Investigating Carbon Storage and Accumulation Rates of Wetlands within the Agricultural Landscape of Southern Ontario

Eric Enanga, Irena Creed, Pascal Badiou, Mark Gloutney

Western

Ducks Unlimited Canada
Conserving Canada's Wetlands

Motivation

Motivated by the challenges in understanding, predicting and managing water systems that are increasingly impacted by humans

Our focus is on **mineral wetland water systems** in highly managed landscapes

Wetland provides important **ecosystem services**:

- Flood control
- Water purification (phosphorus and nitrogen retention)
- Carbon sequestration

We will show how **farmers can increase the supply of ecosystem services by restoring wetlands** that not only improve their livelihoods, but also the many people living within the regional watershed

Motivation

wetlands are being lost at an alarming rate in domesticating landscapes

"up to 70 percent of wetlands have been degraded or lost in settled areas of Canada"

Warner, Asada. 2006. Knowledge gaps and challenges in wetlands under climate change in Canada. In: Price M, J Bhatti, M Apps (Eds). Climate change and managed ecosystems. CRC Press, Boca Raton, FL.

Motivation

"domestication" of landscapes in Ontario agricultural intensification



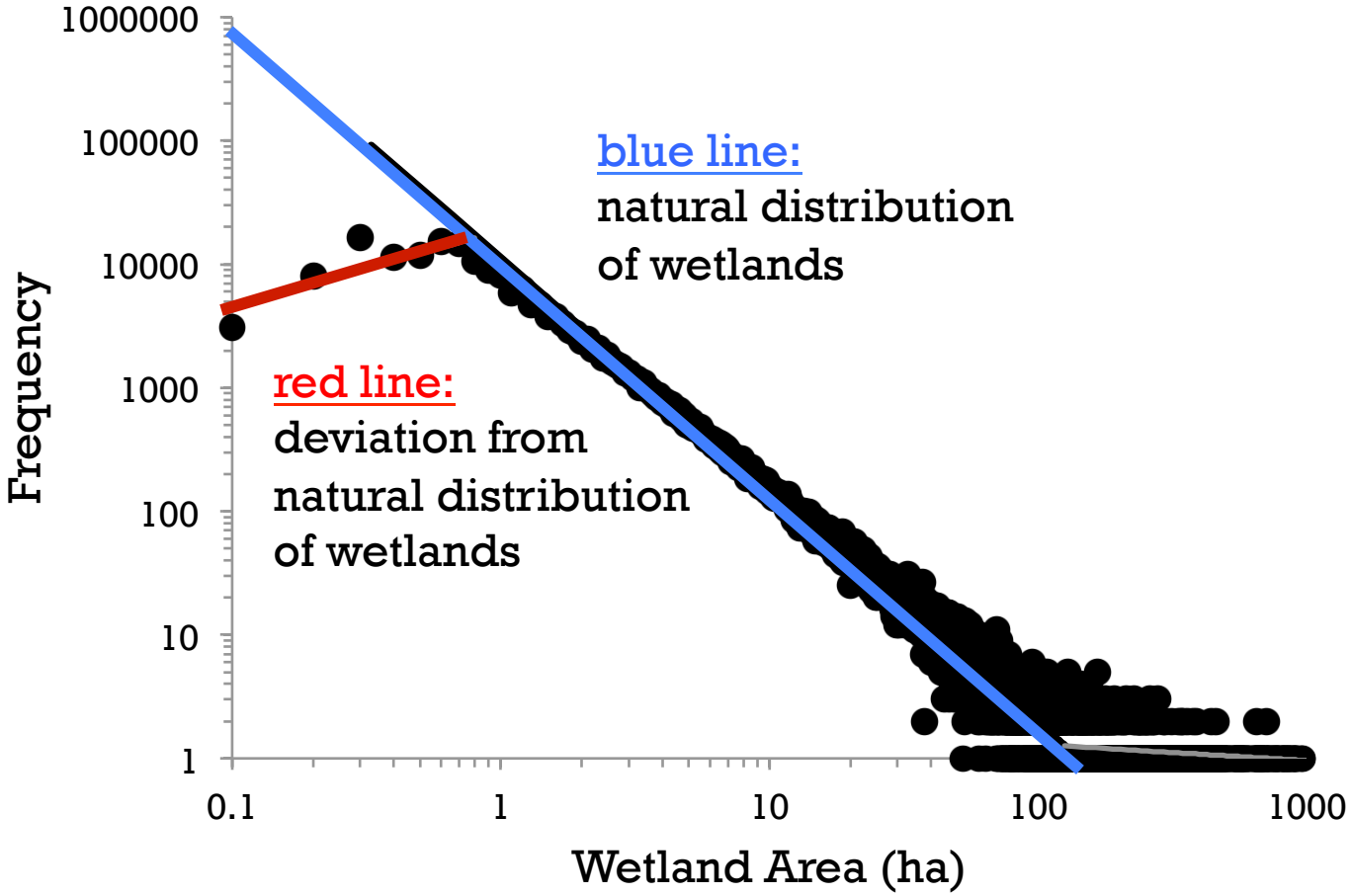



Tockner, Pusch, Gessner, Wolter. 2011. Domesticated ecosystems and novel communities: challenges for the management of large rivers. Ecohydrol. Hydrobiol. 11:167-174

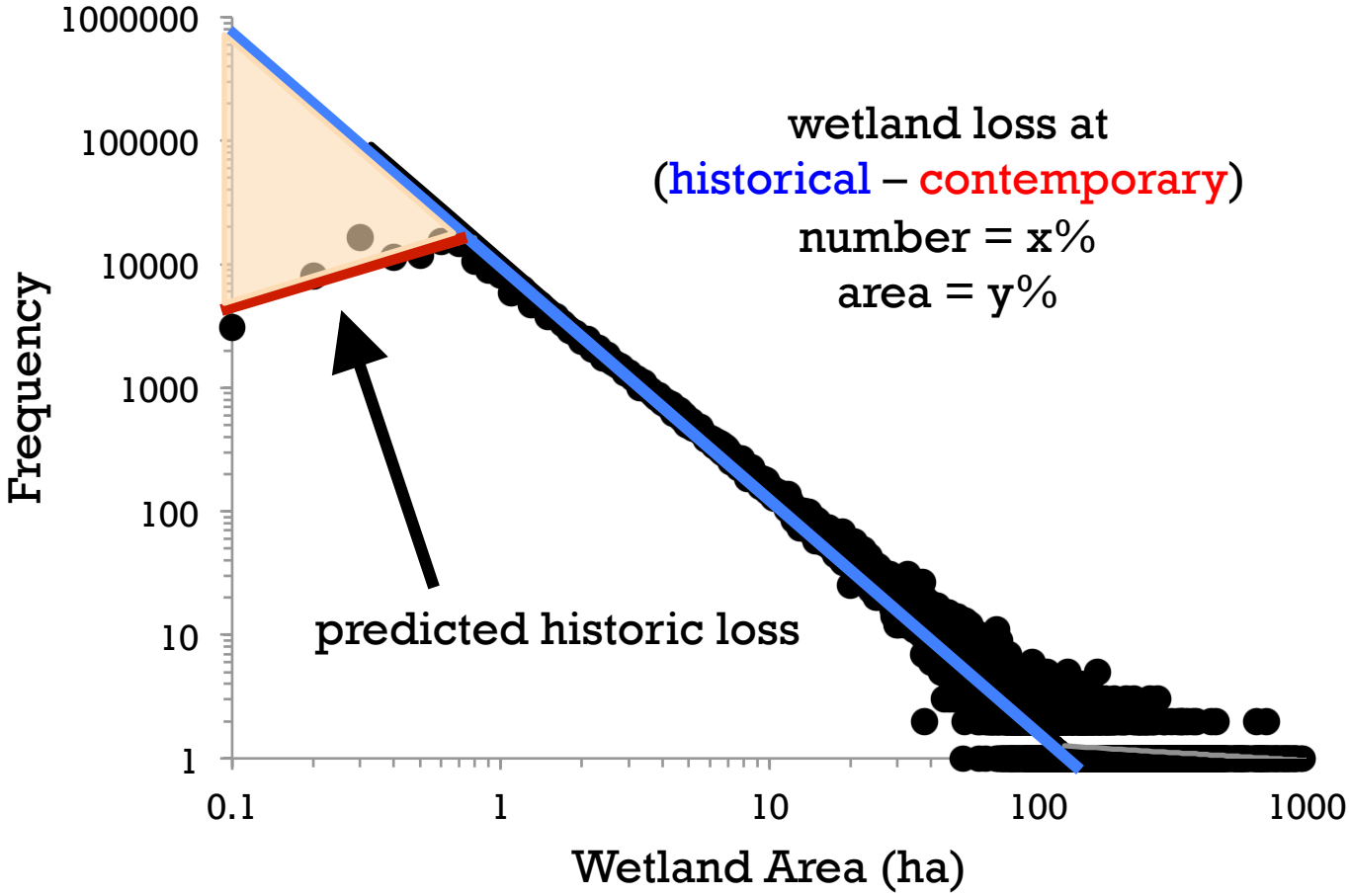
our **objectives** are to:

1. Estimate **historic wetland loss**
2. Establish priorities for **restoration** of drained wetlands
3. Estimate **nutrient retention rate** since restoration
   a. Deepest point of wetland basin
   b. For entire wetland basin
4. Determine the influence of the **surrounding landscape matrix** on nutrient retention potential

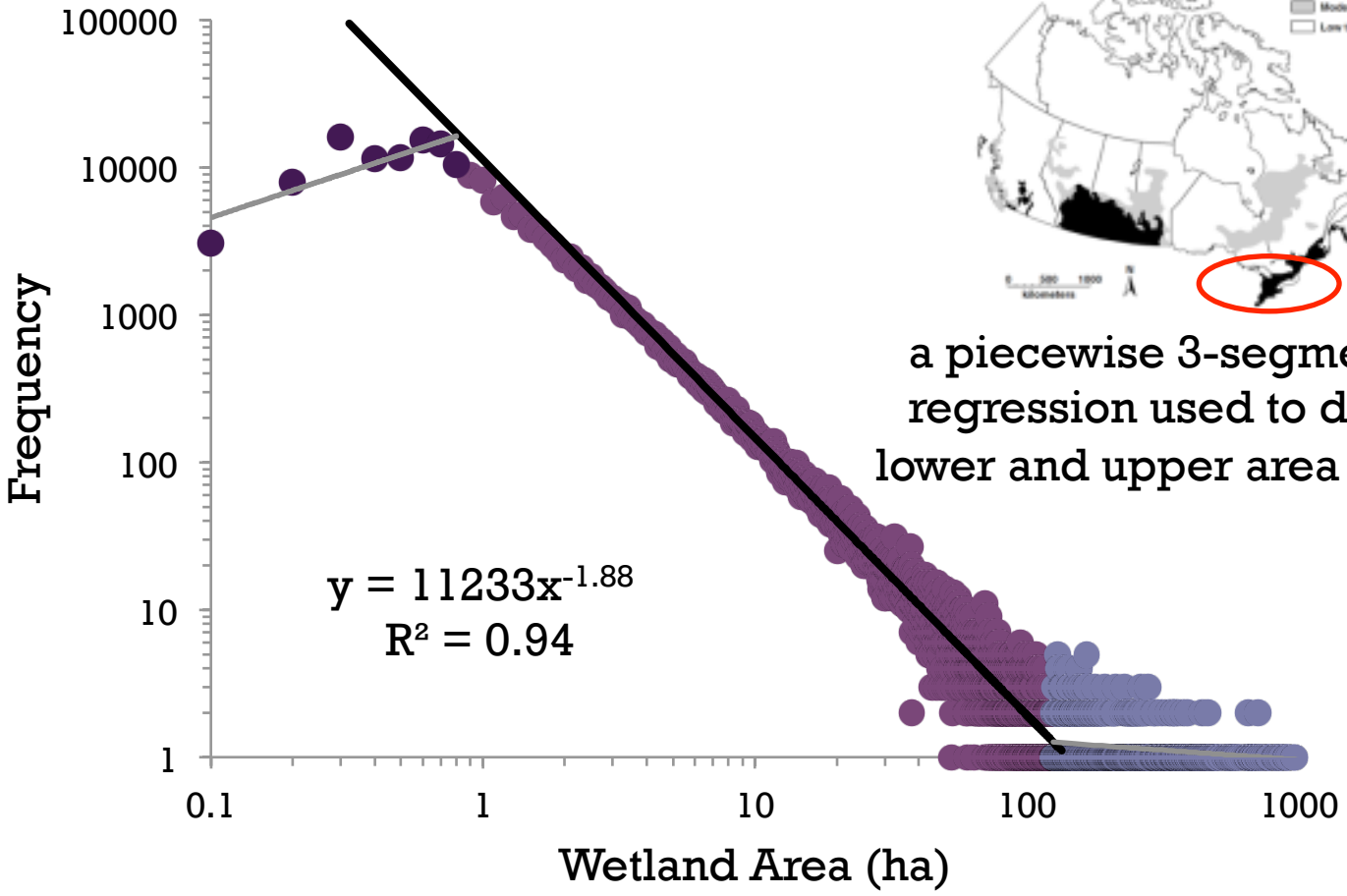
estimating drained wetlands using area-frequency power functions



estimating drained wetlands using area-frequency power functions

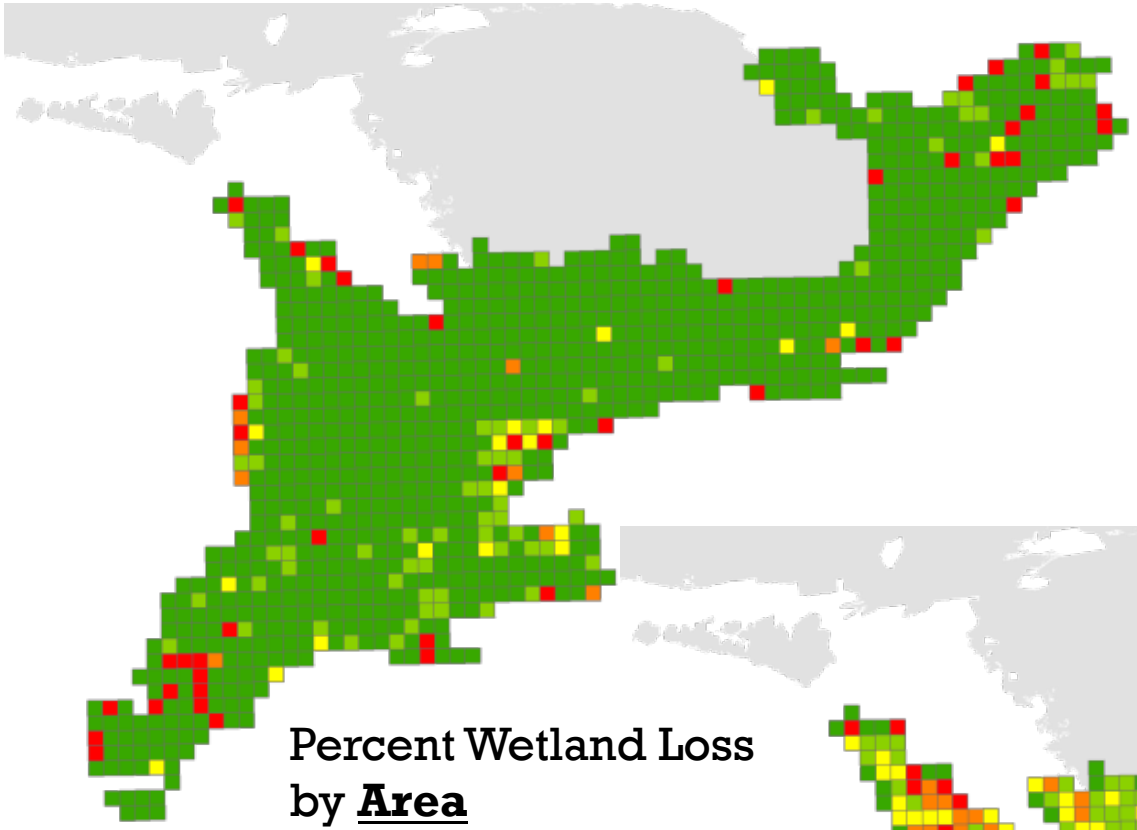


estimating drained wetlands using area-frequency power functions



a piecewise 3-segment linear regression used to determine lower and upper area thresholds

Power Law Statistics (all wetlands)	
Percent number lost	86%
Percent area lost	21%



Percent Wetland Loss
by **Area**

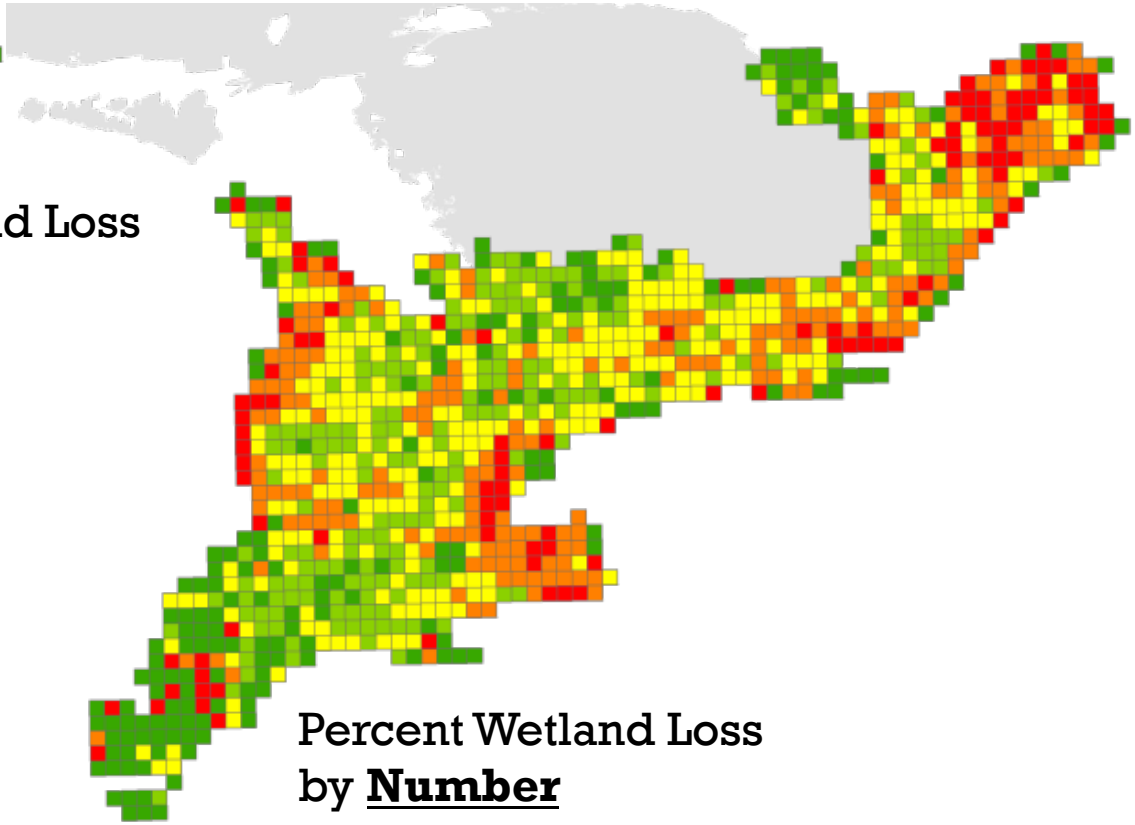
< 20

20 to 40

40 to 60

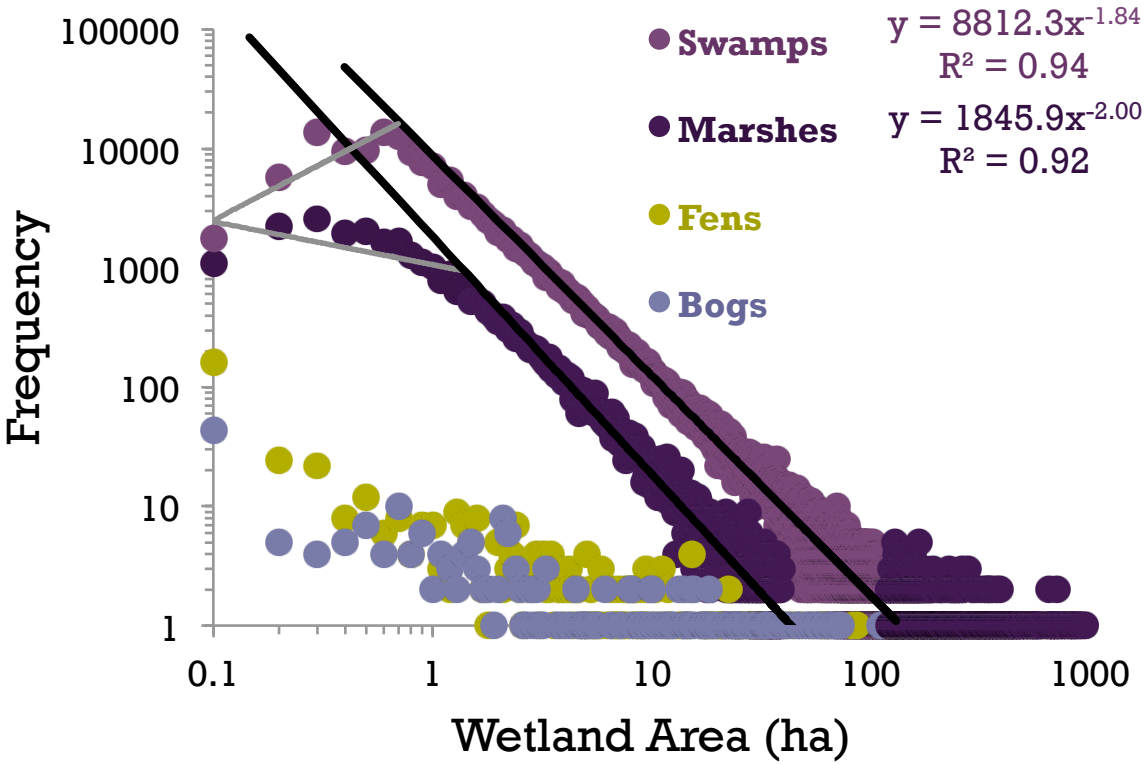
60 to 80

80 to 100



Percent Wetland Loss
by **Number**

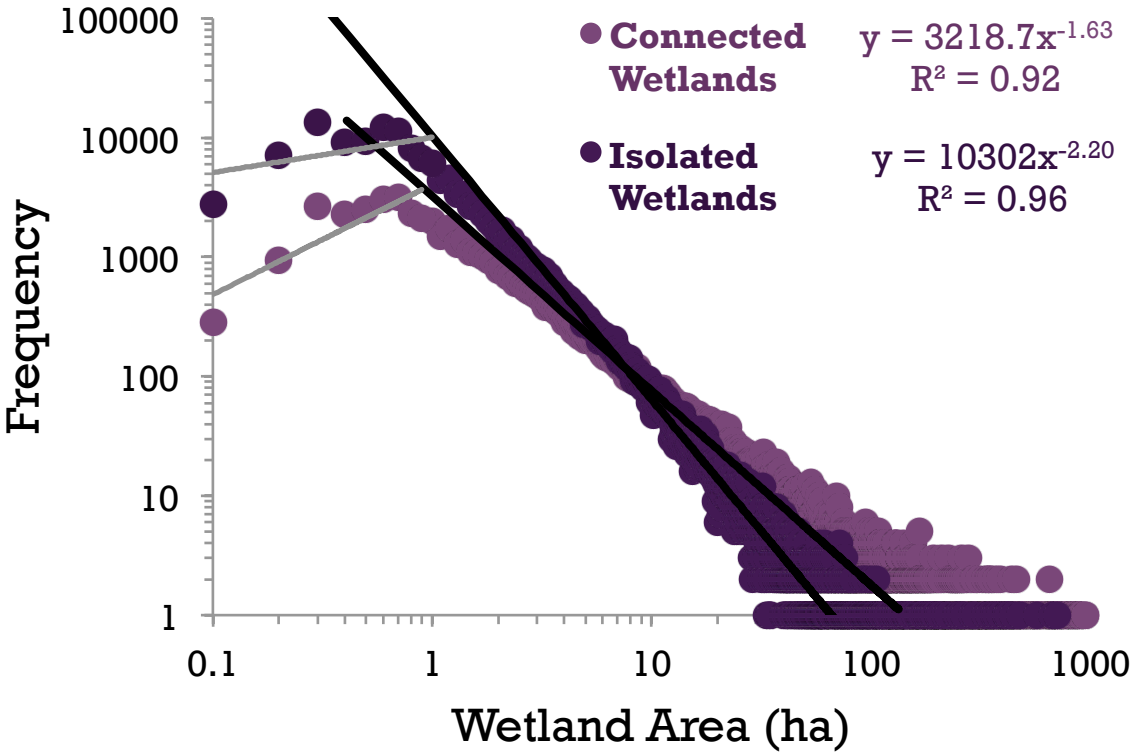
drained wetlands by type



Power Law Statistics (swamps)	
Percent number lost	84%
Percent area lost	18%

Power Law Statistics (marshes)	
Percent number lost	90%
Percent area lost	39%

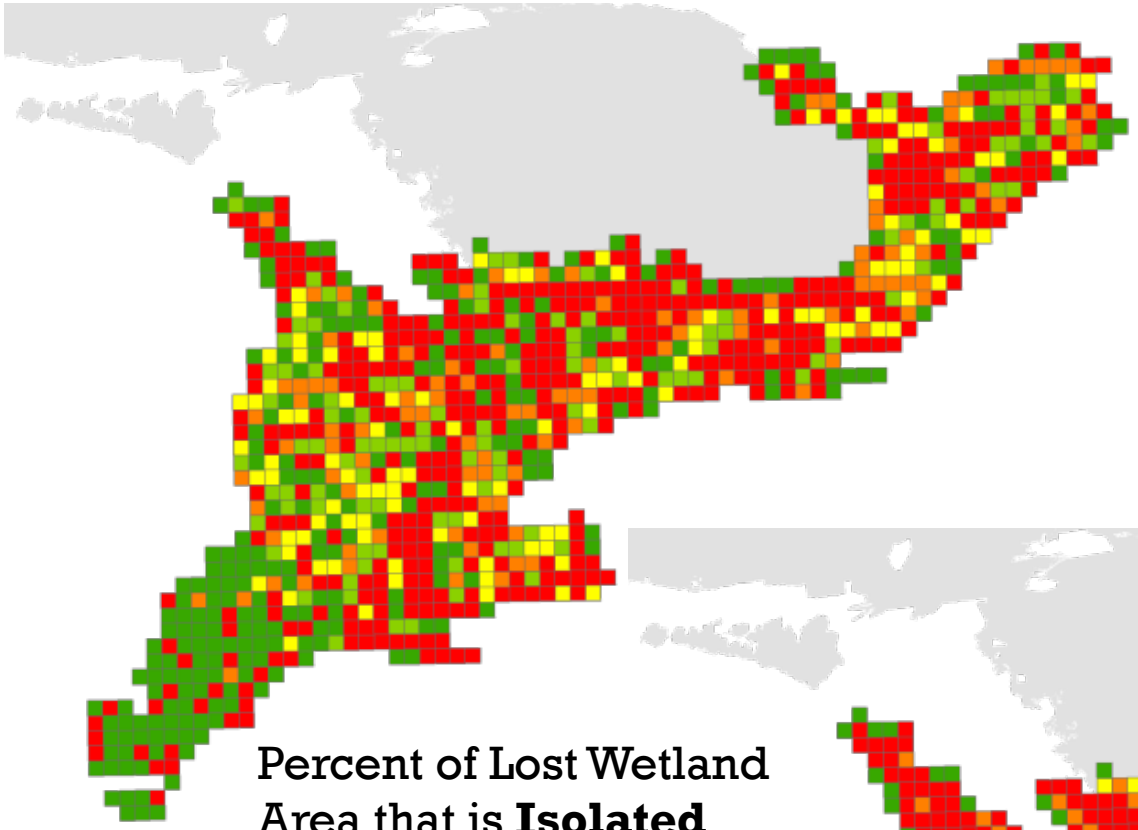
drained wetlands by connectivity



Power Law Statistics (connected)	
Percent number lost	79%
Percent area lost	9%

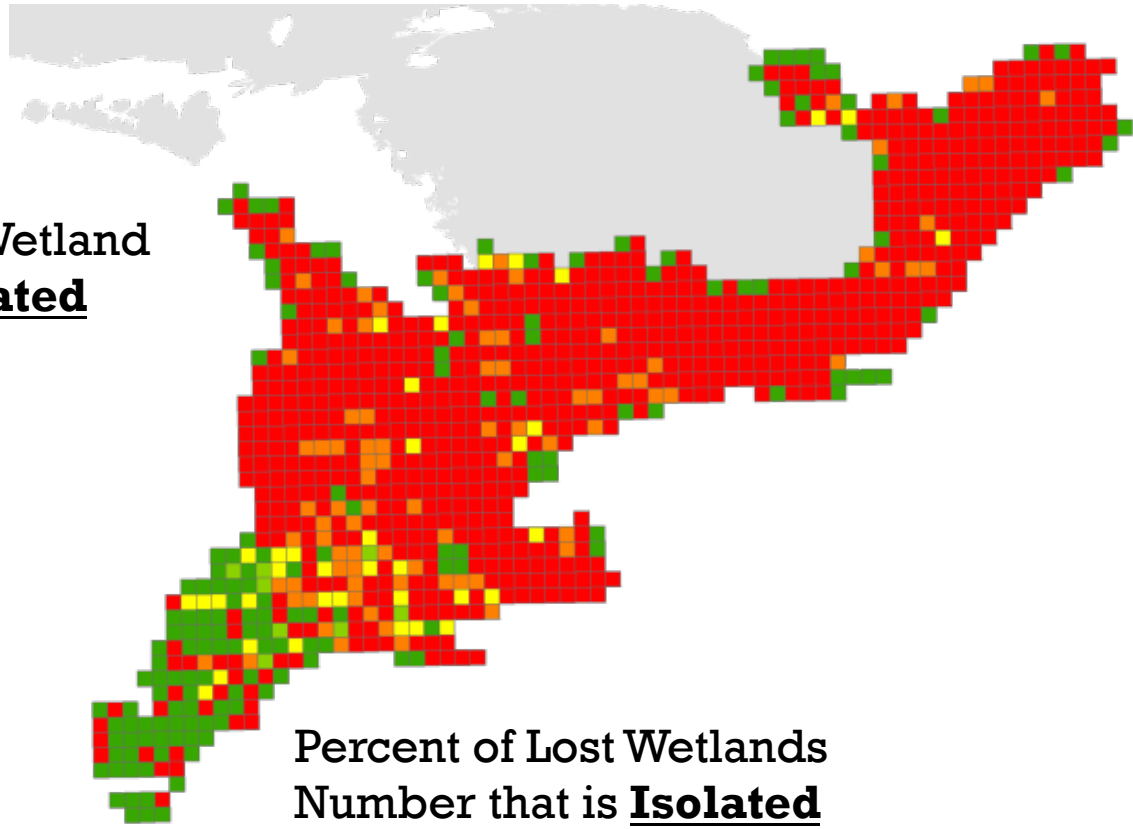
Power Law Statistics (isolated)	
Percent number lost	94%
Percent area lost	53%

Total area:
353,160 ha



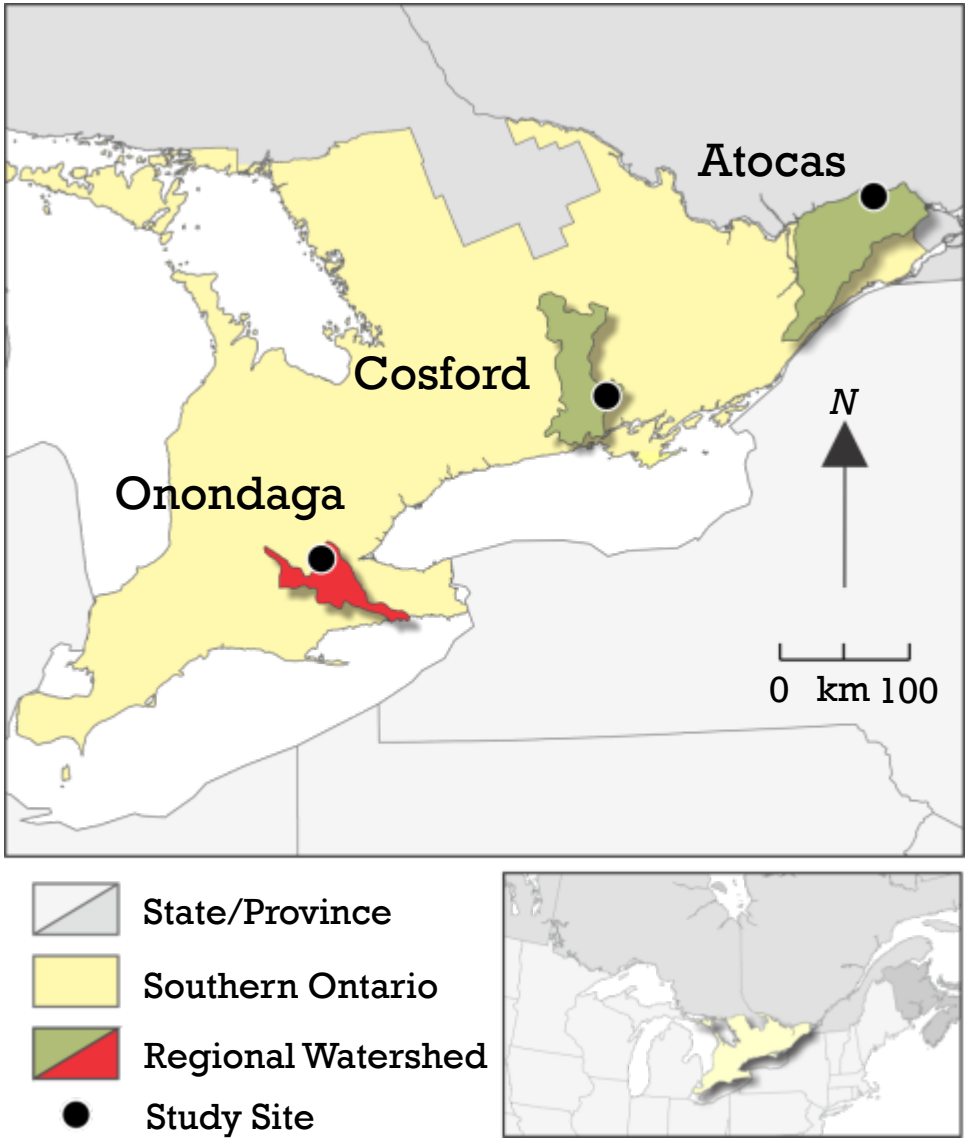
Percent of Lost Wetland
Area that is **Isolated**

- < 20
- 20 to 40
- 40 to 60
- 60 to 80
- 80 to 100



Percent of Lost Wetlands
Number that is **Isolated**

field estimation of nutrient retention rates



three DUC project sites identified along this geographic gradient as potential sites from where wetlands could be sampled

field estimation of nutrient retention rates

sampled three marsh wetlands for each of the following: drained, 10, 20, 35 years since restoration, intact

field estimation of nutrient retention rates

sediment samples taken along a transects at four positions:
P1 - center of wetland (open-water);
P2 - emergent vegetation zone;
P3 – wet meadow zone (i.e., high water mark); and
P4 – upland where flooding rarely occurs.

field estimation of nutrient retention rates

three replicate samples taken using:

- a WaterMark Universal Corer for sediments
- an AMS Extendible Corer for soils

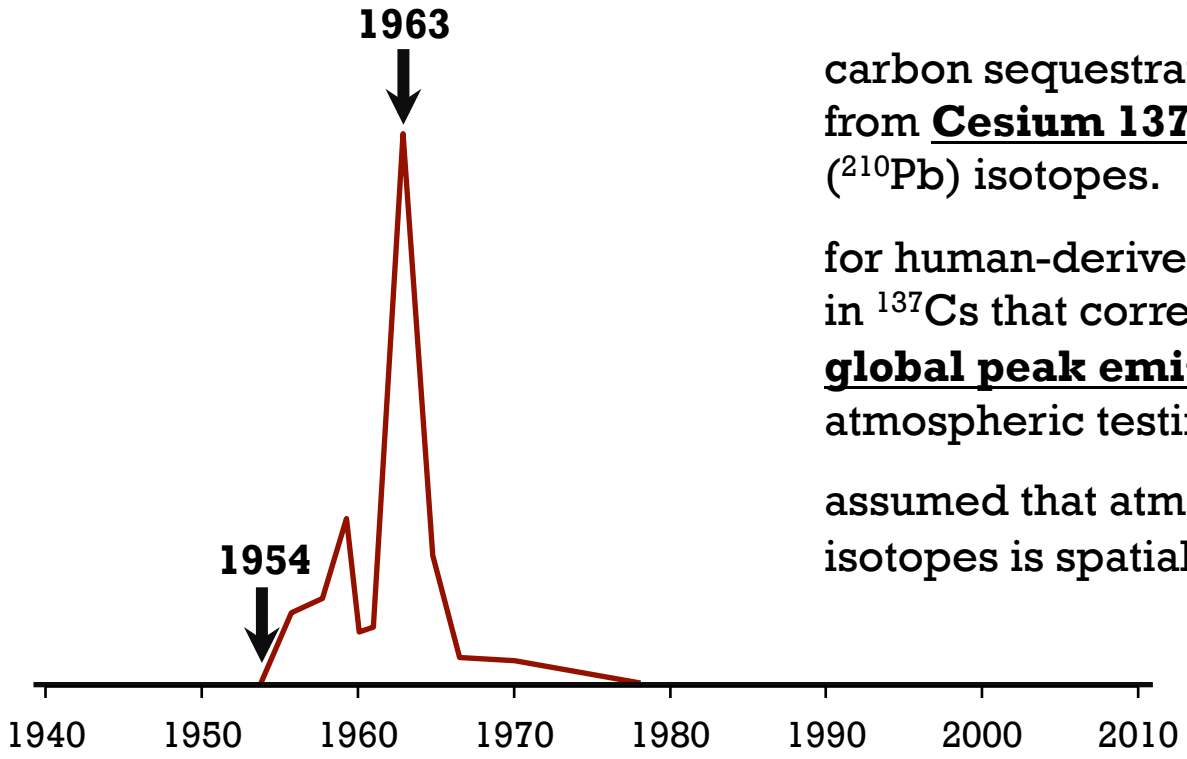
to a **maximum 30 cm of depth**.

each replicate core cut into **1 cm intervals** and composited in the field.

sedimentation rates and **organic C, N, P pools** determined for each 1 cm interval composited sample.

step 1: sedimentation rate

Atmospheric Deposition of ^{137}Cs

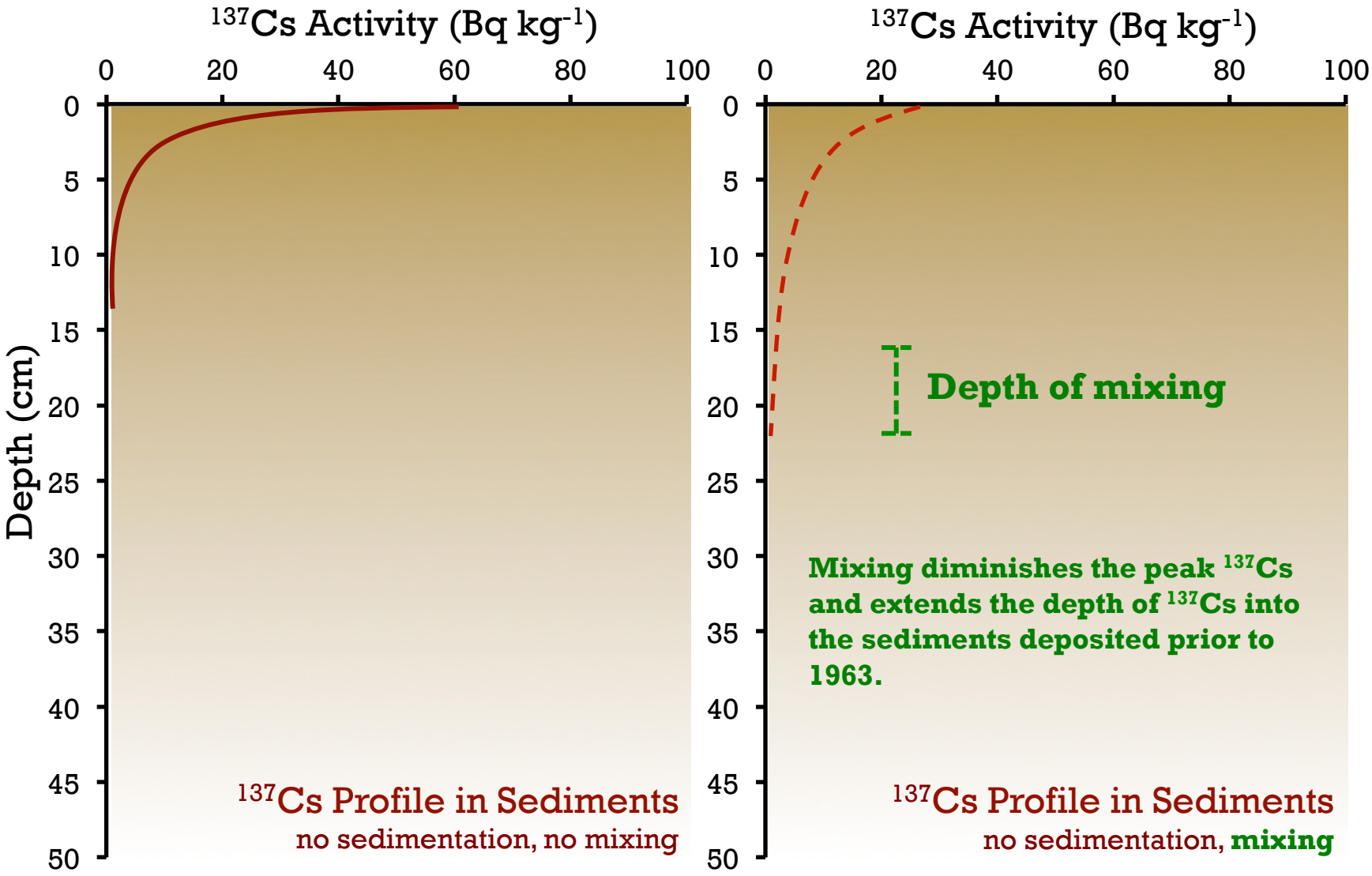


carbon sequestration rates estimated from **Cesium 137 (^{137}Cs)** and Lead 210 (^{210}Pb) isotopes.

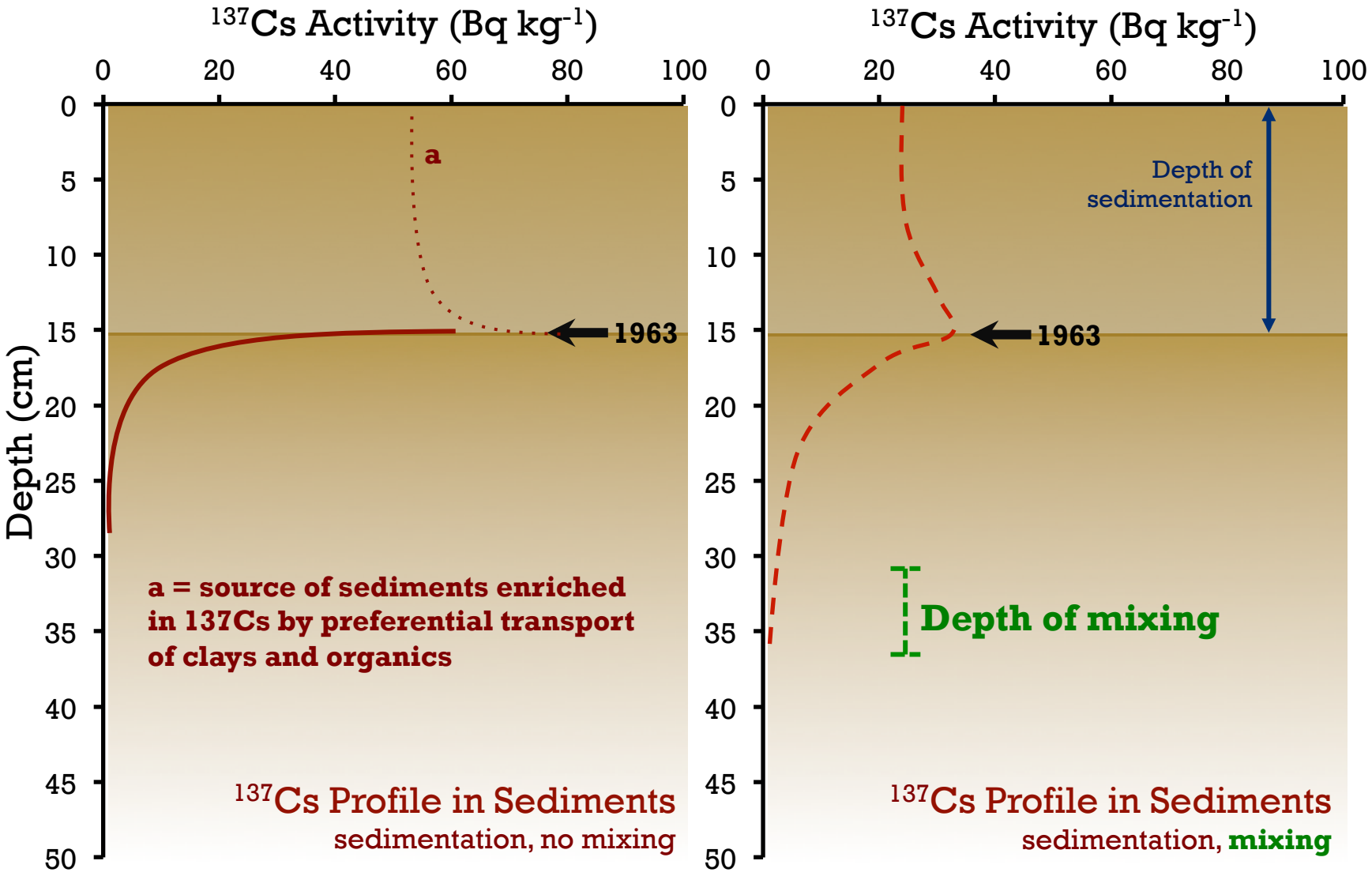
for human-derived ^{137}Cs, there is a peak in ^{137}Cs that corresponds to the **1963 global peak emission** due to atmospheric testing of nuclear weapons.

assumed that atmospheric deposition of isotopes is spatially uniform.

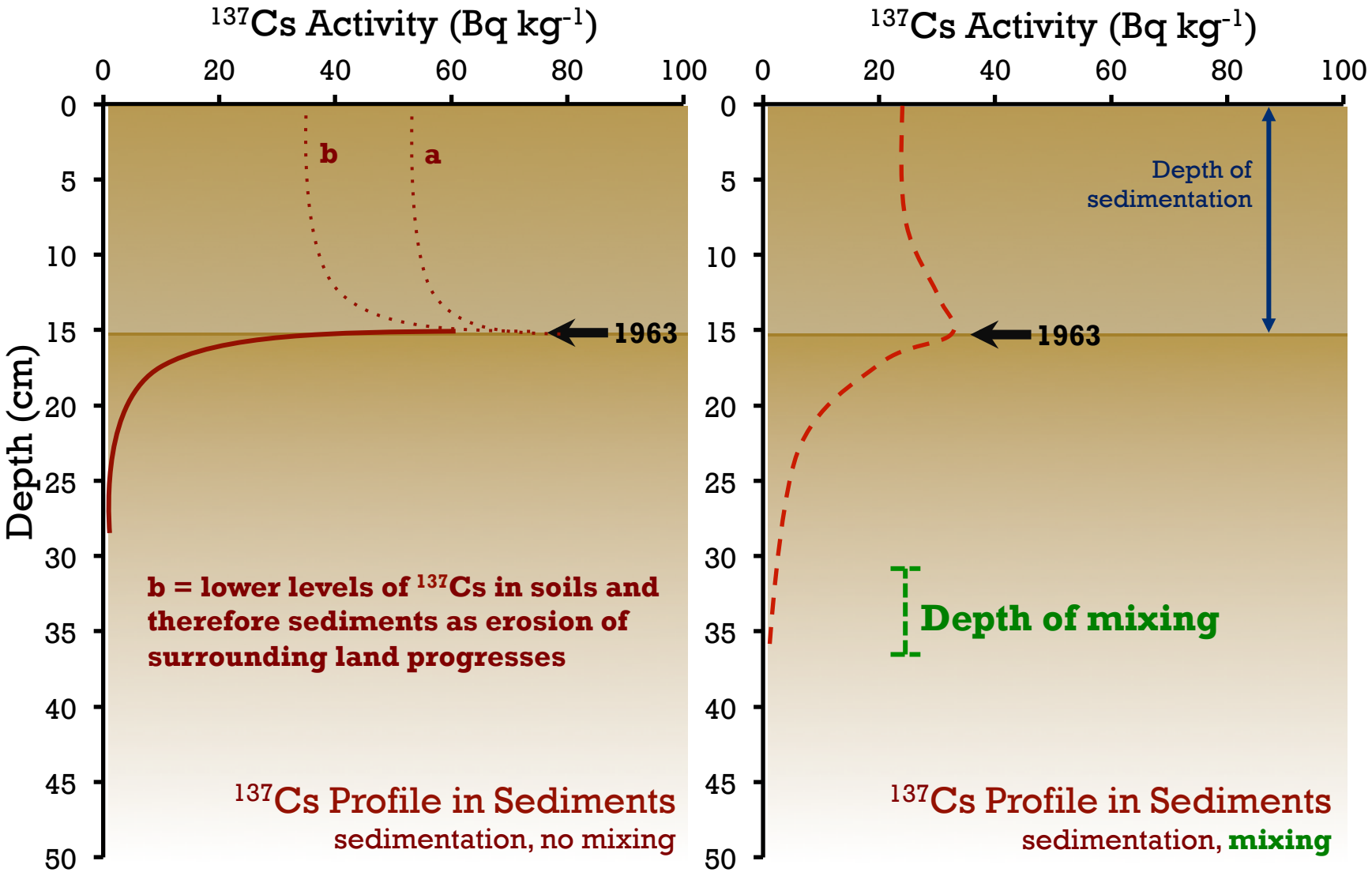
step 1: sedimentation rate



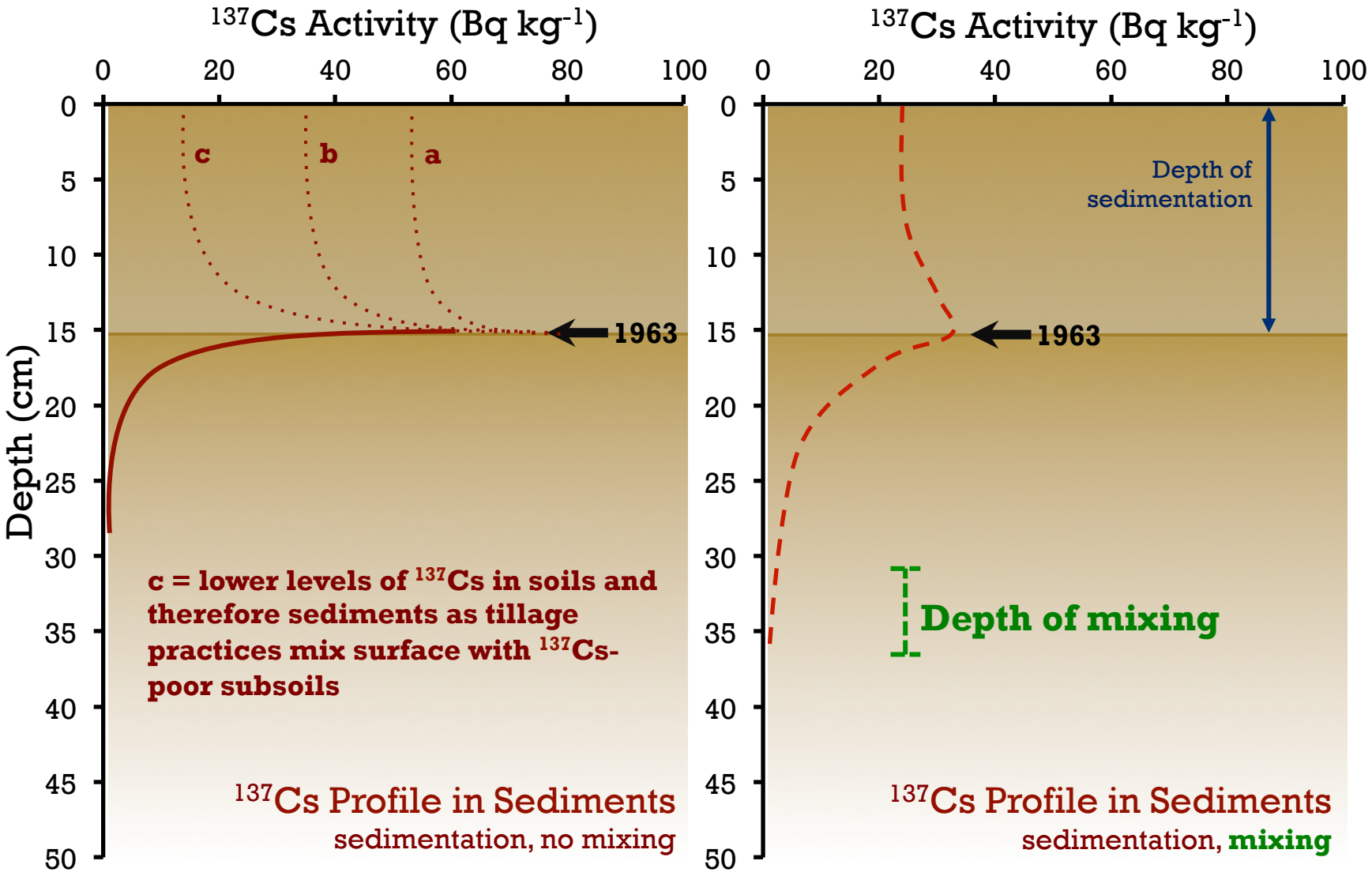
step 1: sedimentation rate



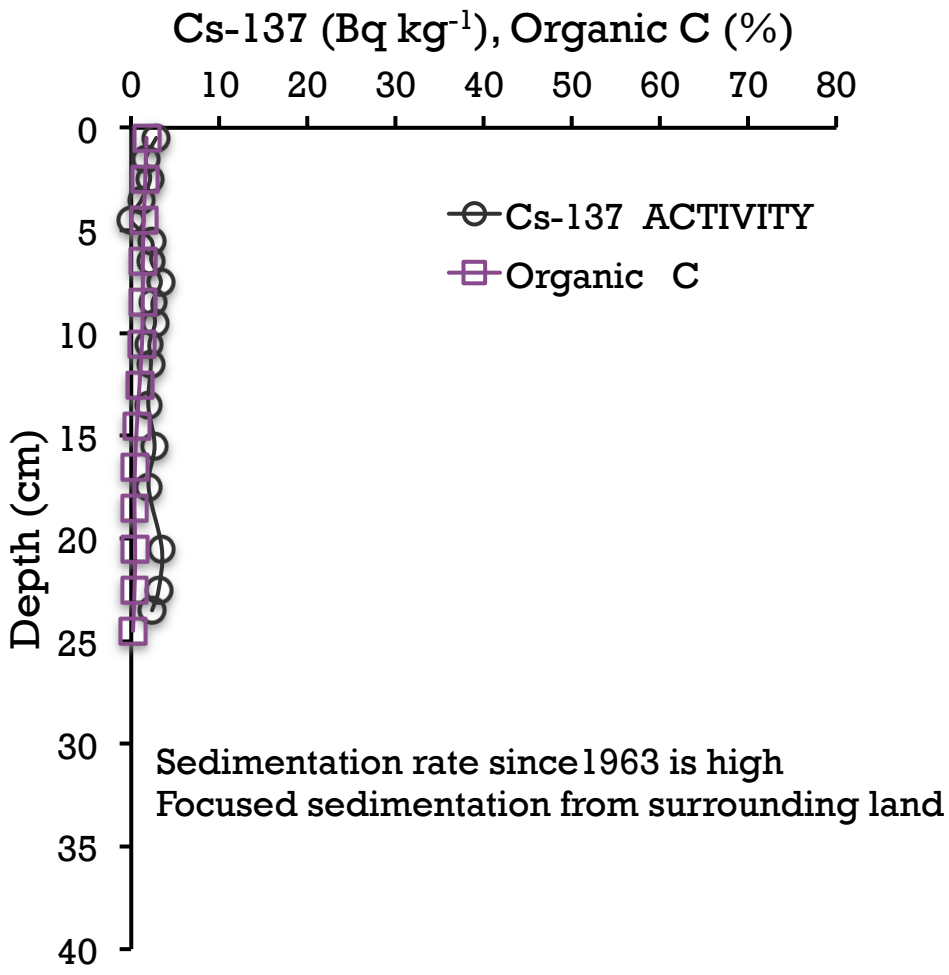
step 1: sedimentation rate



step 1: sedimentation rate



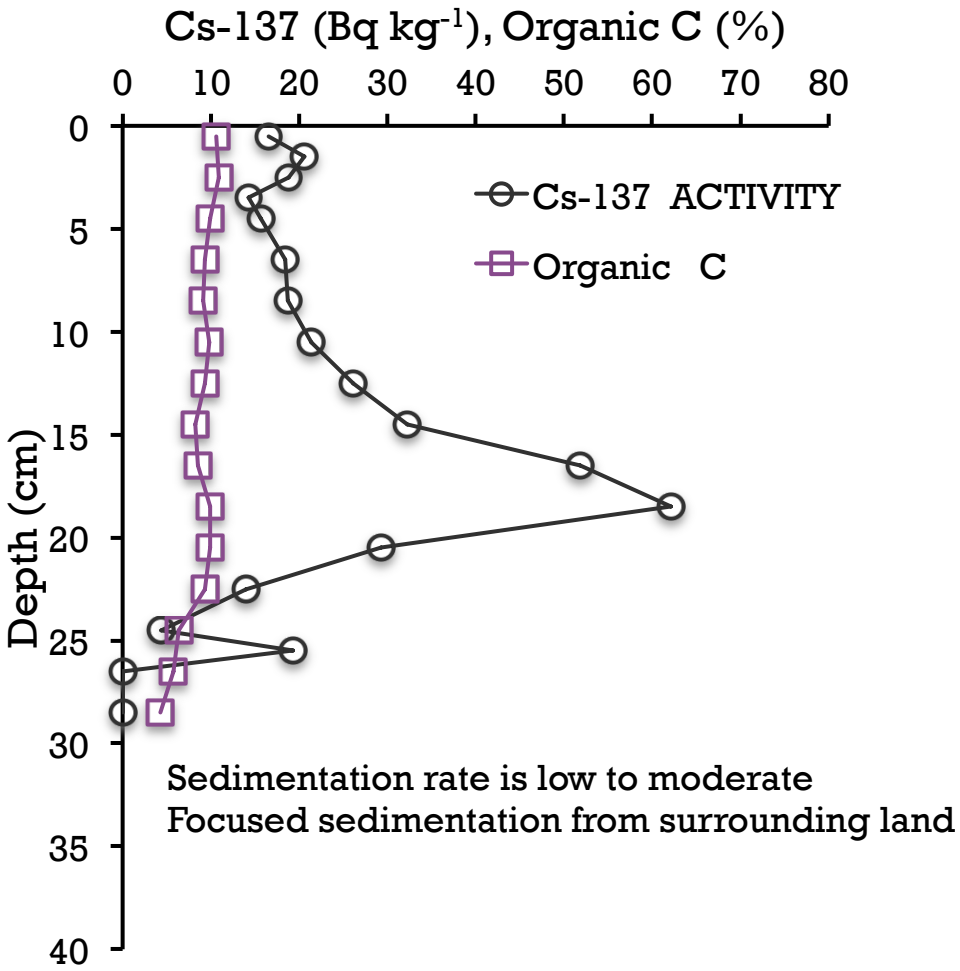
step 2: C sequestration
drained wetland



Total carbon accumulation: **5.1 kg m^{-2}**
Carbon accumulation rate: **101 g m^{-2} yr^{-1}**

step 2: C sequestration

10 years

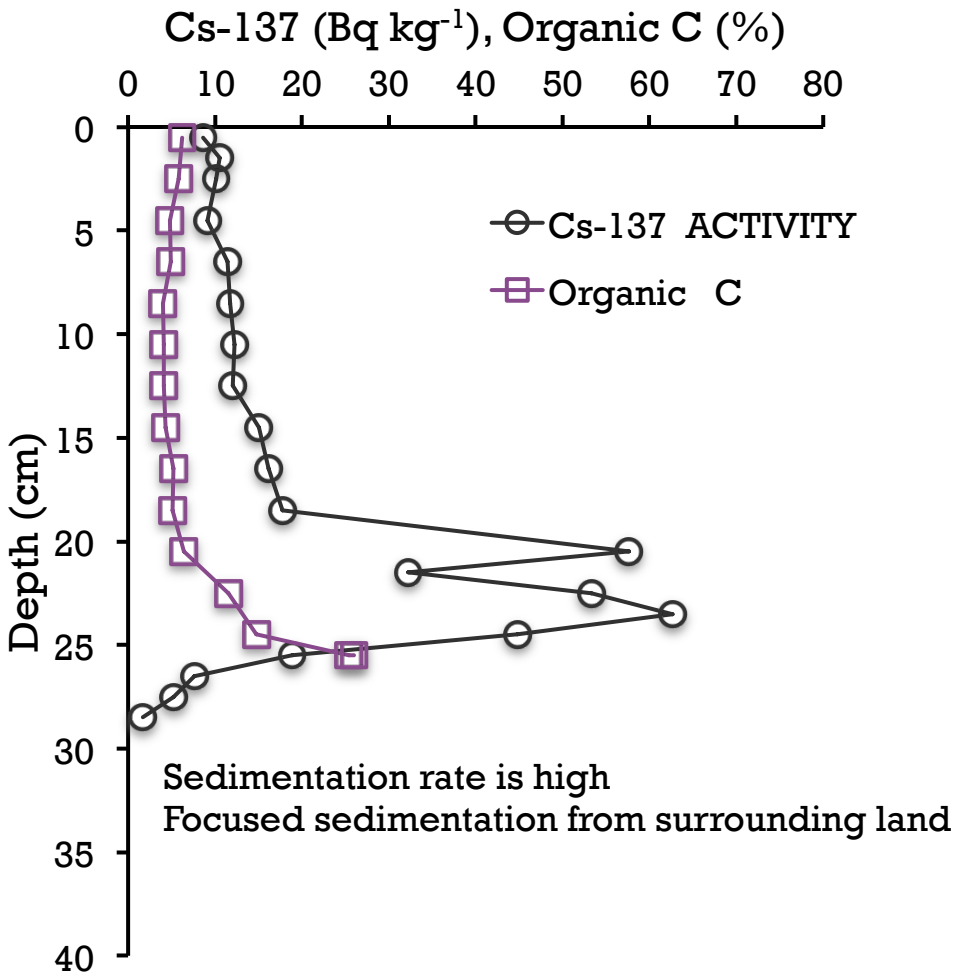


Total carbon accumulation: **7.1 kg m^{-2}**

Carbon accumulation rate: **142 g m^{-2} yr^{-1}**

step 2: C sequestration

20 years

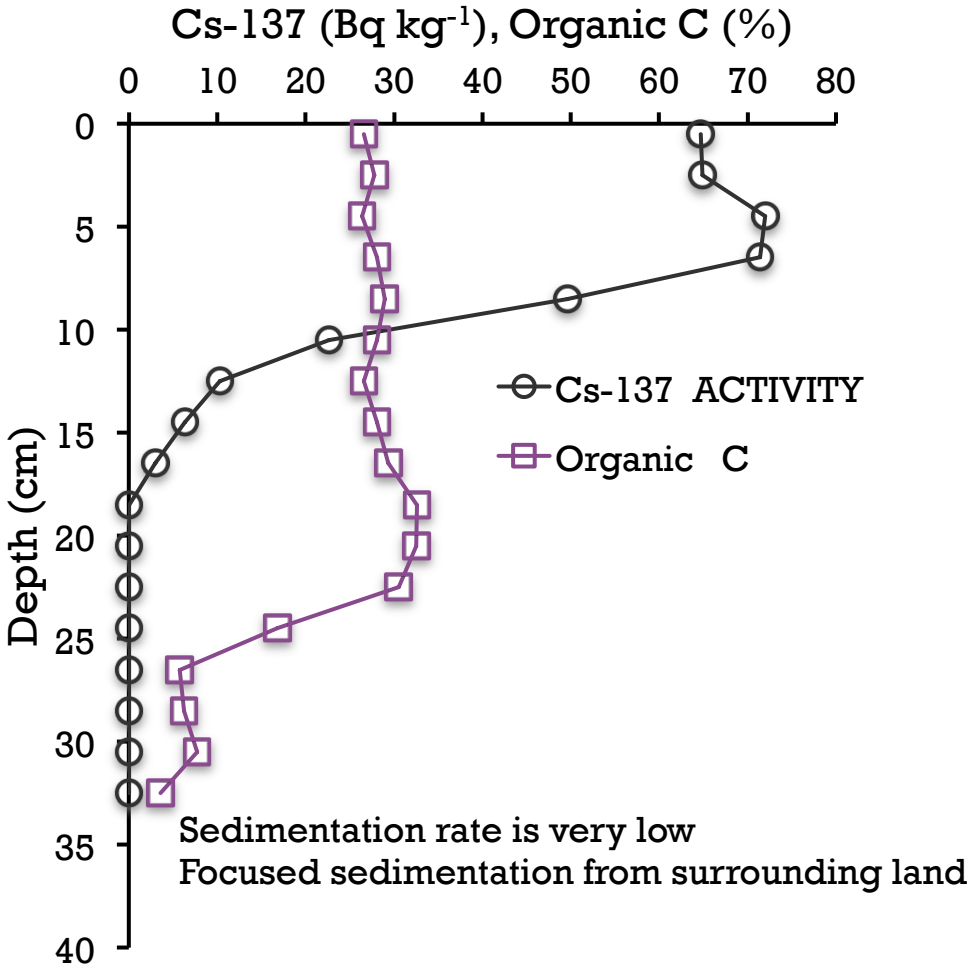


Total carbon accumulation: **18.4 kg m^{-2}**

Carbon accumulation rate: **369 g m^{-2} yr^{-1}**

step 2: C sequestration

35 years

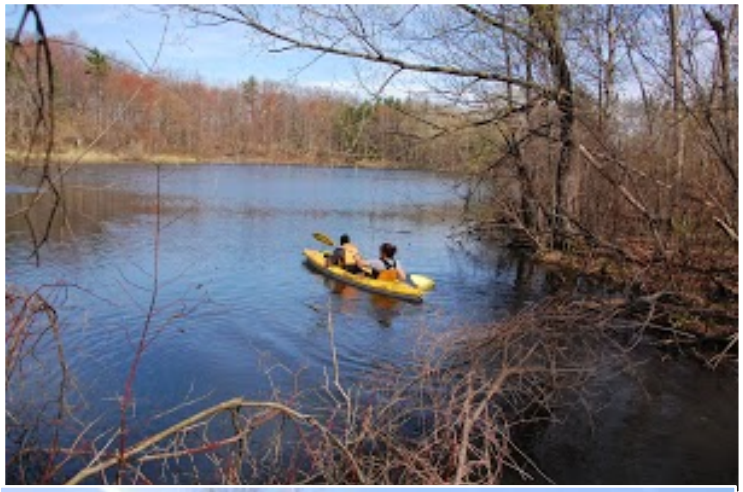


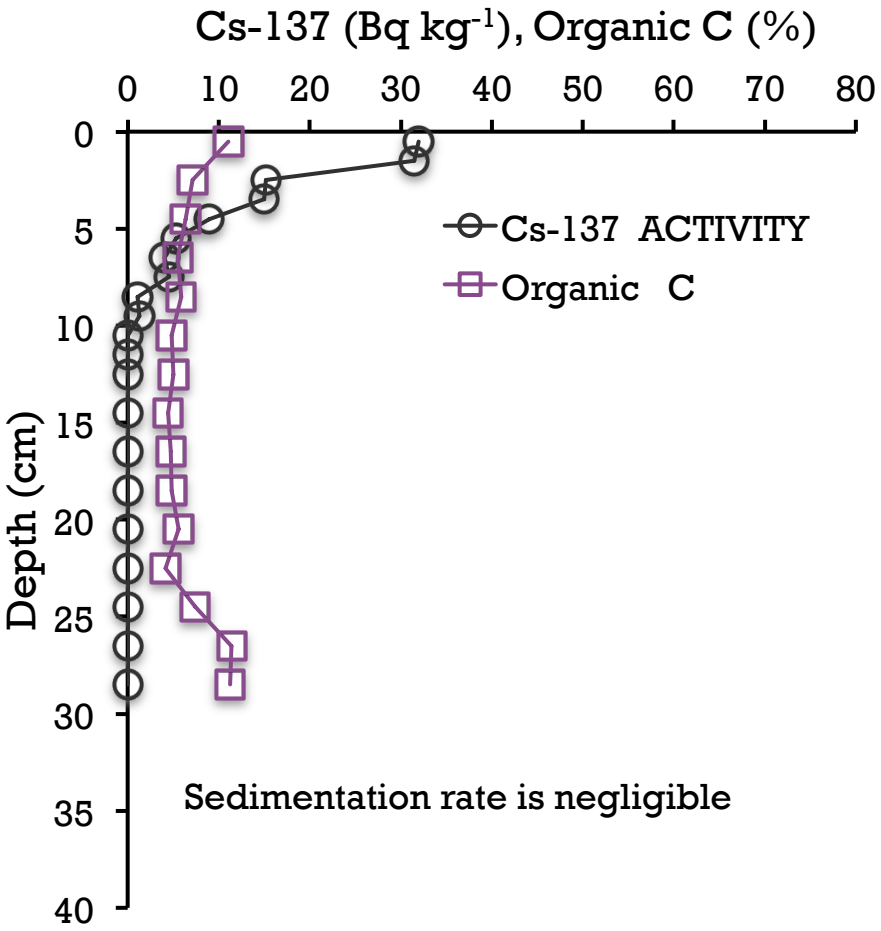
Total carbon accumulation: **2.2 kg m^{-2}**

Carbon accumulation rate: **44 g m^{-2} yr^{-1}**

step 2: C sequestration

intact

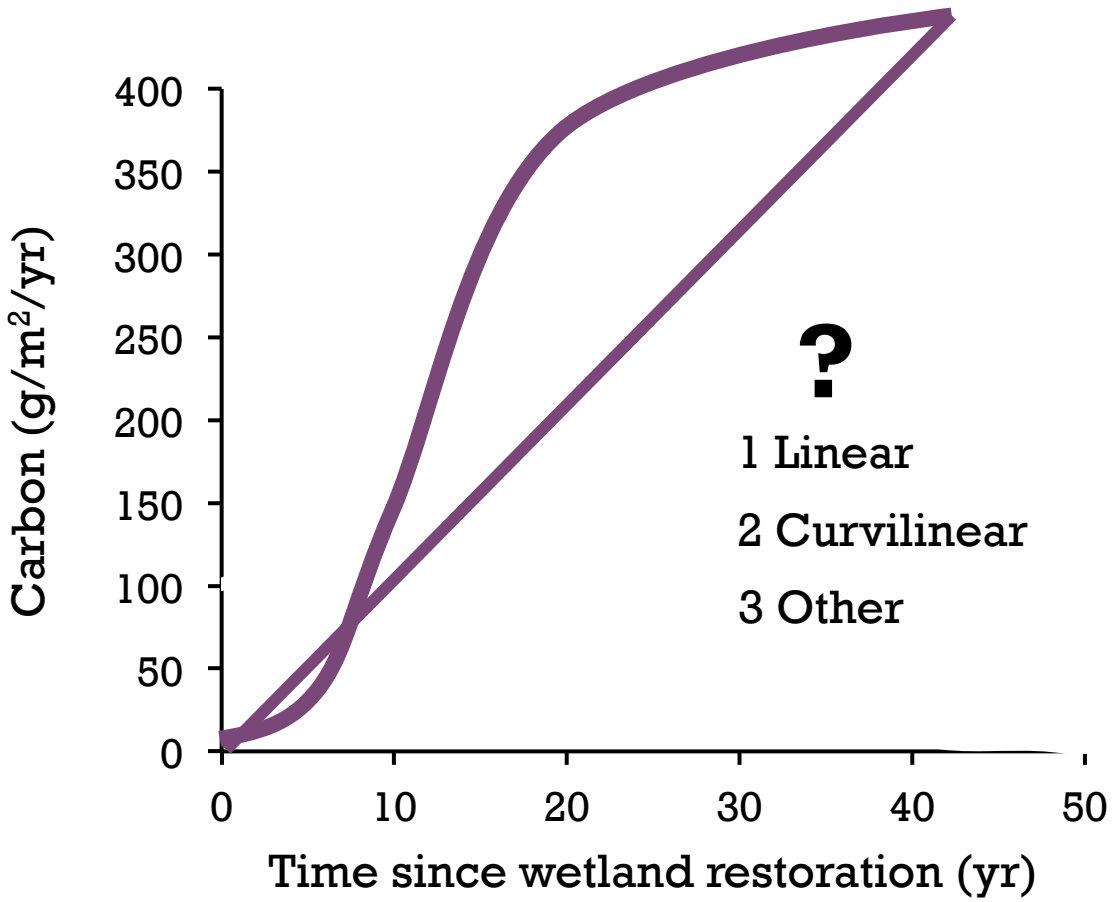




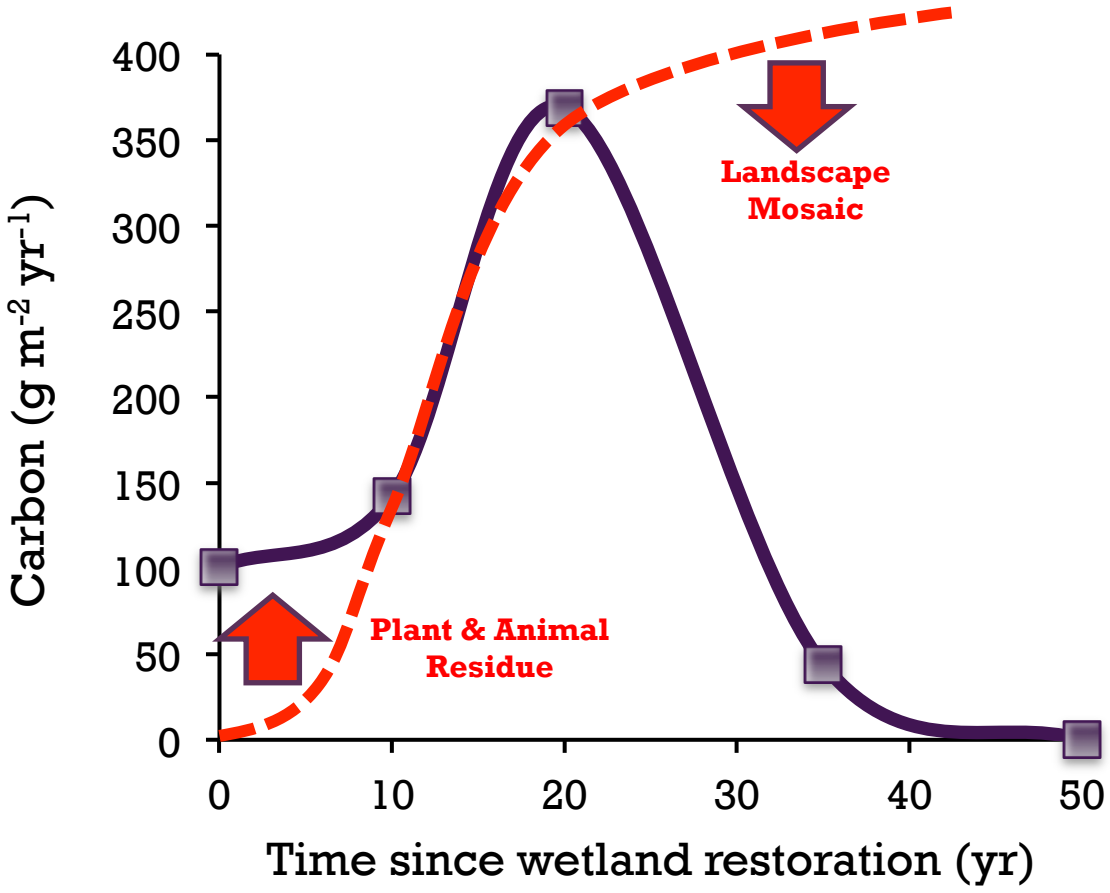
Total carbon accumulation: **negligible**

Carbon accumulation rate: **0 g m^{-2} yr^{-1}**

step 2: carbon sequestration rates

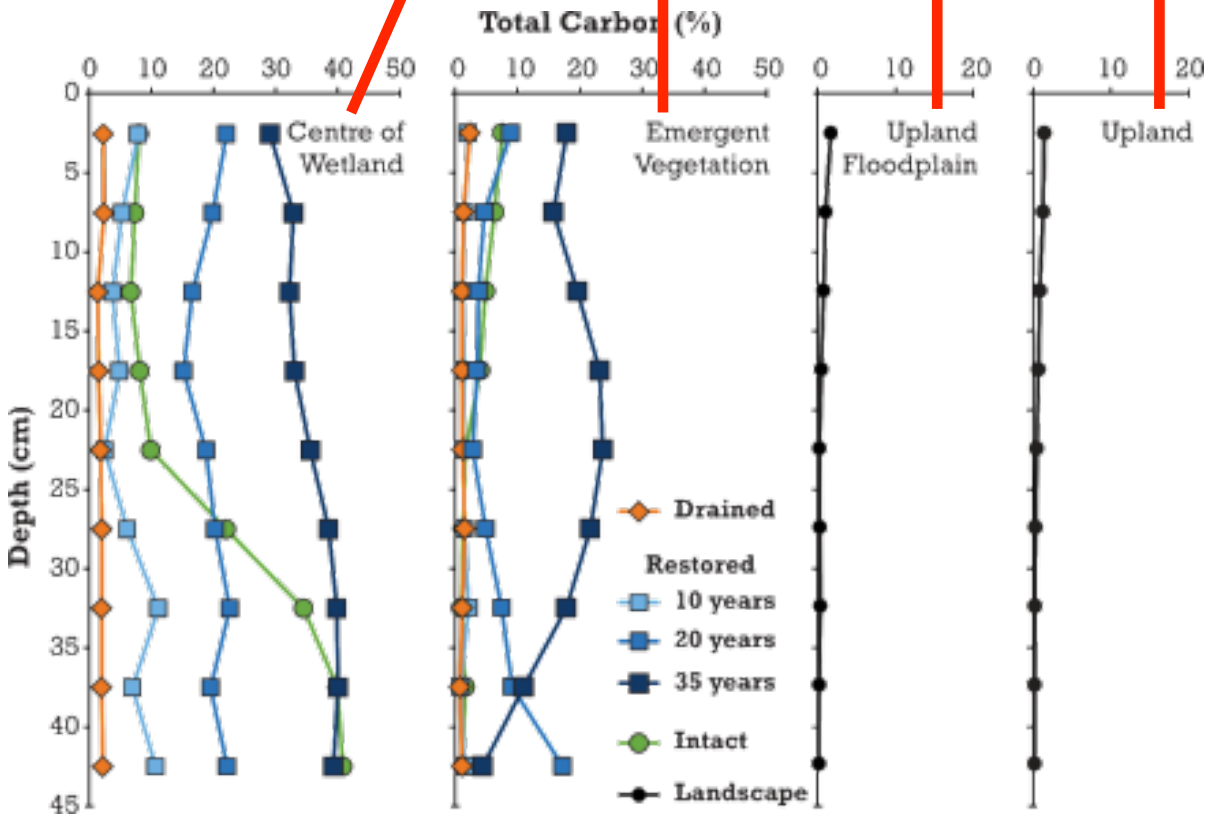


step 2: carbon sequestration rates



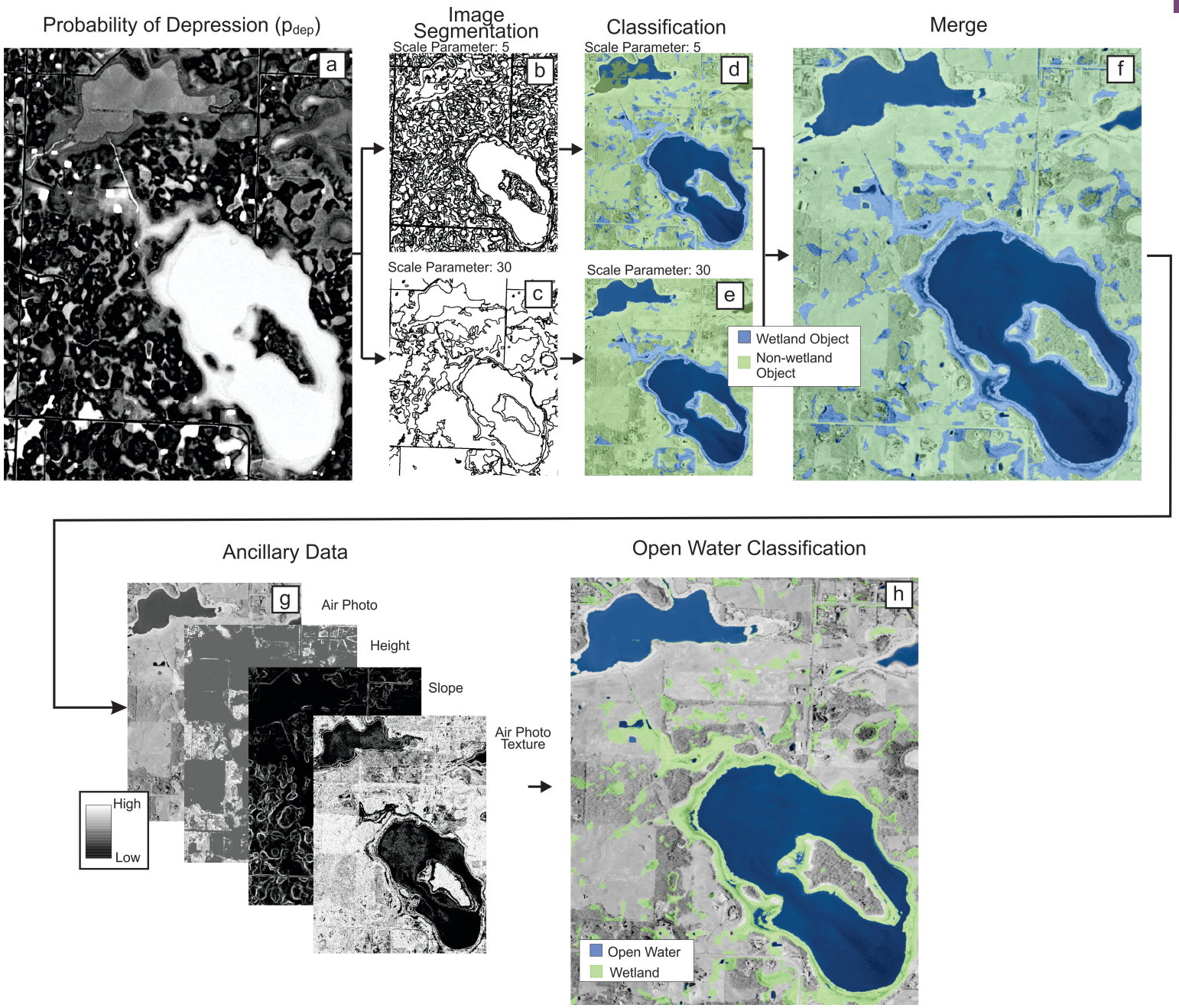
Basin Scale

step 3: carbon pools within wetland basin



step 3: carbon pools within wetland basin

Basin Scale



step 4: landscape mosaic (work in progress)

diversification of farmer's markets

policy options to encourage farmer uptake

- Fixed payments
- Tax rebates/incentives
- Reverse auctions
- Extension/education

diversification of farmer's markets

Restored wetland (ha)	Low carbon storage (52.1 Mg CO_2 eq/yr)	High carbon storage (135.5 Mg CO_2 eq/yr)	Economic Value ($30/yr) of carbon storage based on different estimates	
			Market estimate $/Mg CO_2 eq	
			Low	High
1	52	135	$1,562	$4,059
10	521	1,353	$15,620	$40,590
100	5,207	13,530	$156,200	$405,900
1,000	52,067	135,300	$1,562,000	$4,059,000
10,000	520,667	1,353,000	$15,620,000	$40,590,000
353,160	18,387,875	47,782,578	$551,636,264	$1,433,477,333

**Note: 353,160 denotes total historic loss of isolated wetland area*

next steps for operationalizing

- Include "bundles" of ecosystem services
- Model cumulative effects of the restored wetlands on provision of ecosystem services on regional watersheds
- Conduct model scenarios of future land development plans under global change

acknowledgements

David Lobb
Eva Slavicek
Nicole Larsen
Aleksey Paltsev
Michael Steiff
Nico Trick
Naomi Trick
Tong Zou
Dave McLachlin
Erling Armson