Global importance of bottom-up versus top-down forces to grassland invertebrate communities

Abstract: Many fertilization experiments have shown abiotic influences on terrestrial arthropod community composition via plant quality and compositional changes; additionally, several studies have considered the importance of biotic interactions such as predators or vertebrate competitors on arthropods. Whereas previous studies have pointed to some consistent drivers of consumer community composition, all of these studies have been limited to examining such relationships at local or small regional scales or via meta-analysis. Here we present results from an experimental manipulation of fertilization and vertebrate consumers, replicated at XX sites within and across continents, to directly quantify the relative influence of bottom-up forces and consumer community composition on grassland arthropod community structure. Using one, common, globally abundant plant-feeding taxa (Auchenorrhyncha) we test how tightly linked producer and consumer diversity are.

Bottom-up Constraints on the Composition of Grassland Arthropod Communities: A Global Comparison

An important goal in ecology is to understand the processes that determine community composition. Work in Ecological Stoichiometry (ES) suggests element ratios in organisms provide useful information for community ecologists because they reflect both allocation to functional traits and resource demands for structural investments. Previous studies have shown that disparities in nitrogen and phosphorus content between terrestrial herbivores and plants have major consequences for herbivore success. However, it is not known whether taxonomic and biochemical differences among terrestrial consumer communities reflect the identity and scarcity of nutrients limiting productivity at the base of the food web. Here we use a global-scale evaluation of plant nutrient limitation as a context for assessing the ramifications of nutrient constraints for terrestrial arthropod communities. We test whether 1) arthropod community composition varies with the identity of the nutrient limiting primary production, and 2) the nature and strength of nutrient limitation is reflected in the elemental composition of arthropod community biomass. These results suggest functional trait profiles of grassland arthropod communities generally (do not) reflect current biogeochemical conditions.

General goals:
1. Quantitatively determine whether the biomass, abundance, and morpho-identity of arthropods changes with a factorial manipulation of fertilization and consumer community manipulation (top-down/bottom-up composition – see abstract above).
2. Quantitatively determine whether arthropod tissue chemistry can be predicted from plant tissue chemistry with changing consumer community composition and fertilization (top-down/bottom-up chemistry – see abstract above).

Protocol:

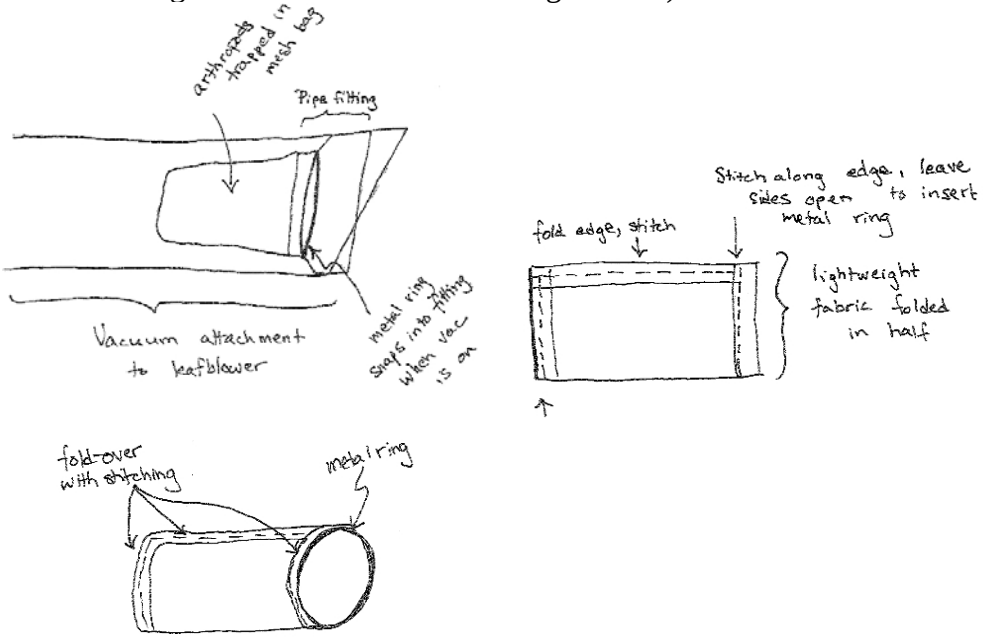
Timing of sampling: Arthropods should be sampled in the fenced plots with and without fertilizer and the paired unfenced (fertilized and unfertilized) control plots of each block. Even if you have not built fences at your site, samples from the NPK and control plots will be an interesting addition to this study. Sample arthropods at peak plant biomass, for most sites we expect this to be at the mid-point of the season. If possible do vacuum sampling before any other sampling at your site, to minimize disturbance to the vegetation prior to sampling. Vacuuming should be done during mid-day and ambient air temperature should be recorded.

Location of sampling: Depending on site/project preferences, etc. sample in the following plots:

1. *Highly preferred:* Sample and sort all 30 plots (even if you didn't build fences - provide data for both datasets);
2. Sample in the 4 plots/block that are the fence x nutrient study (community dataset only);
3. If you didn't build fences, you could also just sample in the N+P+K (all nutrients) and nutrient control plots (this would provide a small amount of data for stoich probably).

Vacuum-sampling: Arthropods are sampled with a modified Craftsman leafblower. Vacuum-sampling has several advantages over other leaf-sampling methods such as sweep-netting or hand-collecting in that it is quick, generally better or as good as other methods for sampling a variety of arthropod orders and does not greatly vary depending on plant type (for example can sample woody as well as grass efficiently and similarly) (Buffington and Redak 1998).

The 25cc Craftsman (gas) Blower with Vac Kit (UPC: 024761015820) needs two changes to act as an arthropod-sampler. First a plumbing piece (3x4 sewer pipe adapter, UPC: 052063337128) is added to the end of the vacuum arm, smaller end down. This should fit snugly without glue. Each participating lab will also need to make a few small mesh (we use fabric-store organza) bags with moldable wire rings fitted to snap onto the plumbing neck. The diameter of the wire ring is roughly 10 cm and the length of the completed bag is roughly 25 cm. (Diagrams below and more diagrams are in Stewart and Wright 1995.)



To begin sampling, with leafblower running, place an open mesh bag onto the plumbing pipe. Sample 1 m^2 plot adjoining the percent cover plot that is not being used for biomass for 30 seconds, brushing the vegetation thoroughly ground to top. Once done, remove the mesh bag, quickly twisting the top closed, place in Ziploc, seal and place on ice. (If you have more plots than mesh bags, the arthropods can be carefully removed from mesh bags by inverting into the Ziploc after they have been cold for at least 15 minutes.)

Store all arthropods in a freezer, labeled by plot.
Do not store in ethanol (or the animals can not be used for stoichiometric work).

Estimated field time: 1-2 hrs.

Costs: Leafblower ($110), plumbing neck ($4), wire ($4), mesh ($10); Total: $128.
Leafblower: Craftsman 25cc Blower with vac kit specs:
25cc/ 1.5 cu. in
2-cycle
205 MPH/410 CFM
Model No.: 358.794964
* If you cannot get this model, get a 25cc one with similar MPH. You may need a different size plumbing neck or piece of stiff plastic, cut to fit (see pictures pdf).

Sample vials: Appropriate vials will depend upon the size of your bugs. Two options are: Fisherbrand 2dr. shell vials with plug (03-339-26C) (~$50) or VWR 1.5 ml (3560-870-000) with o-ring caps (3600-872-000)

Arthropod-sorting: At any later point sort and count frozen samples (note: samples can be frozen for many months before sorting, and can be shipped overnight on ice if needed), under good light in large dissecting trays, to order or gross taxanomic unit (see data sheet) all arthropods ≥ 2 mm (if you have a Berlese or other funnel sorting method you would like to use you may do so as long as you still *sort debris once funneled* for any arthropods that may have been missed). If possible sort all Auchenorrhyncha to morphotype, recording whether immature or adult (sort immatures to morphotype only if you can make definitive ID, which is pretty difficult). *Be sure to keep notes and a voucher collection of morphotypes starting the first year, and refer to each year for consistent morpho-typing!* **Sort each plot's arthropods into a minimum of 4 vials**: one for **Auchenorrhyncha** (for a quick background on this group, check out: http://en.wikipedia.org/wiki/Auchenorrhyncha), one for **Sternorrhyncha,** one for **spiders**, and one for all **others**, and freeze.

Store all arthropods in a freezer, labeled by plot and vial contents and separated into 4 vials (above) until you can send them (2-day or overnight on ice-packs) to:
Adam Kay
Department of Biology
University of St. Thomas
St. Paul, MN 55105

(651) 962-5291

Estimated lab time: We did about 6,000 arthropods (picked out of sample bags, sorted by order, and data entered) in 40 hours of untrained-UG-student-hours (a perfect quarter-long undergraduate project!) plus 15 hours of semi-trained person-hours. With an additional 6 hours trained personnel sorted all the Auchenorrhyncha (3,800 total) to (20 separate) morphospecies. These estimates include *all* arthropods and should go faster with the new ≥ 2 mm size minimum.

Buffington, M. L., and R. A. Redak. 1998. A comparison of vacuum sampling versus sweep-netting for arthropod biodiversity measurements in California coastal sage scrub. Journal of Insect Conservation **2**:99-106.

Stewart, A. J. A., and A. F. Wright. 1995. A New Inexpensive Suction Apparatus for Sampling Arthropods in Grassland. Ecological Entomology **20**:98-102.

Some basic arthropod books you might want:

For a super-easy, cheap guide (with an easy key):
A Field Guide to Insects by White, Borror (Peterson Guide)
http://www.amazon.com/Field-Guide-Insects-Richard-White/dp/0395911702/ref=pd_bbs_sr_5?ie=UTF8&s=books&qid=1207767549&sr=8-5

More expensive, but much more informative and complete:
Introduction to the Study of Insects (Borror, Johnson, Triplehorn, depending on edition)
http://www.amazon.com/Borror-DeLongs-Introduction-Study-Insects/dp/0030968356/ref=sr_1_2?ie=UTF8&s=books&qid=1207767713&sr=1-2