Mangrove encroachment into marshes alters belowground organic matter dynamics with implications for surface elevation and resistance to sea level rise

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Acknowledgements

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

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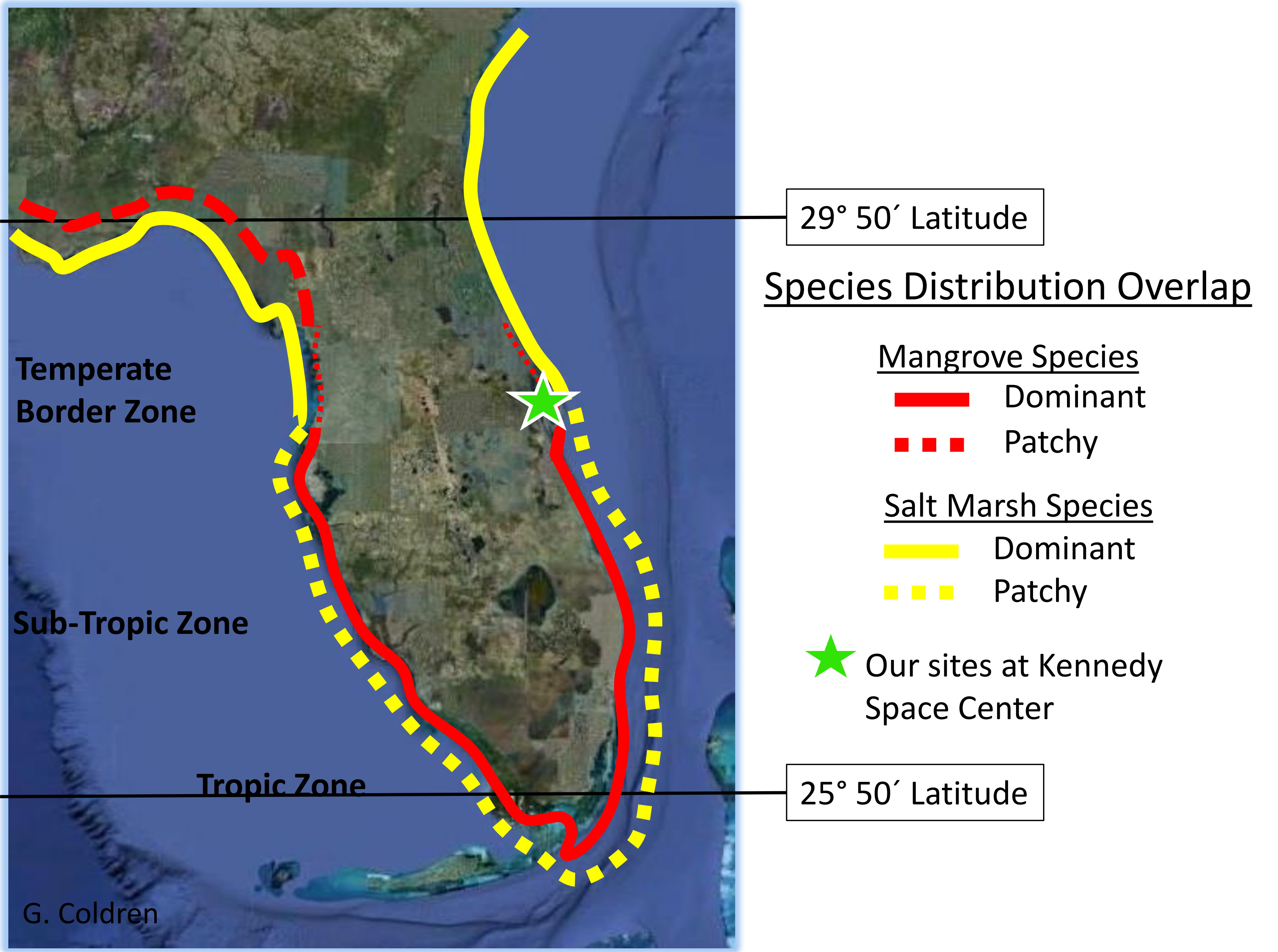

29° 50´ Latitude
Species Distribution Overlap
Mangrove Species
Dominant
Patchy
Salt Marsh Species
Dominant
Patchy
Our sites at Kennedy Space Center
Temperate Border Zone
Sub-Tropic Zone
Tropic Zone
25° 50´ Latitude
G. Coldren

Root biomass with mangroves ↑

Estuaries and Coasts
DOI 10.1007/s12237-015-9993-8

Mangrove Range Expansion Rapidly Increases Coastal Wetland Carbon Storage

Cheryl L. Doughty[1] · J. Adam Langley[1] · Wayne S. Walker[2] · Ilka C. Feller[3] · Ronald Schaub[4] · Samantha K. Chapman[1]

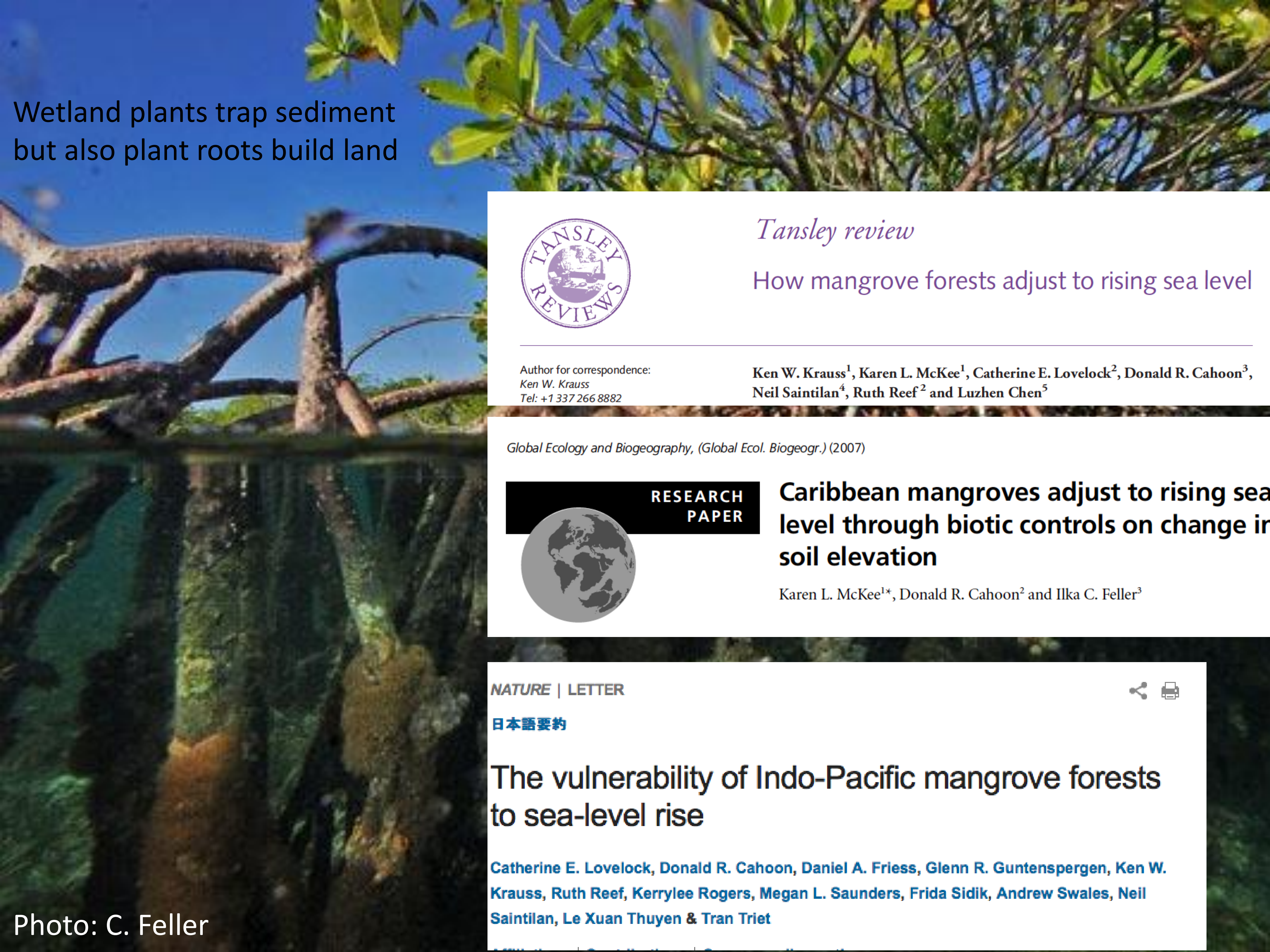
Root biomass with warming ↓

Chronic warming stimulates growth of marsh grasses more than mangroves in a coastal wetland ecotone

G. A. Coldren[1], C. Barreto[1], D. Wykoff [1], E. Morrissey[2], J. Adam Langley[1], I.C. Feller[3], and S.K. Chapman[1*]

Ecology, *in press*

Wetland plants trap sediment
but also plant roots build land



Tansley review

How mangrove forests adjust to rising sea level

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Ken W. Krauss
Tel: +1 337 266 8882

Ken W. Krauss[1], Karen L. McKee[1], Catherine E. Lovelock[2], Donald R. Cahoon[3], Neil Saintilan[4], Ruth Reef[2] and Luzhen Chen[5]

Global Ecology and Biogeography, (Global Ecol. Biogeogr.) (2007)

RESEARCH PAPER

Caribbean mangroves adjust to rising sea level through biotic controls on change in soil elevation

Karen L. McKee[1*], Donald R. Cahoon[2] and Ilka C. Feller[3]

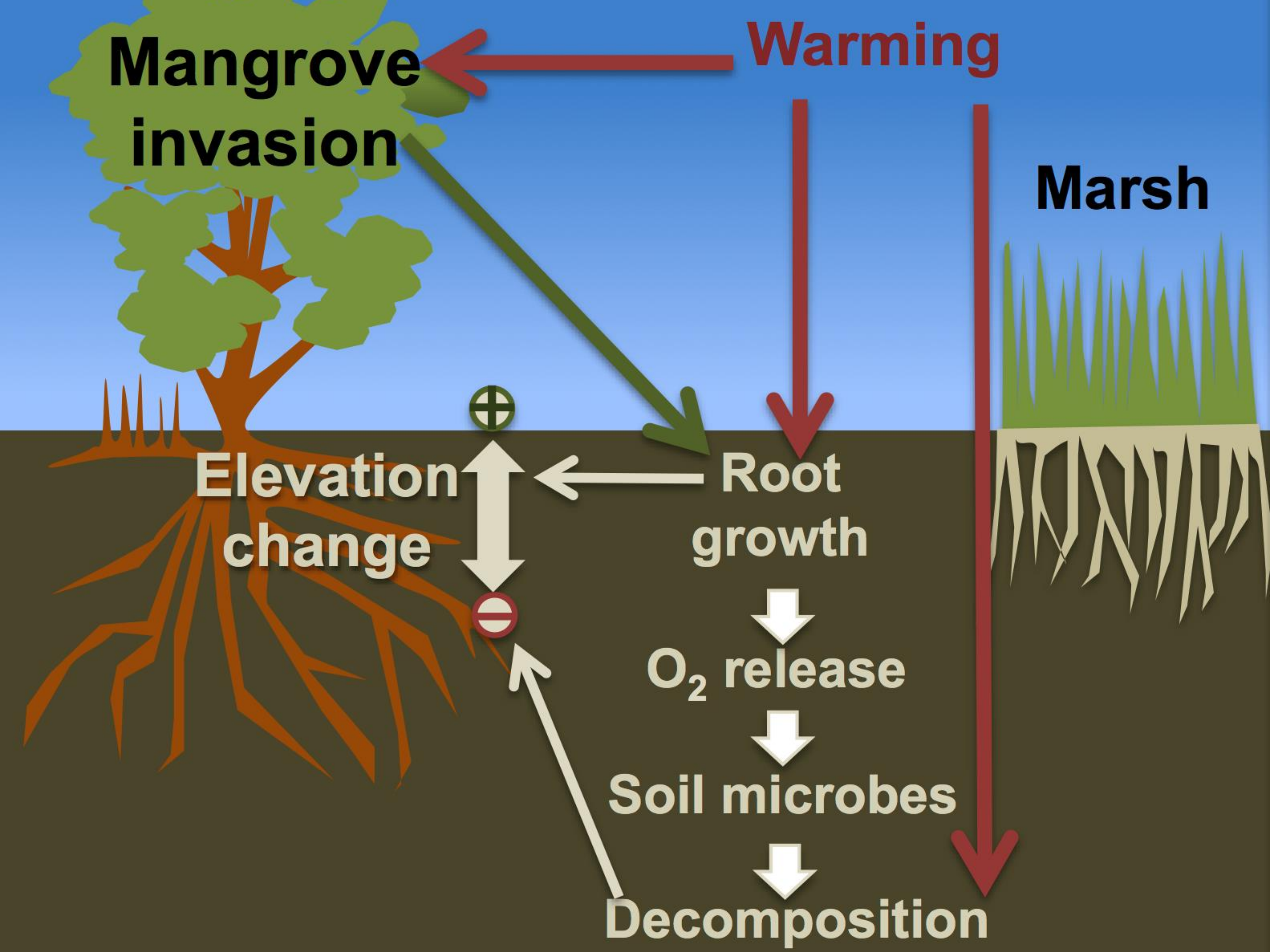
NATURE | LETTER

日本語要約

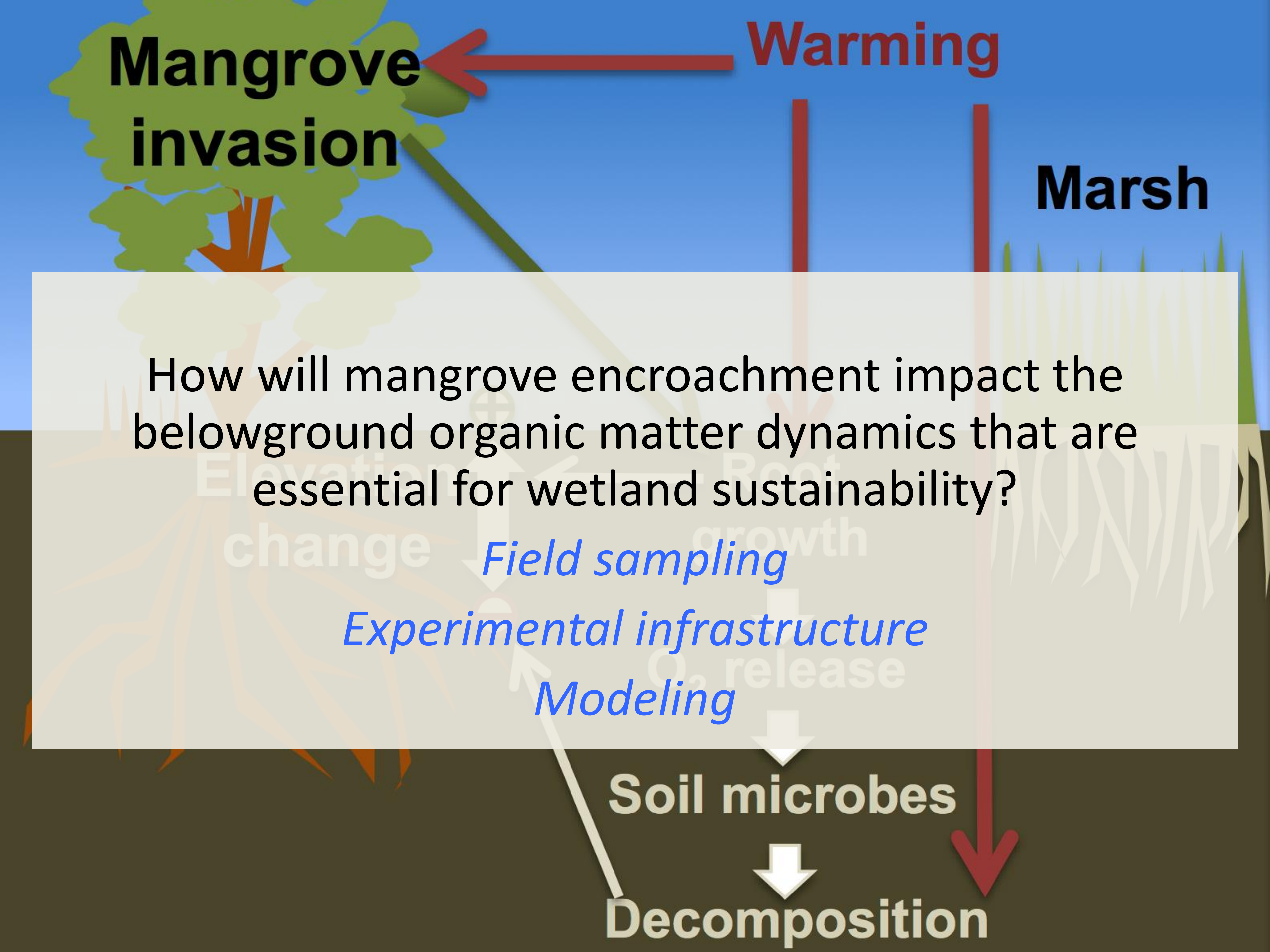
The vulnerability of Indo-Pacific mangrove forests to sea-level rise

Catherine E. Lovelock, Donald R. Cahoon, Daniel A. Friess, Glenn R. Guntenspergen, Ken W. Krauss, Ruth Reef, Kerrylee Rogers, Megan L. Saunders, Frida Sidik, Andrew Swales, Neil Saintilan, Le Xuan Thuyen & Tran Triet

Photo: C. Feller



Mangrove invasion
Warming
Marsh
Elevation change
Root growth
O_2 release
Soil microbes
Decomposition



How will mangrove encroachment impact the belowground organic matter dynamics that are essential for wetland sustainability?

Field sampling

Experimental infrastructure

Modeling

N=10

Mangrove Zone

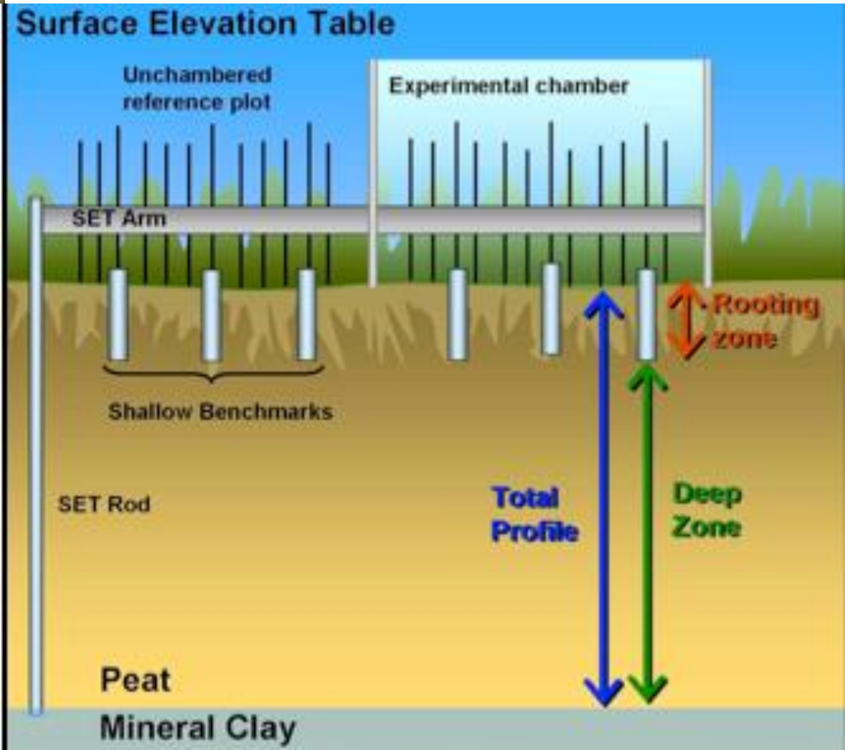
7m

Salt Marsh Zone

Root productivity via Ingrowth bags

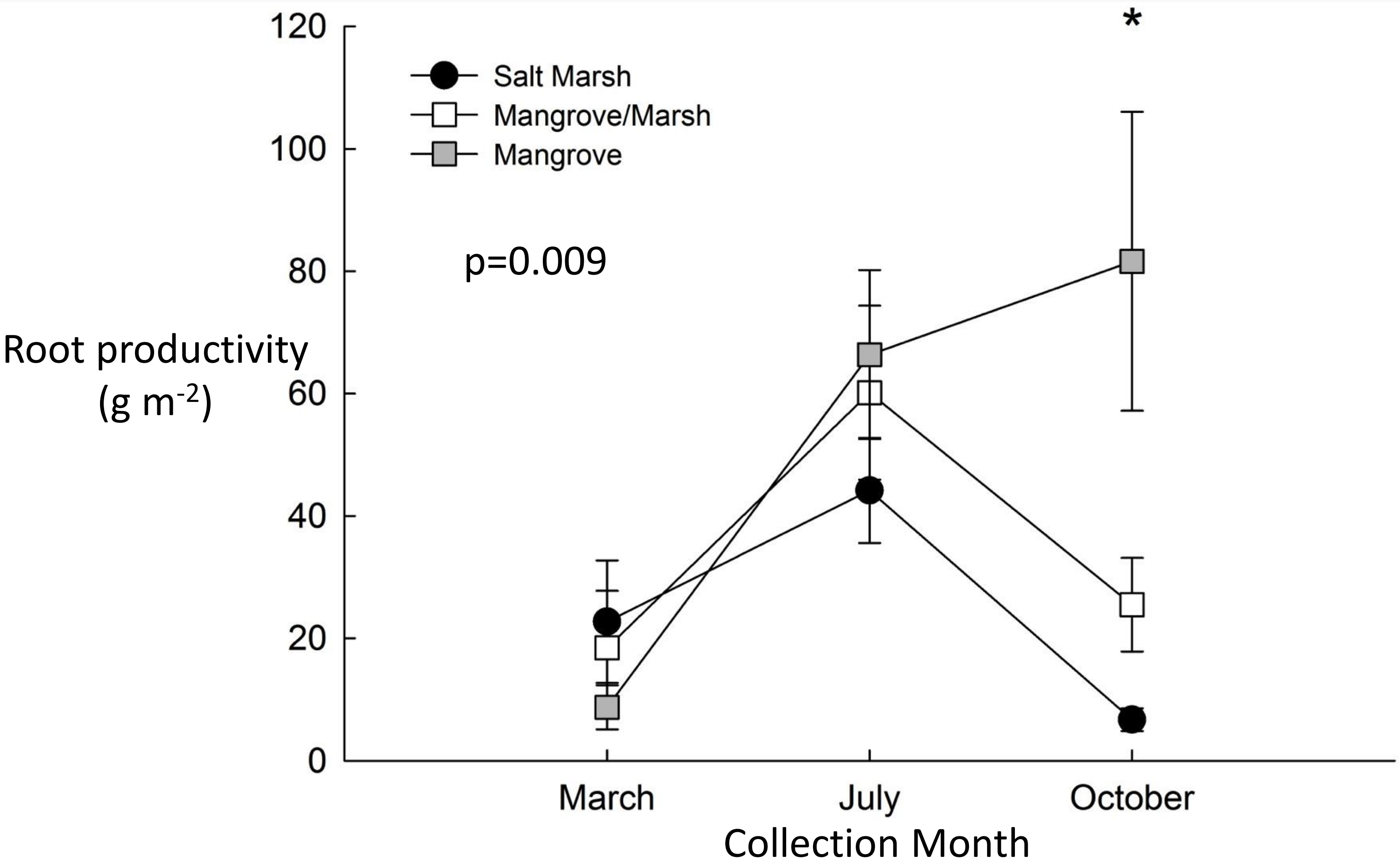
Root decomposition via Litter bags

Surface elevation measurements

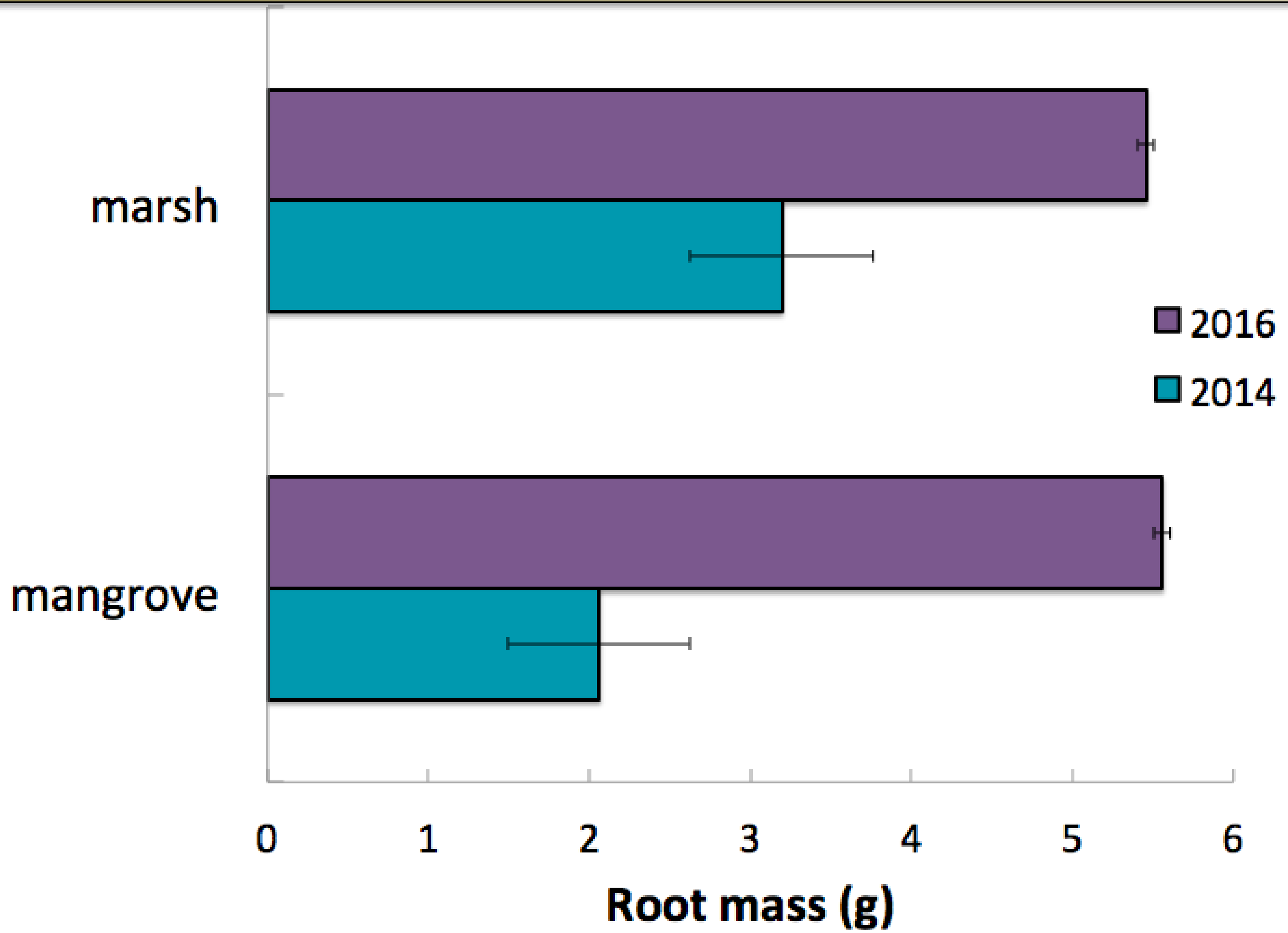


Root ingrowth changes due to mangrove encroachment

Mangrove Zone 7m Salt Marsh Zone



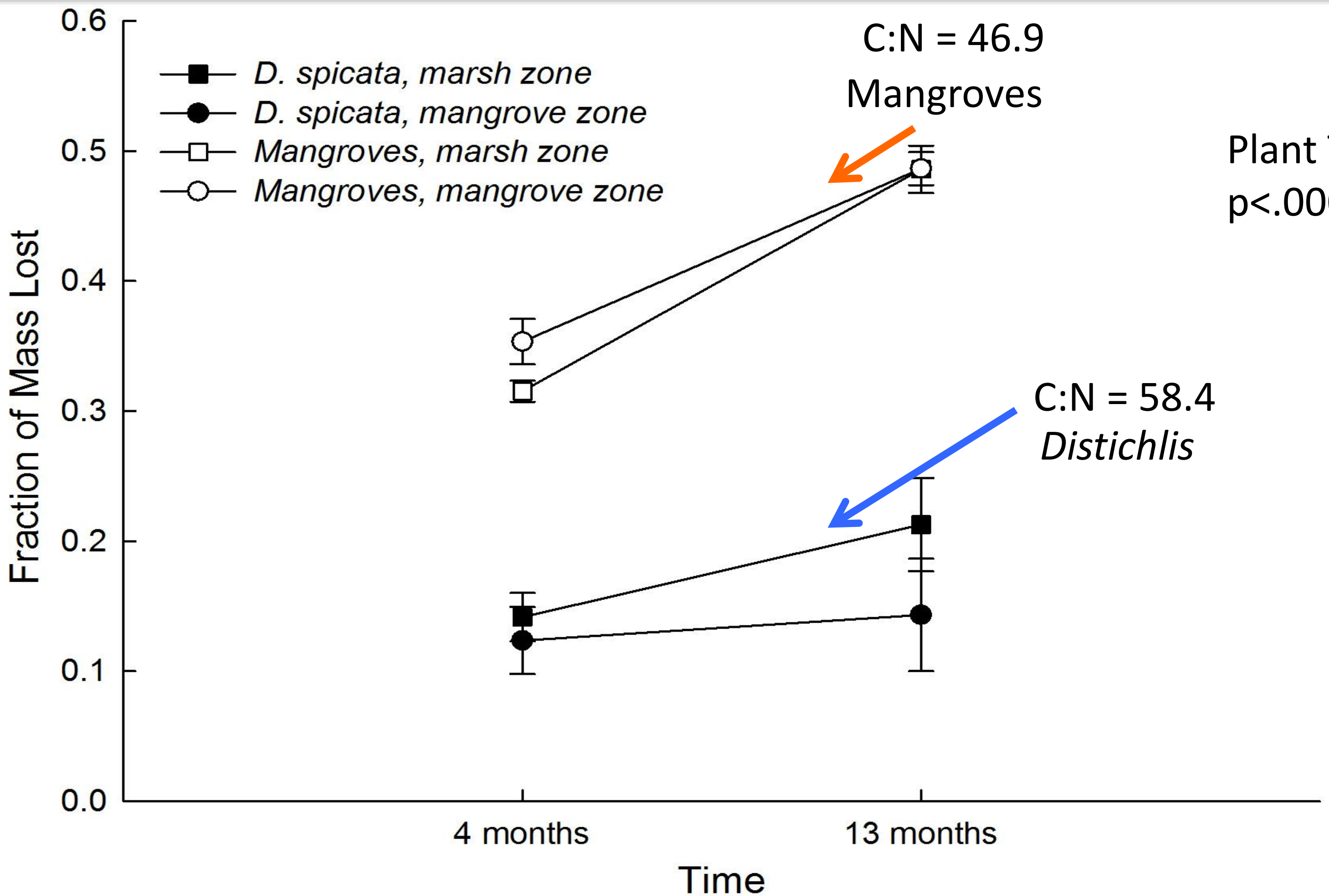
Root mass changes with mangrove encroachment progression



Marsh had significantly more roots in 2014 (p=0.05)

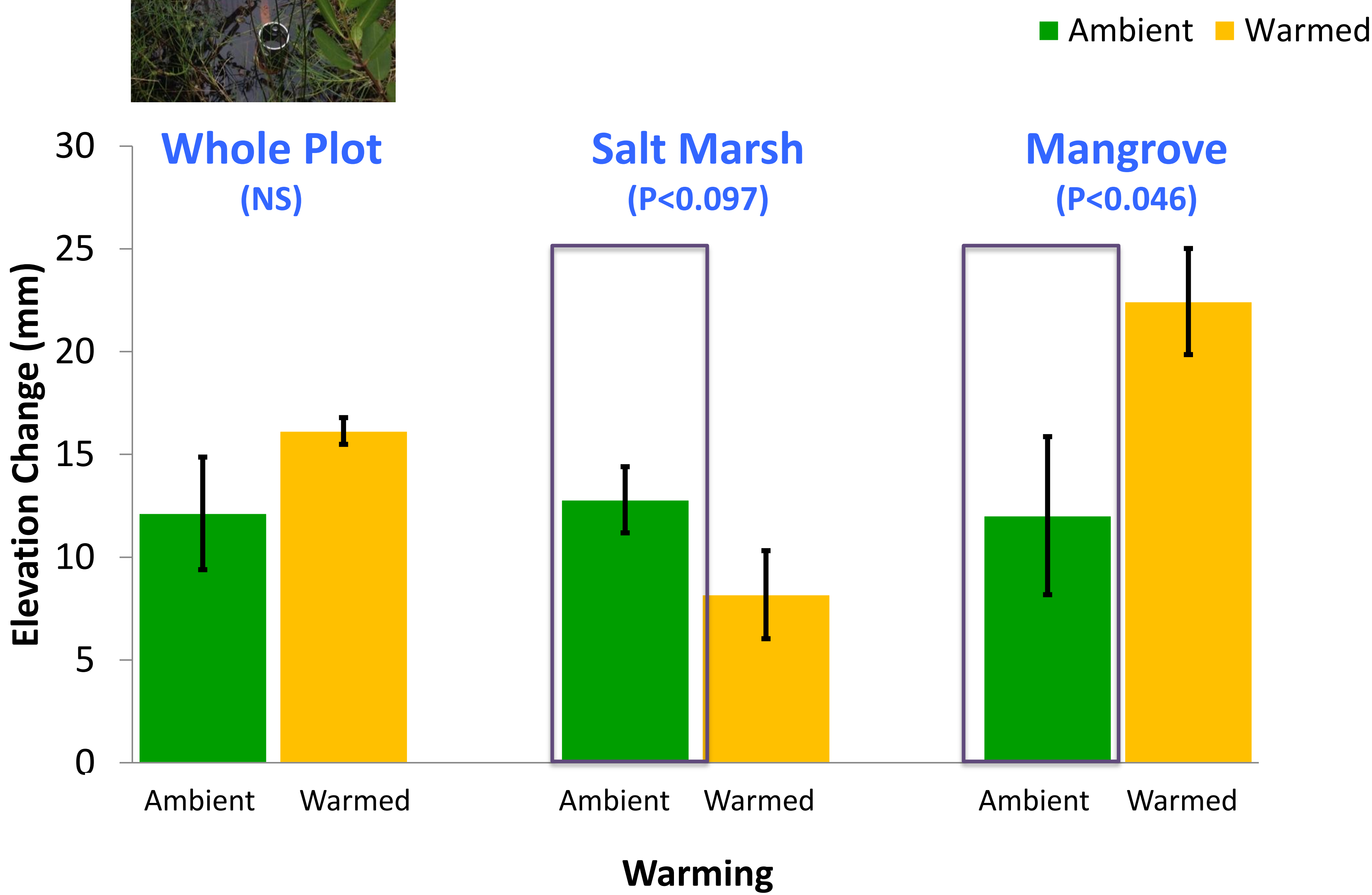
No difference in 2016

Root decomposition changes due to mangrove invasion

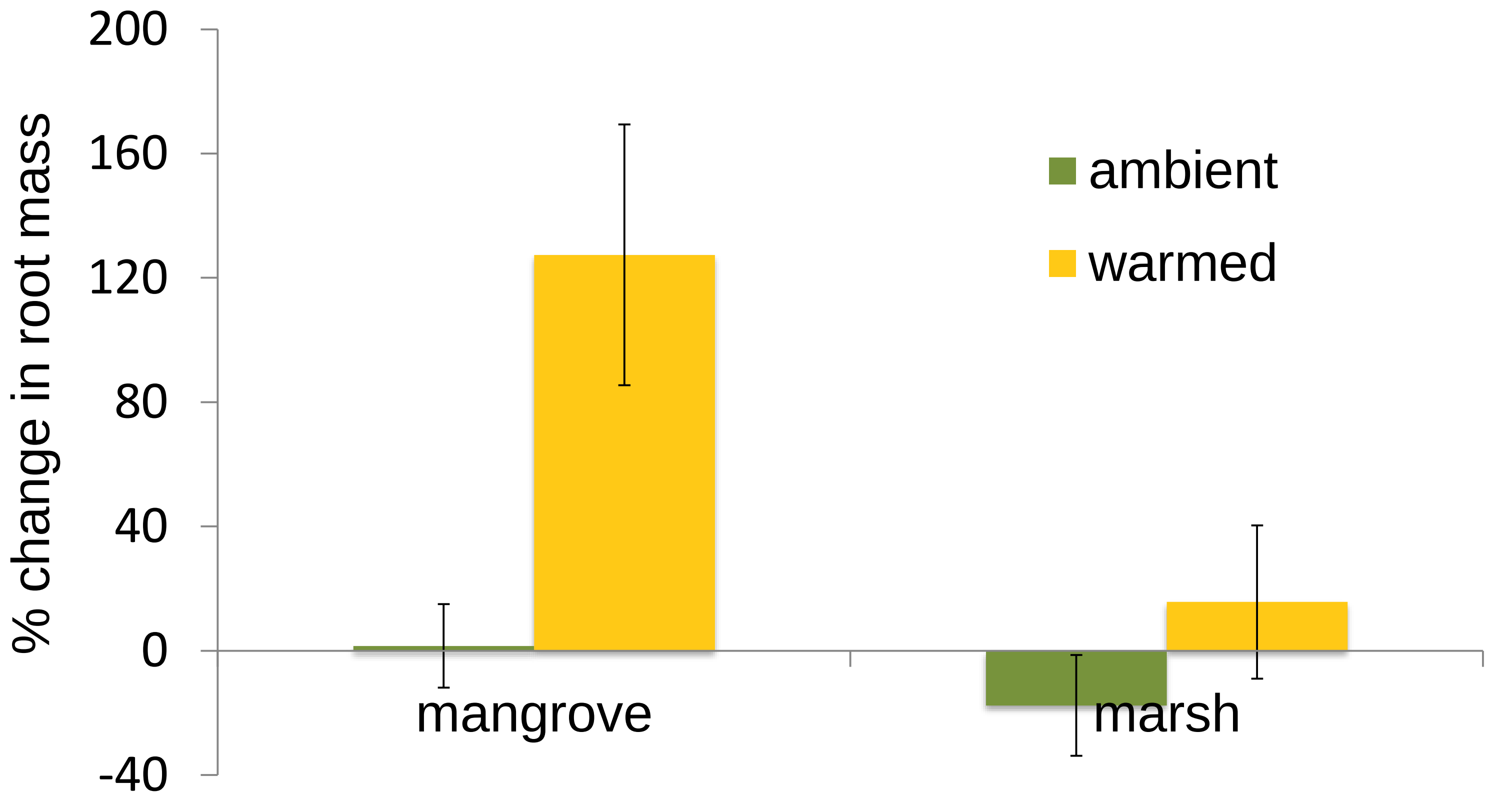


Plant Type Factor:
$p<.0001$

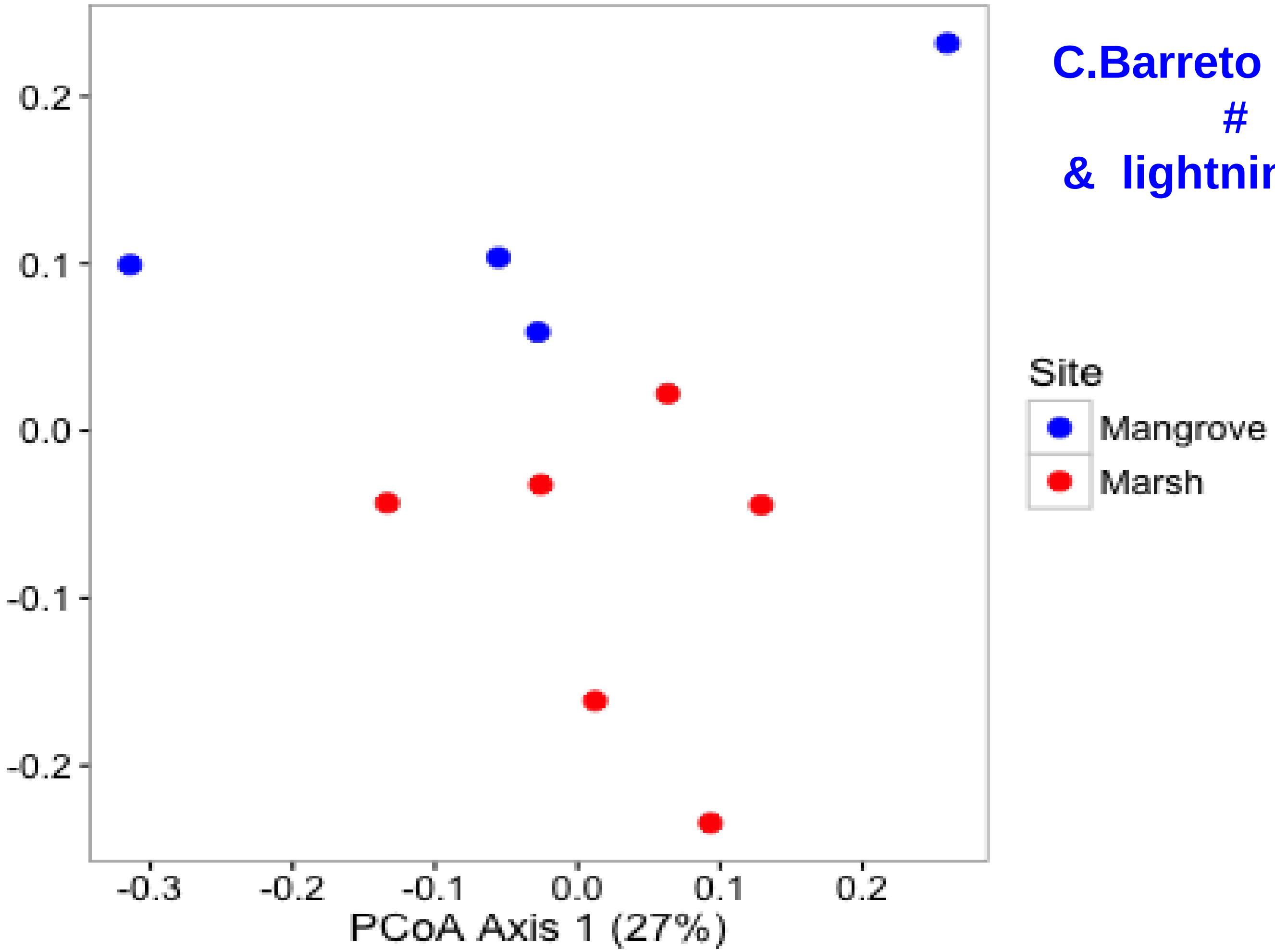
Sediment Elevation Change (22 Months)



Mangrove plot root mass increased over two years due to warming

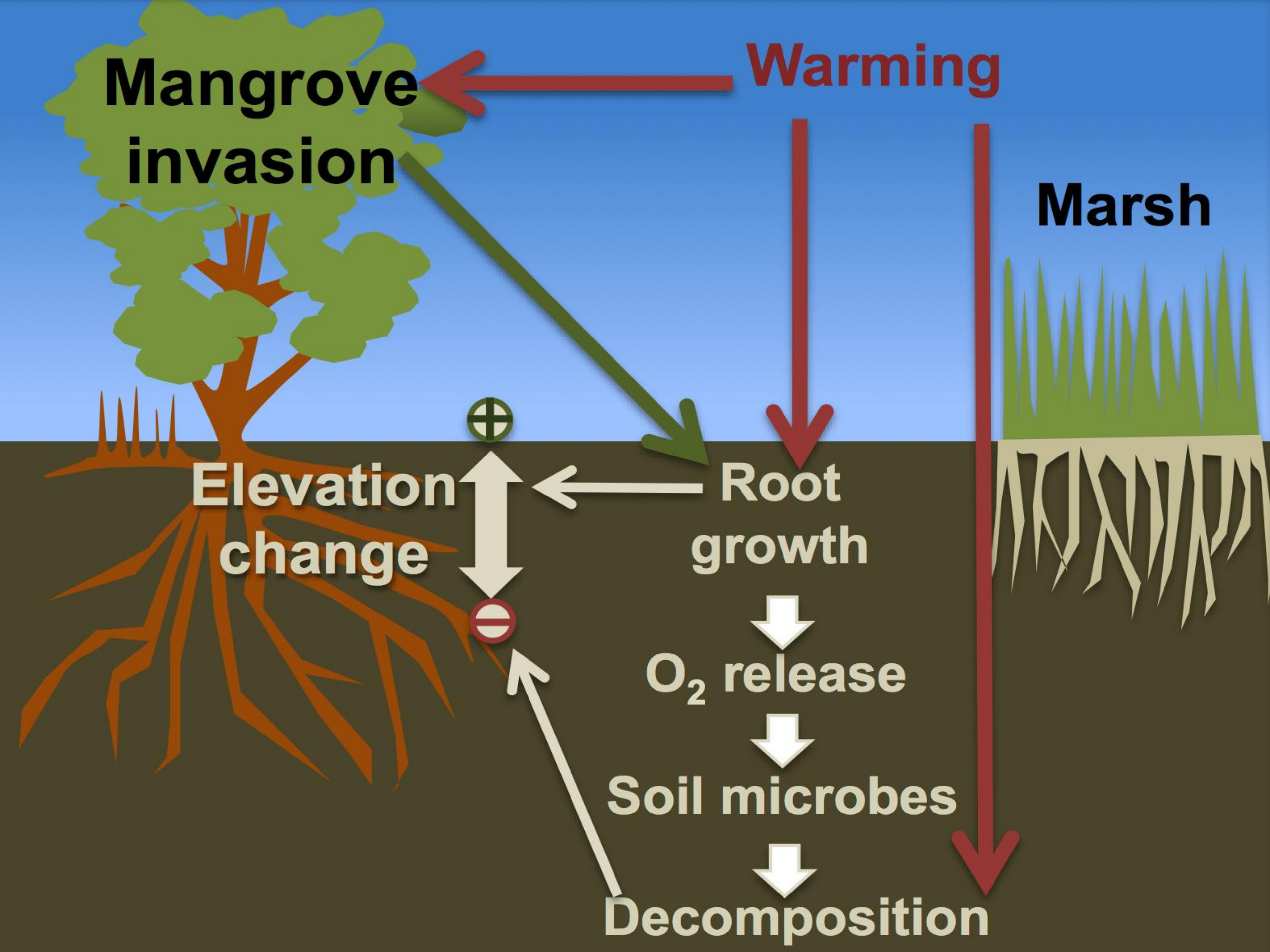


Bacterial communities also differ between mangrove and marsh



PCoA Axis 2
(20%)

C.Barreto Poster
#
& lightning talk



Mangrove invasion
Warming
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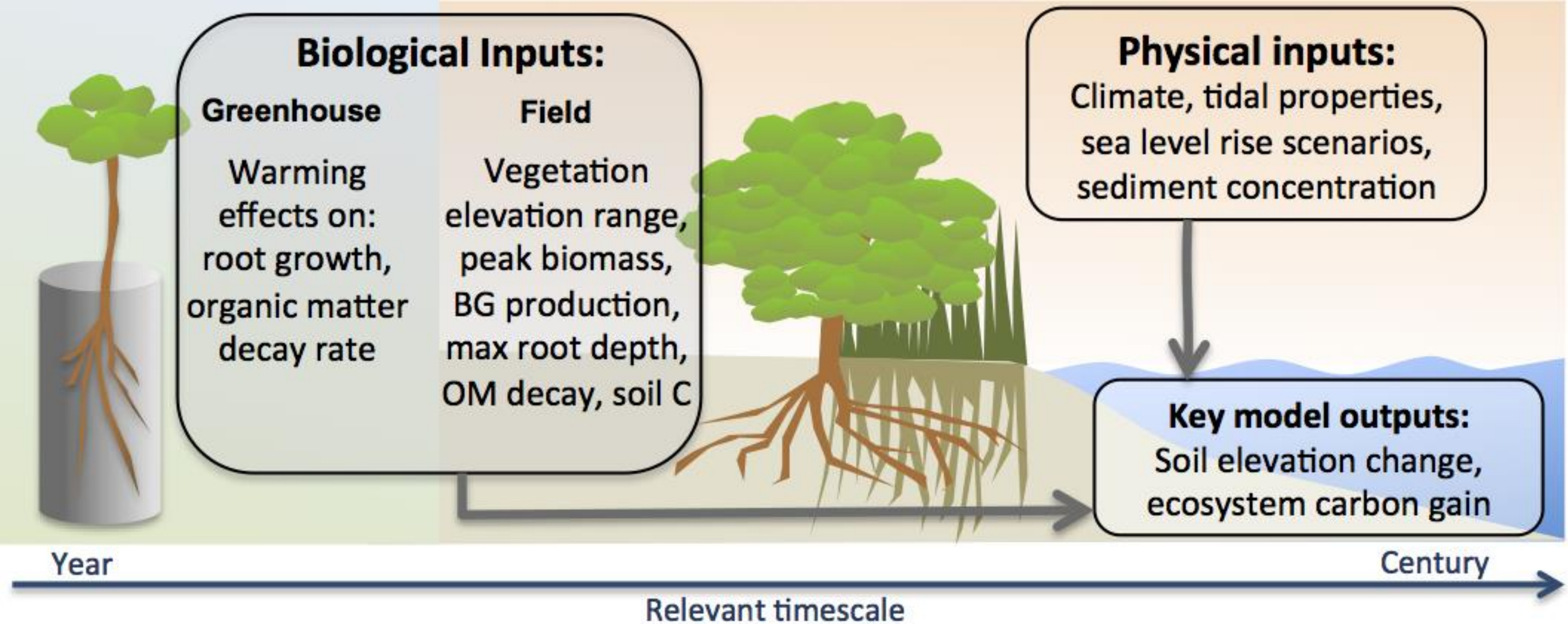
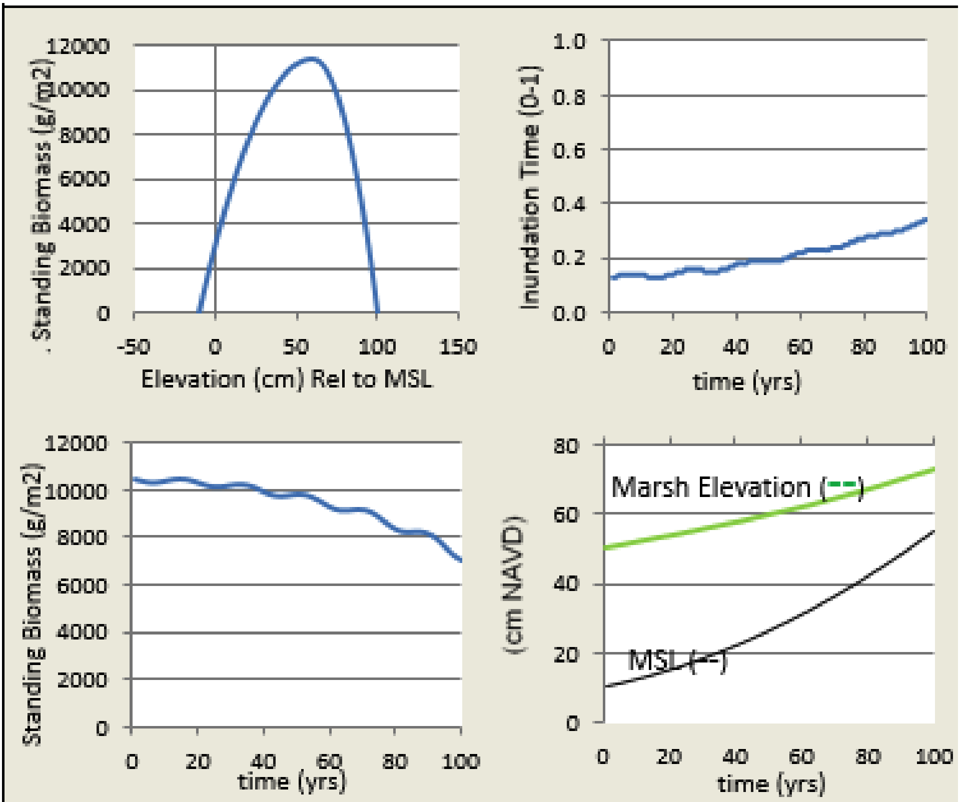


Parameter	Mangrove	Marsh
SLR in 100 yrs	45 cm or 100cm	45 cm or 100 cm
Sediment	6.4mg/L	6.4mg/L
Root:shoot	0.22	0.26
BG Turnover rate	0.36	0.25

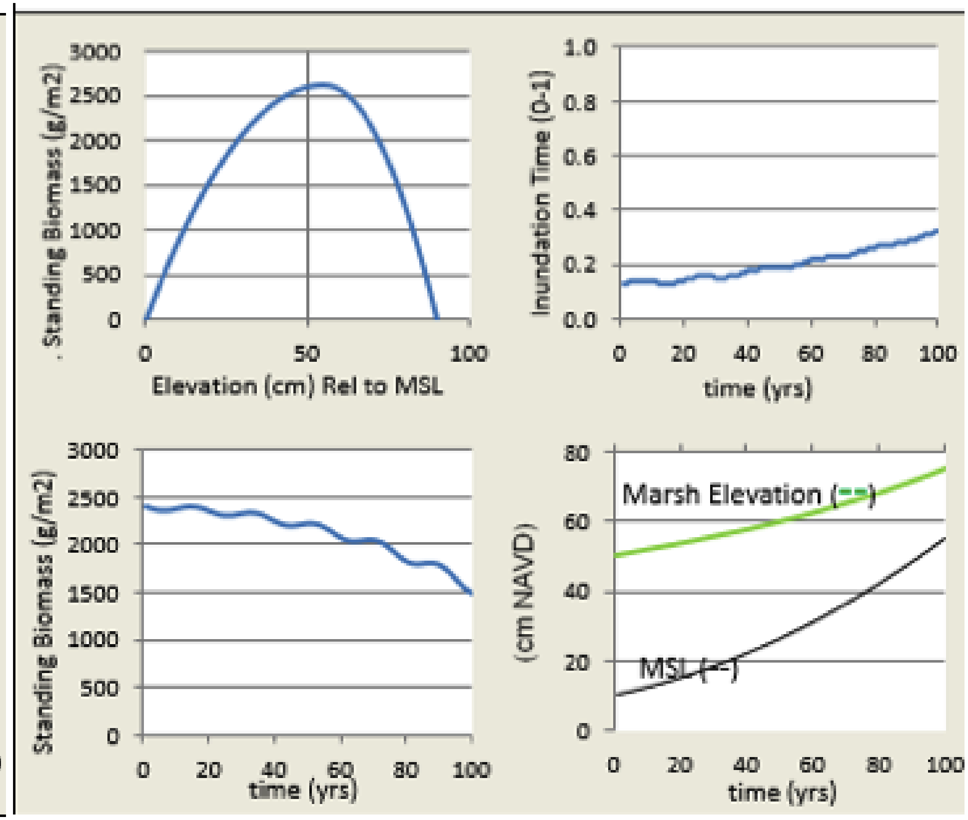
Mangrove vs. Marsh MEM model

45 cm SLR in 100 yrs.

Mangrove



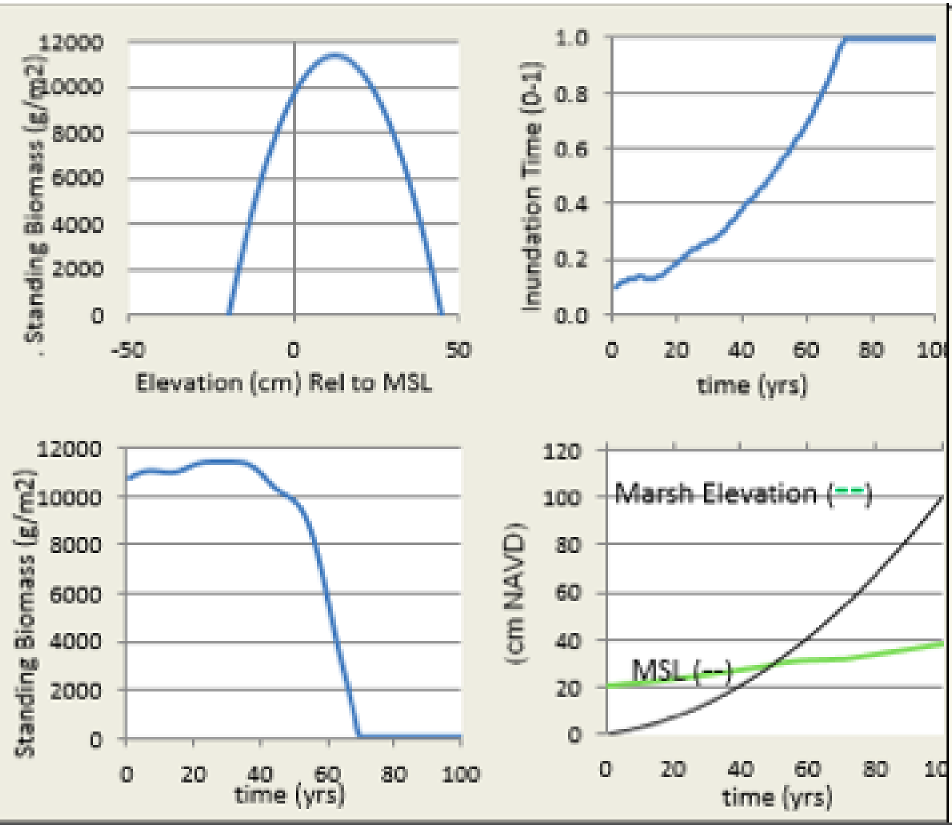
Marsh



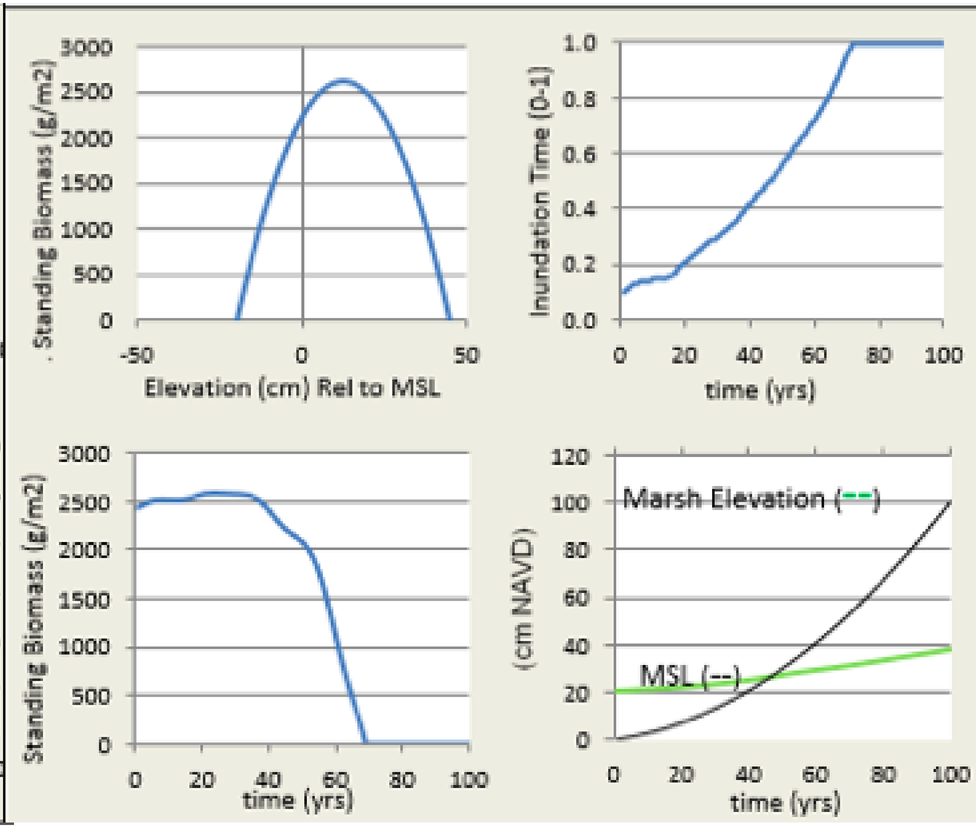
Mangrove vs. Marsh MEM model

100 cm SLR in 100 yrs.

Mangrove



Marsh



Conclusions and Implications

- Mangrove encroachment speeds up belowground organic matter dynamics but this may not have impacts for surface elevation.

- Root productivity responses seem to trump decomposition in regulating surface elevation.

- When sediment supply is low, root productivity increases may not be sufficient for keeping pace with SLR. Chronic warming may help increase surface elevation but for how long?

- [x] Use a generic biom profile
- [ ] Site is supertidal peat
- [ ] Calibrate to accretion rate
- [ ] Use my own kr and q

Run Simulation

Physical Inputs

Sea Level Forecast	100	(cm/100y)
Sea Level at Start	0	cm NAVD
20th Cent Sea Level Rate	0.2	cm/yr
Mean Tidal Amplitude	25	cm
Marsh Elevation @ t0	20	cm NAVD
Suspended Min. Sed. Conc.	10	mg/l
Suspended Org. Sed. Conc.	2	mg/l
Accretion Rate		cm/yr

Biological Inputs

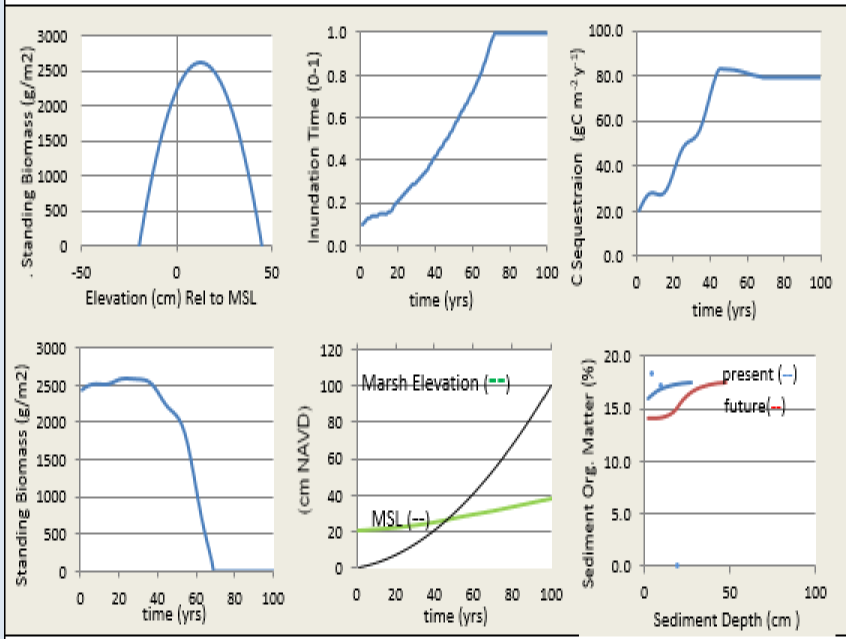
max growth limit (rel MSL)	45	cm
min growth limit (rel MSL)	-20	cm
opt growth elev (rel MSL)	12	cm
max peak biomass	2600	g/m2
%OM below root zone	17.7	
OM decay rate	-0.4	1/year
BGBio to Shoot Ratio	0.26	g/g
BG turnover rate	0.25	1/year
Max (95%) Root Depth	30	cm

Model-Derived Inputs

Capture Efficiency (q)	1.07E+00	$tide^{-1}$
Refrac. Fraction (kr)	7.50E-02	g/g

Other Estuary

MEM 5



- ( ) Plum Island, MA
- ( ) North Inlet, SC
- ( ) Apalachicola, FL
- ( ) Grand Bay, MS
- ( ) Coon Isl, SFB
- (•) Other Estuary

0.1

79.3

79.4

☑ Use a generic biom profile
☐ Site is supertidal peat
☐ Calibrate to accretion rate
☑ Use my own kr and q

Run Simulation

Physical Inputs

Sea Level Forecast	100	(cm/100y)
Sea Level at Start	0	cm NAVD
20th Cent Sea Level Rate	0.2	cm/yr
Mean Tidal Amplitude	25	cm
Marsh Elevation @ t0	20	cm NAVD
Suspended Min. Sed. Conc.	10	mg/l
Suspended Org. Sed. Conc.	2	mg/l
Accretion Rate		cm/yr

Biological Inputs

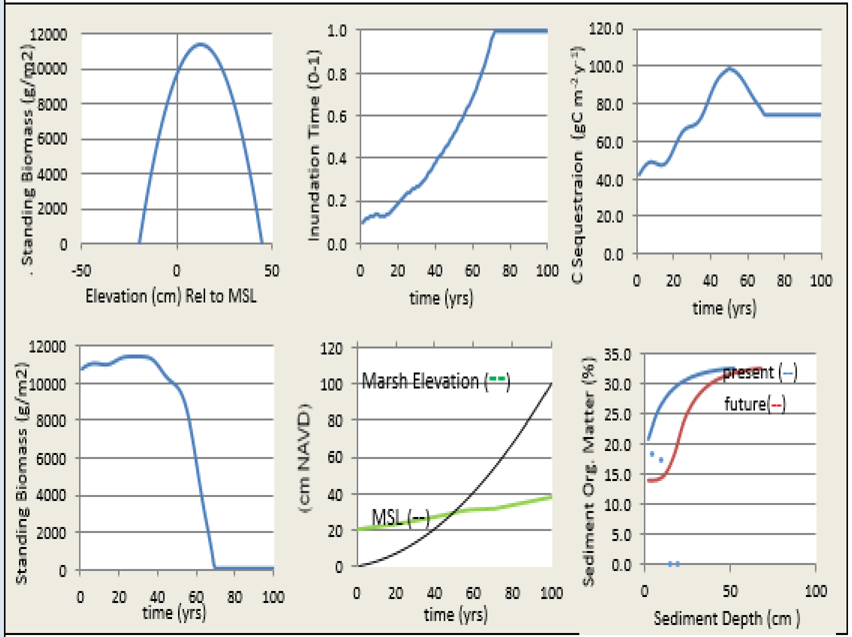
max growth limit (rel MSL)	45	cm
min growth limit (rel MSL)	-20	cm
opt growth elev (rel MSL)	12	cm
max peak biomass	11400	g/m2
%OM below root zone	37.4	
OM decay rate	-0.4	1/year
BGBio to Shoot Ratio	0.22	g/g
BG turnover rate	0.36	1/year
Max (95%) Root Depth	50	cm

Model-Derived Inputs

Capture Efficiency (q)	1.00E+00	$tide^{-1}$
Refrac. Fraction (kr)	9.00E-02	g/g

Other Estuary

MEM 5



○ Plum Island, MA
○ North Inlet, SC
○ Apalachicola, FL
○ Grand Bay, MS
○ Coon Isl, SFB
◉ Other Estuary

0.2
73.9
74.5

☐ Use a generic biom profile
☐ Site is supertidal peat
☐ Calibrate to accretion rate
☑ Use my own kr and q

Run Simulation

Physical Inputs

Sea Level Forecast	45	(cm/100y)
Sea Level at Start	10	cm NAVD
20th Cent Sea Level Rate	0.2	cm/yr
Mean Tidal Amplitude	54	cm
Marsh Elevation @ t0	50	cm NAVD
Suspended Min. Sed. Conc.	6.4	mg/l
Suspended Org. Sed. Conc.	2	mg/l
Accretion Rate		cm/yr

Biological Inputs

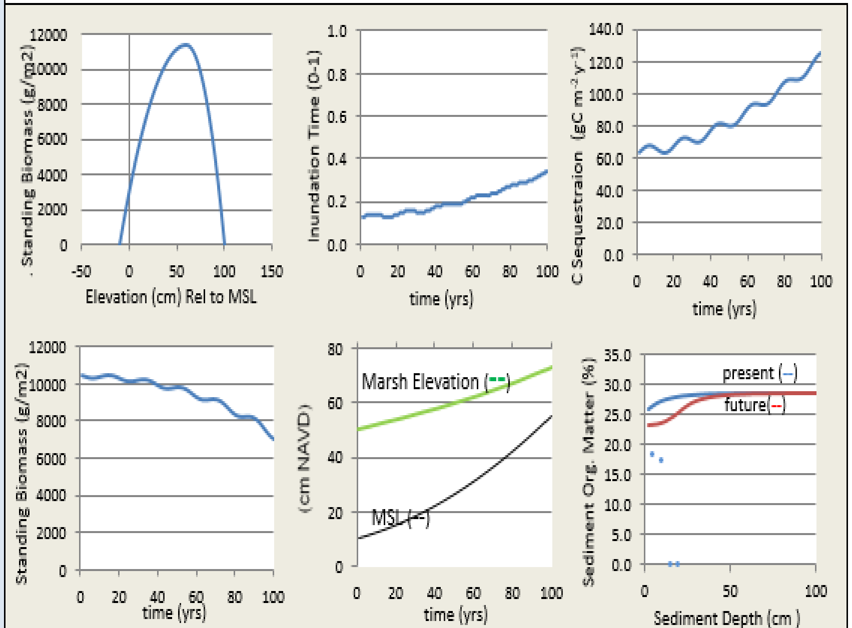
max growth limit (rel MSL)	100	cm
min growth limit (rel MSL)	-10	cm
opt growth elev (rel MSL)	60	cm
max peak biomass	11400	g/m2
%OM below root zone	32.3	
OM decay rate	-0.48	1/year
BGBio to Shoot Ratio	0.22	g/g
BG turnover rate	0.36	1/year
Max (95%) Root Depth	40	cm

Model-Derived Inputs

Capture Efficiency (q)	1.00E+00	$tide^{-1}$
Refrac. Fraction (kr)	7.50E-02	g/g

Other Estuary

MEM 5



○ Plum Island, MA
○ North Inlet, SC
○ Apalachicola, FL
○ Grand Bay, MS
○ Coon Isl, SFB
◉ Other Estuary

0.2
125.5
101.6

Use a generic biom profile

Site is supertidal peat

Calibrate to accretion rate

Use my own kr and q

Run Simulation

Physical Inputs

Sea Level Forecast	45	(cm/100y)
Sea Level at Start	10	cm NAVD
20th Cent Sea Level Rate	0.2	cm/yr
Mean Tidal Amplitude	54	cm
Marsh Elevation @ t0	50	cm NAVD
Suspended Min. Sed. Conc.	6.4	mg/l
Suspended Org. Sed. Conc.	2	mg/l
Accretion Rate		cm/yr

Biological Inputs

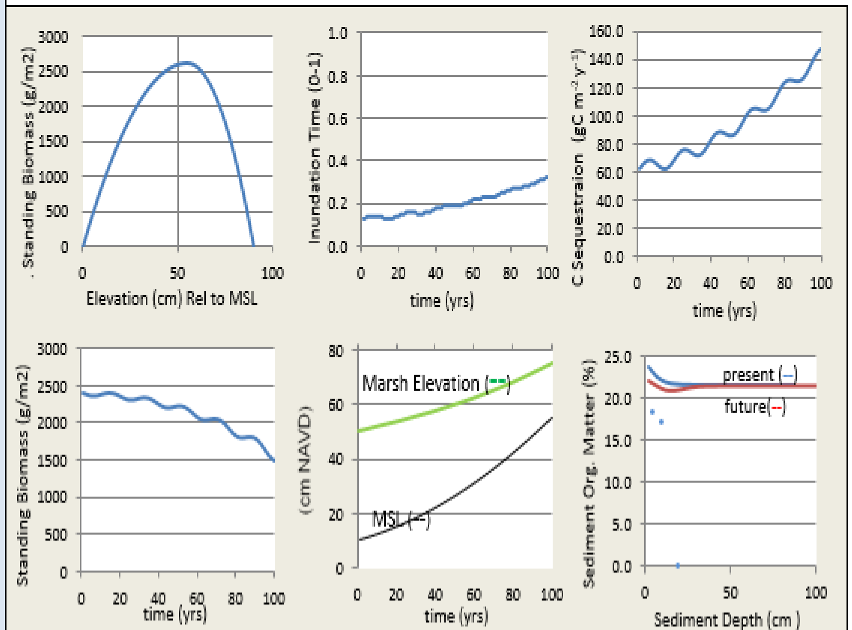
max growth limit (rel MSL)	90	cm
min growth limit (rel MSL)	0	cm
opt growth elev (rel MSL)	55	cm
max peak biomass	2600	g/m2
%OM below root zone	21.5	
OM decay rate	-0.18	1/year
BGBio to Shoot Ratio	0.26	g/g
BG turnover rate	0.25	1/year
Max (95%) Root Depth	15	cm

Model-Derived Inputs

Capture Efficiency (q)	1.40E+00	$tide^{-1}$
Refrac. Fraction (kr)	7.50E-02	g/g

Other Estuary

MEM 5



- Plum Island, MA
- North Inlet, SC
- Apalachicola, FL
- Grand Bay, MS
- Coon Isl, SFB
- Other Estuary (selected)