Effects of flow and nitrogen on filamentous algae in Florida spring-fed rivers

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Artesian Springs in Florida

Highly productive, unique ecosystems

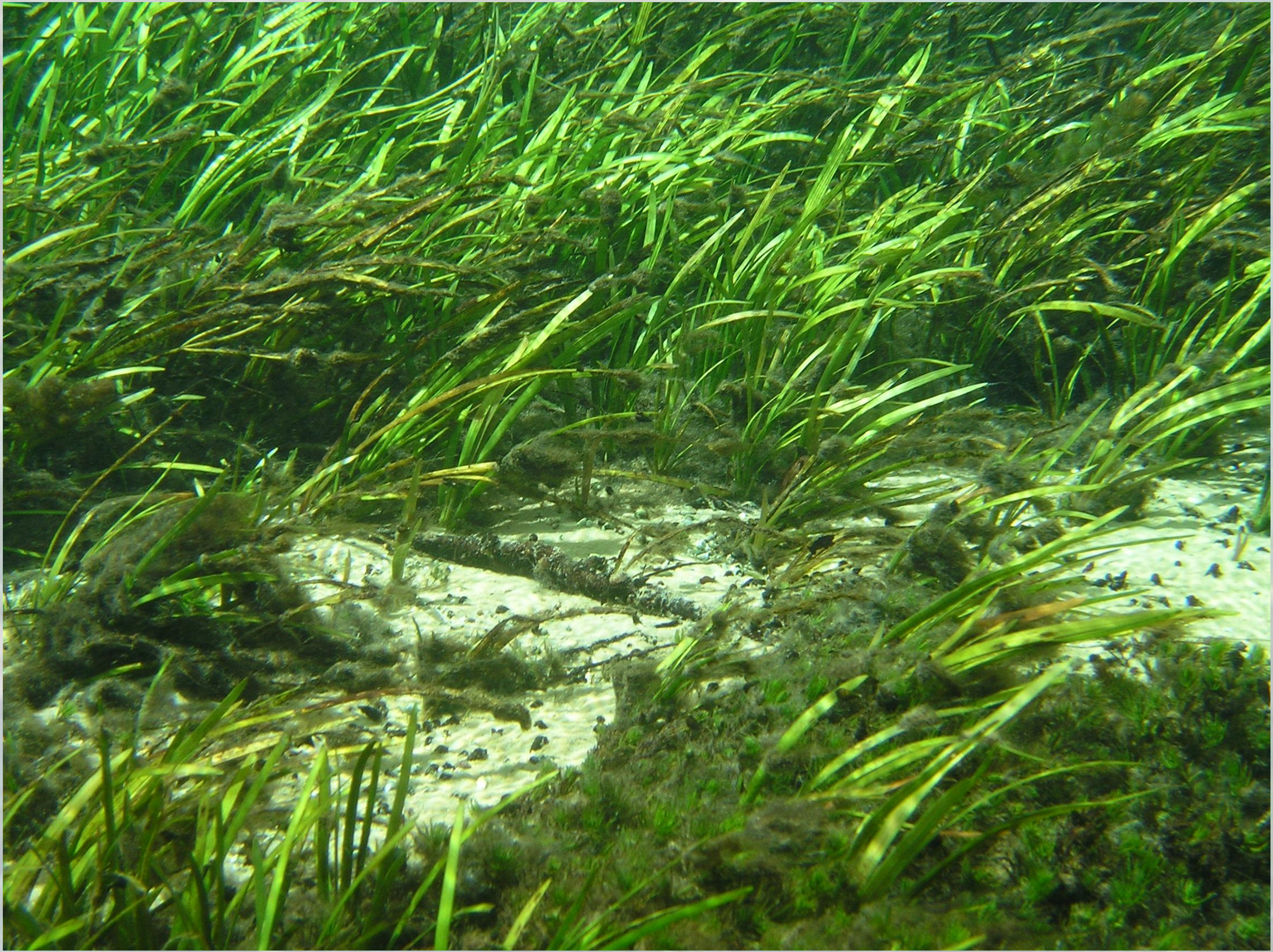
– Extremely clear water, stable hydrology

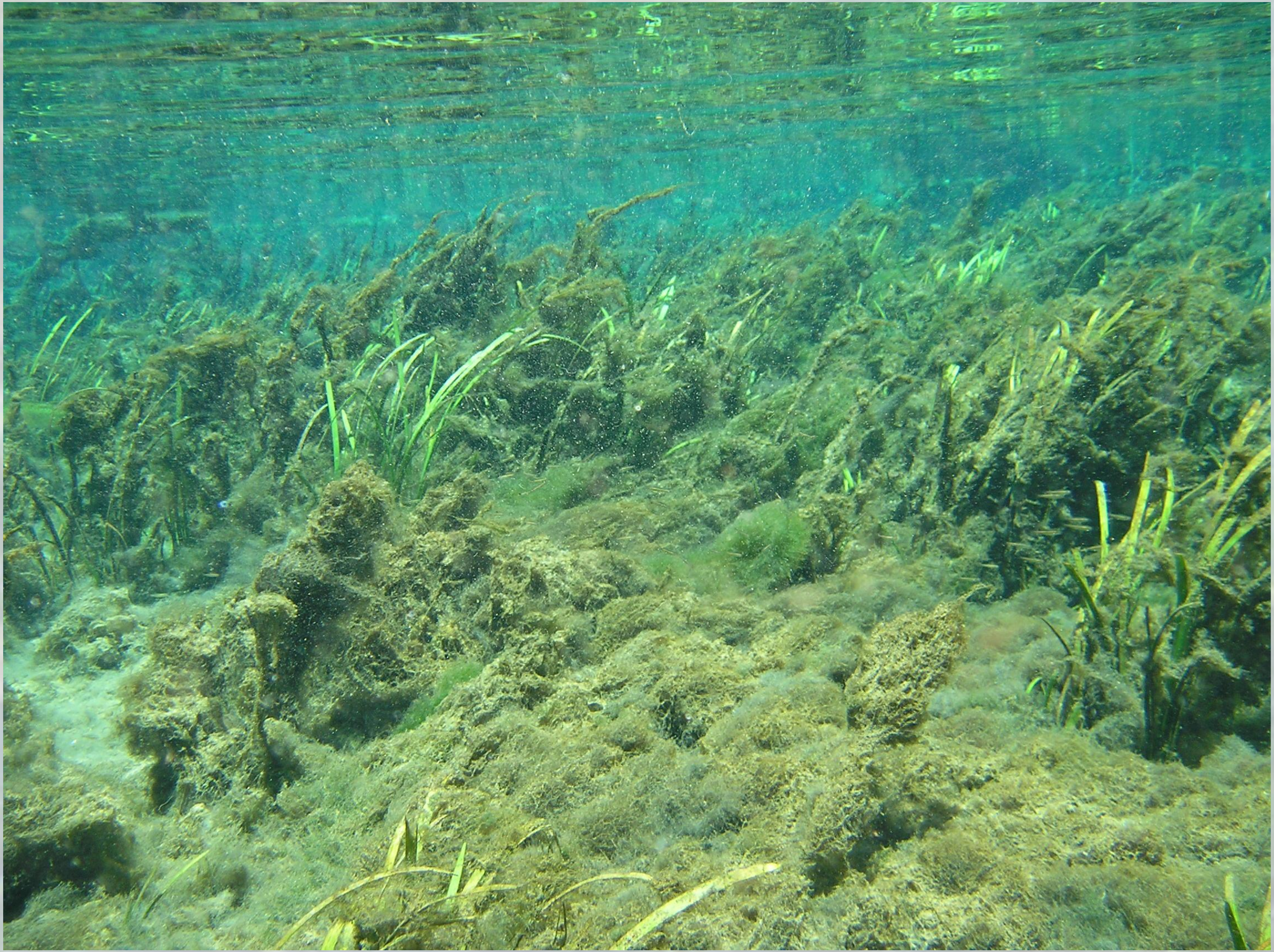
– Dense aquatic plant beds

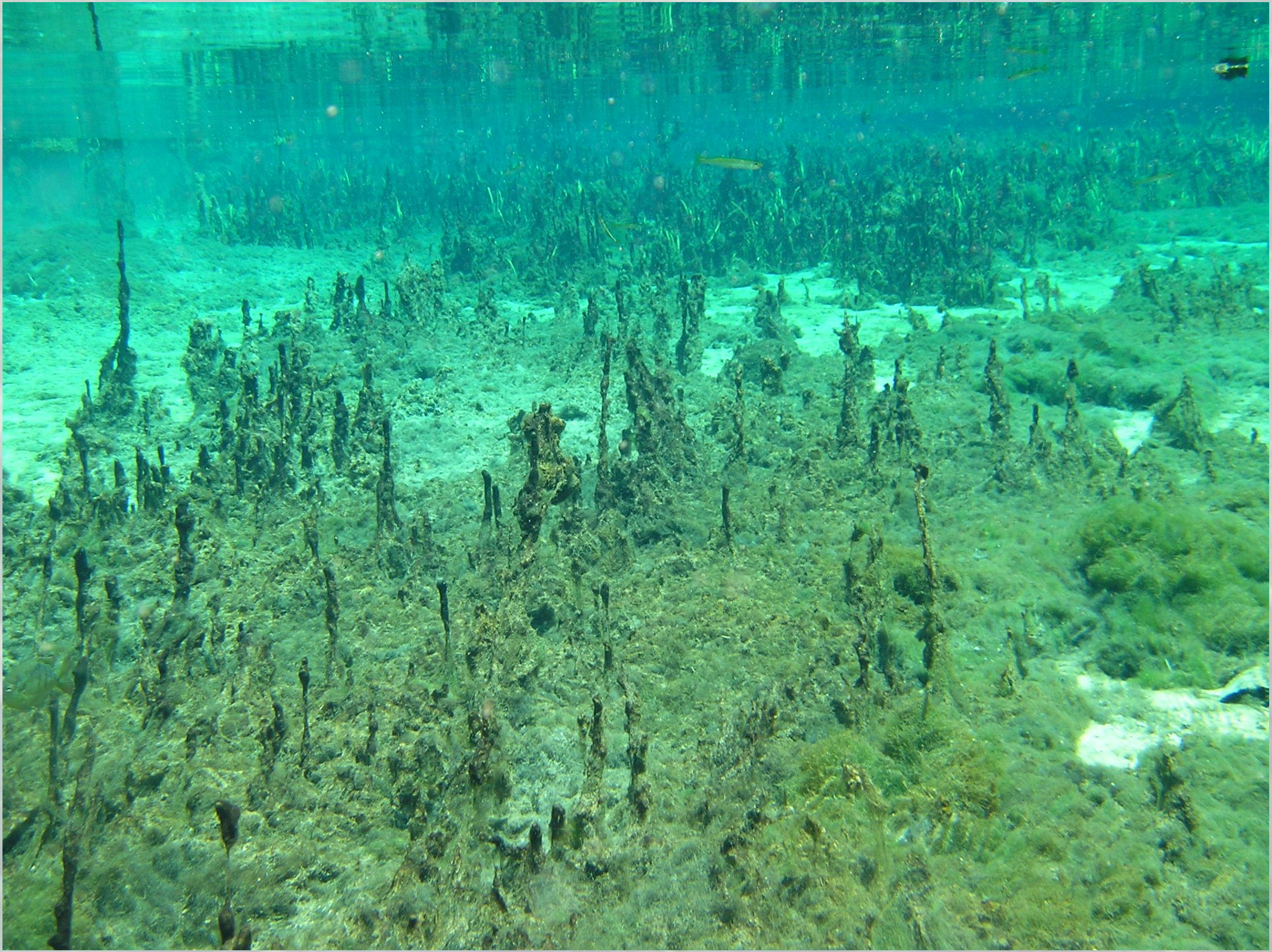
– High biomass and diversity of fish and invertebrates

– Refuge for manatees

FGS







Primary Narrative

Nitrate concentrations have significantly increased in some springs (<0.1 to >1.0 mg N/L)

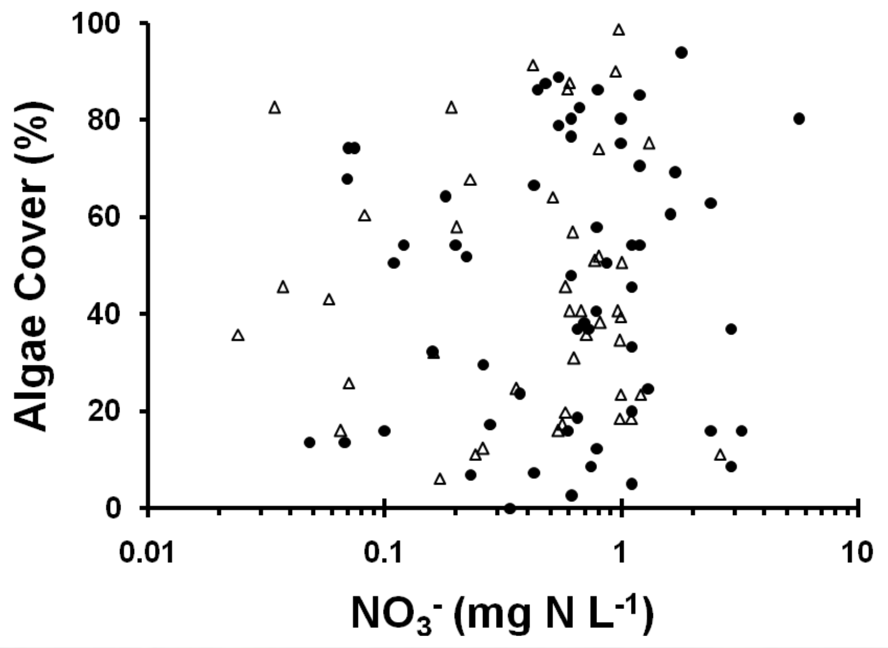
Weeki Wachee – 1950s
Florida Archives

Weeki Wachee – 2001
Agnieszka Pinowska

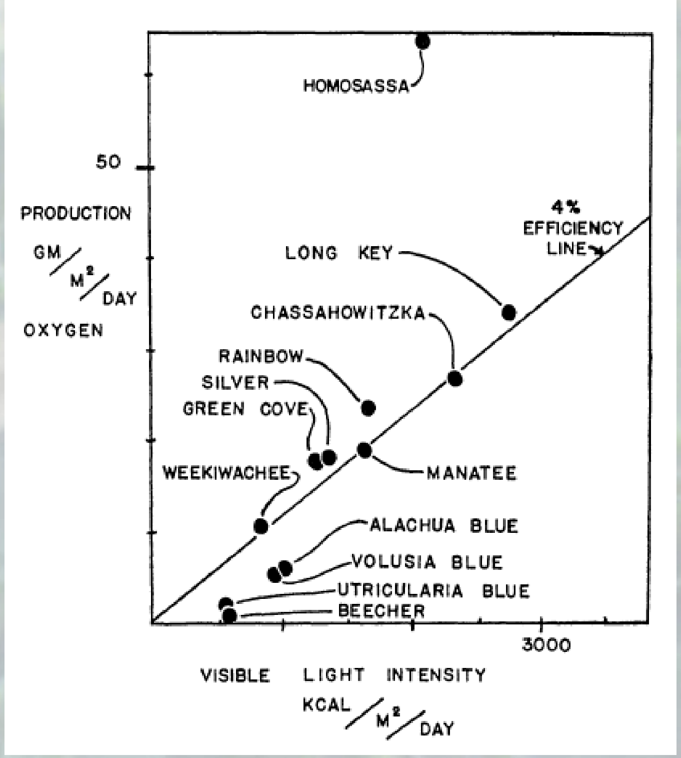
Primary Narrative Evidence

Heffernan et al. 2010 (data from Stevenson et al. 2004)

No clear relationship between algae and NO_3



Fall 2002 (closed circles)
Spring 2003 (open triangles)



Odum 1957

Light was major driver of primary production historically; apparent nutrient saturation

Alternative Narratives

- Nitrate <u>flux</u> was always large enough to fulfill algal demand (e.g. Odum 1957)

- ↓ Snail biomass (Heffernan et al. 2010)
- ↓ Flow velocity
- ↑ Human disturbance
  - boating, wading, aquatic plant management

- Multi-causality?

Subsidy-stress Relationship

Filamentous Algae Abundance

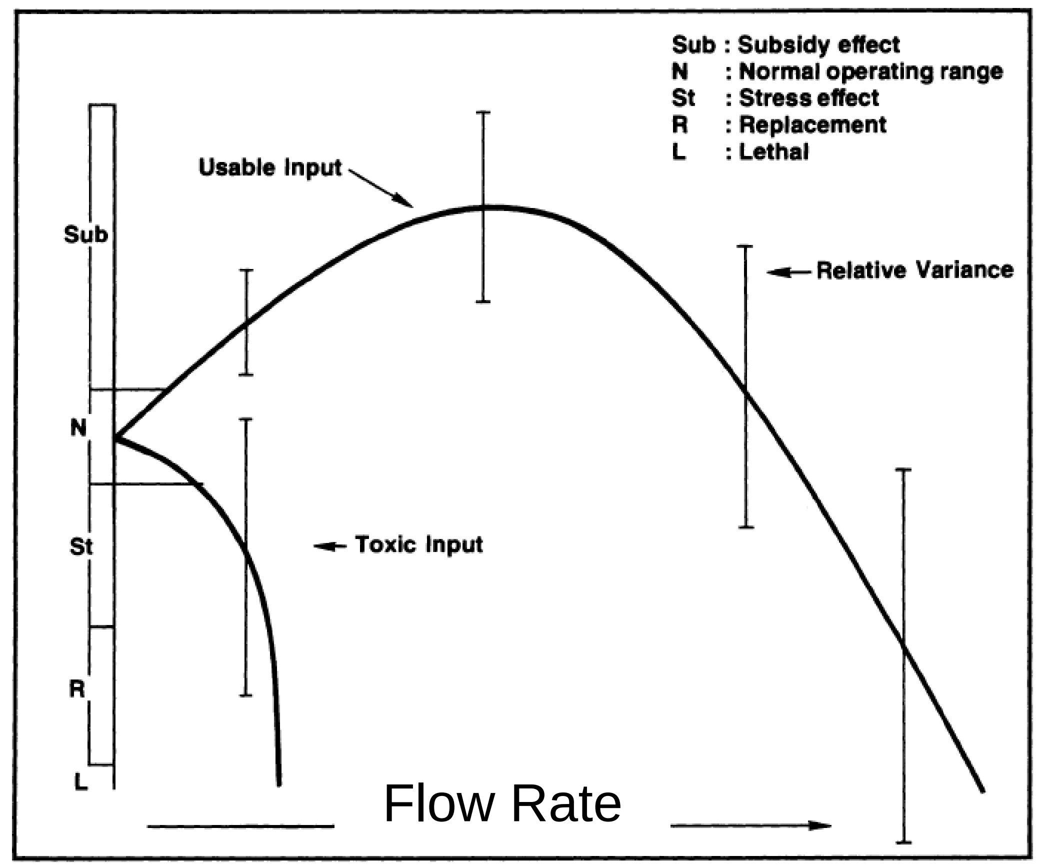


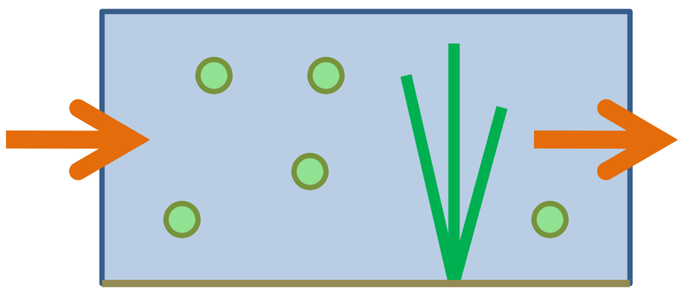
Fig. 1. Hypothetical performance curve for a perturbed ecosystem subjected to two kinds of inputs. The curves simulate the output response (as measured by appropriate systems or component rates of function) to increasing intensity of input perturbation.

E. P. Odum et al. 1979

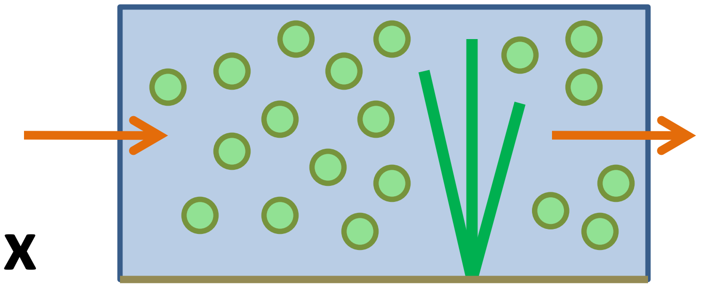
Nutrient Limitation in Streams

Nutrient Flux (mass/time) = Concentration * Flow Rate

<u>Stream 1</u>	<u>Stream 2</u>
Low Conc. * High Flow	High Conc. * Low Flow



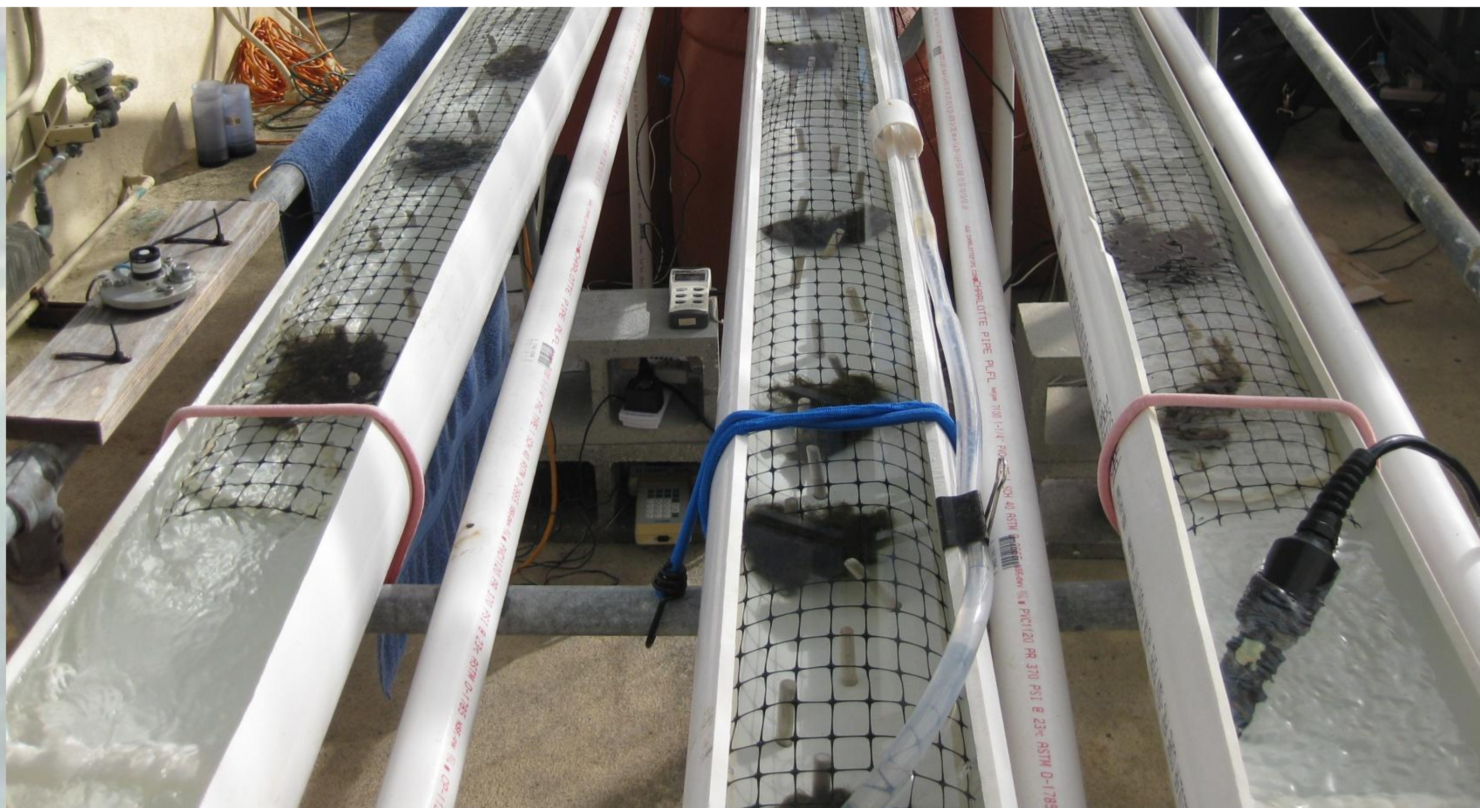
Equal Flux



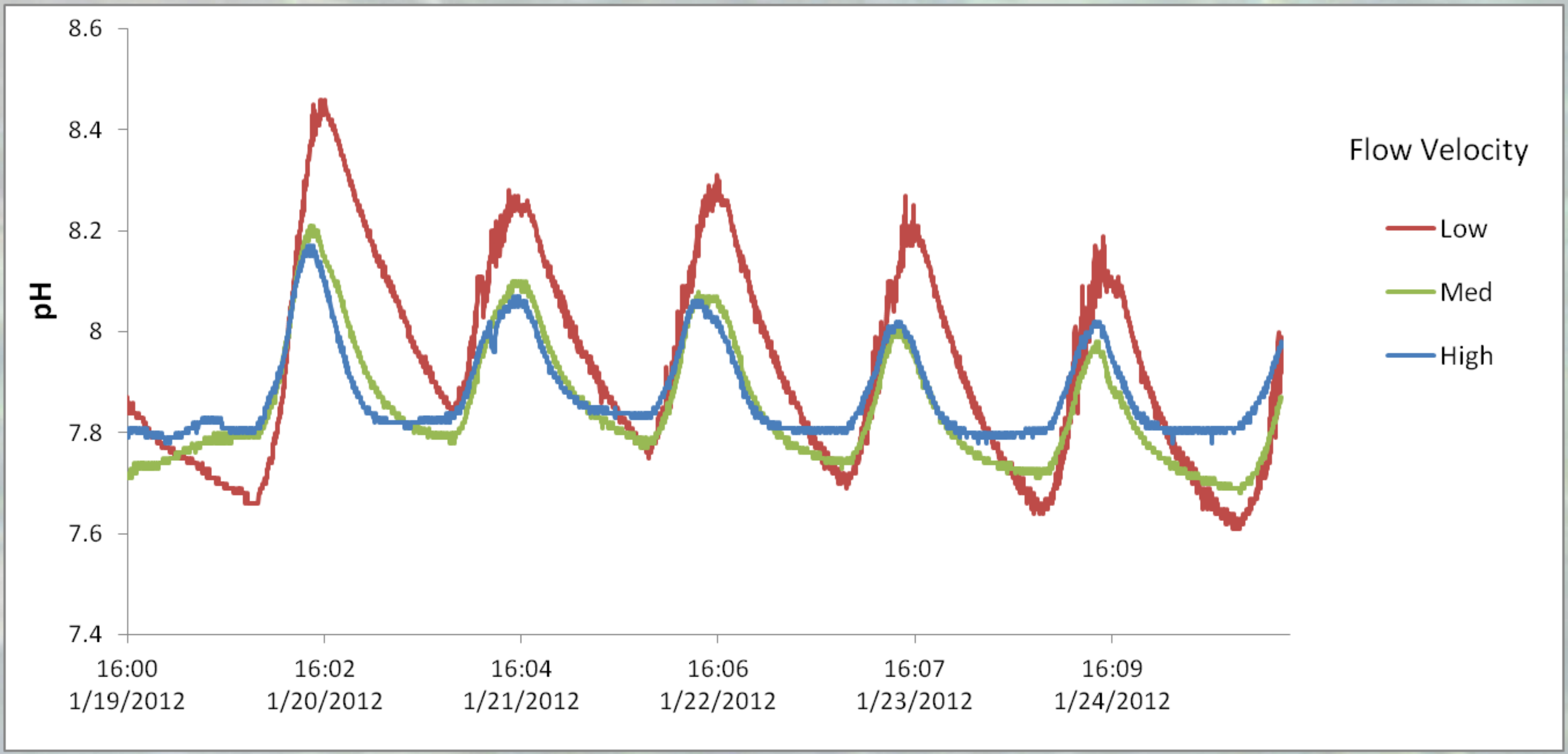
Greenhouse Experiment

How does flow velocity affect the metabolism of the filamentous alga *Lyngbya wollei*?

How does this compare to NO_3 levels?

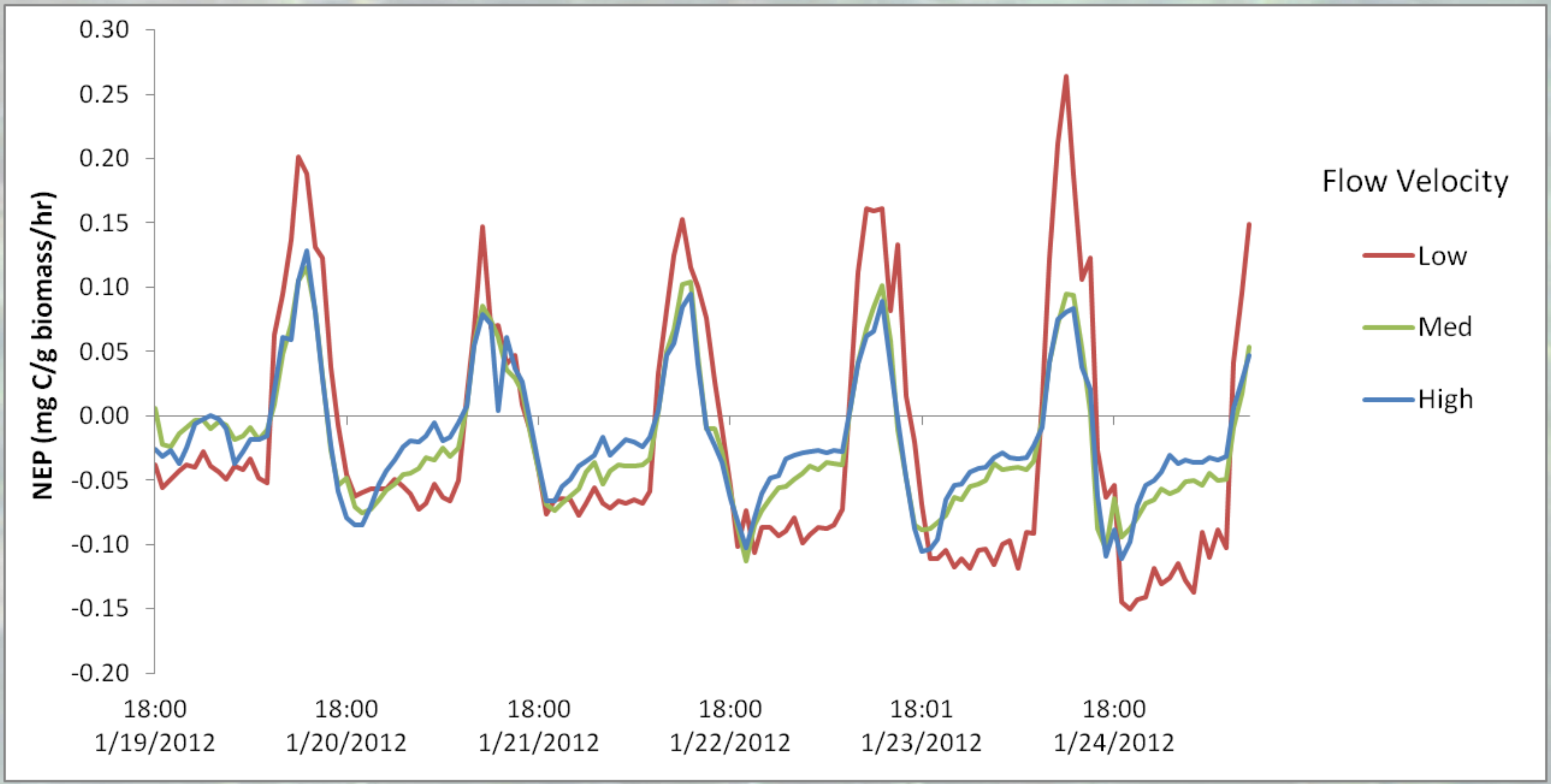


Greenhouse Experiment



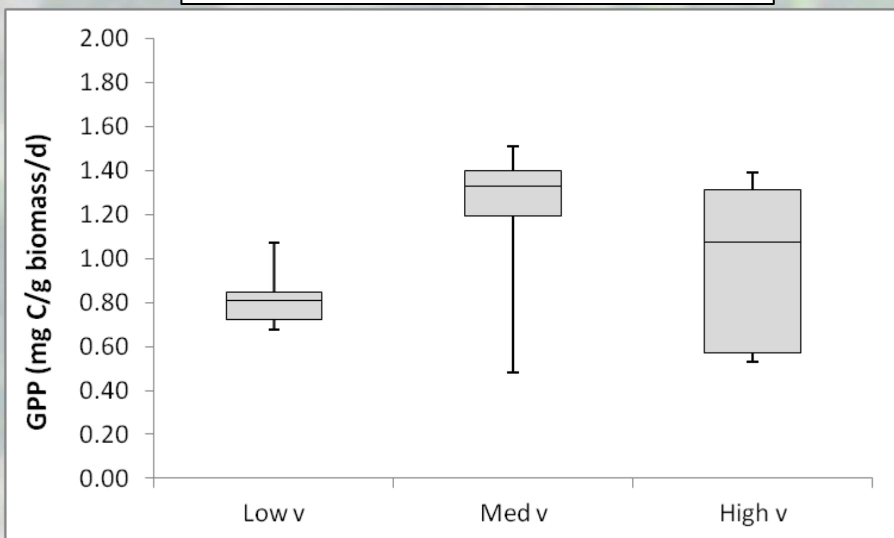
$$CO_2 + H_2O \leftrightarrow H_2CO_3 \leftrightarrow H^+ + HCO_3^- \leftrightarrow H^+ + CO_3^{2-}$$

Greenhouse Experiment

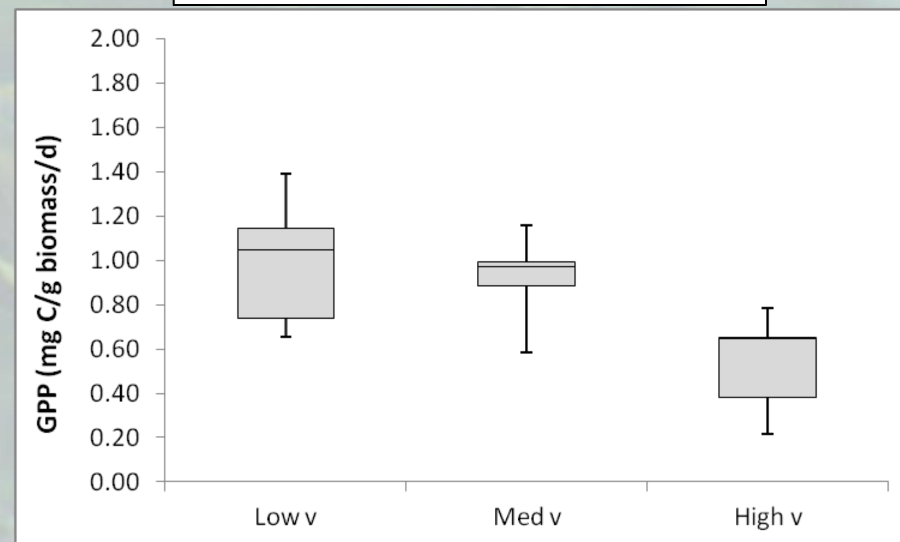


Greenhouse Experiment

Low NO_3-N (0.05 mg/L)



High NO_3-N (1.00 mg/L)



5 trials for each NO_3 concentration

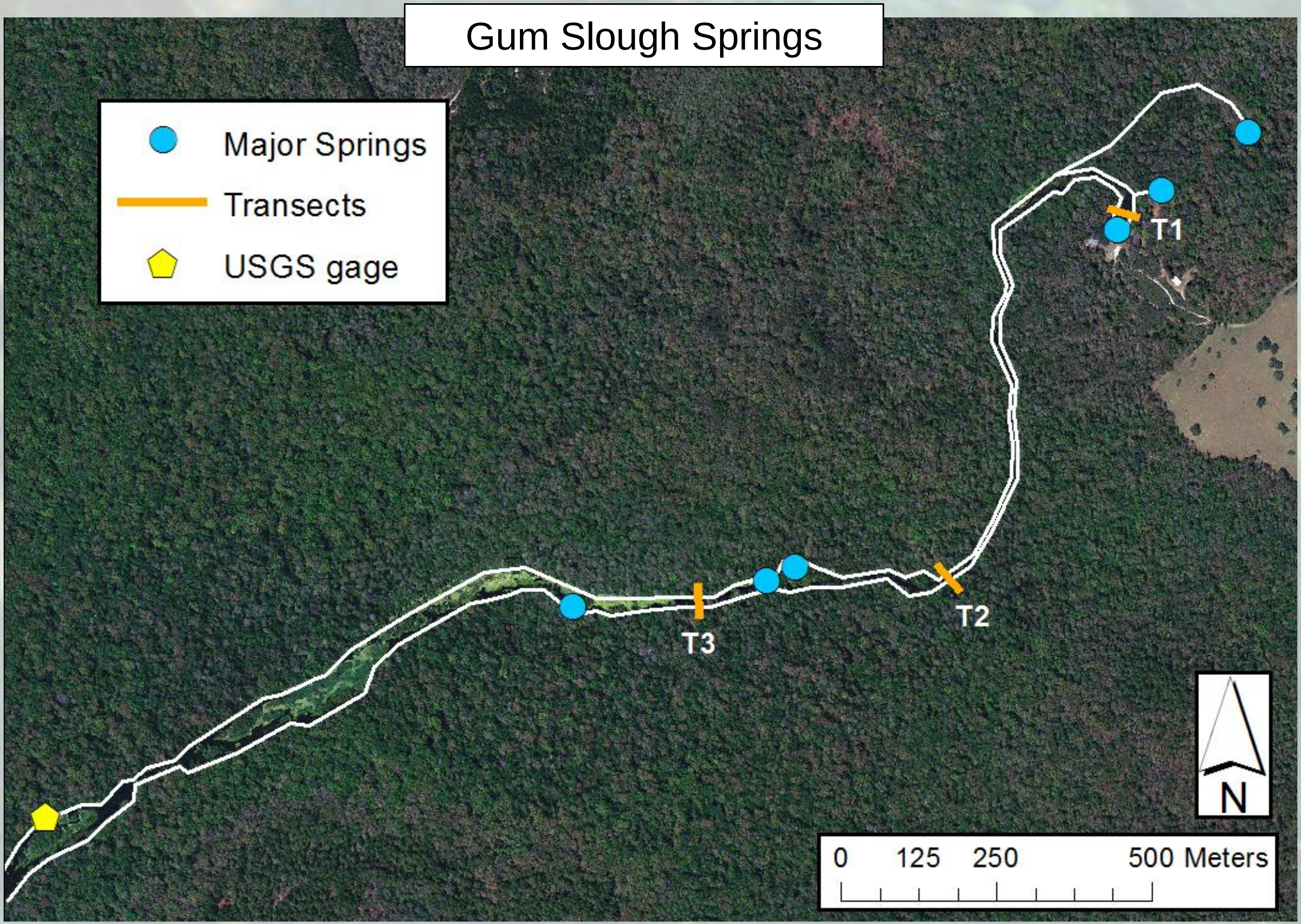
Florida Spring Field Survey

How does flow velocity relate to filamentous algal abundance within Florida springs?

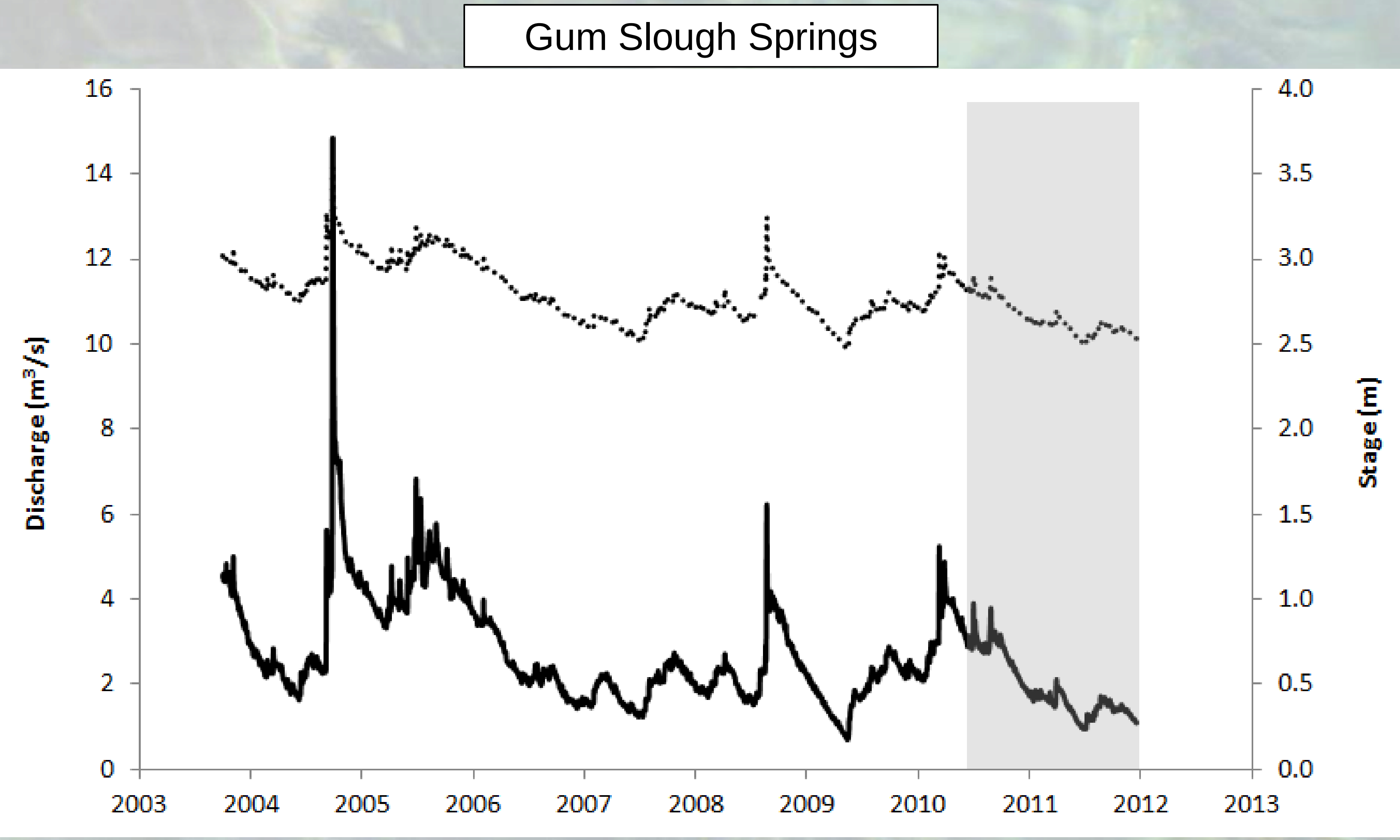
Avg velocity = 13 cm/s

Avg velocity = 7 cm/s

Field Survey

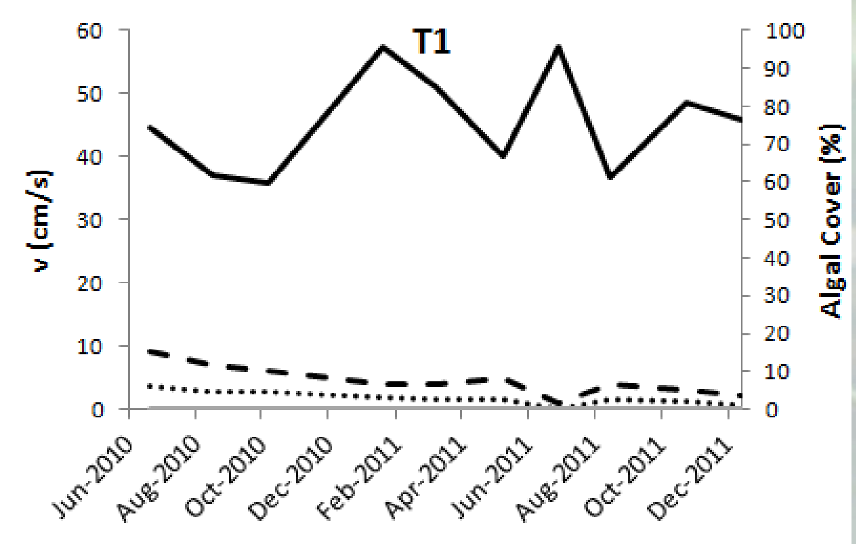


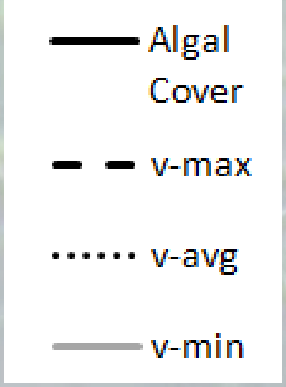
Field Survey



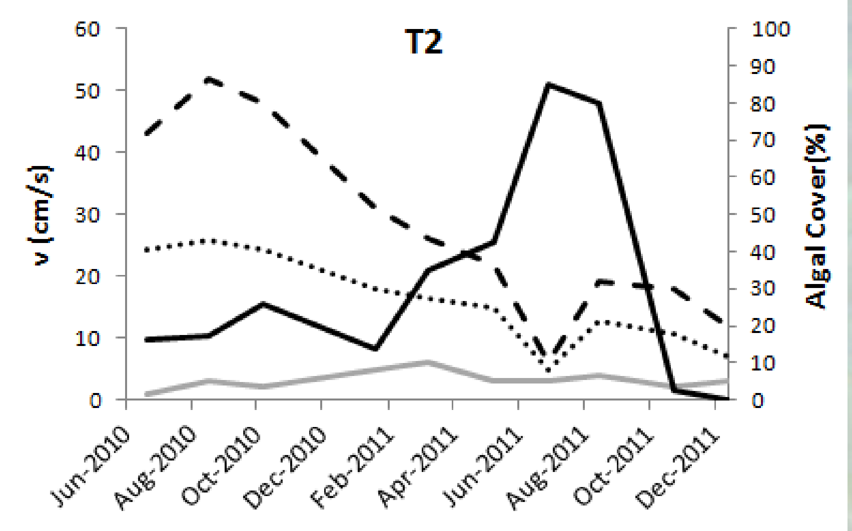
Field Survey

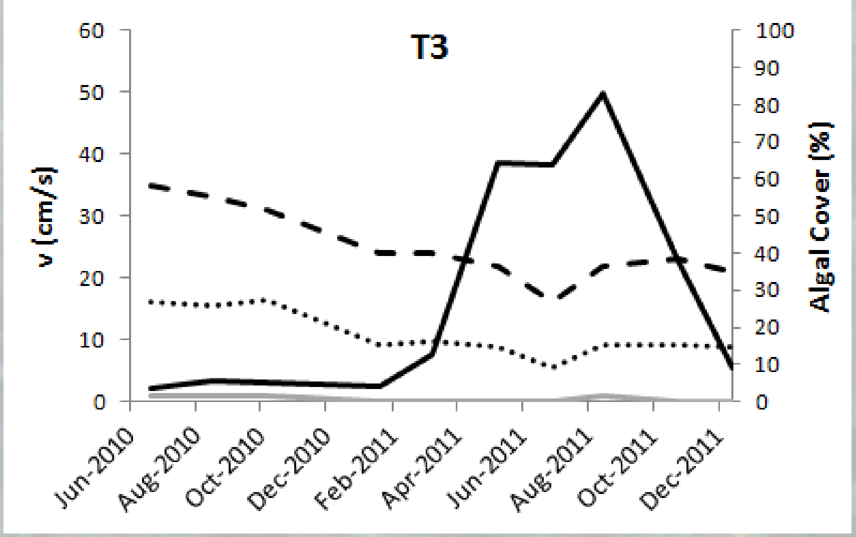
Low Velocity



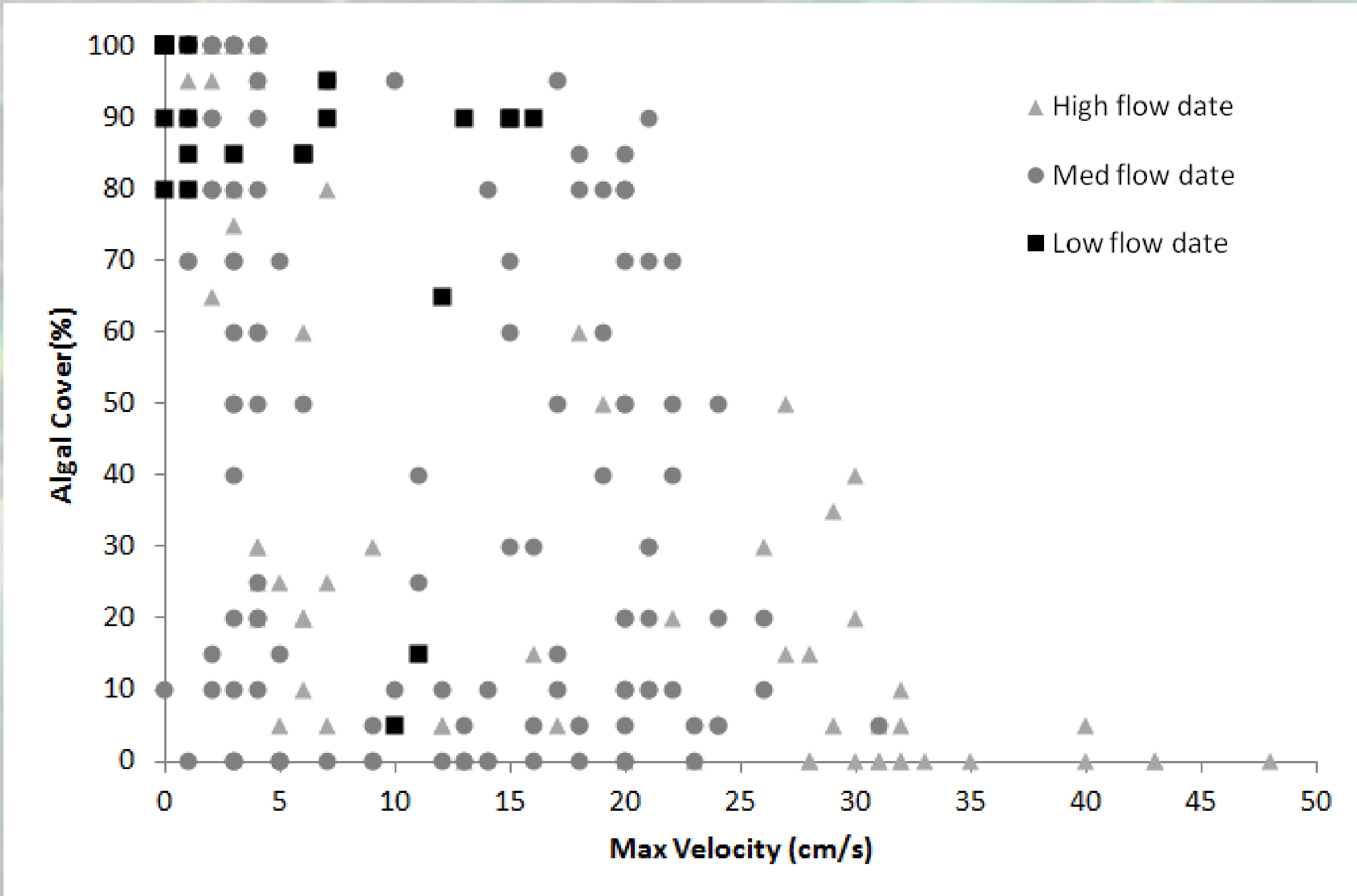


Higher Velocity

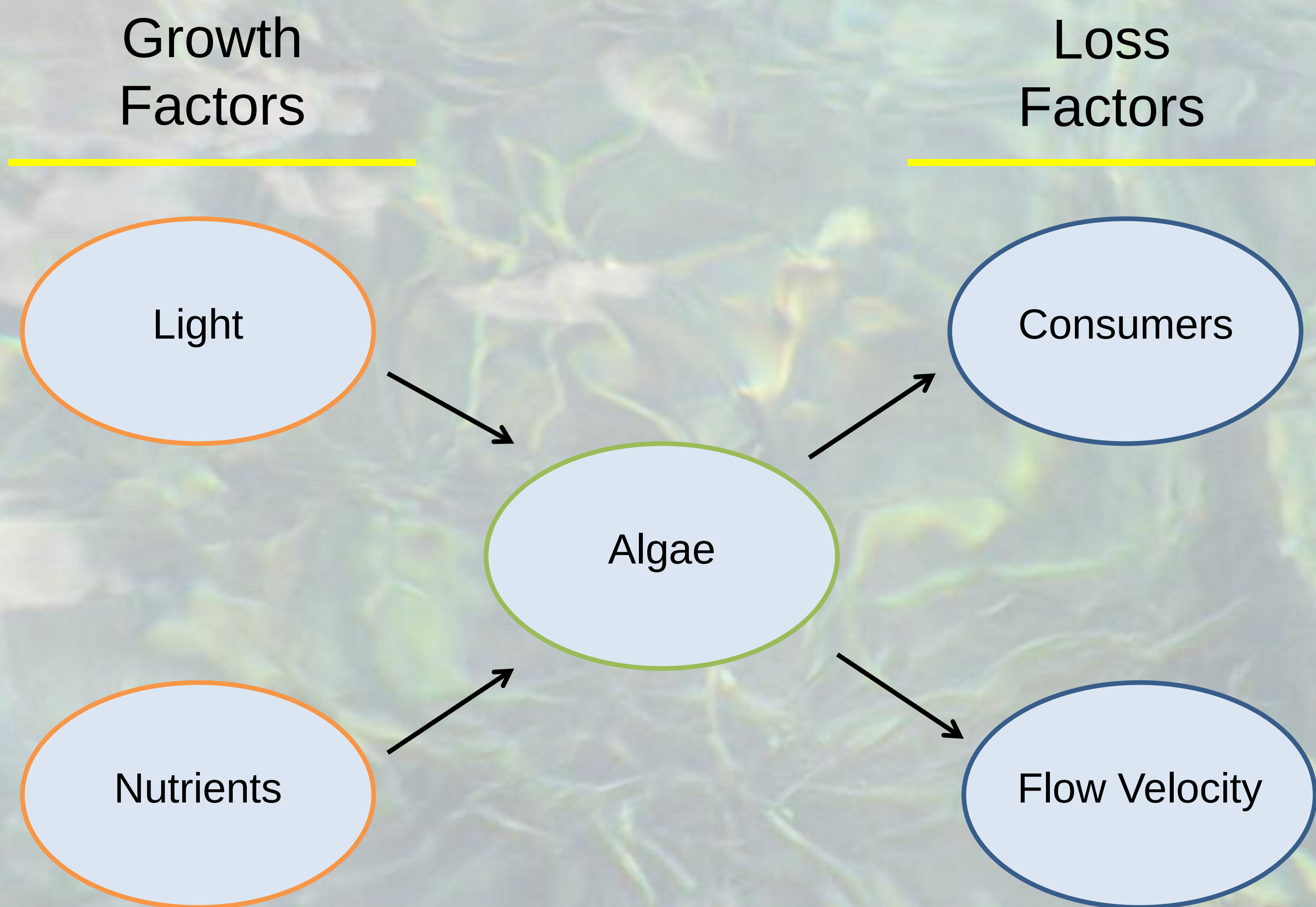




Field Survey



Conclusions



Conclusions

Nutrient limitation in Florida springs:

- Significant N limitation in Florida springs is unlikely due to high N flux
  - However N enrichment could stimulate certain species of algae, particularly in low flow areas (i.e. near spring boils) and over long time periods
- Stevenson et al. (2007) suggests that it would take a N concentration of 0.25 mg/L to begin reducing *Lyngbya*
- Many springs currently have N concentrations > 1 mg/L and are rising
- Nutrient reduction will be a slow process and may not decrease already established algae

Conclusions

Flow and filamentous algae:

- At Gum Slough, flow velocity was negatively related to filamentous algal abundance due to increased drag
  - Threshold of < 30 cm/s for filamentous algal presence
  - Threshold of < 5 cm/s for substantial filamentous algae
- Declining discharge leads to lower velocities which may allow filamentous algae to proliferate

- Neither declining discharge nor NO_3 enrichment appears to be the sole cause of algal proliferation; however these factors and others may each contribute

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