

Straw Proposal for Breakout Discussion

May 9, 2011

- **Perhaps an empirical model would be adequate**
- **We don't need to understand all the mechanisms.**
- **But different background conditions may produce different results.**
- **So we need to identify the potential controlling variables for designing data collection and interpreting data:**
 - **Iron, manganese, copper, zinc**
 - **Organic Matter**
 - **Nitrogen....and so on.**
- **What is the most efficient design for this study?**

- **What is the most efficient way to test as many high-priority hypotheses as possible?**
- **We probably have two field seasons (after a preliminary field survey in 2011).**
- **What should we do over those two field seasons?**

How would you change or add detail to the following straw proposal for assessing the impact of sulfate on wild rice?

General statistical design: replicated regression (Cottingham et al. 2005), in an effort to produce results that can be incorporated into models.

Wild rice (WR) response would be quantified a) in the field by measuring population density, dry weights of plant parts, and elemental concentrations (C, N, P, Zn, S, Fe, Cu, Mo), and b) in greenhouse/growth chamber experiments, additional data would be collected on photosynthetic rate and leaf elongation rate (Li et al. 2009).

First year:

A. In a greenhouse or environmental growth chamber: Test tolerance to varying sulfate levels (necessarily essentially hydroponic to keep sulfate as sulfate, since providing any organic matter would have high potential to produce sulfide).

Goal: Evaluate all life cycle stages, including dormancy and germination through seed production.

Vary: multiple cations (Mg, Na, K, Ca) in association with the multiple levels of sulfate.

Measure: Germination rate, WR response.

Hypotheses addressed: 1A, 1B, 2A

B. In a greenhouse or environmental growth chamber: Test tolerance to varying sulfide levels using hydroponic conditions, which avoids precipitation of iron sulfide through chelation with EDTA (Li, Mendelsohn, Chen, & Orem 2009).

Goal: Evaluate a) germination of seeds, and b) growth of seedlings; determine growth-limiting sulfide concentrations and compare to other species listed in Li et al. (2009).

Vary: sulfide concentrations.

Measure: WR response, redox, actual sulfide concentrations (oxygen release by roots can alter the initial concentrations).

Hypotheses addressed: 3A, 3B (sulfide is directly toxic to seeds (3A) or plants (3B)).

C. Outdoor container studies with organic matter, to produce reducing conditions. Use results of 2011 preliminary field study to determine range of concentrations in the growth matrix.

Goal: Evaluate germination through seed production.

Vary: Fe & organic matter in sediment, and nitrate & sulfate in surface water. But don't vary P, Mn, Zn, Cu, and Mo unless 2011 survey correlates with WR abundance.

Measure: WR response. Vertical structure of geochemistry (sulfide and iron) of sediment using probes. Also measure pore water concentration stratigraphy if feasible.

Hypotheses addressed (empirically): 3A, 3B, 4A, 4B, 5A, 5D, 6A, 6B

D. Install in-situ mesocosms during summer and add sulfate to some immediately, and to some in fall, perhaps adding again under the ice. When drilling through ice note if there is hydrogen sulfide odor.

Goal: If the mesocosms survive the winter intact, compare the effect of sulfate added all year round to effect of sulfate addition just in the non-growing season.

Vary: sulfate levels and compare year-round loading to non-growing season loading of sulfate.

Measure: WR endpoints. Compare vertical geochemistry to findings of C.

Additional hypotheses addressed: 8A, 8B (having to do with seasonality of sulfate loading)

Second year:

E. Repeat C, reflecting lessons learned.

F. Continue or establish new in-situ mesocosm experiments.

Goal: to test findings of C and D.

G. Field Studies of in situ sediment and wild rice as a function of the sulfate concentration of the surface water.

Goal: To validate mesocosm results by comparing to the natural state of stratified biogeochemical processes, which “can take many months or even years to reach a quasi steady state.”

Measure: WR endpoints. Compare vertical geochemistry to mesocosm data.

Hypotheses addressed: That greenhouse and mesocosm experimental results transfer in a believable way to field observation.

H. Issues and hypotheses not addressed above:

1. The multi-year cycle of wild rice growth.

2. Duration and frequency aspects of a standard would not be addressed explicitly, but some information would be derived from the in situ mesocosms, comparing year-round to seasonal loading.

3. The sensitivity of wild rice to sulfate/sulfide relative to other aquatic plant species that co-occur and may compete with wild rice (e.g. pickerel weed, lily pad, water shield, cattail).

5B, 5C (Relatively high oxidized manganese (5B) or iron (5C) inhibits sulfide production.)

7A, 7B, 7C (External factors have increased the production of sulfide from sulfate in recent years.)

9A, 9B, 9C, 9D (The effect of sulfate on the methylation of mercury.)