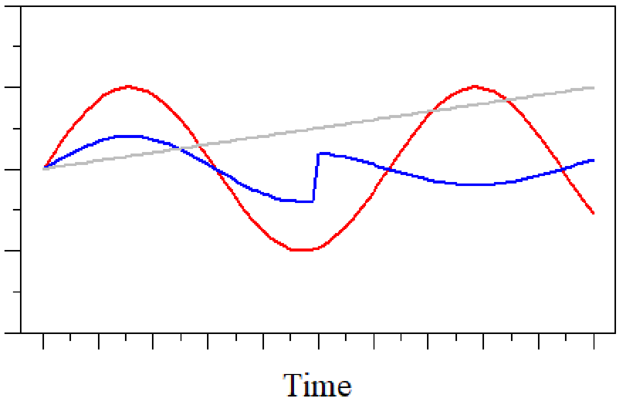
Ecological stoichiometry through the lens of long-term data:

Using stoichiometry to understand dynamic ecological systems

Paul Julian[1], Adam Wymore[2] and John Kominoski[3]

https://www.deviantart.com/oo-ninart-oo



THE WHITNEY LABORATORY for MARINE BIOSCIENCE

University of New Hampshire

FIU Arts & Sciences
School of Environment, Arts and Society

Approximate Schedule

Duration (Minutes)	Agenda Item
15	General Introductions
7	Speaker #1 Dr Walter K. Dodds
7	Speaker #2 Dr Becky Ball
7	Speaker #3 Dr John Kominoski
7	Speaker #4 Dr Adam Wymore
35	Round Table Discussion **Everyone**
	15 Minutes of Small Group Discussion
	20-Minutes Report Back
10	Wrap-up

Objectives/Goals

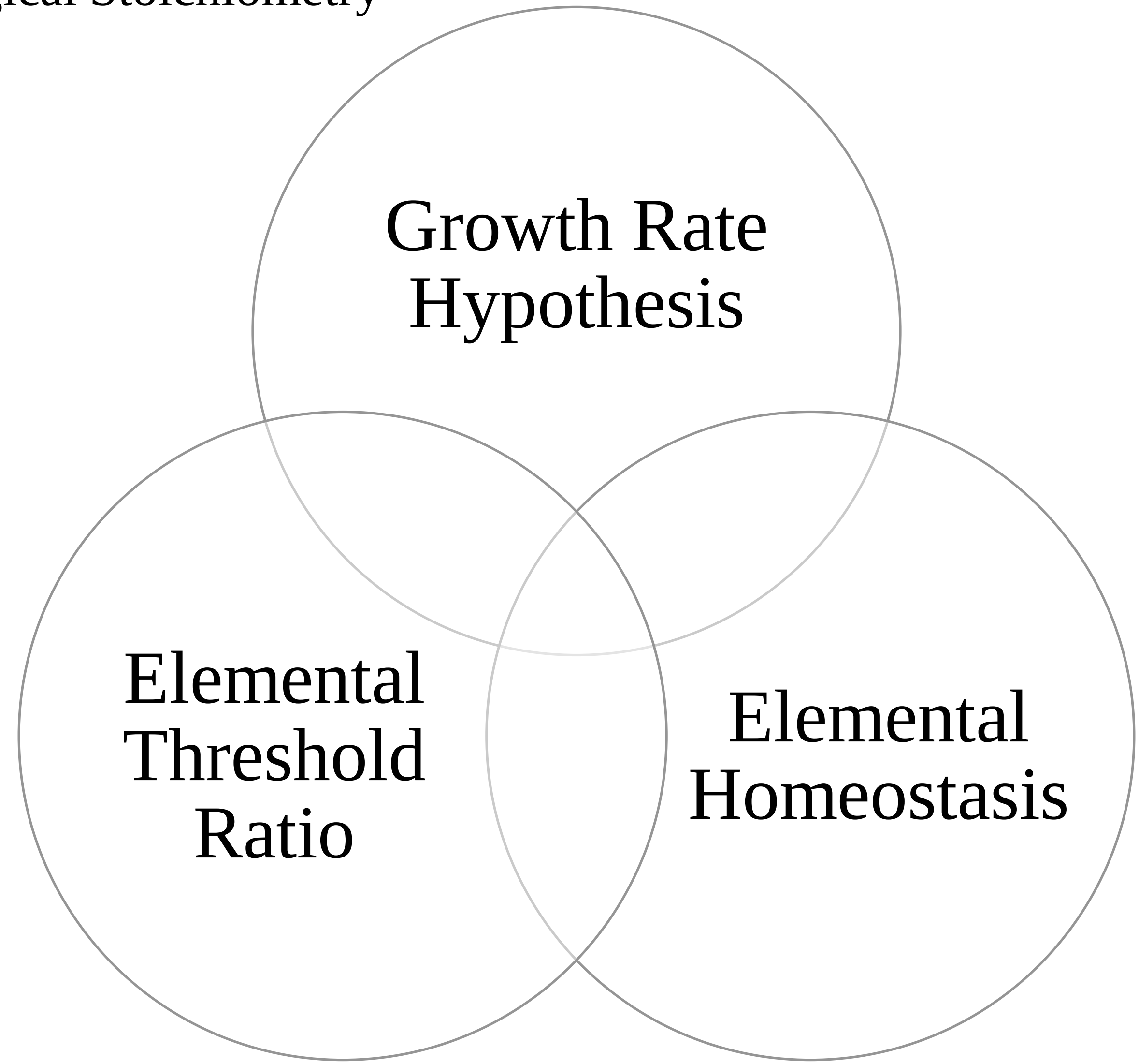
- The objective of this work is to stimulate cross-site syntheses related to biogeochemical cycling of energy and nutrients and to better understanding mechanisms that control productivity (via ecological stoichiometry).

- The primary goal of this work is to foster collaborative synthesis between LTER sites related to ecological stoichiometry.

Introductions

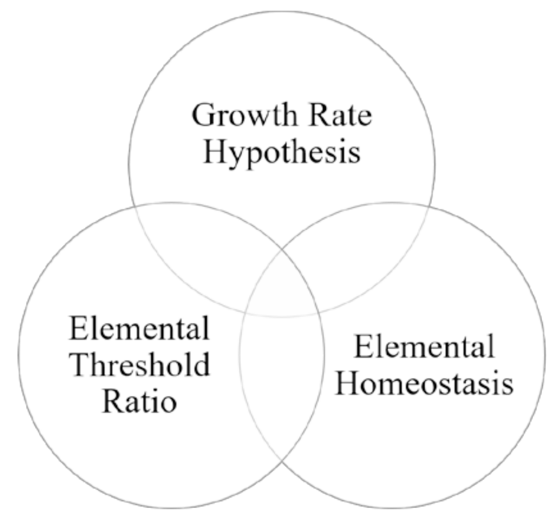
- Name
- Site and Affiliation (LTER site, University/Agency, etc.)
- Feelings on ecological stoichiometry? (love it? Hate it? Want to know more? How will it fit into my site?)

Ecological Stoichiometry



Global Change Drivers:

1. Sea-level rise
2. Nutrient mobilization
3. Fire
4. Temperature
5. Drought
6. Etc.



Growth Rate Hypothesis

- Differences in maximum growth rate drive variation in organismal %P due to greater allocation to support rapid growth.
  - Supported by empirical tests from a variety of organisms as reviewed by Moody et al (2017).
  - Formulated specifically for invertebrate growth under P-limitation and constant temperatures.

- Moody et al (2017) evaluated P-content and growth of macroinvertebrates in tropical streams.
  - Does not apply across temperature.
  - Other factors drive variation in organismal P for marcoinvertebrates

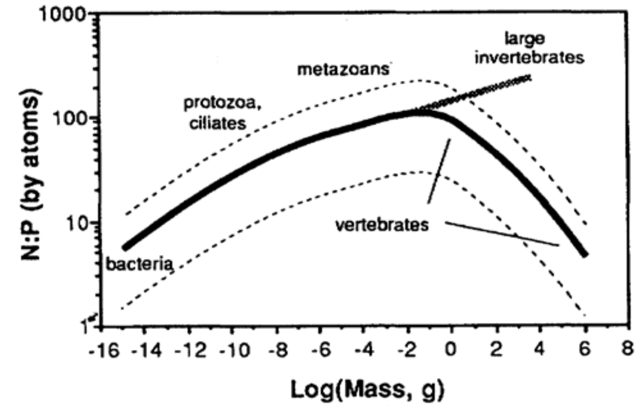


Figure 7. Predicted variation in organism N:P ratio (by atoms) as a function of organism size (g dry weight). Dotted lines above and below the main trend (black line) are meant to indicate that there is likely to be important ecologically or evolutionarily derived variation in organism N:P ratio at any given body size. For large organisms, two trajectories are possible. One trajectory (gray line) corresponds to a continuous increase in organism N:P ratio (which is likely for large invertebrates) and the other to a decline in organism N:P ratio due to increasing bone investment in vertebrates (the main group of animals of large body size).

Elser et al (1996)

- *Elser et al (1996) Organism Size, Life History, and N:P Stoichiometry. BioScience 46:674–684.*
- *Moody et al (2017) Does the Growth Rate Hypothesis Apply across Temperatures? Variation in the Growth Rate and Body Phosphorus of Neotropical Benthic Grazers. Front Environ Sci 5.*

Elemental Threshold Ratio

- Change in growth limitation from one element to another.
    - Optimal nutrient ratio in primary producers.
    - “stoichiometric knife-edge” in consumers

- Nutritional mixture where growth is fastest characterized by high “dietary” and environmental supplies of all needed nutrients.

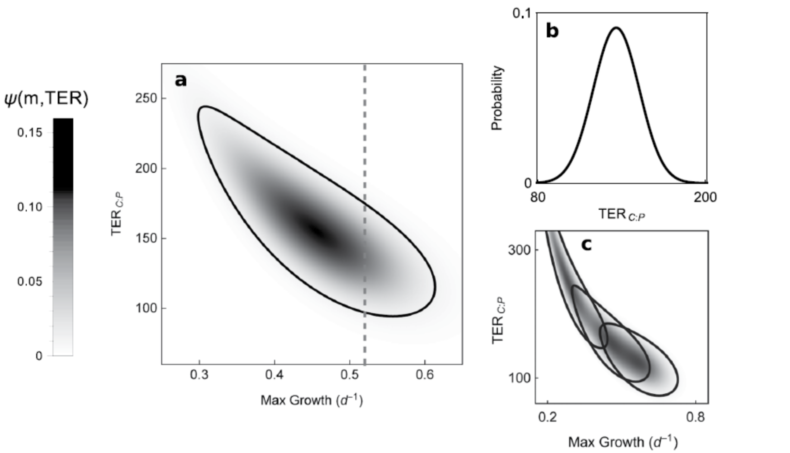


Figure 3. Modelled threshold elemental ratios of carbon and phosphorus in *Daphnia*. (**a**) Probability vs $TER_{C:P}$ and maximum growth rates estimated by individual mass-balance model using parameter values and error found in Table 2. The z scale (amount of shading) indicates how probable it is that with the specified parameters, *Daphnia* will experience the $TER_{C:P}$ and maximum growth combination indicated by the axis values. The solid line surrounding the region of high probability represents the 95% confidence region (**b**) Direct slice of plot a (indicated by dotted line) through a maximum growth rate of 0.52 as indicated by the dotted line in a. (**c**) $TER_{C:P}$ versus maximum growth rates for calculated with different assimilation efficiencies. 95% confidence region for each are circled $A_c = 0.5$ (left), $A_c = 0.68$ (middle) and $A_c = 0.8$ (right).

(Khattak et al. 2018)

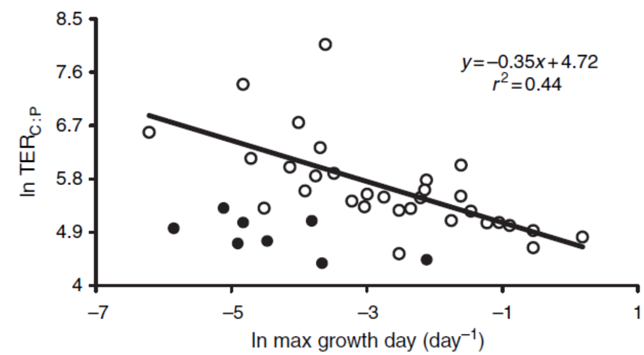


Figure 4 Relationship between threshold elemental ratio $(TER)_{C:P}$ and maximum growth rates among 41 taxa of aquatic animals. Open circles denote invertebrates and closed circles show fish. (a) Maximum growth rates were obtained from published studies of each species included in the database. (b) Fish have been excluded from the linear regression analysis given that their fundamentally different body construction (i.e. high P content of bony skeleton) displaces their $TER_{C:P}$–growth relationship relative to invertebrates.

(Frost et al. 2006)

- *Frost et al (2006) Threshold elemental ratios of carbon and phosphorus in aquatic consumers. Ecology Letters 9:774–779.*
- *Khattak et al (2018) The threshold elemental ratio of carbon and phosphorus of Daphnia magna and its connection to animal growth. Scientific Reports 8:9673.*

Elemental Homeostasis

- Stoichiometric relationship between organisms and the environment.
    - ***Homeostasis***: change in resource stoichiometry has not change in organism stoichiometry.
    - ***Non-Homeostasis***: changes in resource stoichiometry drive corresponding changes in organism stoichiometry.

- Meunier et al (2014) introduced terms conformer and regulator.
    - A better understanding of how organism are affect by and affect their environment.

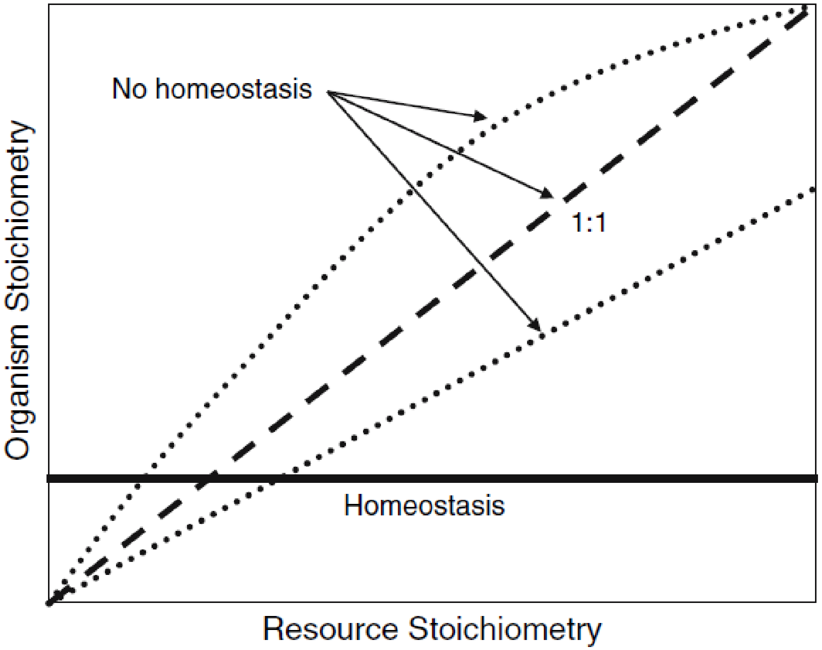


Fig. 1 Potential patterns relating resource to consumer stoichiometry. The stoichiometry of *homeostatic* organisms (solid line) is strictly defined, and changes in resource stoichiometry do not influence organism stoichiometry. The stoichiometry of *non-homeostatic* organisms may match resource stoichiometry in a 1:1 relationship (large dashes) or in a relationship (small dashes) that diverges from the 1:1 line (Adapted from Sterner and Elser 2002)

(Cleveland and Liptzin 2007)

"Without homeostasis, ecological stoichiometry would be a dull subject"

- *Cleveland and Liptzin (2007) C:N:P stoichiometry in soil: is there a "Redfield ratio" for the microbial biomass? Biogeochemistry 85:235–252.*
- *Meunier et al (2014) A New Approach to Homeostatic Regulation: Towards a Unified View of Physiological and Ecological Concepts. PLoS ONE 9:e107737.*

Workshop info and collaboration

Branch: master ▾ | New pull request | Create new file | Upload files | Find file | Clone or download ▾

SwampThingPaul Update README.md ... Latest commit e413983 on Aug 12

CODE_OF_CONDUCT.md	Create CODE_OF_CONDUCT.md	3 months ago
FCE_Stoich.md	Update FCE_Stoich.md	2 months ago
README.md	Update README.md	a month ago
ReferenceFormat.md	Create ReferenceFormat.md	3 months ago
Stoich_Synthesis.xlsx	Add files via upload	a month ago

README.md

Ecological stoichiometry through the lens of long-term data: Using stoichiometry to understand dynamic ecological systems.

This project came to fruishion as a proposed session for the 2018 Long Term Ecological Research (LTER) All-Scientist Meeting (ASM).

Organizers:

- Paul Julian II PhD (webpage, email)
- Adam Wymore PhD (webpage, email)
- John Kominoski PhD (webpage, email)

Overview

The overarching theme of ecological stoichiometric theory is to understand the coupling of energy to nutrient biogeochemical cycles as mediated by the demands and constraints of homeostasis and thermodynamics. Stoichiometric homeostasis is loosely defined as the degree to which organisms maintain elemental stoichiometry relative to the ambient environment. Stoichiometric homeostasis however, is not fixed, rather it can vary among and within organisms. Processes such plant and microbial uptake efficiency and nutrient resorption influence site specific nutrient cycles resulting in a strong feedback mechanism altering the mass-balance between ecosystems compartments (i.e. water column, soil, vegetation, etc.) and a cascade of stoichiometric pressures causing variability and disproportionate stoichiometry across the system. External drivers

https://github.com/SwampThingPaul/LTER_EcoStoich