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Ecosystem Services as Functions of Wetland Restoration Practice in Ohio Watersheds

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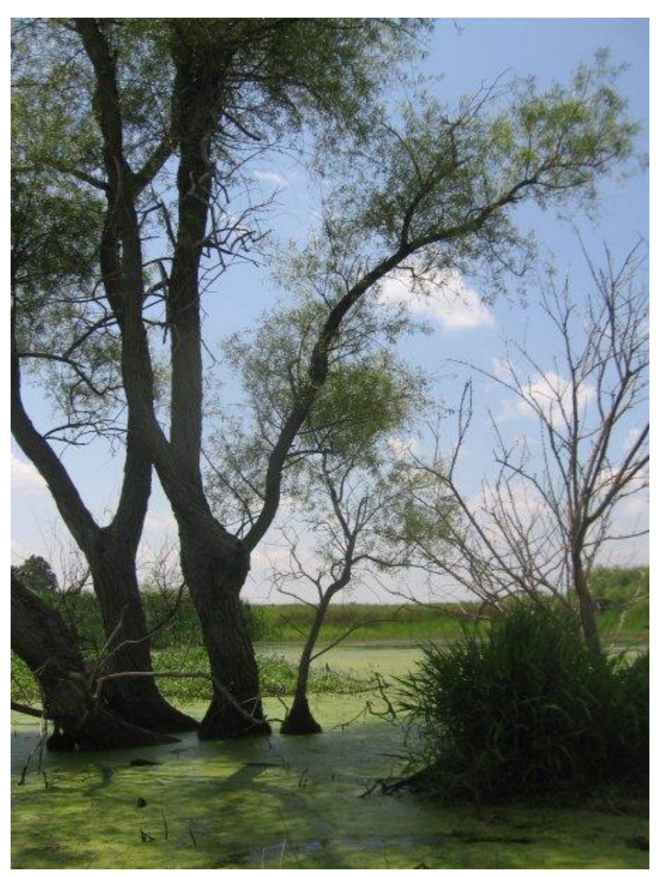
Background and Study Questions

•Wetlands provide important ecosystem services including flood prevention, preservation and support of biodiversity, and the ability to act as nutrient processors and sinks (Figure 1).

•Because wetland conversion to farmland in the Mississippi River watershed has reduced wetland capacity to process nutrients and led to increased nutrient loading from artificial fertilizers and tilling practices[3], the USDA Natural Resources Conservation Service began the Wetland Restoration Program to counter agricultural damage.

•Wetlands were restored at sites across Ohio in the following ways: riparian zones were conserved and extended and depressional wetlands were restored.

•Our questions: Have the restoration programs produced wetlands capable of providing services such as increased biodiversity, carbon and nitrogen sequestration, and downstream water quality benefits? And, if so, which restoration method is most effective?



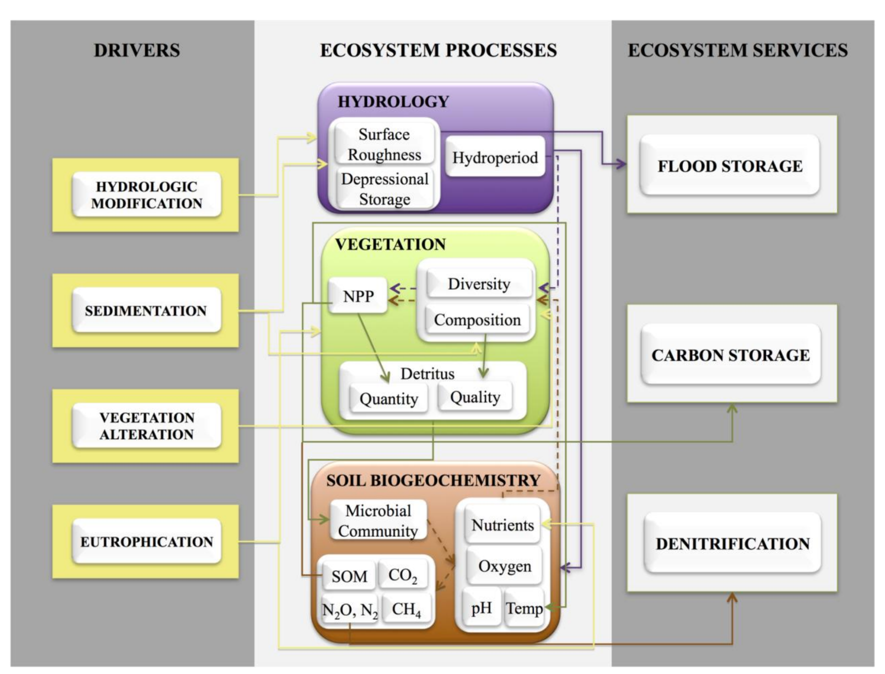


Figure 1. The relationships between drivers, ecosystem processes and ecosystem services in wetlands.
Figure courtesy of Siobhan Fennessy.

Hypotheses

1.Riparian zones will offer greater nitrogen retention than depressional sites due to their greater subsurface water flow [1].

2. Carbon sequestration will be greater in depressional wetlands due to longer hydroperiods and, because high C soils probably support greater biodiversity[4], depressional wetlands will also have the highest species richness.

3. Potential denitrification rates will be higher in depressional wetlands because of the increased likelihood of anaerobic conditions forming at depressional sites.

References

1. Fennessy, M. S., and J. K. Cronk . 1997. The effectiveness and restoration potential of riparian ecotones for the management of nonpoint source pollution, particularly nitrate. *Critical Reviews in Environmental Science and Technology* 27:285-317.
2. Mitsch, W.J., and J.G. Gosselink. 1993. Wetlands, 2nd edition. Van Nostrand Reinhold, New York.
3. Zedler, J. 2003. Wetlands at your service: reducing impacts of agriculture at the watershed scale. *Front Ecol Environ* 1(2): 65-72.
4. Zedler, J. B., and Callaway, J. C.. 2000. Evaluating the progress of engineered tidal wetlands. Ecological Engineering **15**:211-225.

Methods

- Sites were selected along a chronosequence in central and western Ohio. Restored riparian sites (n=6) were paired with their adjacent conserved sites and two natural control sites were also included. Depressional sites (n=6) were chosen in the same region and a natural control site was included.

Biodiversity

•Riparian sites: all plants within two 10x10 meter plots were identified. These sites are marked as red boxes on the riparian site sampling map in Figure 2.

•Depressional sites: all plants within 30 1x1 meter plots were identified along transects in each third of the wetland according to the method shown in the depressional site setup in Figure 3.

Soil Characteristics

•Depressional and Riparian: soil cores were collected to a depth of 10cm for nitrogen and carbon analysis, moisture content analysis and for denitrification assays.
Soil cores of 200cm³ were also taken to establish soil bulk density. Soil sampling locations are marked as green X's on the depressional and riparian sampling plan figures.
• N and C were measured using a Perkin-Elmer 2400 CHN AutoAnalyzer and potential denitrification rates will be determined using the acetylene block technique and by measuring the resulting nitrous oxide with a Shimadzu gas chromatograph.

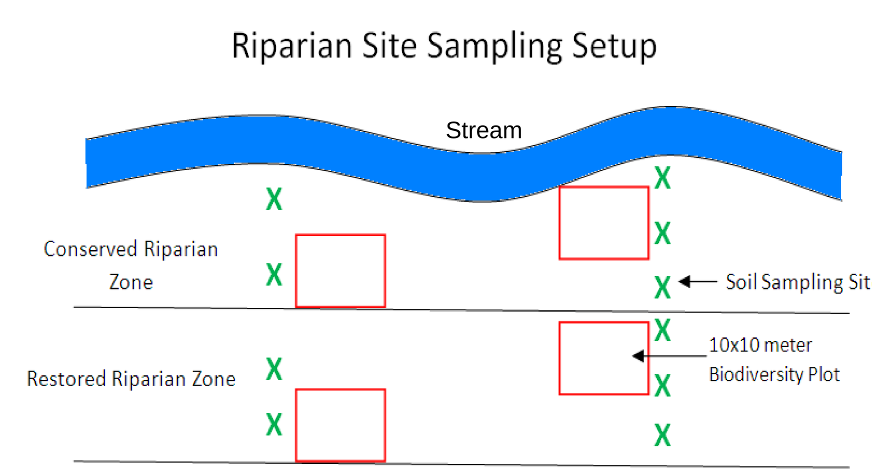


Figure 2

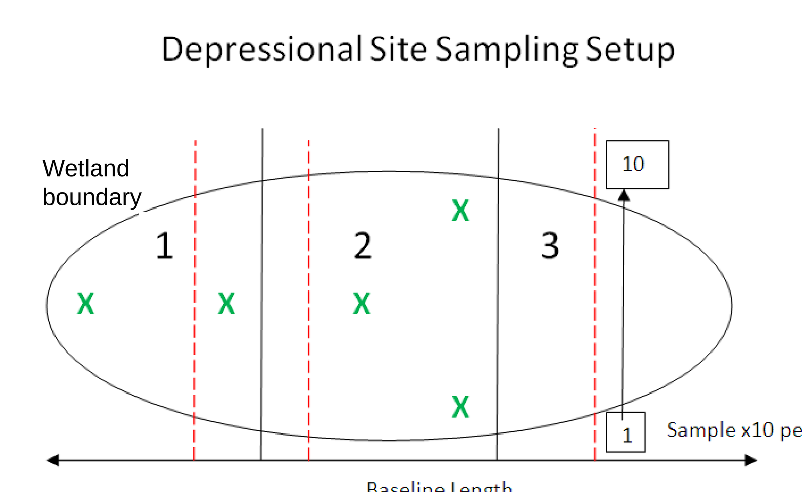


Figure 3

Results and Discussion

- Species richness was positively correlated with soil C content in depressional sites (Figure 4, $R^2 = 0.79$, ANOVA p=0.007).
- Although some differences in C sequestration were found between the three types of conservation practices (Figure 5), the results were not significant (ANOVA, F=1.40, p=0.279). No differences were found between practices for N sequestration (ANOVA, F=0.25, p=0.784).
- Conserved riparian sites had the highest species richness, with a mean >40% higher than the restored depressional sites and about 15% higher than the restored riparian sites (Figure 6, ANOVA, F=7.52, p=0.008).
- In depressional sites, soil moisture was found to be strongly negatively correlated with soil bulk density (Figure 7, $R^2 = 0.93$ ANOVA p=0.002) and carbon content was slightly positively associated with site age (Figure 8, $R^2 = 0.44$ ANOVA p=0.22).

Discussion

- Although depressional restoration sites lagged behind the riparian zones in C sequestration and biodiversity, one outlying depressional wetland that was restored without removing topsoil fared much better than the rest (Species richness=30 and kg C per m²=8.7, comparable to a natural wetland). Exact restoration technique should be considered in future analyses.
- Thus far determined, riparian zone conservation and restoration provide the greatest ecosystem services. Conservation programs could work more efficiently to achieve their goals if they prioritize the most effective restoration practices[3].

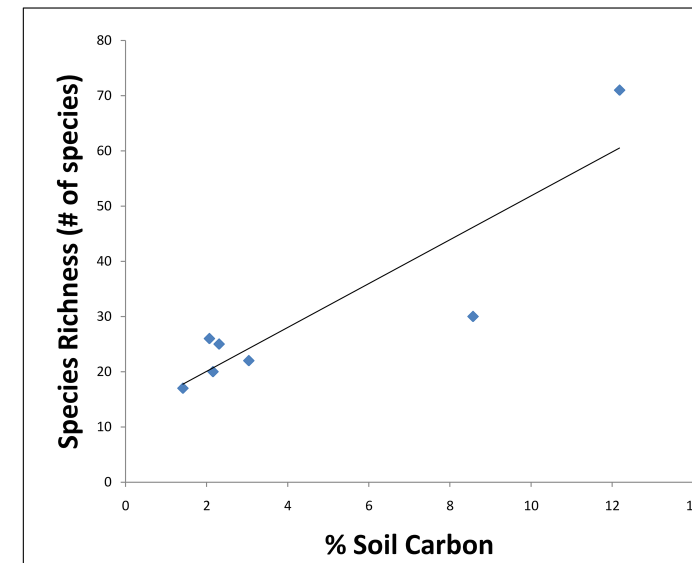


Figure 4. The relationship between soil carbon content and species richness of vascular plants in depressional wetlands. $y=3.937x+12.123$, $R^2 = 0.79$, ANOVA p=0.007

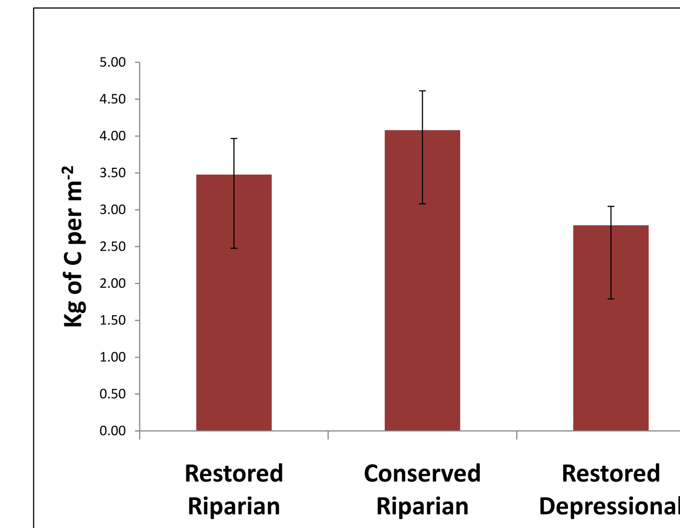


Figure 5. The mean carbon content of wetland soil, taken to a depth of 10 cm, in three conservation practices. ANOVA, F=1.40, $df_{factor}s=2$, $df_{error}=14$, p=0.279. Error bars indicate standard error of the mean.

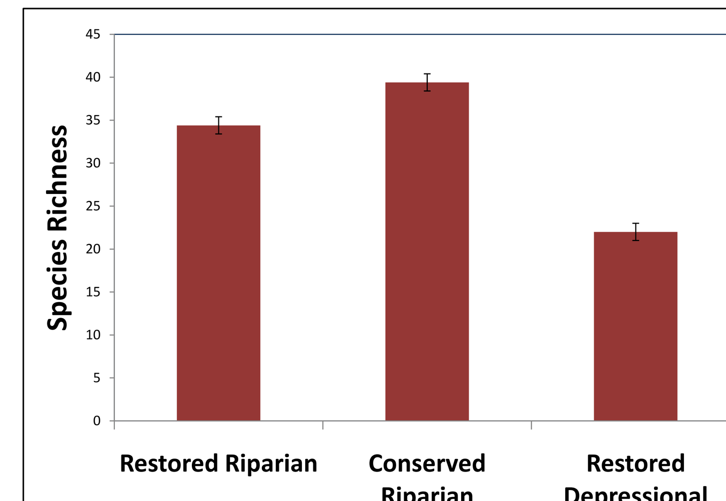


Figure 6. The mean species richness of wetlands in three conservation practices. ANOVA, F=7.52, $df_{factor}s=2$, $df_{error}=12$, p=0.008. Error bars indicate standard error of the mean.

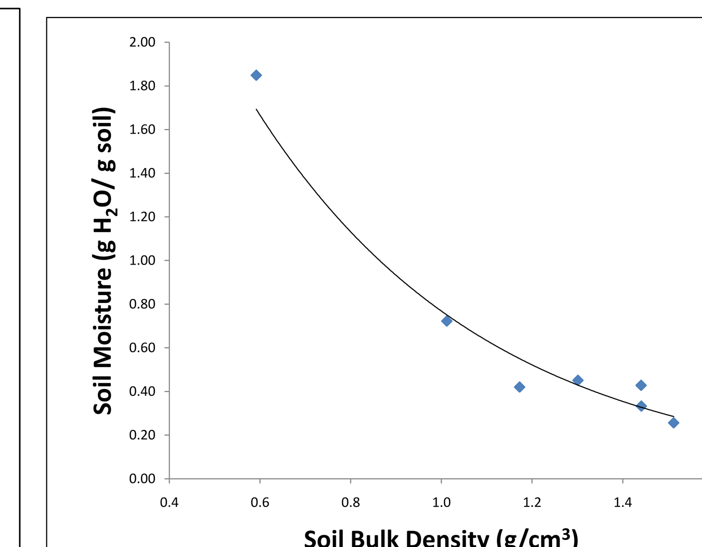


Figure 7. Soil moisture versus soil density in depressional wetland soils. $y = 5.3186e^{-1.934x}$, $R^2 = 0.93$ ANOVA p=0.002

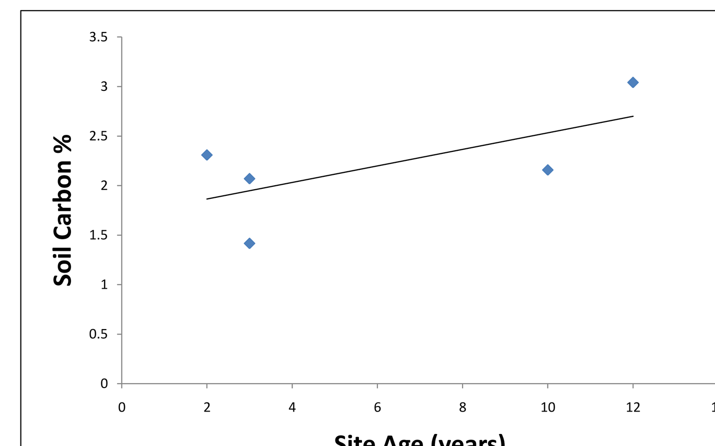


Figure 8. The relationship between restored depressional site age and soil carbon percentage. $y=0.0835x+1.698$, $R^2 = 0.4439$ ANOVA p=0.22

Future Work

Denitrification is an important wetland microbial process that turns biologically available N back into atmospheric N, thus removing excess nutrients that would otherwise contribute to eutrophication[2]. A study of the relative denitrification services provided by the three restoration programs is forthcoming.

Acknowledgements

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