Carbon sequestration in tropical wetlands of Costa Rica

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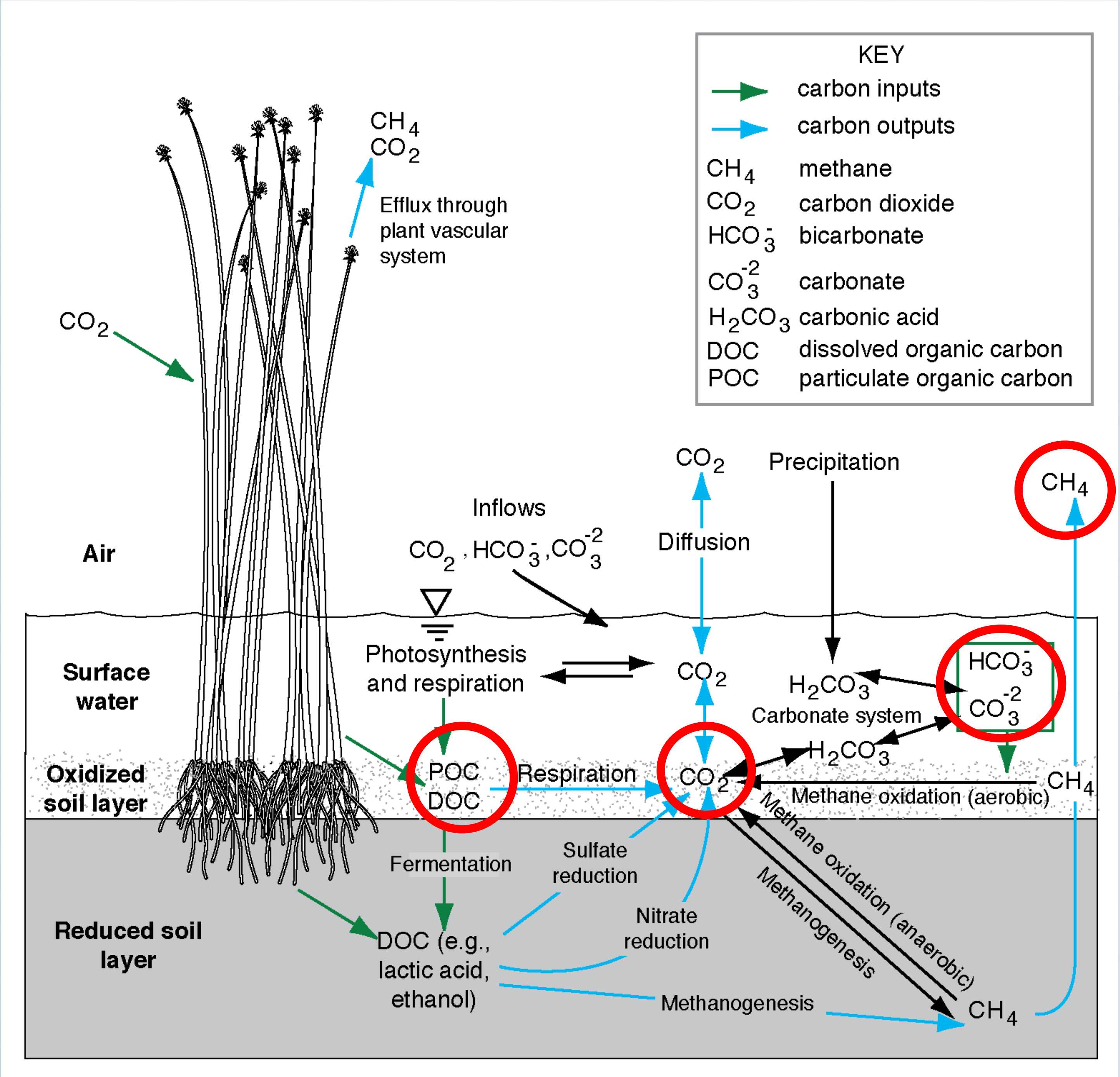
Wetlands sequester carbon

Wetlands are dynamic ecosystems.

High organic matter inputs and low decomposition rates - net retention of carbon

Accumulation rates depend on climate, vegetation communities, hydrology, and wetland type.



Adapted from Mitsch and Gosselink 2007

Wetlands only cover 6-8% of the land, but account for about one-third of the organic soil carbon pool and 25% of yearly methane emissions to the atmosphere.

The role of wetlands in global carbon cycles is not well defined - there are uncertainties regarding factors determining carbon accumulation in wetlands.

If factors that enhance carbon sequestration in wetlands are better understood, natural and created wetlands could be used as a tool to abate climate change.

Tropical wetlands might be more vulnerable than temperate and boreal wetlands because of over-exploitation and lack of legal protection.

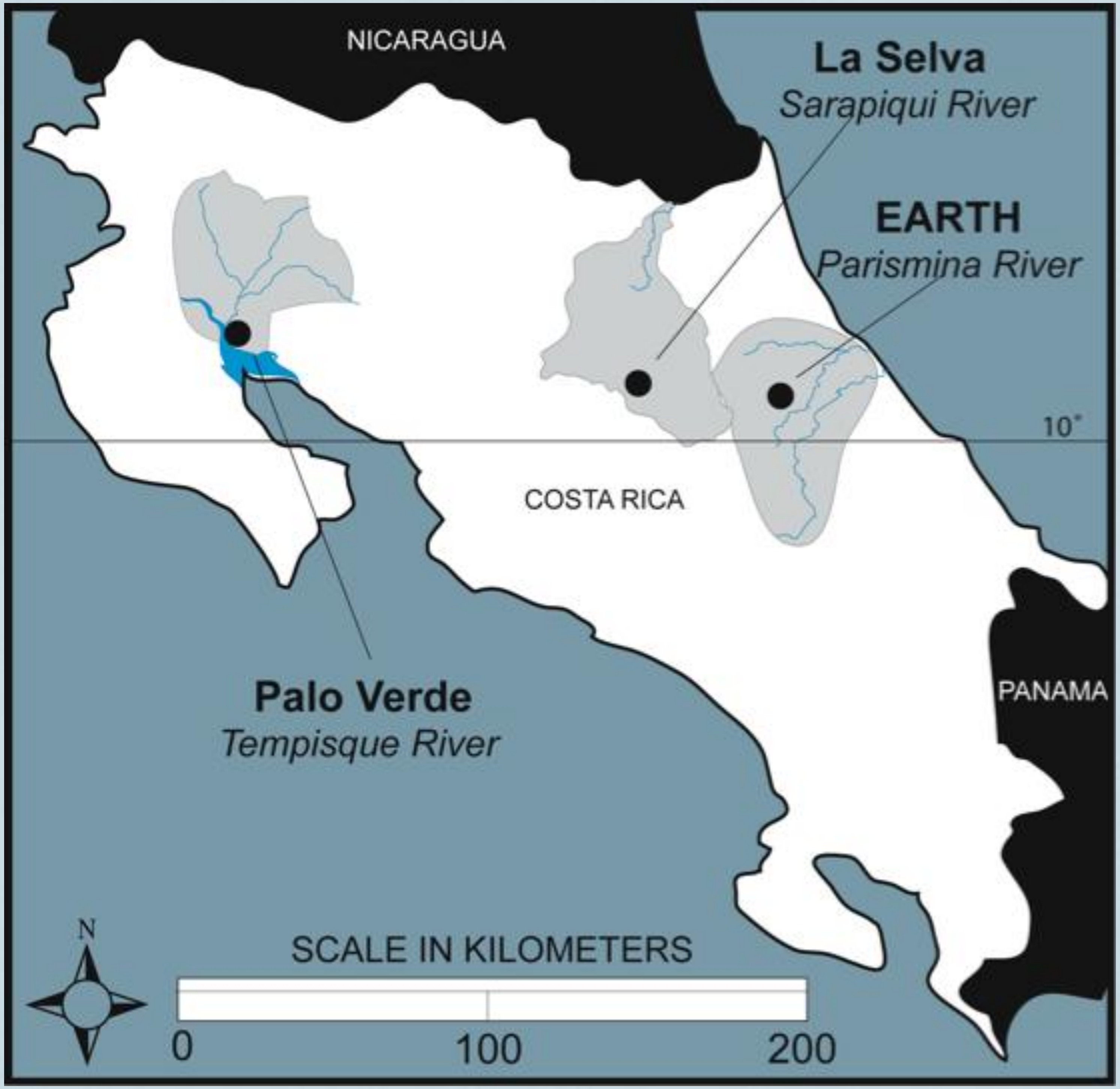
research questions

Are tropical wetlands efficient sequestering carbon in the soil?

- Tropical wetlands are amongst the most productive ecosystems, but high temperatures may hinder carbon accumulation in the soil.

Do wetland type, wetland community, and climate affect carbon sequestration in tropical wetlands?

Study sites

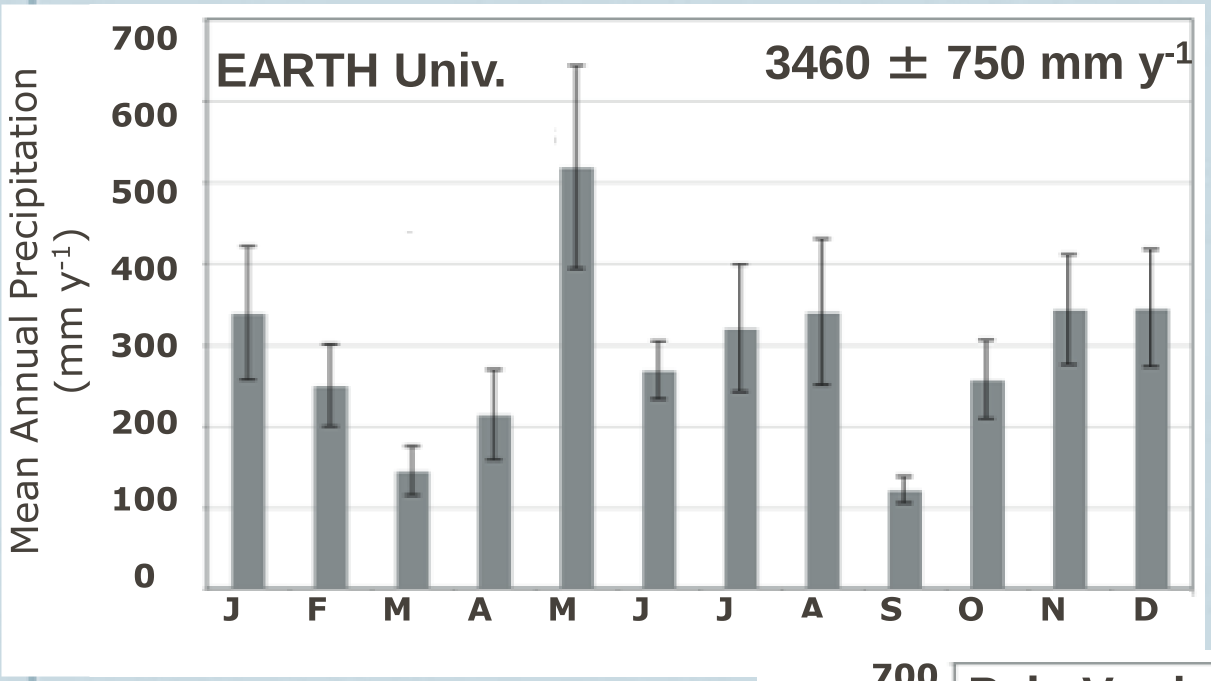


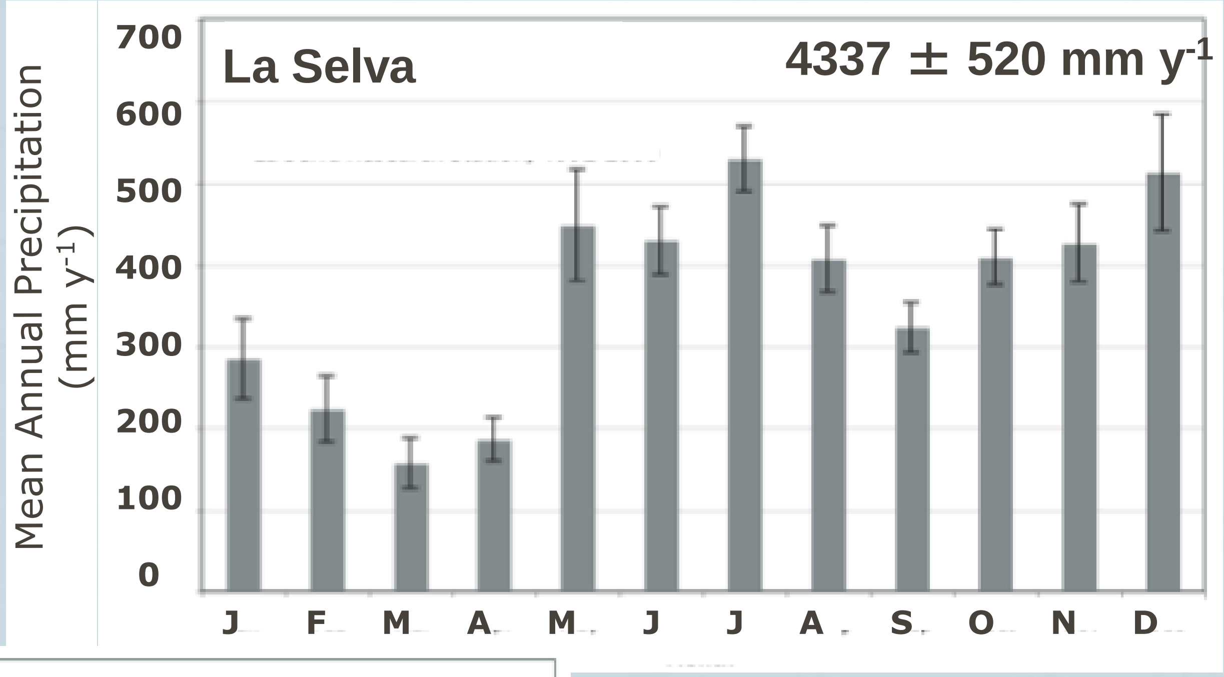
Map drawn by A. M. Nahlik

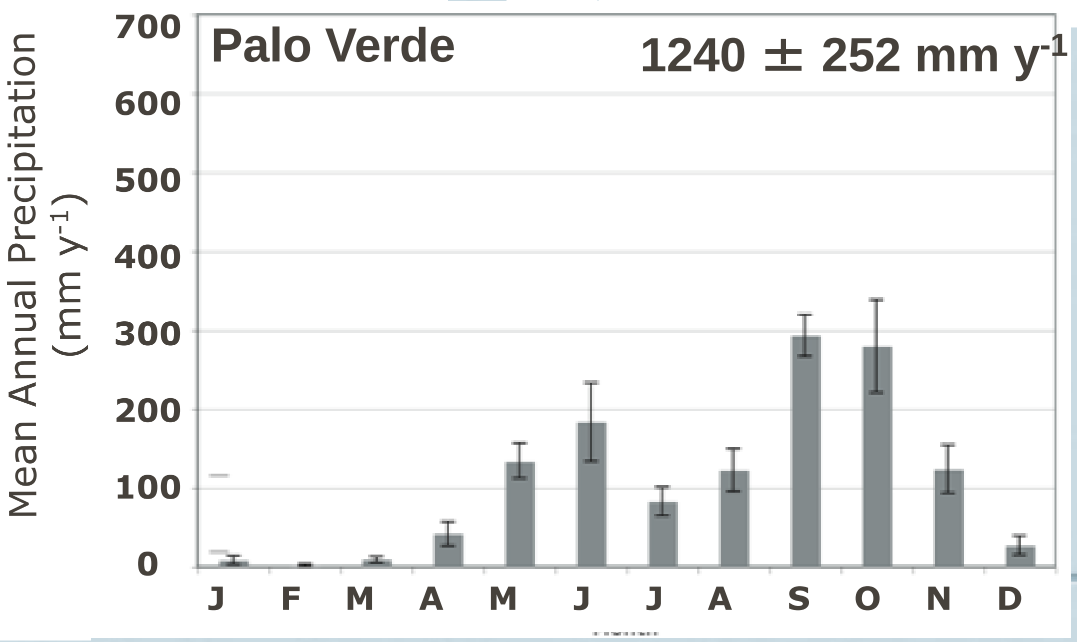
Study sites - Precipitation

Two distinct climates in Costa Rica

- wet rainforest biome in Eastern (Caribbean) Side
- wet/dry climate in Western (Pacific) Side







EARTH University

Humid tropic.

112-ha slow-flow wetland with peat accumulation in a rainforest reserve.

La Selva Biological Station

Humid tropic.

3-ha isolated wetland (not flooded permanently) in a mature rainforest.

Palo Verde Biological Station

Dry tropic

(wet/dry seasons).

1200-ha riverine wetland seasonally dry with a few permanent ponds.

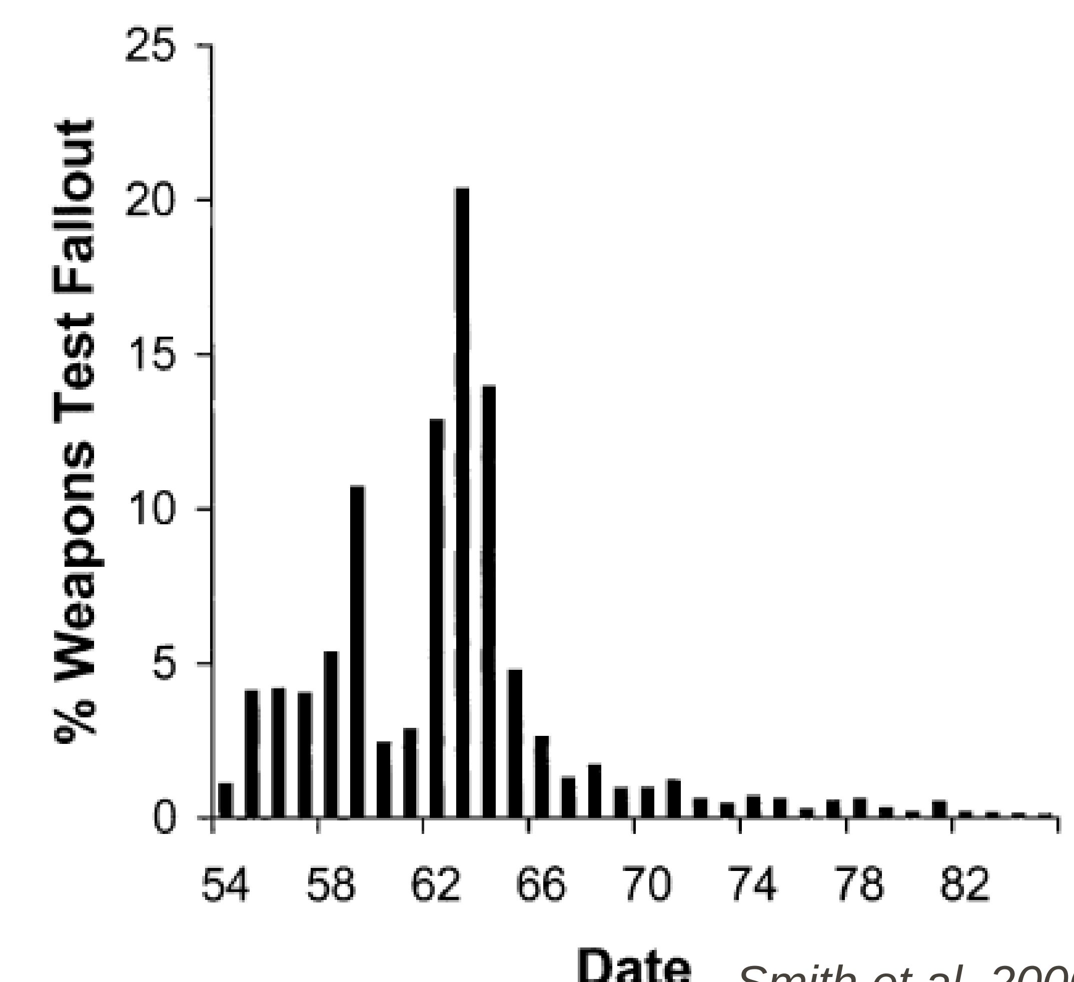
^{137}Cs and ^{210}Pb for accumulation rates

^{137}Cs is a man-made fallout radionuclide. Half-life: 30.1 years.

Atmospheric deposition from nuclear weapon tests performed since 1956 until Nuclear Test Ban Treaty (1963).

1964 - year of maximum ^{137}Cs deposition.

Worldwide distribution.



Smith et al. 2000

^{137}Cs and ^{210}Pb for accumulation rates

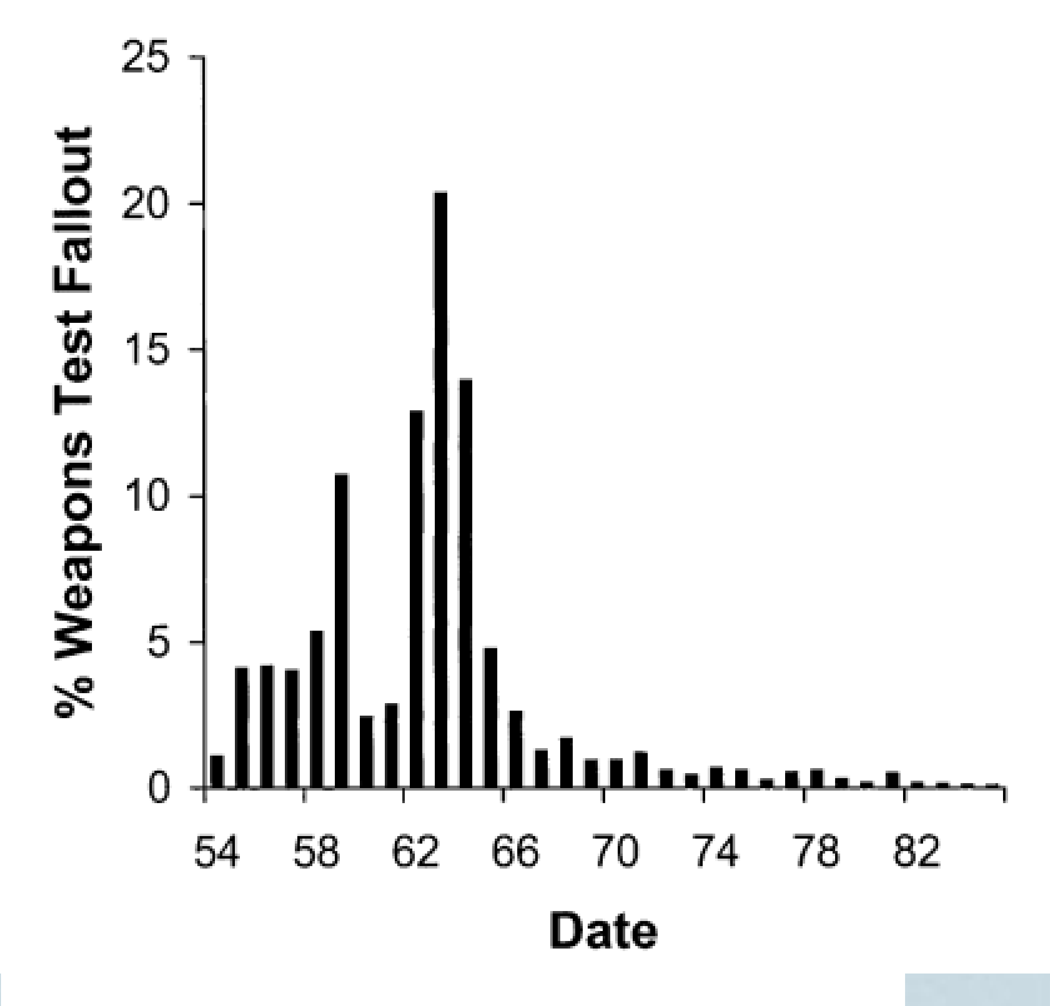
Total amount of ^{137}Cs in the sediment depends on physical, geochemical, and biological factors or processes:

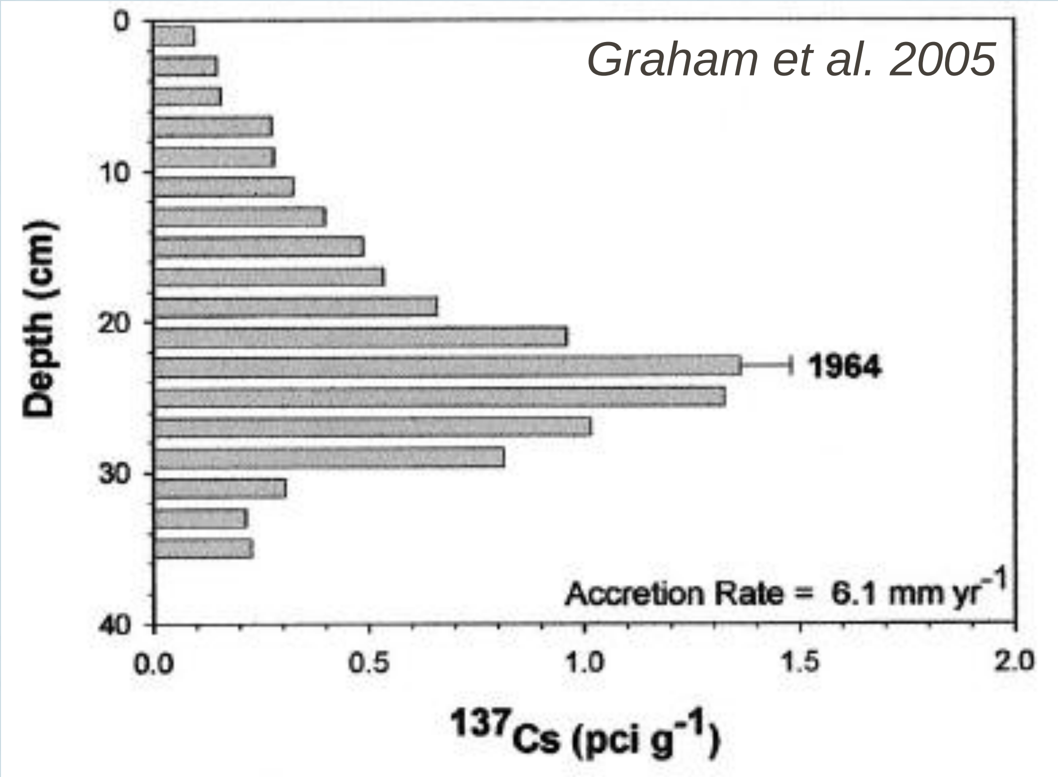
sedimentation rates, re-suspension of sediments, erosion, vegetation intercepting runoff or direct deposition, etc.

what determines sediment accretion is what is going to determine ^{137}Cs concentration in the soil.

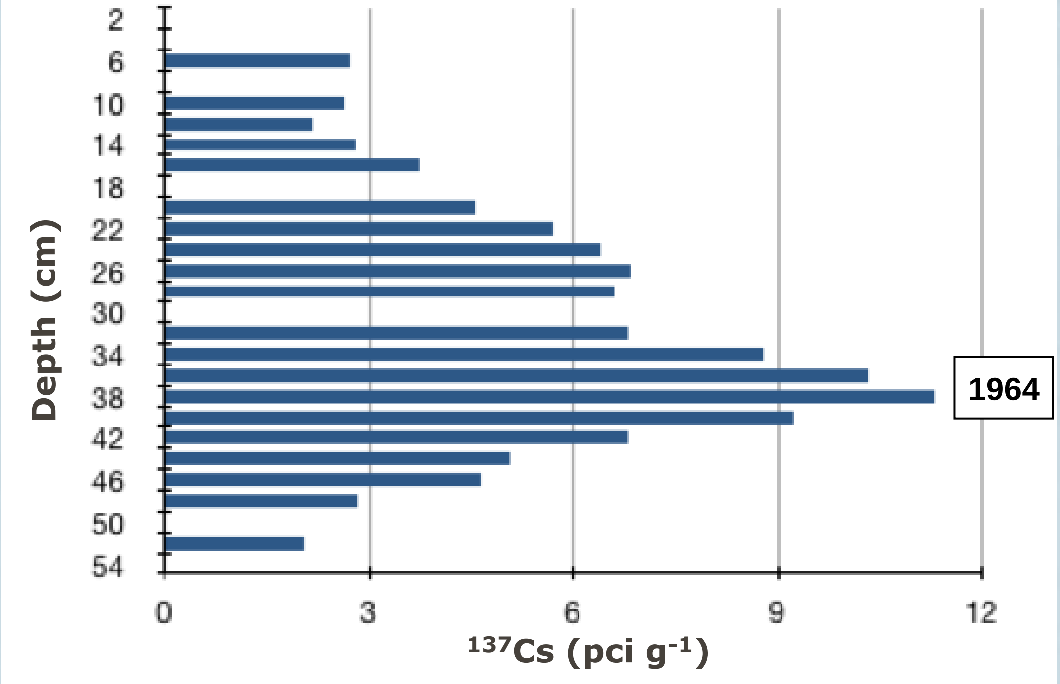
Wetlands are depositional environments - natural sinks for sediments and nutrients.

^{137}Cs and ^{210}Pb for accumulation rates





Hank's Marsh, Upper Klamath Lake, OR



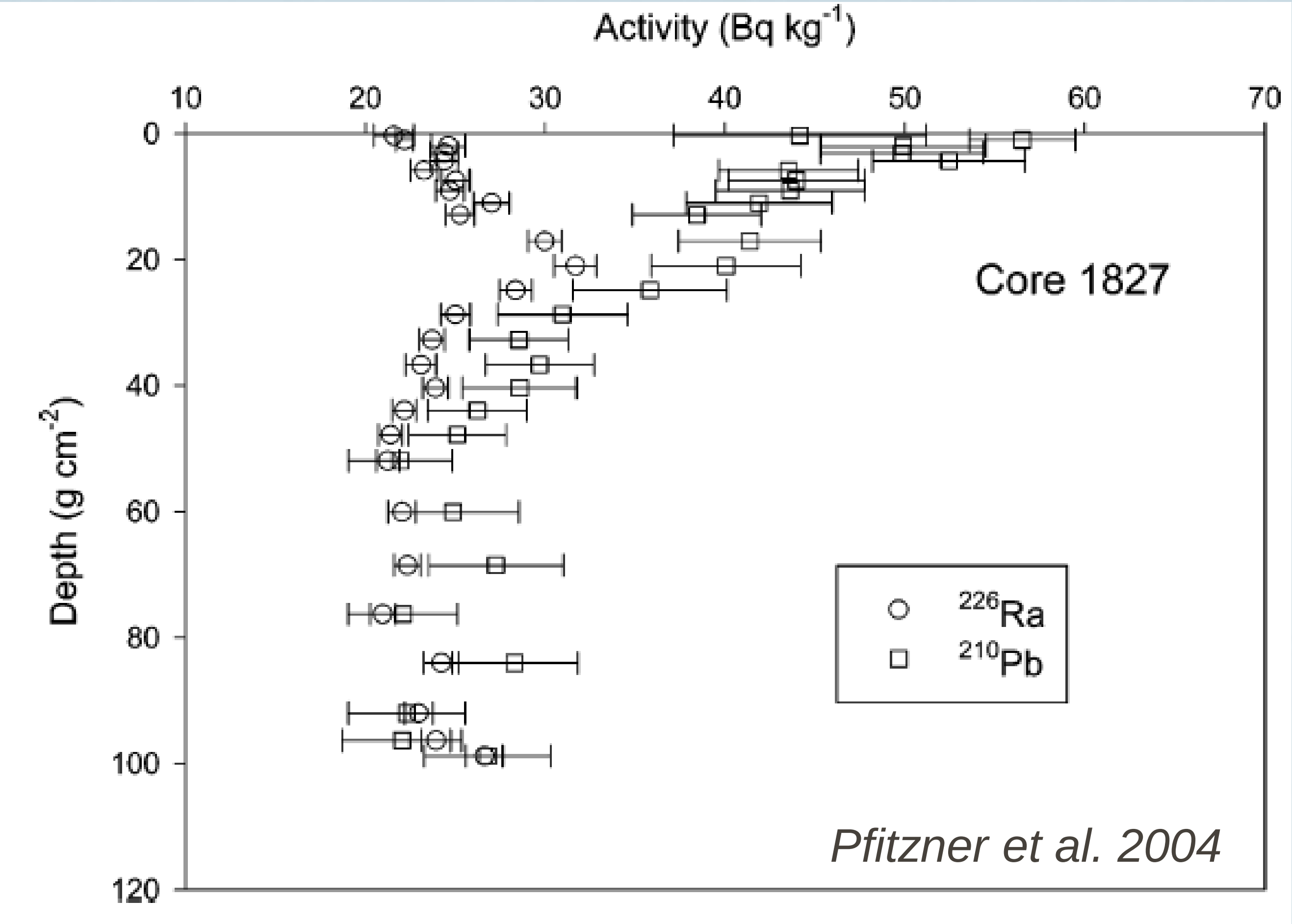
^{137}Cs and ^{210}Pb for accumulation rates

^{210}Pb is a naturally occurring radionuclide from ^{226}Ra decay. Atmospheric deposition. Half-life: 22.2 years.

Used to estimate accretion of the last 100 years.

^{210}Pb and ^{137}Cs have the same depositional pattern and similar behavior in the soil.

Great Barrier Reef Lagoon, Australia



Samples collection and preparation

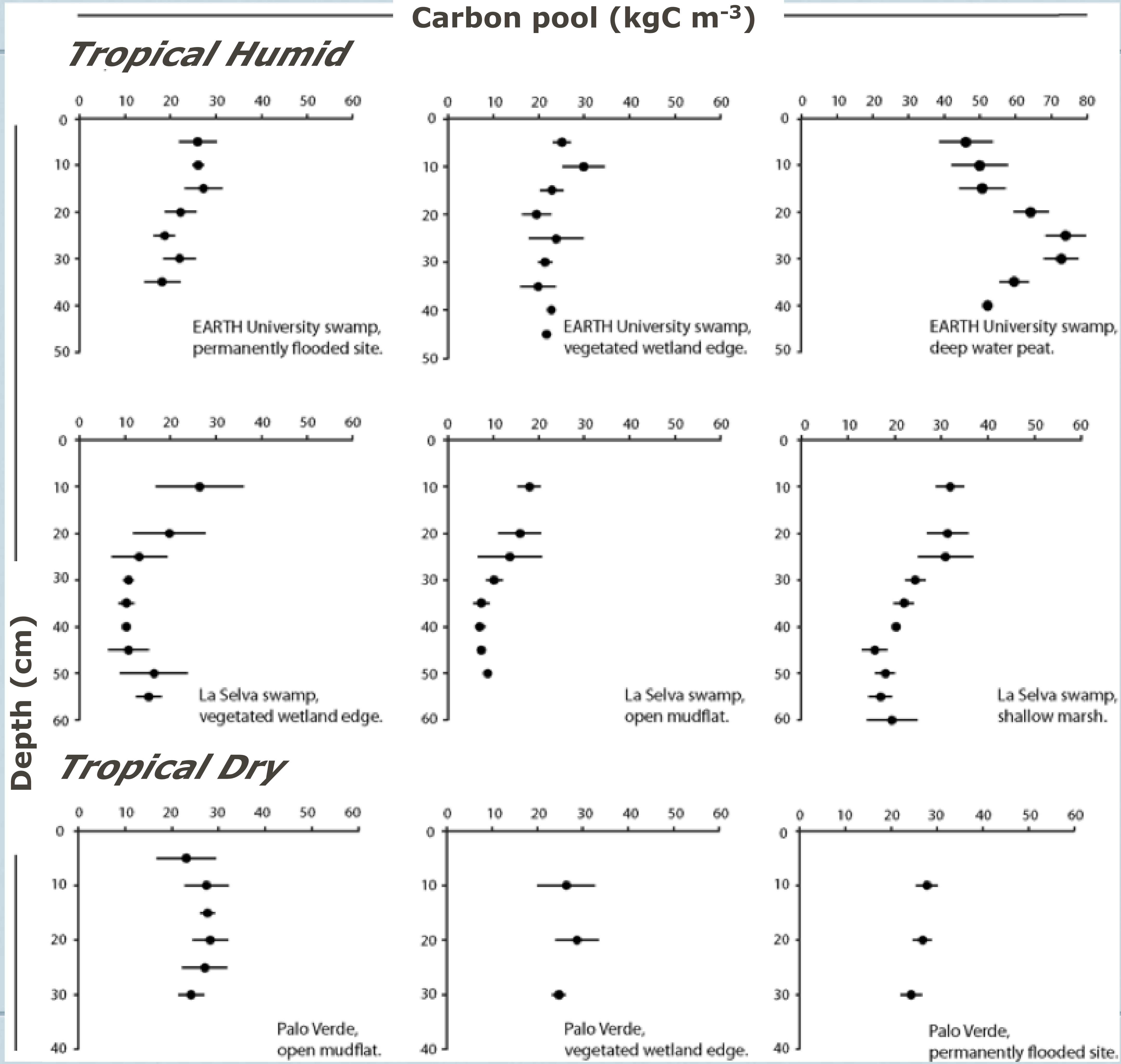
Soil analyses

Radioactivity is measured by Ɣ spectrometry in a high efficiency germanium detector.

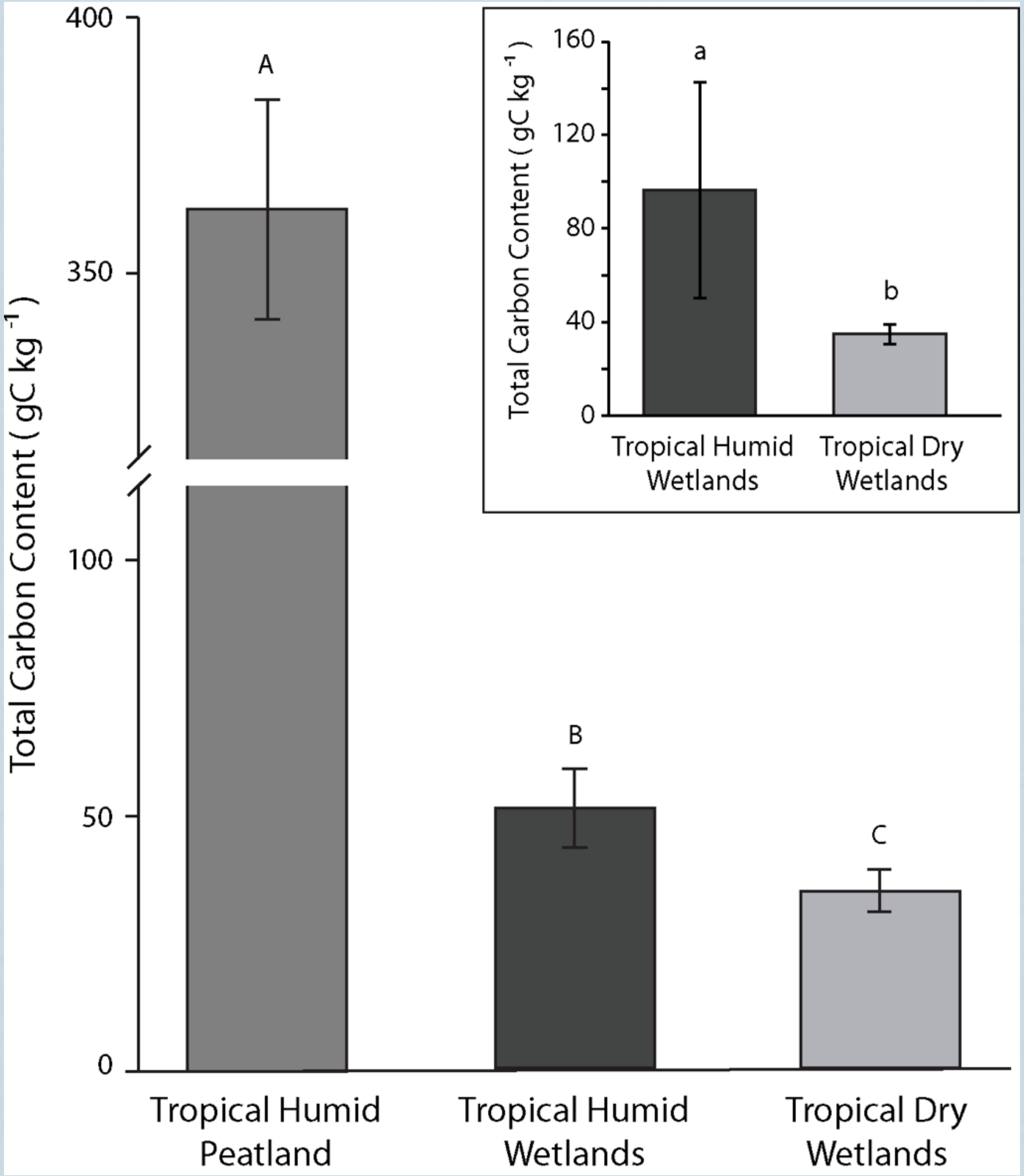
Soil carbon content (gC kg^{-1}) of each depth increment is measured in carbon analyzer, and the soil carbon pools (kgC m^{-2}) and sequestration rates (gC $m^{-2}y^{-1}$) are calculated.

Comparison of the wetland communities

	Bulk Density ($Mg\ m^{-3}$)	Carbon Content ($gC\ kg^{-1}$)	Accretion Rate ($mm\ y^{-1}$)	Carbon Sequestration Rate ($gC\ m^{-2}\ y^{-1}$)
Tropical humid				
Depressional, open mudflat	0.56 ± 0.04	32.5 ± 14.3	4.0	60.6 ± 15.2
Depressional, vegetated edge	0.53 ± 0.04	31.6 ± 12.8	4.6	60.7 ± 11.9
Depressional, shallow marsh	0.45 ± 0.06	61.3 ± 7.6	4.8	130.9 ± 11.6
Swamp, perm. flooded	0.36 ± 0.04	71.4 ± 11.8	9.7	222.1 ± 13.4
Swamp, vegetated edge	0.45 ± 0.08	56.9 ± 10.5	10.0	232.1 ± 13.5
Swamp, deep peat	0.19 ± 0.03	325.0 ± 42.9	7.8	464.7 ± 33.8
Tropical dry				
Riverine, perm. flooded	0.70 ± 0.28	39.1 ± 2.3	3.2	84.2 ± 3.3
Riverine, mudflat	0.65 ± 0.07	44.1 ± 4.2	3.3	89.3 ± 2.9
Riverine, vegetated edge	0.65 ± 0.03	44.9 ± 1.8	3.0	79.9 ± 3.5



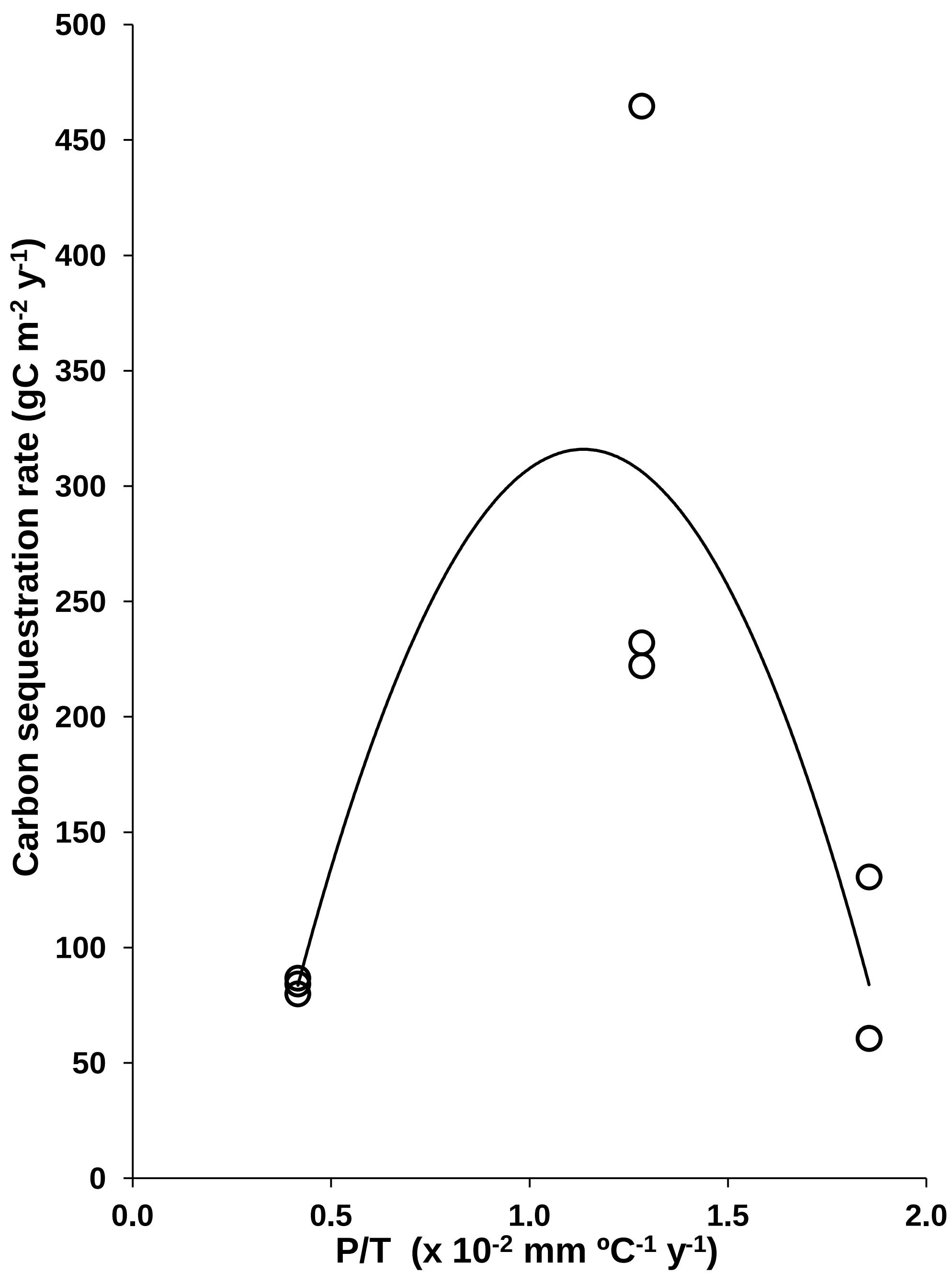
Carbon pool (kgC m-3)
Tropical Humid
EARTH University swamp, permanently flooded site.
EARTH University swamp, vegetated wetland edge.
EARTH University swamp, deep water peat.
La Selva swamp, vegetated wetland edge.
La Selva swamp, open mudflat.
La Selva swamp, shallow marsh.
Tropical Dry
Palo Verde, open mudflat.
Palo Verde, vegetated wetland edge.
Palo Verde, permanently flooded site.
Depth (cm)



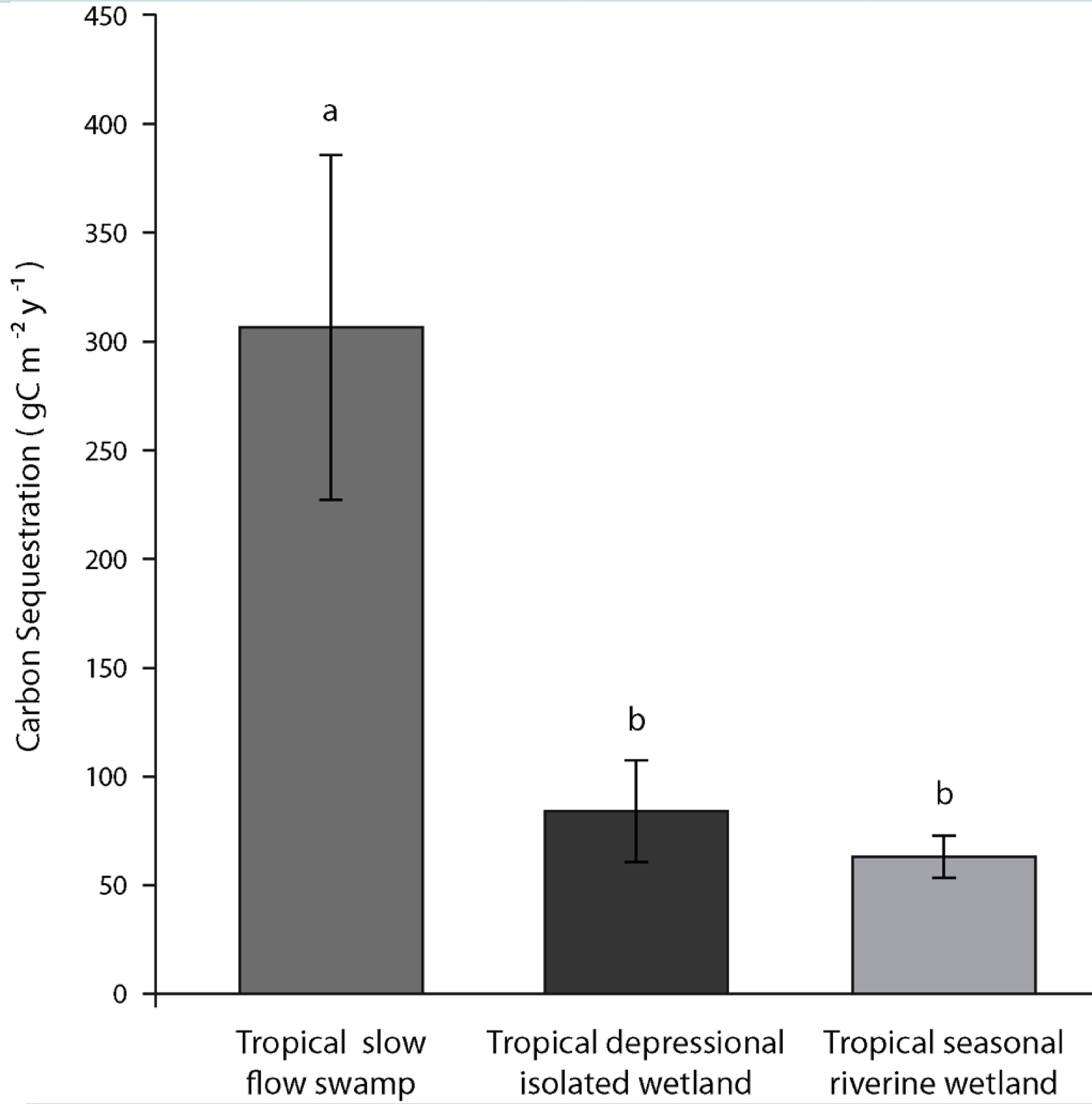
Average carbon contents differ significantly in tropical climates (*P*<0.1)

Carbon content (gC kg^{-1})

Carbon sequestration rate ($gC\ m^{-2}\ y^{-1}$)



P = mean annual precipitation (mm y^{-1})
T = temperature (ºC)



Carbon sequestration is significantly higher in the slow-flow swamp than in the isolated or riverine tropical wetlands (*P*<0.01), especially in the peat accumulating site.

Conclusions

Wetland communities in tropical humid climates had higher carbon content than did those in tropical dry regions.

Tropical wetlands can be significant carbon sinks when the conditions allow for peat accumulation.

Permanently flooded tropical wetland communities had the highest carbon accumulation rates, suggesting that the presence of water enhances carbon sequestration.

Changes in temperature and precipitation patterns can alter seasonality of tropical wetlands, potentially modifying their soil carbon accumulation rate - the wetland could “switch” from a carbon sink to a source.

THANK YOU

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