Carbon Dynamics of a Restored Temperate Wetland in Ohio and the Effects of Nitrogen Loading on Carbon Dioxide Efflux

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Introduction

- Wetlands are considered to be carbon reservoirs because decomposition occurs slowly in waterlogged conditions.
- Wetlands are extremely dynamic and productive systems due to their carbon richness *(Gorham 1991)*.
- Wetlands have been drained and destroyed for farming, urbanization and deforestation which has released carbon back into the atmosphere, affecting the carbon cycle and global climate change.
- The Midwest has suffered the loss and degradation of over 80% of its original wetlands due to agriculture *(Wagner 2005)*.
- Carbon dioxide release is affected by water table levels and temperature. Previous studies show that higher temperatures and lower water tables lead to higher soil respiration *(Waddington, et al, 2001)*.
- There are 2 opposing views to the effect of nitrogen loading on wetlands:
  1. Elevated nitrogen levels would result in more acidic soil which would decrease soil respiration and therefore carbon dioxide release *(Cheney, 2002)*.
  2. The addition of nitrogen increases plant growth which increases the amount of sequestered carbon which is then available for release as carbon dioxide via soil respiration.
- Aims:
  1. Quantify the carbon dynamics in a restored temperate wetland.
  2. Investigate the effects of nitrogen loading on carbon dioxide efflux.
- Hypothesis: Nitrogen loading will increase carbon dioxide efflux as a result of increased carbon sequestration.

Methods

- Site: Temperate wetland in the Brown Family Environmental Center
- This is a continuation of a study that started in 2004. The same study design was used.
- 2 transects with 5 stations each set-up parallel to each other and perpendicular to Wolf Run Creek.
- Each station consists of 5 PVC collars surrounding a well.
- Stations I-V (Figure 1) were fertilised (12% nitrogen) at a rate of 5 g m^{-2} in three applications on the following dates: 06/05/09, 07/01/09, and 07/23/09.
- Measured regularly between June and September 2009:
  1. Soil carbon dioxide efflux at each collar using an infra-red gas analyzer (IRGA) with a soil chamber attachment.
  2. Temperature at each station using IRGA temperature probe and temperature data loggers.
  3. Water table level at each station using an electronic depth measure.
- Measured towards the end of the growing season:
  1. Above-ground biomass from each station.
  2. Soil organic matter from each station using loss on ignition method.

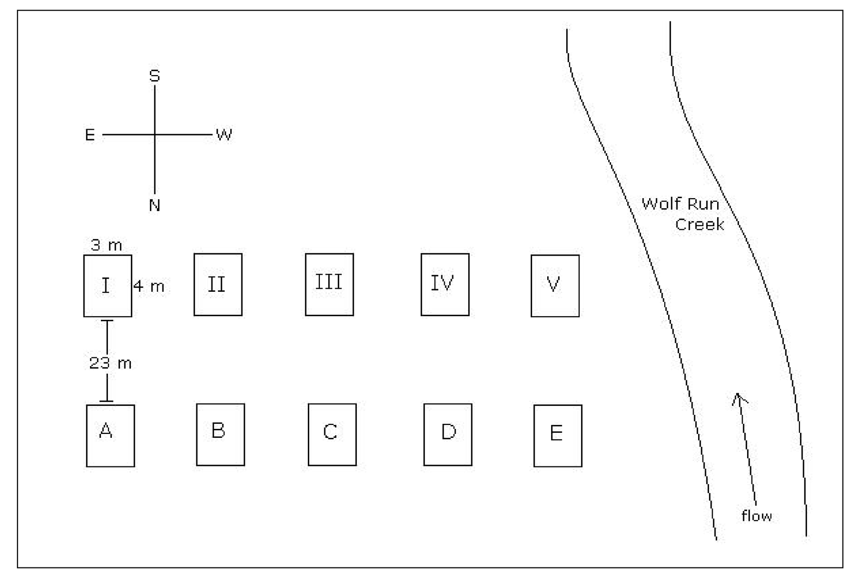

Figure 1. Diagram of wetland site in the Brown Family Environmental Center. Stations I-V were fertilised and stations A-E were unfertilised.

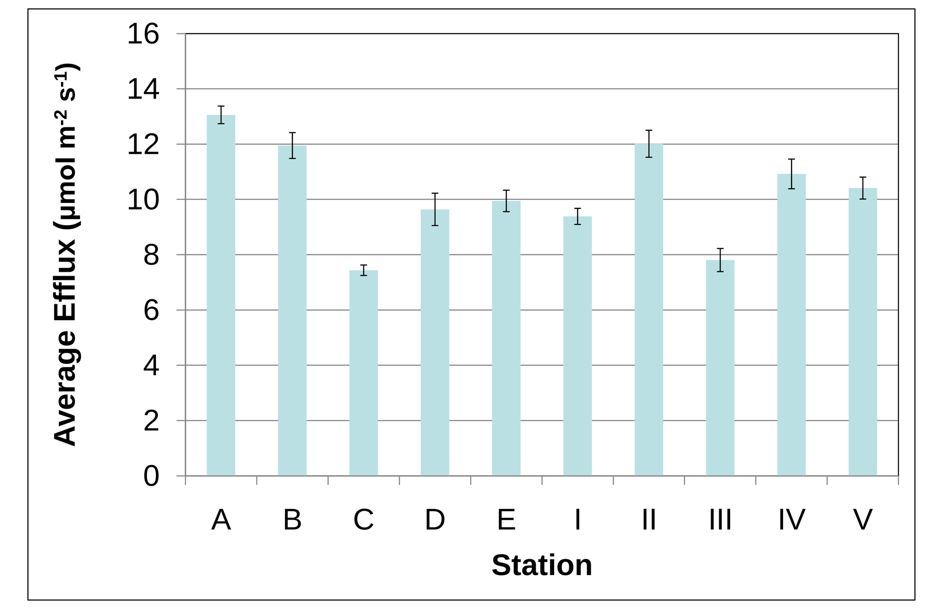

Figure 2. Averages of all the carbon dioxide efflux values collected over the study period by station. Collars containing standing water were not included in the averages (ANOVA, p<0.001). Error bars = SE

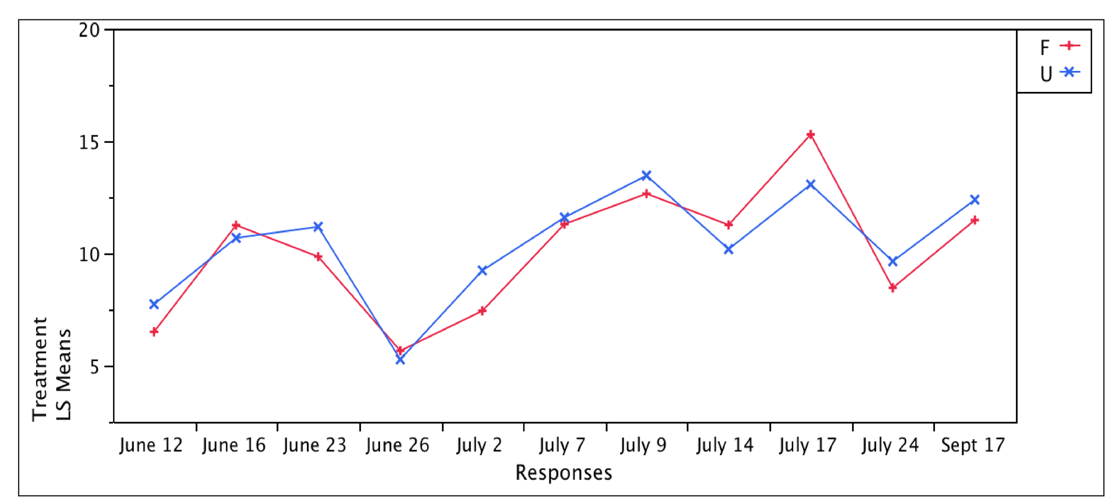

Figure 3. A time-series plot showing average carbon dioxide efflux ($\mu mol\ m^{-2}\ s^{-1}$) at each transect, fetilised (F) and unfertilised (U) over the data collection period.

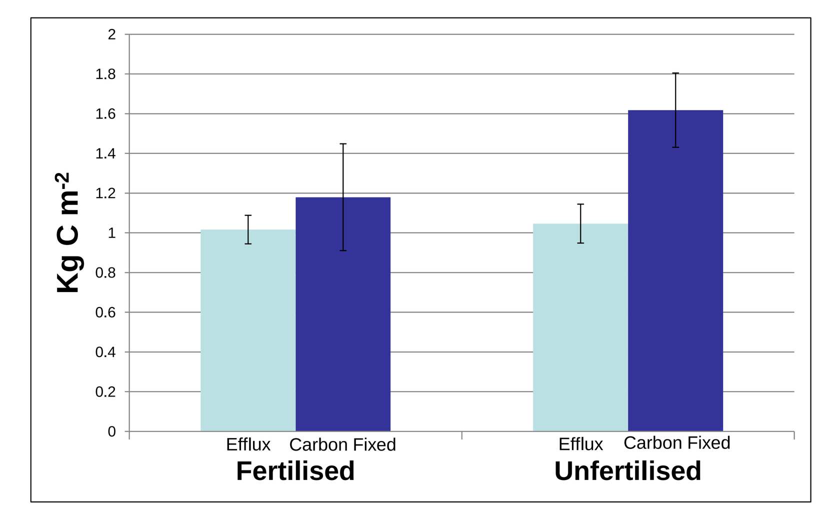

Figure 4. A comparison of the average amount of carbon released and the amount of carbon fixed per square meter in both transects. Error bars = SE.

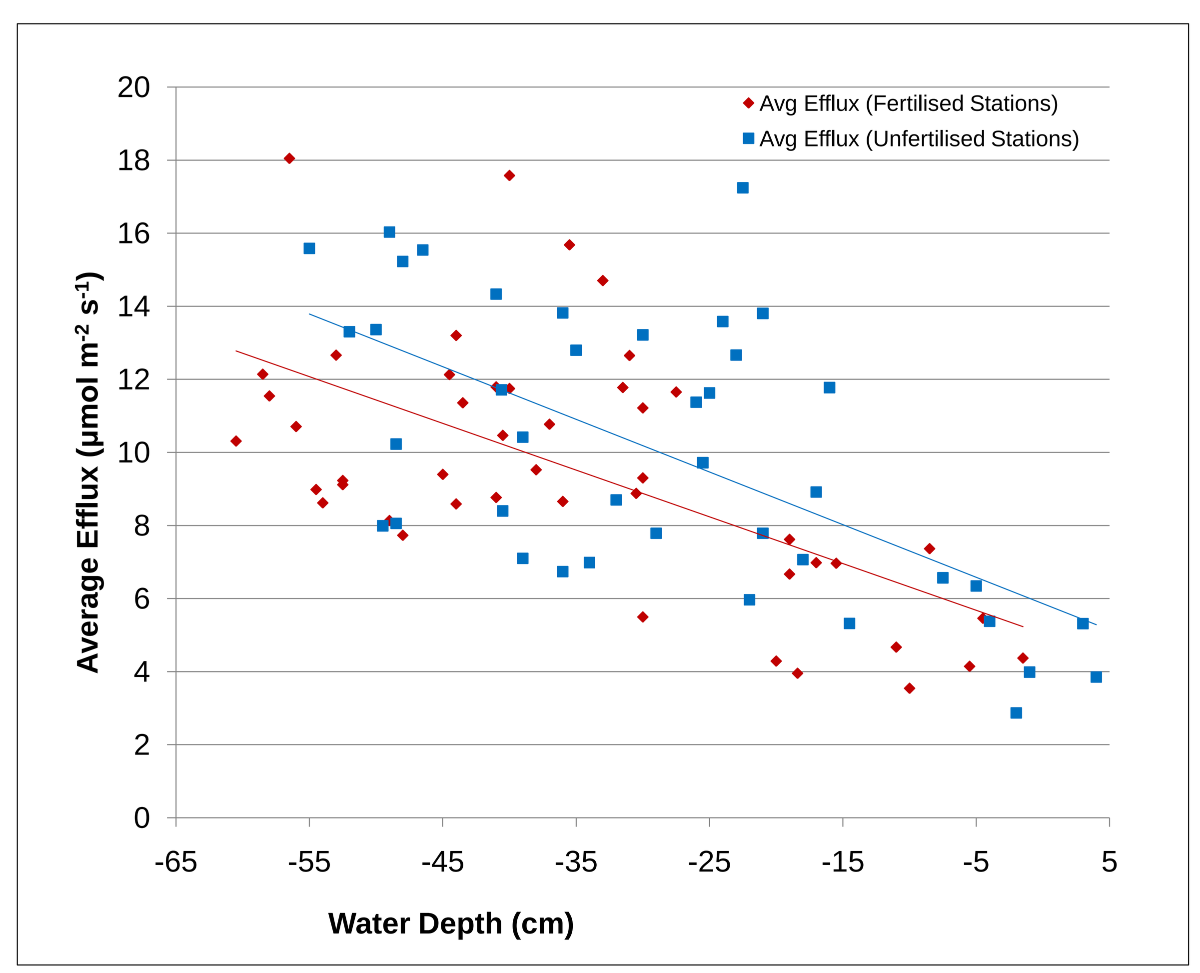

Figure 5. Scatterplot showing the average efflux per station and its relationship to water table levels in each station for each transect. Fertilised stations, y = -0.1441x + 5.8608, R^2 = 0.3852; Unfertilised stations, y = -0.1279x + 5.0372, R^2 = 0.3716. (GLM, T=2.309, p=0.0213).

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Results

- Overall summer carbon dioxide efflux data shows that differences in efflux between the sites was significant (Figure 2, ANOVA, p<0.001).
- Carbon dioxide efflux between the unfertilised and fertilised stations was not significantly different over the course of the study period.
- The unfertilised stations had a higher mean CO_2 output by 0.5598 $\mu mol\ m^{-2}\ s^{-1}$ where water depth and temperature were covariates (Figure 5, GLM, T=2.309, p=0.02).
  - This was unexpected as data from previous years suggested otherwise *(Cheney, 2002)*.
- Differences in above-ground biomass and soil organic matter between the two treatments were not significant.
- The amount of carbon fixed was greater than the amount of carbon released over the study period in both transects (Figure 4).

Discussion

- It is possible that nitrogen treatments did not continue long enough to affect the results.
- Carbon dioxide efflux was influenced by water table levels and temperature. In general, the higher the temperatures, and the lower the water table level, the higher the efflux.
  - The wetland is sloped in a way that stations C, D, III and IV are the wettest and stations A and I are the driest.
- The wetland seems to be sequestering more carbon than it is releasing.

Future Research

- Extend carbon dioxide efflux data by extending the study period and prolonging nitrogen treatments
- Investigate other forms of carbon efflux, such as methane efflux
- Produce a carbon budget of the wetland.

References

1. Cheney, K. D. 2002. *Carbon Dynamics in a Temperate Wetland: Factors that Afftect Carbon Dioxide Efflux*. Biology Honors Thesis, Kenyon College.
2. Gorham, E., 1991. *Northern Peatlands: Role in the Carbon Cycle and Probable Responses to Climatic Warming*. Ecological Applications 1: 182 – 195.
3. Waddington, J. M., Rotenberg, P. A., Jones, M. H. 2001. *Peat CO_2 Production in a Natural and Cutover Peatland: Implications for Restoration*. Biogeochemistry 54: 115 – 130.
4. Wagner, H. *Man-made Wetland's Effectiveness Similar to Natural Marsh*. Ohio State Research. Updated 03/07/05. Accessed 02/02/09. http://researchnews.osu.edu/archive/creatwet.htm