Phosphorus availability and leaf species affect litter stoichiometry

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Funding:

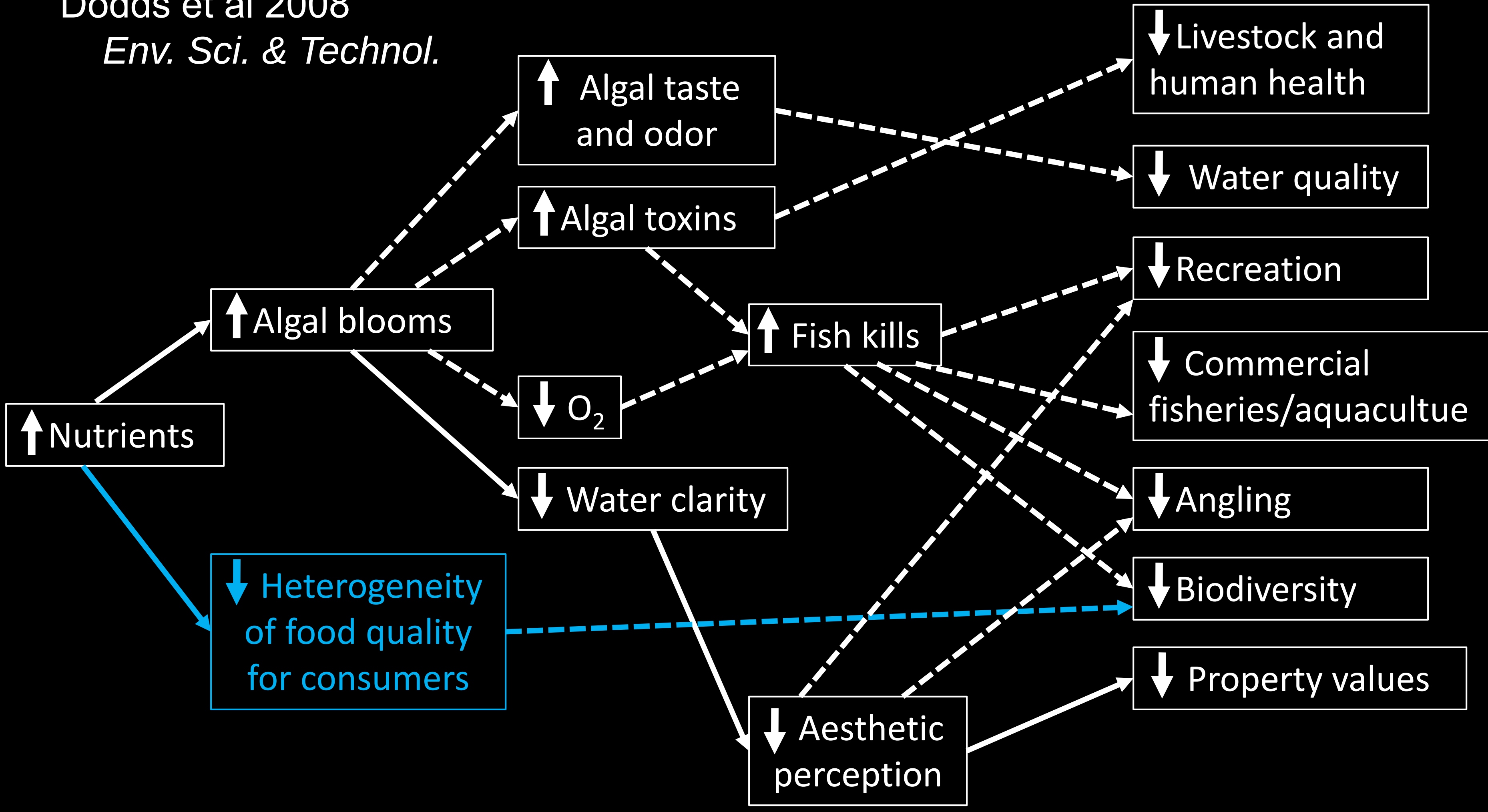
NSF
AR Dept. Higher Ed.
AR Ag. Exp. Stat.

Outline

- Background
- Methods
- Results
- Conclusions

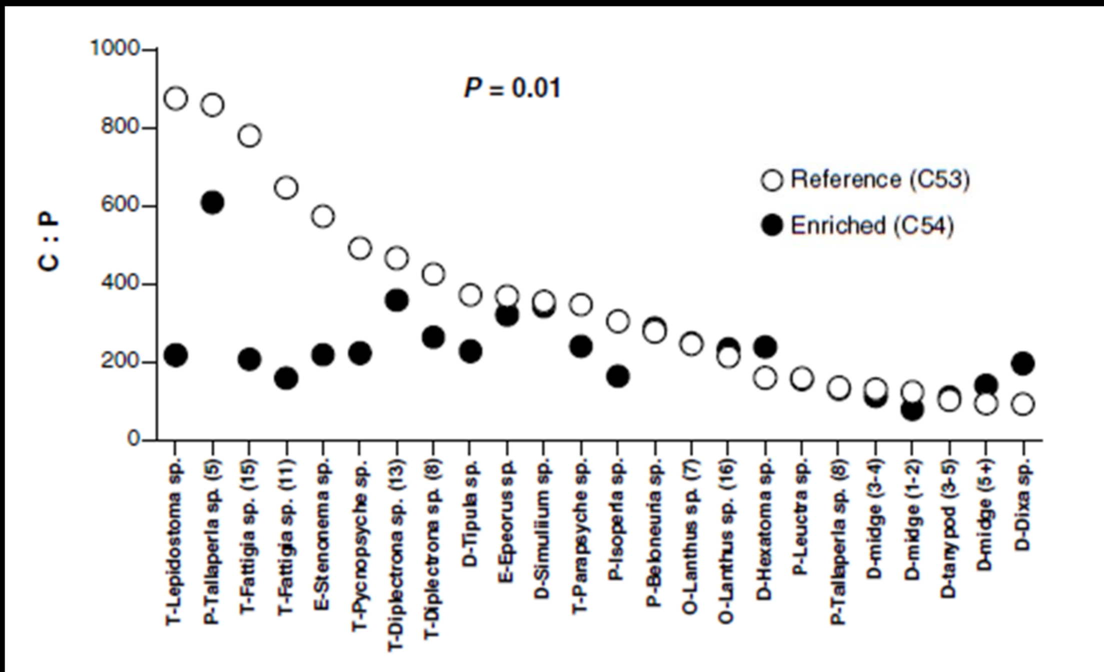
Economics of Eutrophication

Dodds et al 2008
Env. Sci. & Technol.



Homeostasis and Elemental Imbalances

Cross et al., 2003



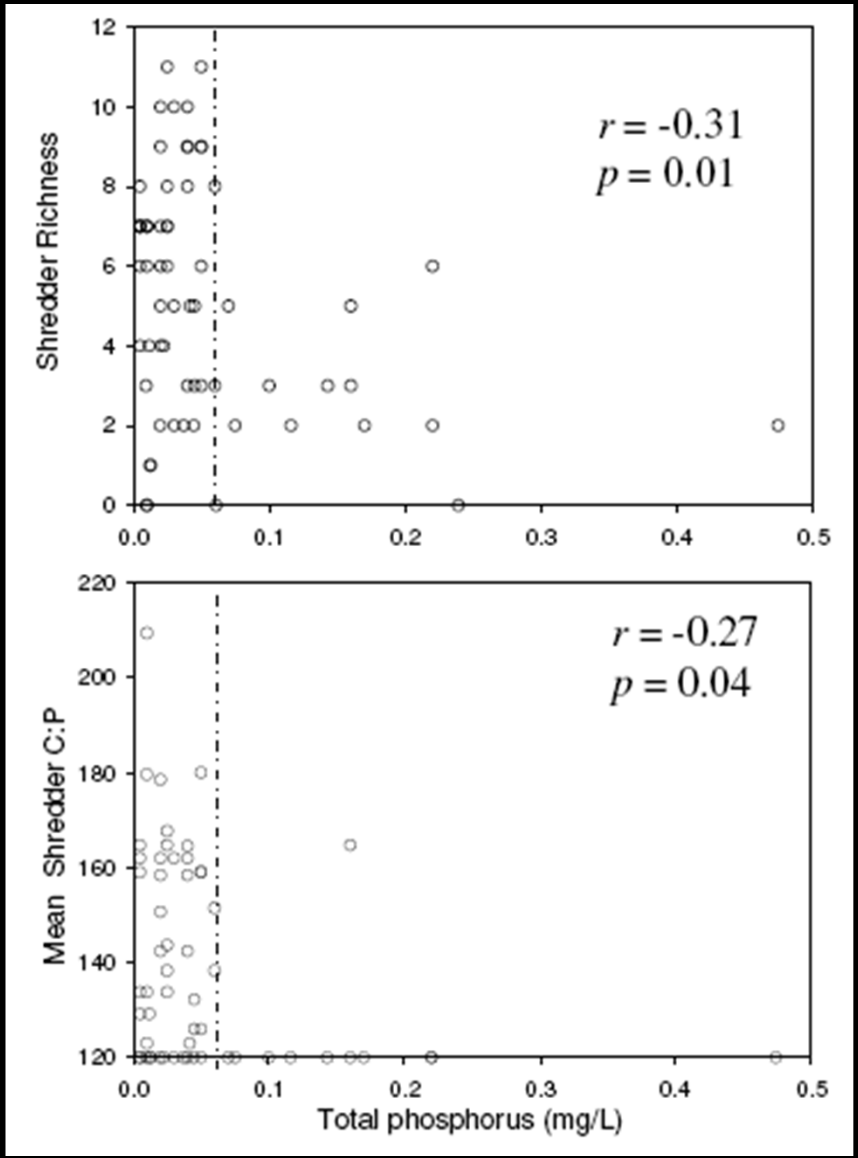
Deviation from strict homeostasis

Energetic cost for some taxa (Boersma and Elser, 2006)

Consequences?

	Trophic group						Food resource			Imbalance	
	C 53			C 54			C 53	C 54		C 53	C 54
	Mean	Range		Mean	Range		Mean	Mean		Mean	Mean
Shredders							Leaf detritus				
C : P	498	(136-877)		252	(123-610)		4858	3063		4360	2565

P effects on shredders



Shredder richness is often lower in Ozark streams with high total P

Shredder C:P is low in Ozark streams with high total P

Ability to cope

Evans-White et al. *unpublished data*

Economics of Eutrophication

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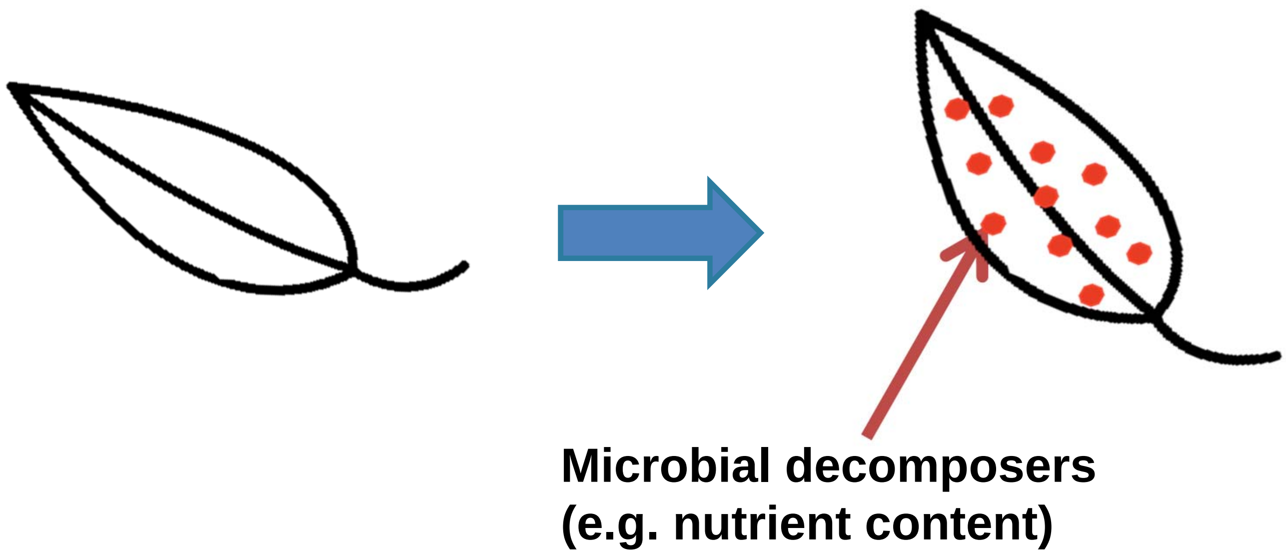
What is the mechanism?

Microbial activities

- Aquatic microbes decompose fallen leaves in streams
  - N and P from leaves and water column (Suberkropp 1998)
- Increase N & P leads to increased microbial activity
- Detritus is a basal food resource in forested streams
- Microbial colonization as the basis of invertebrate consumer selection (Kaushik and Hynes, 1971)

Leaf litter decomposition

- Factors affecting decomposition:
  - Leaf nitrogen and phosphorus
  - Lignin content (Gessner and Chauvet, 1994)
  - Dissolved N & P from the water column (Caraco et al., 1998)



Experimental and multi-scale observational studies

- Laboratory experiment at environmentally relevant P concentrations
- In-stream experiment with nutrient diffusing substrata (NDS)
- Multi-stream phosphorus gradient

Methods – Laboratory Exp.

- Sugar maple & post oak

P treatments: 0 P, 0.05 mg/L, 0.5 mg/L

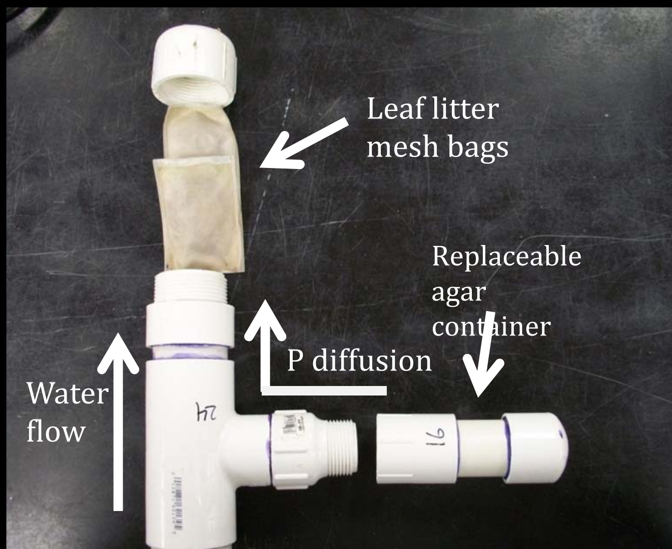
Sampled on days: 0, 5, 8, 13, 20, 28, 36, 43, 59, 72, 95, 115, and 139

Litter elemental composition:

-CHN elemental analyzer

-Ascorbic acid following persulfate digestion

Methods – In-stream Exp.



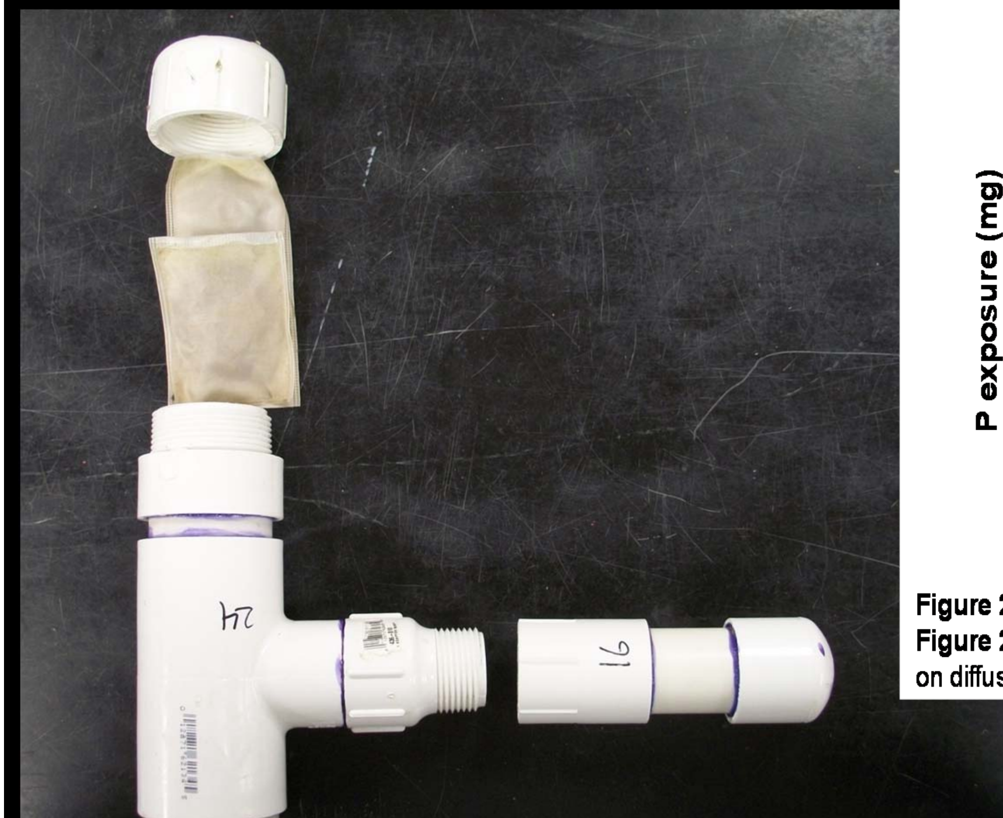
- NDS Units
  - Agar
    - High P, moderate P, or no P (control)
  - 50 µm mesh litterbags

- Placed along 4 stream transects
- 12 sampling dates over 154 days
- C and P content

In-stream experiment

Nutrient diffusing substrata

- P release rates
- pulse additions



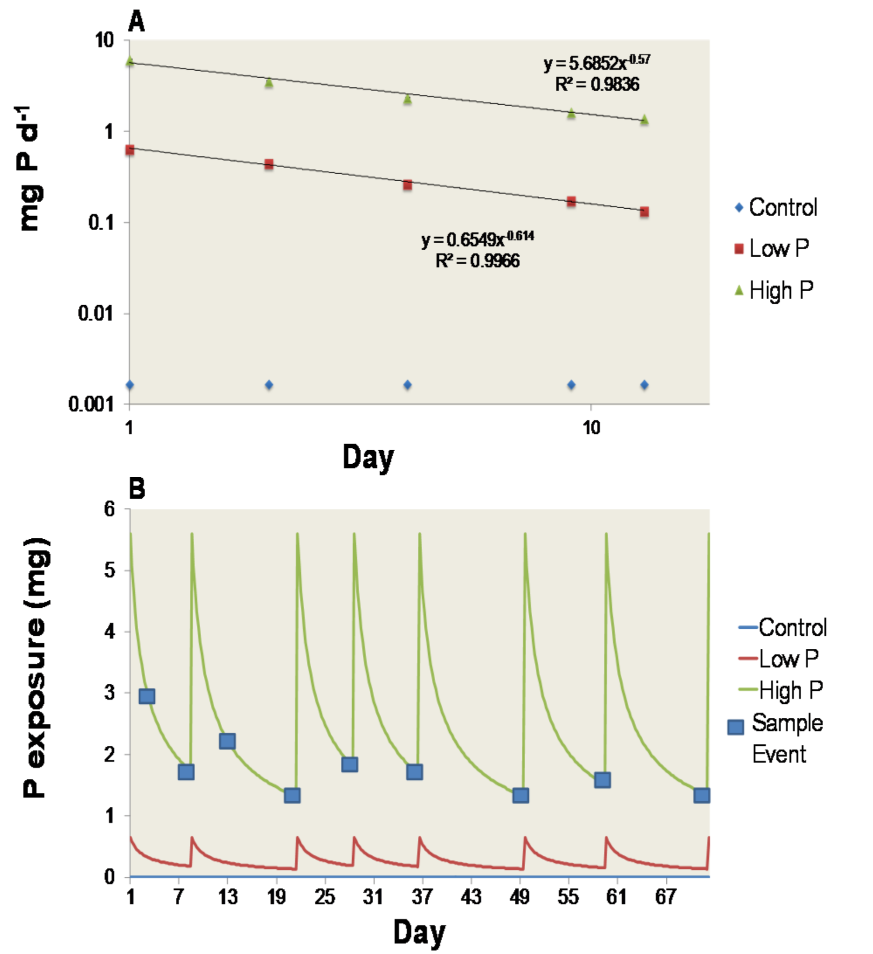


Figure 2A. P diffusion rates shown as mg P d^{-1} vs. day on a log scale.
Figure 2B. Amount of P leaves were exposed to throughout the study period based on diffusion rates and when agar was replaced.

Methods – Natural P gradient

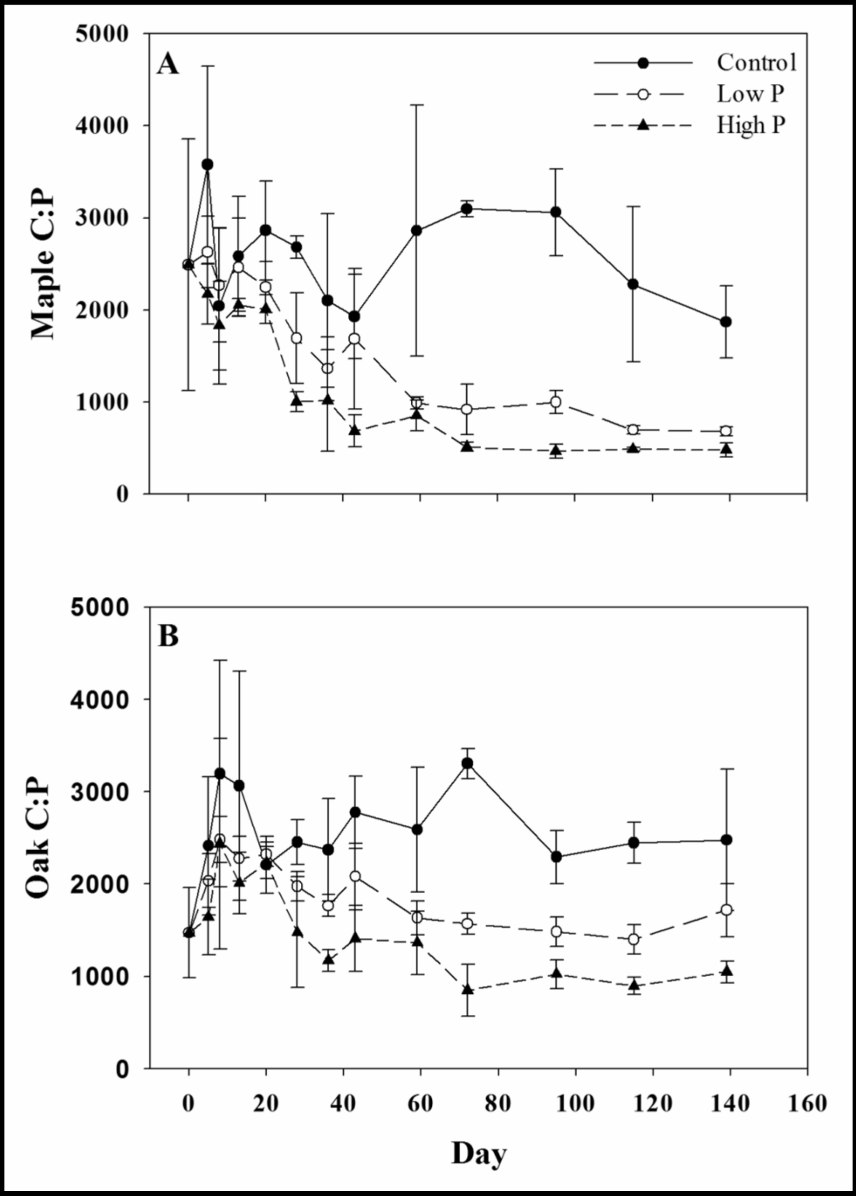
Mixed leaf litter:
-CHN elemental analyzer
-ascorbic acid following HCl digest

Stream water:
-Ascorbic acid following persulfate digestion

Statistical analyses

- Cumulative probability of threshold followed by one way ANOVA post hoc means test, REGWQ
- ANOVA REGWQ
- Linear regression of leaf C:P versus TP in SigmaPlot

Laboratory experiment

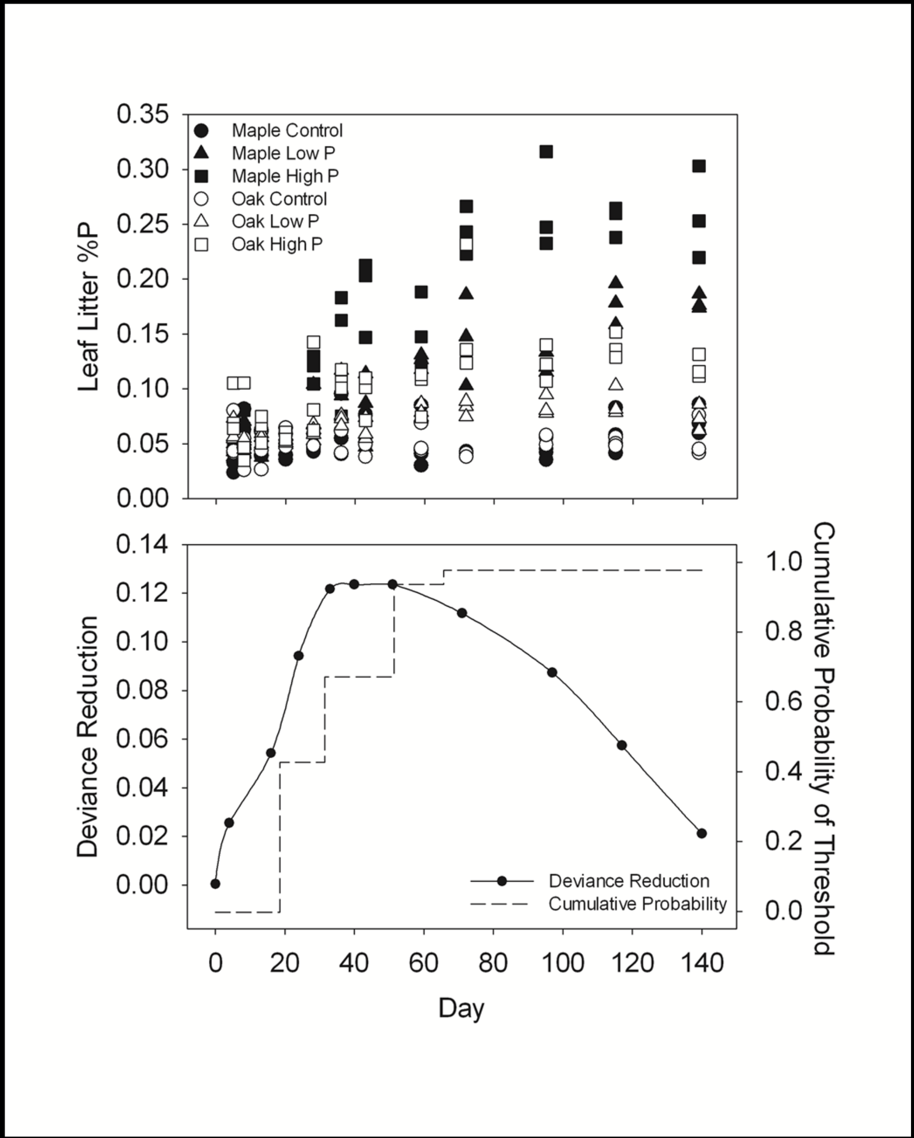


Initial increase in C:P

Greater separation across P treatments in maple leaves

Divergence begins after ~ 20 and 60 days for maple and oak, respectively

Laboratory experiment



Raw data for all treatments on all days

Non-parametric change point analysis

When can a change in leaf chemistry be detected?

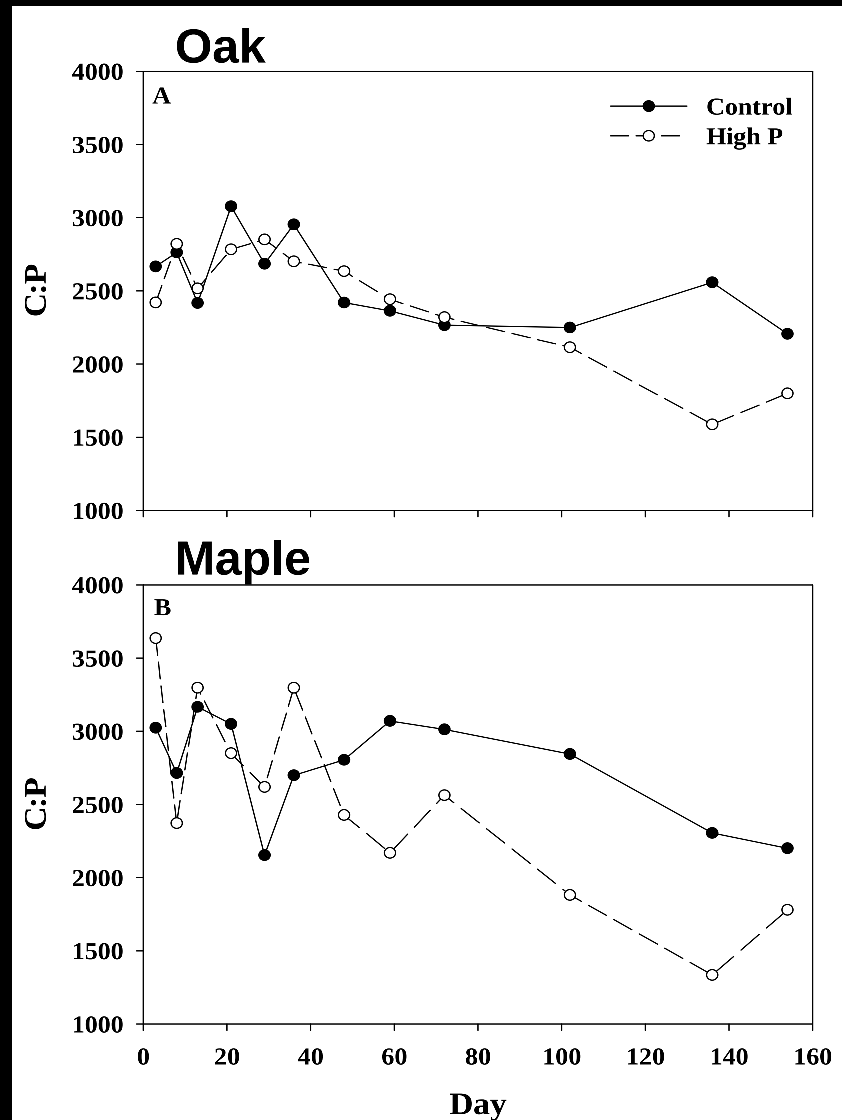
Laboratory experiment

Treatment	C:P Maple	C:P Oak
Control	2578 ± 705 A	2629 ± 553 A
Low P	825 ± 194 CD	1541 ± 205 B
High P	488 ± 55 D	953 ± 175 C

* Means after day 70 ± 1 SD (n = 12)
* Means with same letter are not significantly different

In-stream experiment

- Treatment divergence starting on day 49 for maple, day 136 for oak
- Response to P enrichment faster in maple, slower in oak
- Response to P enrichment greater in maple



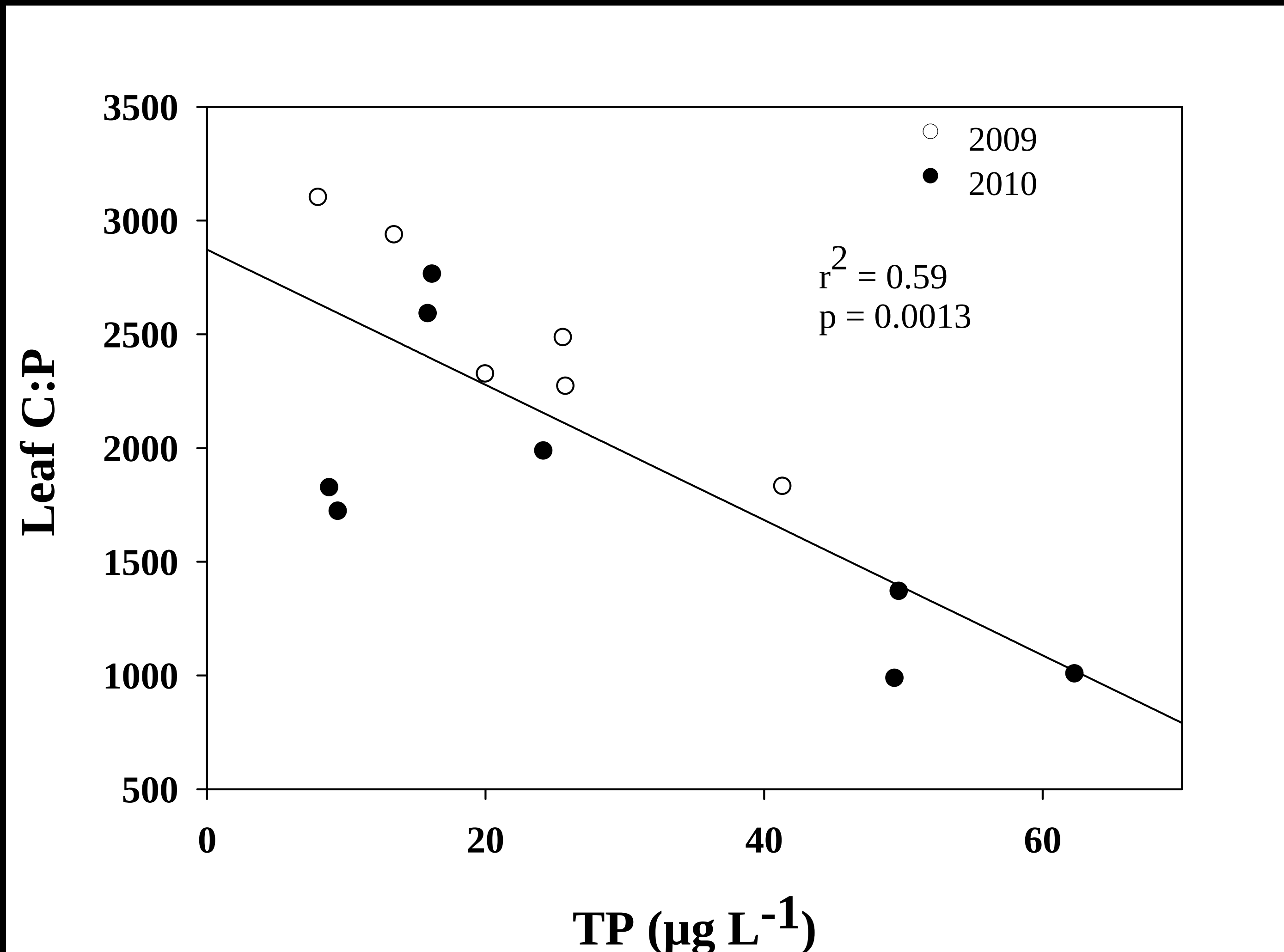
In-stream experiment

Labile versus recalcitrant, P enrichment

	C:P	
Treatment	Maple	Oak
Control	2450 ± 346 A	2338 ± 192 A
High P	1665 ± 291 B	1833 ± 265 AB

* Means after day 100 ± 1 SD (n = 3)
* Means with same letter are not significantly different

Multi-stream phosphorus gradient



Future Research

Importance of autotrophic component?
- variable P enrichment
- variable light intensities

P enrichment / light effects on:
- algal biomass
- microbial respiration
- P uptake and release rates
- detrital stoichiometry

Conclusions

- Effects vary across leaf type and P concentration
- P enrichment may change litter C:P by an order of magnitude between oligotrophic and eutrophic Ozark streams
- Leaf stoichiometry varies in Ozark streams in response to very minimal increases in P availability
- Potential negative effect on macroinvertebrate communities


Thank you.
Questions?