Verified Carbon Standard:
Progress and Challenges for Wetlands

Patrick Megonigal, SERC

Restore America's Estuaries VCS Methodology Working Group:
Steve Crooks, ESA-PWA
Igino Emmer, Silvestrum
Steve Emmett-Mattox, RAE
Doug Myers, Ecolidays
Brian Needelman, University of Maryland

Verified Carbon Standard:
Progress and Challenges for Wetlands

- **A greenhouse gas accounting program used by projects around the world to verify and issue carbon credits in voluntary markets.**

- **VCS relies on expert committees to develop and update requirements that reflect state-of-the art knowledge and global good practice.**

- **Alternative programs include the *American Carbon Registry*, the *Climate Action Reserve*, and the *California Air Control Board*.**

VCS | VERIFIED CARBON STANDARD

A Global Benchmark for Carbon

Steps in Awarding Carbon Credits

- <u>Standards</u> for project activities
  - General requirements and guidance for GHG accounting
  - Procedures for validation and verification
  - Registry and clearing house for 'carbon credits'

- <u>Methodologies</u> are step-by-step explanations of how emission reductions or removals are to be estimated in line with the requirements following accepted scientific good practice

- <u>Project description</u> or design documents provide information on how a specific project complies with the requirements and applies the methodology

Silvestrum

Source: Igino Emmer

Big Year For Wetland Carbon Crediting

Sep 2012: American Carbon Registry approves first wetland methodology
•*Restoration of Degraded Deltaic Wetlands of the Mississippi Delta*
•Requirements under ACR Forest Carbon Project Standard

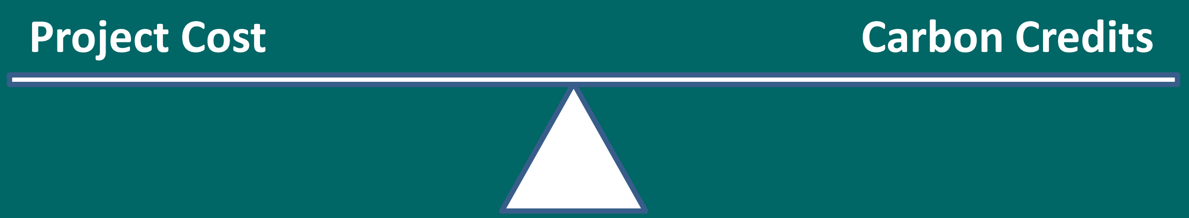
Oct 2012: Verified Carbon Registry approves first requirements for wetlands
VCS Requirements: *Wetlands Restoration and Conservation (WRC)*

Likely in 2013
VCS Methodology: Restoration of Coastal Wetlands (Restore America's Estuaries)
VCS Methodology: Creation of Gulf Coast Tidal Wetlands (CH2M Hill)

Future
VCS Methodology: Coastal wetlands conservation
VCS Methodology: Sea grasses

Principles for Applying Science to Carbon Crediting

1. Be true to the science
2. Be conservative when uncertain
3. Minimize the cost of applying science to methodology



↑ Adoption → ↑ Conservative Simplifications → ↓ Project Cost → ↓ Carbon Credits

↑ Carbon Credits → ↓ Conservative Simplifications → ↑ Project Cost → ↓ Adoption

Options for Managing Project Costs

Default Values

Provide the project developer information in a look up table.

De minimis

Demonstrate that GHG sources account for less then 5% of the CO_2-equivalents generated by the activity.

Proxy Data

Demonstrate that GHG sources can be estimated indirectly by measuring some characteristic of the project site that is correlated with the GHG source.

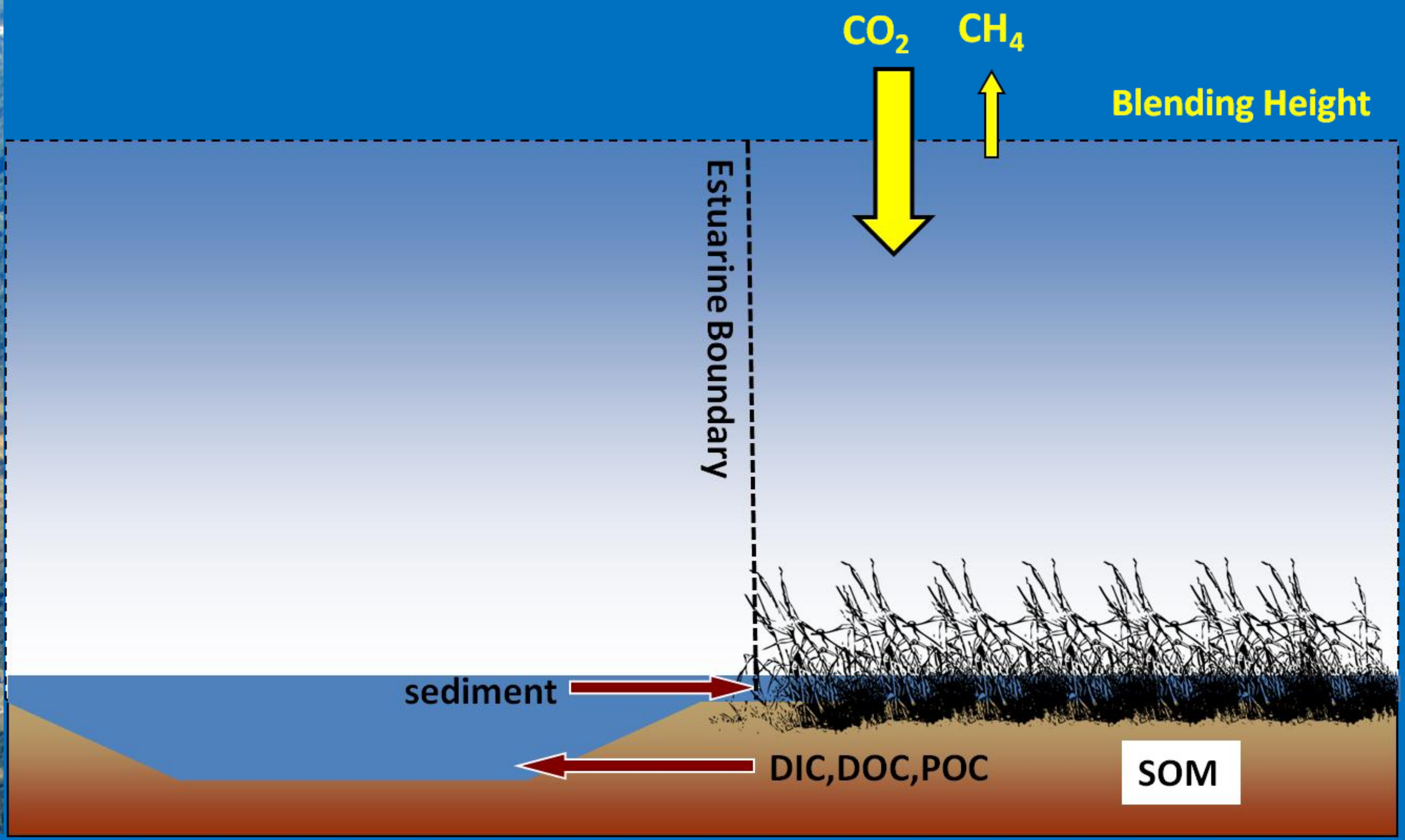
Models

Statistical models and simulation models can be used provided the project can show they apply to the project site.

Measurement

- Tools for estimating sample size
- Conservative sample design

Carbon Accounting at Landscape Level



Net Ecosystem Carbon Balance (NECB) = $F_{CO2} + F_{POC} + F_{DIC} + F_{DOC} + F_{CH4} + F_{VOC} + F_{CO}$

Net Biome Production = Σ NECB

Well Constrained Methodological Issues

Current Wetland boundary

- GIS
- Surveying

Soil carbon pools

- Soil Coring
- Marker Horizons

Poorly Constrained Issues

- Trace gas emissions
- Landscape-level carbon issues
    - Allochthonous Carbon Sources
    - Fate of Inundated Carbon Pools
- Changes in wetland boundary

Allochthonous Carbon

Question: What portion of the carbon in tidal wetland soils is imported from outside the wetland?

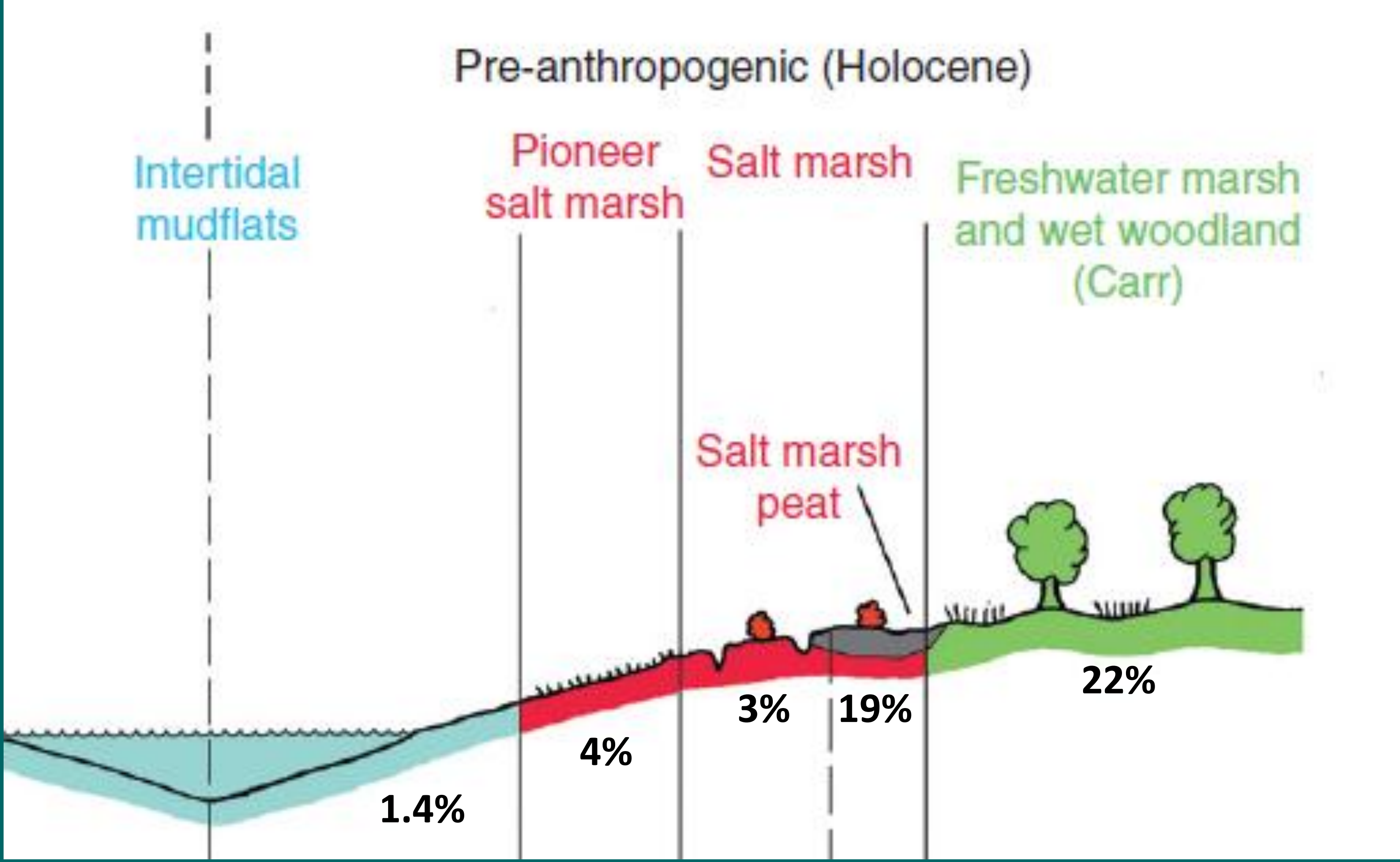
Credit Issue: Allochthonous carbon receives credit only if decomposition rate decreases in the wetland.

Science: Allochthonous carbon is mostly of terrestrial origin and recalcitrant. Its non-wetland fate can be complete burial or partial decomposition.

Conservative Approach: Assume no change in preservation when stored in the wetland.

Challenge: Simple approach to account for allocthonous carbon sequestration.

Allocthonous Carbon



% Soil Organic Carbon

Andrews et al. 2011

Allocthonous Carbon

Table 2. A carbon budget for the *Spartina* site at the Waarde Marsh, The Netherlands.

	Total rate (g C·m^{-2}·y^{-1})	Contribution from *Spartina*-derived material (%)	Rate based on *Spartina*-derived material (g C·m^{-2}·y^{-1})
Sediment			
Respiration	600*	<10‡	<60
Burial	105†	30–45§	30–50
Total			30–110
Macrophyte			
Belowground production			>600‖

Boschker et al. 1999

Fate of Carbon in Inundated Tidal Wetlands

Question: What is the fate of soil organic carbon when a systems converts to open water?

Credit Issue: Credit for intervening to prevent inundation can be granted only if carbon is returned to the atmosphere.

Science: Coast shelf sediments have low carbon content. Submerged wetland soils persist for decades.

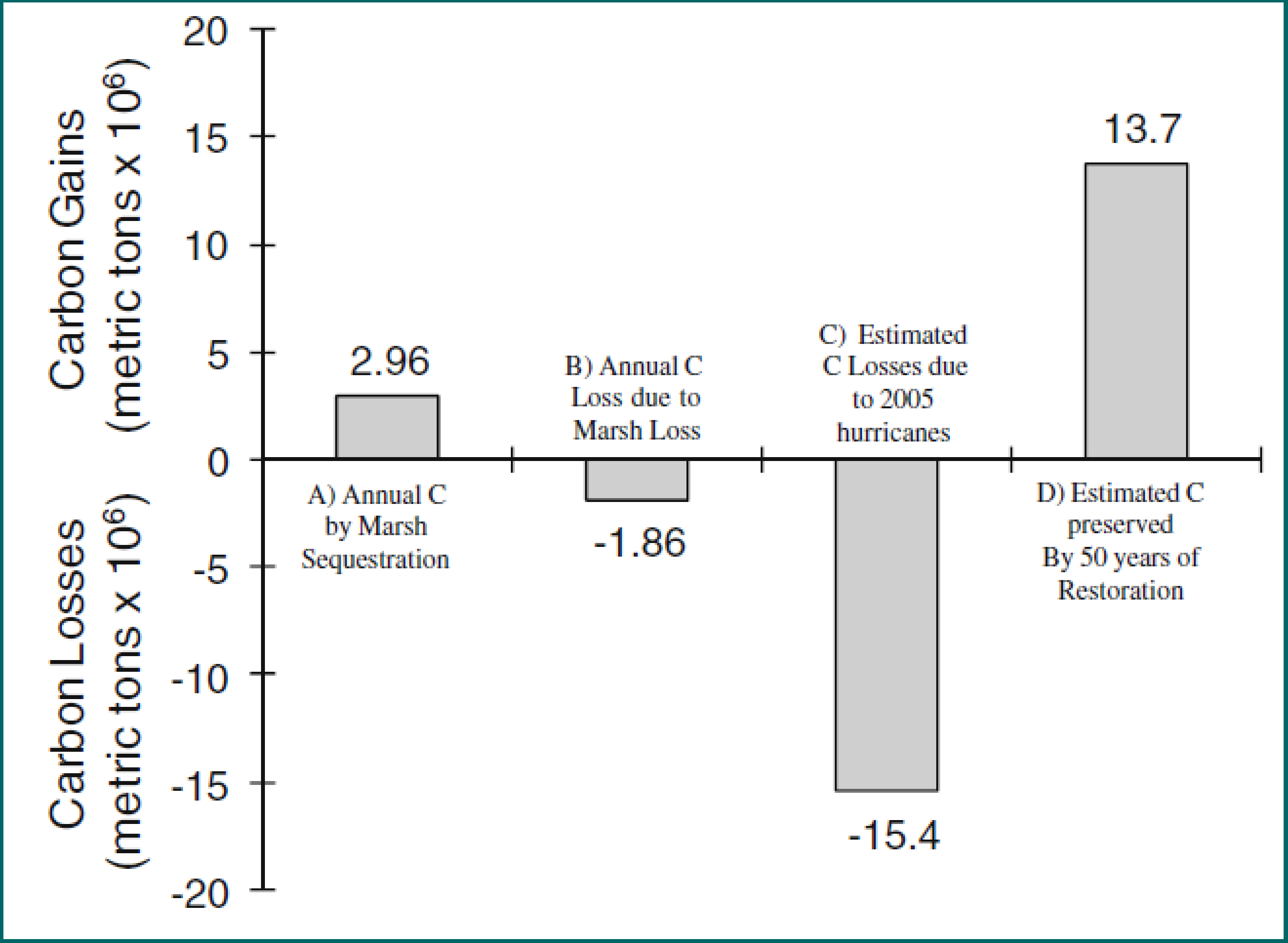
Conservative Approach: Assume inundated soil carbon remains sequestered.

Challenge: Increase carbon credit value by accounting for loss via inundation.

Chincoteague Bay Subaqueous Soils

Balduff & Rabenhorst, *unpublished*

Fate of Carbon in Inundated Tidal Wetlands



DeLaune & White 2011

Methane & Nitrous Oxide

Question: How much methane and nitrous oxide do tidal wetlands emit?

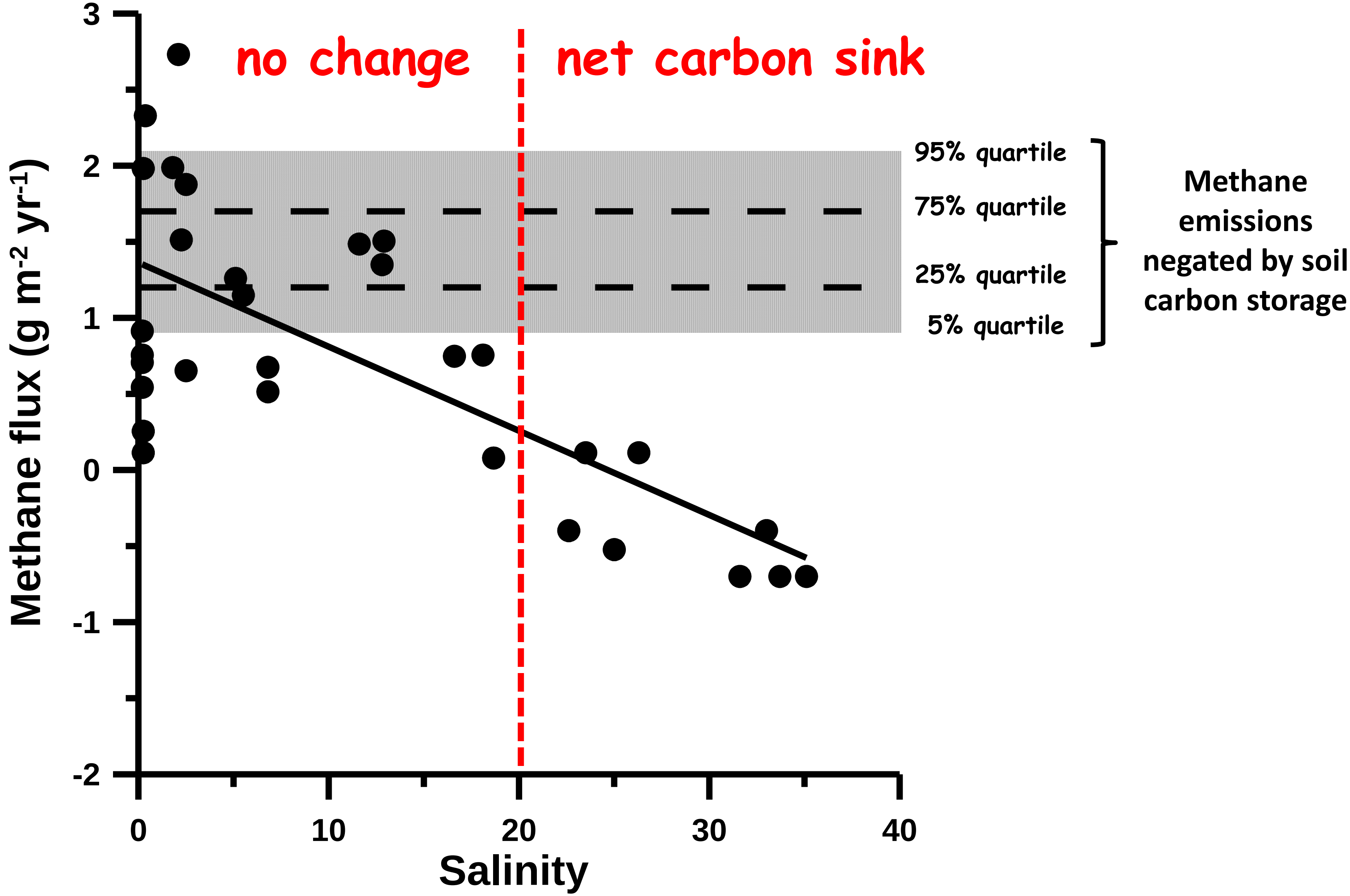
Credit Issue: Credit is given for reduction in total greenhouse gas emissions, and wetlands generally emit methane and nitrous oxide.

Science: Methane emissions are low at high salinity. Nitrous oxide emissions are low if nitrate loading is low.

Conservative Approach: Assume zero baseline emissions. Measure project emissions at times and places where they will be highest.

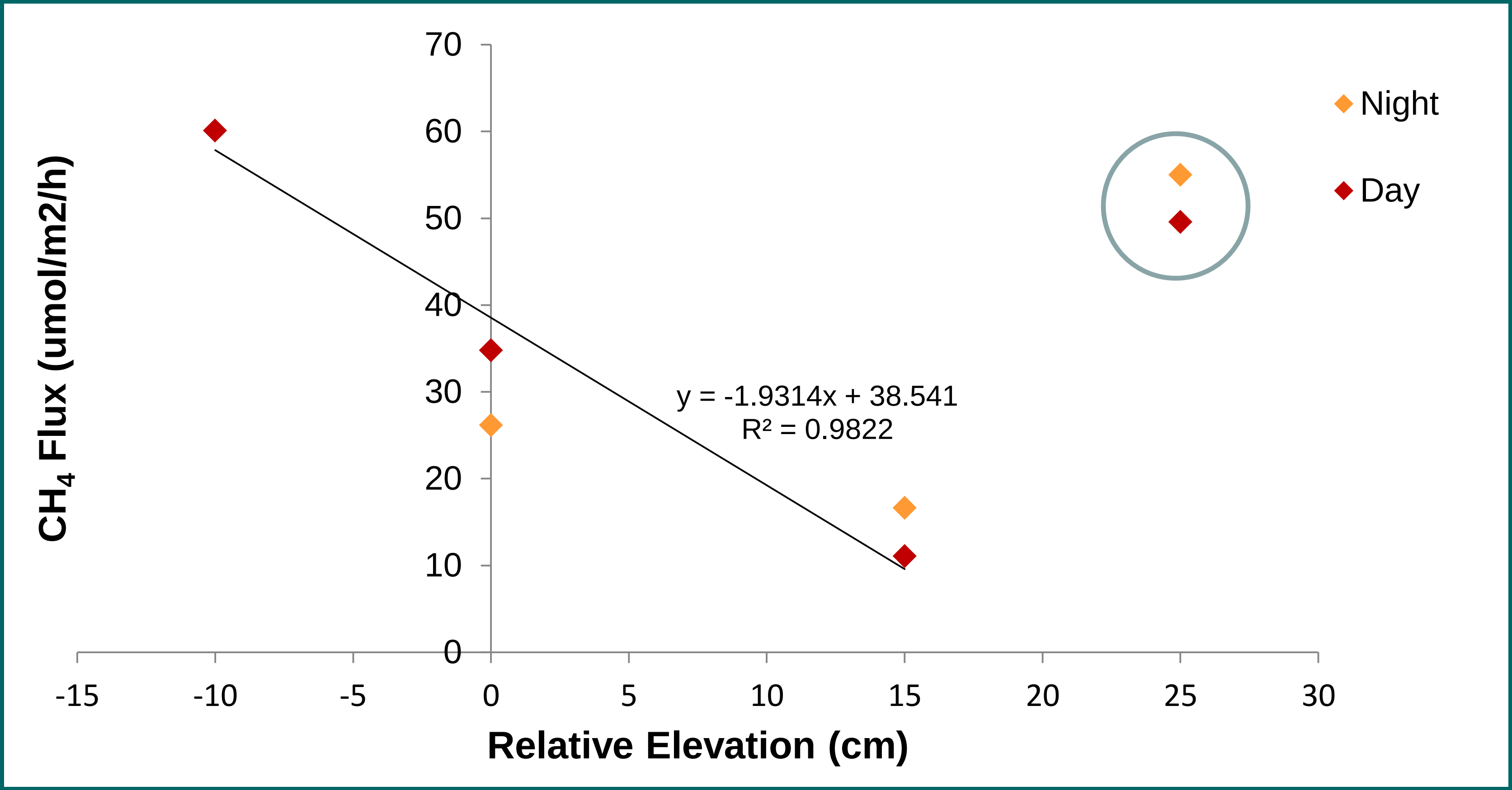
Challenge: Develop proxies and methods that decrease effort and allow less conservative estimates.

Salinity as a Proxy



Poffenberger, Needelman & Megonigal (2011)

Water Table and Species as Proxies



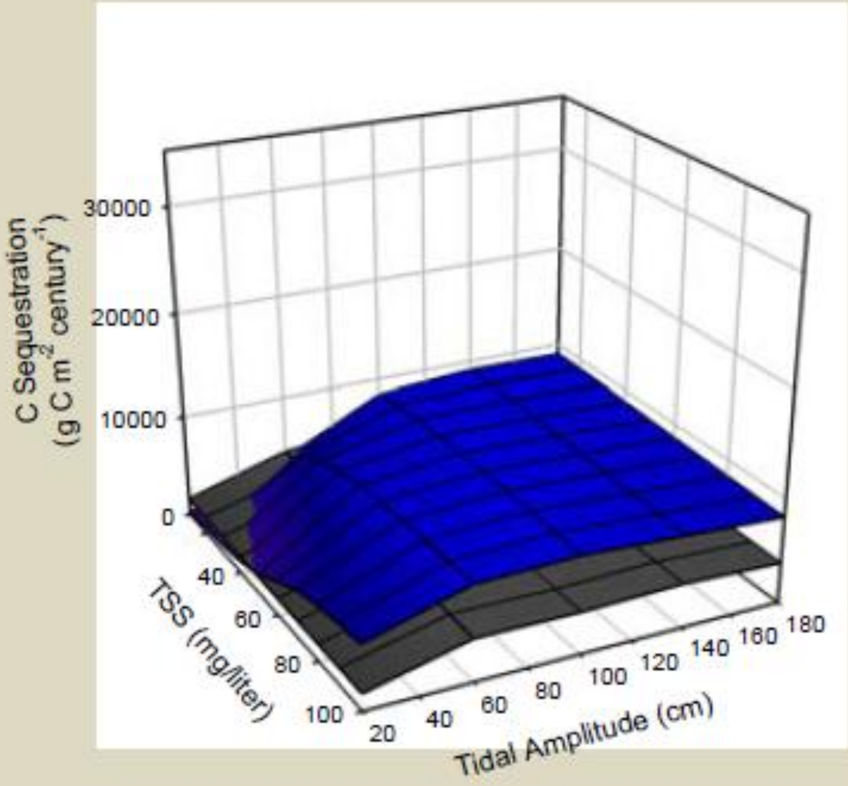
wet → dry

Megonigal, unpublished

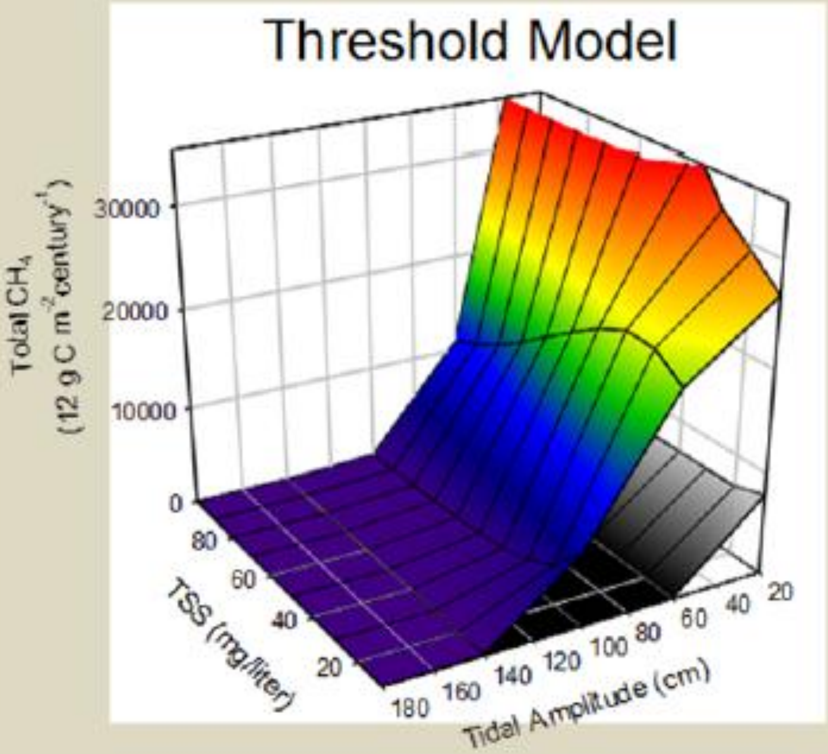
Mechanistic Models

Equilibrium rates of C sequestration and CH4 emissions at constant SLR =0.05 mm/yr (grey surface) and following 100 yr of accelerating sea level to 1 m (color surface).

Century Level
C Sequestration Rate

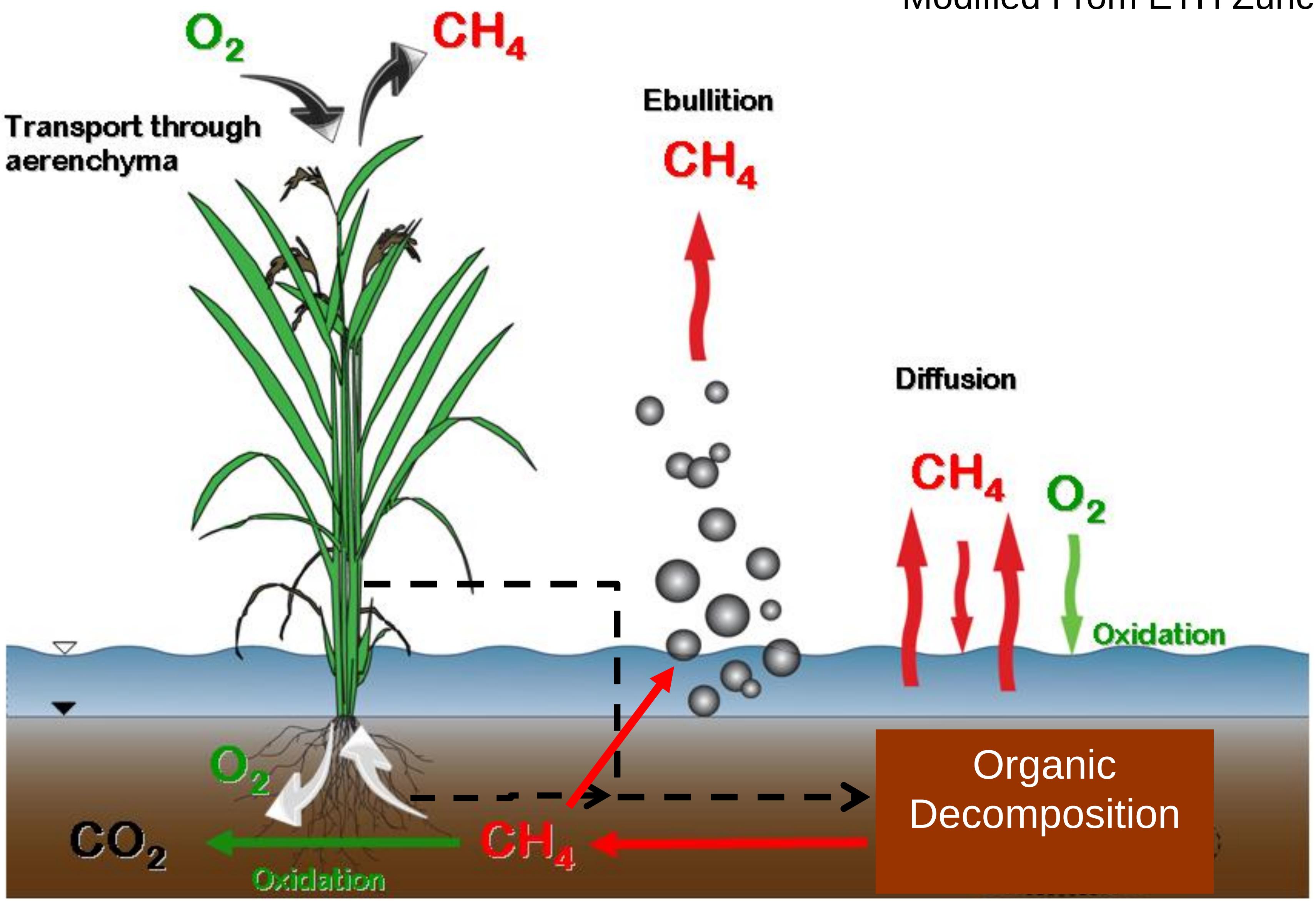


Century Level
CH4 Emissions (CO2 Equivalent)



Morris & Megonigal, unpublished

Modified From ETH Zurich



Methane oxidation:

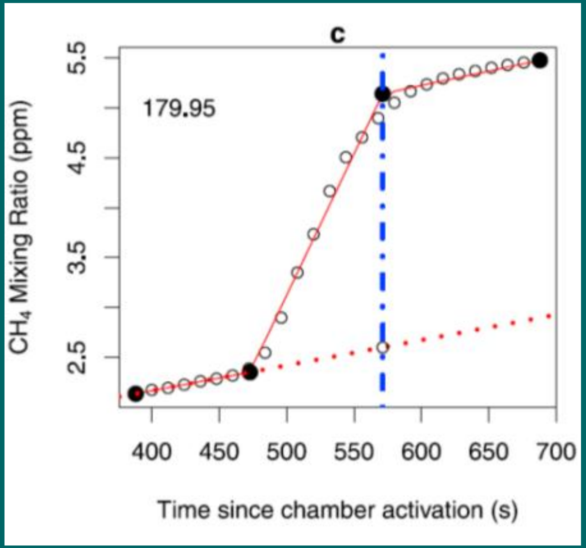
$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$

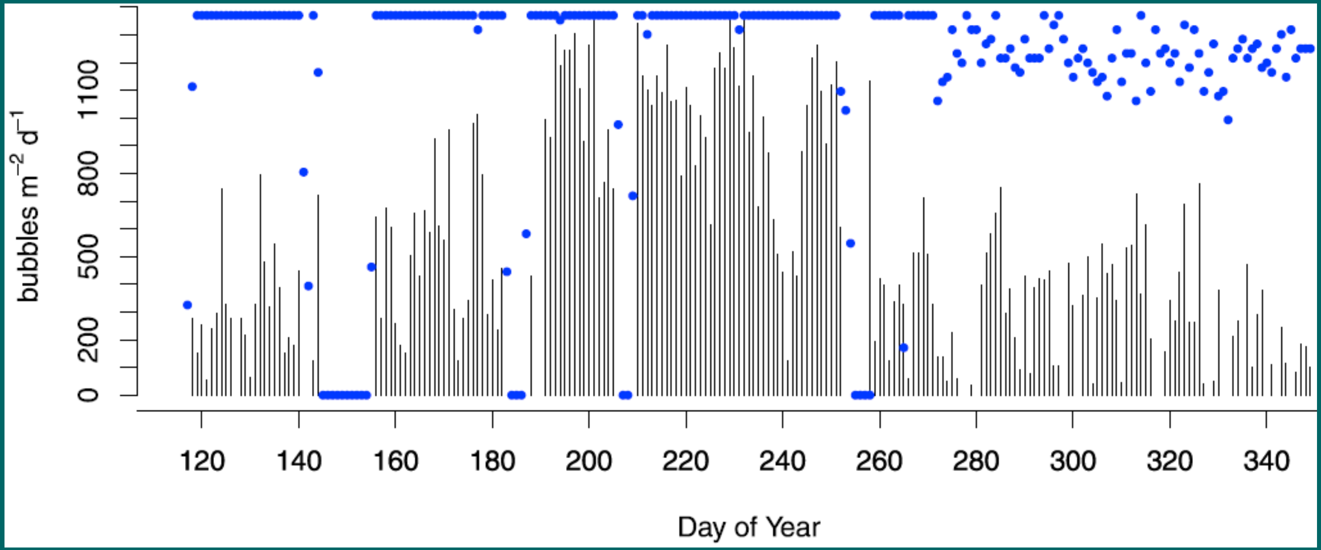
Methanogenesis:

Hydrogenotrophic: $CO_2 + 4H_2 \rightarrow 2\ H_2O + CH_4$

Acetotrophic: $CH_3COOH \rightarrow CO_2 + CH_4$

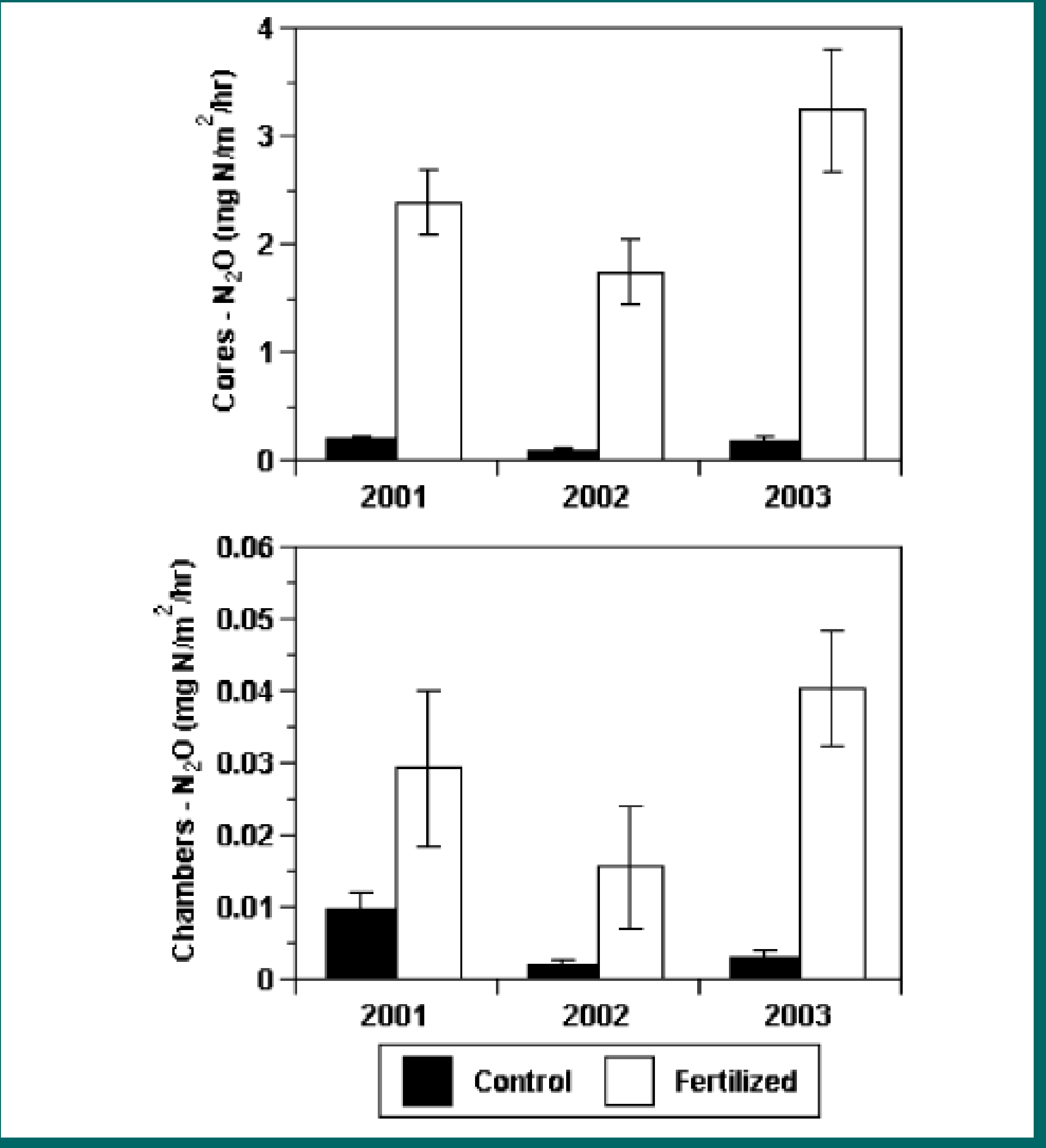
The Bubble Problem





Goodrich et al. *Geophysical Research Letters* 2011

Nitrous Oxide



Whigham et al. *2009*

Nitrous Oxide

Firestone Leaky Pipe Model

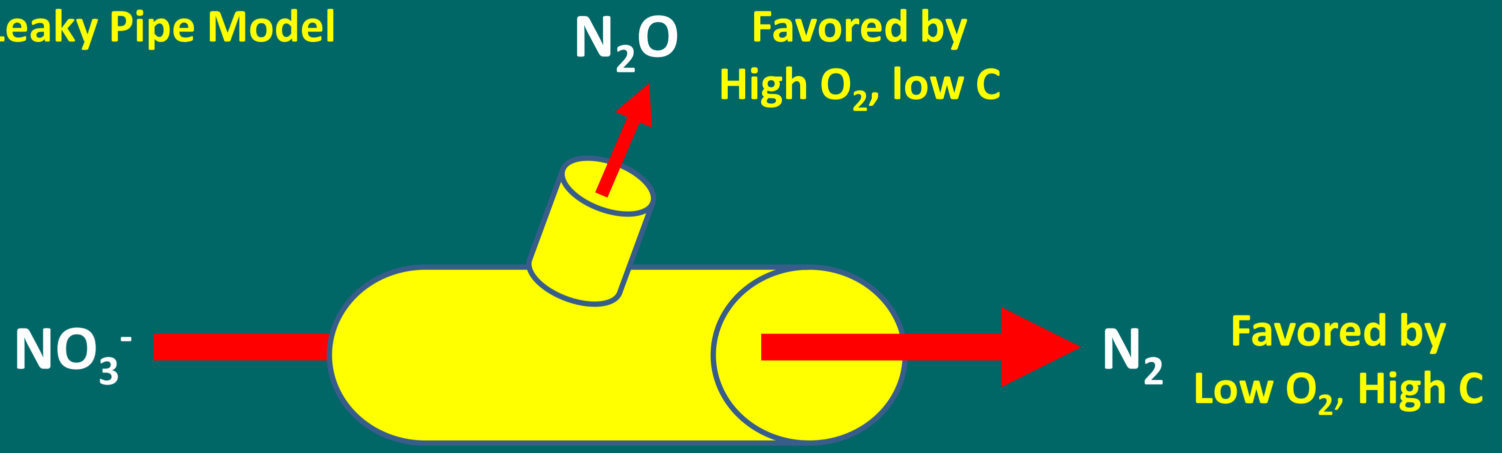


Table 2. Mean N_2O-yield values from various laboratory and field studies of denitrification

Ecosystem	$N_2O\text{-}N/(N_2+N_2O)N$
Agricultural soils	0.375 ± 0.035 (SE)
Soils under natural or recovering vegetation	0.492 ± 0.066 (SE)
Freshwater wetlands and flooded soils	0.082 ± 0.024 (SE)

Schlesinger 2009

Issue of Open Water Strata

Wetland Ecosystem	N_2O Emissions (mg N_2O m^{-2} yr^{-1})
Salt Marsh	31
Open Water	10
Brackish Marsh	48
Open Water	21
Freshwater Marsh	55
Open Water	34

Smith et al. *1983*

Discussion