University of New Hampshire

Heterogeneity in a Suburban River Network:

Understanding the impact of fluvial wetlands on dissolved oxygen and metabolism in headwater streams

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LTER
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1. Background

The Issue: Many reaches within the Ipswich River Watershed are characterized by low dissolved oxygen content (DO), which threatens fish populations, aquatic organisms, and the health of the entire ecosystem.
•Anthropogenic factors, including nutrient loading, road crossings, etc. and natural beaver dams found in this suburban watershed influence metabolism .
•Little is known about the influence of fluvial wetlands on the dissolved oxygen, metabolism, and nutrient dynamics of a river network (O Brien et al. 2012).

Project Summary: This study focuses on understanding the interaction of geomorphology, dissolved oxygen, metabolism, transient storage and nutrients in headwater streams of the Ipswich River Watershed.

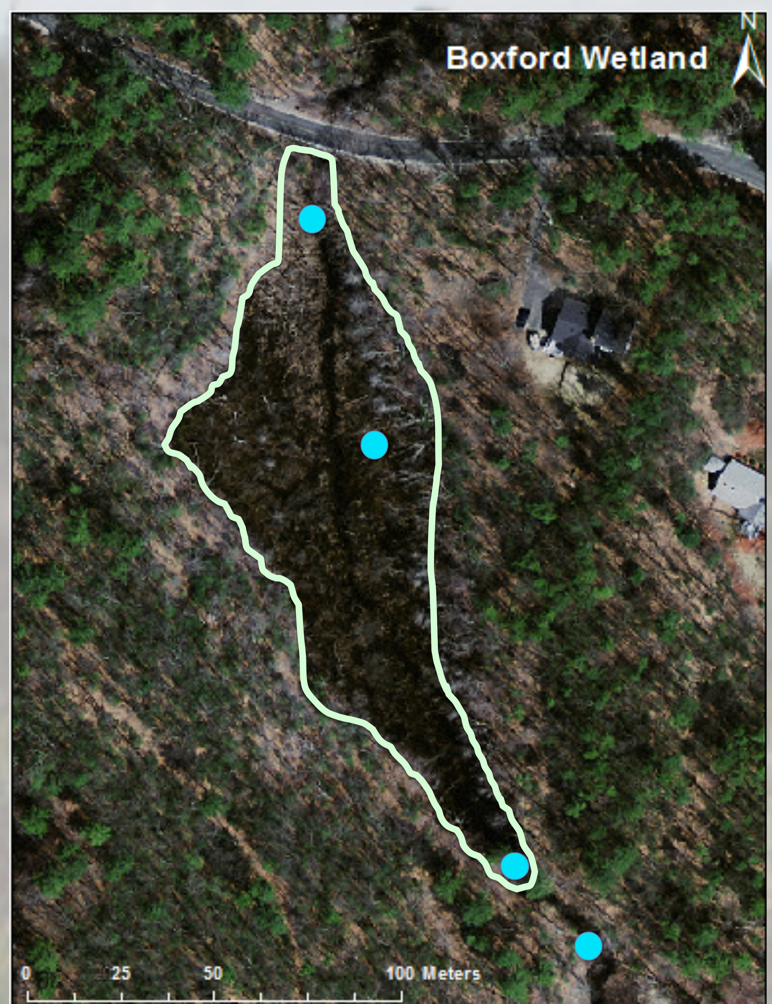

Figure 1: (Left) Boxford Wetland Site. Blue circles represent DO logger locations. (Above) Image of large beaver dam at the Cart Creek beaver complex

2. Research Question and Hypotheses:

Question:
What Is causing the extremely low dissolved oxygen content and high metabolic rates observed in streams of the Ipswich river watershed?
Hypotheses:
•Fluvial wetlands are extremely heterotrophic, driving down oxygen, while re-aeration in channels is low, keeping depressed oxygen levels over long reaches.
•Humans are exacerbating this issue through road crossings, etc., while increased beaver activity also contributes to the problem

3. Approach:

Overarching Approach: Dissolved oxygen, metabolism, and biogeochemical patterns are measured continuously for weeklong periods at each fluvial wetland during base flow conditions. Transient storage is also assessed through rhodamine additions. DO transects are conducted on each headwater stream where the intensive sites exist.
Sites:
• Chestnut Wetland – Wilmington MA
• Boxford Wetland – Boxford MA (Figure 1)
• Boston Hill Beaver Pond – North Andover MA
• Cart Creek beaver pond network – Newbury/ Byfield MA (Figure 1)

3a. Approach (Continued):

Instrument Suite and Logger locations:
- *Instruments:* Onset U 26 Dissolved Oxygen, Onset U 24 Conductivity, Onset U 22 water level, Odyssey PAR sensors, turner C3 fluorometer
- Experimental Design:
  - Within each site, there are 4 logger (dissolved Oxygen and light) locations (sub sites)
    - one channel uninfluenced by fluvial wetland, one fluvial wetland (side pool), one at outflow of wetland, and one downstream of wetland
  - Water level water level and conductivity loggers are located at outflow
  - Discharge is measured to create a rating curve for each site

Nutrients:
•Grab samples taken multiple times during each deployment and are tested for multiple constituents, including ammonium, anions (including NO3, SO4, and Cl), phosphate, dissolved organic carbon (DOC), and total dissolved nitrogen (TDN).
•This allows us to understand interactions between GPP, R, and nutrients.

4. Results

- **Diurnal variation in DO and processing is more prominent in the storage zones and the outflow of the wetland than the inflow (Figure 2).**

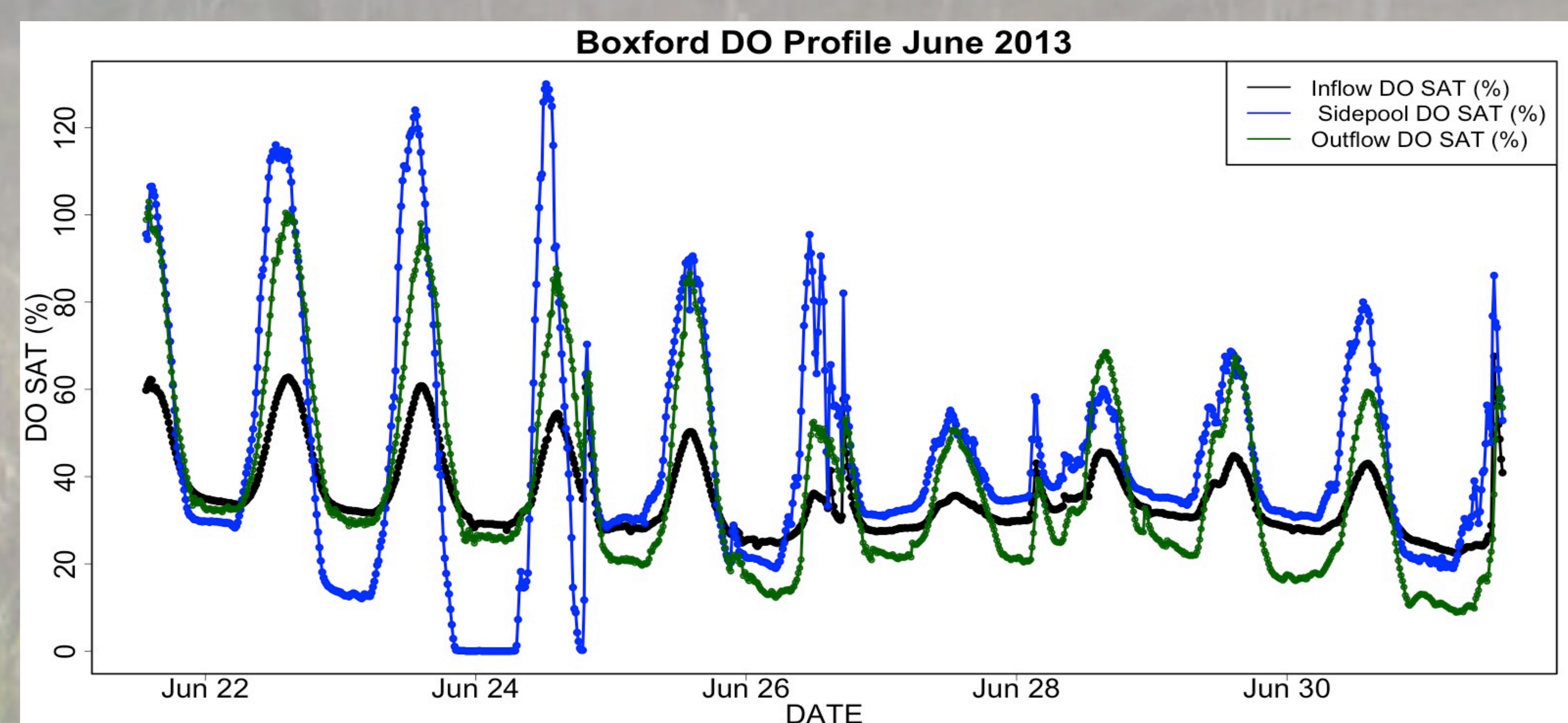

Figure 2: The diurnal DO pattern observed at the Boxford Wetland site in June of 2013. The large diurnal swings present in the sidepool location (blue) are evidence of the metabolic processing within the wetland

- **The magnitude of the diurnal swing in the sidepool is highly dependent on flow. The sidepool needs to be inundated for the processing to occur but flows need to be at a level that allows residence time of water in these storage zones to be high.**

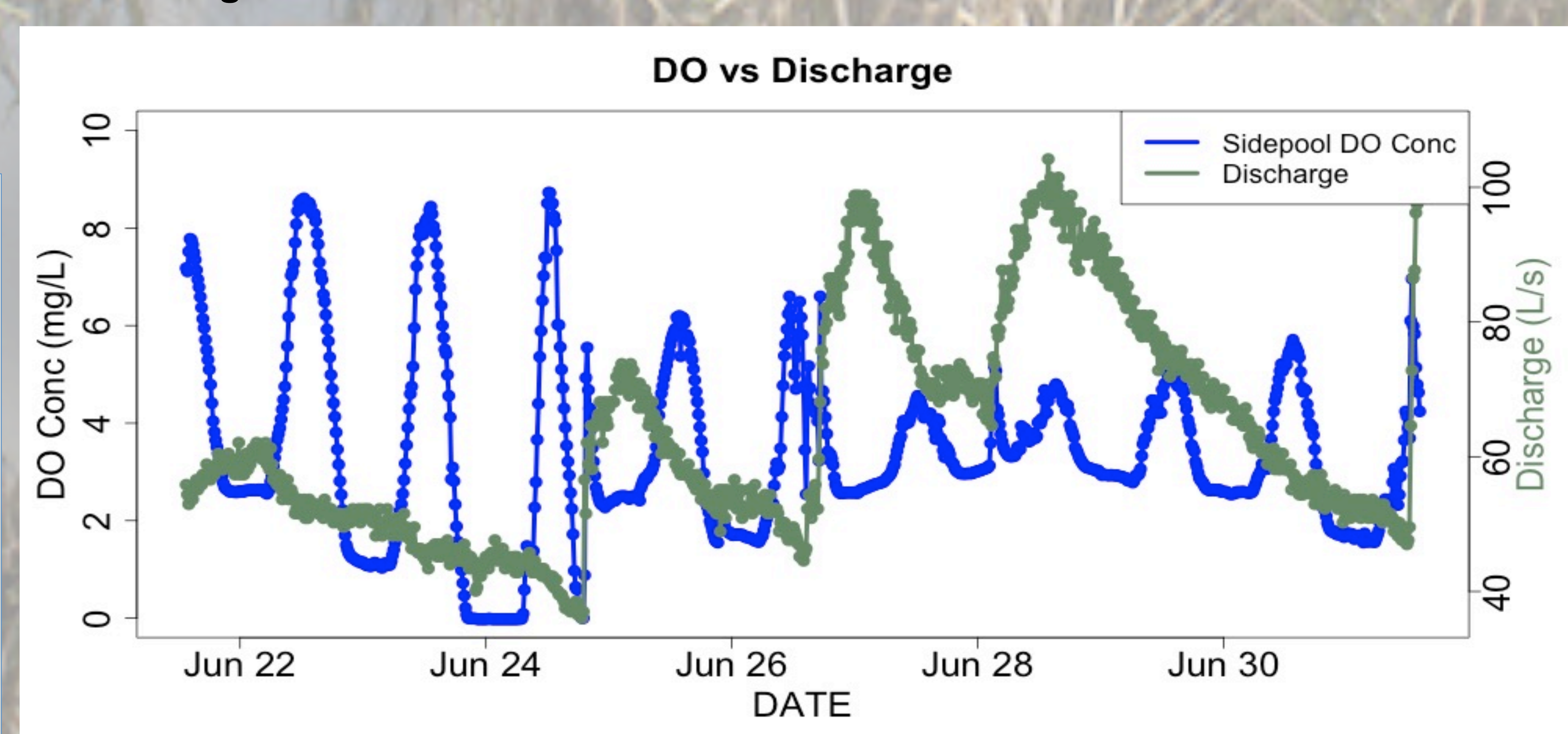

Figure 3: Sidepool dissolved oxygen concentration vs. discharge

- **Point measurements along each headwater stream show DO is depleted downstream of fluvial wetlands (figure 4 a), and in urban areas (sawmill brook) nitrate is also reduced (figure 4 b).**

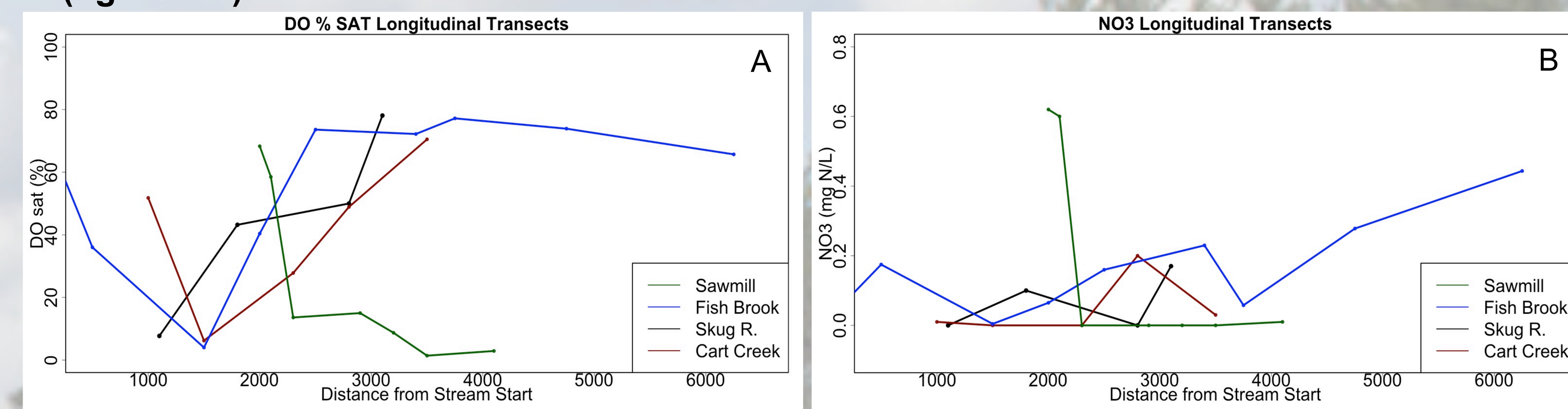

Figure 4: (A) Point measurements of DO percent saturation measured along each headwater stream containing an intensive site. (B) Same transects as A but showing nitrate

- **DO fluxes into and out of each fluvial wetland do not always show DO depletion as expected (Figure 5 a, b). DO depletion is dependent on wetland size (Figure 5 c). Boston Hill beaver pond is very large in size.**
- **Metabolism (GPP, R) is higher within the wetland than at the inflow (Figure 5 d, Table 1)**

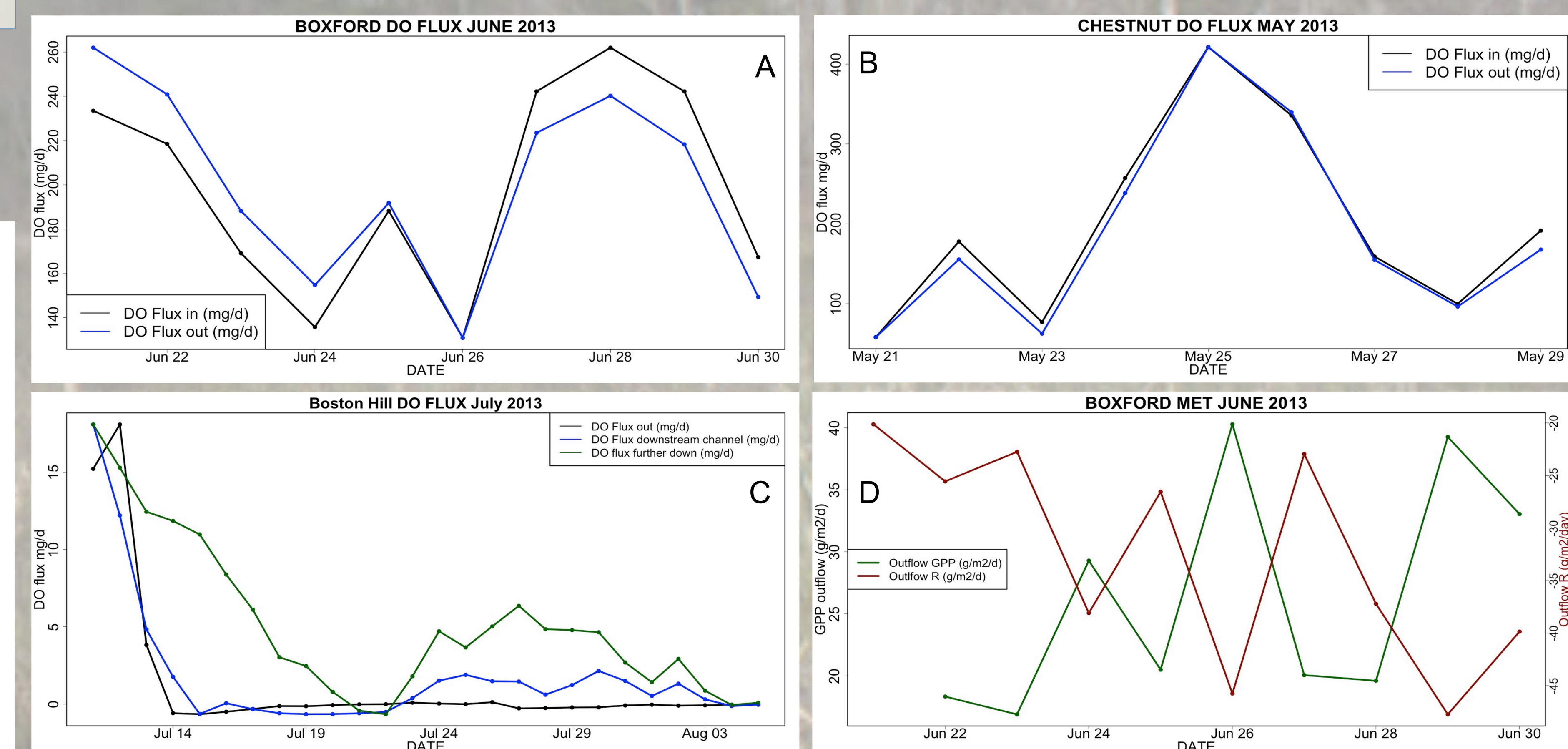

Figure 5: (A) Boxford Wetland DO flux (mg/d). (B) Chestnut Wetland DO flux (mg/d). (C) Boston Hill Beaver Dam Outflow DO flux (mg/d). (D) Boxford Wetland Metabolism (g/m2/day)

Table 1: 10 day averages of metabolism parameters calculated using the nighttime regression method for Boxford Wetland during June 2013.

	BOX UP				Box Side				Box Out				Box Down			
Date	k (/ day)	R (g/ m2/ day)	GPP(g/ m2/day)	MET(g/ m2/day)	k (/ day)	R (g/ m2/ day)	GPP(g/ m2/ day)	MET(g/ m2/day)	k (/ day)	R (g/ m2/ day)	GPP(g/ m2/day)	MET(g/ m2/day)	k (/ day)	R (g/ m2/ day)	GPP(g/ m2/day)	MET(g/ m2/day)
6/21-30 /2013	-12.92	-26.83	25.28	-2.08	-26.52	-37.05	29.35	-9.14	-17.42	-32.66	26.37	-7.68	-16.09	-31.55	26.88	-5.52

5. Summary and Conclusions:

• DO is influenced by flow, storage zone connectivity, light, temperature and other environmental variables.
•Point measurements of DO along headwater streams in the Ipswich show evidence of DO depletion below fluvial wetland environments
• DO fluxes across multiple intensive sites show little change between inflow DO flux and outflow DO flux.
•DO depletion appears do be highly dependent on wetland size(see Boston hill wetland flux). Large wetland/beaver pond complexes can result in DO being very low at the outflow.
• The magnitude of processing within the wetland is highly dependent on flow
• GPP, R, and metabolism are higher in the sidepool and outflow locations than the inflow

References:
1.O' Brien, J. M., Hamilton, S. K., Kinsman-Costello, L. E., Lennon, J. T., & Ostrom, N. E. (2012). Nitrogen transformations in a through-flow wetland revealed using whole-ecosystem pulsed 15 N additions, *57*(1), 221–234. doi:10.4319/lo.2012.57.1.0221
2.http://www.ourworldfoundation.org.uk/turbine.jpg - - background photo