The Nutrient Network
2011 Workshop

Sponsored by
NSF, UMN, and Institute on the Environment
The Nutrient Network

- Conceived in 2006, in part because of the limitations of meta-analysis
- 66 sites (45 expt, 21 obs), 10 countries, 5 continents
- Standard NPK fertilization protocol implemented in 2008 (at most sites)
- 40 sites have built standard vertebrate exclusion fences
- 3 papers published; 14 more in progress (so far)!
Creating a predictive framework for a critical global biome

- How general is our current understanding of productivity-diversity relationships?
- To what extent are plant production and diversity co-limited by multiple nutrients?
- Under what conditions do grazers or fertilization control plant biomass, diversity, and composition?
The Nutrient Network

• Standardized experimental and sampling protocols
• Nominal annual time and financial investment for any single site

At all experimental sites:
• N,P, K factorial addition

At all fence sites:
• 2 Herbivore exclusion fences per block (around N+P+K, and control plots)
Global Biodiversity: Species Numbers of Vascular Plants

Diversity Zones:
Species Numbers of Vascular Plants per 10,000 km²

1. < 20
2. 20-200
3. 200-500
4. 500-1000
5. 1000-1500
6. 1500-2000
7. 2000-3000
8. 3000-4000
9. 4000-5000
10. > 5000
State of the Nut-work

- 40 sites in 9 countries with full factorial experiment
  - 2,004 – 5 x 5 m plots in the network
- Information on species identity, cover, biomass, light, soil chemistry from almost all 2,000 plots
- 1,700 taxa, 113 distinct families, 47 orders
  - (~0.6% of Earth’s estimated vascular plant flora)
- New this year: soil data
NutNet Add-on Studies

Current projects:
• Arthropod sampling (Lind, Borer [Wolkovitch]) (18 sites)
• Seed predation (Orrock) (12 sites)
• Litter decomposition (Hobbie) (40 sites)
• Resin bag/soil nutrient study (Harpole) (40 sites)
• Functional traits (Jenn Firn) (23 sites)
• Soil fauna and belowground production (Dirt Squad) (39 sites)
• NSF CAREER: Soil microbial response to fertilization (Fierer)(39 sites)

Coming your way soon:
• Nutrient pools and fluxes (link current population/community data to ecosystems) (Harpole, Hobbie, Hofmockle, Borer, Seabloom, Menge)
• Plant microbial community sampling (bacteria, fungi, viruses) (Borer et al)
• Insect communities and stoichiometry (Kay, Lind, Borer)
NutNet inkblot test: write down what you see in this image (c’mon, be creative!)
Field Course - Undergraduate, Graduate (e.g. Dartmouth/Cottingham)

REU/RET - Summer opportunities (e.g. OSU/Borer)

Population/Community/Ecosystem Ecology - teaching examples, field trips

Statistics exercises in writing code, analysis (e.g. UT State/Adler, UMD/Gruner)

Finlay, Oregon
Research Papers: in progress

• A global test of whether niche complexity begets diversity (Stan Harpole)
• Light mediation of diversity-productivity relationships (Yann Hautier)
• What limits productivity in grasslands worldwide? (Jean Knops)
• Do nutrients other than N and P matter for grassland biomass? (Stan Harpole)
• Drivers of aboveground primary production and litter accumulation in grass dominated systems (Lydia O’Halloran)
• Global variation in nutrient limitation of grassland litter decomposition (Sarah Hobbie)
• Drivers of spatio-temporal variation in the composition of globally-distributed herbaceous communities (Peter Wragg)
• Native-exotic richness relationships in the world’s grasslands (Andrew MacDougall)
• Biological invasion in the world’s grasslands (Eric Seabloom)
• Are naturalized plants doing something different than natives (Jenn Firn)
• Do fluctuating resource conditions alter the abundance of introduced species home or away? (Jenn Firn)
Do introduced species behave differently at home & away sites?

Firn et al.
How does mycorrhizal colonization change with latitude and nutrient addition? Frater et al.
Mycorrhizae and Reproductive Effort
Frater et al.

How do mycorrhizae and nutrient addition affect seedhead production?
2011 Update: Nutnet Seed-removal ms #1 (Orrock et al.)

**Objective:** Examine how key interaction varies across large-scale gradients in productivity

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**Graphs:**

1. **Prop. Seeds Removed (arcsin)** vs **Actual evapotranspiration**
   - r-squared 0.80, P < 0.001

2. **Prop. Seeds Removed (arcsin)** vs **Mean total biomass**
   - r-squared 0.11, P = 0.32
A global test of niche destruction and biodiversity loss

(Previous title: A global test of whether niche complexity begets diversity)

- Lead: Stan Harpole
- Evidence for multiple nutrient limitation
- Addition of nutrients to remove limitation = niche destruction
- Linear loss of species with greater numbers of added nutrients
- Joint Richness-Biomass response points to further levels of mechanism and hypotheses (Hautier, Grace, ), and builds on Adler et al.
Does the origin of species matter to their role in communities?
Seabloom et al.

- Exotic species are 6 times more likely to cover 80% or more of a surveyed area than native species.
- Exotic species are 4 times more likely to occupy at least 50% of a given area.
Does the origin of species matter to their role in communities? (Seabloom et al.)

- Fertilization causes native and exotic diversity to decline
- N causes native diversity loss and P causes exotic diversity loss
- Exotic cover increases with addition of N and P, but native cover is unaffected
Top-down vs. bottom-up control of litter disappearance in grasslands worldwide: influence of climate, soils, and region

Hobbie et al.

Decomposition rate \( (k) = -\ln(\text{Alive}_{t+1}/(\text{Alive} + \text{Dead})_t) \)
Relative importance of deterministic vs. stochastic community assembly increases with increasing productivity (experimental)

How to read the graphs:

- The green lines and points are the controls. Black are nutrients added.
- X-axis is the observed productivity in the first year, pre treatment.
- Y-axis, deviation from null, is how much the community deviates from a null community. Zero is a community assembled completely at random. The further you move away from zero, the more the community deviates from a community that is assembled at random. That is, the more deterministic (nichey) the community assembly is.
- By year three, increasing productivity by adding nutrients has created communities that deviate further from the null than communities in which productivity was not increased. Further, the effect varies with baseline productivity: at low productivity sites, increasing productivity does not change community structure, while at productive sites, increasing productivity creates communities that are more deterministic.
Working title:
Relative importance of deterministic vs. stochastic community assembly increases with increasing productivity (experimental)

Lead authors Davies, Melbourne, Chase, NCEAS working group, all data contributors and anyone who is interested.

Other thoughts:
• We are hoping that the results will strengthen further in year four.
• We plan a second panel of graphs that include some environmental variables like temperature and rainfall that might help further explain what is going on.

• It would make sense to report the effects of nutrient addition on alpha and gamma diversity -- an option would be to have this paper follow up the paper that reports these results (is there one?).
Under what conditions do grazers and/or fertilization control plant biomass, diversity, composition, and turnover?
Does fertilization interact with large herbivores to determine how much plant biomass is consumed?

Vertebrate herbivory ~10%

Fence p=0.0080
Nutrient p<0.0001
N&F NS

N+P+K effect
Across all years, richness and evenness are controlled by nutrients, not vertebrate consumers.
The task at hand:
Under what conditions do grazers and/or fertilization control plant biomass, diversity, composition, and turnover?
Notice anything different?