# Re-Evaluating Nitrogen Limitation in Florida Springs

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Photo: Larry Kohrnak

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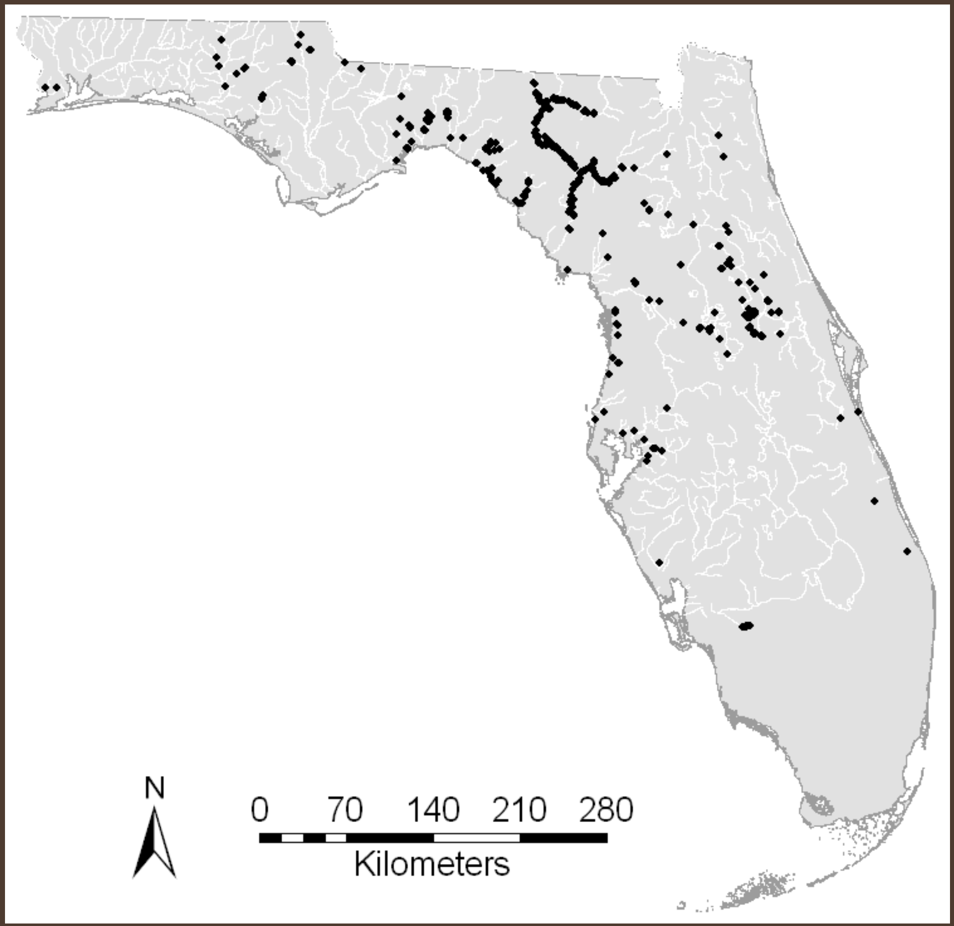
# Florida Springs




700+ artesian springs
in North and Central Florida

Among highest density globally

38 first-magnitude springs

Discharge > 100 cfs

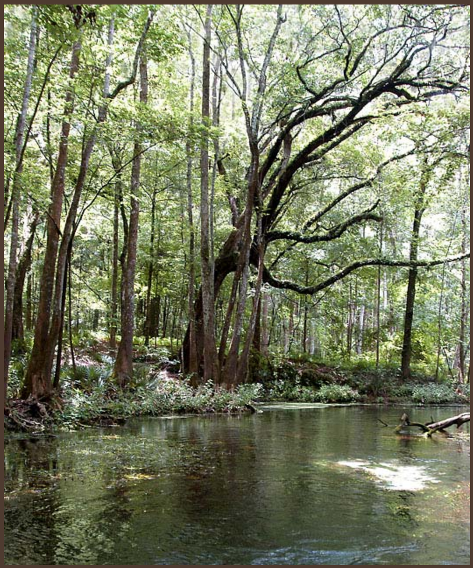
Springs have significant ecological, cultural, economic value

# Spring Ecosystems

Hydrologic, chemical, and thermal stability

High water clarity

Productive macrophyte communities



# Algae in Springs

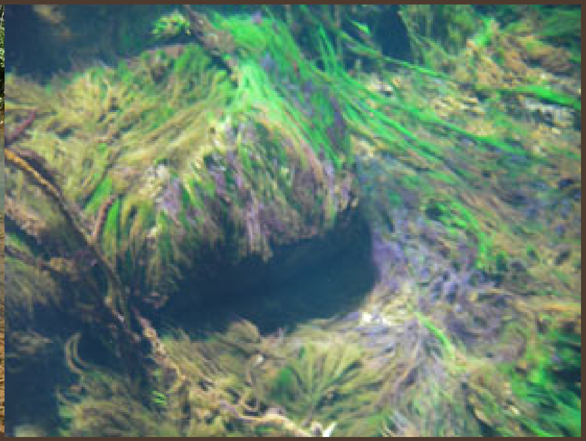
Mid-1980s – Earliest observations

Presently observed in nearly all springs

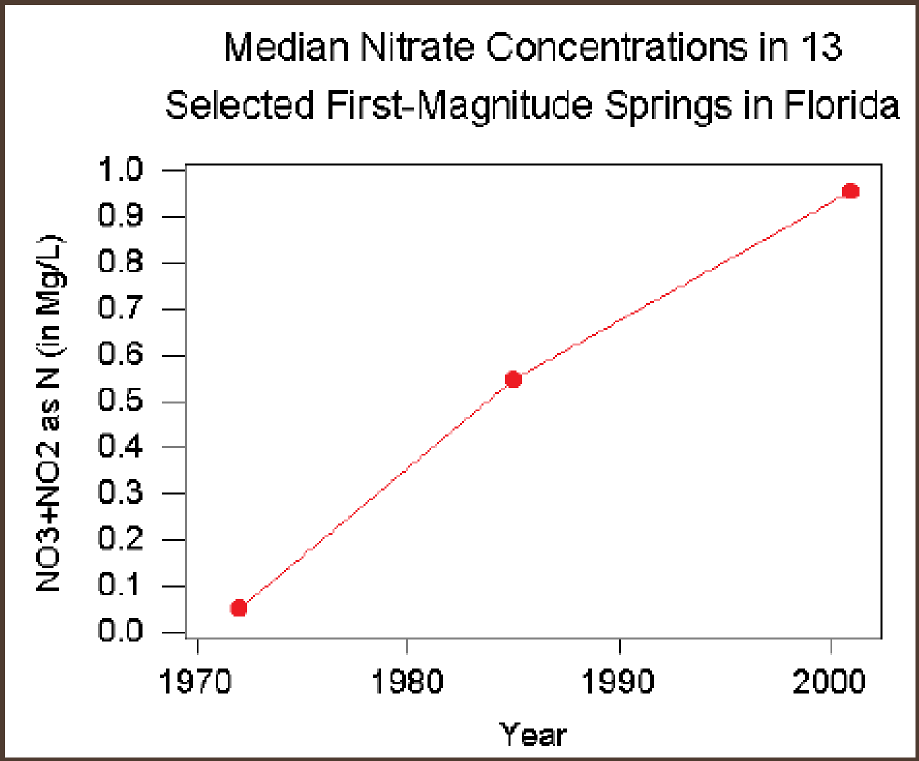
Cover 50% of spring bottoms

*What are the causes of algal overgrowth?*





# Changes in nutrient chemistry of Florida Springs




Nitrate concentrations have increased dramatically over the past 30-50 years

Background ~ 50-100 ug $NO_3$-N/L

Cause of algal blooms?

Alleviation of N limitation

Scott et al. 2004 Springs of Florida. FDEP Bulletin 66

# Evidence for eutrophication in other ecosystems

Lakes, Estuaries, Coastal Oceans

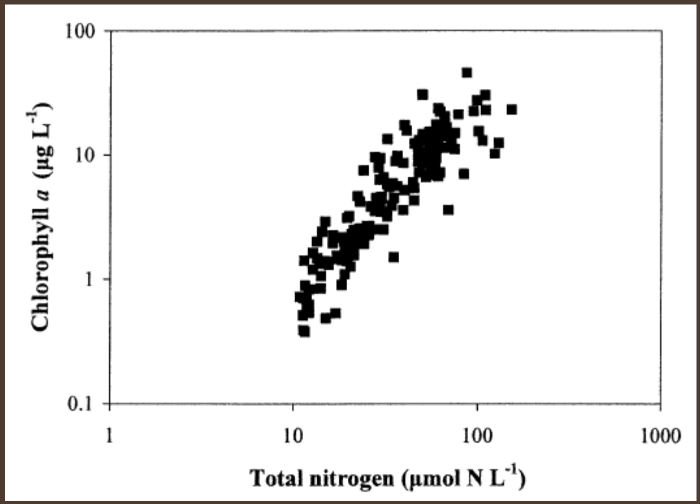
Correlations

Within and across systems

Experimental enrichments

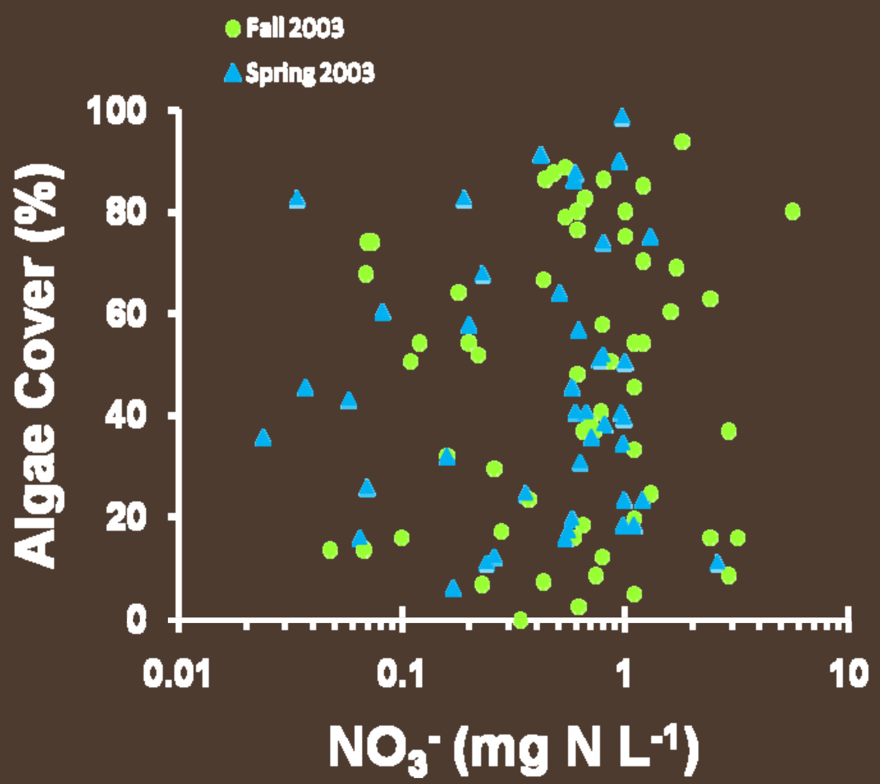
Lab and field

*Do we observe these patterns in springs?*



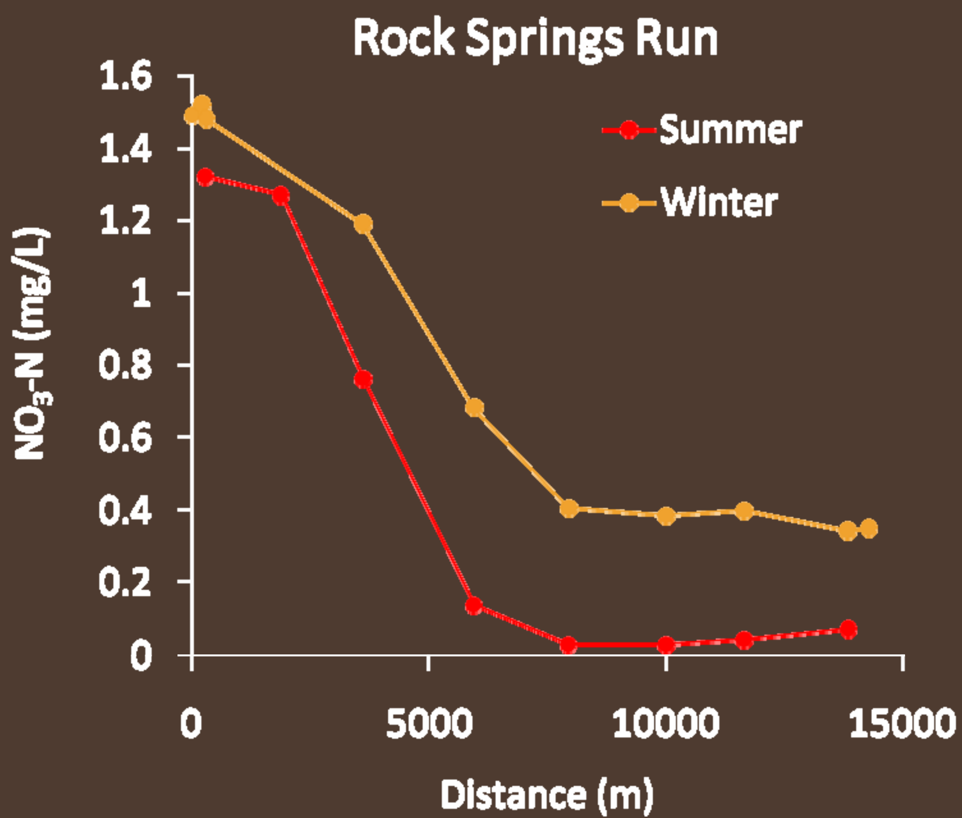

V. Smith, 2006 L&O

# Nitrate-algae relationships among springs

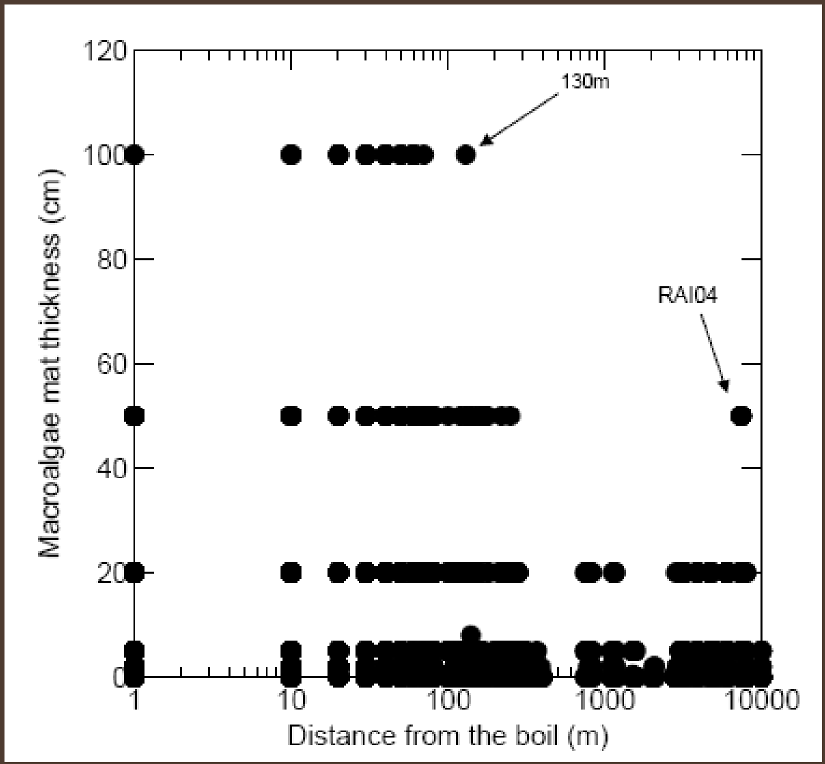



From Stevenson et al. (2004) Ecological condition of algae and nutrients in Florida springs.  FDEP Report.

# Nitrate-algae relationships within springs



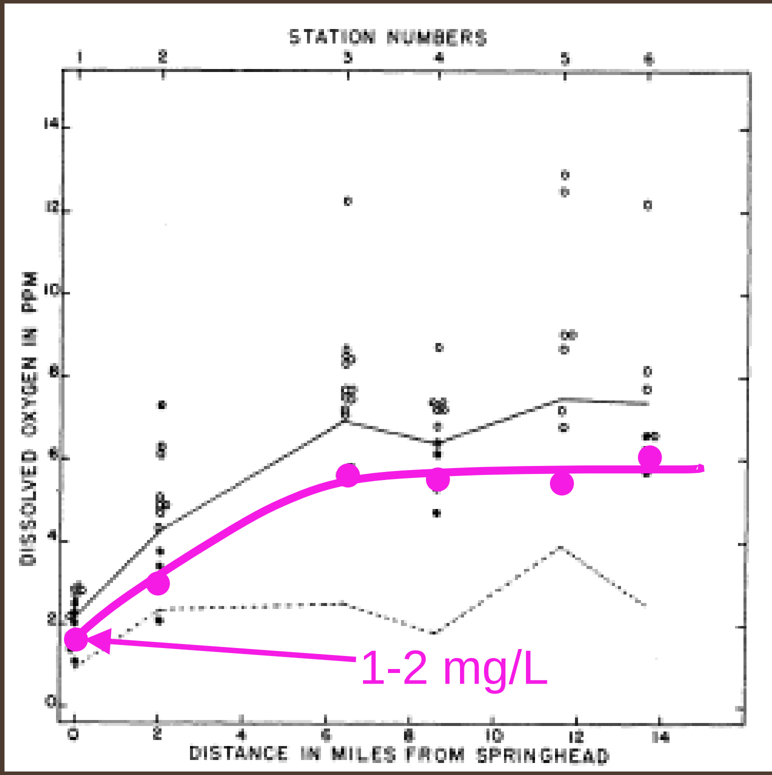

Data from Mattson et al. 2006




From Stevenson et al. 2004

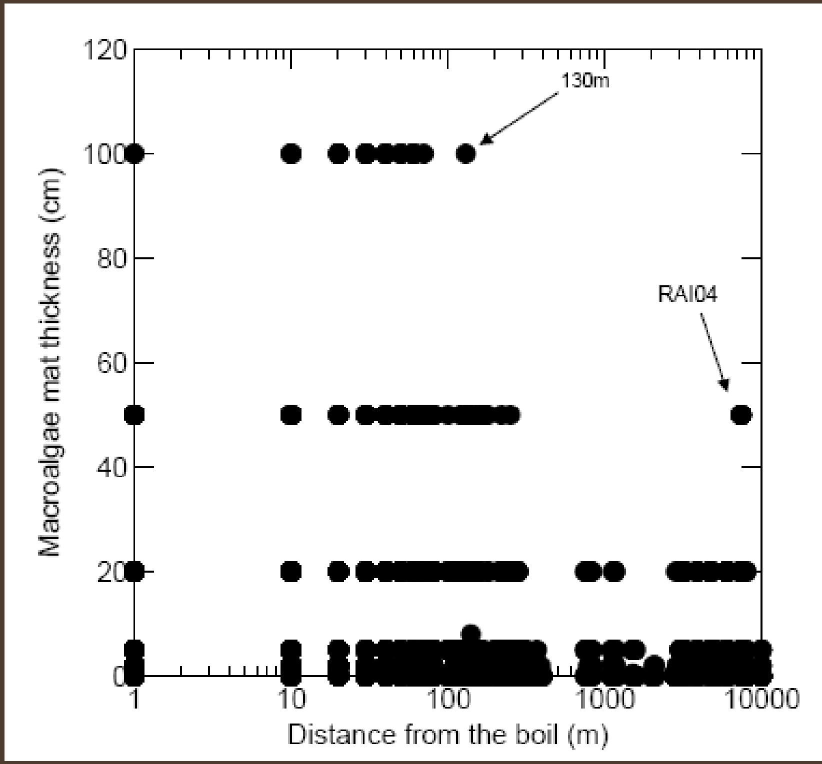
# Nitrate-algae relationships within springs

Dissolved Oxygen (mg/L)



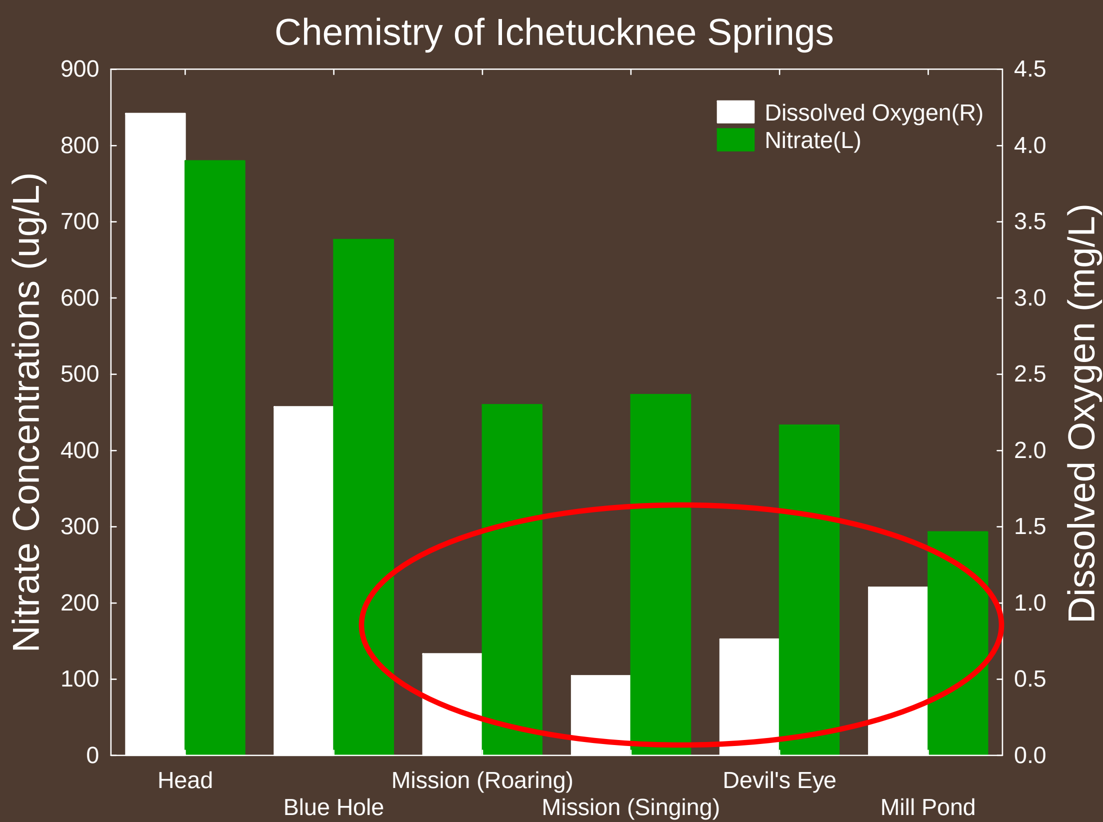

Distance downstream (miles)

From Sloan 1956




From Stevenson et al. 2004

# Nitrate-algae relationships within springs



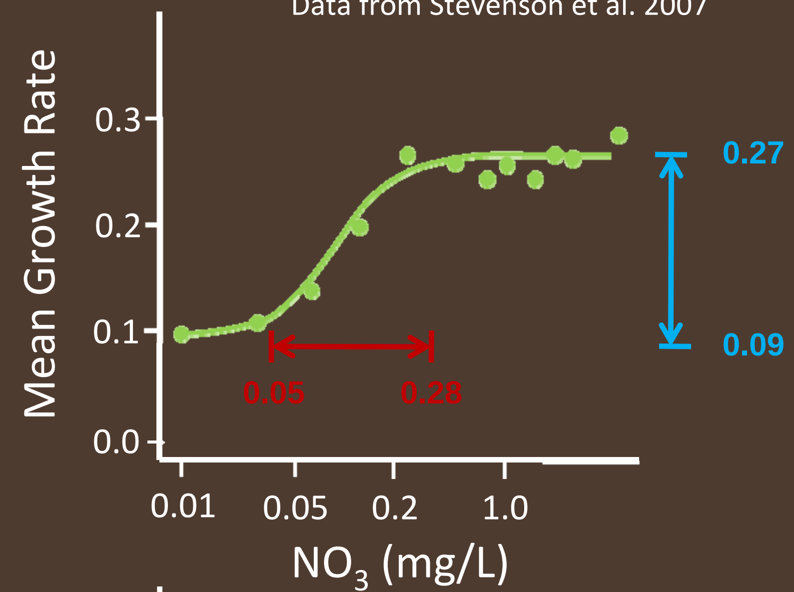

Ichetucknee River

Mission Springs, Devil's Eye and Mill Pond have greatest algae problem

Kurz et al. 2004 report to FDEP

# Nutrient limitation experiments

Data from Stevenson et al. 2007

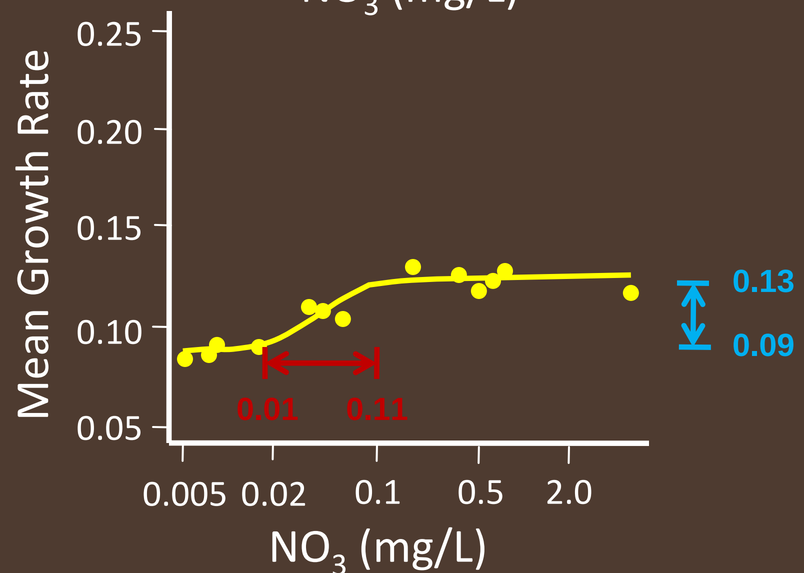



Laboratory microcosms

$NO_3$ < 0.28 mg/L

Other studies: 0.3-0.6

Growth rates increase 200%




Flow-through mesocosms

$NO_3$ < 0.1 mg/L

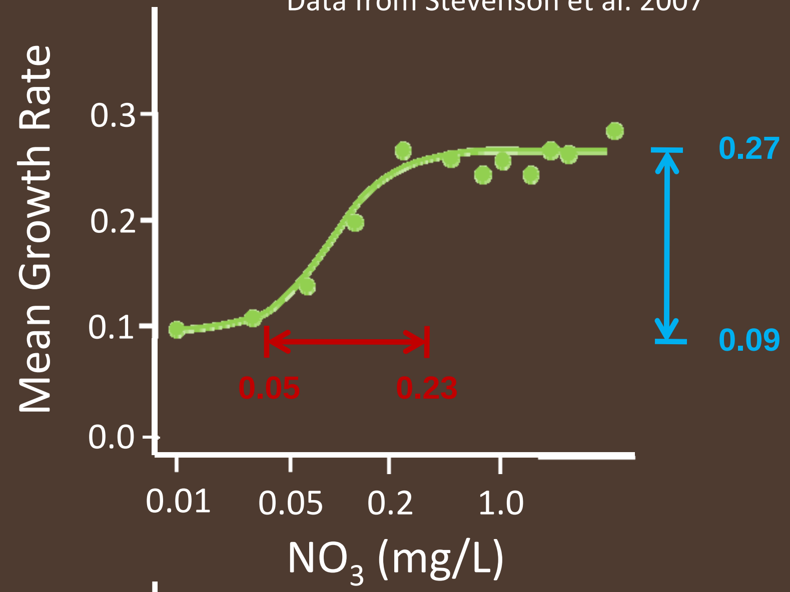
Growth rates increase 50%

# Nutrient limitation experiments

Data from Stevenson et al. 2007

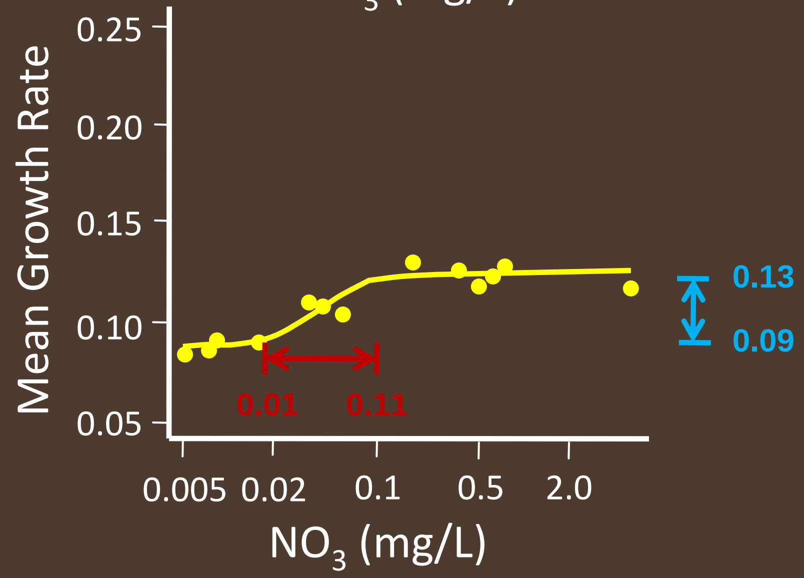
## Why does flow matter?

- Constant delivery even at low concentration
- Flux is better metric of nutrient availability (Borchardt 1996)




## *In situ* experiments

- Little response even in low-N springs



# Spring Nutrient Loads in Perspective

- At present concentrations (~500 ppb), N loads to Ichetucknee River bed are 5x greater than fertilizer inputs to high-intensity cornfields
- At historic concentrations (~100 ppb), N loads would still be about equal to that fertilizer input

# Implications

Reductions in nutrient loads may not reduce occurrence of nuisance algal blooms

Adaptive Management

- Development and evaluation of alternative hypotheses
- Evaluate responses in springs where nitrate is reduced

# Caveats

**This analysis is 'global'**

Suggests that N enrichment is not primary cause of algal blooms in springs generally

Some springs might be sensitive to nutrient enrichment

**N-limitation hypothesis is simplistic**

Feedbacks and interactions could account for at least some contradictory observations

**Precautionary principle applies**

N effects could interact with or be masked by other variables

**Other strong rationales exist for reducing N loads**

- Toxic effects of nitrates
- Human health concerns
- Export to N-sensitive ecosystems downstream
  - e.g. Gulf Coast, St. John's River

**Watershed protection efforts have a wide range of benefits**

- Discharge
- BOD and DO

# Alternative Hypotheses

**Changes in dissolved oxygen**

Significant declines since 1970s

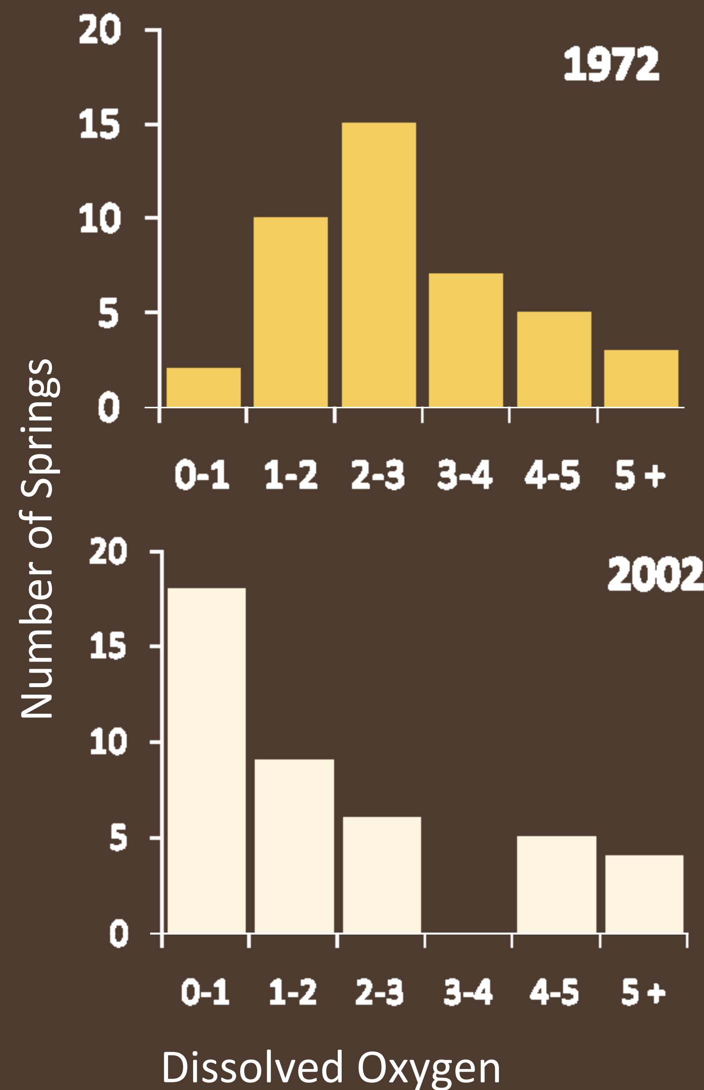
Known effects on invertebrate grazers

**Declining discharge and flow velocity**

Climate

Consumptive use

**Recreational disturbance**

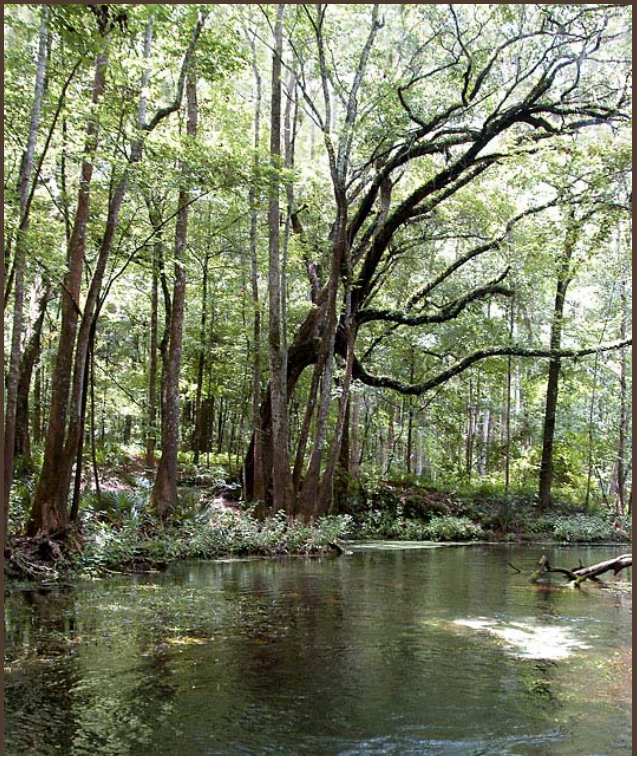



Data from Scott et al. 2004

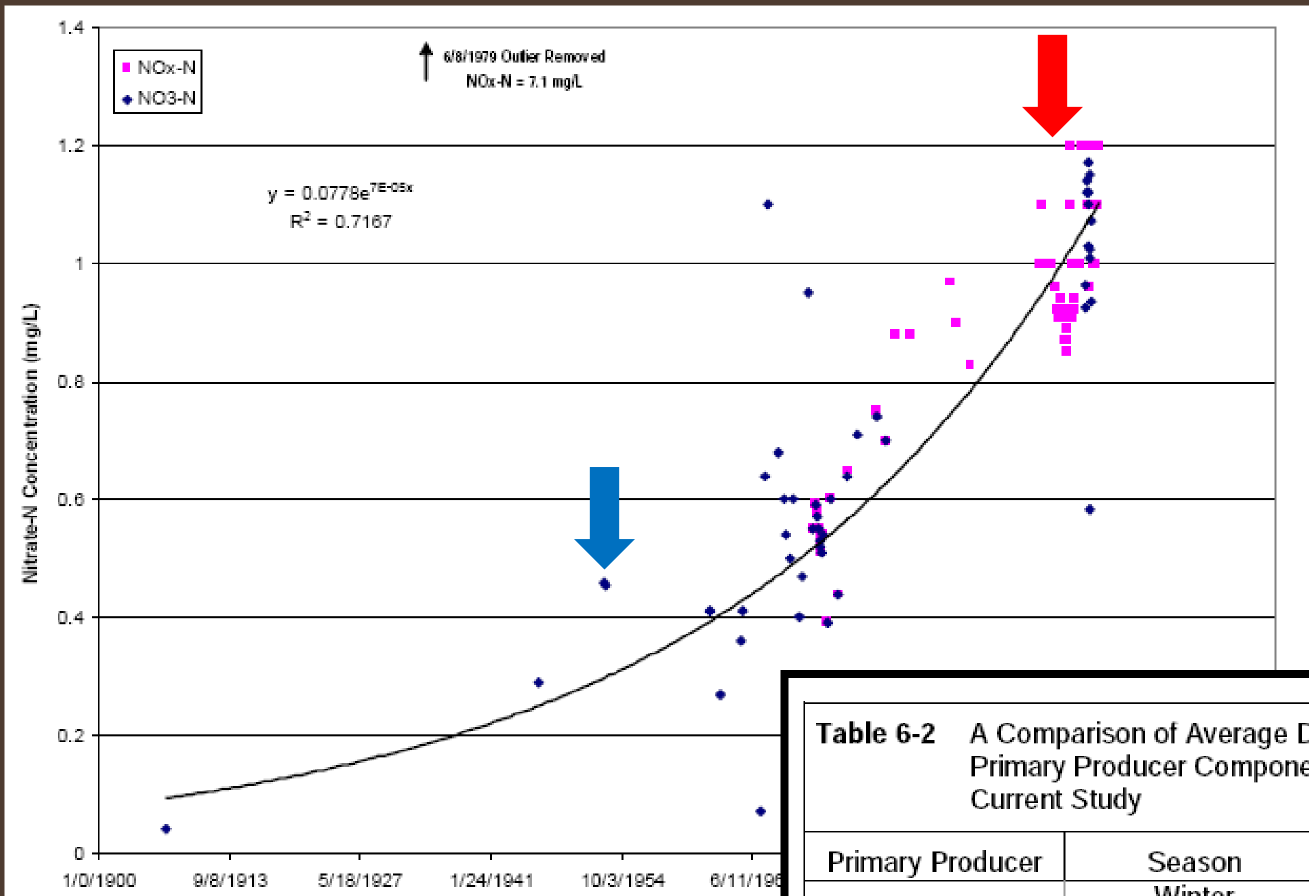
# Acknowledgements


- Santa Fe River Hydrologic Observatory
  - Wendy Graham
  - Travis Rayfield
  - John Martin
  - Joe Delfino


- Questions?



# Timing of Algal Overgrowth




Data from Munch et al. 2006 Silver Springs Retrospective

**Table 6-2** A Comparison of Average Dry Weights (g dry weight m-2) for Major Primary Producer Components Observed by Odum (1957) and in the Current Study

| Primary Producer | Season | Odum (1957) | Current Study |
|---|---|---|---|
| Macrophytes | Winter | 621 | 402 |
| | Summer | 621 | 580 |
| Epiphytes | Winter | 188 | 221 |
| | Summer | 188 | 572 |
| Benthic Mats | Winter | negligible* | 379 |
| | Summer | negligible* | 601 |

*not measured