

# Global controls on carbon storage in mangrove soils

Andre S. Rovai, PhD  
arovai1@lsu.edu

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Grant # OCE 1135427



Grant # BEX1930/13-3





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Andre **Rovai** - LSU ([arovai1@lsu.edu](mailto:arovai1@lsu.edu))

Robert **Twilley** - LSU

Edward **Castañeda-Moya** - FIU

Pablo **Riul** - UFPB

Miguel **Cifuentes-Jara** - CATIE

Marilyn **Manrow-Villalobos** - CATIE

Paulo **Horta** - UFSC

José **Simonassi** - UFSC

Alessandra **Fonseca** - UFSC

Paulo **Pagliosa** - UFSC

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# Global controls on carbon storage in mangrove soils

- Part 1.** A little bit of context and concept
- Part 2.** Brief account on the methods
- Part 3.** Global controls on C storage in mangrove soils
- Part 4.** Wrapping up

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**Bruce G. THOM**

*Journal of Ecology*, Vol. 55, No. 2 (Jul., 1967), pp. 301-343

**MANGROVE ECOLOGY AND DELTAIC GEOMORPHOLOGY:  
TABASCO, MEXICO  
BY BRUCE G. THOM**

*Journal of Ecology*, Vol. 63, No. 1 (Mar., 1975), pp. 203-232

**MANGROVE ECOLOGY AND DELTAIC-ESTUARINE  
GEOMORPHOLOGY: CAMBRIDGE GULF-ORD RIVER,  
WESTERN AUSTRALIA  
BY BRUCE G. THOM\*, L. D. WRIGHT†‡ AND J. M. COLEMAN†**

Proceedings of the Australian National Mangrove Workshop  
Australian Institute of Marine Science  
Cape Ferguson  
18-20 April 1979

**M MANGROVE ECOSYSTEMS S**  
**IN AUSTRALIA**  
Structure, function and management

**Mangrove Ecology – A Geomorphological Perspective**  
*B.G. Thom*



**Colin D. WOODROFFE**

Pacific Science (1987), vol. 41, nos. 1–4

**Pacific Island Mangroves: Distribution and Environmental Settings**

COLIN D. WOODROFFE

*Journal of Biogeography* (1991) 18, 479–492

**Mangrove biogeography:**

the role of Quaternary environmental and sea-level change

COLIN D. WOODROFFE and JOHN GRINDROD

Coastal and Estuarine Studies

Tropical Mangrove Ecosystems

Vol. 41

**Mangrove Sediments and Geomorphology**

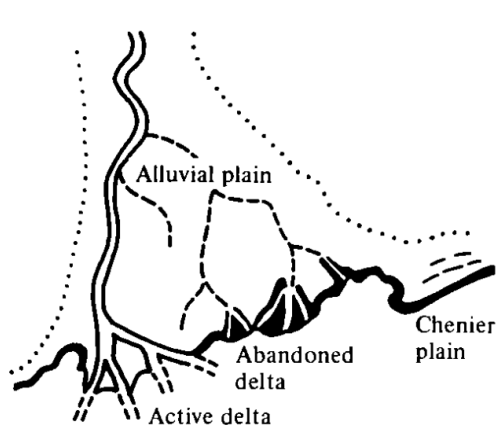
Colin Woodroffe



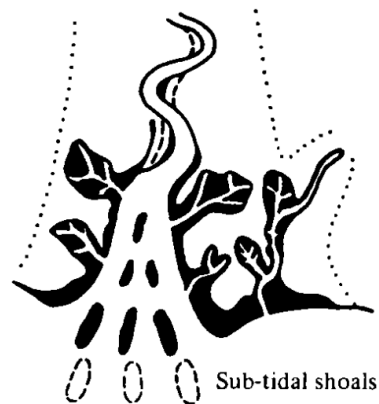
**Mangrove Sedimentation  
and Response to Relative  
Sea-Level Rise**

C.D. Woodroffe,<sup>1</sup> K. Rogers,<sup>1</sup> K.L. McKee,<sup>2</sup>  
C.E. Lovelock,<sup>3</sup> I.A. Mendelssohn,<sup>4</sup> and N. Saintilan<sup>5</sup>

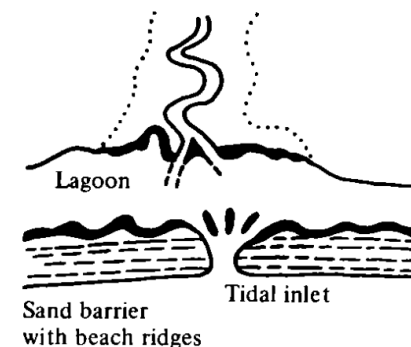
## THOM'S Environmental Settings For Mangroves



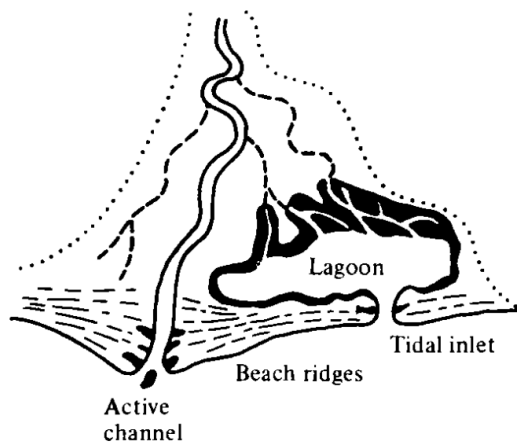
1. River-dominated allochthonous



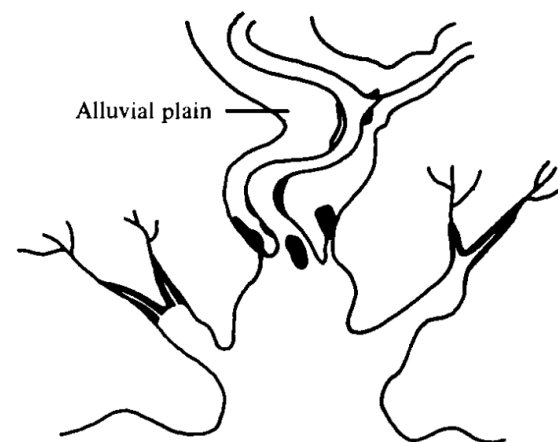
2. Tide-dominated allochthonous



3. Wave-dominated barrier lagoon (autochthonous)



4. Composite—river and wave dominated



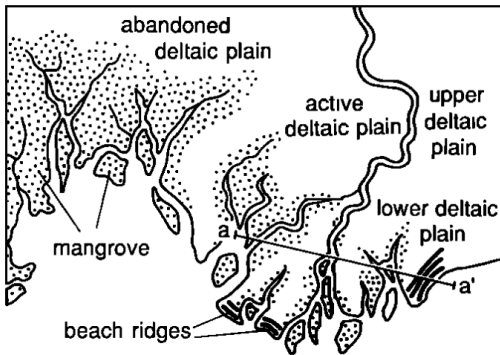
5. Drowned bedrock valley

Thom (1982)

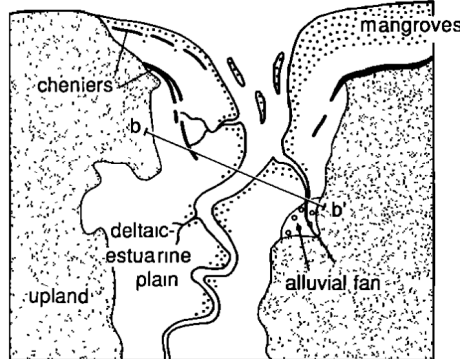


# WOODROFFE'S Environmental Settings For Mangroves

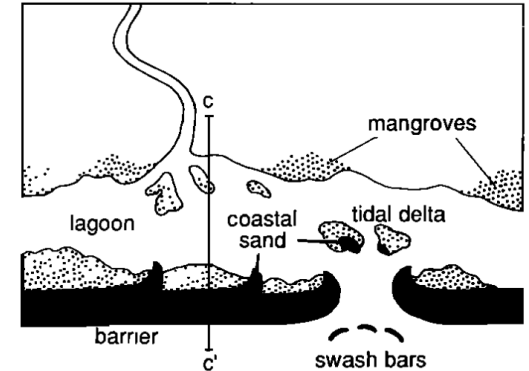
A. River dominated



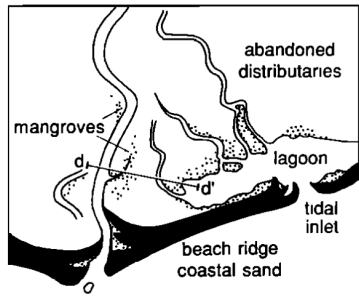
B. Tide dominated



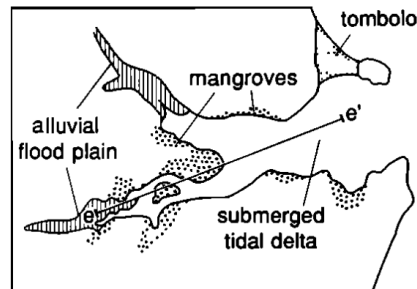
C. Wave dominated



D. Composite river and wave dominated



E. Drowned bedrock valley

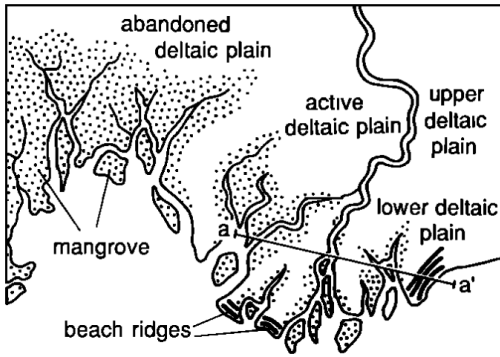


Woodroffe (1992)

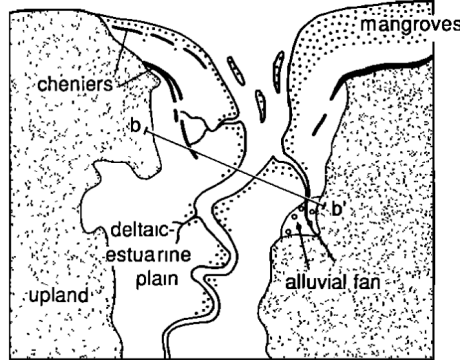


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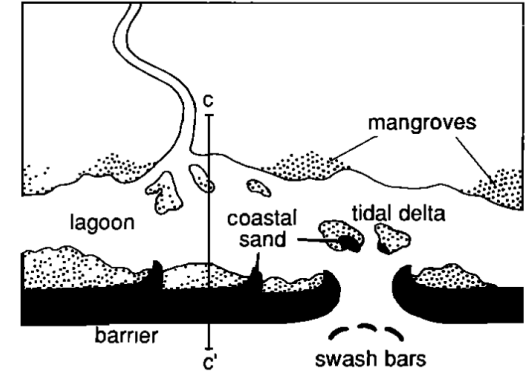
A. River dominated



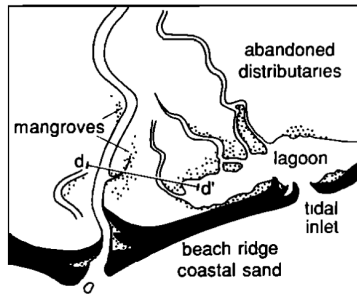
B. Tide dominated



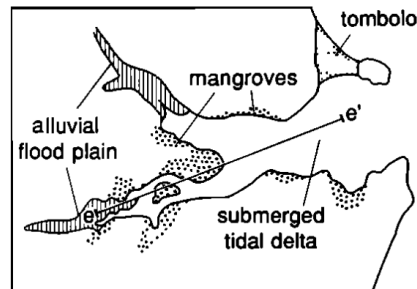
C. Wave dominated



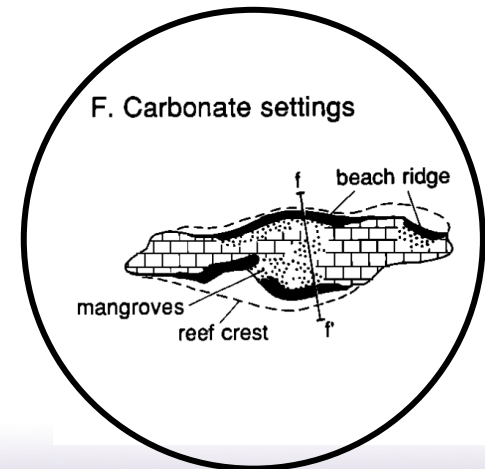
D. Composite river and wave dominated



E. Drowned bedrock valley

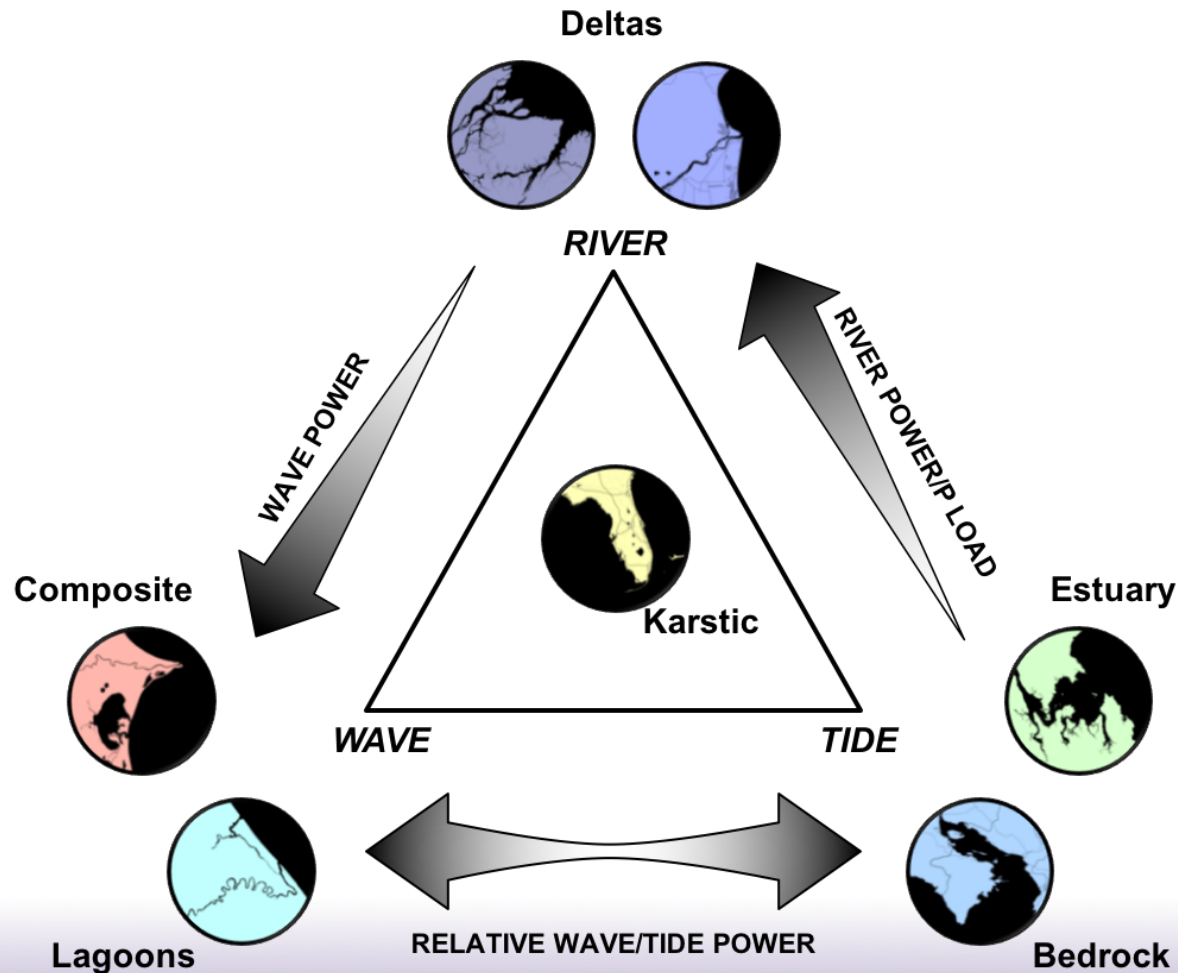


F. Carbonate settings



Woodroffe (1992)

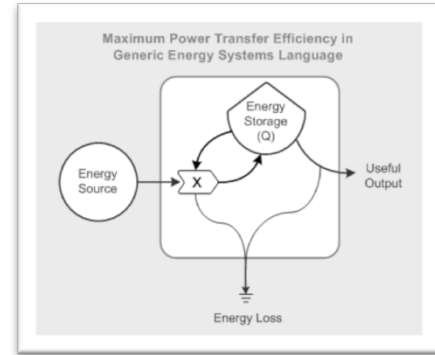
# THOM'S + WOODROFFE'S Environmental Settings For Mangroves



After Boyd et al. (1992), Dürr et al. (2011), Thom (1982), Twilley (1995), Woodroffe et al. (1992)

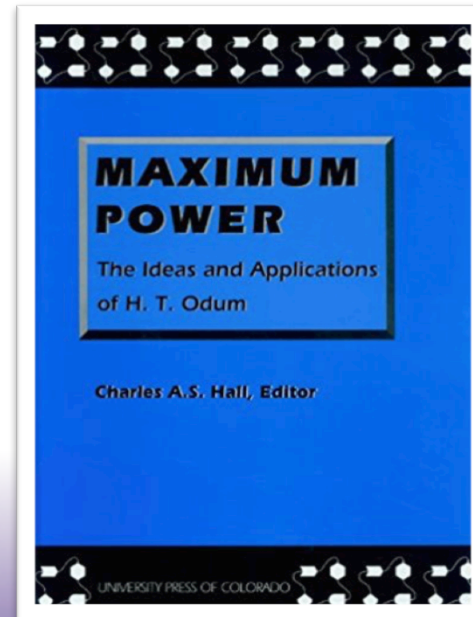


**Robert R. TWILLEY**



**PROPERTIES OF MANGROVE ECOSYSTEMS RELATED TO THE ENERGY SIGNATURE OF COASTAL ENVIRONMENTS**

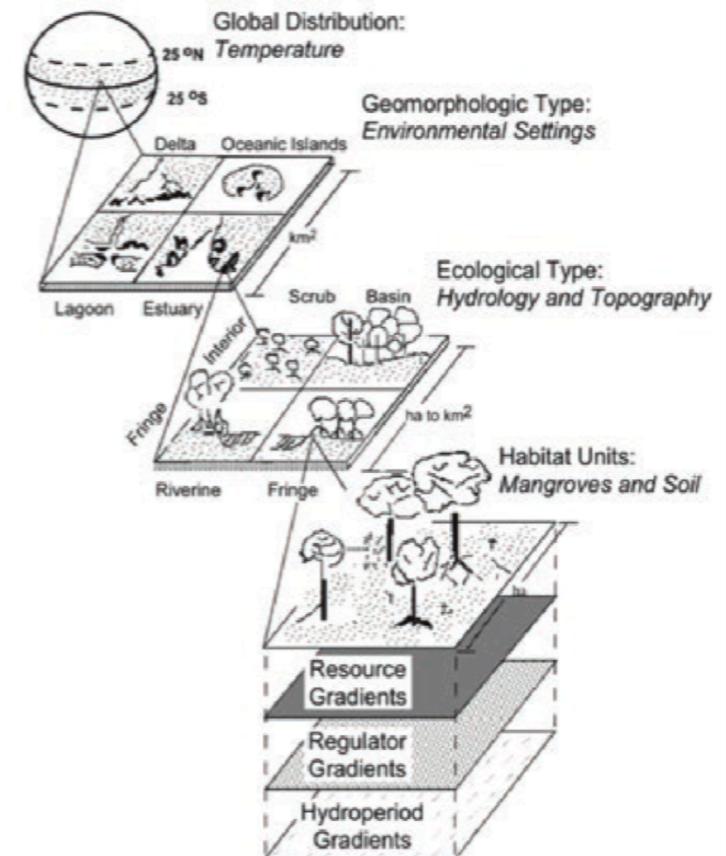
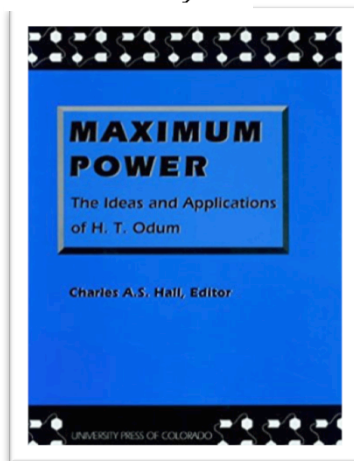
*Robert R. Twilley*





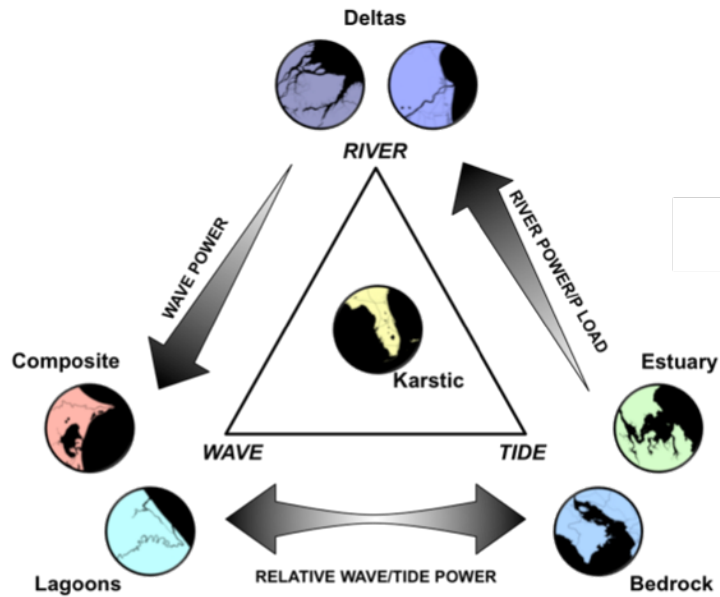
PROPERTIES OF MANGROVE ECOSYSTEMS RELATED TO THE ENERGY  
SIGNATURE OF COASTAL ENVIRONMENTS

Robert R. Twilley

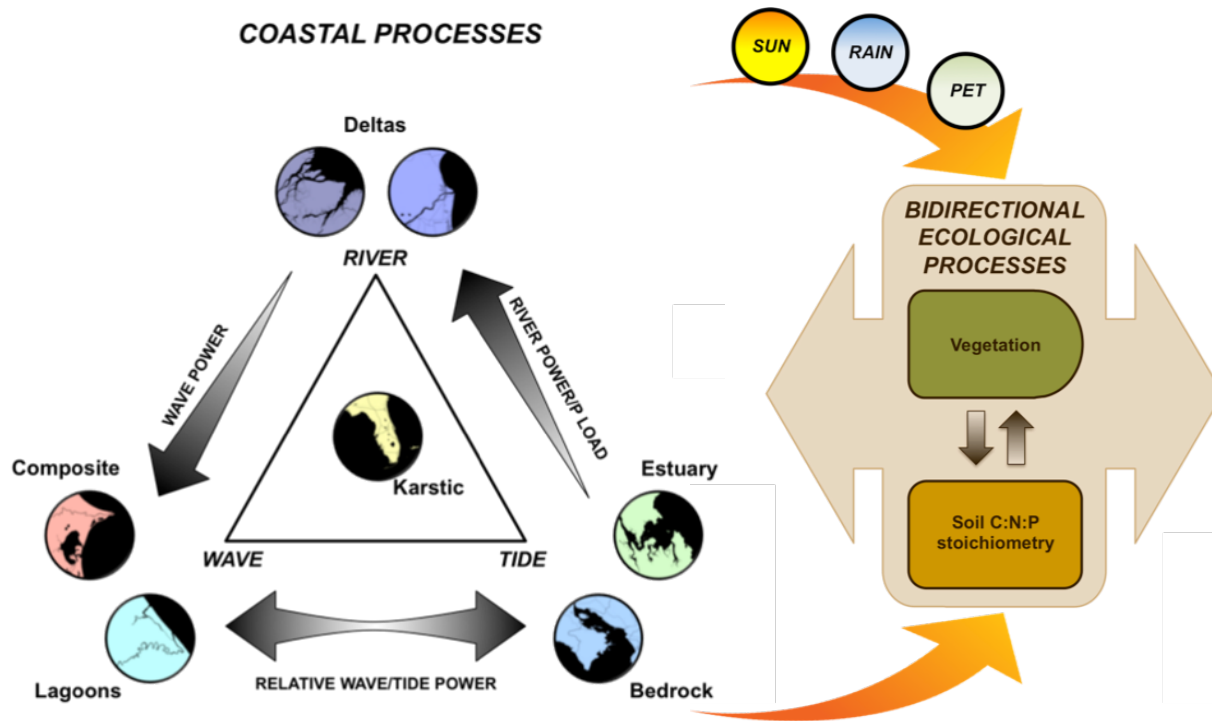


Twilley et al. (2017)

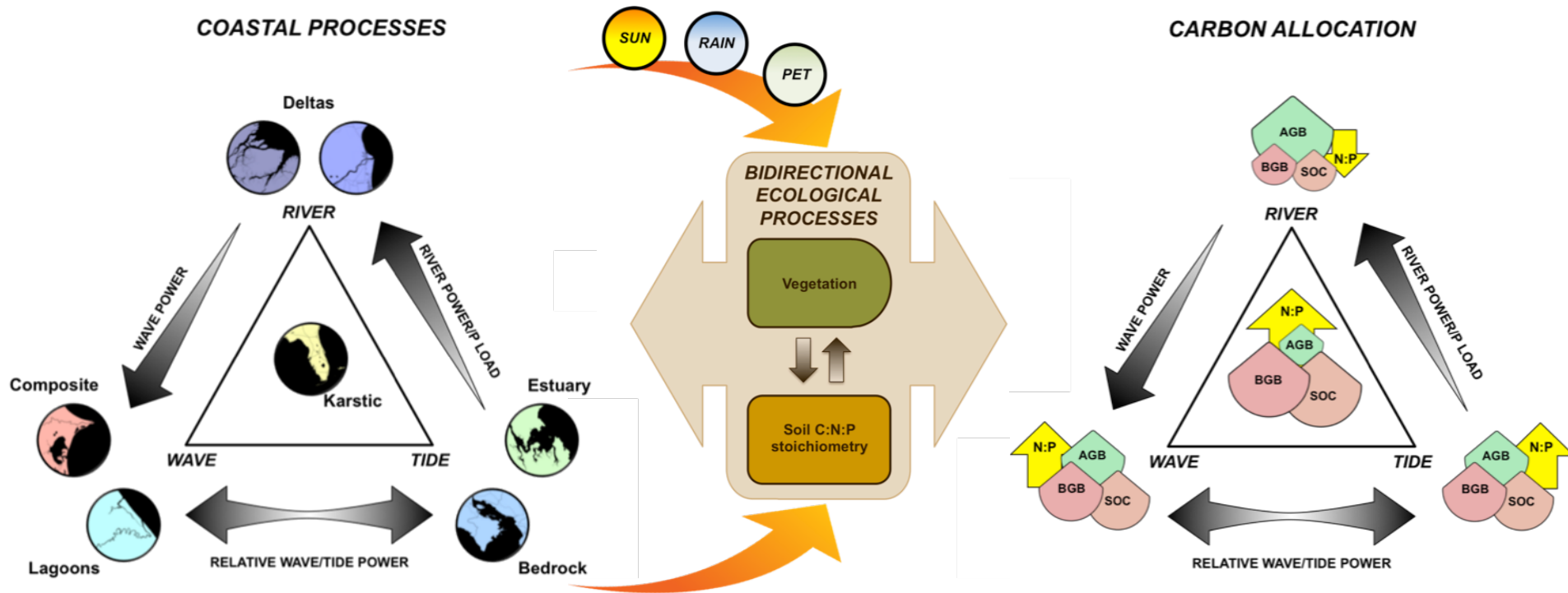
## COASTAL PROCESSES



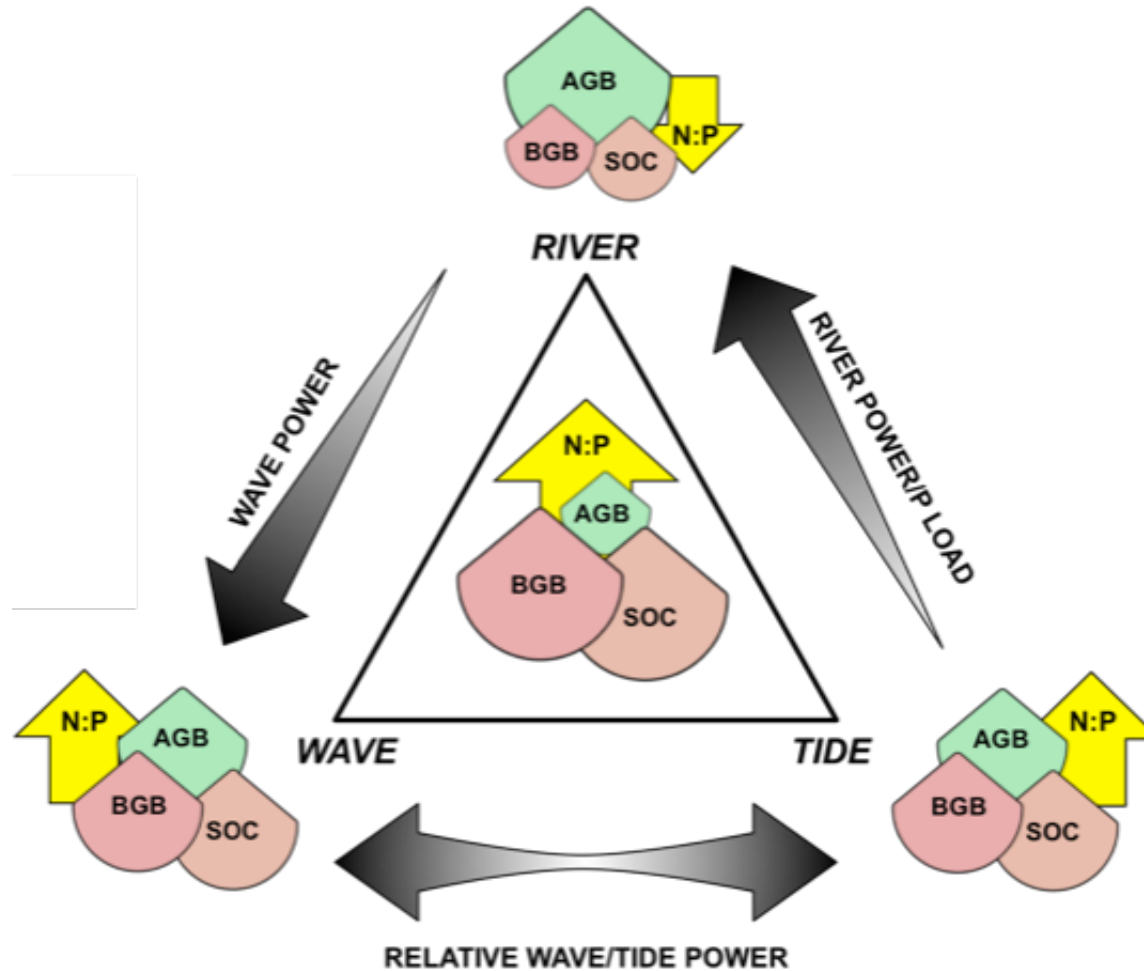
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After Boyd et al. (1992), Dürr et al. (2011), Thom (1982), Twilley (1995), Woodroffe et al. (1992)



## **H1.** Geophysical forcings, along with regional climate, shape distinct Coastal Environmental Settings (CES)

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 **H2.** Global patterns of soil C:N:P ecological stoichiometry are driven by geophysical and climatic forcing functions

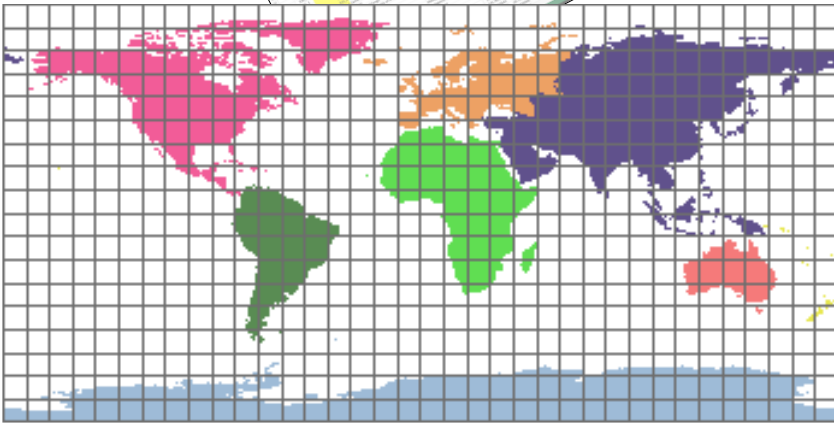
 **H1.** Geophysical forcings, along with regional climate, shape distinct Coastal Environmental Settings (CES)

 **H2.** Global patterns of soil C:N:P ecological stoichiometry are driven by geophysical and climatic forcing functions

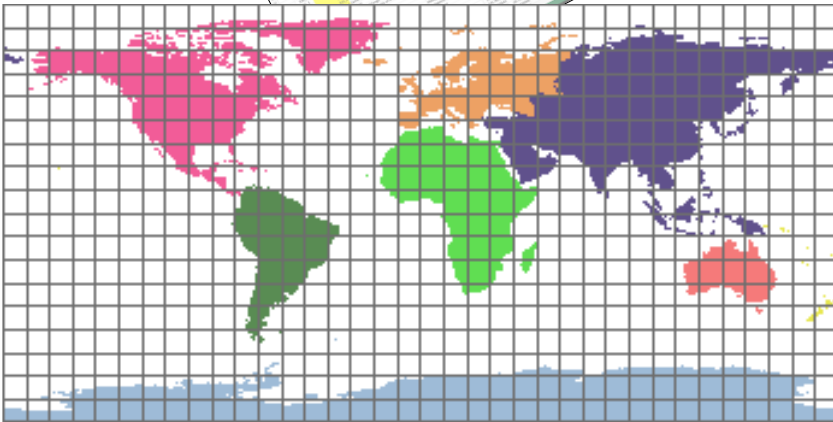
 **H3.** Geophysical and climatic drivers explain global variability in mangrove Soil Organic Carbon (SOC) stocks

# Global controls on carbon storage in mangrove soils

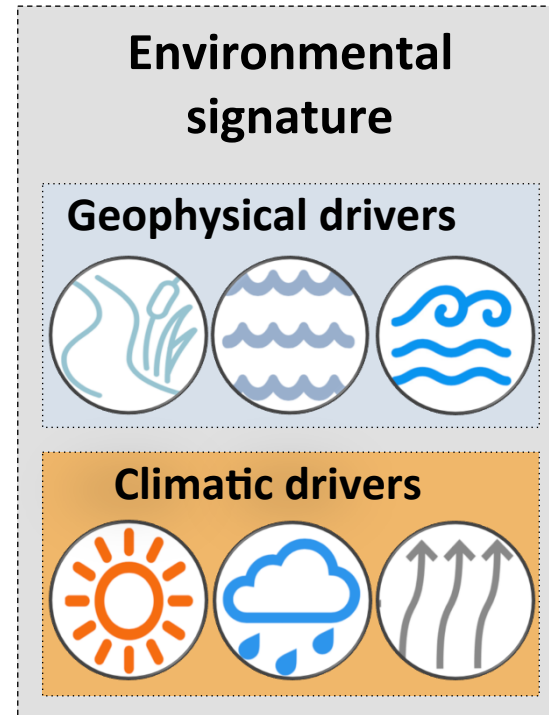
- Part 1. A little bit of context and concept
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**XXX cells**  
(0.25 degrees)



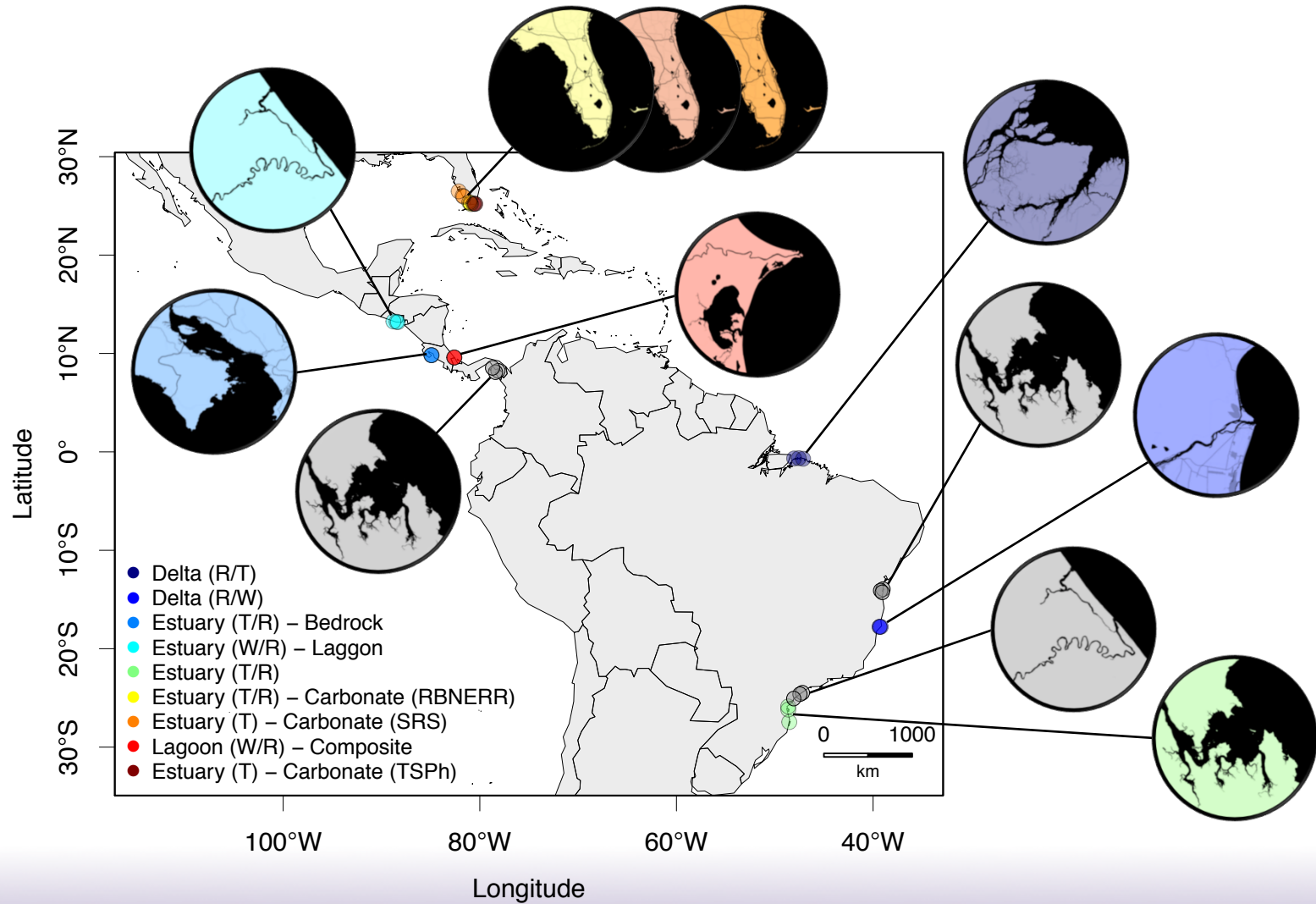
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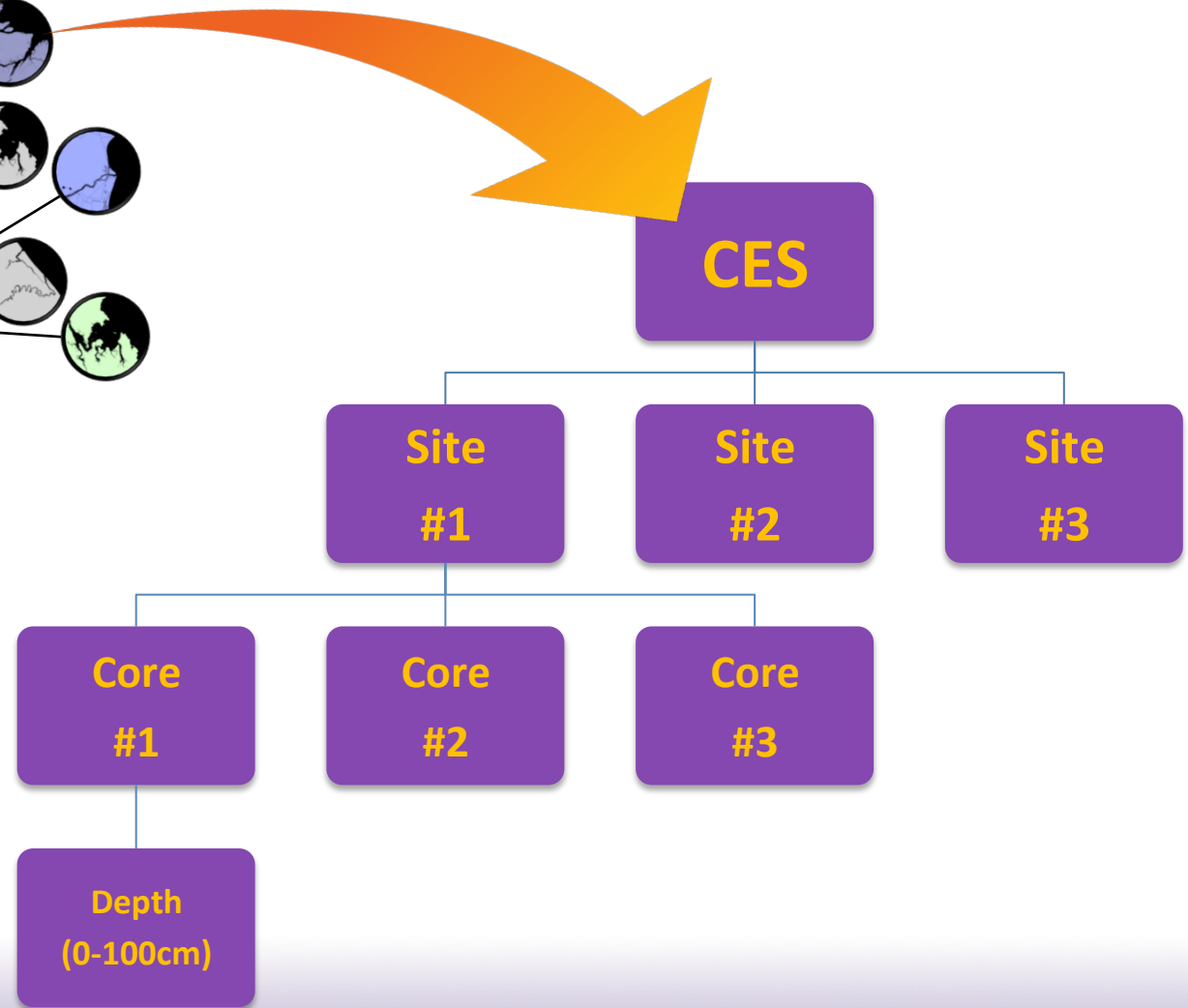
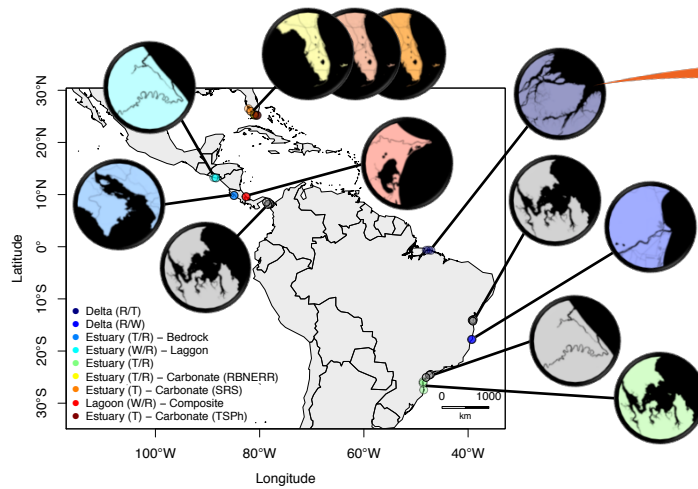
From Carrère et al. (2012), Fekete et al (2002),  
Hijmans et al. (2005), Mu et al. (2011)

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1m deep cores







1m deep cores





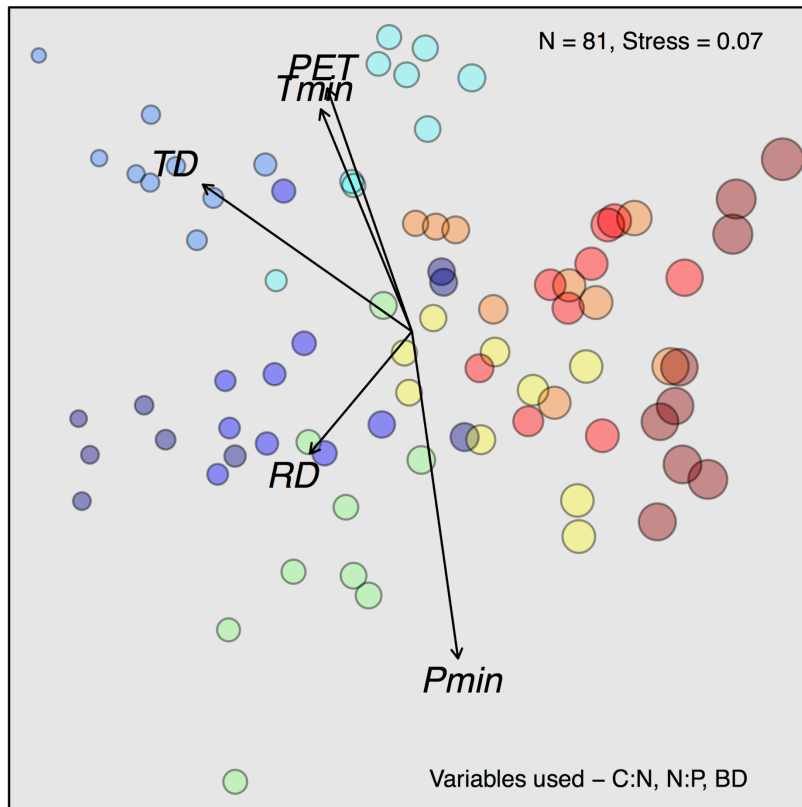
☞ C,N,P concentration ( $\text{mg cm}^{-3}$ )



## *n*MDS

- ✓ C:N, N:P stoichiometry
- ✓ BD ( $\text{g cm}^{-3}$ )

a



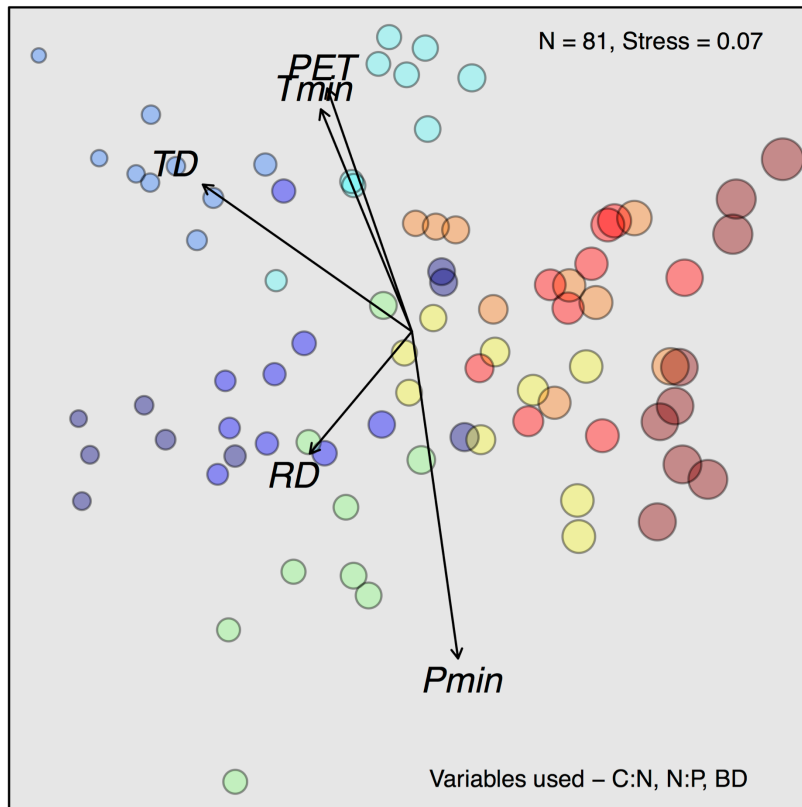
**RIVER**

**NO RIVER**



**DELTA – BEDROCK – LAGOON – ESTUARIES – COMPOSITE – CARBONATE**

**a**



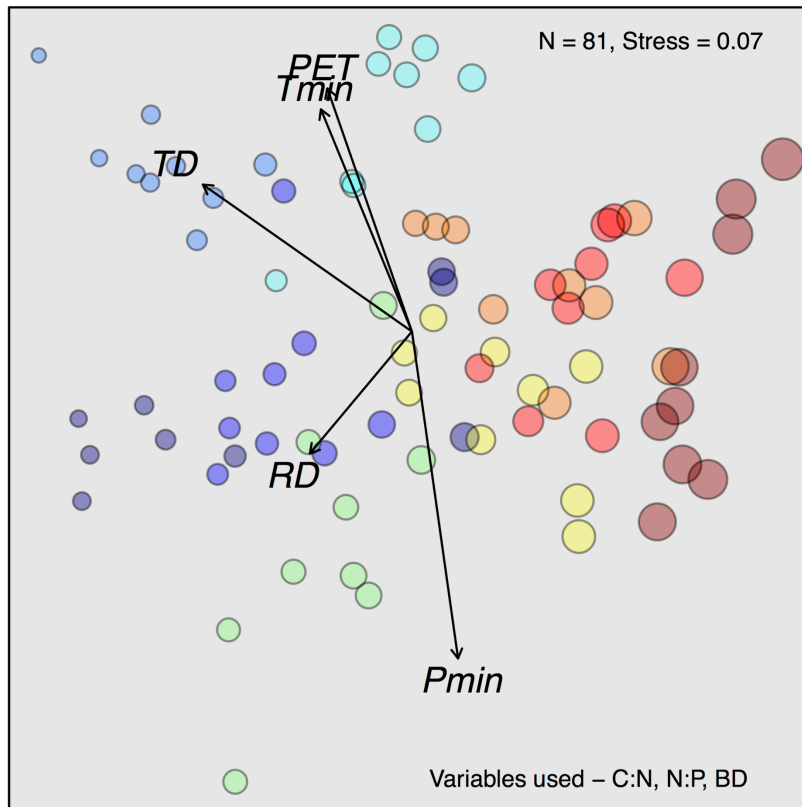
**RIVER**

**NO RIVER**

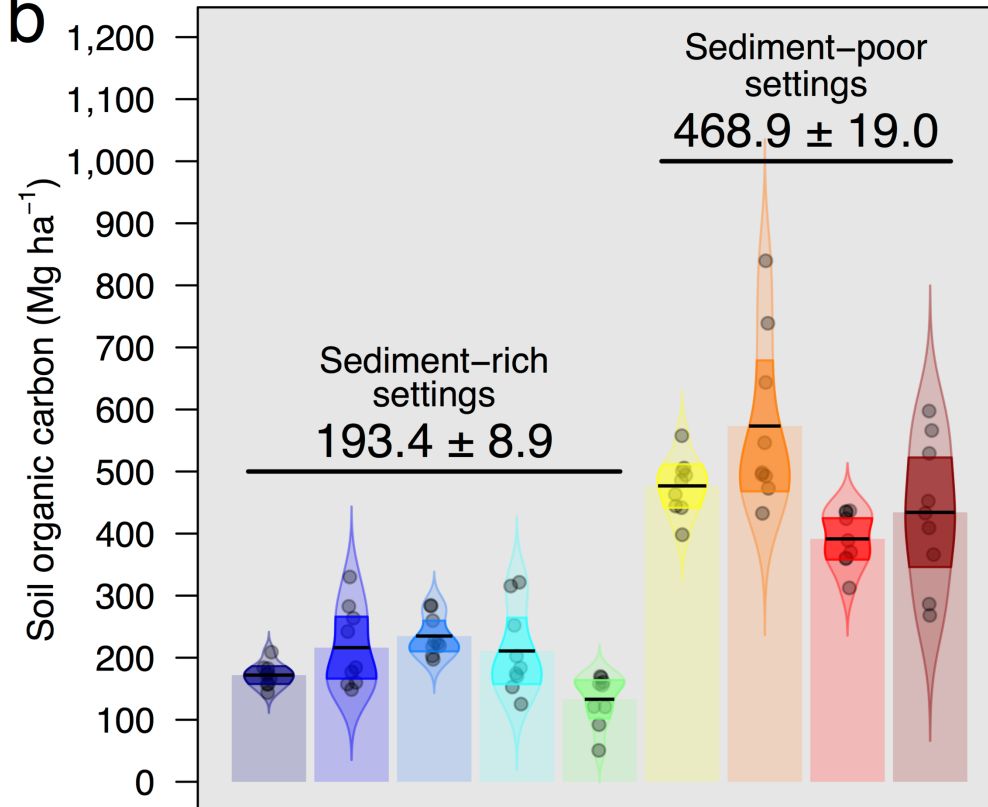


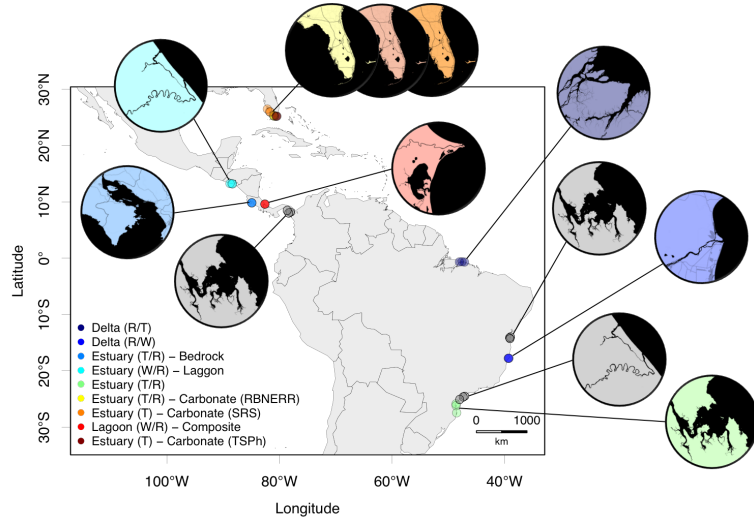
**DELTA – BEDROCK – LAGOON – ESTUARIES – COMPOSITE – CARBONATE**

**a**

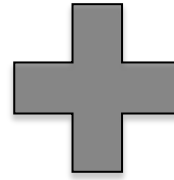
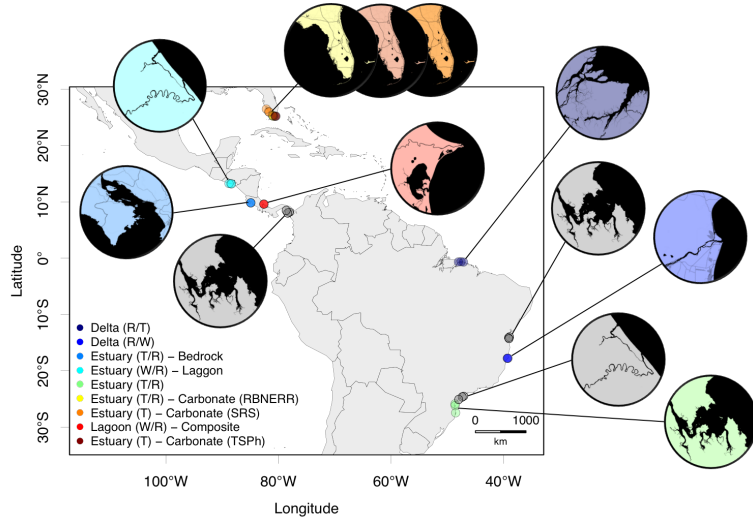


**b**









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Environ. Res. Lett. **9** (2014) 104013 (9pp)

### A global predictive model of carbon in mangrove soils

Sunny L Jardine<sup>1</sup> and Juha V Siikamäki<sup>2</sup>

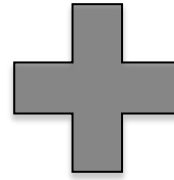
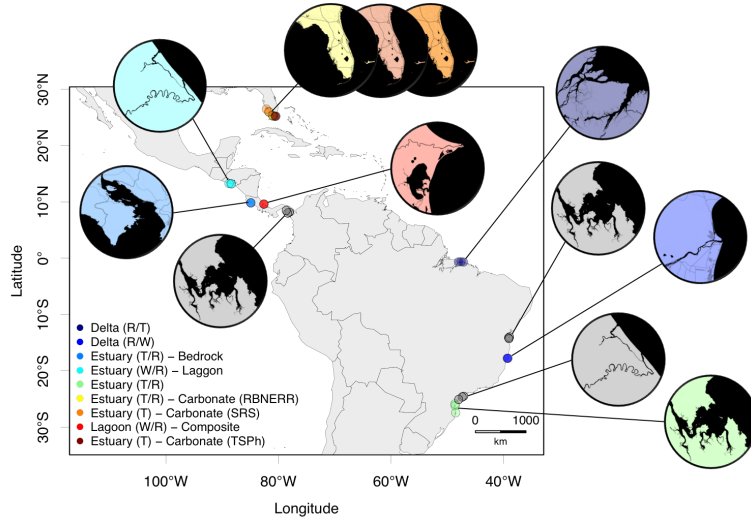
nature  
climate change

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PUBLISHED ONLINE: 26 JUNE 2017 | DOI: 10.1038/NCLIMATE3326

### Global patterns in mangrove soil carbon stocks and losses

Atwood et al. (2017)



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Environ. Res. Lett. 9 (2014) 104013 (9pp)

## A global predictive model of carbon in mangrove soils

Sunny L Jardine<sup>1</sup> and Juha V Siikamäki<sup>2</sup>

nature  
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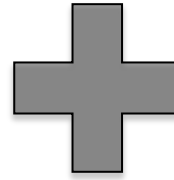
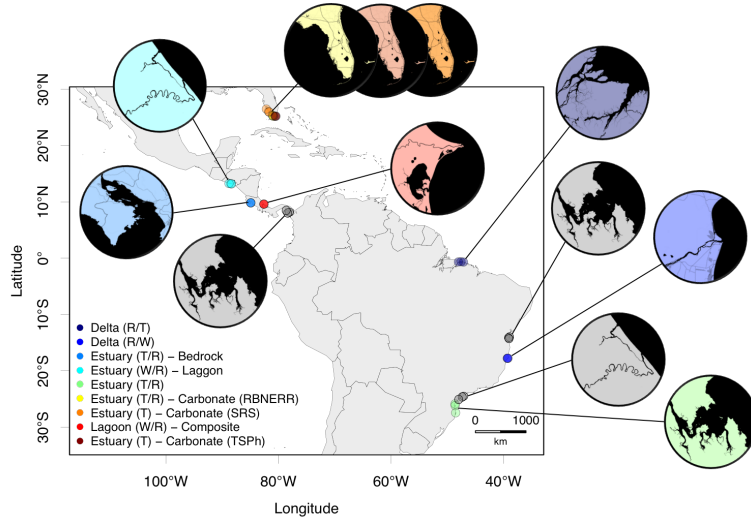
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Depth <0.3m  
C from LOI



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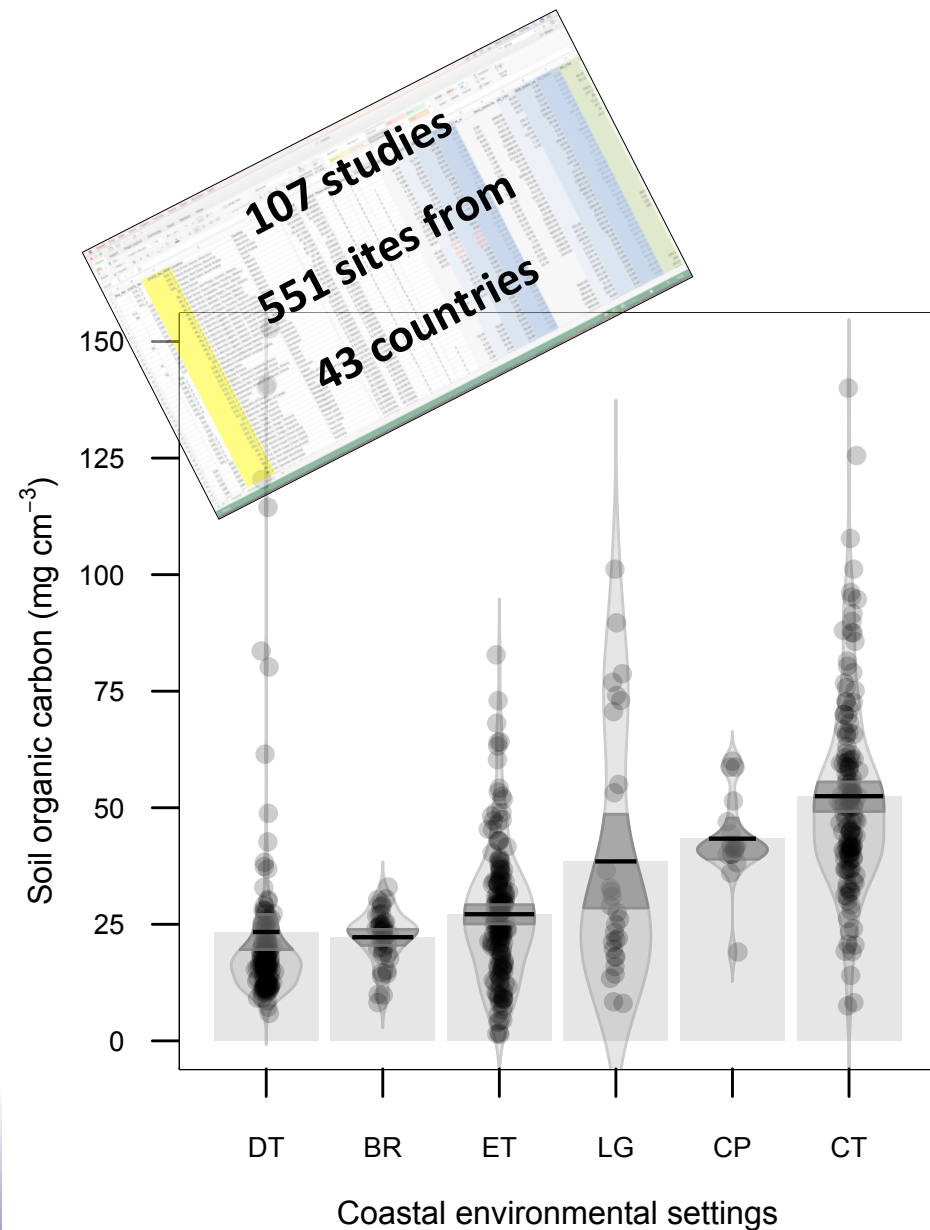
Atwood et al. (2017)



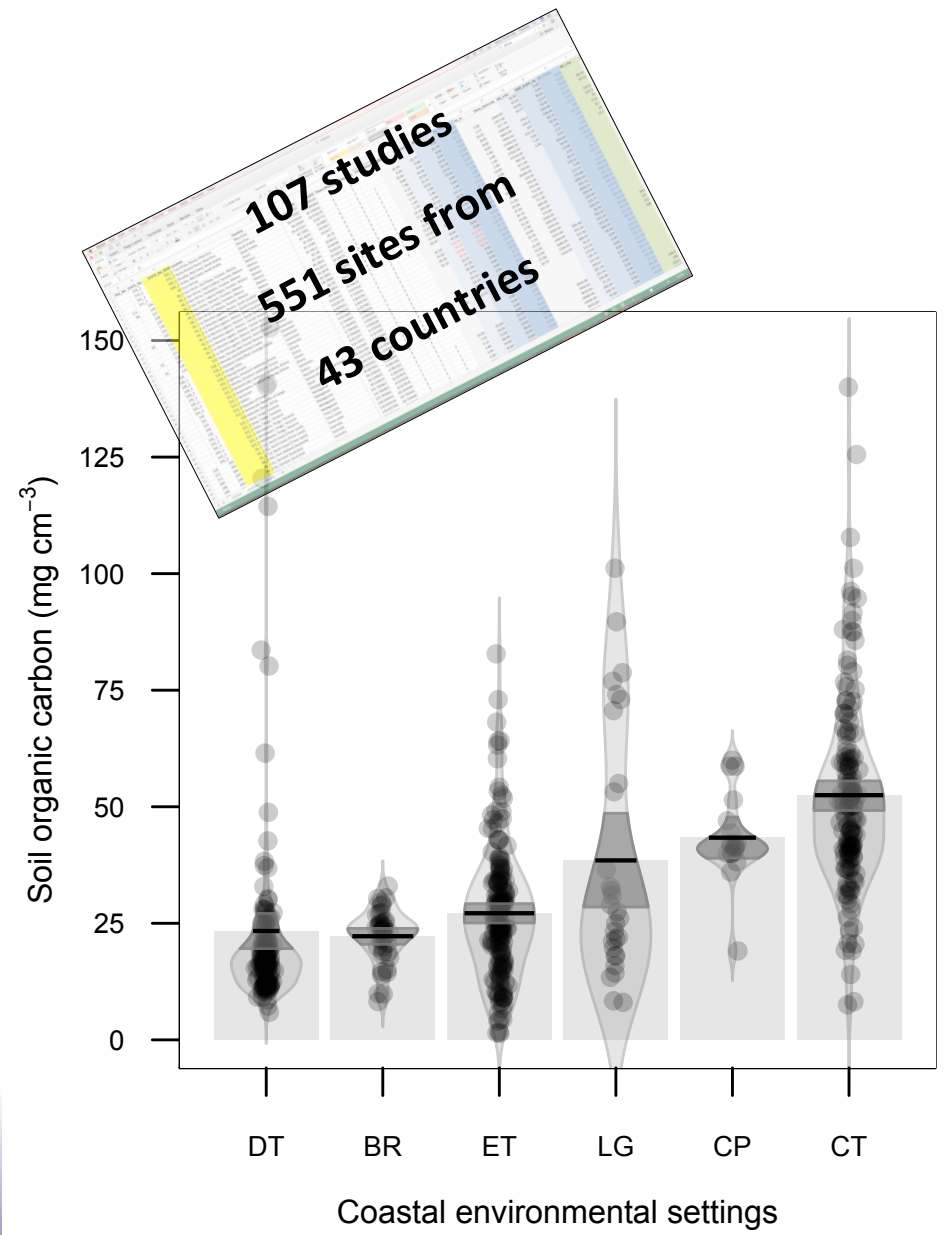
**107 studies**

**551 sites from**

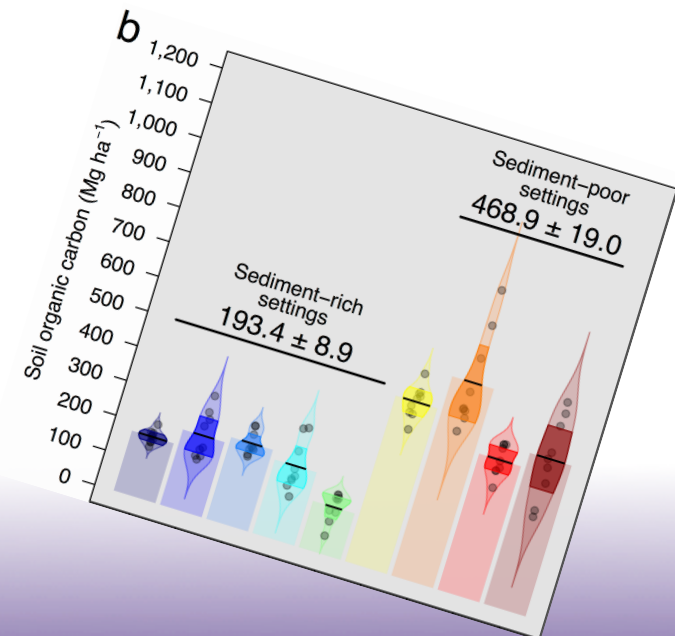
**43 countries**

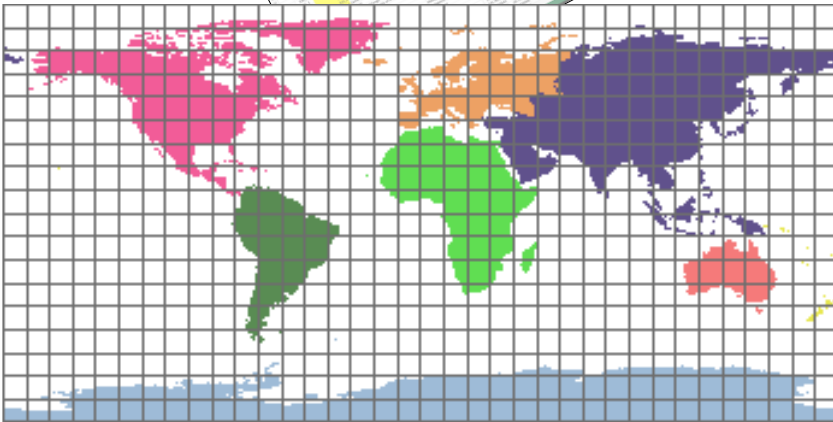


DT = DELTAS  
BR = BEDROCK  
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ET = ESTUARIES  
CP = COMPOSITE  
CT = CARBONATE

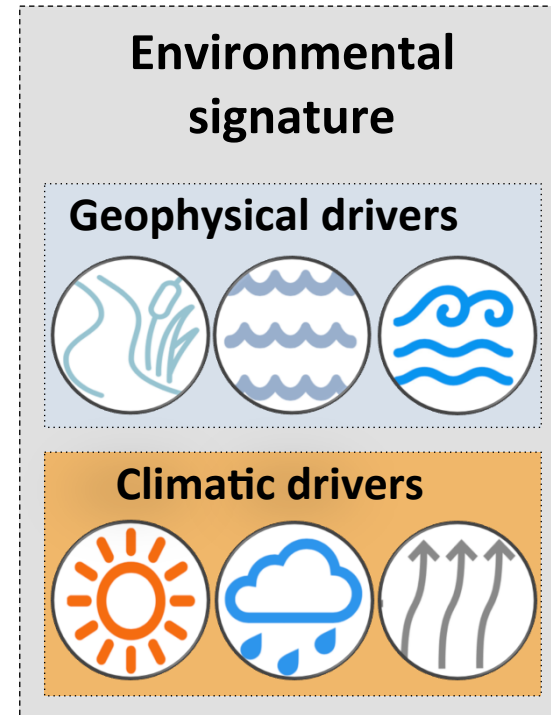


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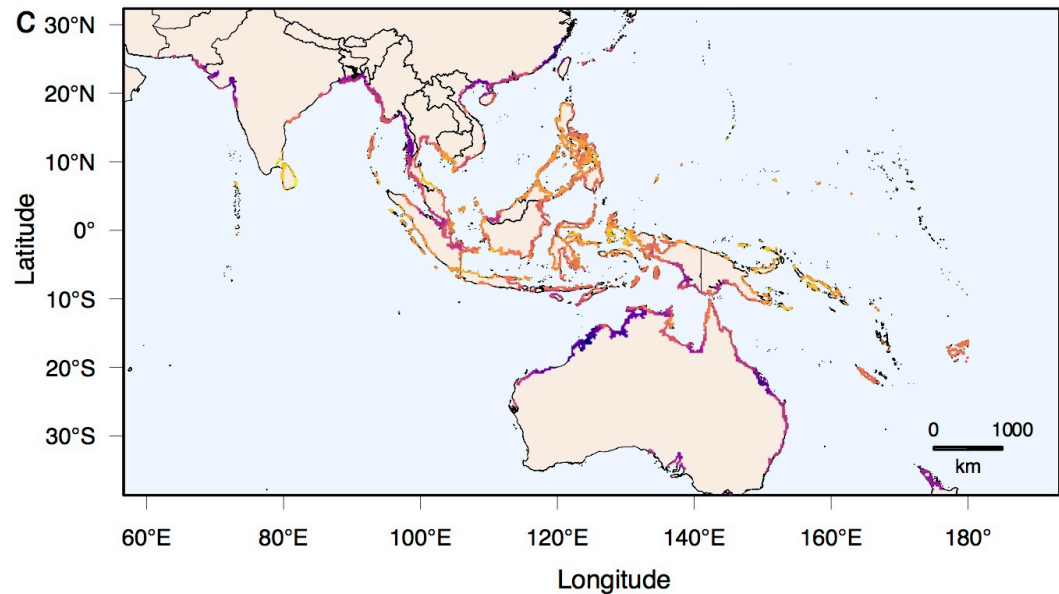
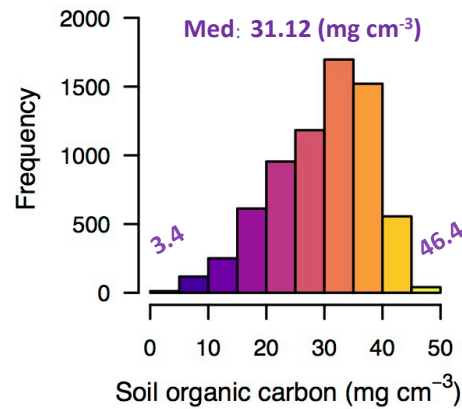
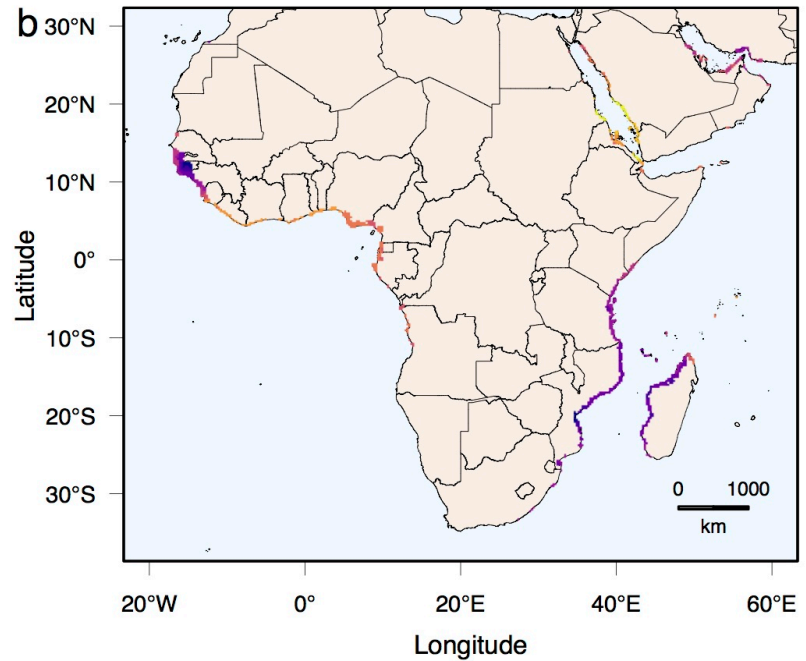
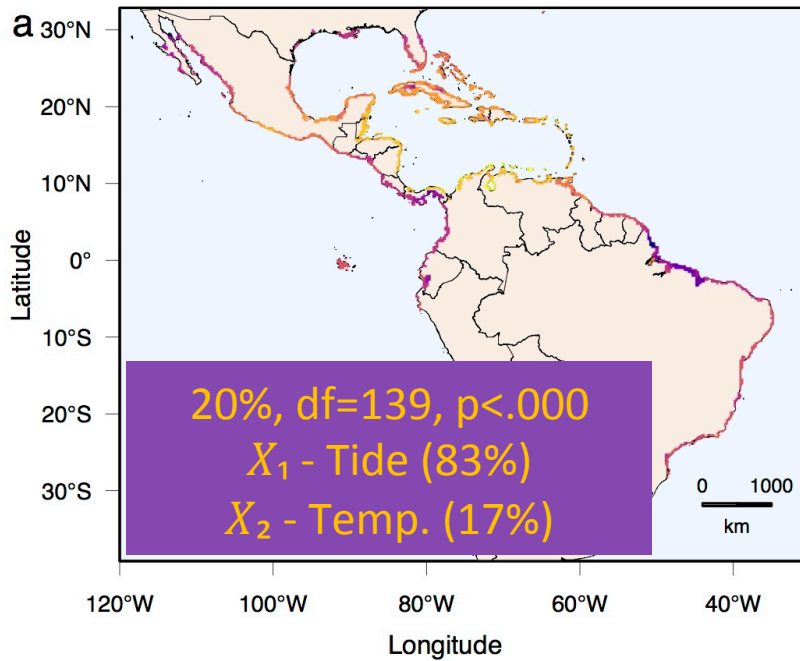
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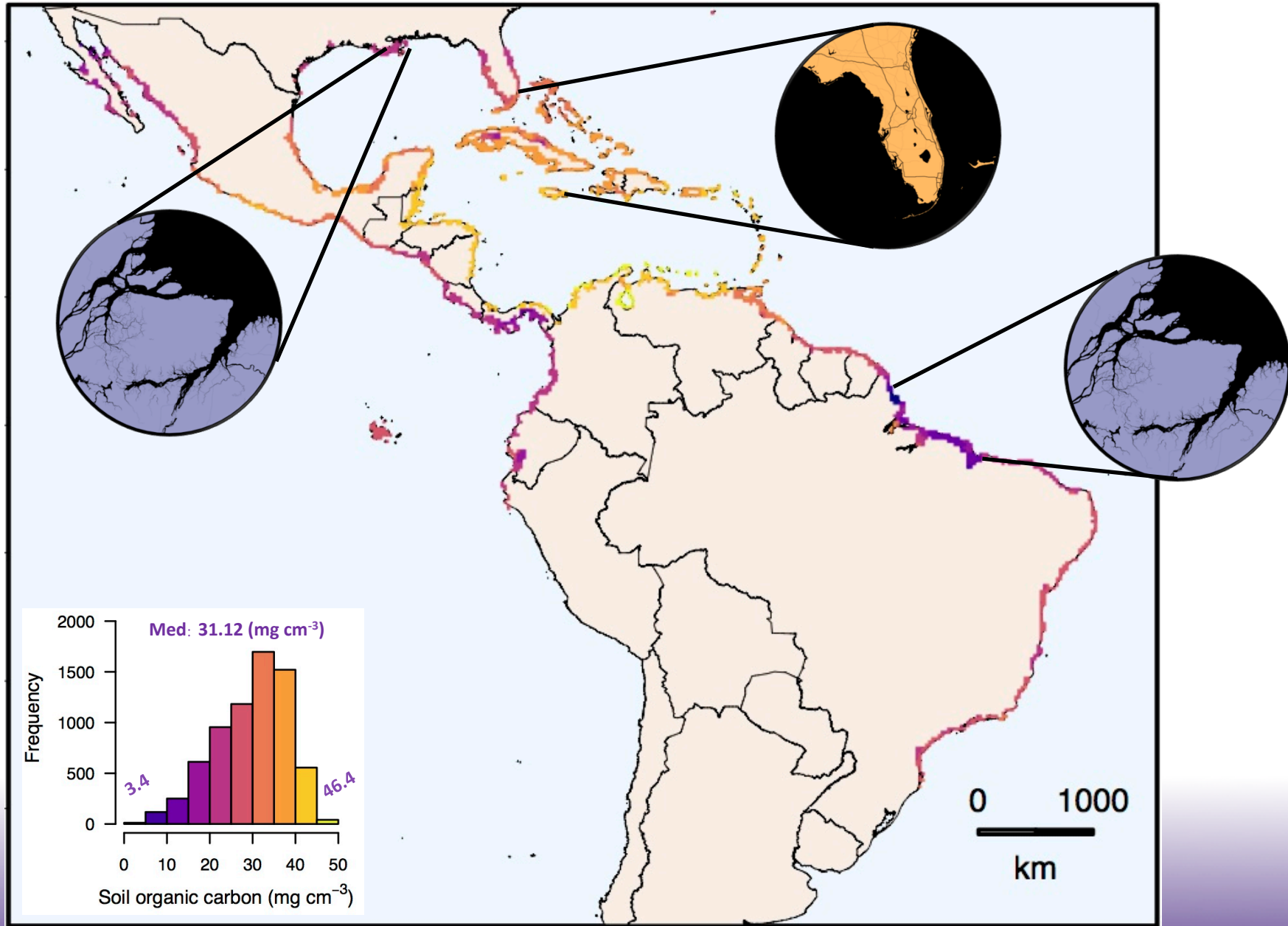


From Carrère et al. (2012), Fekete et al (2002),  
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### Part 3. Global controls on C storage in mangrove soils





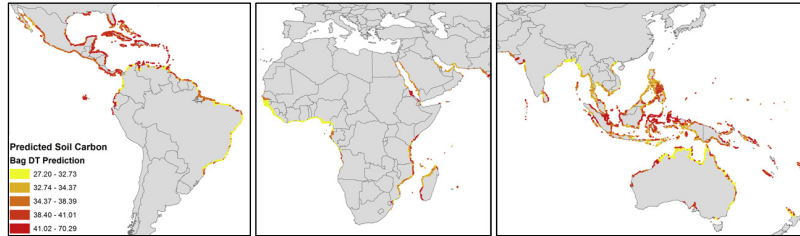


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Environmental Research Letters  
doi:10.1088/1748-9326/9/10/104013

## A global predictive model of carbon in mangrove soils

Sunny L Jardine<sup>1</sup> and Juha V Siikamäki<sup>2</sup>



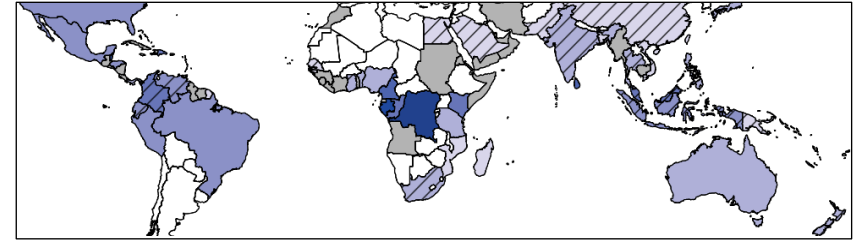
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## Global patterns in mangrove soil carbon stocks and losses

Atwood et al. (2017)



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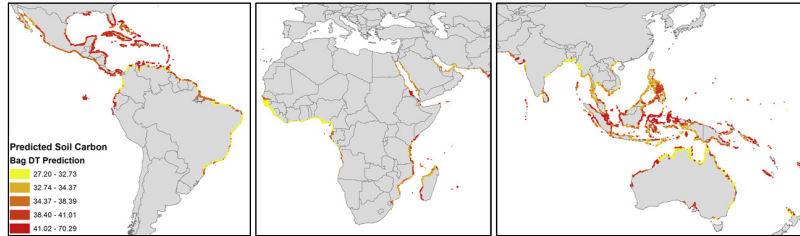
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Environmental Research Letters

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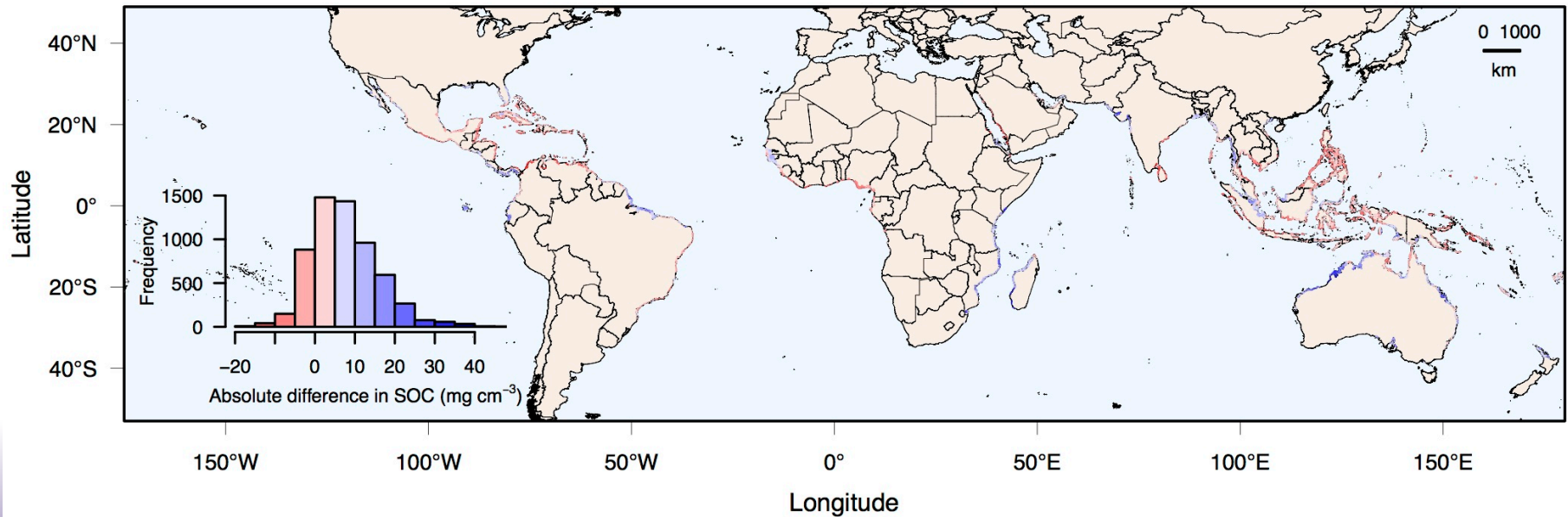
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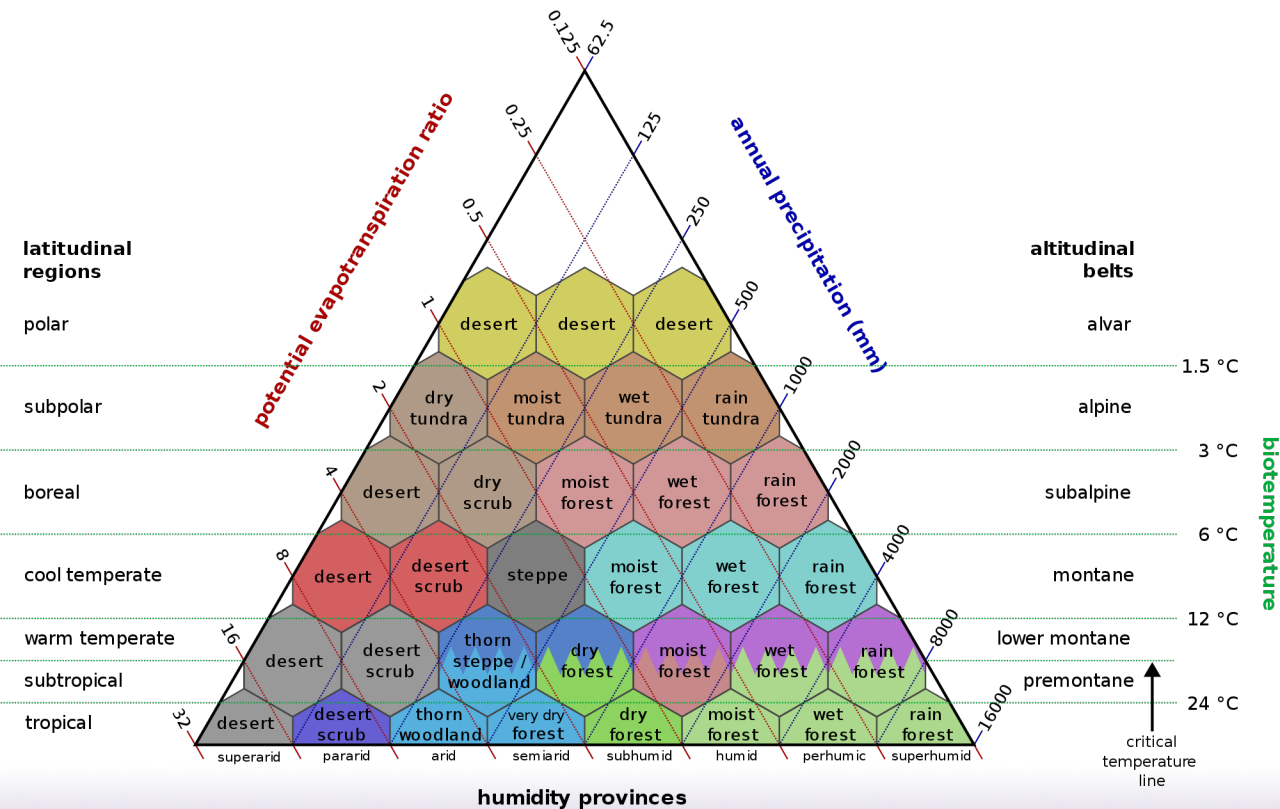
- **CES control C:N:P stoichiometry and SOC stocks in mangrove soils at the global scale;**

- **CES control C:N:P stoichiometry and SOC stocks in mangrove soils at the global scale;**
- **Mangrove SOC stocks increases from river-dominated ( $\sim 190$  Mg C ha<sup>-1</sup>) to carbonate, peat-dominated settings ( $\sim 550$  Mg C ha<sup>-1</sup>);**

- **SOC stocks have been underestimated by up to 50% (a difference of roughly 200 Mg ha<sup>-1</sup>) in carbonate settings, and overestimated by up to 86% (ca. 400 Mg ha<sup>-1</sup>) in deltaic coastlines;**

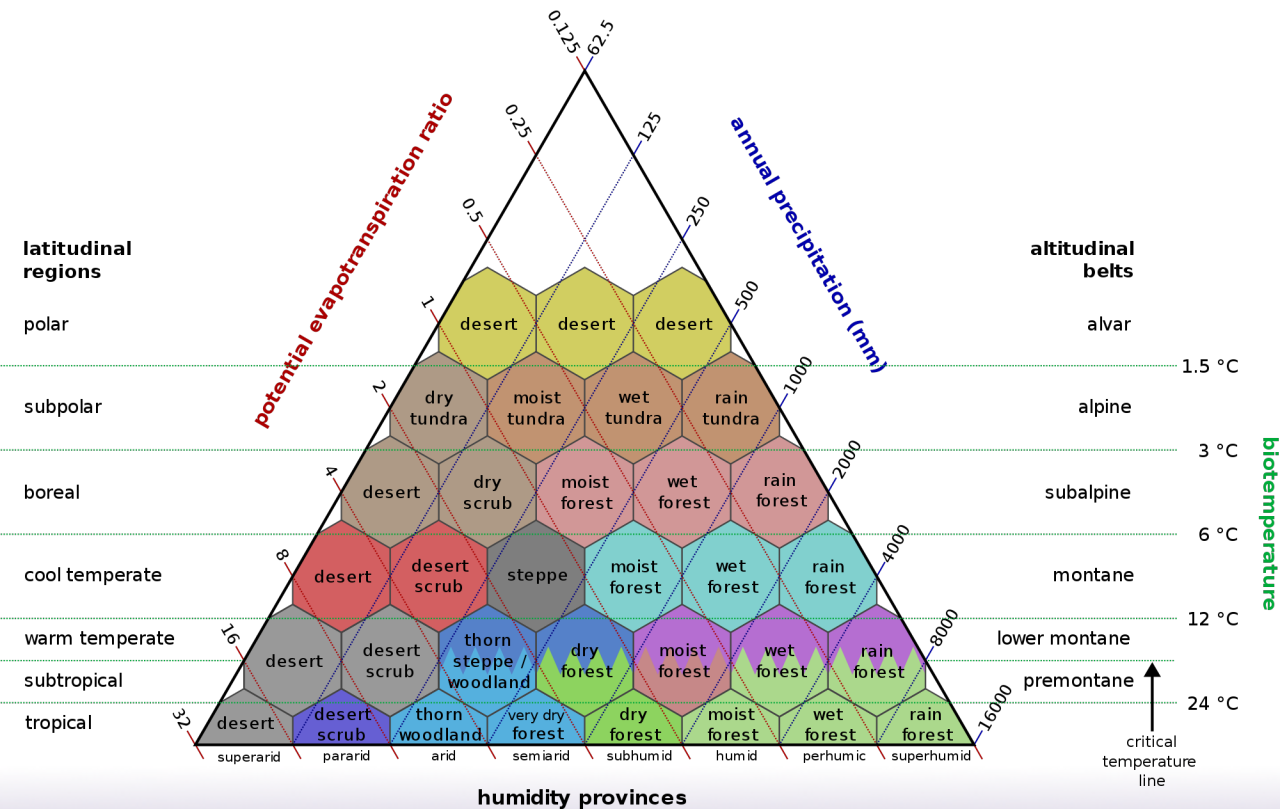
- **SOC stocks have been underestimated by up to 50% (a difference of roughly 200 Mg ha<sup>-1</sup>) in carbonate settings, and overestimated by up to 86% (ca. 400 Mg ha<sup>-1</sup>) in deltaic coastlines;**
- **The CES approach improves current global mangrove SOC stock estimates, specially in terms of spatial variability;**

# Holdridge life zones (1947,1967)

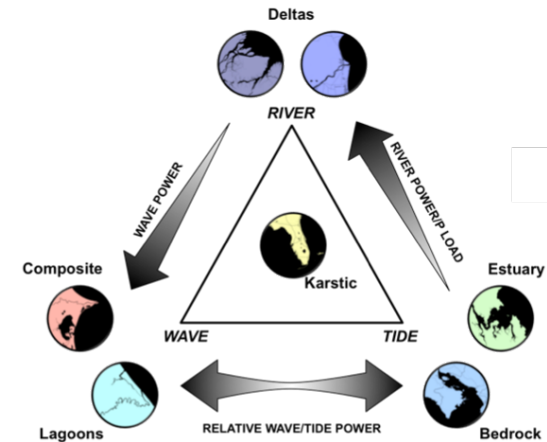




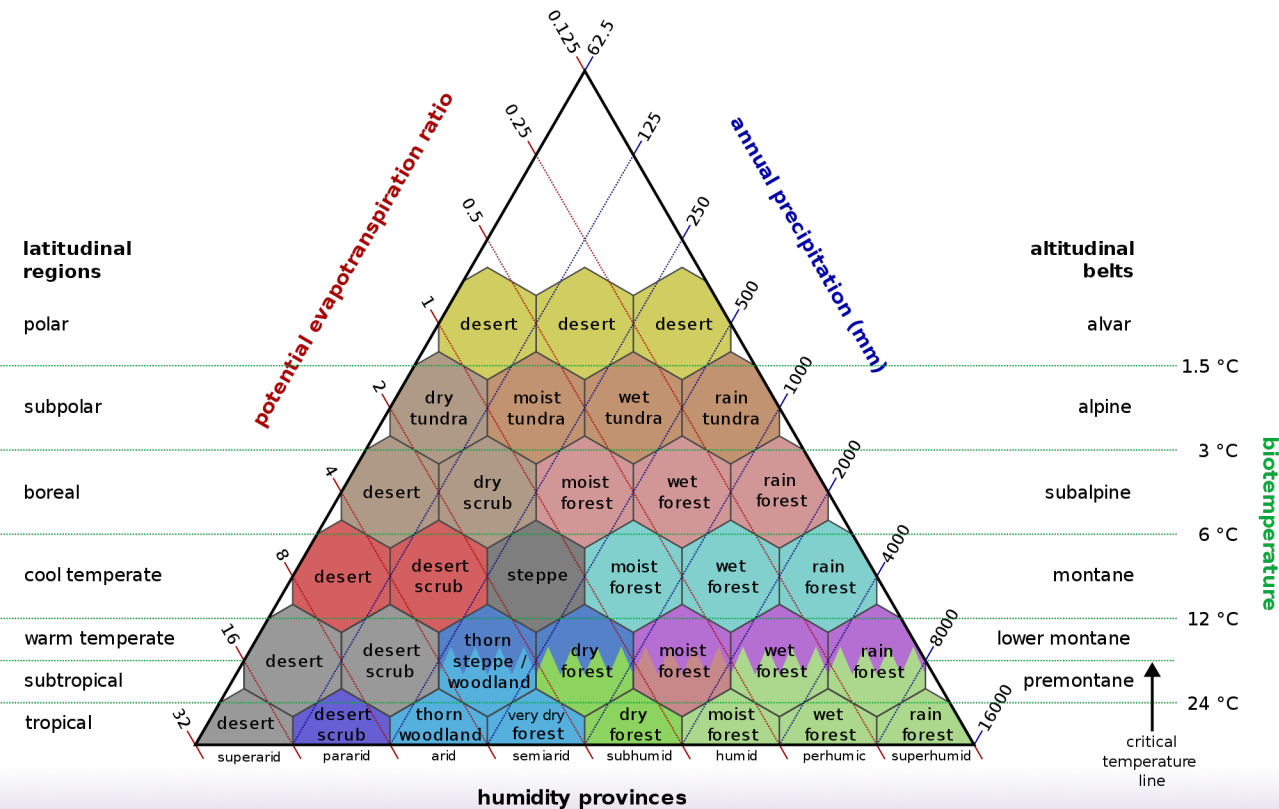
# Holdridge life zones (1947,1967)



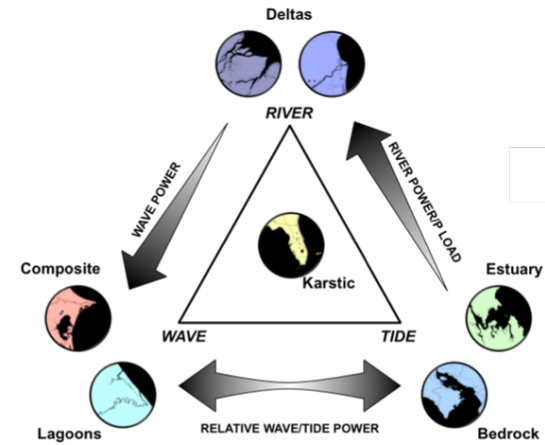
## COASTAL PROCESSES



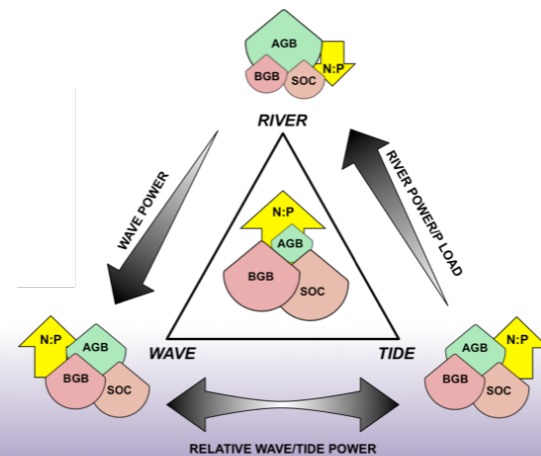
# Holdridge life zones (1947,1967)



## COASTAL PROCESSES



## CARBON ALLOCATION



ALL MODELS ARE WRONG  
BUT SOME ARE USEFUL  
G. E. P. Box 1954

# THANK YOU!!

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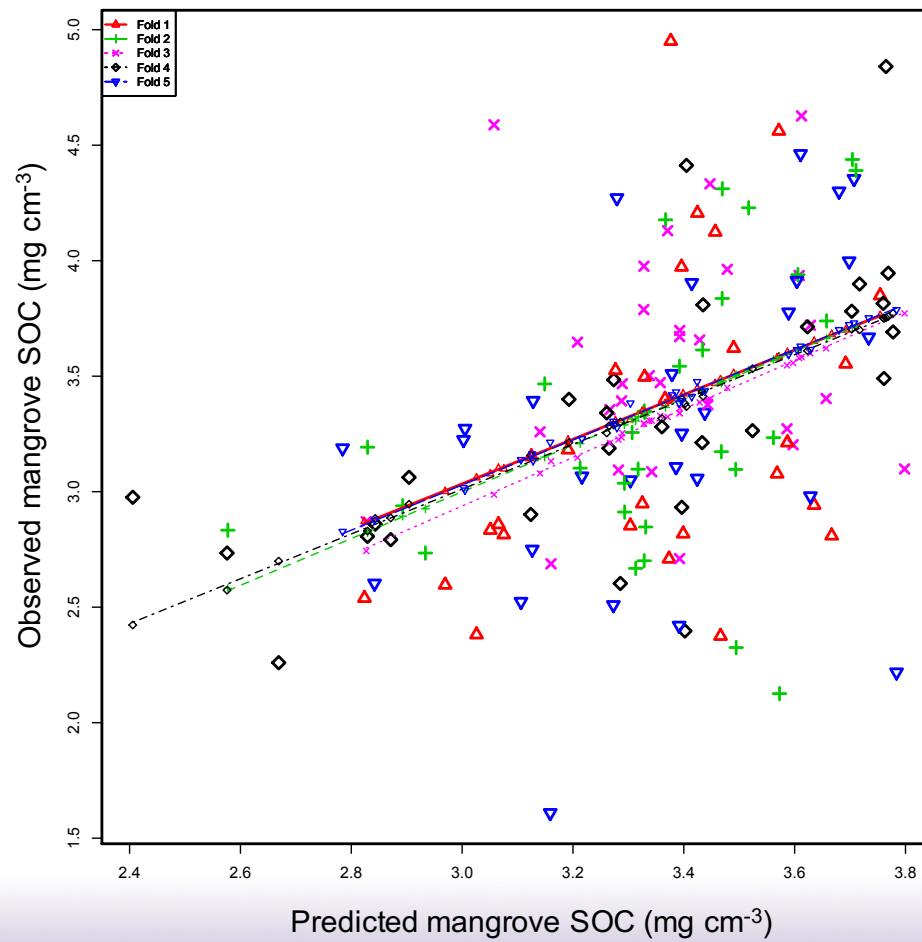
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# THANK YOU!!

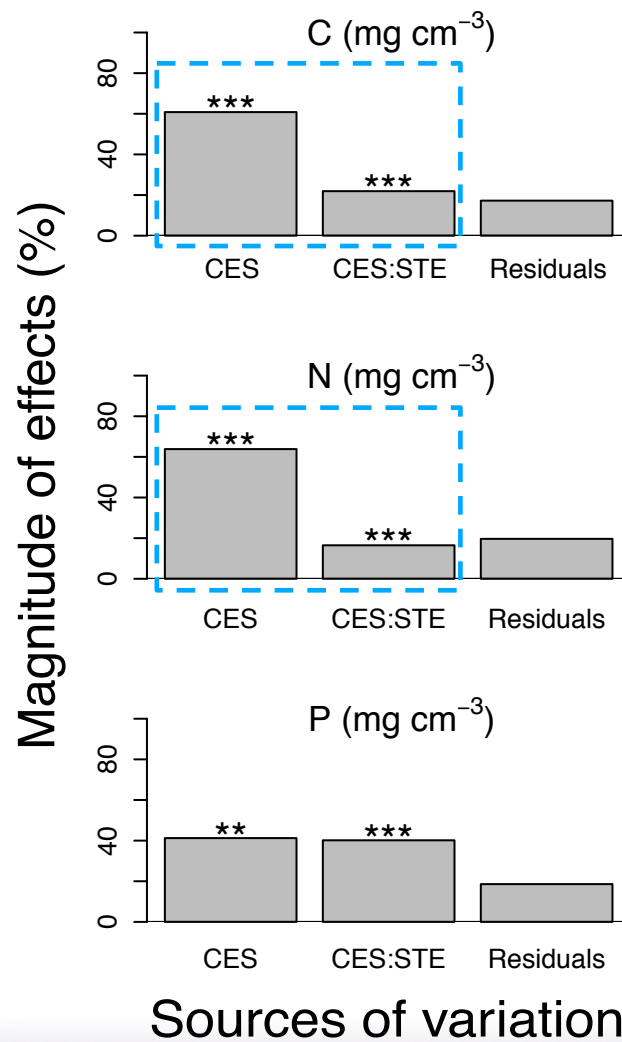
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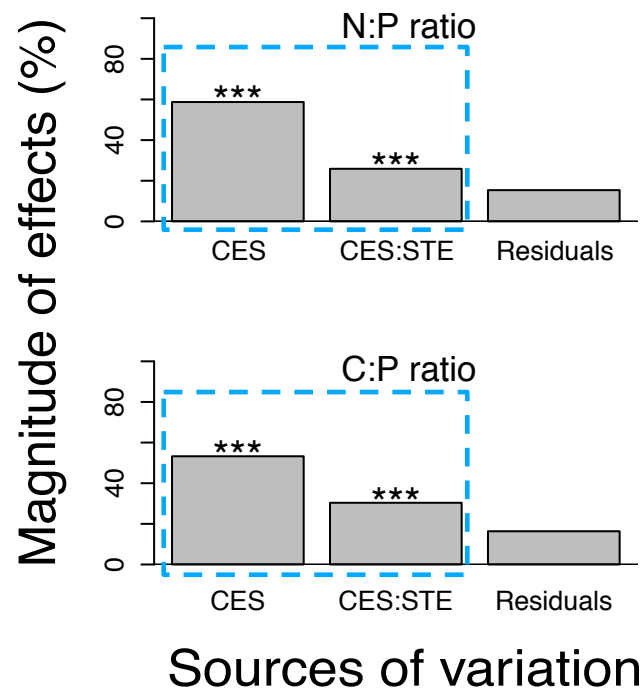
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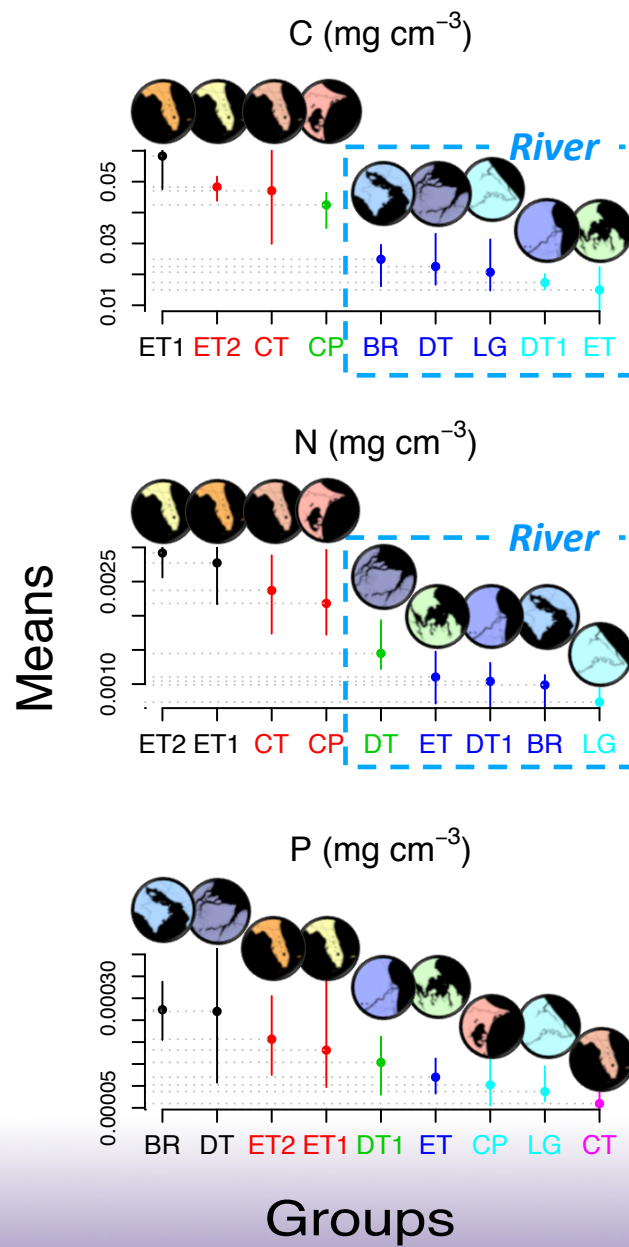
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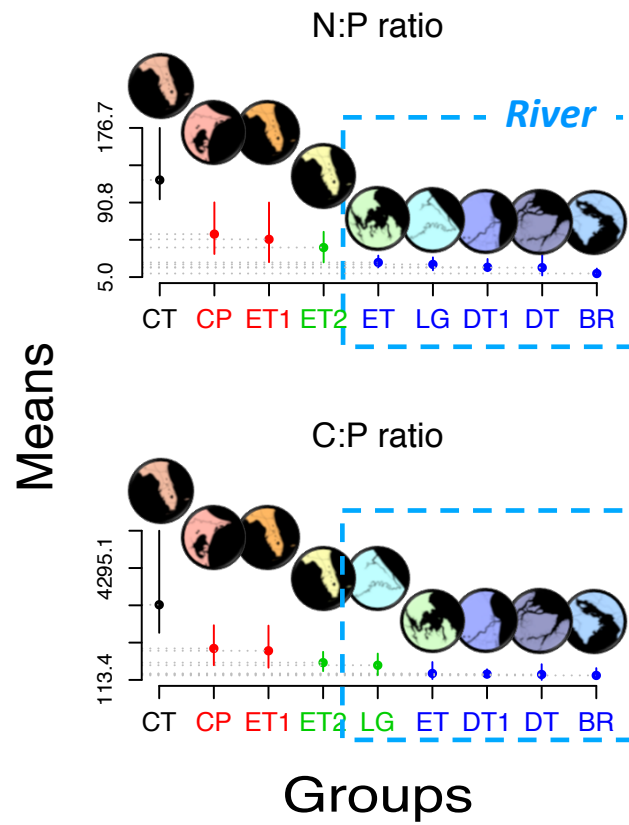


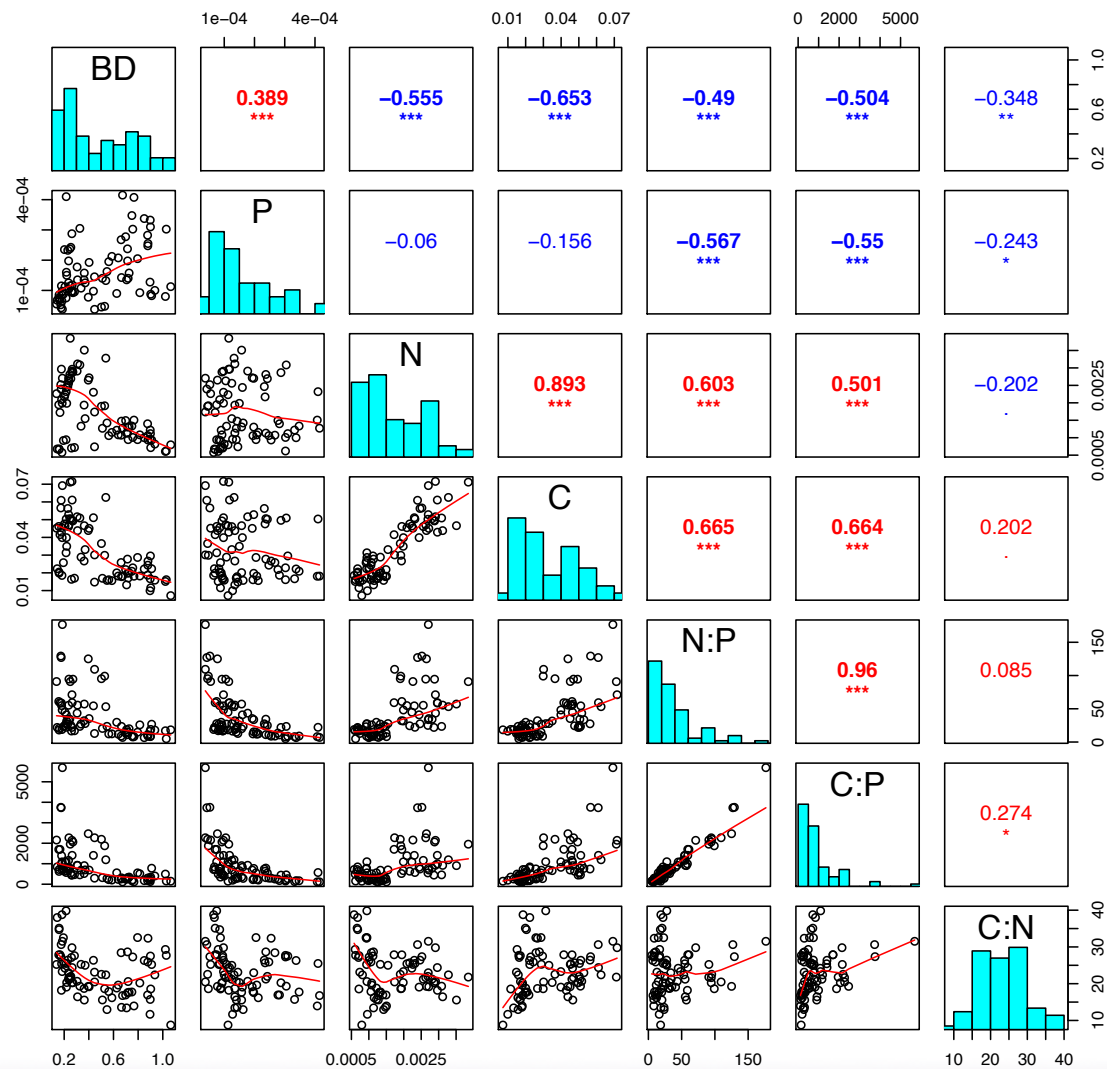


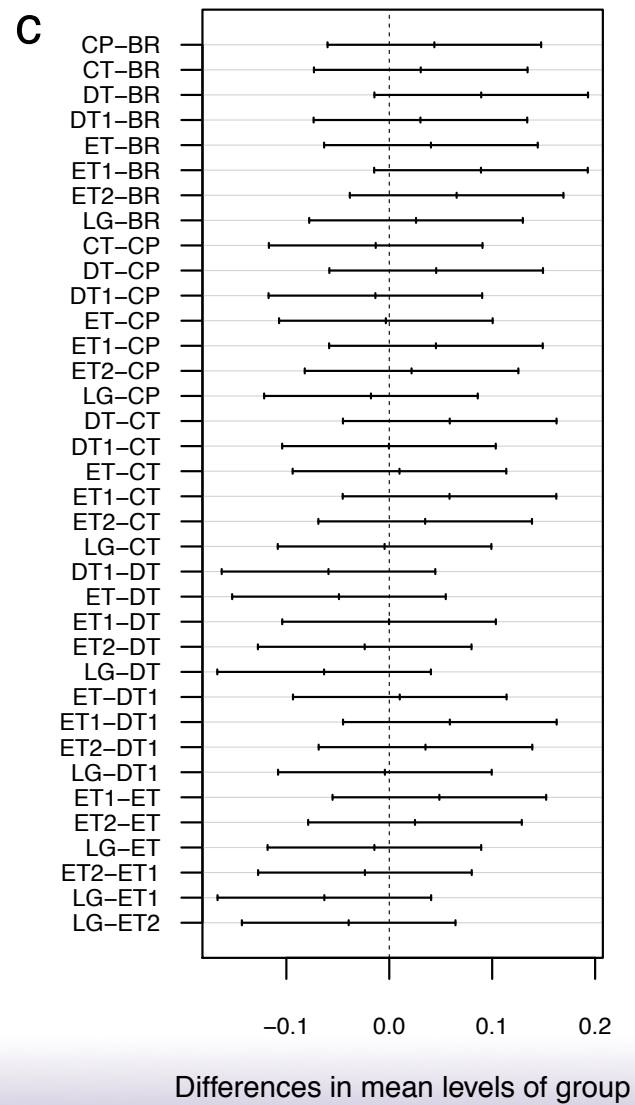
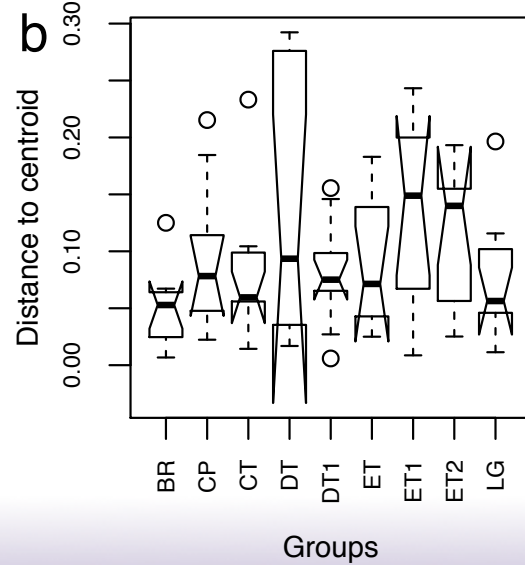
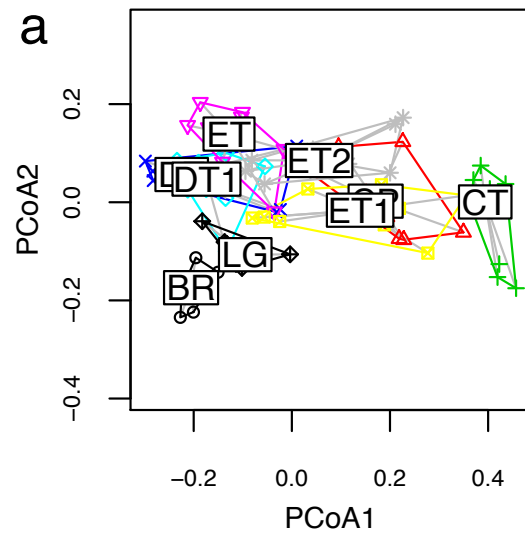




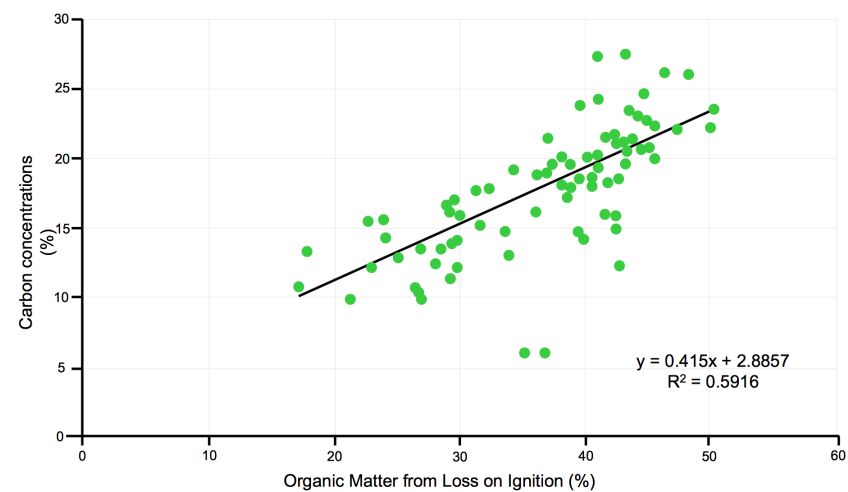
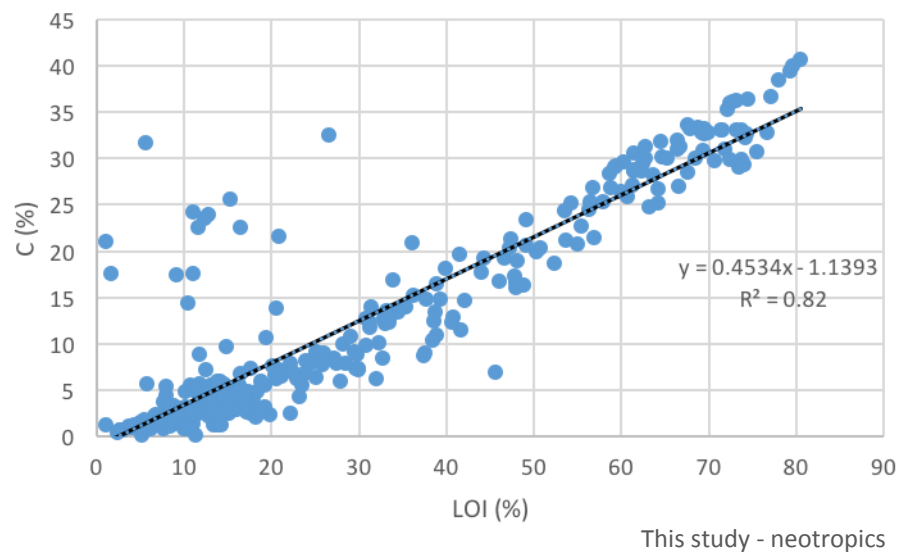












**Figure D1** The relationship of organic matter calculated via loss on ignition to carbon concentration (percent) calculated via dry combustion for mangrove soil samples from the republic of Palau (Kauffman *et al.* 2011).

Howard *et al.* (2014) - high oceanic island

