

FINAL REPORT

“Stream ecosystem responses to nutrient enrichment at multiple trophic levels” LTER synthesis working group 2013

The goals of our working group were:

- (1) to initiate and coordinate the integration of data from multiple sites on stream ecosystem responses to nutrient amendment
- (2) to synthesize these data with a quantitative evaluation of functional responses at the microbial, primary producer, consumer and whole-stream levels
- (3) to promote interaction between LTER and the NEON experiment (Stream Experimental and Observatory Network, STREON)

Participants included:

Marcelo Ardon, East Carolina University (CWT) *co-PI
Becky Bixby, University of New Mexico (SEV) *co-PI
Jim Brock, Desert Research Institute
Ayesha Burdett, New Mexico Museum of Natural History and Science
Scott Cooper, University of Santa Barbara
Walter Dodds, Kansas State University (KNZ) *co-PI
Natalie Griffiths, Oak Ridge National Laboratory
Nancy Grimm, Arizona State University (CAP)
Tamara Harms, University of Alaska-Fairbanks (BNZ)
Sherri Johnson, Oregon State University (HJA) *co-PI
Jay Jones, University of Alaska-Fairbanks (BNZ)
John Kominoski, Florida International University (FCE)
Bill McDowell, University of New Hampshire (LUQ)
Amy Rosemond, University of Georgia (CWT) *co-PI
Jennifer Follstad-Shah, Utah State University
Matt Trentman, Kansas State University (KNZ)
Ryan Utz, National Ecological Observatory Network
Dave Van Horn, University of New Mexico (MCM)
Amy Ward, University of Alabama
Lydia Zeglin, Oregon State University (HJA) *PI

Our group met twice:

Meeting 1: 2-day Workshop April 4-5, 2013, Boulder, CO
Meeting 2: Lunch discussion May 21, 2013, Society for Freshwater Sciences (SFS) Annual Meeting, Jacksonville, FL; plus informal follow-up discussions during SFS

Products include:

1. Database of stream biological rate and state responses to experimental nutrient enrichment
2. Manuscript in preparation addressing the overarching synthesis question
3. Ongoing motivation for additional manuscripts, proposals, and collaborative activities
 1. The database meets the first working group goal by compiling published data from multiple sites on stream ecosystem responses to nutrient amendment. Working group participants contributed to this database by discussing and agreeing upon data inclusion criteria

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(Meeting 1) and by harvesting data from primary literature into the database template. The full Access database file is currently shared among all group members and will be made public following publication of the overarching manuscript and participant agreement via *e.g.* Ecological Archives &/or an LTER data repository. The data included, as finalized during Meeting 1, is as follows:

- Source information
 - Study reference (code and name)
 - Initials of data harvester with unique identifier for each LRR
 - Individual experiment (coded) for each nutrient manipulation treatment (N &/or P) within each reference
 - Site name
 - Site coordinates (latitude and longitude in decimal degrees)
 - LTER status
- Response variable information
 - Trophic category and rate/state categorization
 - Metrics/methods utilized (text description for reference only)
- Categorical (for groups comparison analyses)
 - Type of nutrient: N &/or P; ammonium, nitrate, TN, SRP, TP
 - Experimental type category: bottle, flume, NDS, whole-stream
 - Continent
 - Biome
 - Land use
 - Season
 - Canopy cover (closed vs. open (open = < 75-90% cover))
- Independent continuous variables (for correlation/covariate analyses)
 - Ambient nutrient concentrations ($\mu\text{g L}^{-1}$)
 - Experimental nutrient concentrations ($\mu\text{g L}^{-1}$)
 - % Nutrient augmentation (calculated)
 - Experiment duration (d)
 - MAP (mm y^{-1})
 - Stream order
 - Stream width (m)
 - Mean temperature (degrees C)
 - DOC (mg L^{-1})
 - PAR ($\mu\text{mol photons m}^{-2} \text{s}^{-1}$)
 - pH
 - Conductivity ($\mu\text{S cm}^{-1}$)
- Dependent
 - Control value of response variable
 - Experimental value of response variable
 - Variance of control value
 - Variance of experimental value

Trophic levels for response variables were defined:

Response variable = **rate of accumulation of carbon** within a defined trophic level
= **standing stock of carbon** within a defined trophic level

Acceptable proxies for rate or state of C accumulation follow. Only ONE control/response pairing for each #x category may be included in the metaanalysis per experiment. Data types that take precedent for inclusion in the dataset if multiple data types are recorded for a single category are highlighted in **bold**.

1. Microbial trophic level
 - a. Rate: heterotrophic cell production rate (substrate-specific)
 - b. State: bacterial or fungal **cell abundance**, conidia counts
2. Primary producer trophic level
 - a. Rate: autotrophic cell production rate (substrate-specific) or whole-stream GPP
 - b. State: **chlorophyll-a**, cell density or biovolume
3. Primary consumer trophic level
 - a. Rate: growth rate, **total production** of total of measured taxa (choose grazers or shredders as substrate-appropriate)
 - b. State: abundance or biomass of total of measured taxa (choose grazers or shredders as substrate-appropriate)
4. Secondary consumer trophic level
 - a. Rate: growth rate or **total production** of total of measured taxa (predators or fish as appropriate)
 - b. State: abundance or biomass of total of measured taxa (predators or fish as appropriate)
5. Integrated trophic levels – includes multiple trophic levels in one metric
 - a. Substrate-specific or whole-stream respiration rate, leaf litter decomposition rate (k^{-1} (per day))

The final database includes 156 papers, 505 individual experiments, and 2432 response-ratio datapoints, with data on experiments from around the globe. Of these studies, 37 (24%) are from LTER sites or authors. All four trophic levels have good coverage: the majority of datapoints are primary producers (1522 or 63%) particularly due to the inclusion of nutrient diffusing substrata, microbial datapoints number 372 (15%), consumer datapoints number 270 (11%) and integrated datapoints number 268 (11%). Concurrent nitrogen and phosphorus addition experiments comprise 52% of the response datapoints, while sole additions of nitrogen or phosphorus comprise 23% and 24% respectively. Preliminary analyses of these data are included in the manuscript in preparation.

2. The manuscript in preparation addresses the second goal of synthesizing these data with a quantitative evaluation of functional responses at the microbial, primary producer, consumer and whole-stream levels. At Meeting 1, we outlined the manuscript outline and discussed preliminary results; at Meeting 2 we discussed further results and prioritized activities for finalizing the manuscript. The target for manuscript submission is early summer 2014.

The manuscript's overarching question is: How does the magnitude of rate and state responses to experimental nutrient enrichment differ among pre-defined "trophic level" groupings? We expect that response magnitude (LRR) will be lower at higher "trophic levels", because response is dampened by loss of energy, thus slower at higher trophic levels. Following this main question, the manuscript examines whether certain stream characteristics (e.g. temperature, latitude, DOC, light level, ambient nutrient concentration) mediate response to nutrient amendment; and whether experimental conditions (amount of nutrients added, proportional increase in nutrients added, duration of experiment, spatial scale of experiment) mediate response to nutrient amendment.

The database is also a resource for additional studies. At Meeting 1, we discussed a number of ideas for peripheral manuscripts, and noted which synthesis group members are interested in pursuing these ideas. Authorship guidelines were also discussed and written up. Any follow-up manuscripts or activities will follow the submission of the overarching manuscript.

3. The two meetings and ongoing planning for follow-up activities all address the goal of promoting interaction between LTER and the NEON experiment (Stream Experimental and Observatory Network, STREON). NEON hosted Meeting 1 in Boulder, CO, where synthesis group members met and interacted with NEON Aquatic staff and had the opportunity to tour NEON testing facilities, and NEON staff sat in on a portion of the meeting and took the opportunity to discuss their work in the context of synthesis goals. STREON coordinator Ryan Utz was a substantive contributor to synthesis activities and to the discussion of continuing future collaboration. NEON Aquatic staff also contributed to the organization of Meeting 2 at SFS, which was primarily devoted to discussion of follow-up coordination activities on the theme of stream responses to increased nutrient concentrations. Group members and those contributing to the follow-up discussion agreed that while there is a lot of literature on stream biotic responses to nutrients (i.e. the database), information on responses to chronic (greater than one season) nutrient addition comes primarily from LTER-based research (which is a fraction of the database), hence a need for coordination between LTER-based researchers and those planning the upcoming STREON experiment (which will impose nutrient addition experiment on ten streams across the US in the near future). This engaged discussion, including ideas for various follow-up activities, progressed to a Research Coordination Network proposal, which was compiled and submitted independently of this synthesis effort.