

Sixth Annual Conference on Carbon Capture & Sequestration

Terrestrial-Related Sequestration Research and Development

**Permanent Carbon Sequestration in Marine Sediments:
The Effect of Oxygen on the Degradation of Crop Residues**

Jonathan Nuwer, Richard Keil, and Stuart Strand

May 7-10, 2007 • Sheraton Station Square • Pittsburgh, Pennsylvania

Goal

Can we reduce the annual anthropogenic increase in atmospheric CO₂ by 25% simply by storing crop residues at the bottom of the ocean?

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Can we reduce the annual anthropogenic increase in atmospheric CO₂ by 25% simply by storing crop residues at the bottom of the ocean?

YES!

1. Crop residues are slowly degraded in marine sediments
2. CO₂ produced remains sequestered in deep-water

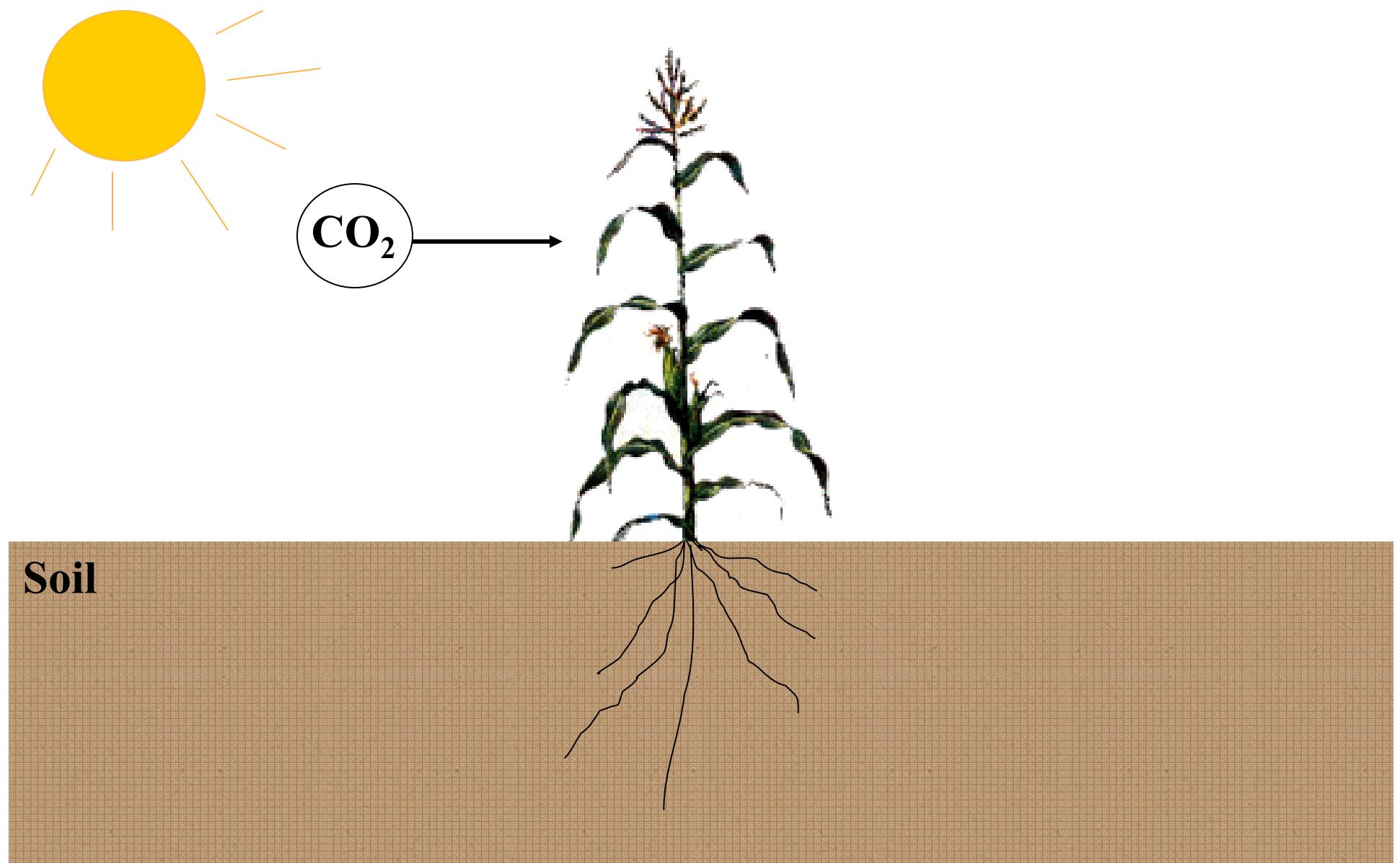
Outline



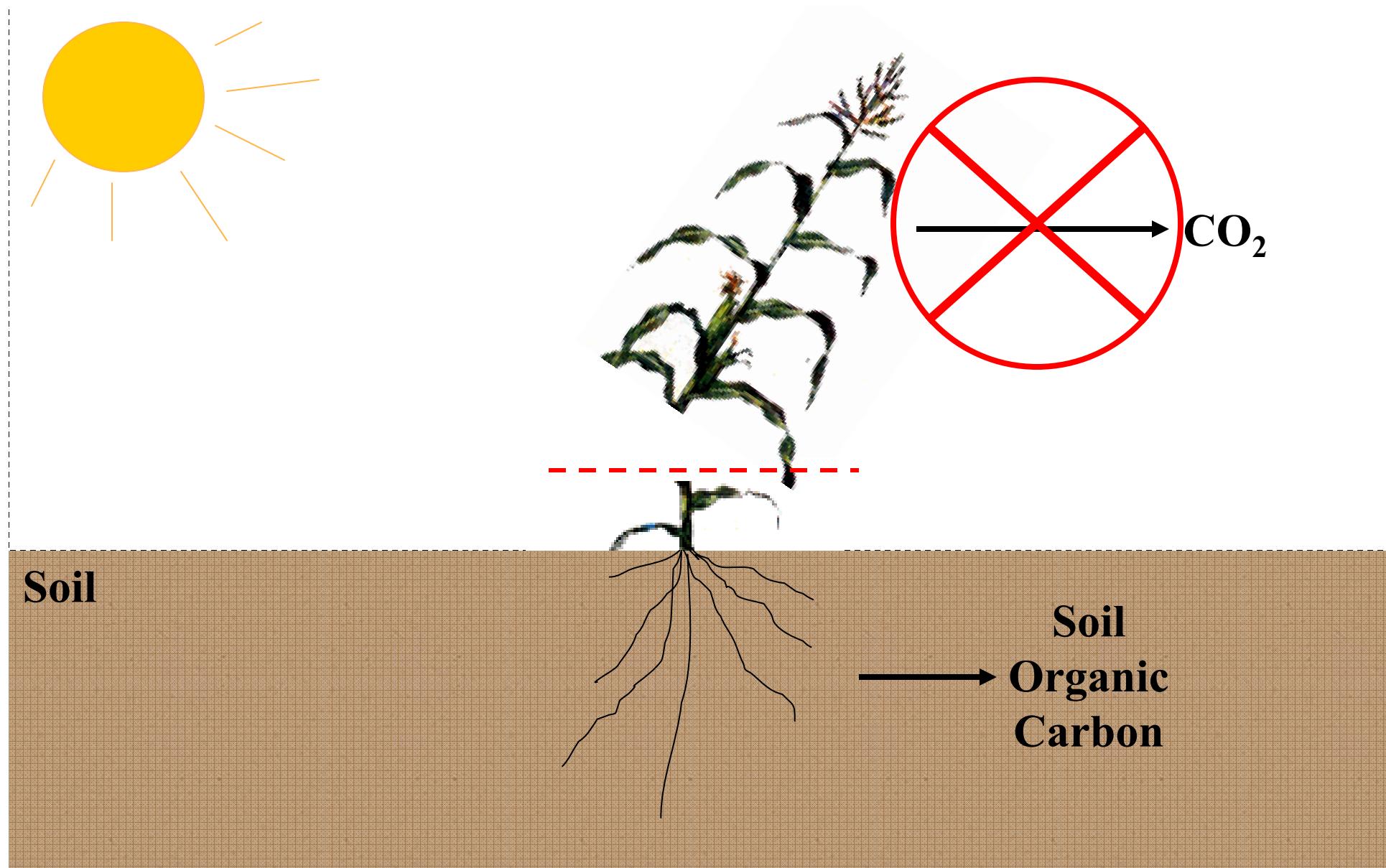
School of Oceanography
University of Washington

1. Introduce C.R.O.P.S.
2. Incubation experiment
3. Degradation of organic matter
4. Quantify crop degradation
5. A theoretical scenario

Crop Carbon Cycle



Crop Carbon Cycle



Crop Residue Ocean Permanent Sequestration



Crop Residue Collection



Offshore Transportation



Seafloor Deposition

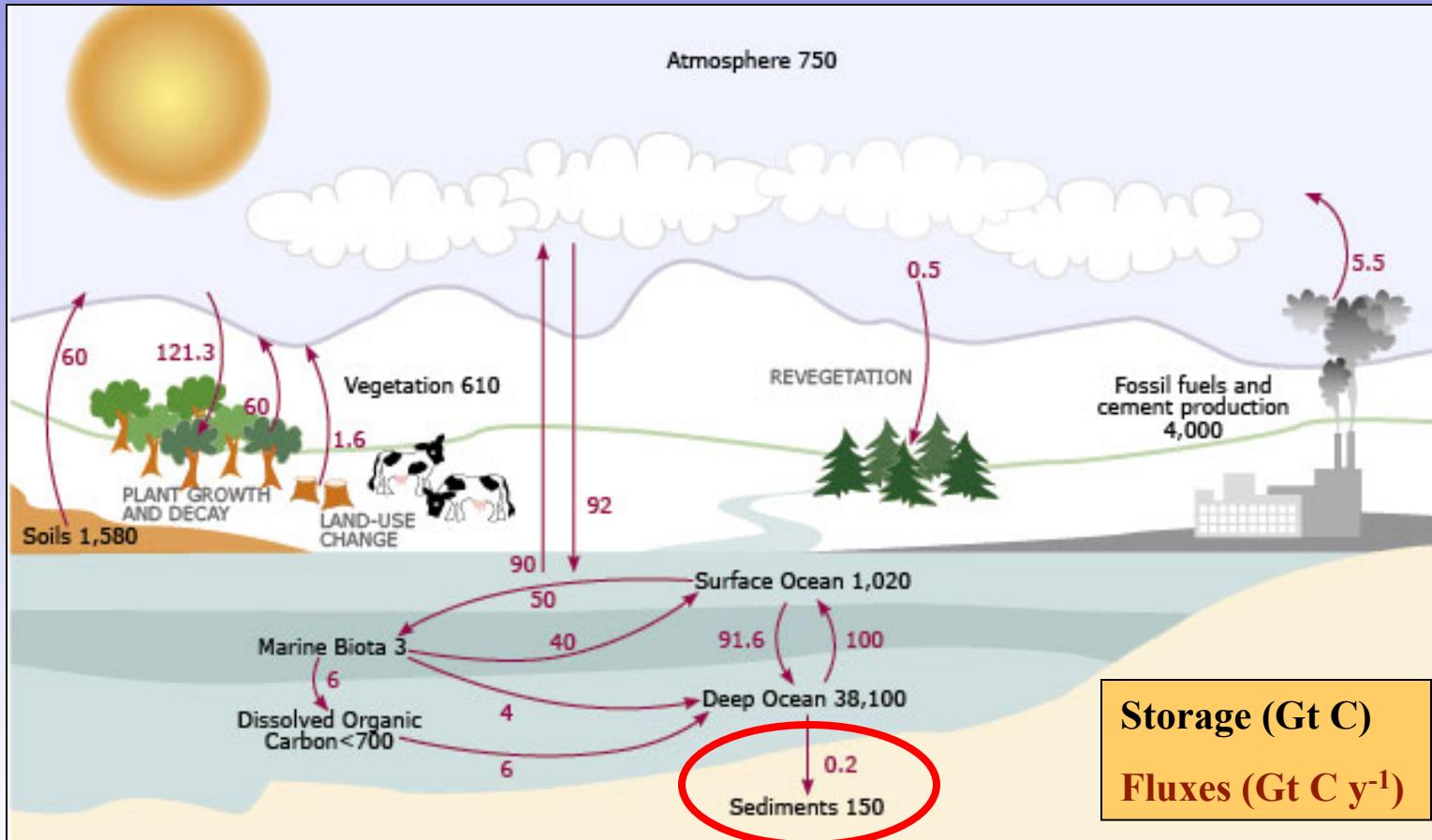


Benefits:

- No new land
- Readily available
- No commercial value

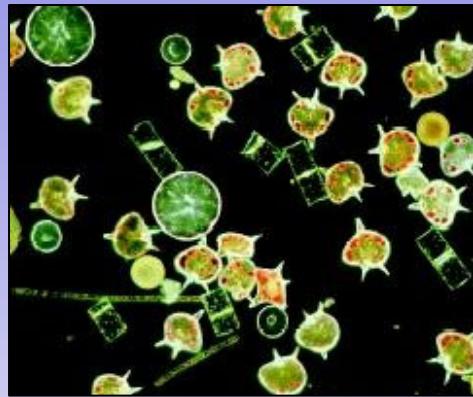
For more on CROPS, please stay for next talk.

Global Carbon Cycle

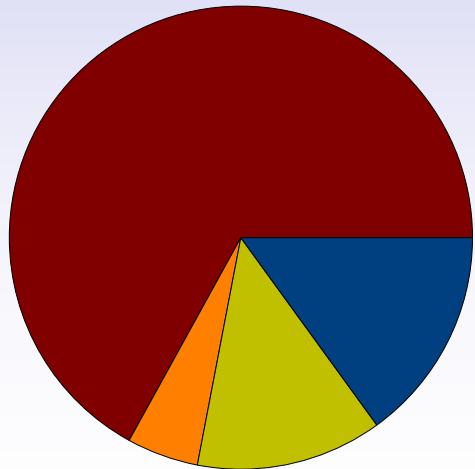


- ◆ Burial in marine sediments is the ultimate long-term sink in the global carbon cycle.

Organic Matter Composition



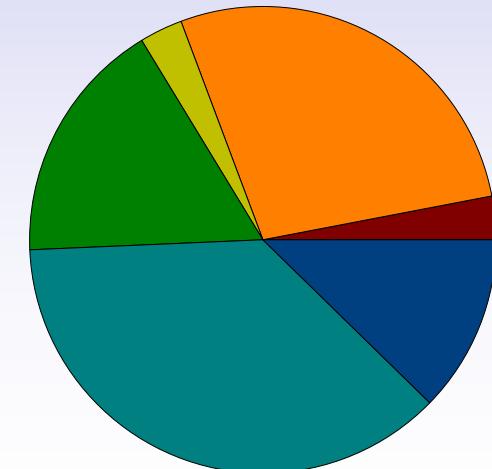
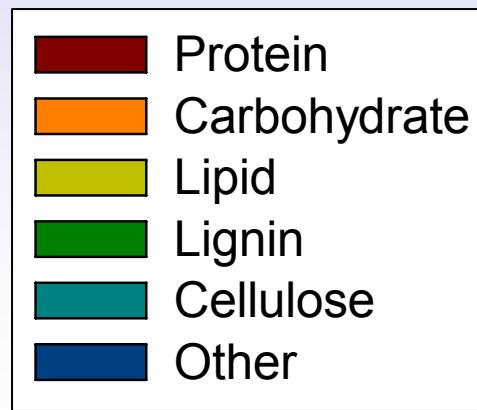
Marine Plankton



Lee et al., 2004



Corn Stalk



Sheehan et al., 2001

Incubation Experiment

corn stalk

soy stalk

Alder wood

plankton

Incubation Experiment

corn stalk

soy stalk

Alder wood

plankton

+

+

+

+

sediment

sediment

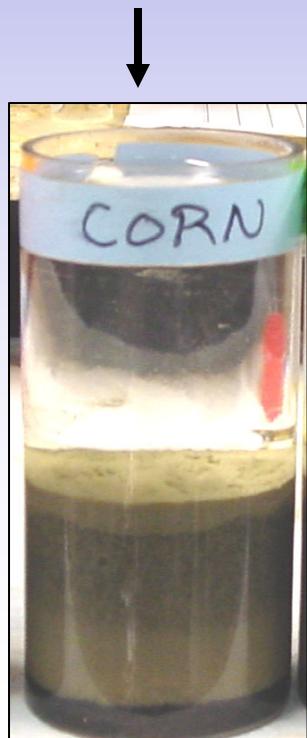
sediment

sediment

sediment

Incubation Experiment

corn stalk	soy stalk	Alder wood	plankton
+	+	+	+
sediment	sediment	sediment	sediment



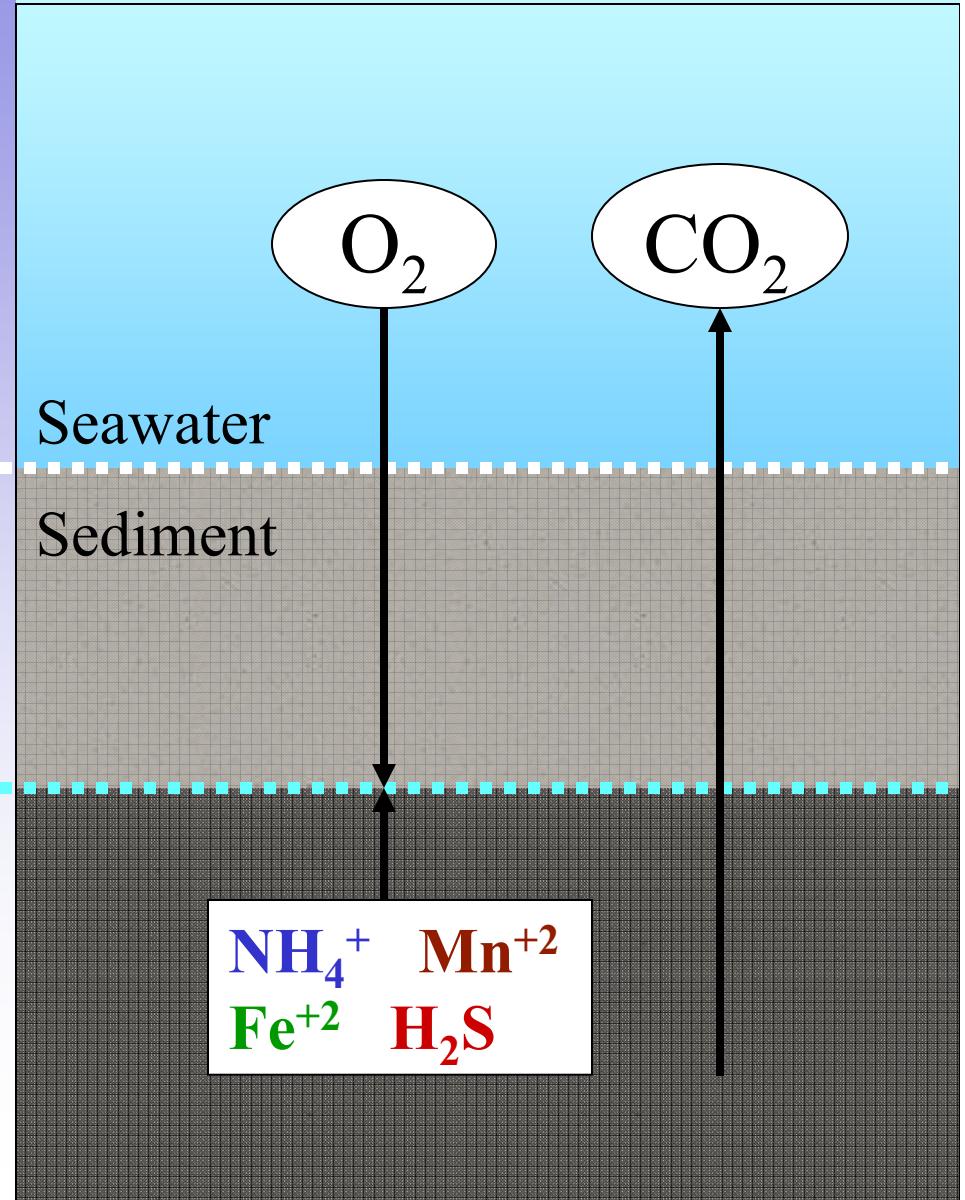
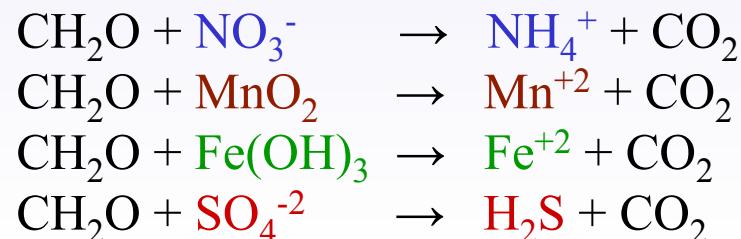
*degradation = remineralization

Sedimentary Remineralization

Aerobic Respiration

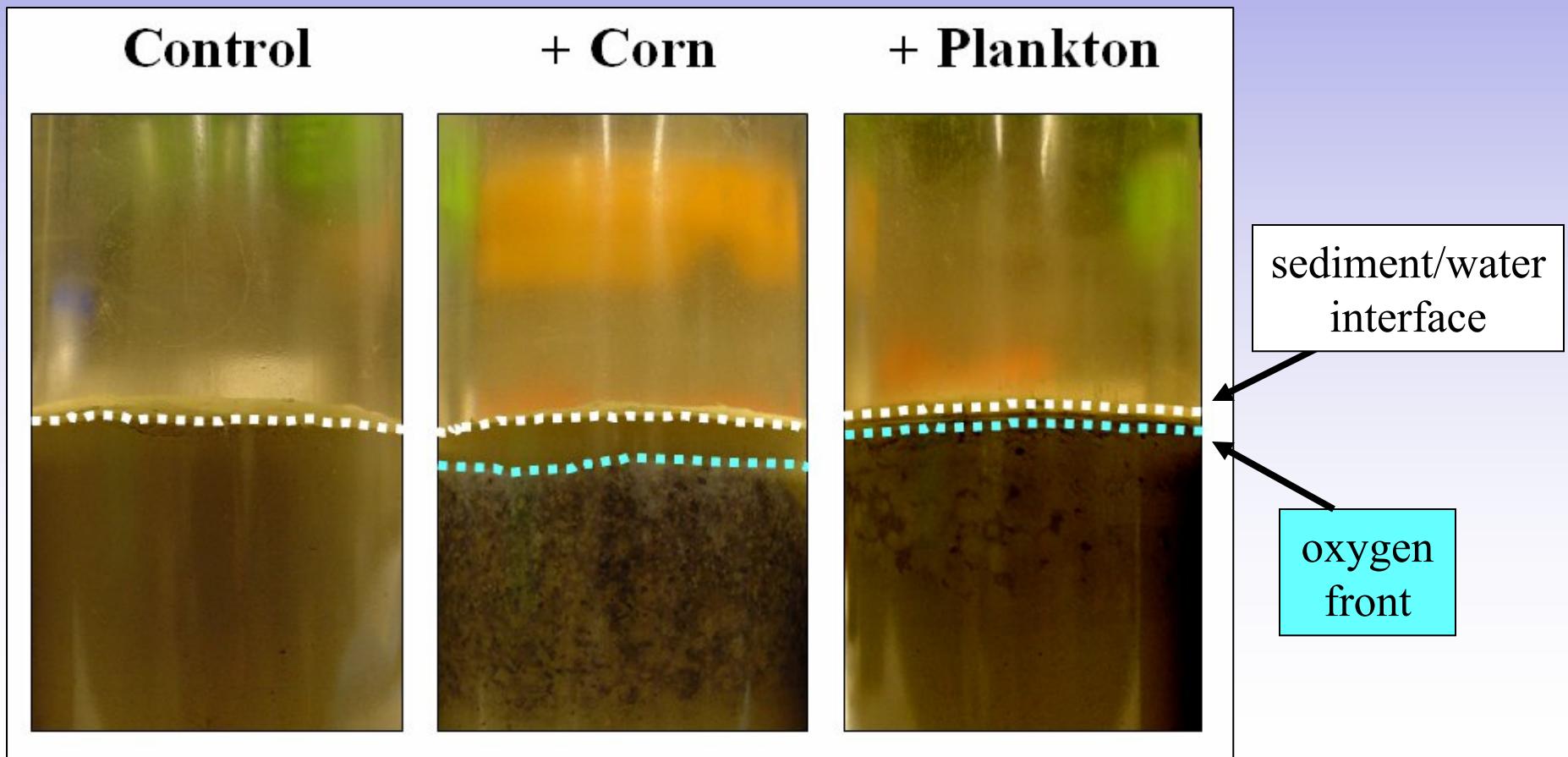


Anaerobic Respiration

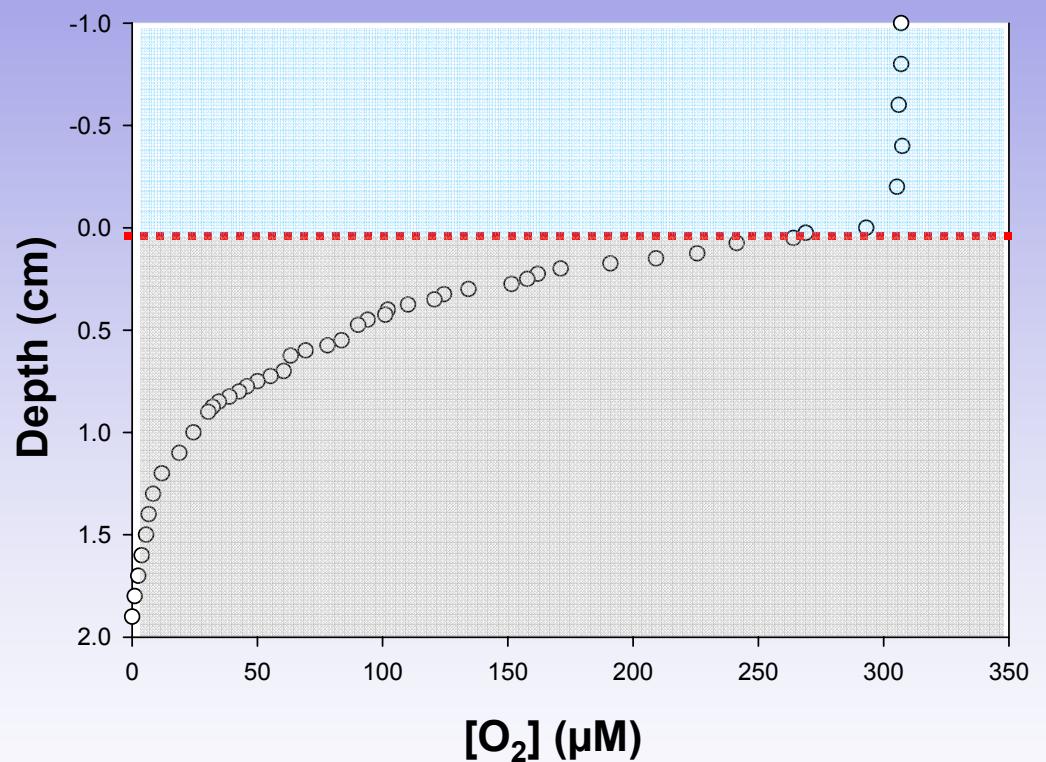
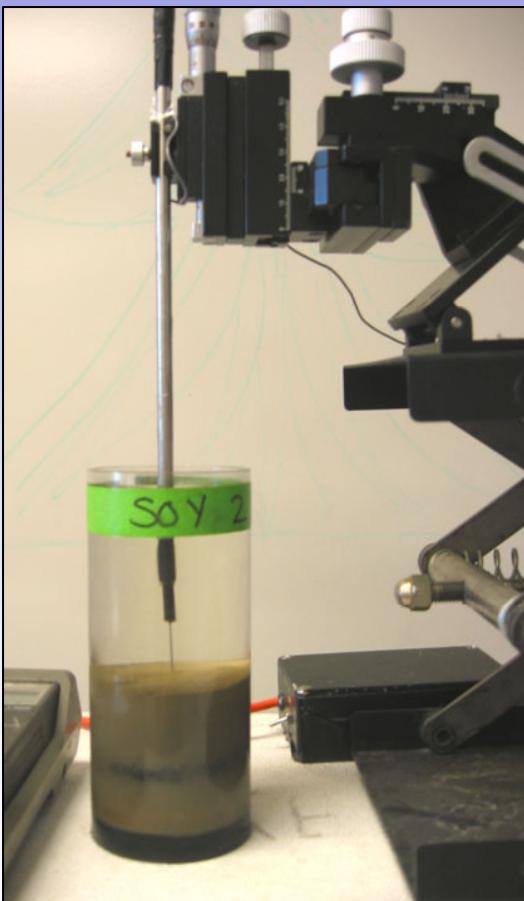


The Oxygen Front

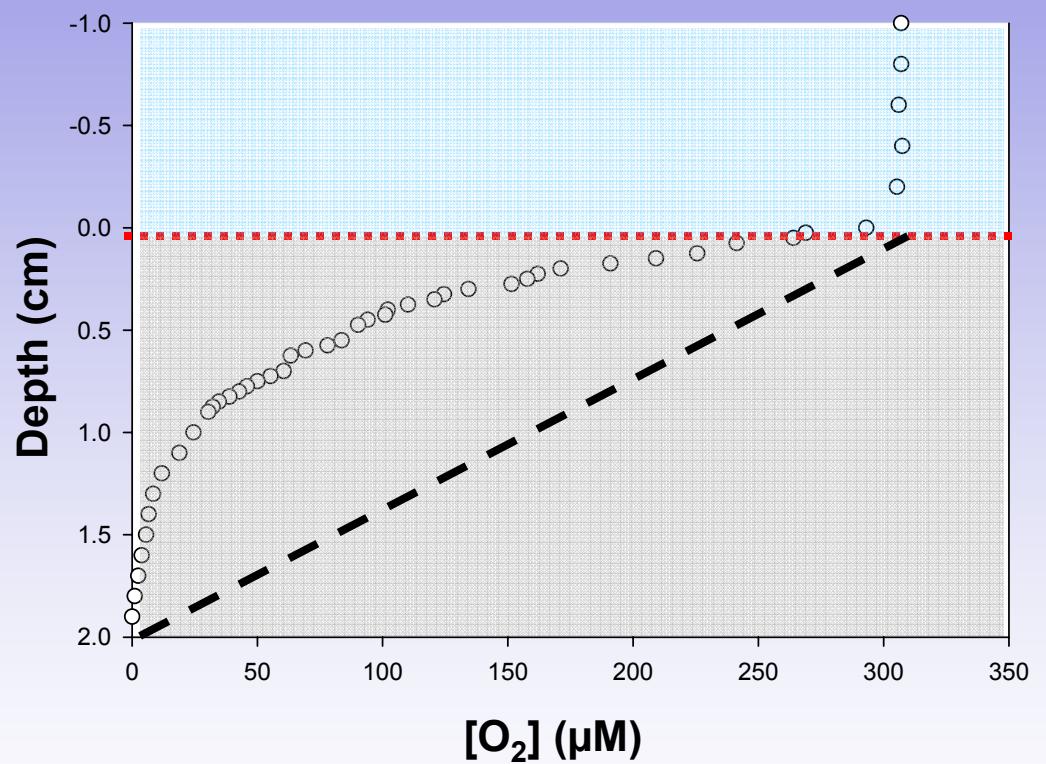
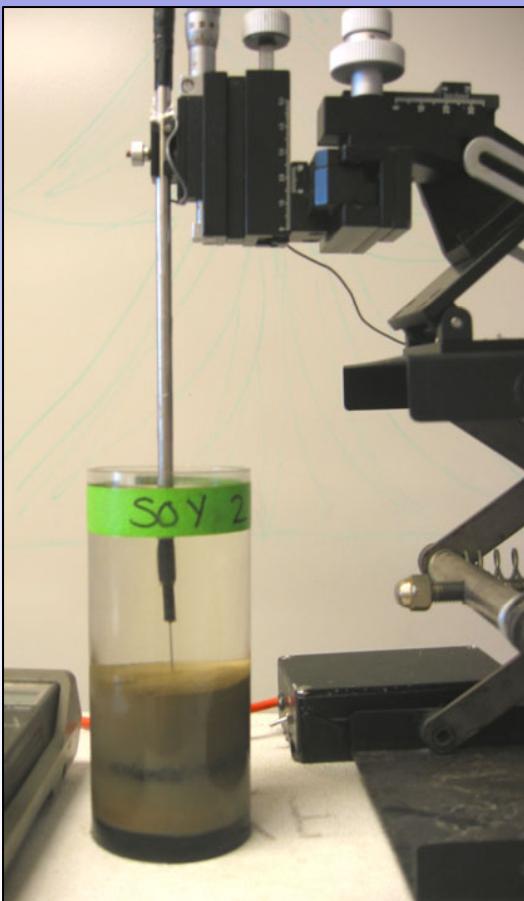
After 90 days of incubation...



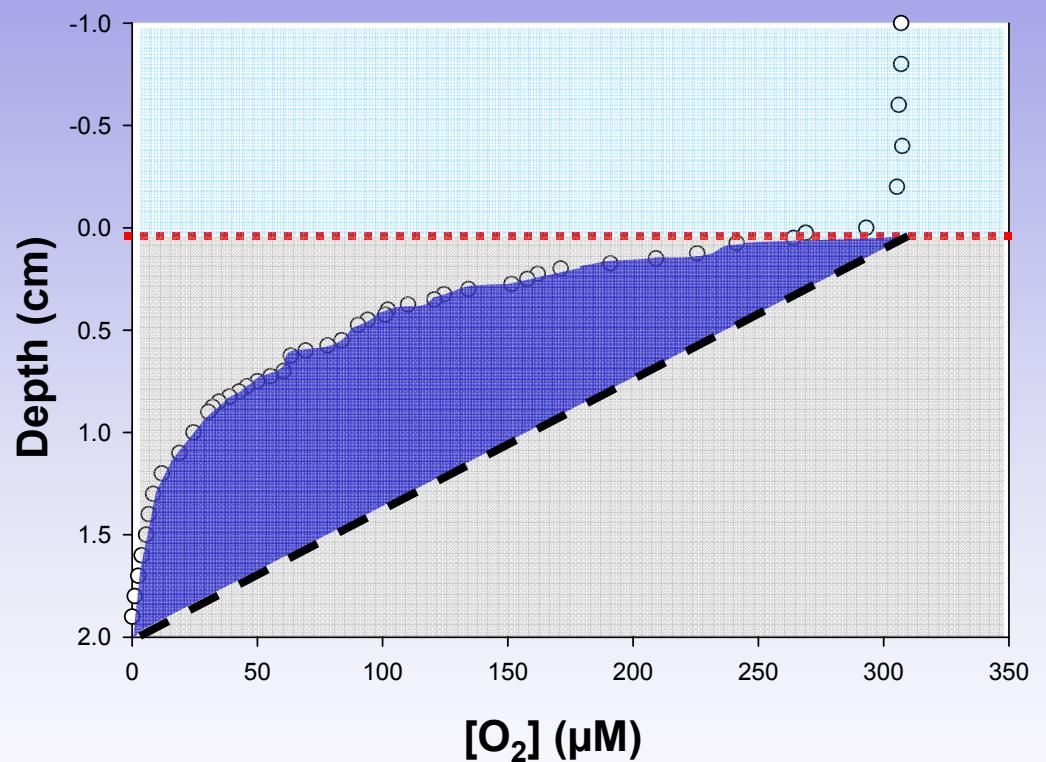
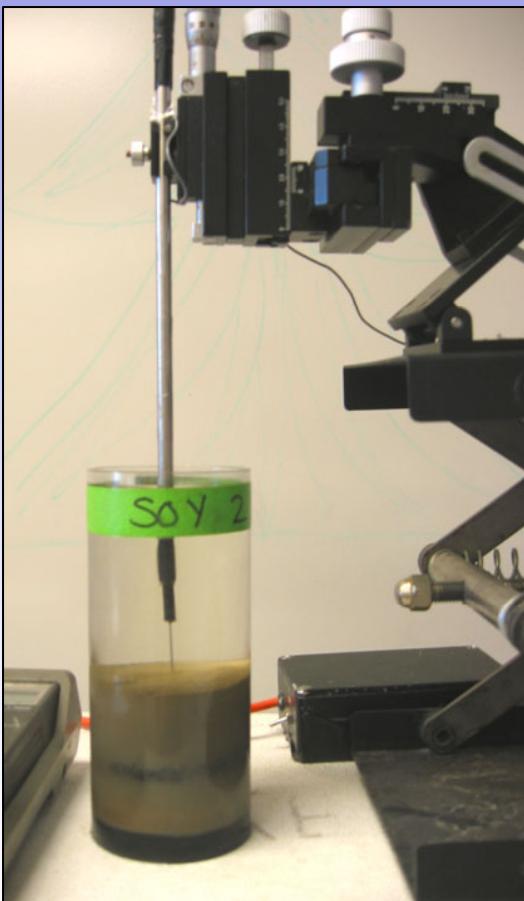
Oxygen Profiles



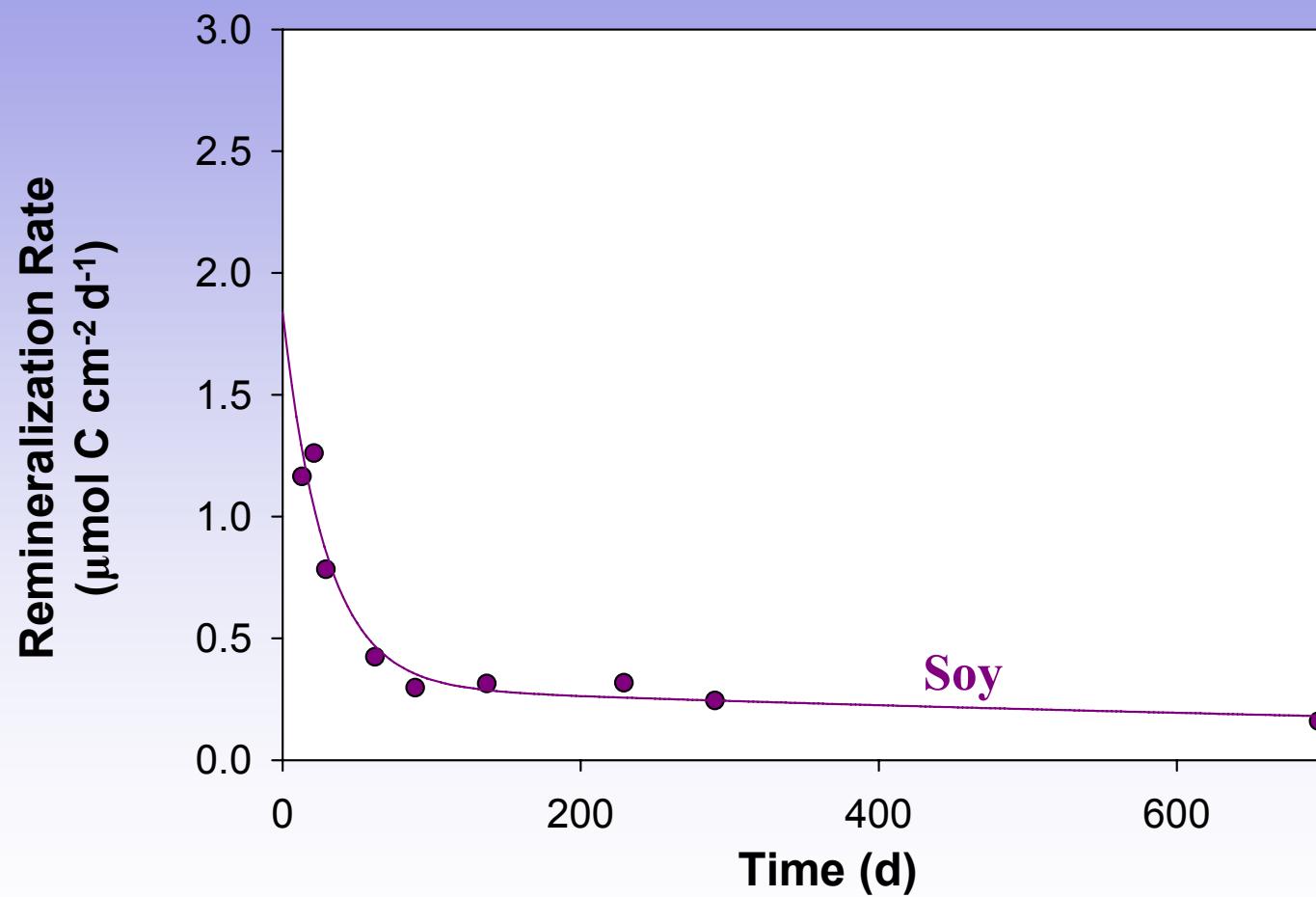
Oxygen Profiles



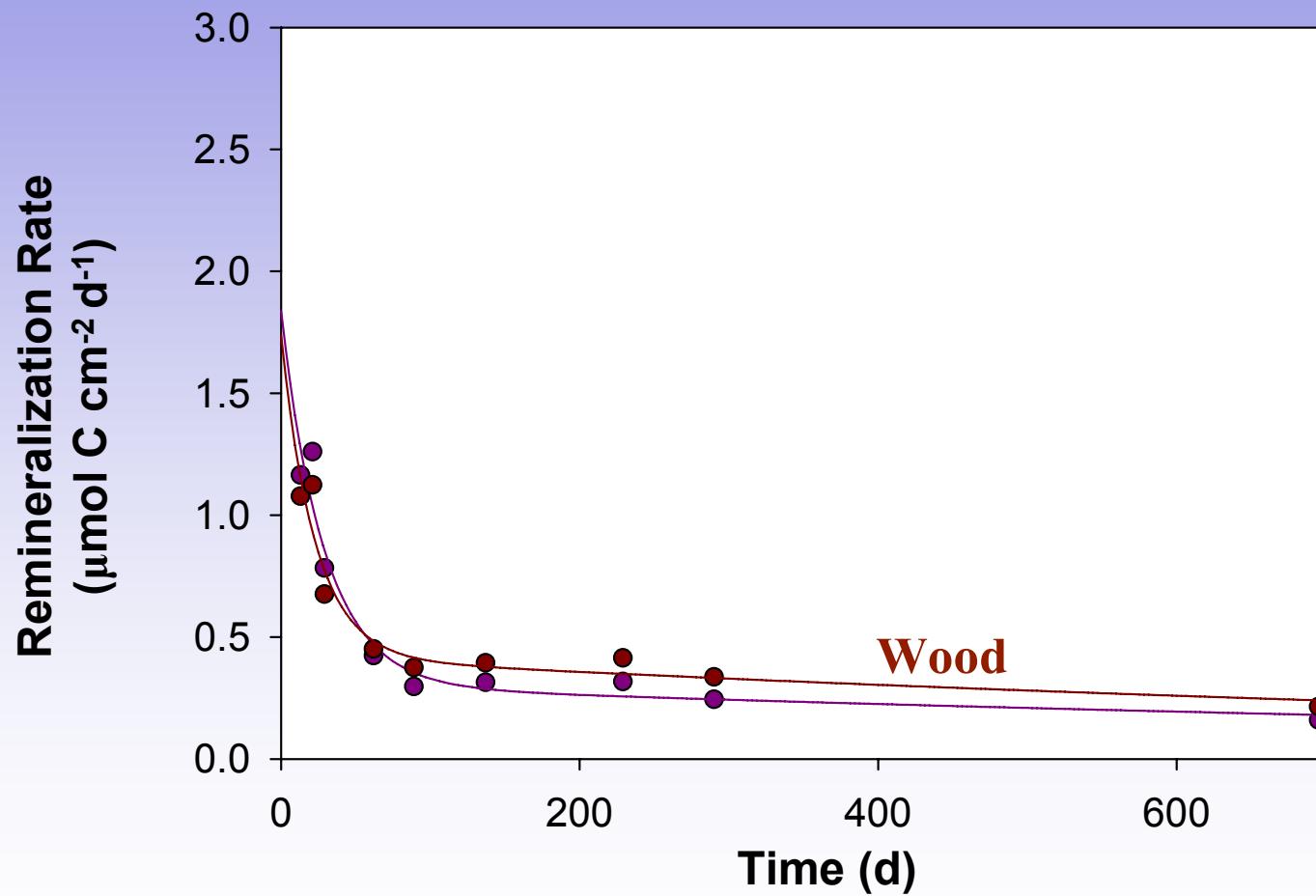
Oxygen Profiles



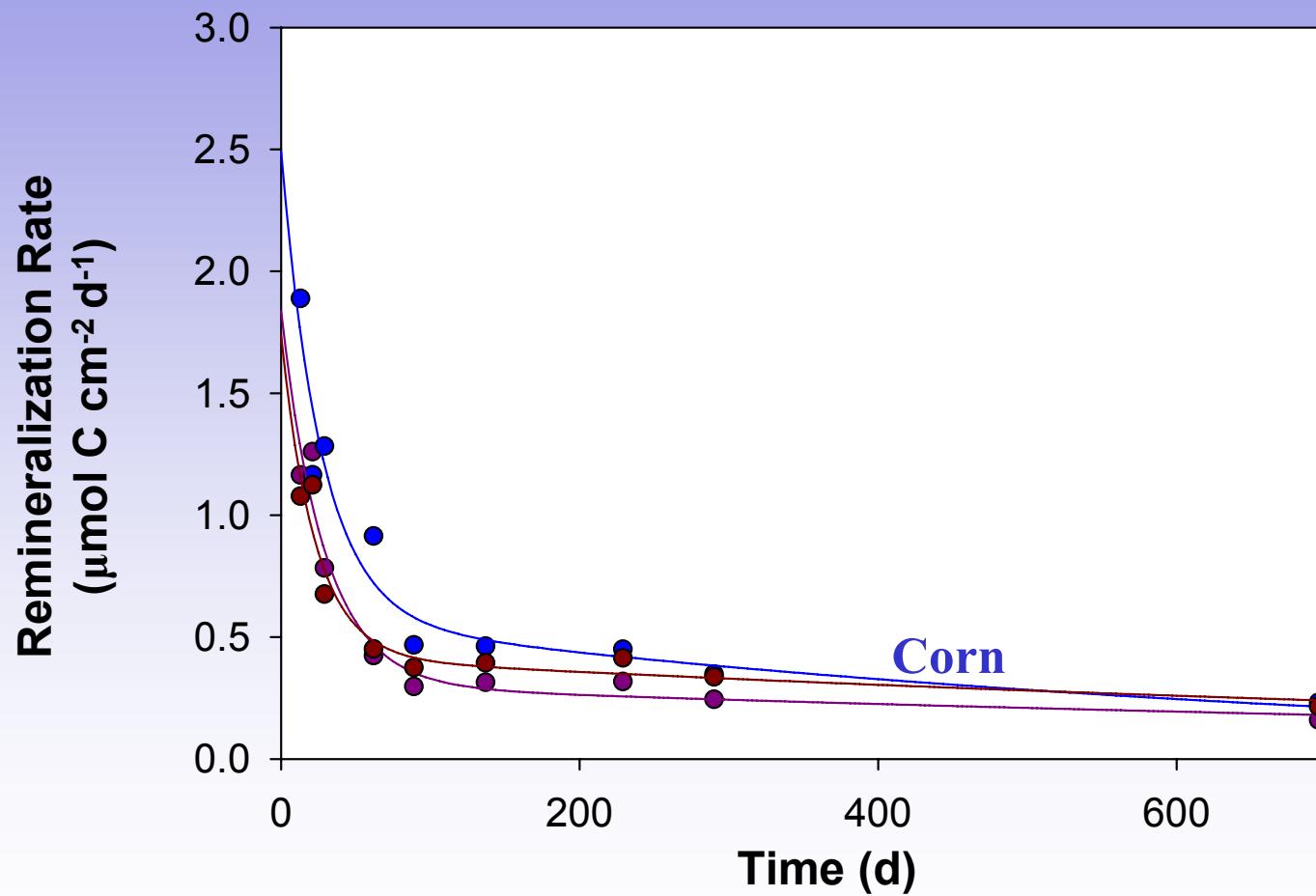
Carbon Remineralization Rate



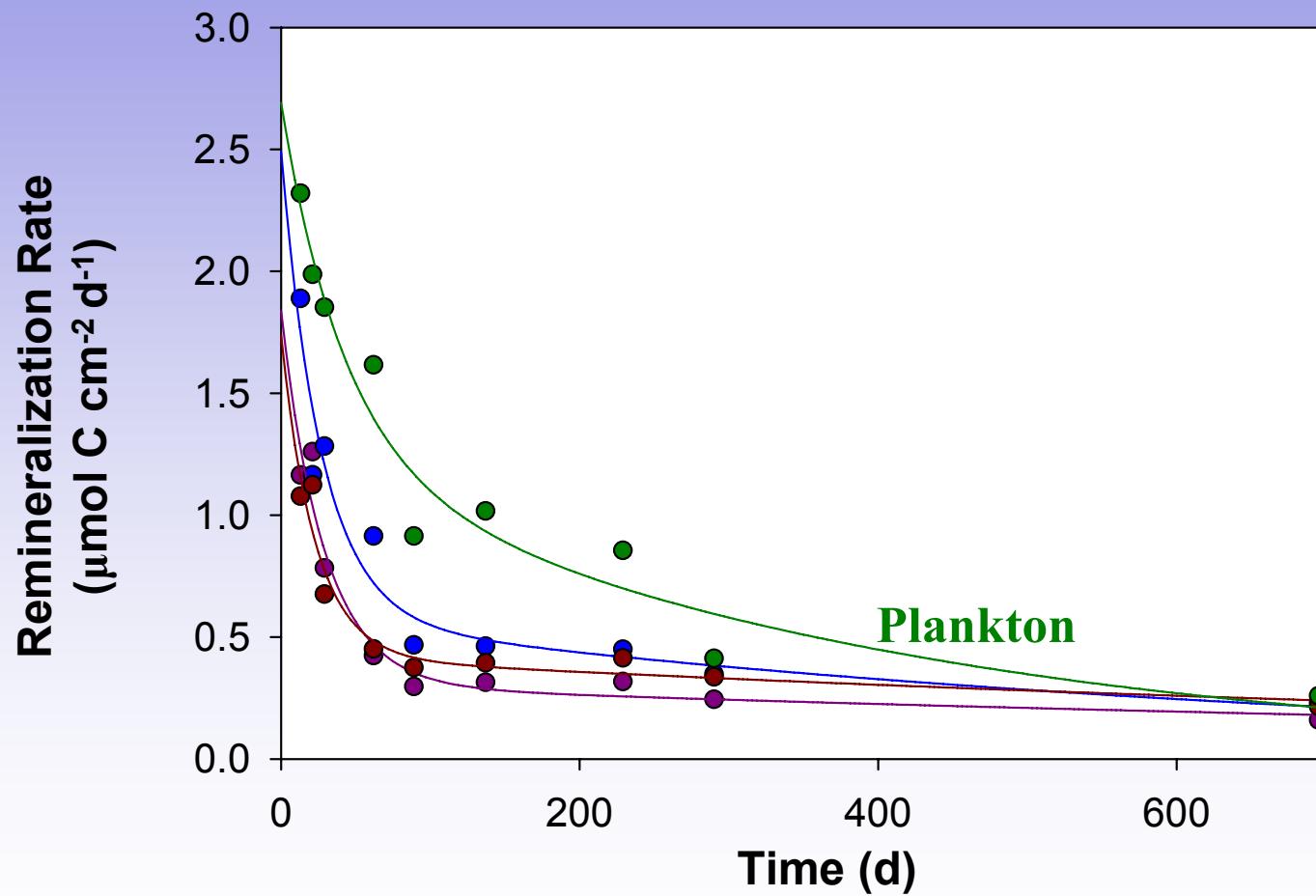
Carbon Remineralization Rate



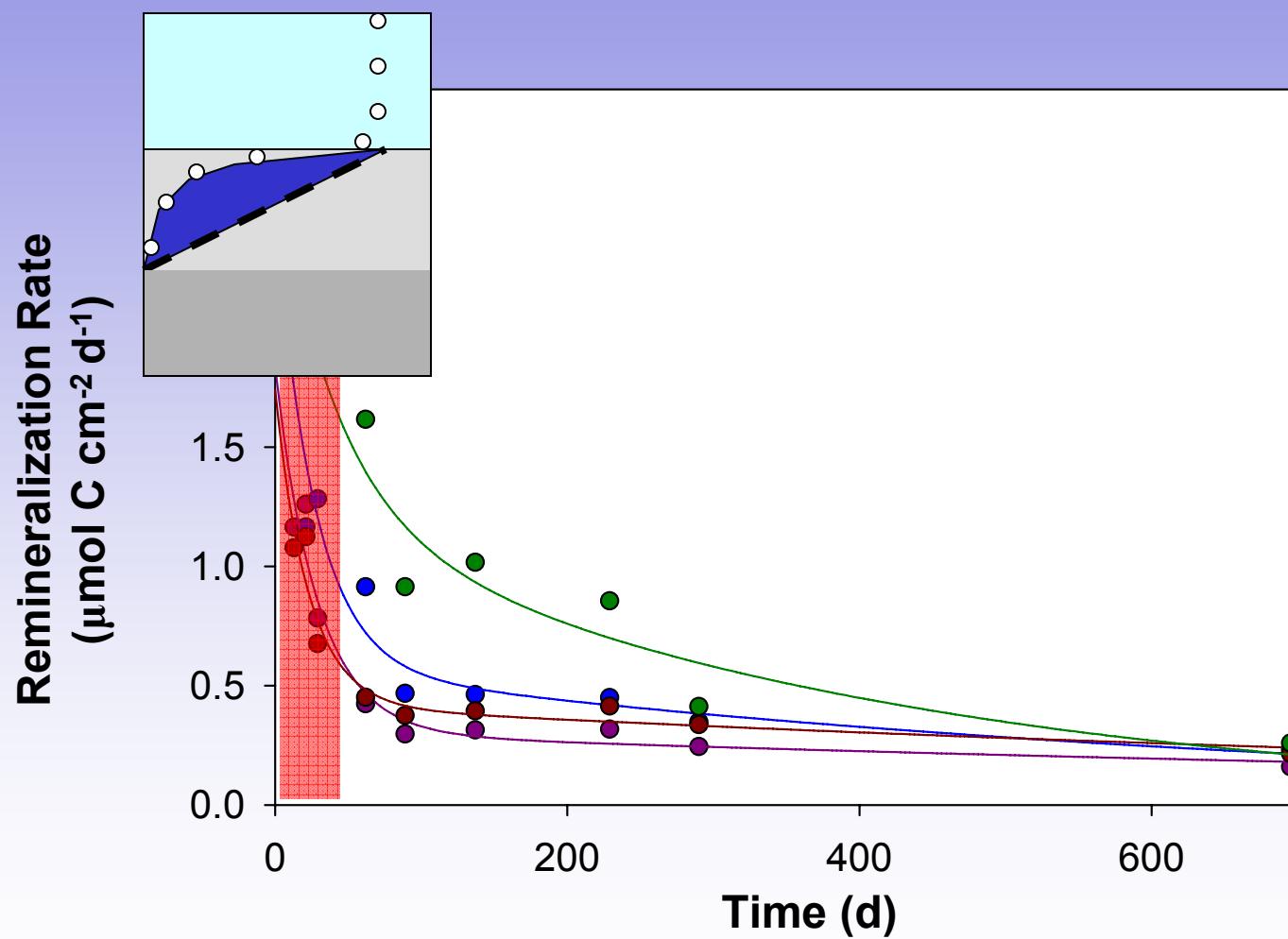
Carbon Remineralization Rate



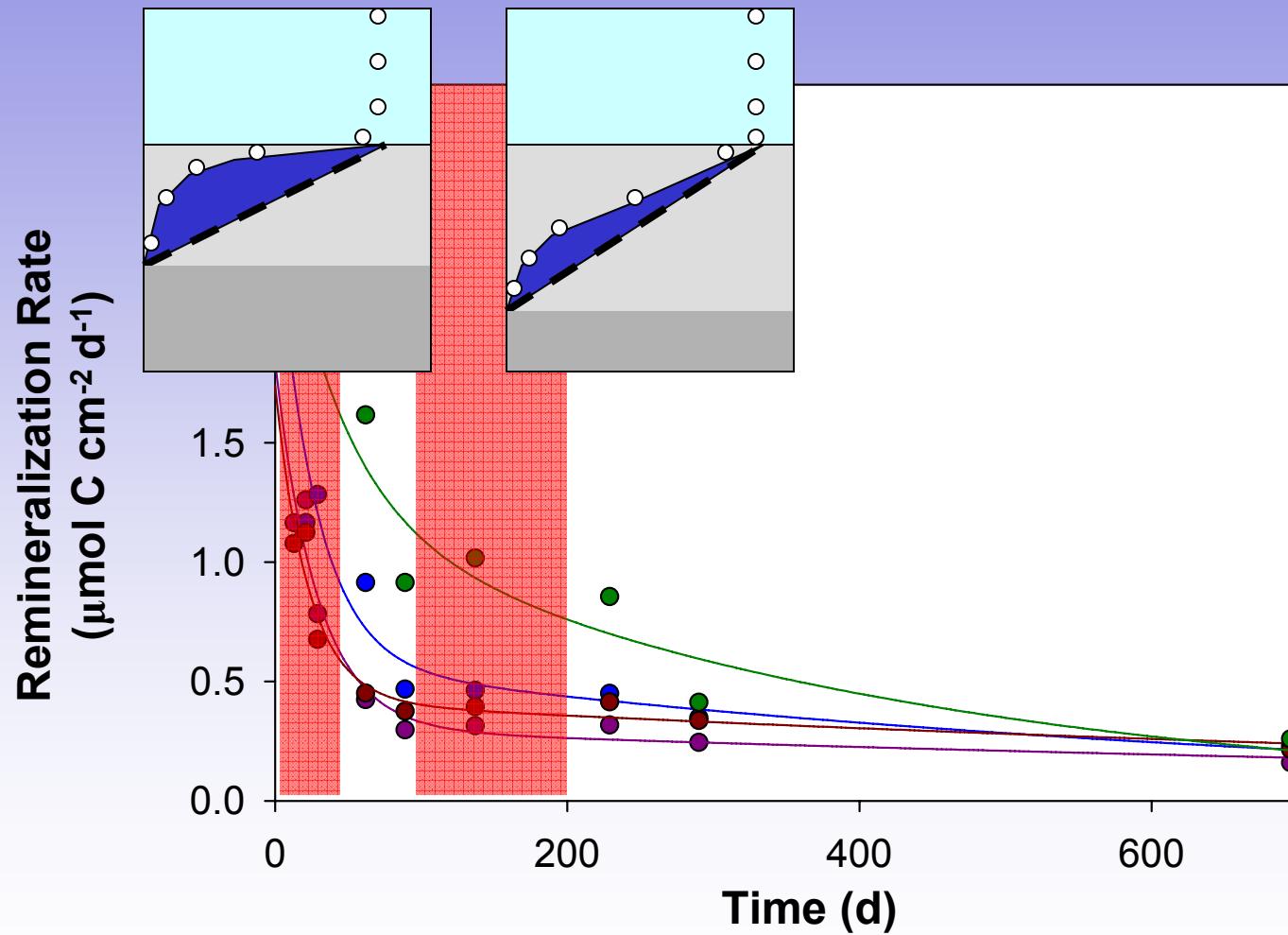
Carbon Remineralization Rate



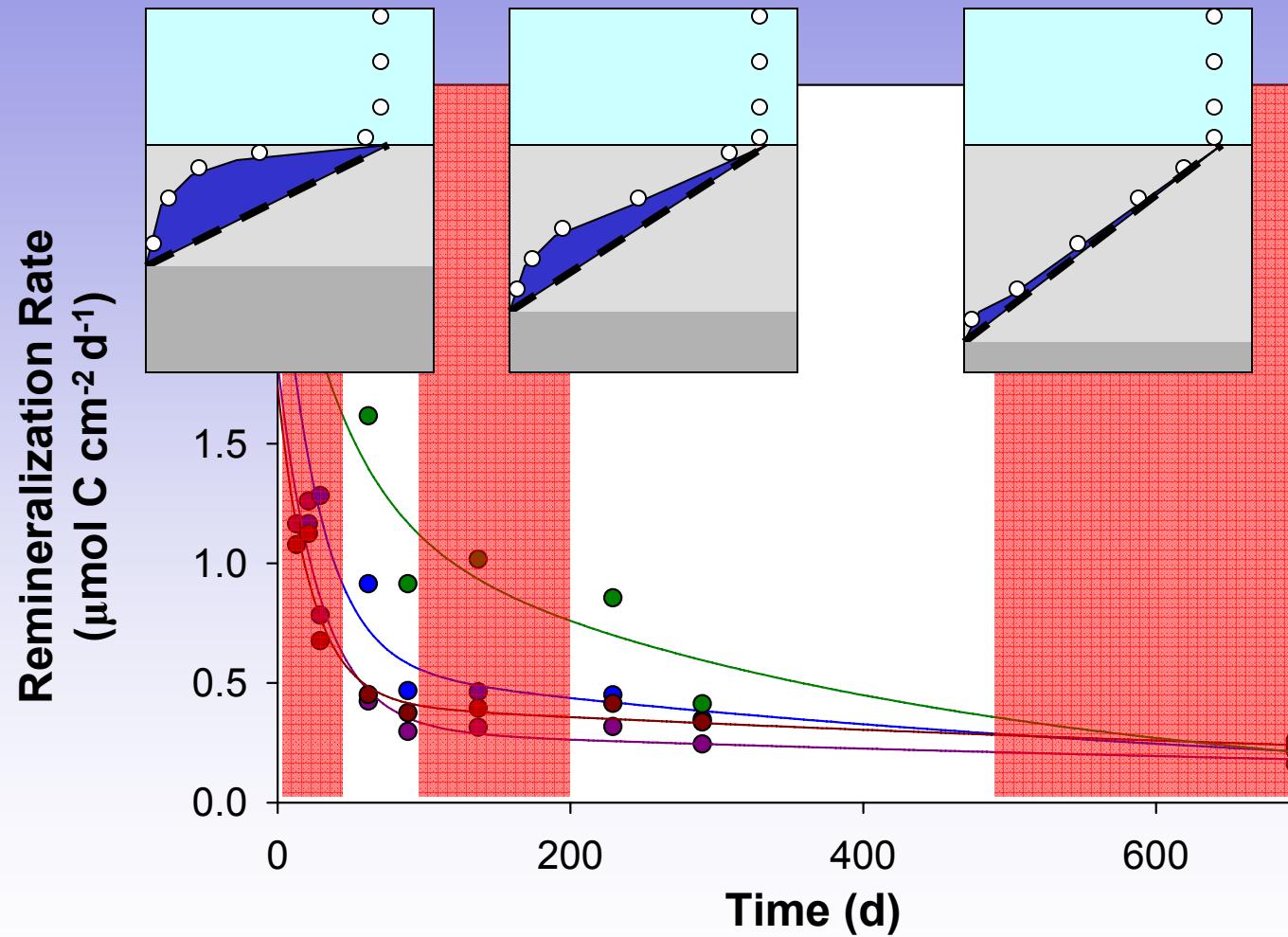
Carbon Remineralization Rate



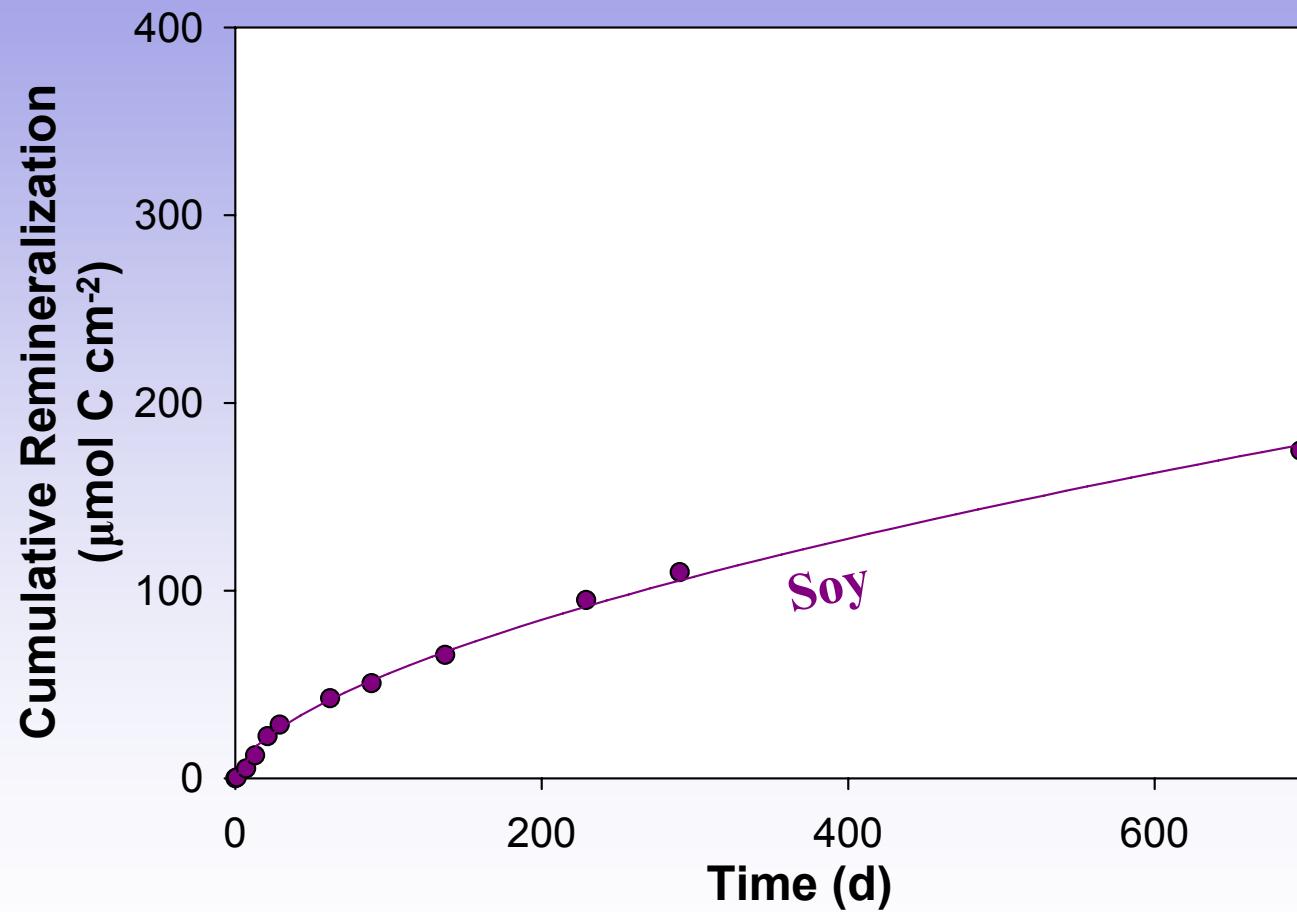
Carbon Remineralization Rate



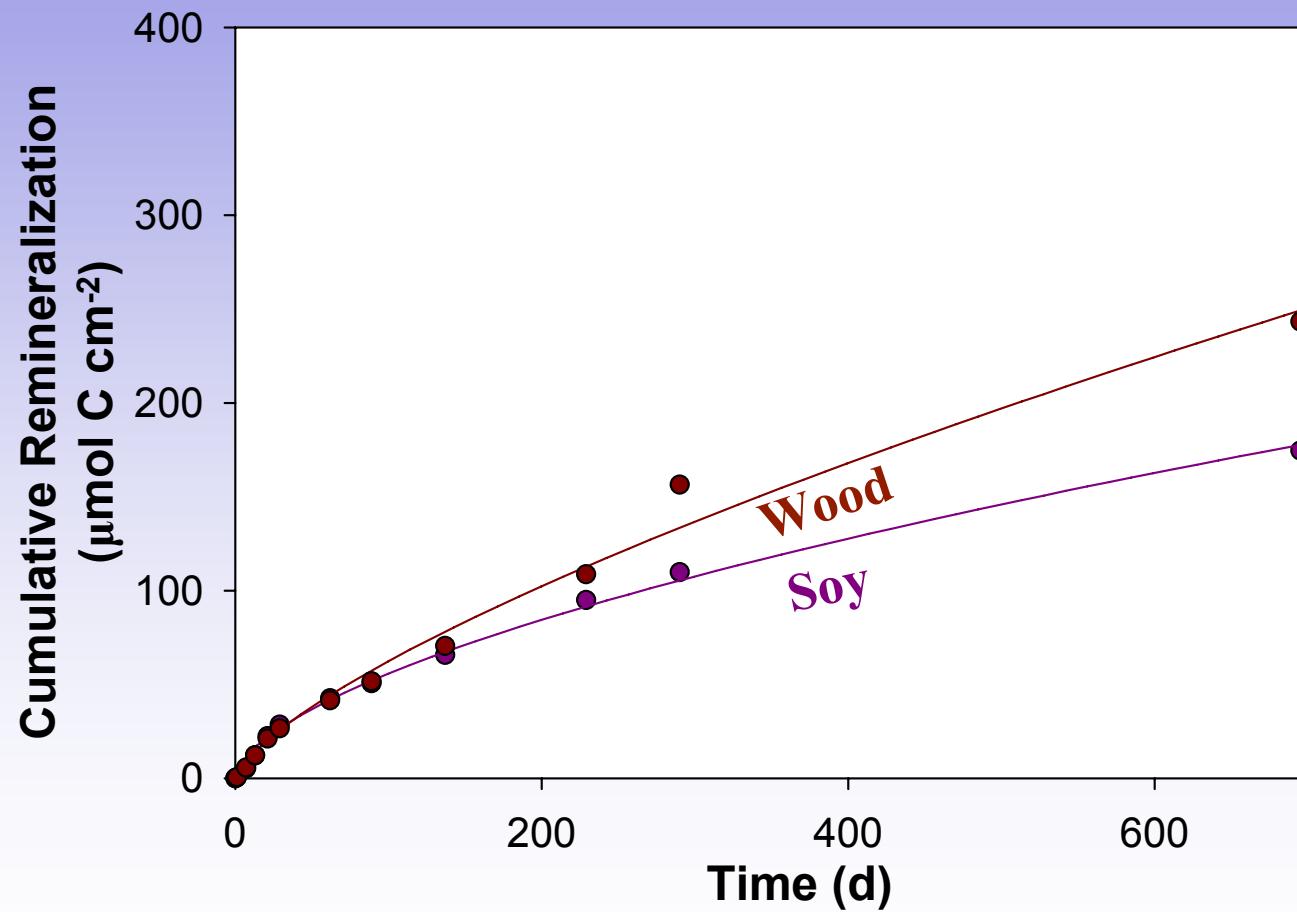
Carbon Remineralization Rate



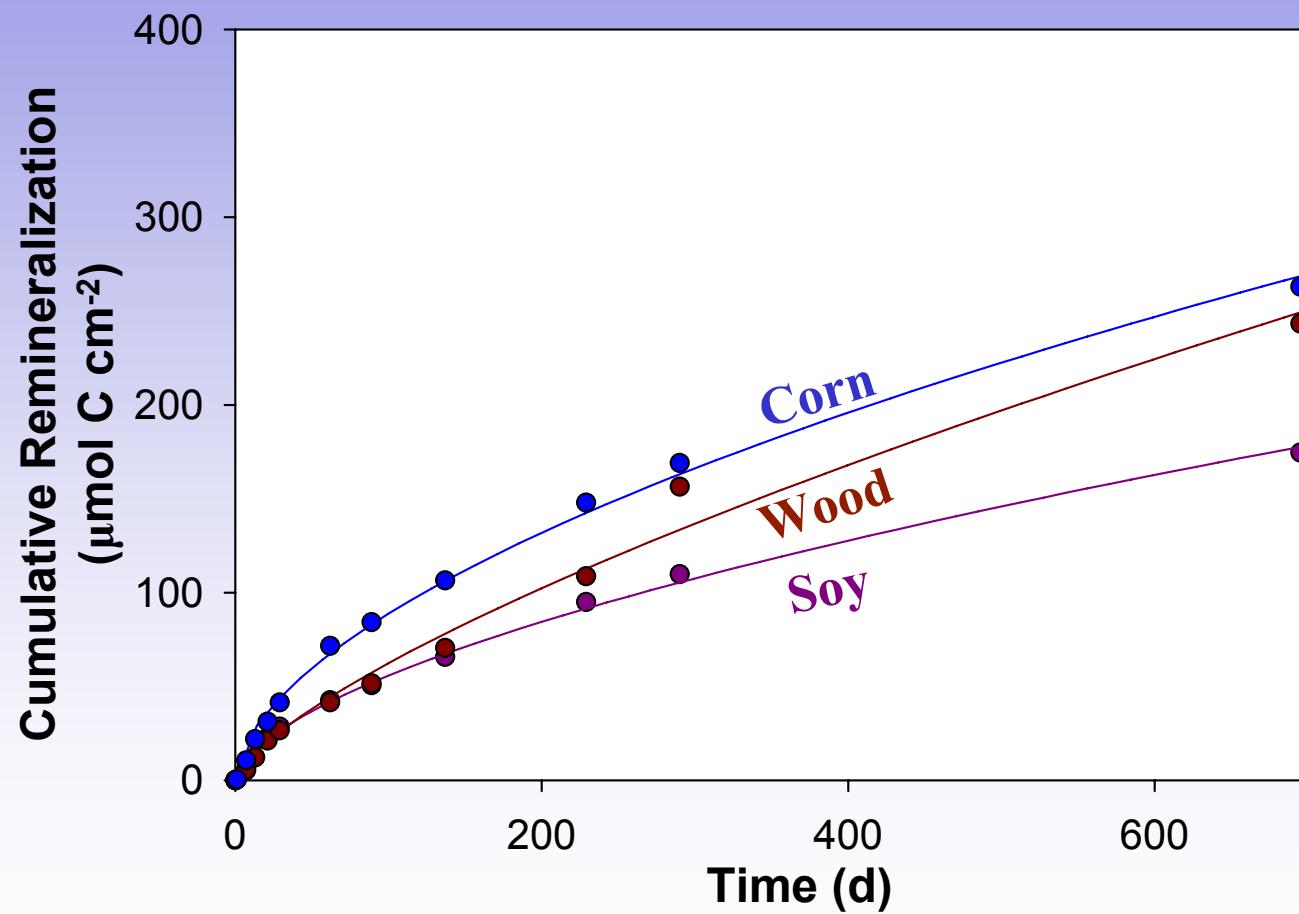
Cumulative Remineralization



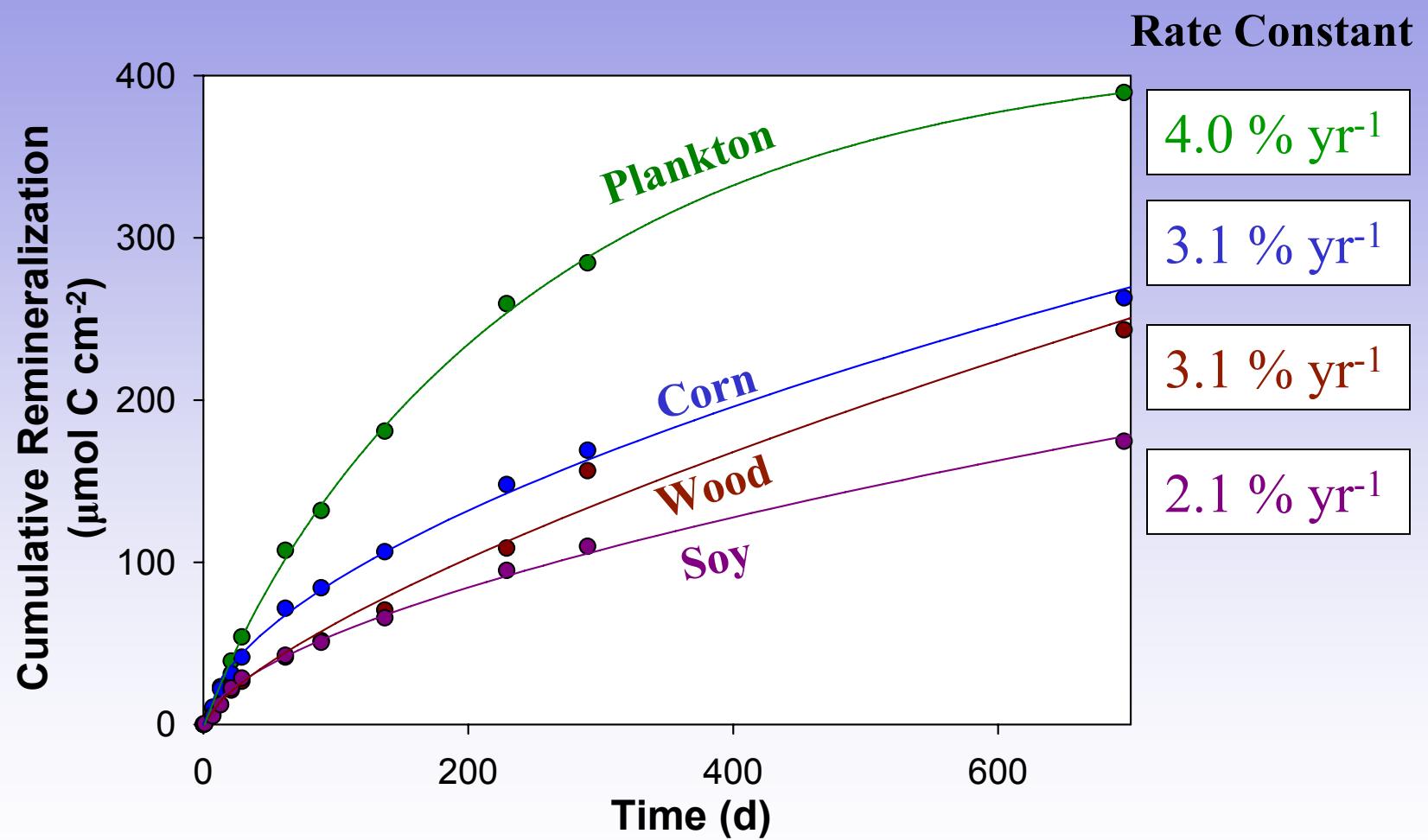
Cumulative Remineralization



Cumulative Remineralization



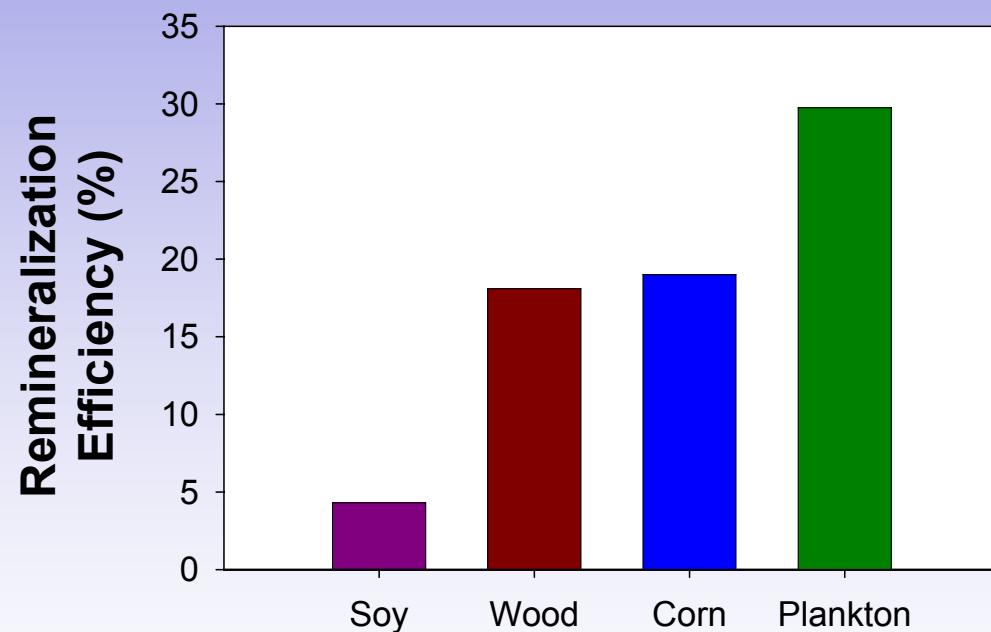
Cumulative Remineralization



Remineralization Efficiency

Remineralization Efficiency =

$$\frac{\text{Carbon Remineralized}}{\text{Carbon Added above O}_2 \text{ Front}} \times 100$$



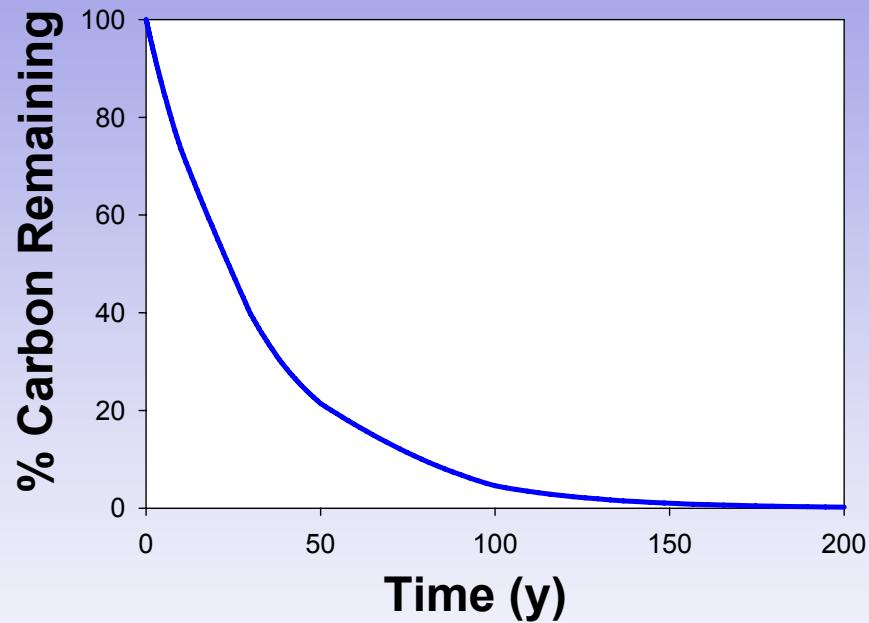
	Soy	Wood	Corn	Plankton
Remineralization Efficiency (%)	4.3	18	19	30
Rate Constant (% y⁻¹)	2.1	3.1	3.1	4.0

Theoretical Scenario

U.S. produces **0.24 Gt y⁻¹** of crop residue carbon

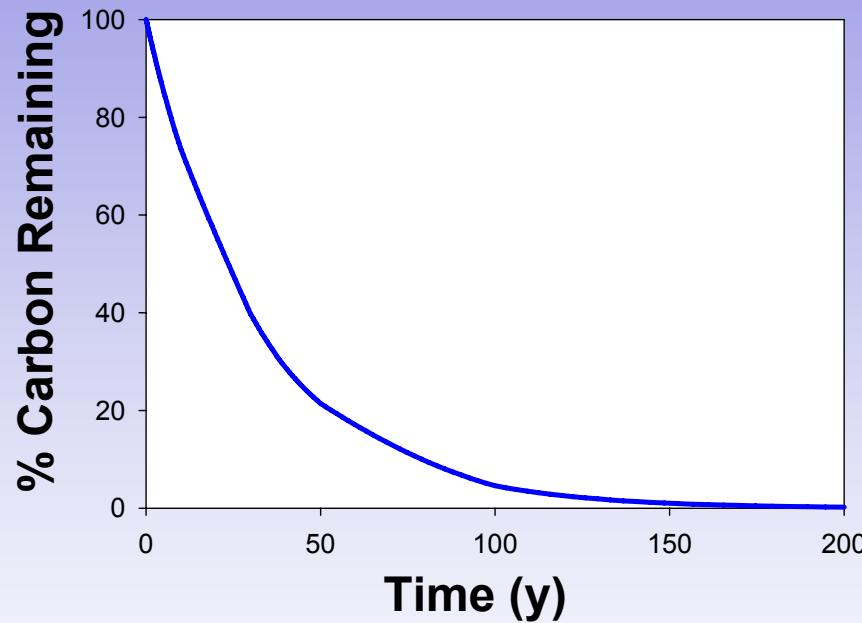
Theoretical Scenario

U.S. produces 0.24 Gt y^{-1} of crop residue carbon

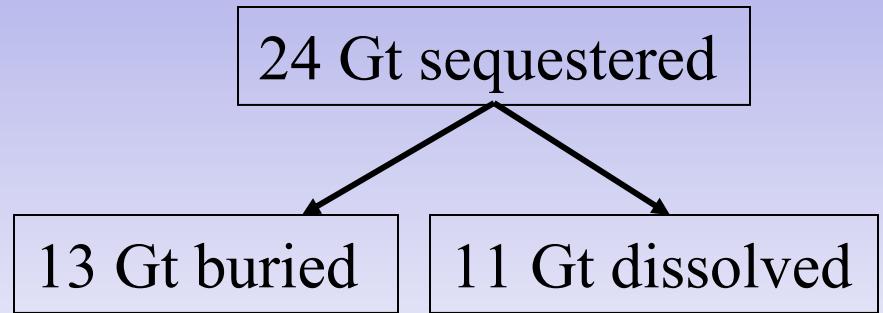


Theoretical Scenario

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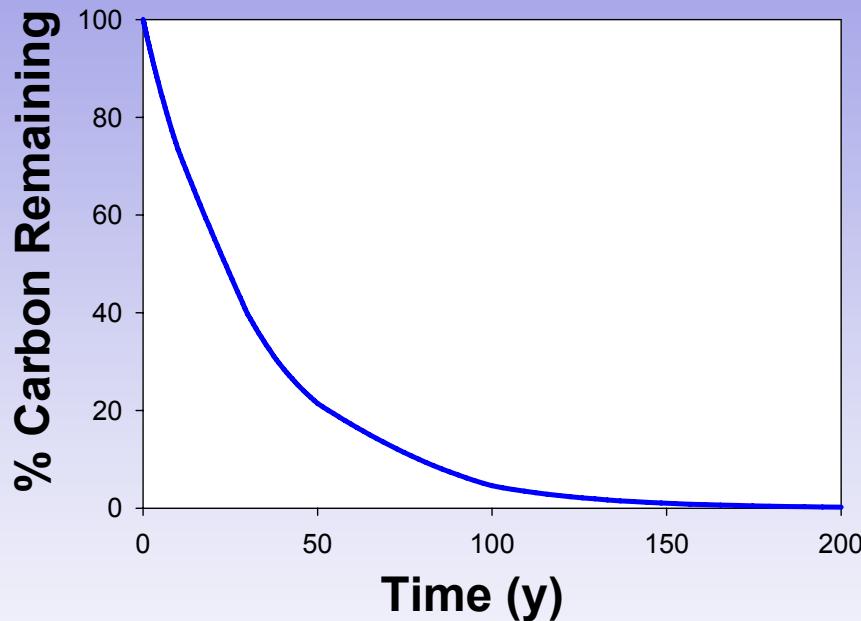


After 100 years...

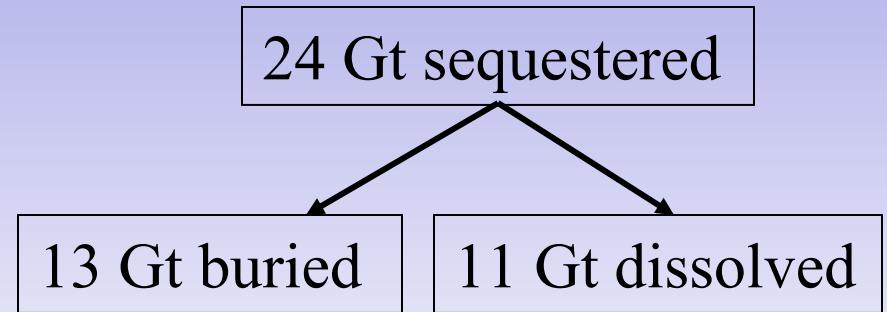


Theoretical Scenario

U.S. produces 0.24 Gt y^{-1} of crop residue carbon



After 100 years...



Effects on worldwide deepwater:

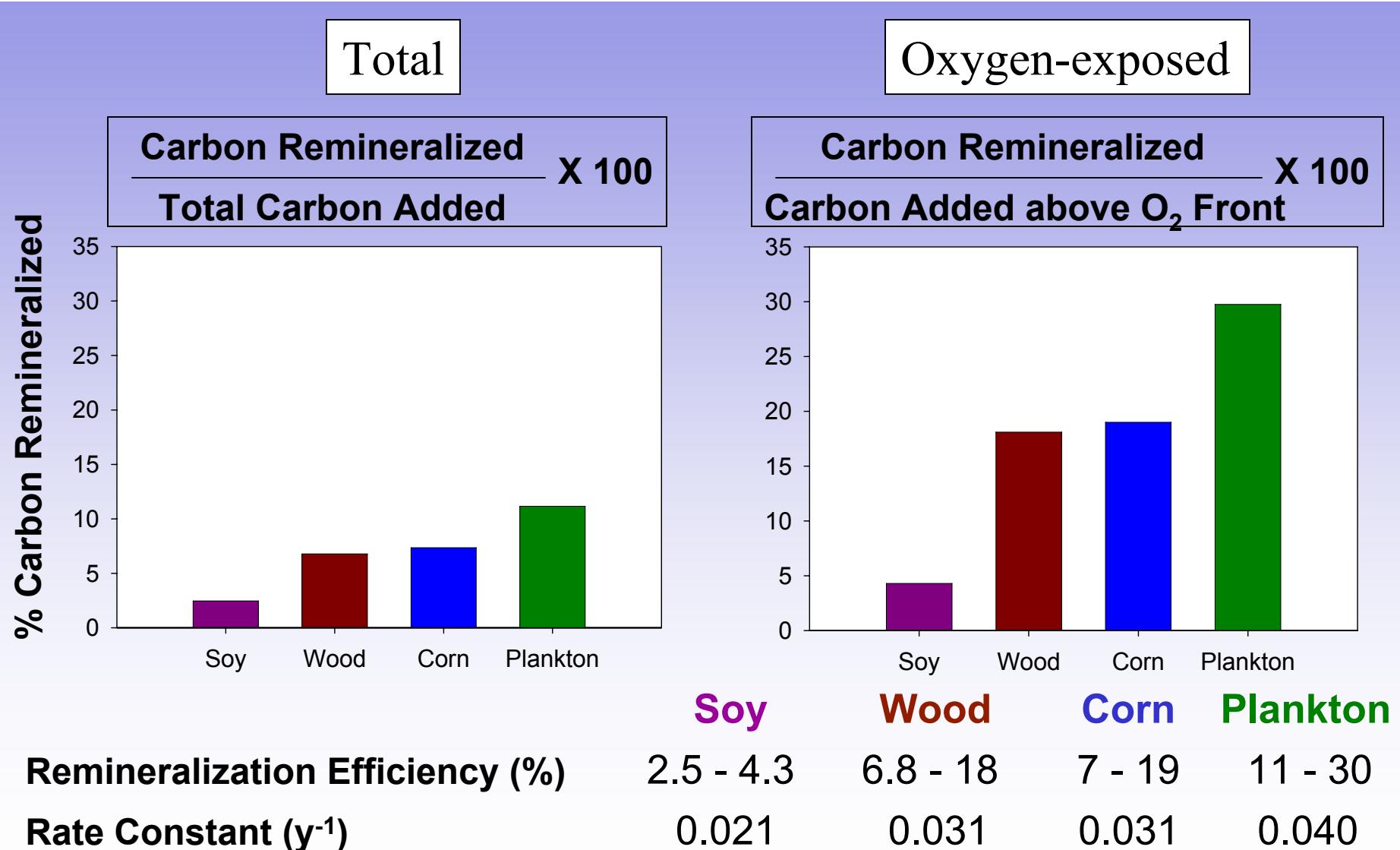
$$[\text{O}_2] \downarrow 0.5\%$$

$$[\text{CO}_2] \uparrow 0.03\%$$

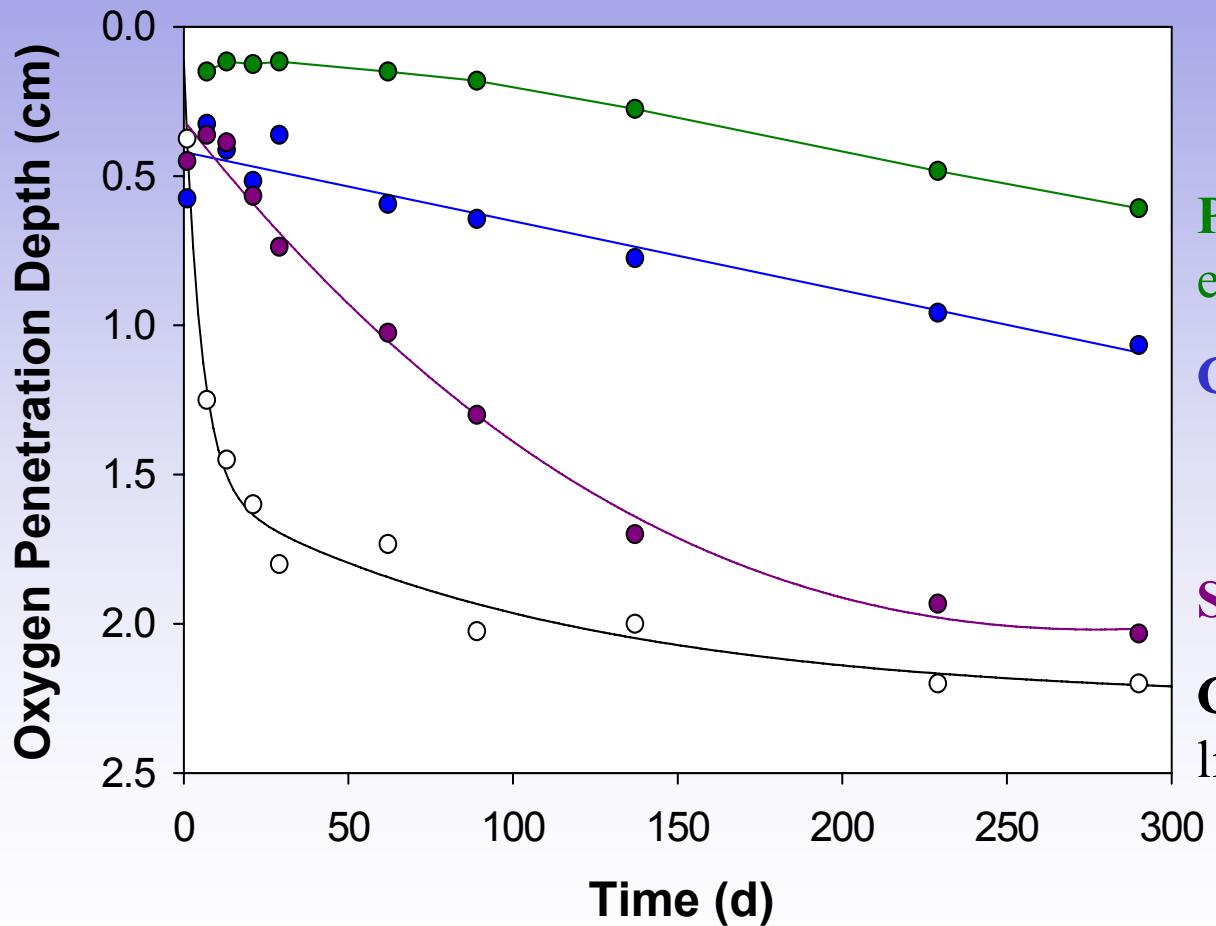
$$\text{pH} \downarrow 0.001$$



Remineralization Efficiency



Oxygen Penetration



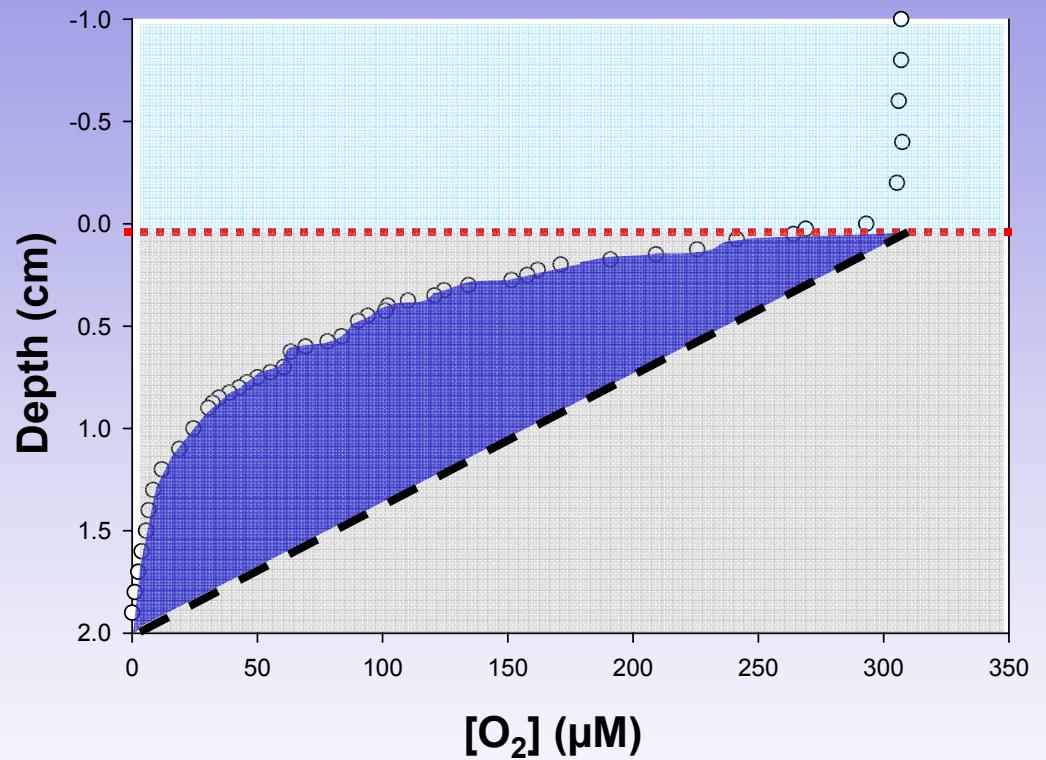
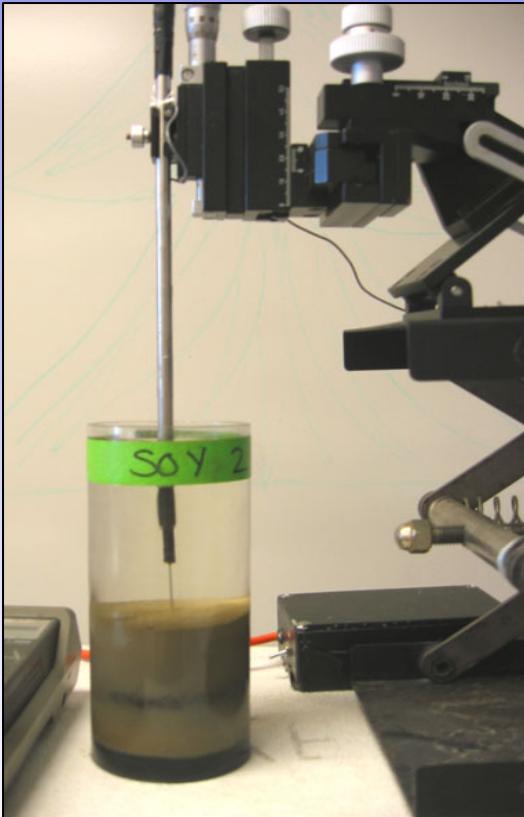
Plankton – slow penetration,
extensive degradation

Corn

Soy

Control – rapid penetration,
little degradation

Oxygen Profiles

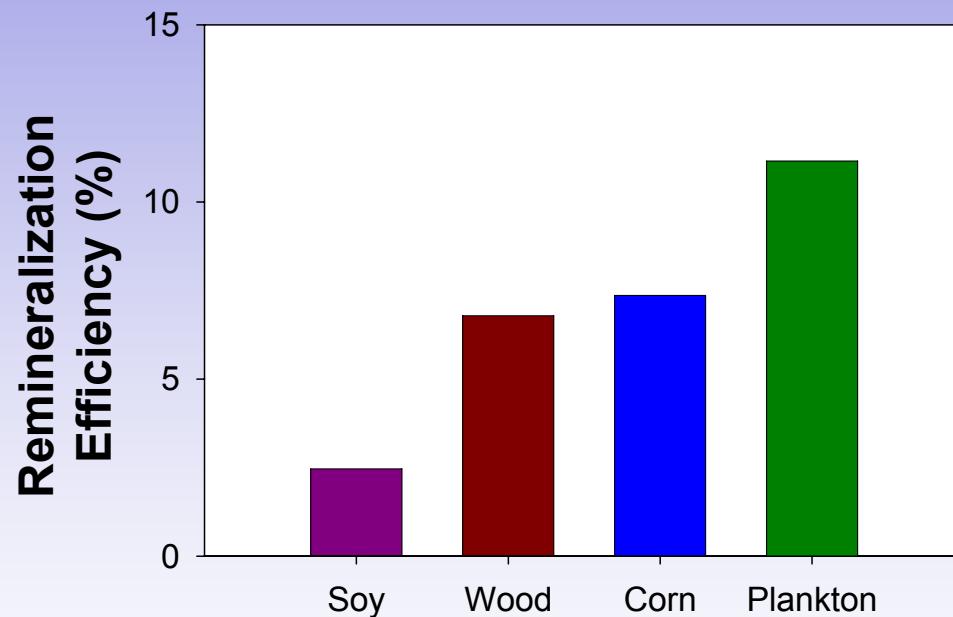


Calculating Carbon Remineralization



Remineralization Efficiency

$$\text{Remineralization Efficiency} = \frac{\text{Carbon Remineralized}}{\text{Total Carbon Added}} \times 100$$



	Soy	Wood	Corn	Plankton
Remineralization Efficiency (%)	2.5	6.8	7.0	11
Rate Constant (y^{-1})	0.021	0.031	0.031	0.040

Marine Carbon Cycle

