Research Update: Effects of Sulfide on Wild Rice Seedlings

Kurt Anderson

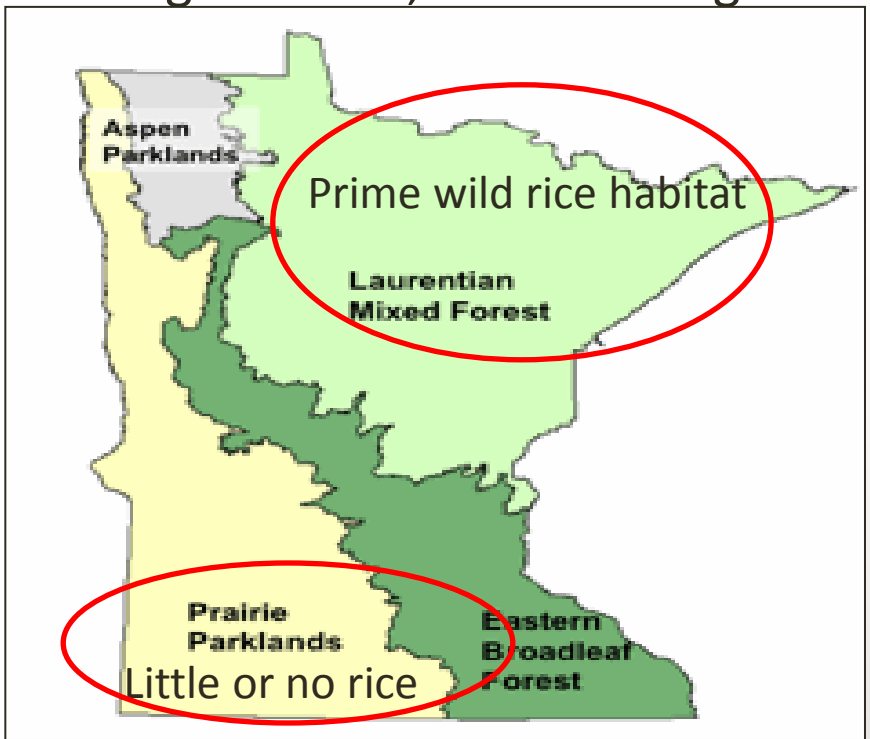
Ecotoxicology Principles

- Determine impact to organism
- Identify suspected stressors
- Identify potential pathway
  - Exposure route and physiological impact
- Test
  - Isolate stressors
  - Expose to organism via pathway to confirm
- Identify actual risk

History of 10 mg/L standard

- John Moyle, MN DNR, performed a series of field recons across MN in the 1930s & 1940s
- Stated that “wild rice generally absent when sulfate >10 mg/L”
- While scientists did not agree on the “correct number”, all agreed that is sulfate was affecting wild rice, it was during early life stages

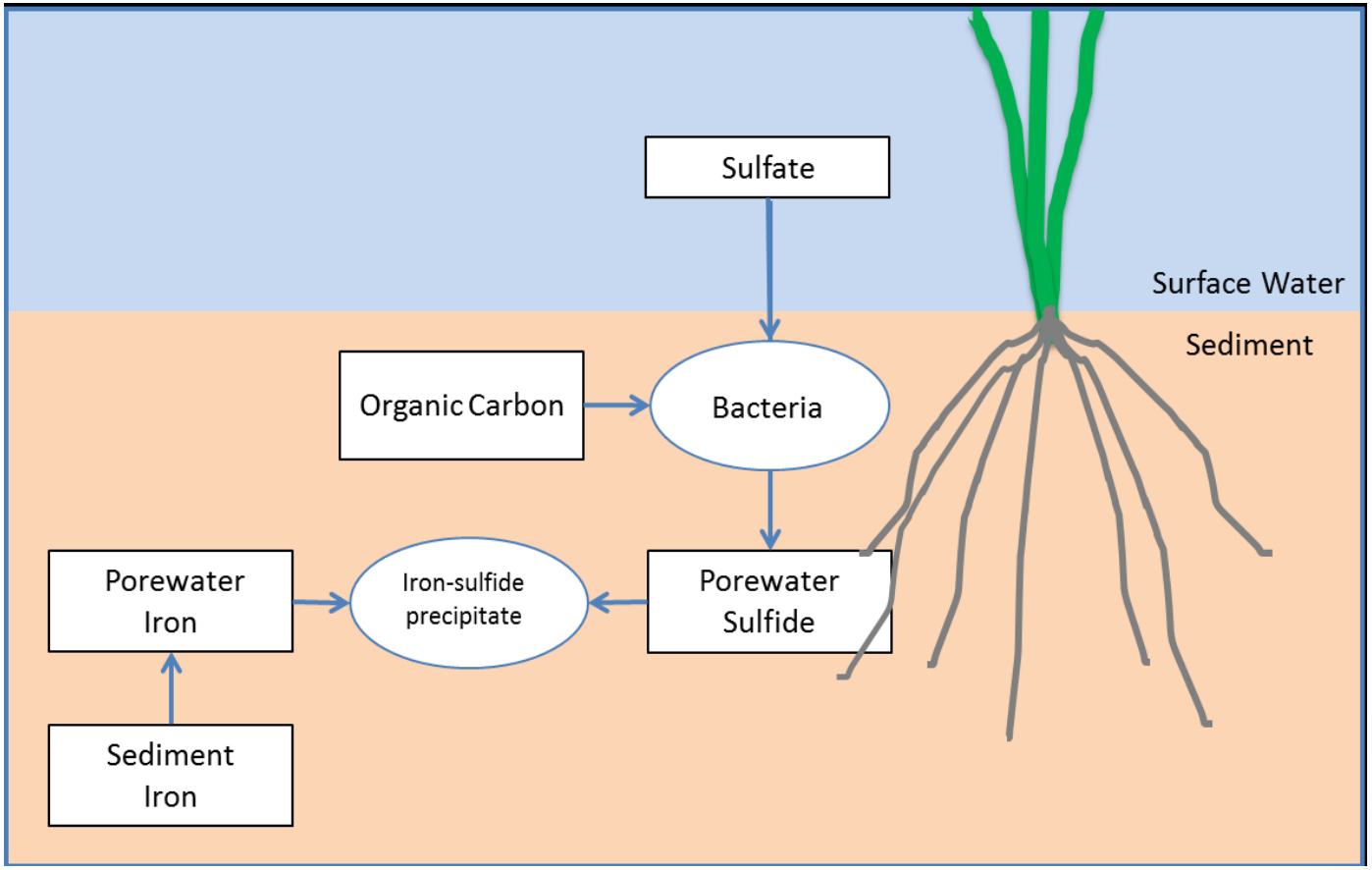
John Moyle, Minnesota DNR



Stressor identified: Sulfate

- Supportive Information
  - Generally lower rice abundance to the south and west, generally less rice
- Conflicting Information
  - Field sites with stands of rice in high sulfate water
  - Field sites with low sulfate but no rice
  - Sulfate hydroponics: no effect on seedlings until 1600-2500 mg/L
  - Similar toxicity to chloride; osmotic stress
- Missing information
  - Other ions, land types, other species, climate, etc
- Sulfate's status as stressor unclear

Refined Theory: Sulfide stressor, not sulfate



Sulfide's Ecotox Pathways: Known vs Unknown

Humans

- Inhalation main source of exposure
- Enters blood stream (can be measured)
- Inhibits cytochrome c oxidase
  - Mitochondrial impacts
- Obvious effects on respiratory and nervous systems
  - Eye irritation
  - Headaches
  - Balance problems
  - Long term impacts
- Kidneys process to sulfate and eliminate (mitigation)

Wild Rice

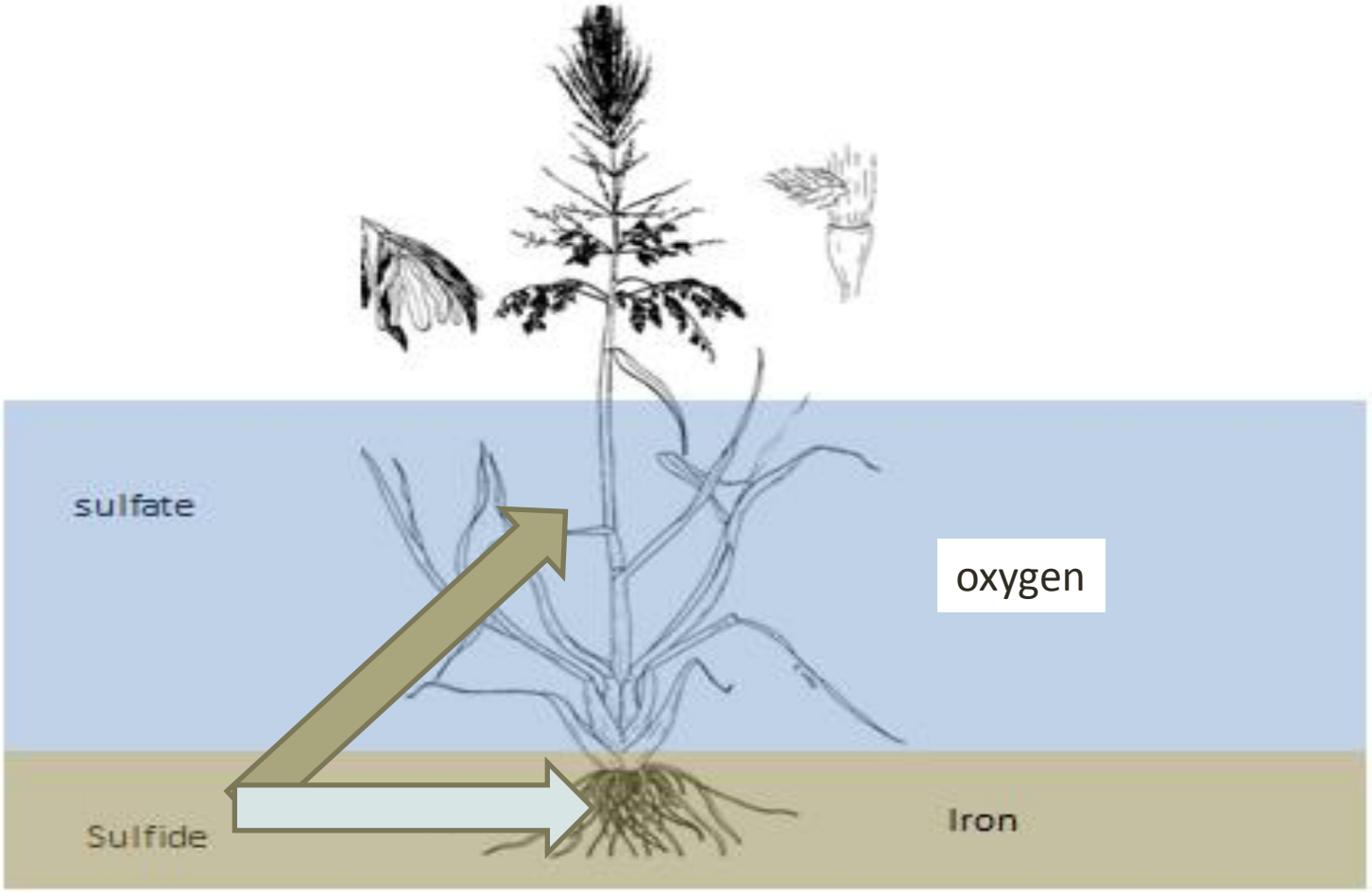
- Surface contact with seeds and roots main source of exposure
- Absorption into plant unknown (not measured)
- Cellular impacts unknown
- Mitigating defenses unknown

Sulfide impacts wild rice: MPCA Funded Research

- Entire plant in anaerobic water with sulfide
- Sulfide impacted “green parts” of wild rice at 165 µg/L
- Seeds, roots not impacted at concentrations tested

UMD sulfide hydroponics research results

Correct exposure pathway critical

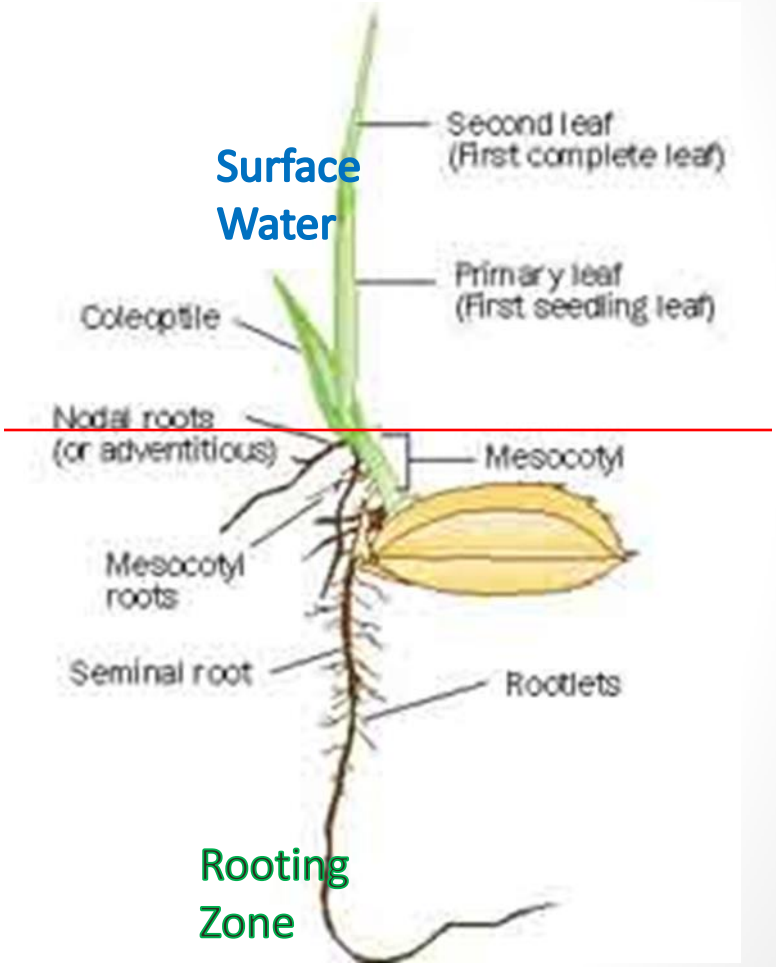


Hydroponics exposure system

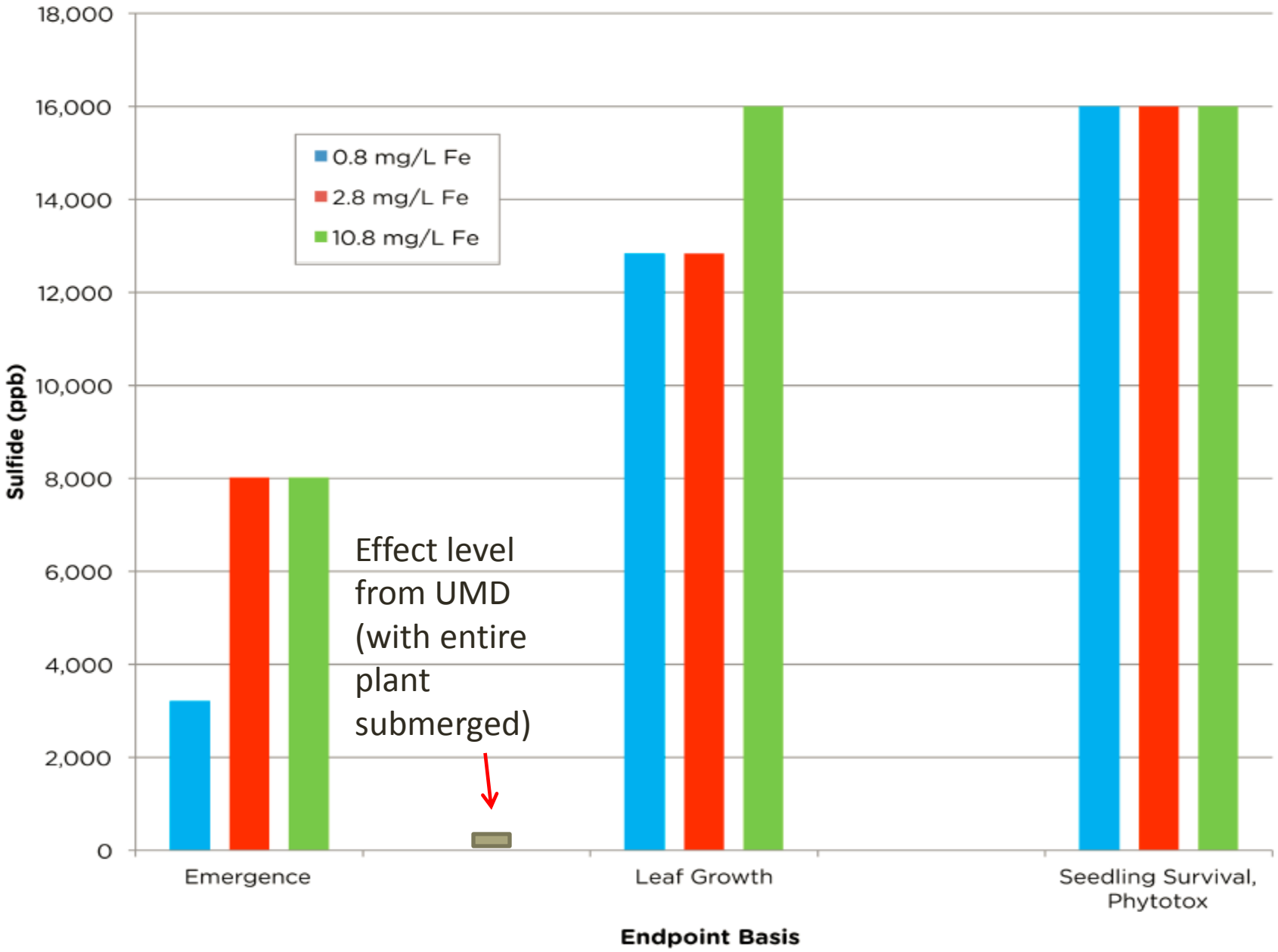
Exposure chamber with N_2 bubbles and germinating wild rice

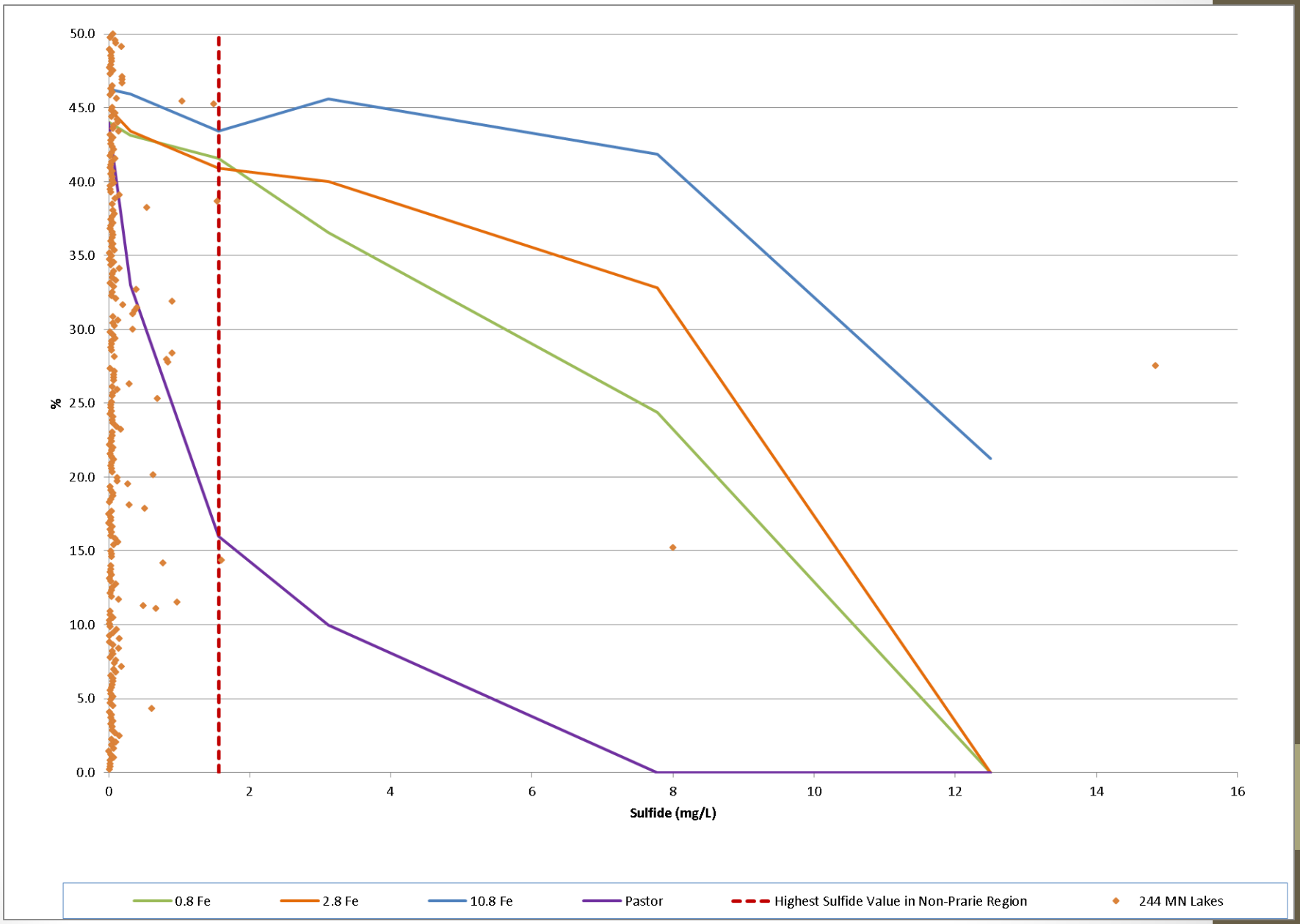
FEL Research: Sulfide has less impact w/ proper pathway

- FEL kept rooting zone anaerobic, “green” plant parts aerobic, like in nature
- FEL showed no impact at concentrations less than 1,600-3,200 µg/L
- Iron further mitigated toxicity



Sulfide LOEC values at varying iron concentrations




50.0
45.0
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
%
0
2
4
6
8
10
12
14
16
Sulfide (mg/L)
0.8 Fe
2.8 Fe
10.8 Fe
Pastor
Highest Sulfide Value in Non-Prarie Region
244 MN Lakes

Summary

- Sulfate
  - No signs of toxicity until levels reach >1,600 mg/L
  - Osmotic stress probably the “how”
- Sulfide
  - Pronounced change in toxicity when pathways adjusted
  - Effect level on young seedlings far above almost all field data endpoints
  - “How” it affects wild rice still unknown