Comparing Ecosystem Carbon Fluxes in Restored Versus Natural Wetlands

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Introduction:

Wetlands provide numerous ecosystem services such as water filtration, habitat for numerous species and carbon sequestration (Figs. 1 and 2).

Wetlands are experiencing significant declines due to human impacts. Over half of the pre-existing wetlands in the US and 90% of wetlands in Ohio have been lost. This makes wetlands a target for ecological restoration.

Carbon (C) sequestration is an ecosystem service provided by wetlands. Wetlands sequester atmospheric C as a function of high primary productivity and slow decomposition in anaerobic soils. They contain approximately 30% of the world's soil C despite covering only 6% of the earth's surface. Wetlands are also sources of methane – a greenhouse gas approximately 25 times more potent than CO_2.

Objective: Examine the relationship between wetland soil C fluxes and ecological condition (High ecological condition, low ecological condition and restored). What effect does a wetland's ecological condition have on its net contribution of greenhouse gases to the atmosphere?

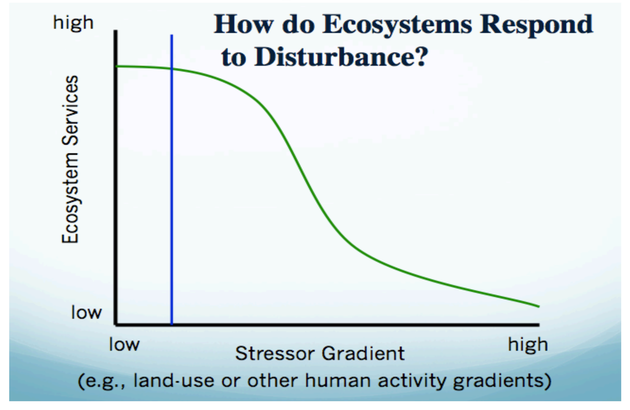

Fig.1 Wetland condition is highly related to wetland ecosystem services and chemical processing. (Modified from Trepel and Palmeri 2002.)

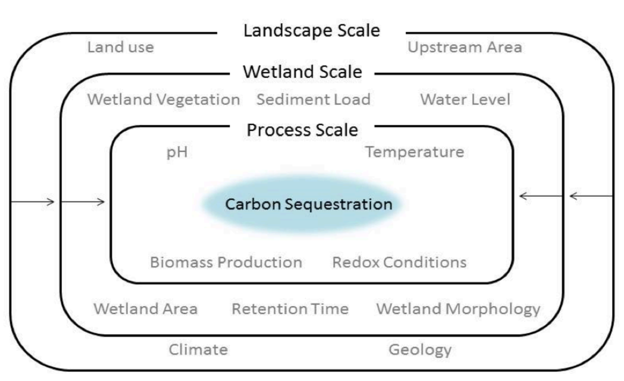

Fig.2 A conceptual model showing how ecosystem services decrease as anthropogenic stressors become more prevalent.

Methods:

Six wetland sampling sites were selected from a previous study's set of sites. The ecological condition (Condition Category) of each site was determined using the FQAI score, where FQAI= Σ(CC of all species)/ √(number of native species).

FQAI was calculated based on Coefficients of Conservatism (CC) – rankings of plant species on a scale of 0-10, where 1-10 = the degree of a species' fidelity to specific habitat conditions and 0=nonnative. A high FQAI score is correlated with high ecological condition.

Soil Sampling: A 50-cm soil core was taken from each site using a handheld soil corer. Soil cores were then sectioned into 2-cm segments and analyzed for carbon content and Cs-137, in order to calculate carbon and soil accretion. Soil carbon percentages were determined using a Perkin-Elmer 2400 series CHN analyzer.

Methane Analysis: Methane was sampled using a static chamber setup, where air samples were taken at 7 minute intervals for 35 minutes. Methane concentrations in each air sample was then assessed using a Shimadzu GC-2014.

Wetland primary productivity was estimated using clip plots. Four quadrats ($0.25m^2$) were selected along the hydrological gradient at each site, and all herbaceous material was collected.

Table 1. Soil characteristics of wetland sites by condition/category.

Site Name	Condition Category (High, Medium, Low)	FQAI Score	Mean CC	Mean % Soil Carbon	Soil Accretion Rate (cm/yr)	Carbon Accretion Rate (gC/m²-yr)	Seasonal Biomass Production (g/m²)
Skunk Forest	H	21	4.0	5.46	0.15	53.12	*
Lizard Tail	H	24	4.6	5.43	0.15	44.17	*
Bee Rescue	H	16	2.6	8.81	0.28	100.2	*
Hellbender	M	13	2.8	2.31	0.24	66.48	*
Vernal Pool	L	7	2.8	4.22	0.5	149.6	*
Blackout	L	15	1.9	5.15	0.28	131.9	*
Kokosing	L/M	12	2.8	4.22	0.33	121.8	32
Bat Nest	L	9	1.7	3.21	0.34	128.2	438
Ballfield	H	25	3.6	16.9	0.20	72.04	291
Blackjack	H	26.4	*	*	*	*	10
BFEC	R	11.5	1.9	6.5	*	*	671
Sacks	R	11.7	2.1	3.1	*	*	909

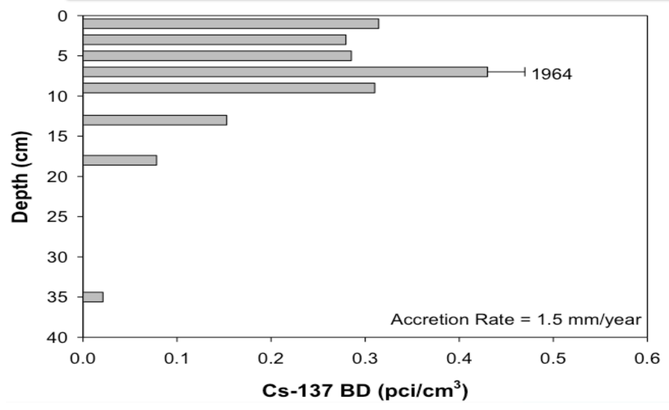

Fig.3 (left to right) Cesium peak in a single soil core. Peak = 1964. A soil core, pre-sectioning. A methane sampling chamber.

Results:

Fig.4 A low condition (L) wetland site (top left), a high condition (H) wetland site (top right), and a restored (R) wetland site (bottom center).

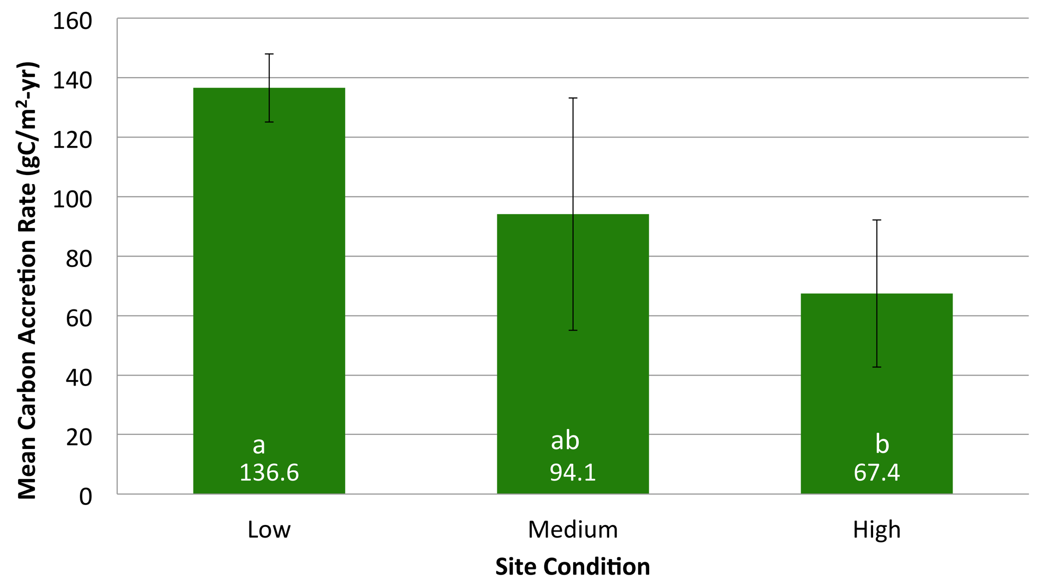

Fig.5 Low condition wetlands (a) have significantly higher carbon accretion rates than high condition wetlands (b). Carbon accretion by wetland condition/category. One-way ANOVA, P=0.029. Error Bars = standard deviation. Bars with the same letter are not significantly different.

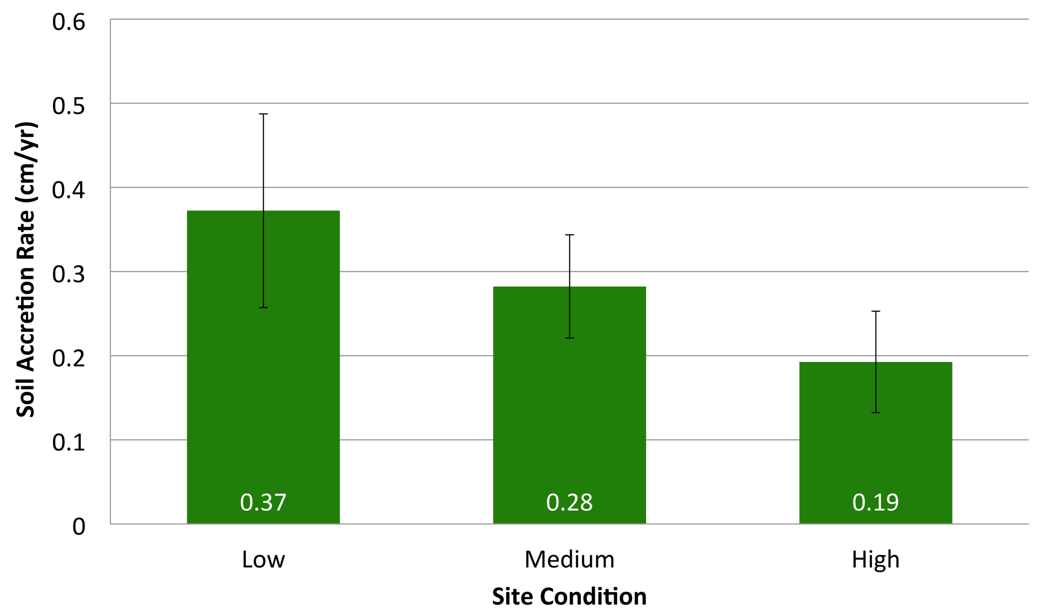

Fig.6 Low Condition Wetlands have higher soil accretion rates than High Condition Wetlands. Soil accretion rate by wetland condition/category. One-way ANOVA, P=0.077. Error Bars = standard deviation.

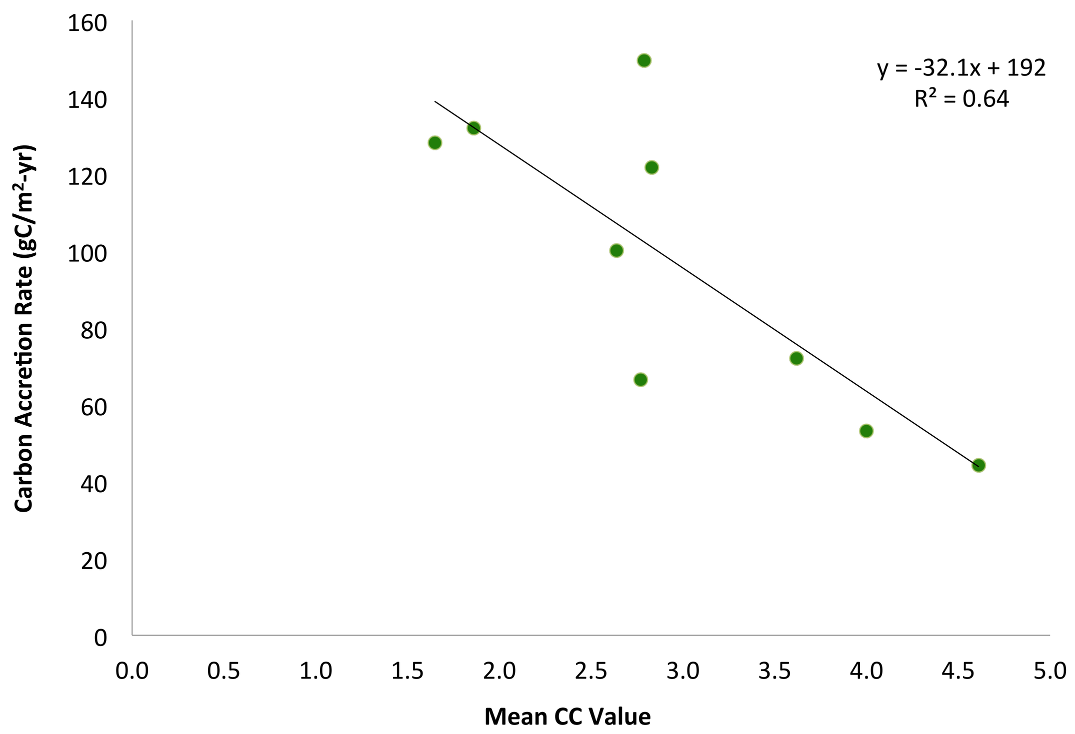

Fig.7 Carbon accretion rates in these sites are negatively correlated with Coefficient of Conservatism (CC). Linear Regression of carbon accretion rates versus mean CC. P=0.01.

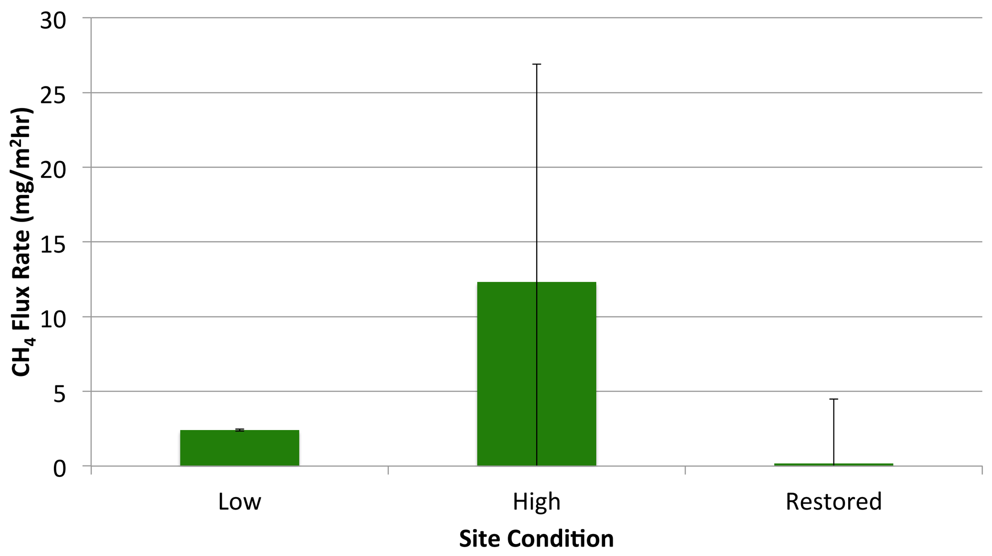

Fig.8 Methane emission rates across wetland Condition Categories. One-way ANOVA, P=0.067. Error bars = standard deviation.

Discussion:

Low condition wetlands exhibited significantly higher carbon accretion rates than medium or high condition wetlands, indicating a negative correlation between carbon accretion and mean CC value. Although the differences in soil accretion rates are not statistically significant at P=0.07, there is evidence of a similar trend.

Increased soil deposition may be responsible for the greater soil carbon accretion rate in lower quality wetlands. This is possibly due in part to the high hydrologic variability in the low condition sites. Low, medium and high condition wetlands experienced mean 7-day differences in water level of 12.7, 8.7 and 27.1 cm respectively.

The relationship of mean CC values to carbon accretion rates (R^2=0.64) demonstrates the potential efficacy of using wetland condition as a predictor of ecosystem services.

To date, wetlands demonstrate no significant differences in methane emission rates across Condition Categories, although there is some evidence of a trend (One-way ANOVA, p=0.067). Sample analysis is ongoing.

Future Directions:

In the future, I will examine mycorrhizal populations in wetlands of varying condition to further examine the biotic factors behind methane emissions.

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