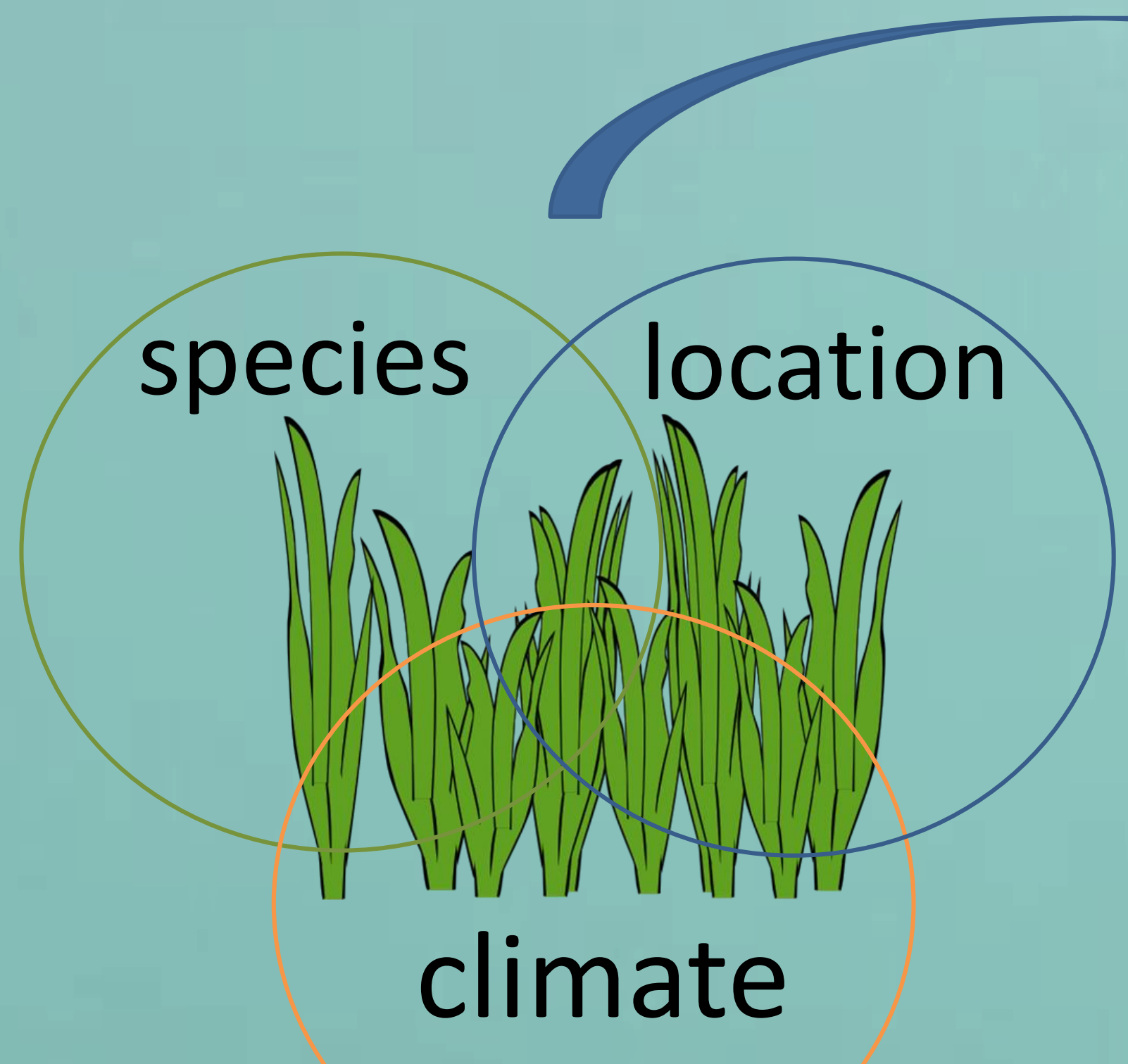
Step 2 Screen — Estimates based on conceptual validity

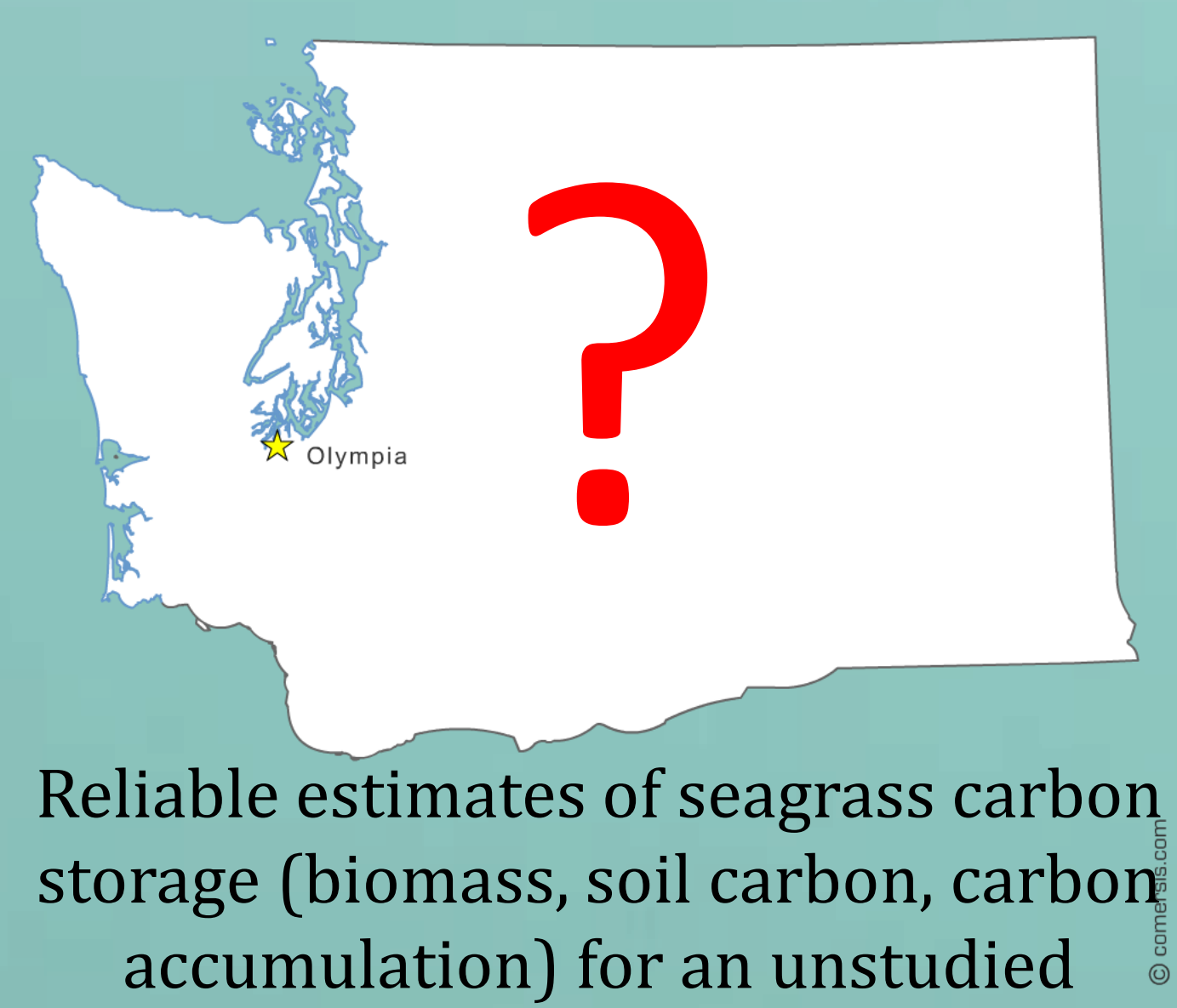
Step 3 Evaluate — Operational validity: context similarity
- a. Contextual locations: comparability and applicability
- b. Qualitative context variable comparison
- c. Quantitative context variable analysis

Step 4 Address — Sources of error and uncertainty

Figure 1: Framework to conduct ecological estimate transfers developed by Errend (2015). Logical methodology for approaching the contextual comparability for benefit transfer.

Which Aspects of Context are most Important?



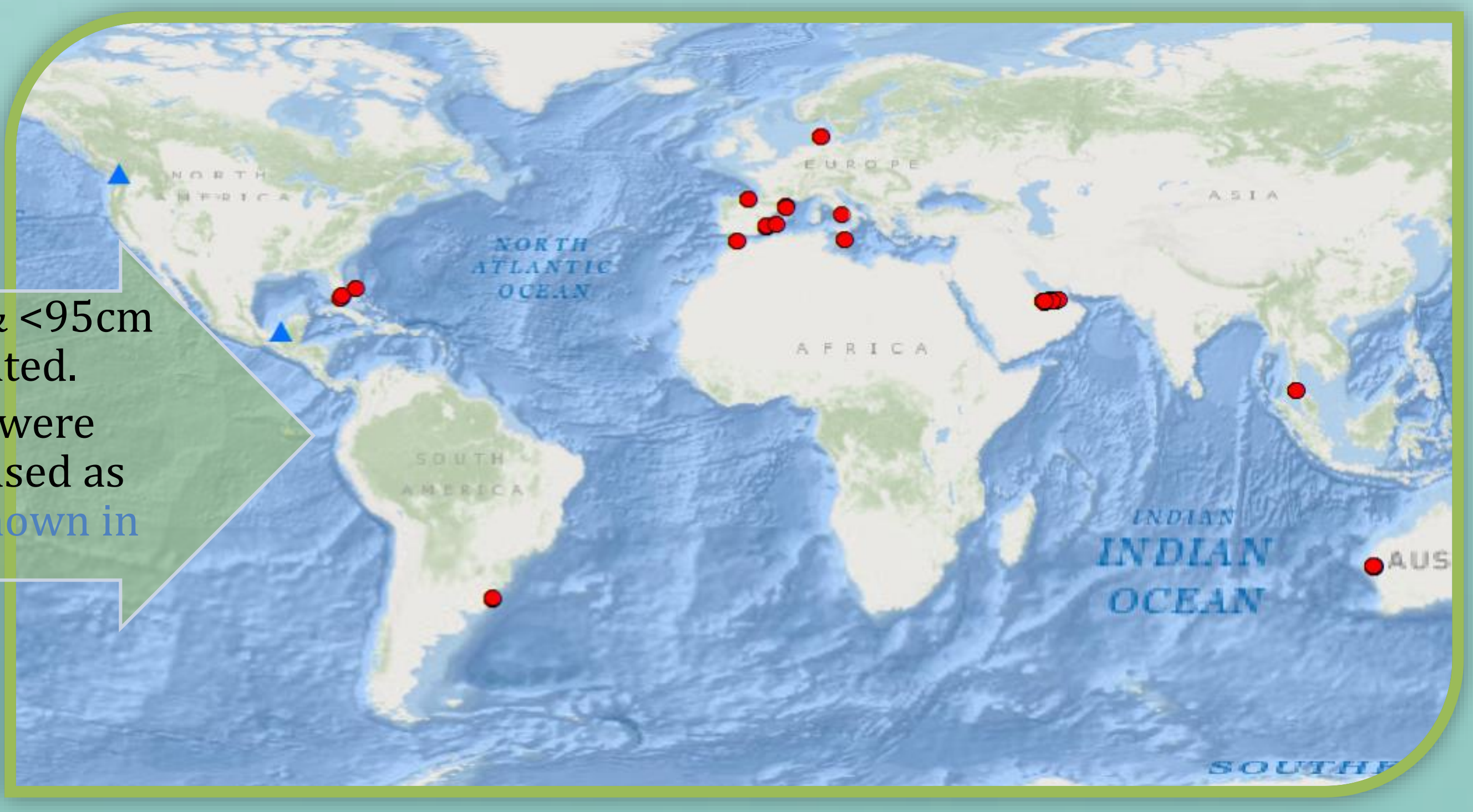


Reliable estimates of seagrass carbon storage (biomass, soil carbon, carbon accumulation) for an unstudied location.

Case Study: Global Estimates of Seagrass Total Soil Organic Carbon Storage (TSOC)

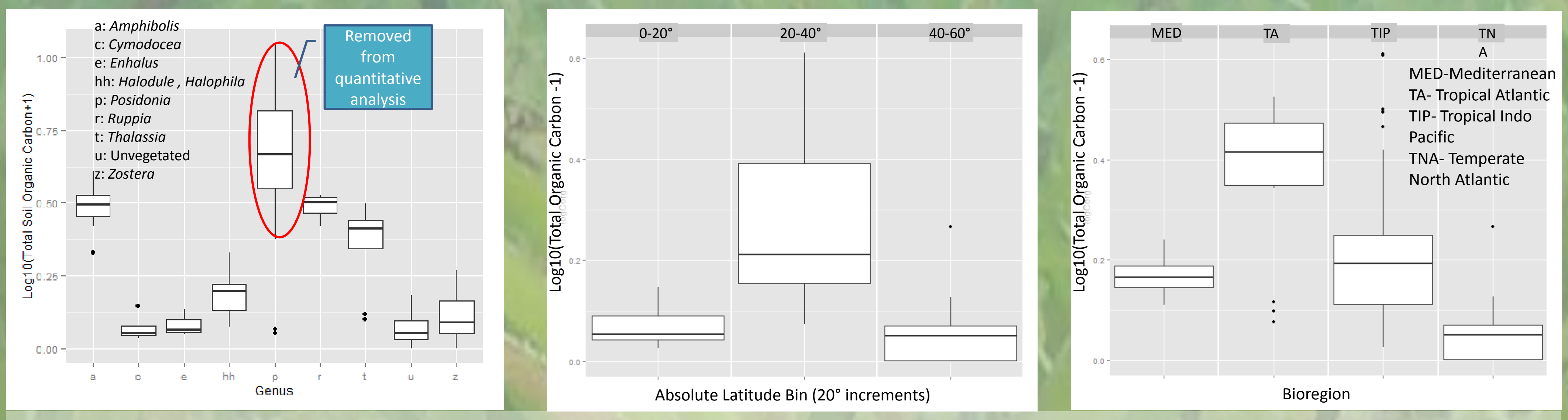
Soil dry bulk density and organic carbon content (%) was taken from Fourqurean et al. (2012) and the literature. Only cores >20cm depth were used.

- Cores >20cm & <95cm were extrapolated.
- Unique values were excluded and used as Policy Sites (shown in blue)



In addition to the 140 values of TSOC, we examined context variables: water depth, absolute latitude, climate, species, and bioregion. we investigate ways to reliably predict values for seagrass TSOC in sites unique to our data site. These Policy Sites are: Padilla Bay, Washington, USA and Laguna de Terminos, Yucatan, Mexico.

Context Analysis



From the left: Figure 3, 4, 5. Figure 3: Log_{10} of total soil organic carbon content +1 with relation to genus. *P. oceanica* data was removed from the quantitative assessment, as it is noticeably unique. **Figure 4:** Log_{10} of total soil organic carbon content +1 with changing absolute latitude. **Figure 5:** Log_{10} of total soil organic carbon content +1 with Bioregion (Short et al. 2007).These exploratory plots helped inform the focus of further quantitative analysis.

Results: Total Transfer Error and Uncertainty Analysis

Table 1: Percent Transfer Error associated with total soil organic carbon estimates derived from quantitative testing.

Model or Estimate Type	Policy Site	Contextual Variable(s)	Policy Site Estimate (g/cm^2)	95% Confidence Interval	Absolute Percent Transfer Error	
Two-Way ANOVA: Species & Absolute Latitude	Mexico	Tropical Atlantic; 0-20°	0.793	0.427-1.393	2.35	Best
ANOVA: Climate	Mexico	Tropical	0.715	.0572-.872	7.62	|
Study Site Average	Mexico	Global Data	0.547	.443-.653	29.36	|
ANOVA: Absolute Latitude	Mexico	0-20	0.176	-0.41700	77.24	Worst
Study Site Average	Washington	Global Data	0.547	.443-.653	0.14	Best
ANOVA: Climate	Washington	Temperate	0.348	.218-.491	27.41	|
Two-Way ANOVA: Species & Absolute Latitude	Washington	Temperate North Pacific; 40-60°	0.197	.050-.284	58.90	|
ANOVA: Absolute Latitude	Washington	40-60	0.13178	0.01850-1.25766	72.51	Worst
		True Policy Site: Mexico	**0.774**	**Average PTE**	**48.76**	
		True Policy Site: Washington	**0.479**	**Average PTE**	**77.46**	

What are reliable predictors?

Percent Transfer Error (PTE) was calculated (see Table1) in the manner described by (Rosenberger and Phipps 2007):

$$\frac{V_t - V_k}{V_k} * 100$$

where V_t is the transfer estimate and V_k is the known value.

Mexico Policy Site:

- The species and absolute latitude bin Two-Way ANOVA performed the best.
- The absolute latitude bin ANOVA performed the worst.
- Mexico had overall lower average PTE than Washington. This may be a result of the Mexico policy site contextual variables being better represented by the data.

Washington Policy Site:

- Surprisingly, Study Site Average had the greatest accuracy; this may be attributed to stochasticity.
- An ANOVA analyzing country had the worst performance.
- Consistent with Mexico: the climate ANOVA performed the second best and the latitude bin ANOVA performed second worst.

Summary

- Evaluated seagrass Blue Carbon transfer needs
- Obtained reliable data and derived total soil organic carbon
- Compiled available context variables
- Determined there was sufficient data for context assessment
- Identified important variables
- Used context variables to estimate total soil carbon content

Conclusions

- Results challenge natural assumptions that proximate transfers = reliable transfers
- P. oceanica, demonstrates that, for at least some locations, species has the strongest influence on TSOC
- Quantitative testing and error analysis identify a measure of geographic location (climate or latitude) as being the best overall predictor
- Refining estimates based on species will ultimately allow for more reliable ecological estimates and, likewise, result in more reliable service value estimates

What does this mean?

- The framework approach to assessing ecological transfers is useful for exploring transferability
- Species and geographic location may be reliable predictors of seagrass blue carbon
- Greater coverage of contextual variables (i.e., temperature, salinity, habitat type) would improve transferability conclusions and reliability

Background Image: http://np.cpami.gov.tw/youth/filesys/image/01_chinese/12_equarterly/201306/02-A-009.jpg