Contributions of Mineral and Organic Components to Tidal Marsh Accretion

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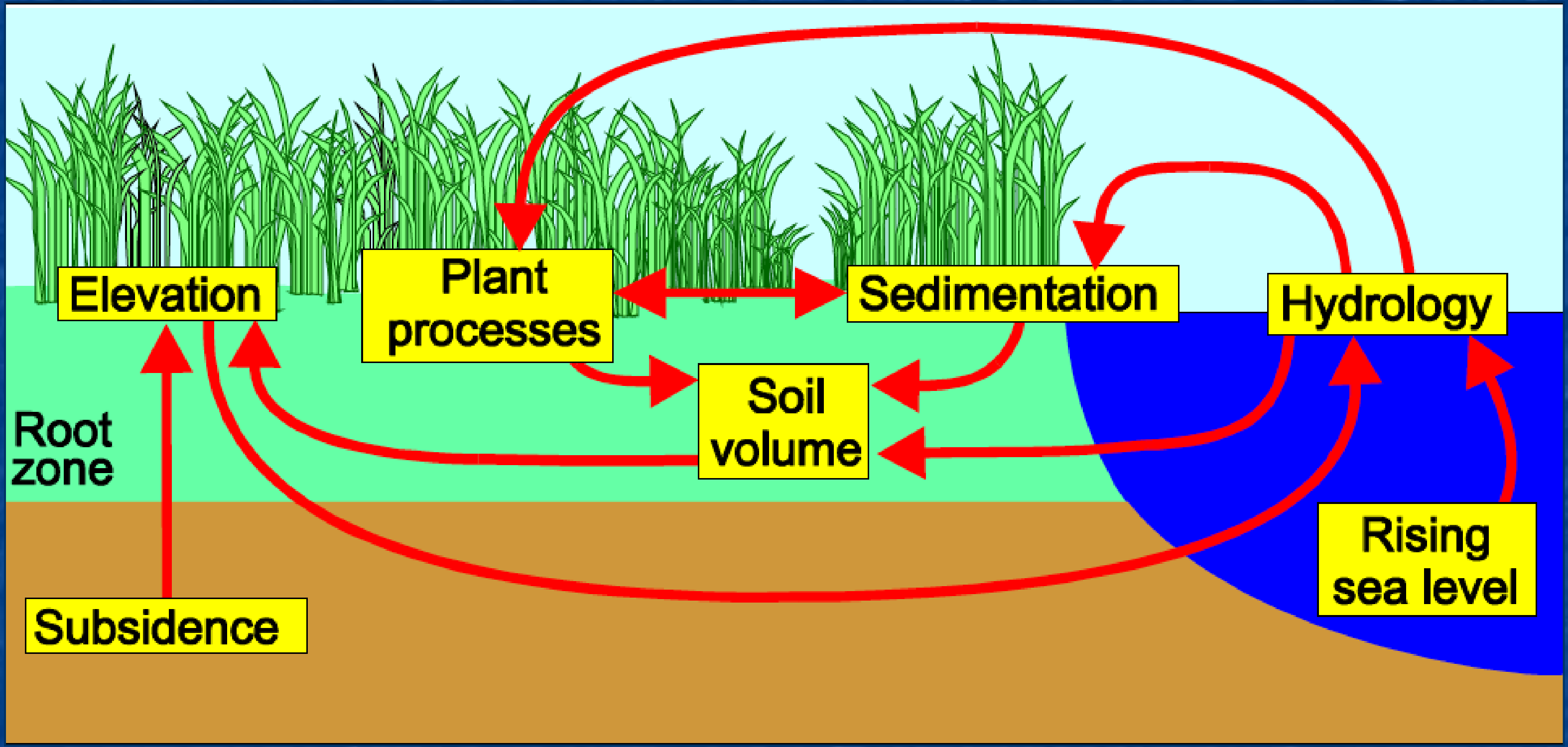
Marshes can grow by accumulating mineral and/or organic materials



» Feedbacks between hydrology, plant production, and sedimentation allow marshes to grow vertically

USGS FS-091-97 Global warming, sea-level rise, and coastal marsh survival

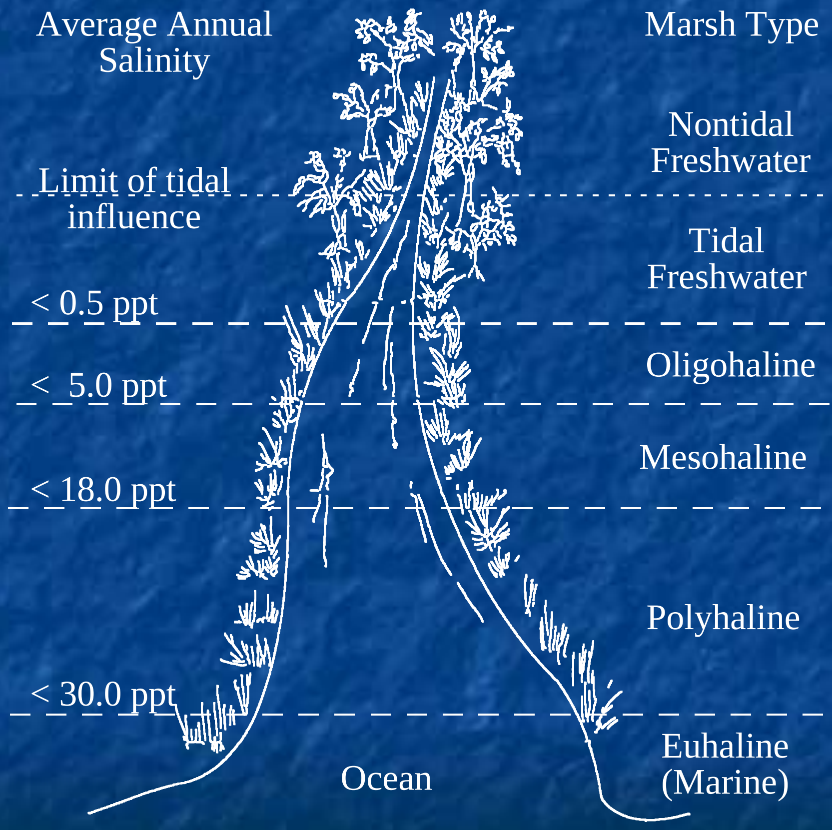
Questions for this talk

1) Which is more important - organic matter or mineral accumulation?

2) What evidence is there for allochthonous C inputs?

3) How can we quantify autochthonous vs. allochthonous C inputs?

The diversity of coastal wetland types is tremendous



Odum et al. 1984. FWS/OBS-83/17

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Tidal freshwater marsh accretion

Location	n	Method
Abagadasset River, ME	1	^{210}Pb
Hudson River, NY	6	^{210}Pb
Delaware River, NJ	11[b]	^{210}Pb
	10[c]	^{137}Cs
	1	Pollen
	1	Sand layer
Otter Point Creek, MD	3	^{210}Pb
Patuxent River, MD	25	^{210}Pb
	2	Pollen
Pamunkey River, VA	3[d]	^{137}Cs
Altamaha River, GA	4	^{137}Cs
Gulf of Mexico, LA	7[d]	^{137}Cs
Scheldt River, Belgium	2	Macrofossils
All sites	76[e]	Various

» Accretion rates and soil properties from literature

» Multiple techniques used to determine accretion

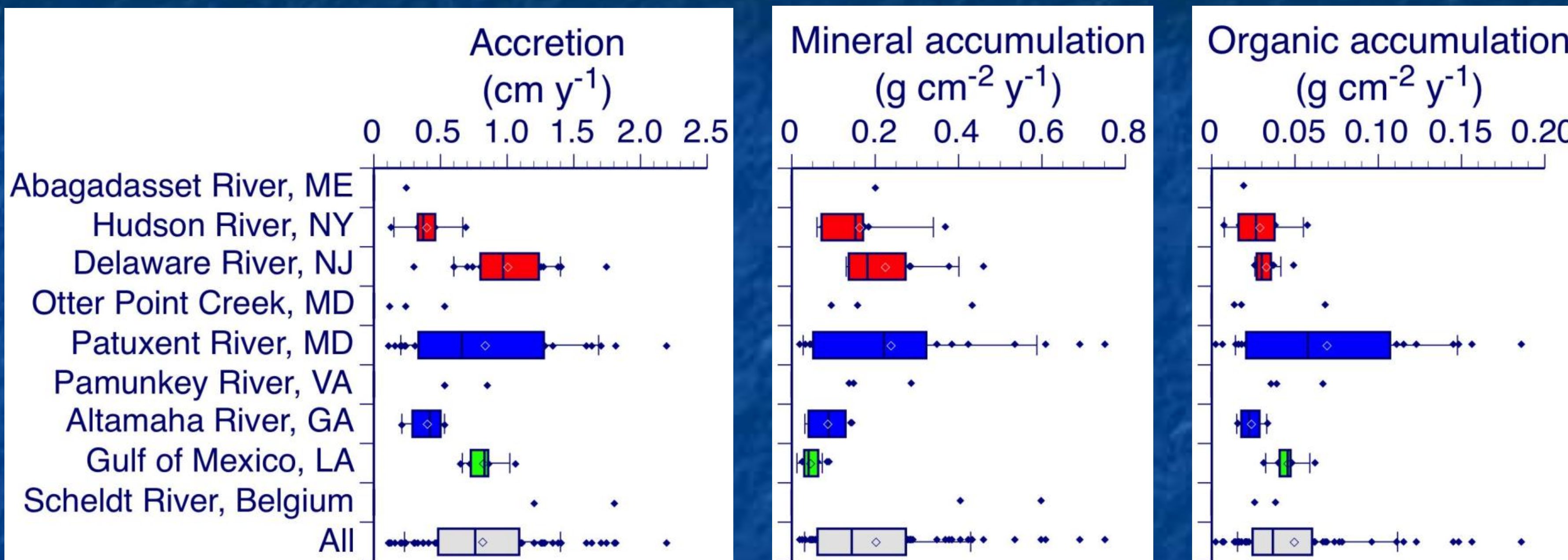
» Soil bulk density:
= 0.040-0.846 g cm^{-3}

» Soil organic content:
= 5.8-87.9% by weight

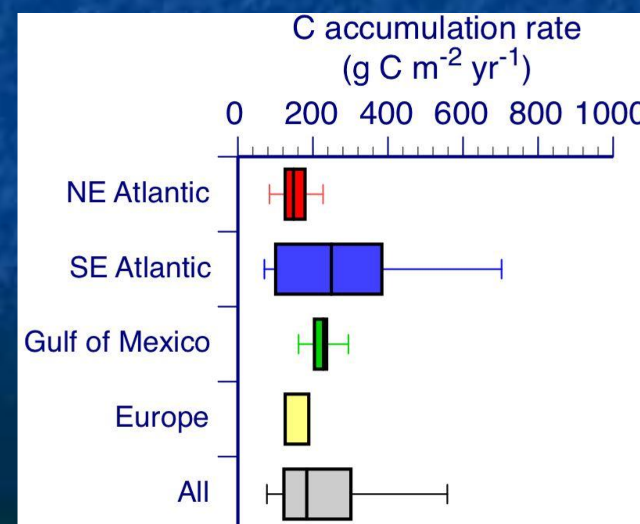
» Similar analyses done for salt marshes (Turner et al. 2000)

Neubauer. 2008. *Est. Coast Shelf Sci.*; Turner et al. 2000. *Concepts and Controversies…* book

Vertical accretion and mass accumulation

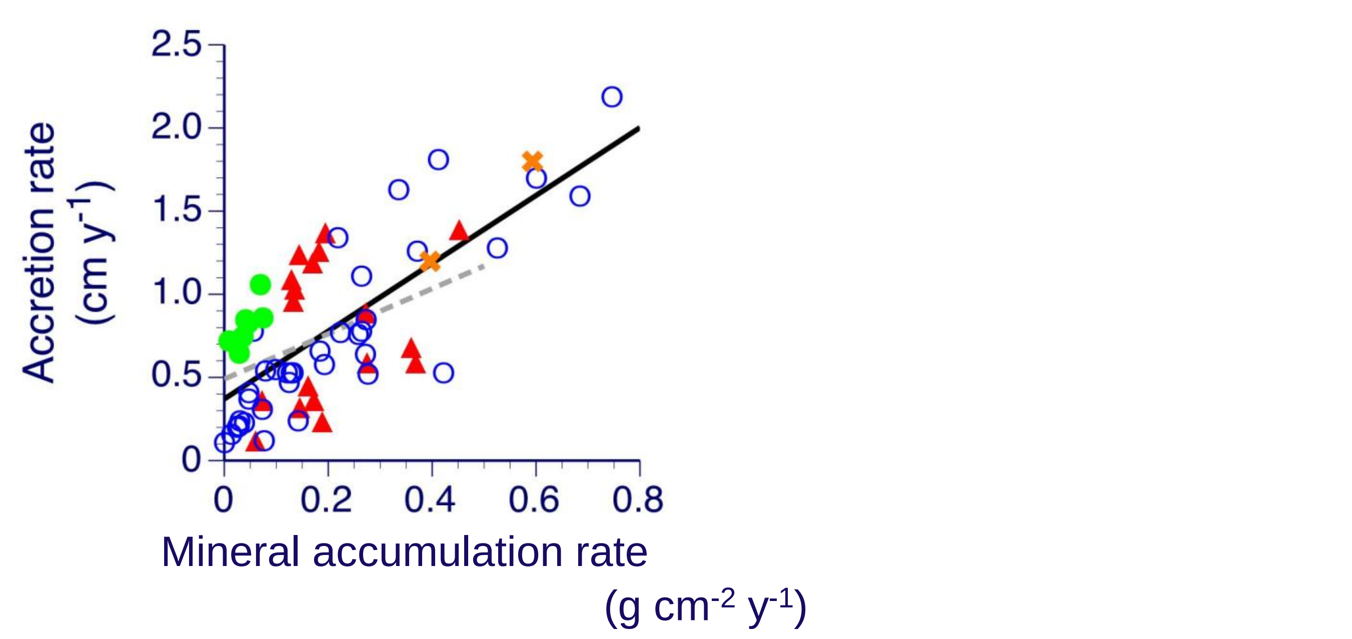


- Large range in vertical accretion: (0.11-2.19 cm y^{-1})
- On a mass basis, mineral accumulation >> organic accumulation
- Carbon accumulation rates are comparable in tidal freshwater and salt marshes



Neubauer. 2008. *Est. Coast Shelf Sci.*

Accretion vs. accumulation



- » Vertical marsh accretion is correlated with both mineral and organic accumulation.
- » Mineral and organic accumulation are correlated with each other
- » Similar relationships for tidal salt marshes (dashed lines)

Neubauer. 2008. *Est. Coast Shelf Sci.*; Turner et al. 2000. *Concepts and Controversies…* book

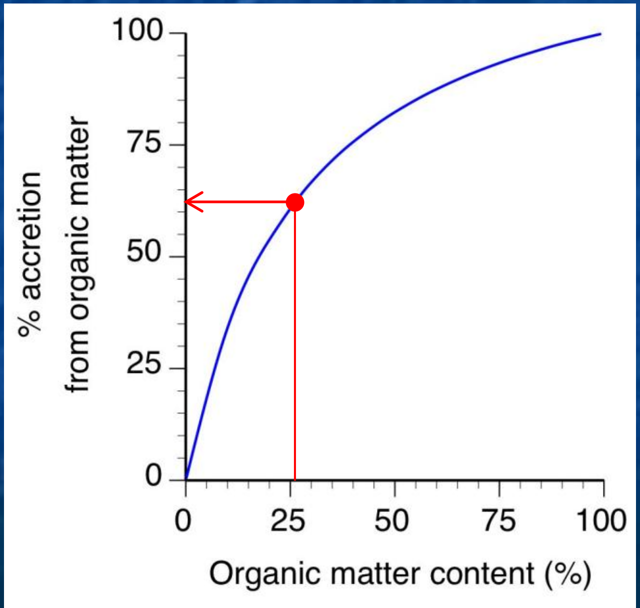
Volumetric leverage

Region	n	Slope ($cm^3\ g^{-1}$)		Intercept ($cm\ y^{-1}$)	Adj. r^2
		Mineral	Organic		
Northeast U.S.A.	18	n.s.	18.80**	0.22	0.220
Southeast U.S.A.	37	0.52*	8.99***	0.08	0.917
Gulf coast U.S.A.	7	4.45**	n.s.	0.63	0.516
All sites	64	1.18***	5.50***	0.27	0.618

» Input of organic matter has ~4x leverage of same mass of mineral matter

- Similar relationship for east coast USA salt marshes (Turner et al. 2000)

» For the average tidal freshwater marsh, ~62% of accretion driven by organic matter accumulation



Neubauer. 2008. *Est. Coast Shelf Sci.*; Turner et al. 2000. *Concepts and Controversies…* book

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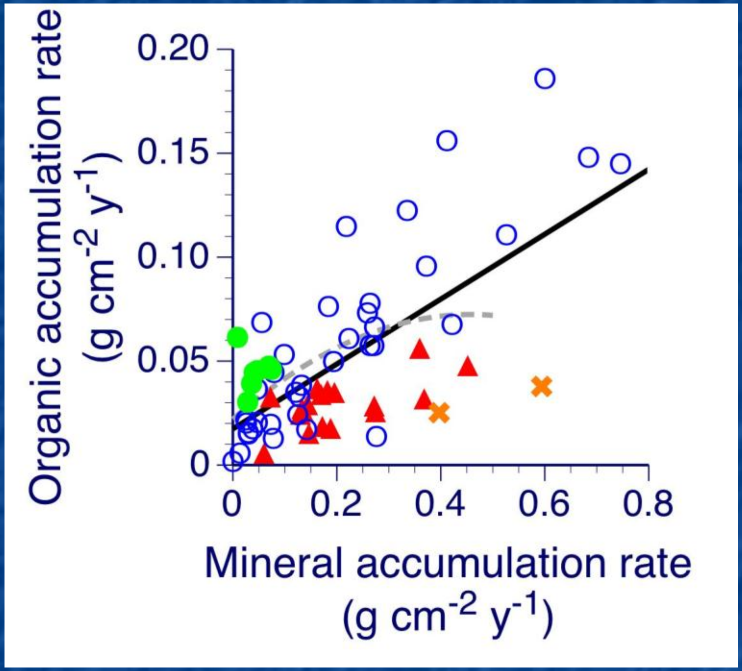
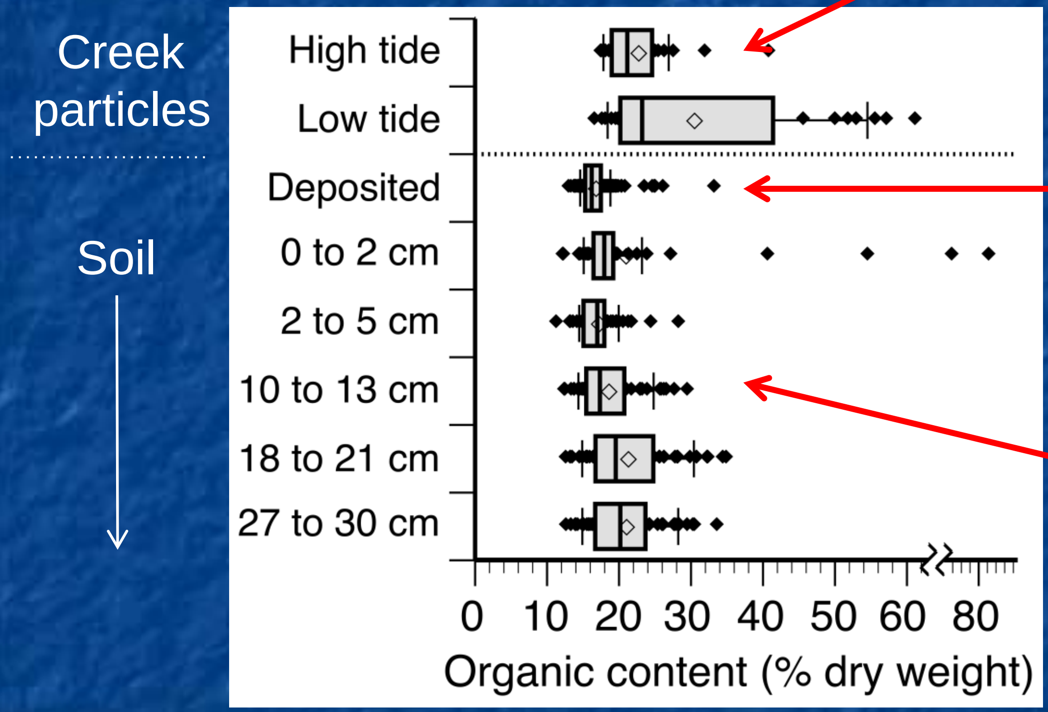
Evidence for allochthonous C inputs – 1



- Correlation reflects co-deposition of allochthonous mineral and organic matter
- Alternately: High autochthonous production promotes mineral deposition.
- Alternately again: High mineral deposition promotes autochthonous production.
- Alternately again, again: Any or all of the above are true.

Neubauer. 2008. *Est. Coast Shelf Sci.*

Evidence for allochthonous C inputs - 2



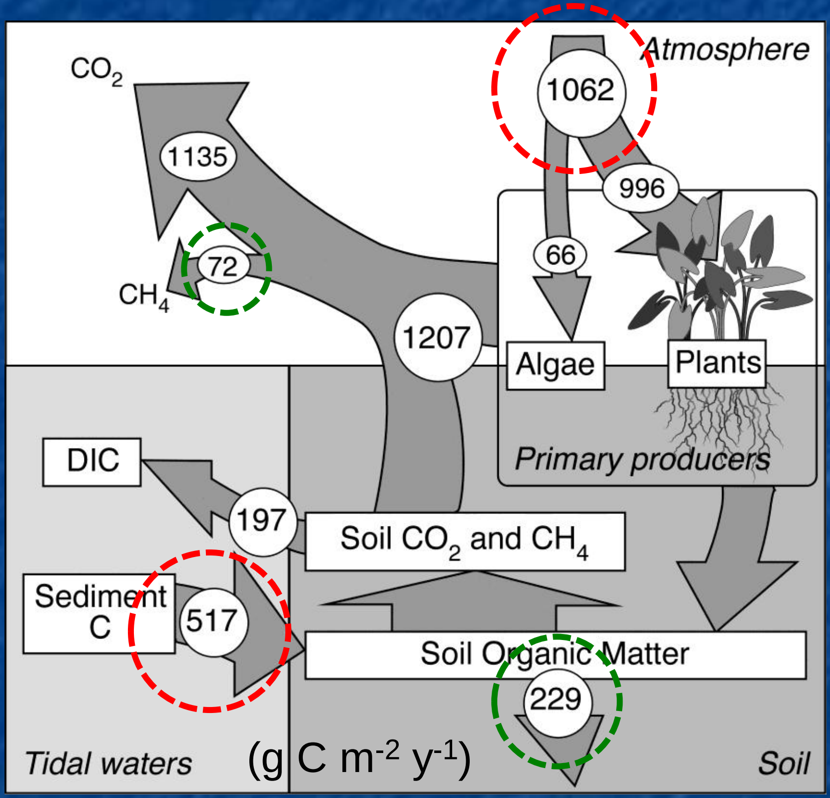
(Sweet Hall marsh, Pamunkey River, Virginia)

- Suspended material in creek has high %OM (~20-60% phytoplankton).
- Material deposited on the marsh surface has considerable organic content.
- Increases in OM with depth reflect plant influences

Neubauer. 2008. *Est. Coast Shelf Sci.*

Evidence for allochthonous C inputs - 3

A tidal freshwater marsh carbon budget



(Sweet Hall marsh, Pamunkey River, Virginia)

- » Gross primary production fixes ~1000 g C m^{-2} y^{-1}
- » Sedimentation delivers ~500 g C m^{-2} y^{-1} to marsh surface
- » Conclusion: Sedimentation is a significant source of allochthonous C (and N) in marsh elemental budgets
- » Greenhouse gas balance:
  - C sequestration = 840 g CO_2-eq m^{-2} y^{-1}
  - CH_4 emissions = 2400 g CO_2-eq m^{-2} y^{-1}

Megonigal and Neubauer. 2009. *Tidal freshwater marsh biogeochemistry* chapter.

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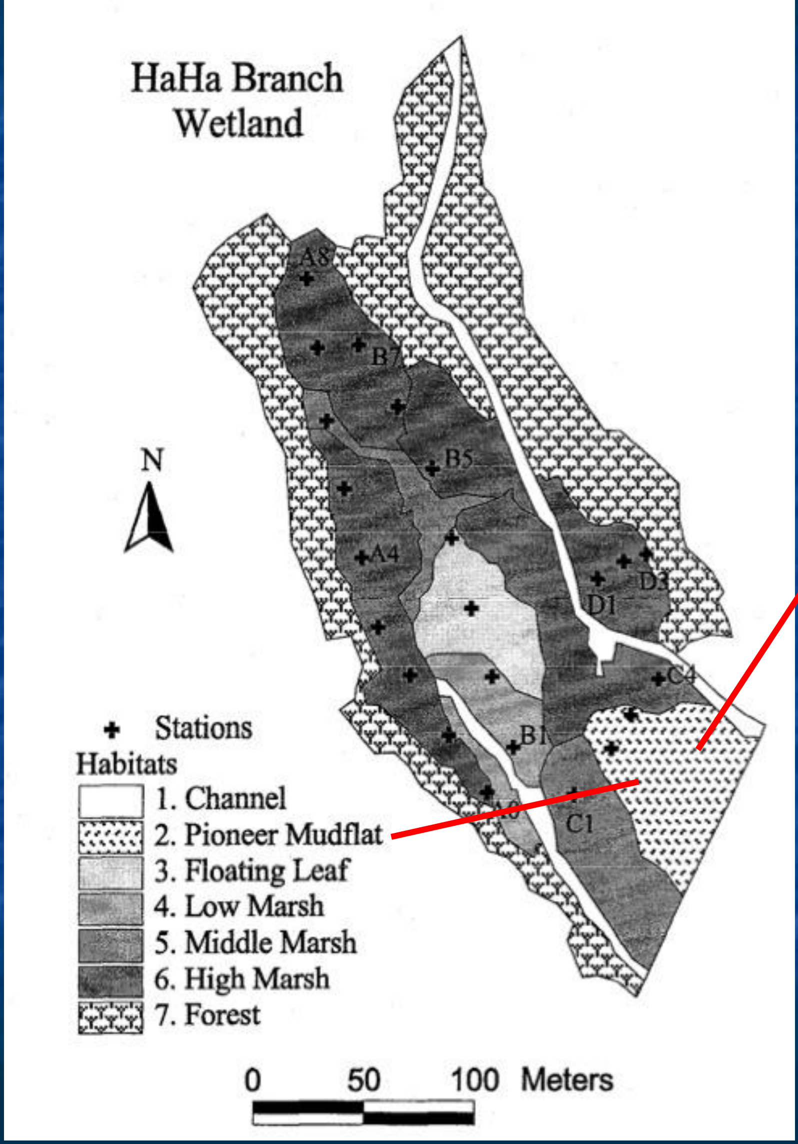
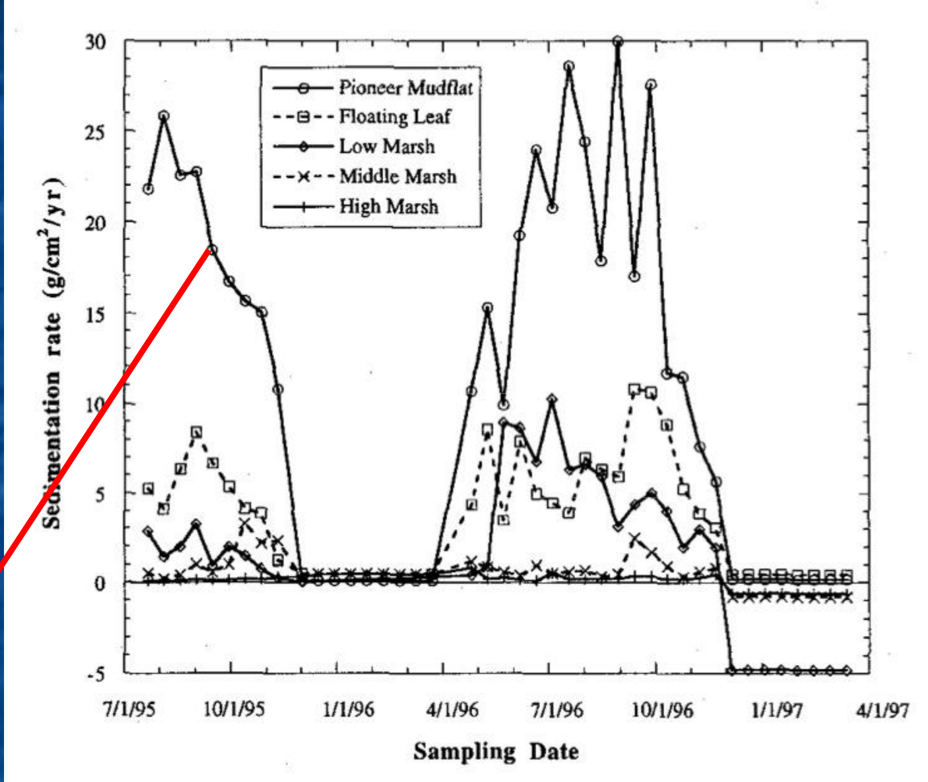
Mudflat vs. vegetated marsh?

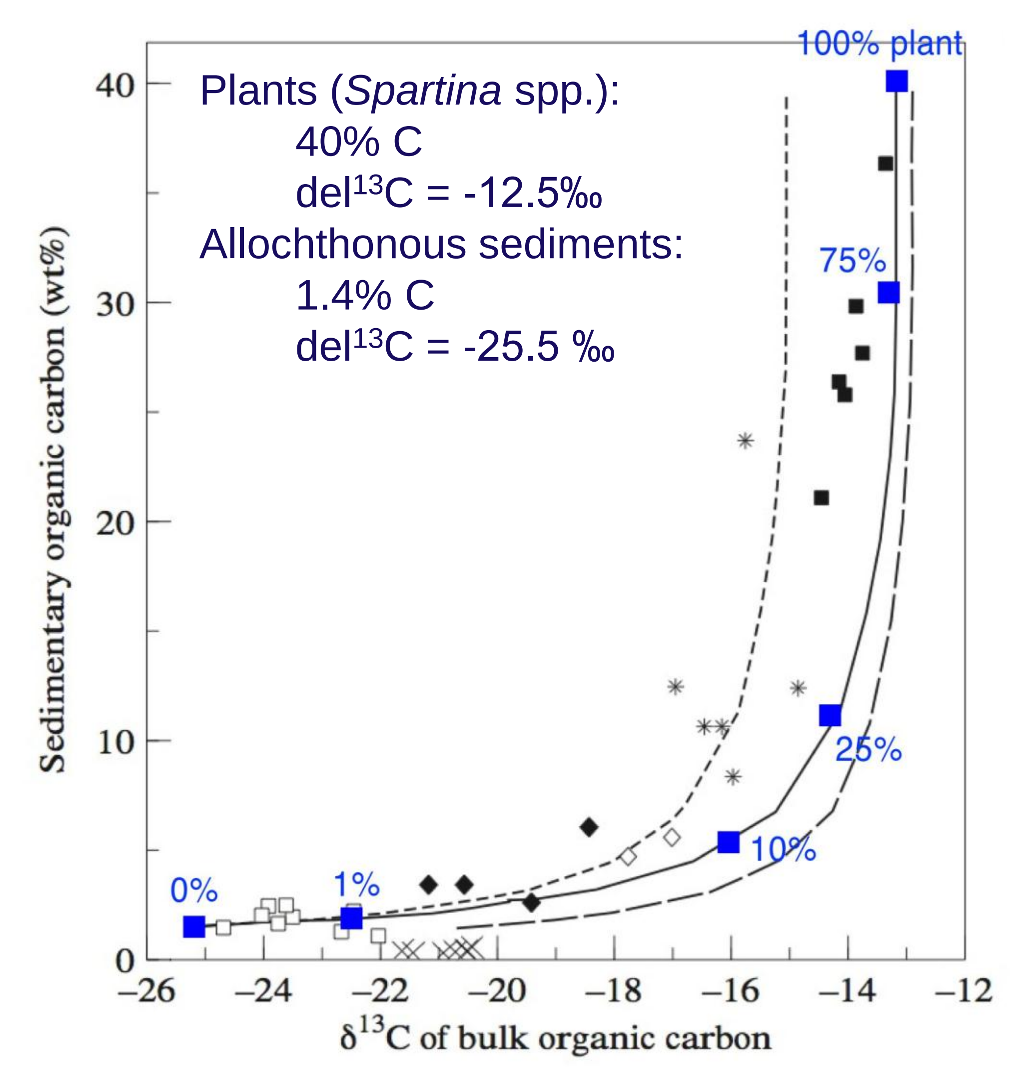




» Highest sedimentation (and organic deposition) in unvegetated mudflat.

Pasternack and Brush, 1998. *Estuaries.*

Mixing models



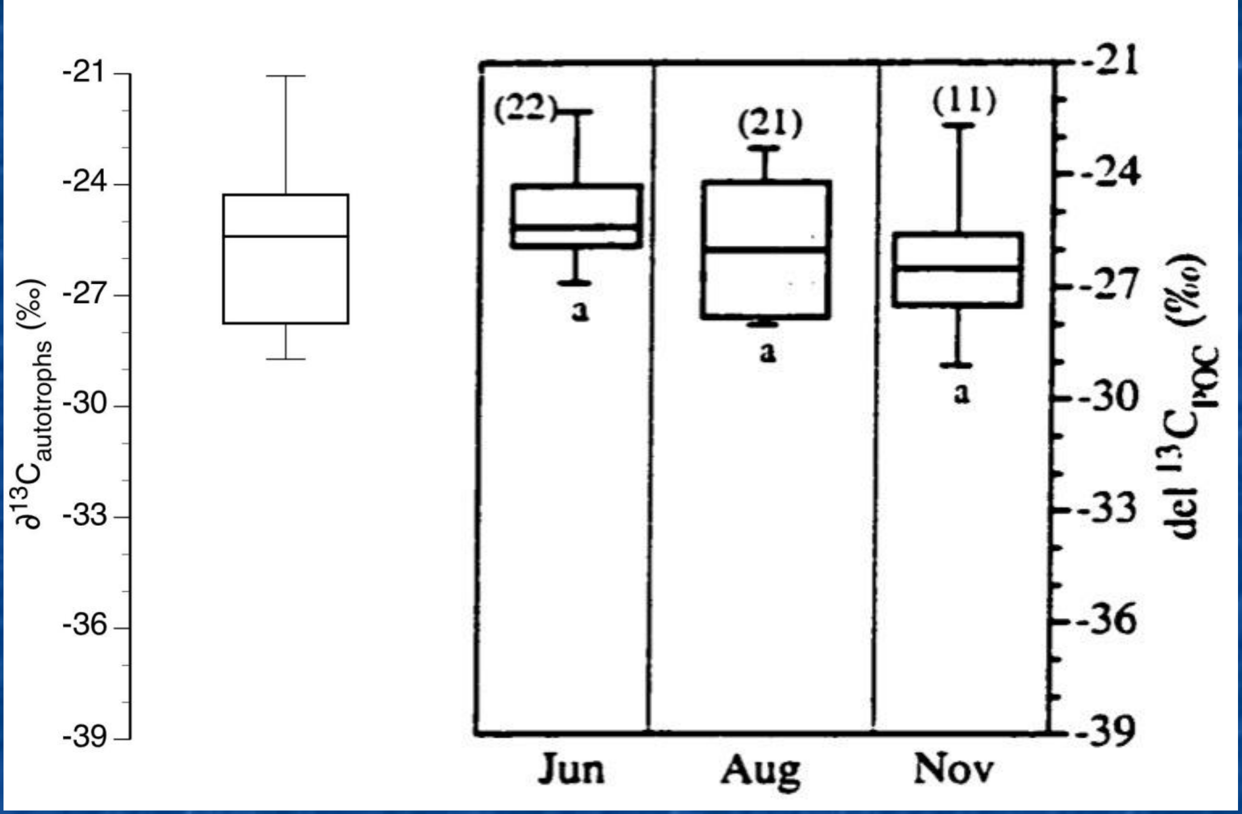
- » Assume soil/sediment C = mixture of two distinct sources
- » Use mixing model to determine relative contributions of each source
- » Simple and straightforward if end-members are compositionally distinct
  - May work best in *Spartina* salt marshes

Middelburg et al. 1997. *Est. Coast Shelf Sci.*

But what if it's a C_3-dominated marsh?

Plants, microalgae Particulate matter in creek

(Sweet Hall marsh, Pamunkey River, Virginia)

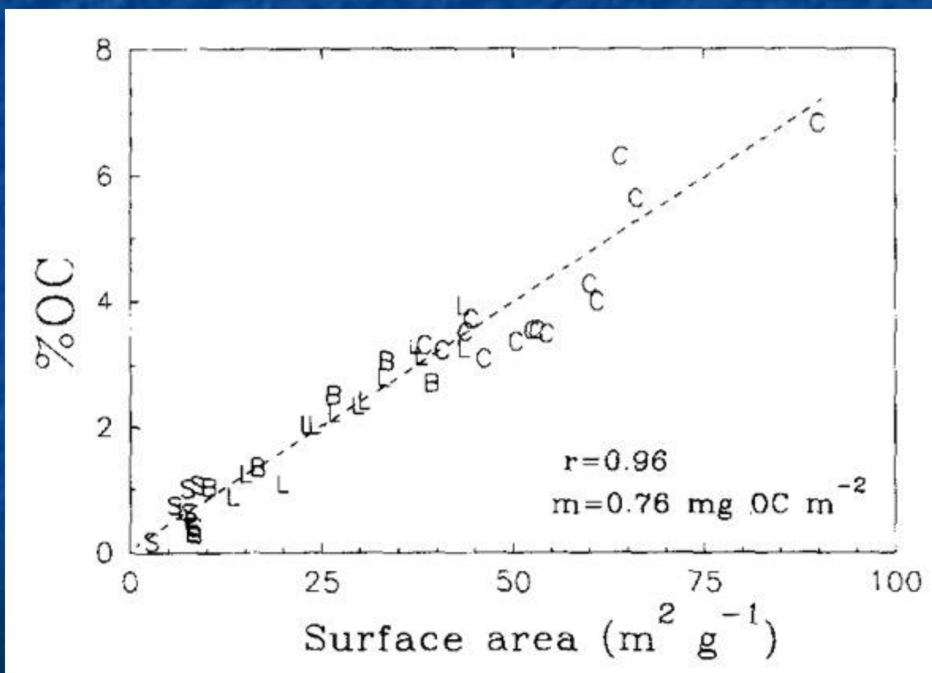


» No isotopic separation between autochthonous and allochthonous C sources … mixing model won't work!

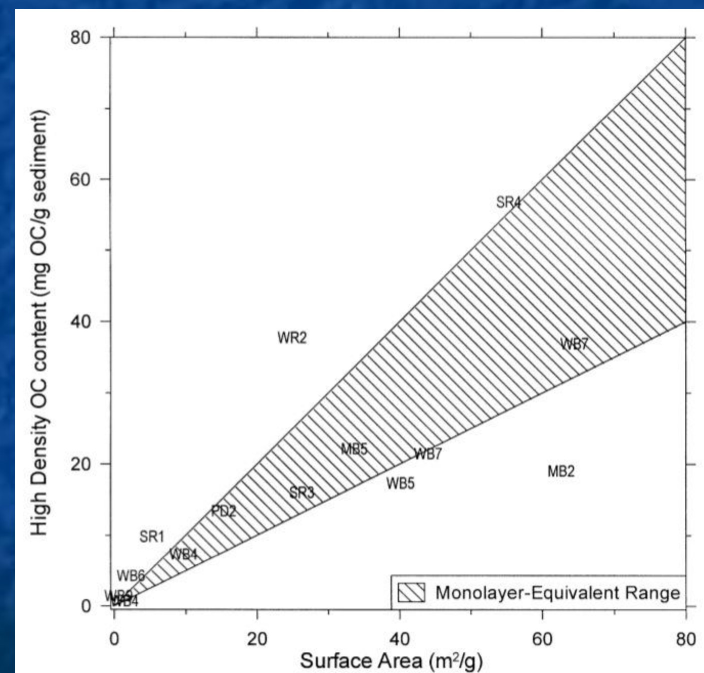
Neubauer 2000 dissertation

Sorptive preservation of organic matter

- Organic matter sorption to mineral sediments protects against decay
- "Monolayer" of 0.5-1.0 mg organic C per m^2 sediment surface area
- Is sorbed C ~ allochthonous C?



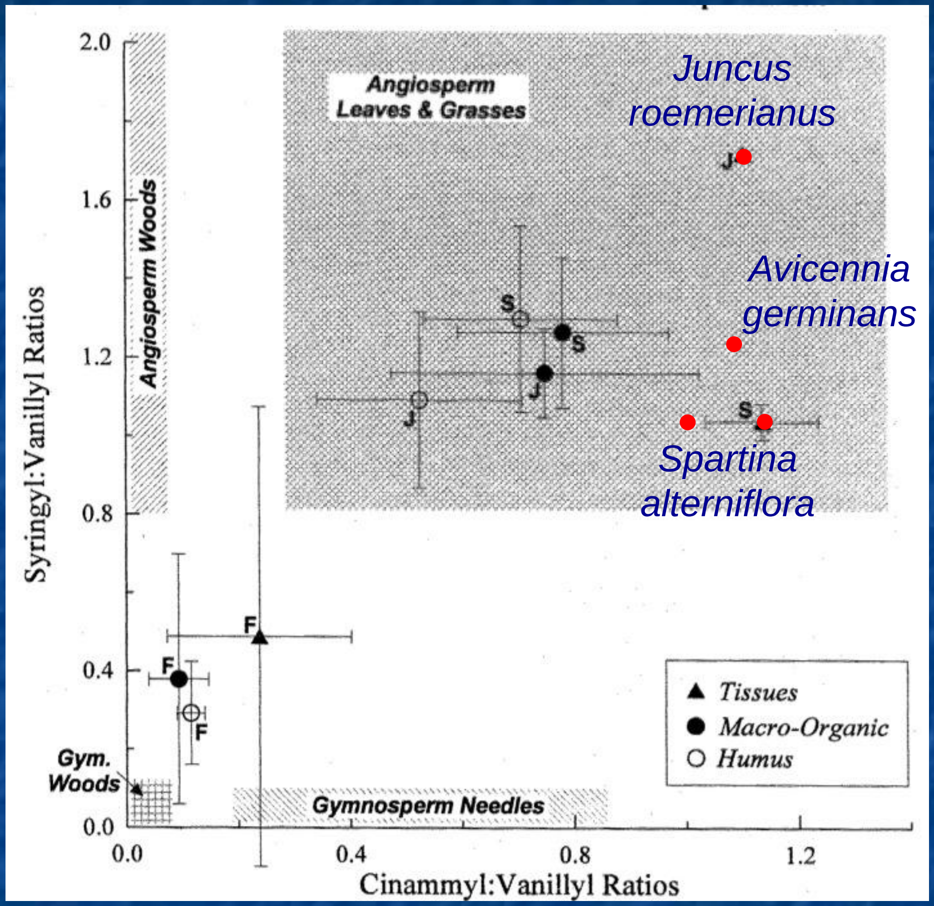
(Columbia River estuary, Washington/Oregon)



(Winyah Bay estuary, South Carolina)

Hedges and Keil, 1995. *Mar. Chem.*; Goñi et al. 2003. *Est. Coast. Shelf Sci.*

New slide title



Marine plants (seagrass) are generally devoid of lignin (Hedges and Mann)

Goñi and Thomas. 2000. *Estuaries.;* Hedges and Mann. 1979. *Geochim. Cosmochim. Acta*