Has the Lower Boise River AQUATOX modeling been driven by dials?

- What is the conceptual model of nutrient-benthic algae relations?
- Modeling been driven “dialing in” input parameters to approximate observations
- Overwhelmed by complexity?
- Are the concepts maintained ?

Environmental Management (2010) 45:603–615

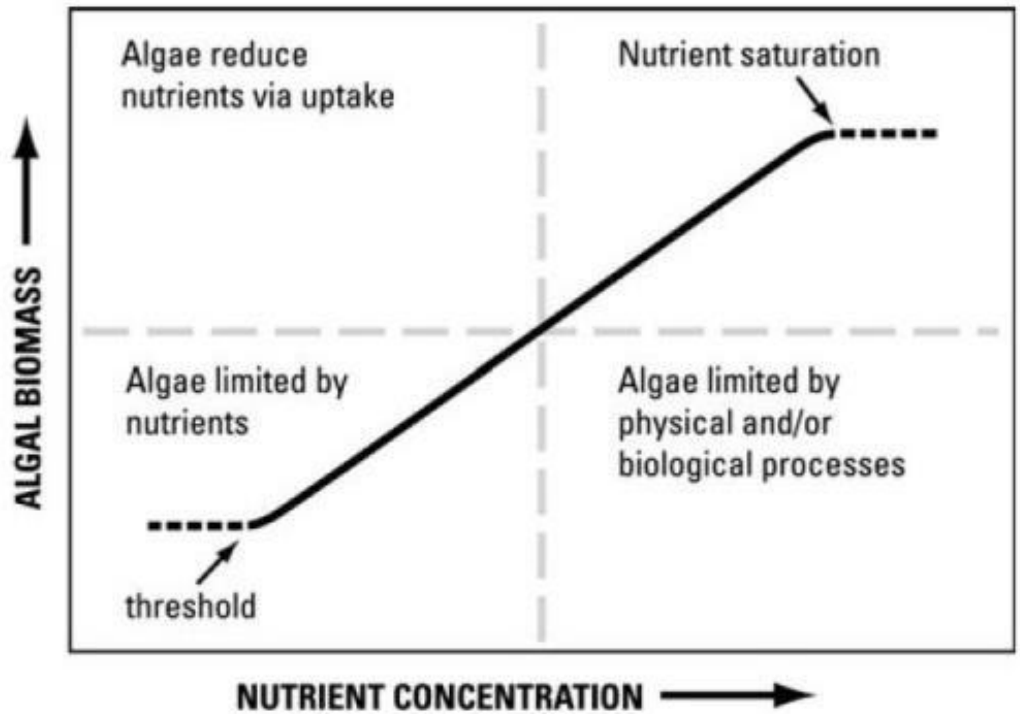
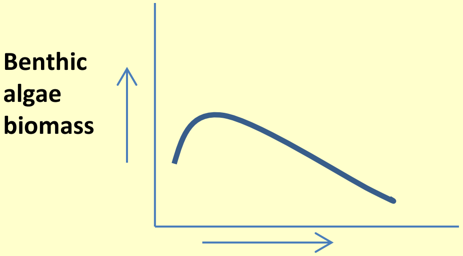
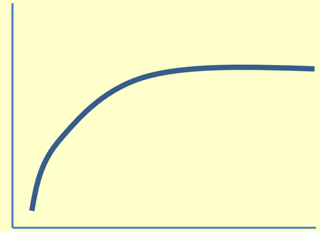


Fig. 3 Nutrient-Algal Biomass Conceptual Model illustrating the interaction of nutrients and algal biomass (chlorophyll *a*). The solid line represents a linear response of algal biomass as a function of increasing nutrient concentration. Individual sites fall into one of the four quadrants depending on nutrient-biomass interactions

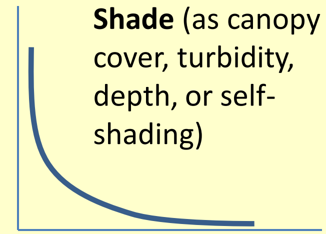
Munn, M.D., J.W. Frey, and A.J. Tesoriero. 2010. The influence of nutrients and physical habitat in regulating algal biomass in agricultural streams. *Environmental Management*. 45(3): 603-615



Current (stimulation via enhanced nutrient delivery & waste removal, then constraining algae through physical stress)



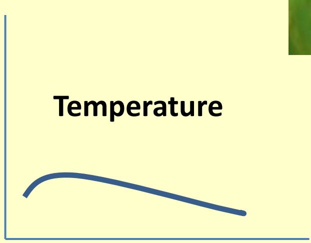
Nutrients (nitrogen, phosphorous, dissolved inorganic carbon: one or more may be limiting; if saturated reductions will have little or no effect on benthic algae)



Shade (as canopy cover, turbidity, depth, or self-shading)

Grazing?

Temperature



Substrate size for algal attachment

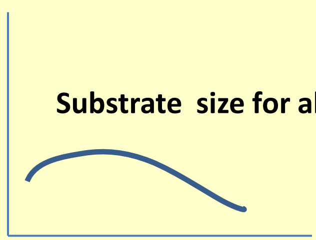


Table 2 Multiple regression models for macrophyte and periphyton biomass

Model 1. Predicted variable: log (macrophyte biomass g m ^{2}): r^2 0.75, adjusted r^2 0.71, SE (ε) 0.57, IRP 2.6 groups

Explanatory variables (x_k)	Coefficient (β_k)	Std. coefficient	*P*
Intercept (β_0)	2.38		
Log (TN)	0.923	0.37	0.004
Sqrt (Sed Al/P ratio)	−0.181	−0.34	0.007
Log (Q_{max}/Q)	−0.530	−0.31	0.009
Asin (open)	0.987	0.24	0.038

Model 2. Predicted variable: Sqrt (periphyton chlorophyll *a* biomass mg m ^{2}): r^2 0.58, adjusted r^2 0.52, SE (ε) 2.15, IRP 2.0 groups

Variable	Coefficient	Std. coefficient	*P*
Intercept	−0.23		
Log (LS *P*)	4.06	0.36	0.02
T30	0.397	0.34	0.03
Asin (open)	3.26	0.28	0.07
HCO_3	0.0085	0.24	0.10

The adjusted r^2 is an r^2 that penalizes models for including more explanatory variables (Helsel & Hirsch, 2002). *IRP* index of resolution power; the number of different groups of the whole range of dependent values can be predicted with 95% confidence (Prairie, 1996)

Fig. 4 Macrophyte biomass in relation to selected measures of light, current, sediment-nutrients, and water-nutrients: **a** percent of channel that is unshaded, **b** turbidity, **c** ratio of peak flows in the year prior to sampling to flows at the time of sampling (Q_{max}/Q_{sample}), **d** maximum water velocity in the year prior to sampling, **e** total N in water, **f** loosely sorbed P in sediment, **g** total N in sediment, and **h** ratio of Al to total P in sediments. *Circled numbers* are springbrooks, *other numbers* are runoff streams. Pearson's *r* correlation coefficients are with transformed data, with the data transformations, in *X*–*Y* order, in *parentheses* ▶

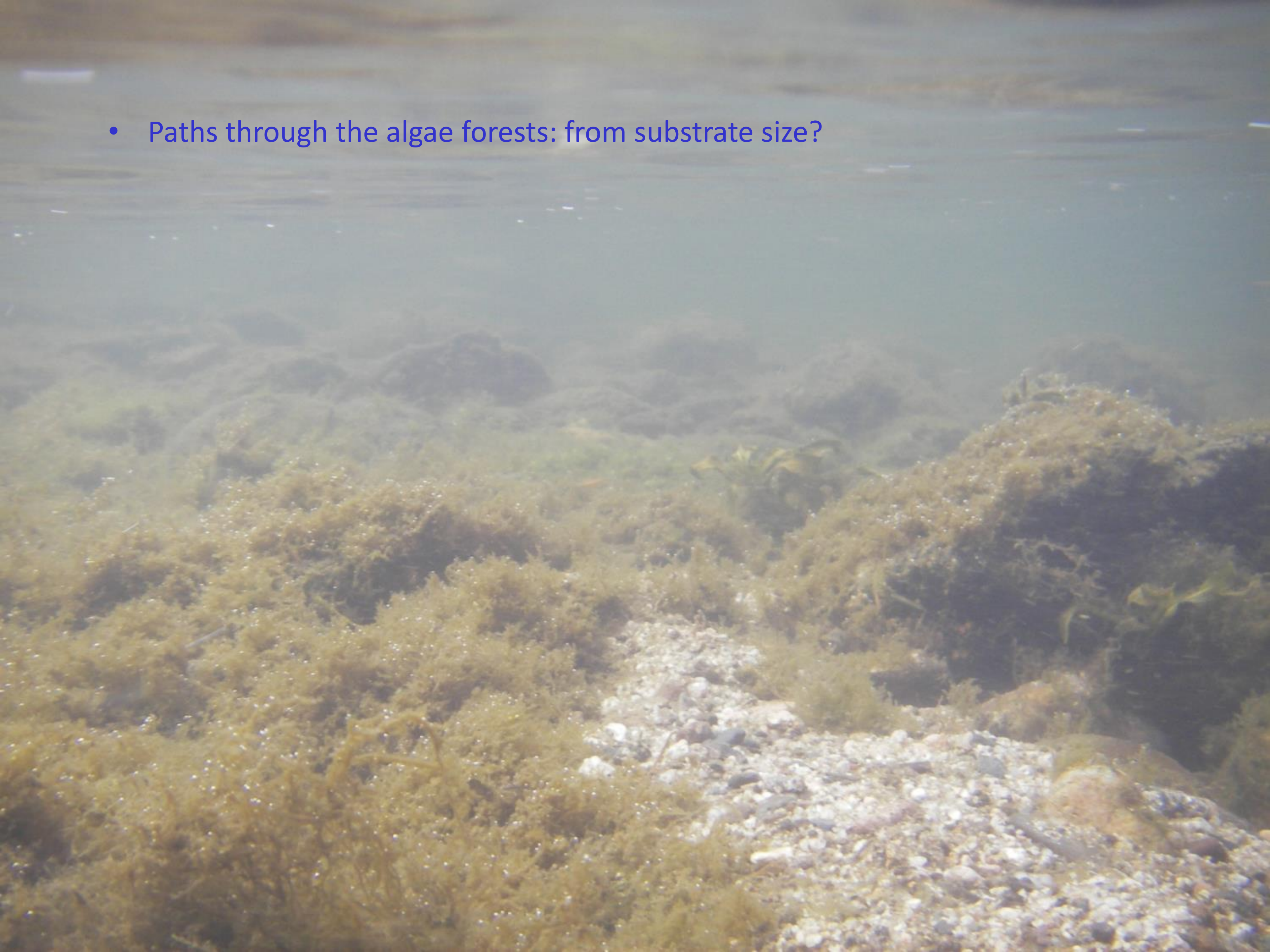
water was not correlated with macrophyte biomass (Online Resource 1).

Loosely sorbed P in sediment was correlated with macrophyte biomass (Fig. 4f). Similarly, when total P in sediment was normalized to either Al or Fe concentrations to estimate bioavailable P, correlations with macrophyte biomass were stronger than was the ... for Al:P ... for total ... ectively

- Labile P in bed sediments
- Average temperature, 30 days prior
- Channel shading (open to sky)
- Inorganic carbon (bicarbonate)

... rrelated with macrophyte biomass. Periphyton biomass in turn was positively correlated with loosely sorbed P in sediment, antecedent stream temperature, bicarbonate, and percent of the channel without shade. Other variables that we had anticipated might be strongly correlated with macrophyte abundance but were not

- Paths through the algae forests: from substrate size?

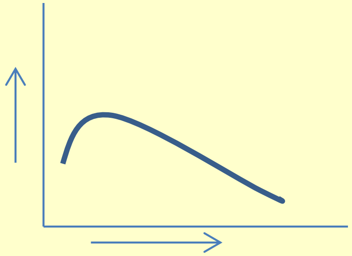


- Algae on sand and gravel, Silver Creek, ID

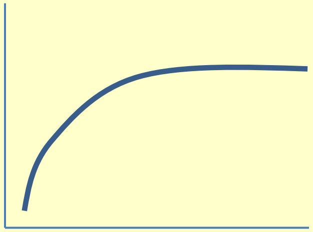
- **Algae on mixed gravel and small cobble, Big Wood River, ID**

- Benthic algae can do just fine on mixed substrate
- Substrate cleaned of algae by spawning brown trout

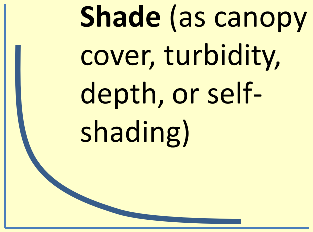
Benthic algae biomass



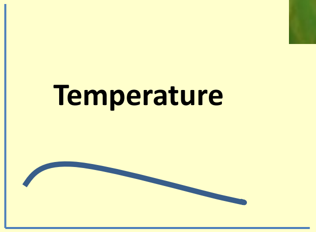
Current (stimulation via enhanced nutrient delivery & waste removal, then constraining algae through physical stress)



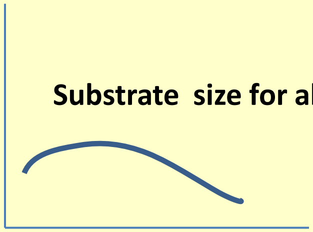
Nutrients (nitrogen, phosphorous, dissolved inorganic carbon: one or more may be limiting; if saturated reductions will have little or no effect on benthic algae)



Shade (as canopy cover, turbidity, depth, or self-shading)



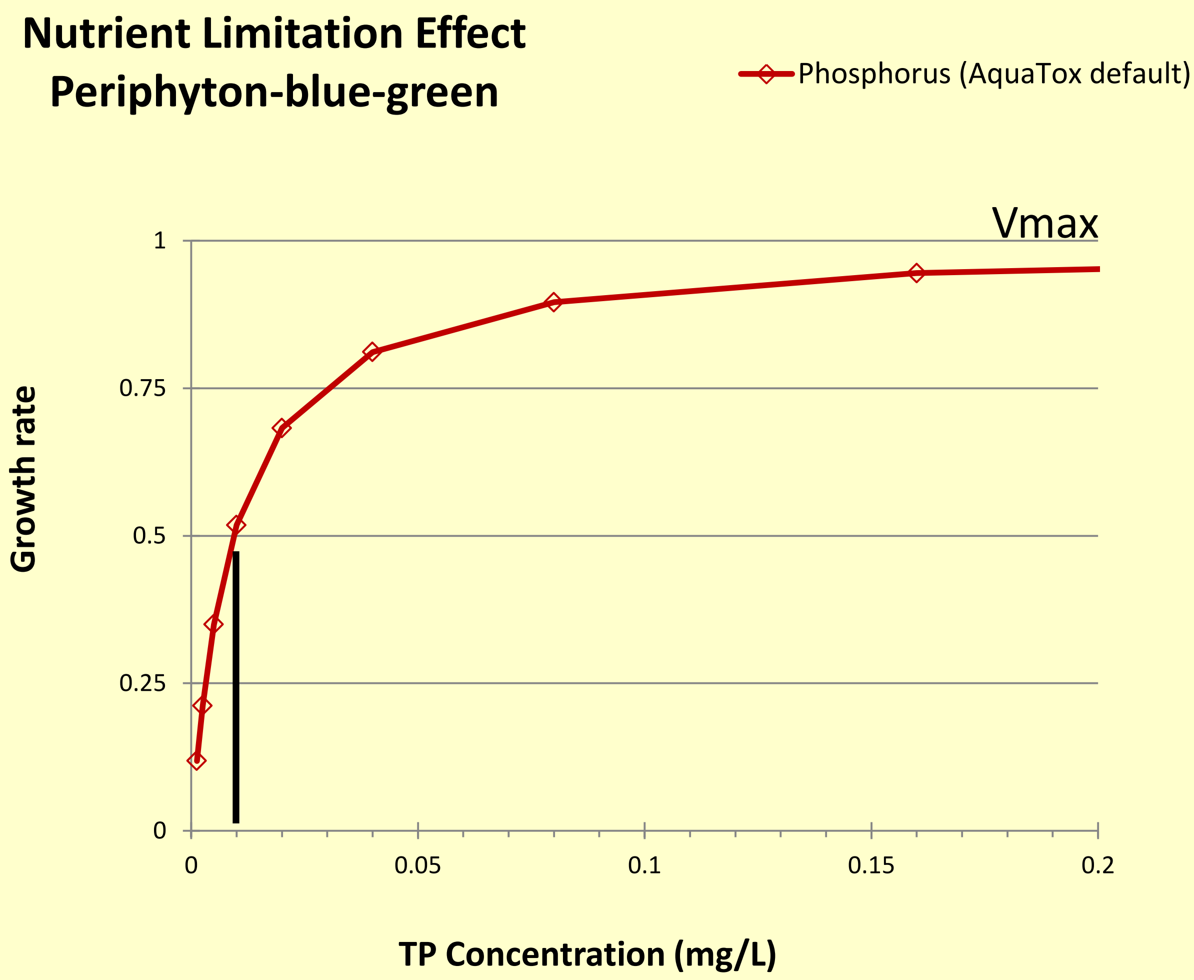
Temperature



Substrate size for algal attachment

Grazing?

$$y = \frac{V_{\max} \bullet x}{K_m + x}$$

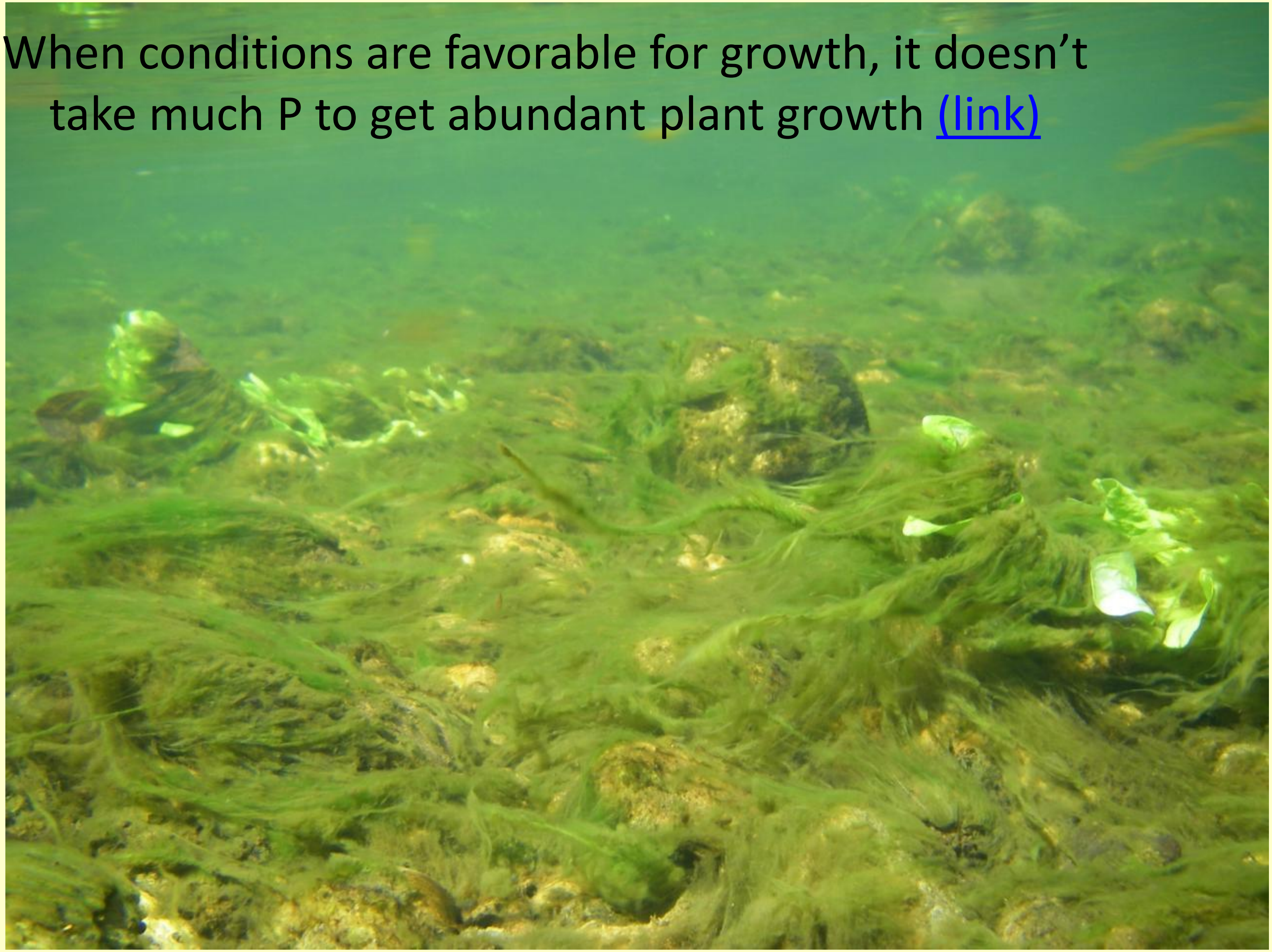


Vmax = 1

y= x/(Km+x)

Click for spreadsheet

When conditions are favorable for growth, it doesn't take much P to get abundant plant growth (link)



Rooted aquatic plants, filamentous macroalgae, and periphyton in a low-nutrient stream, the Big Wood River, October 23, 2008 (TP 5.3 µg/L, TN 64 µg/L, periphyton chl(a) 50 mg/m^2, macrophyte/macroalgae cover, 85%)

Linking P in streams to periphyton: a fool's errand?

Influence of Environmental Factors on Biotic Responses to Nutrient Enrichment in Agricultural Streams

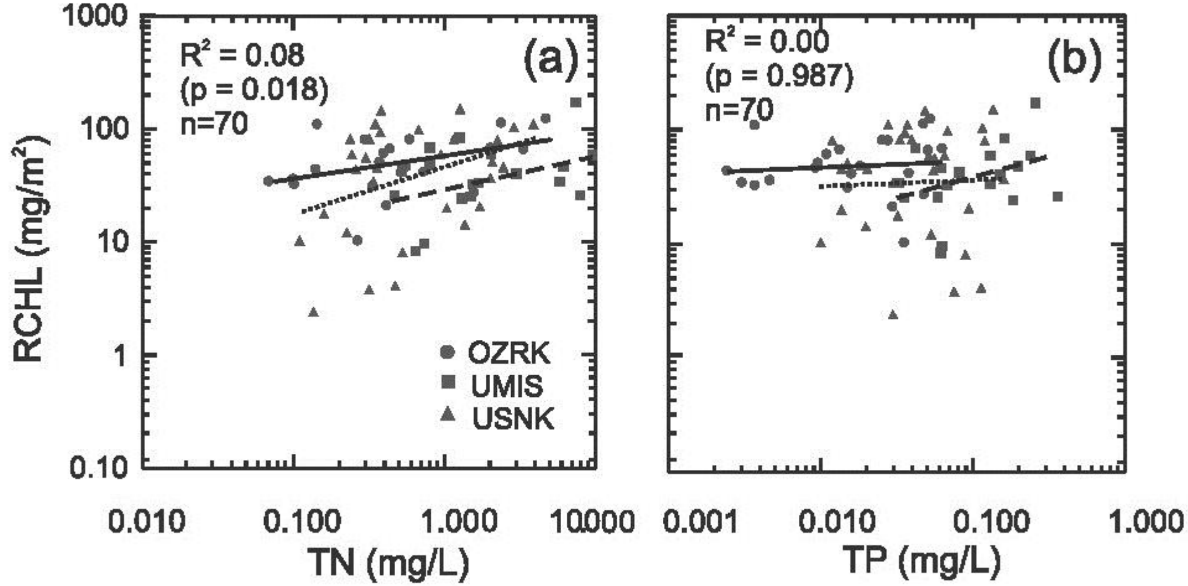


FIGURE 5. Bivariate Plots of the Biotic Response Variables Periphytic (a and b) Chlorophyll *a* (RCHL), (c and d) Sestonic Chlorophyll *a* (SCHL), and (e and f) Aquatic Macrophyte (AQM) Percent Coverage and Total Nitrogen (TN) and Total Phosphorus (TP) Concentrations. The lines indicate the best fit linear regression for streams in the OZRK (solid line), UMIS (dashed line), and USNK (dotted line). Regression equations of all sites combined and individual regions can be found in Table 4.

Maret, T.R., C.P. Konrad, and A.W. Tranmer. 2010. Influence of environmental factors on biotic responses to nutrient enrichment in agricultural streams. *Journal of the American Water Resources Association*. 46(3): 498-513.

Experimental control

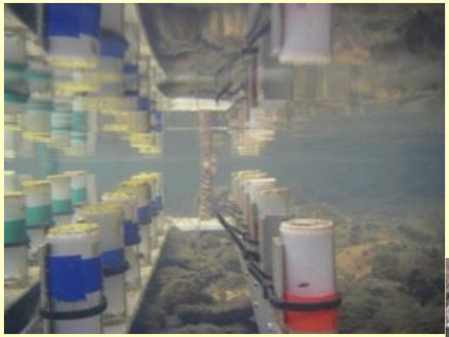
Suzanne Pargee, GEI

Single-species, *Selenastrum* green-algae laboratory tests

Multiple-species periphyton and duckweed microcosm


Chris Mebane, USGS

In situ nutrient diffusing substrate tests


Chris Mebane, USGS

Field studies


Terry Maret, USGS

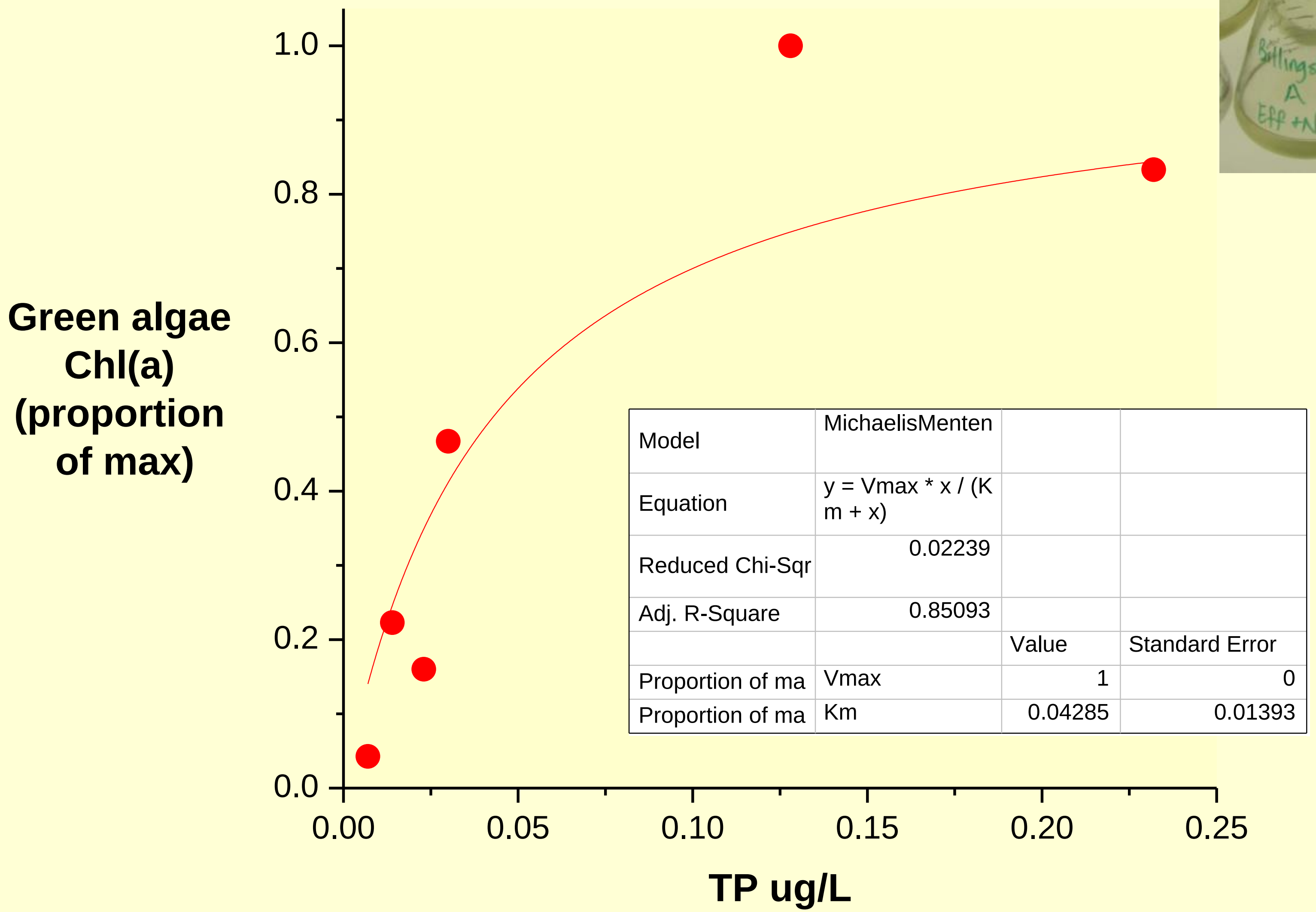
Environmental relevance

Sestonic green algal nutrient limitation assays

- **Variation on EPA's whole effluent test (WET)**
- **Green algae *Pseudokirchneriella subcapitata* (formerly *Selenastrum capricornutum)***
- **Water from 6 streams tests with 4 conditions: Unaltered stream water; stream water spiked with N, P, or both N+P**
- **12-14 days test duration**

Suzanne Pargee, GEI Consultants-Chadwick Ecological, Littleton, CO

Green algae growth curve



Model	MichaelisMenten		
Equation	y = Vmax * x / (Km + x)		
Reduced Chi-Sqr	0.02239		
Adj. R-Square	0.85093		
		Value	Standard Error
Proportion of ma	Vmax	1	0
Proportion of ma	Km	0.04285	0.01393

Low P stream

Total P ~ 0.007 to 0.015 mg/L (7 to 15 µg/L)

Total N ~ 1.0 mg/L (1000 µg/L)

- **Stalker Creek**

Few overt disturbances; located on The Nature Conservancy's Silver Creek Preserve

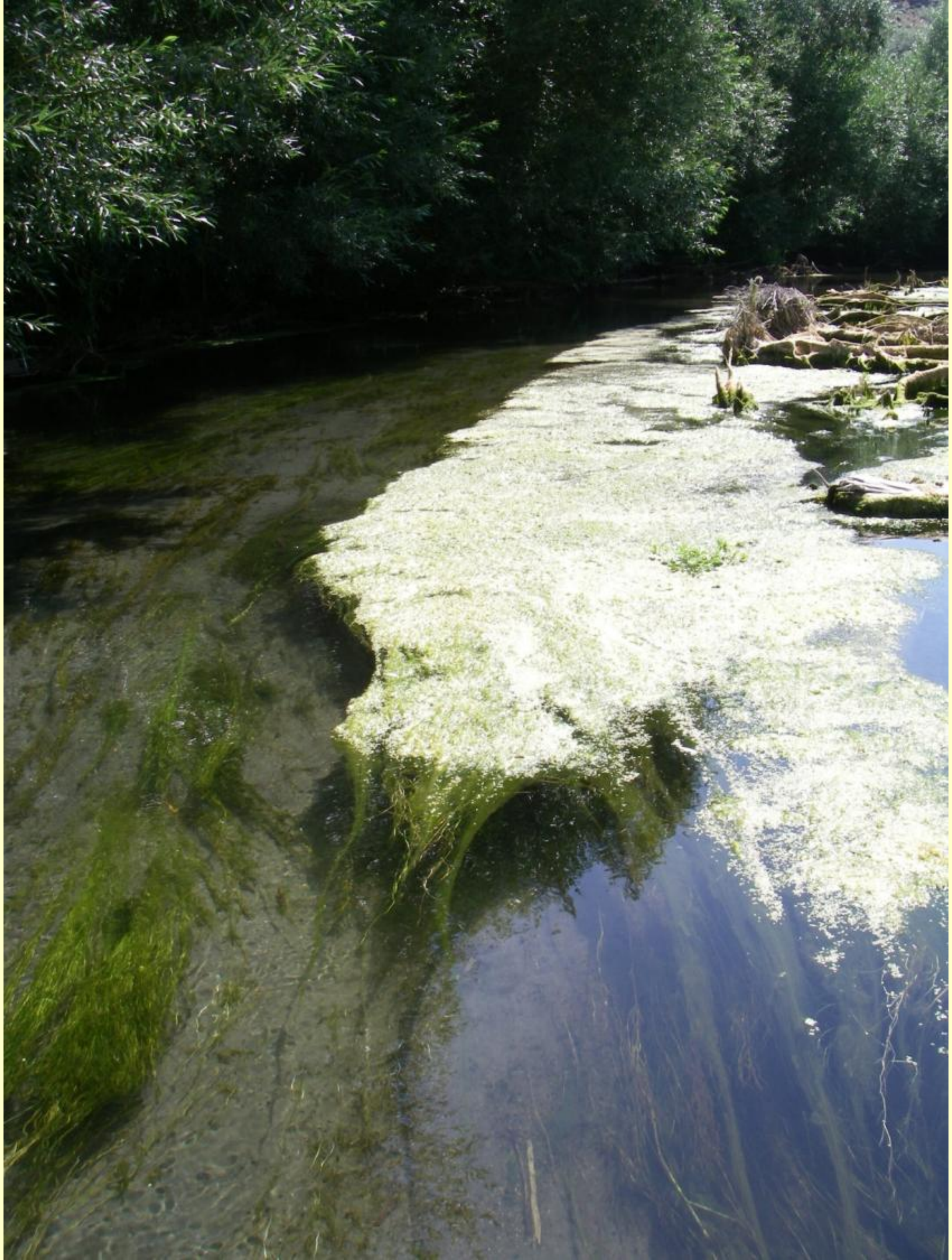
Limitation Experiments: Low N stream

Total P ~ 20 – 35 μg/L (0.020 to 0.035 mg/L)

Total N ~ 40 to 400 μg/L (0.04 to 0.4 mg/L)

Big Cottonwood Creek

Pristine rangeland watershed: no diversions, roads, cows, or motorized access





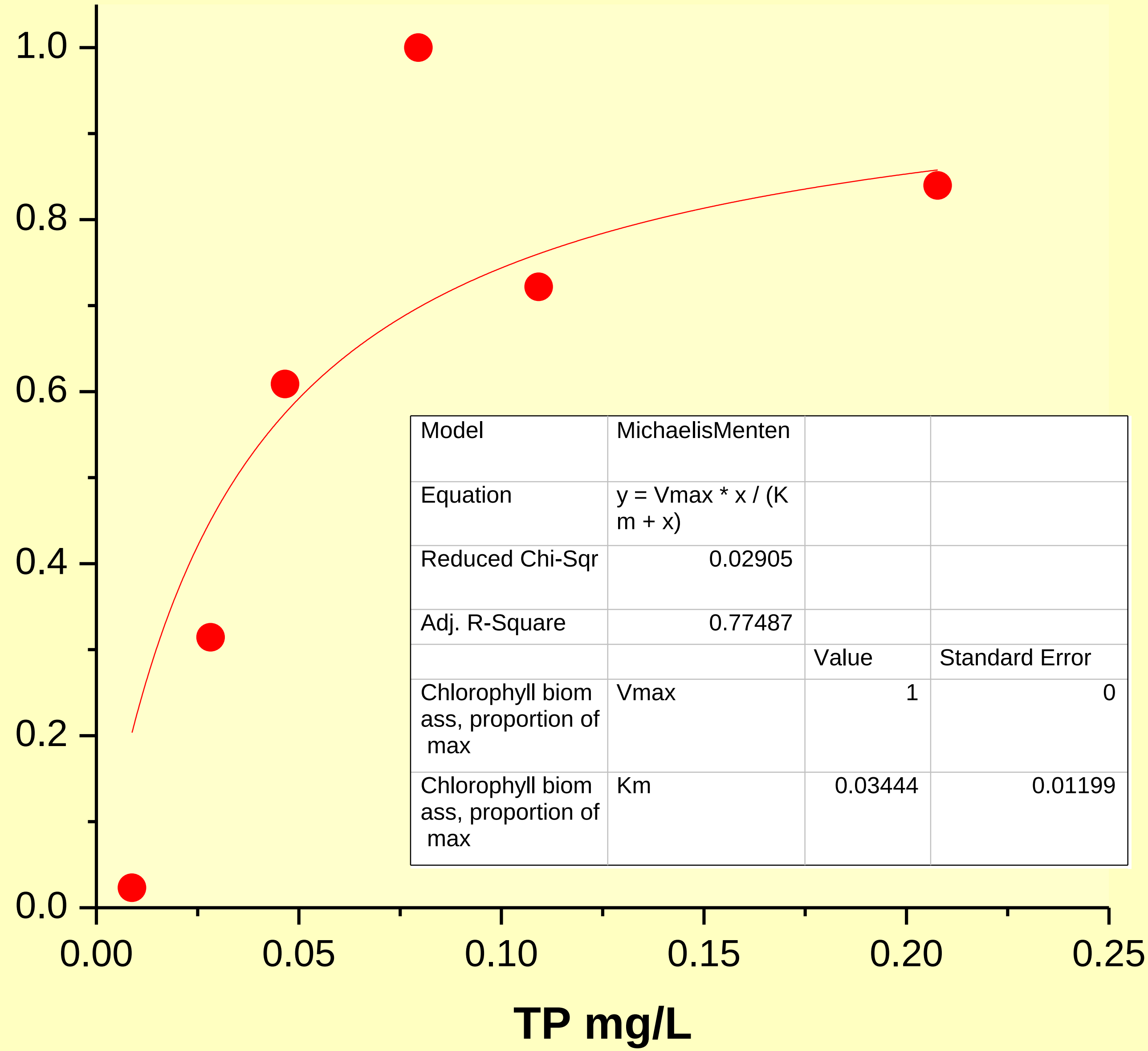


WATER LINES

Periphyton response: Epiphytic algae community was introduced with the duckweed

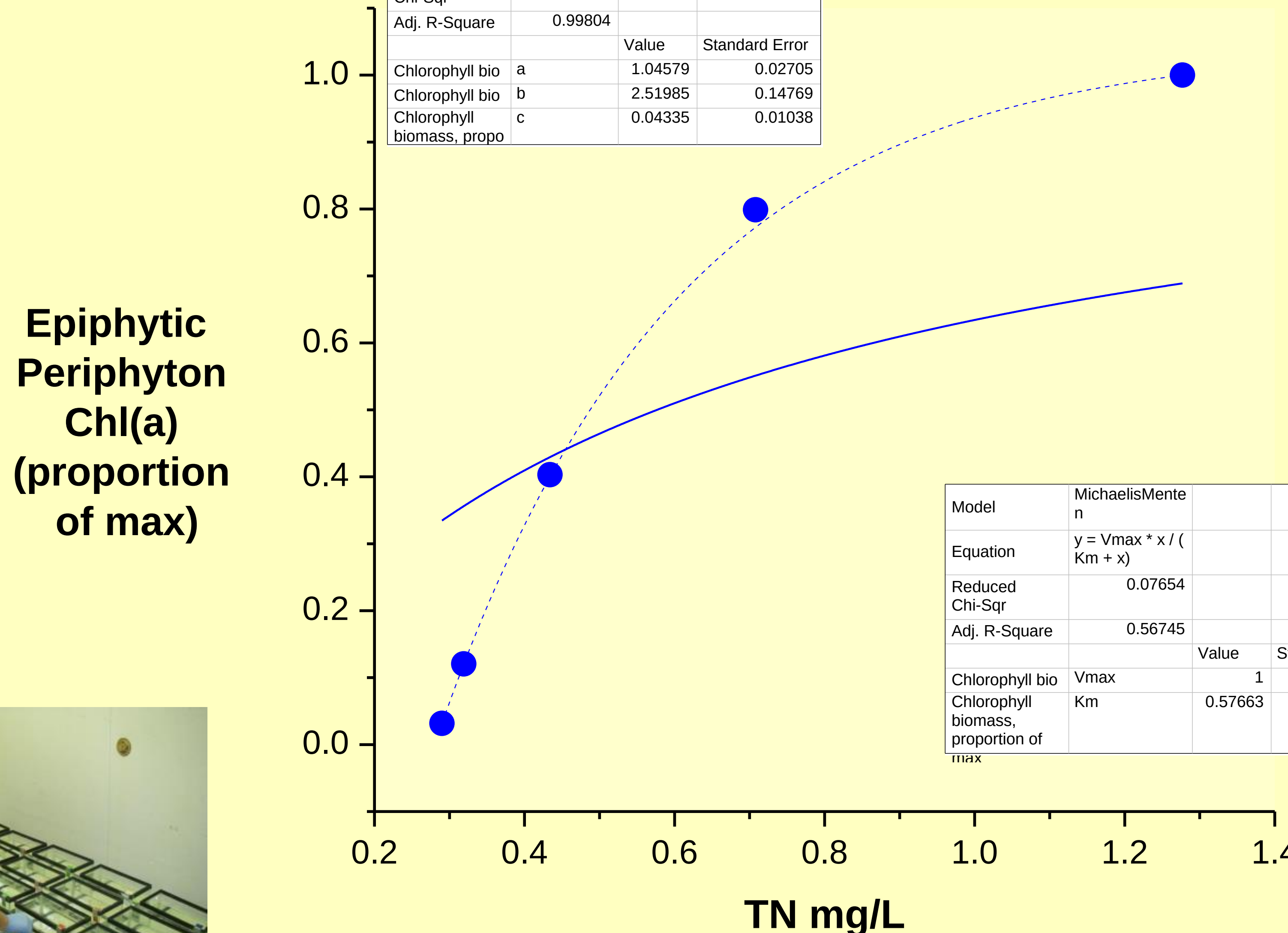

FIRST AID
FIRST AID

(2) Periphyton (multiple undifferentiated species) growth in aquaria using water from a P-limited stream (low P, high N), spiked with increasing P concentrations; unpublished tests conducted at ISU



Model	MichaelisMenten		
Equation	y = Vmax * x / (Km + x)		
Reduced Chi-Sqr	0.02905		
Adj. R-Square	0.77487		
		Value	Standard Error
Chlorophyll biomass, proportion of max	Vmax	1	0
Chlorophyll biomass, proportion of max	Km	0.03444	0.01199

(2) Periphyton (multiple undifferentiated species) growth in aquaria using water from a N-limited stream (“high” P, low N), spiked with increasing N concentrations; unpublished tests conducted at ISU



Model	Asymptotic1		
Equation	y = a-b*c^x		
Reduced Chi-Sqr	3.46272E-4		
Adj. R-Square	0.99804		
		Value	Standard Error
Chlorophyll bio	a	1.04579	0.02705
Chlorophyll bio	b	2.51985	0.14769
Chlorophyll biomass, propo	c	0.04335	0.01038

Model	MichaelisMenten		
Equation	y = Vmax * x / (Km + x)		
Reduced Chi-Sqr	0.07654		
Adj. R-Square	0.56745		
		Value	Standard Error
Chlorophyll bio	Vmax	1	0
Chlorophyll biomass, proportion of max	Km	0.57663	0.3074

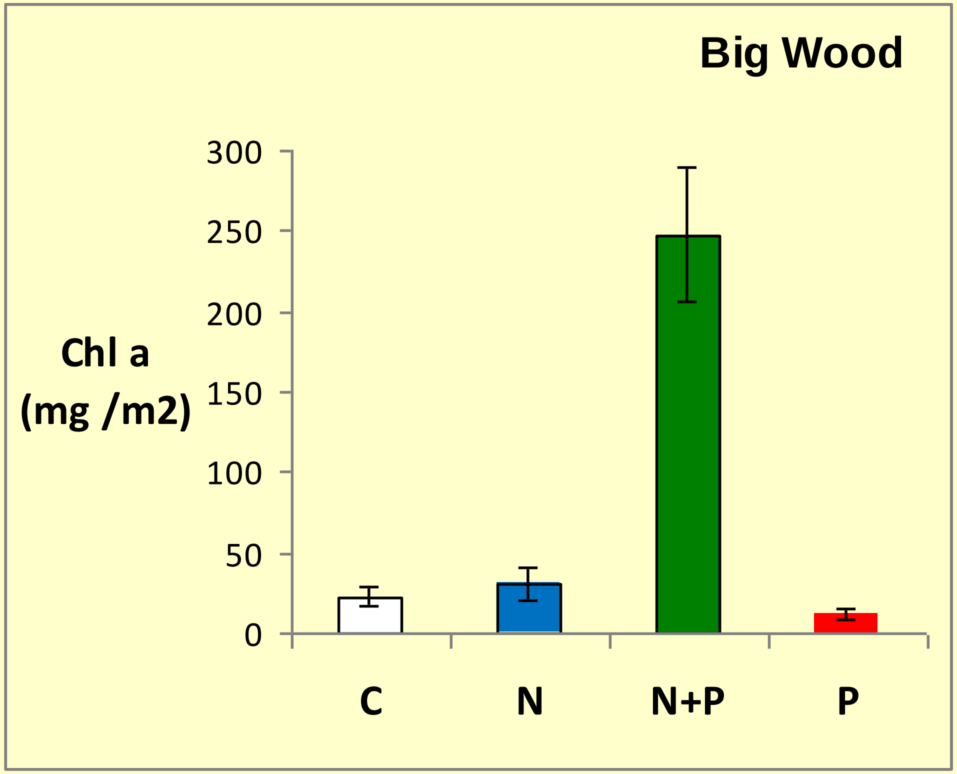
In stream benthic periphyton limitation experiments with nutrient

Red – Phosphorus (P), Blue – Nitrogen (N), Green – N+P, White - controls

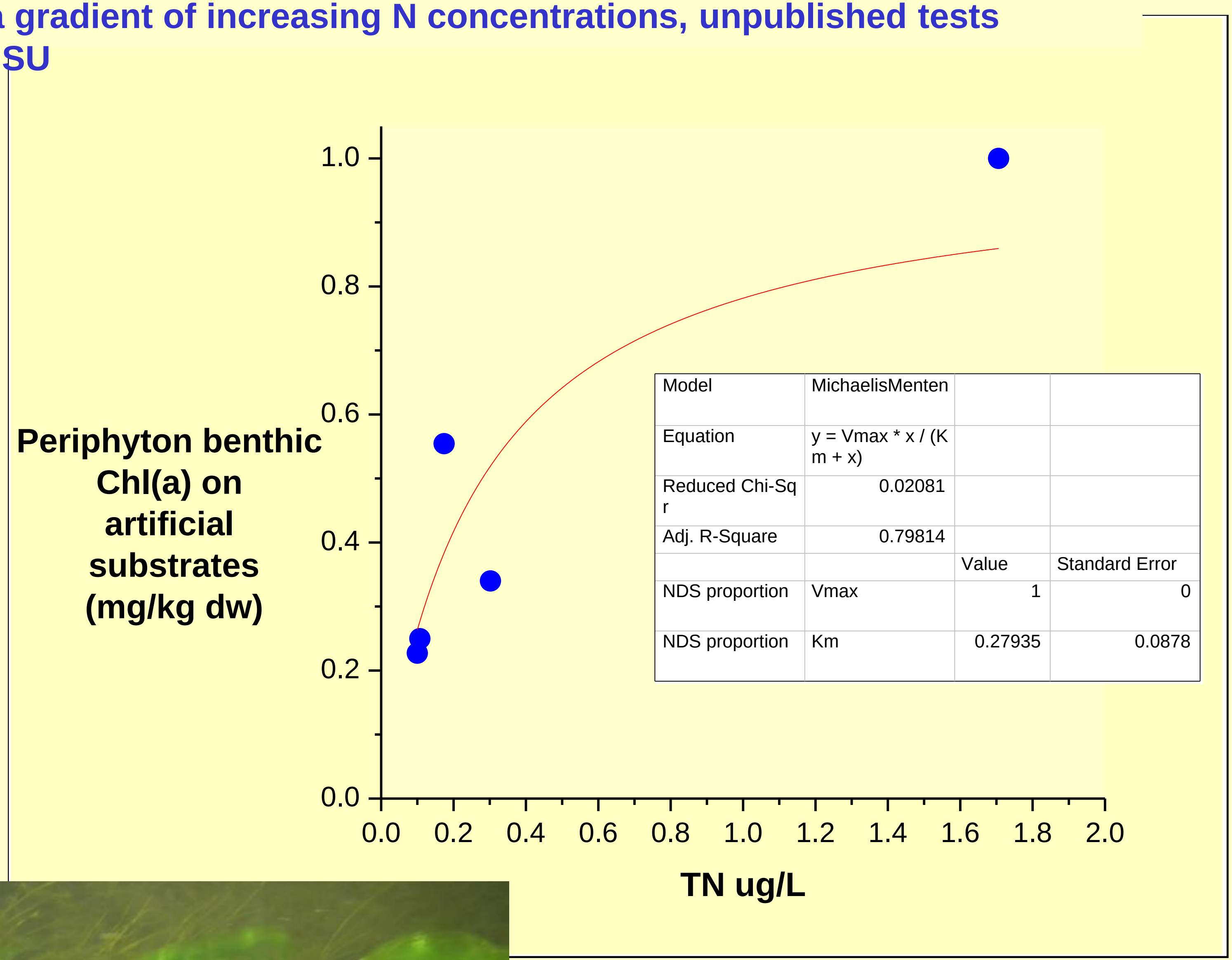

Big Wood River

N+P are co-limiting

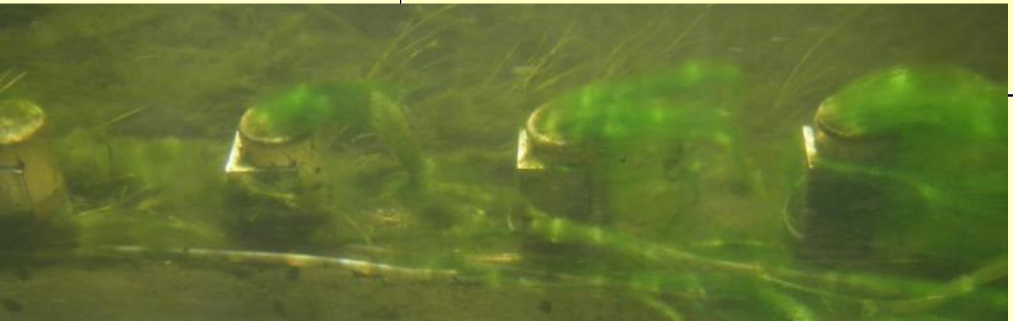
TP: 7 – 10 µg/L
TN: 50 – 100 µg/L
N:P molar ratio: 15 – 22



(4) Periphyton (multiple undifferentiated species) growth in-situ in N-limited streams with a gradient of increasing N concentrations, unpublished tests supported by ISU



Model	MichaelisMenten		
Equation	y = Vmax * x / (Km + x)		
Reduced Chi-Sqr	0.02081		
Adj. R-Square	0.79814		
		Value	Standard Error
NDS proportion	Vmax	1	0
NDS proportion	Km	0.27935	0.0878



Grazing: maybe important, but difficult to capture

“Lawnmower Lymnaea” in Camas Creek, near Fairfield, ID