Spring 2004
BSES Senior Research Symposium

22 April, 2004

BSES Spring Research Symposium

I welcome you to the Spring 2004 BSES Research. This event marks the gathering of students and faculty associated with the BSES degree program, a joint endeavor of the College of Arts and Sciences and the School of Public and Environmental Affairs. It is a time to showcase the accomplishments of students who have been working for the past year on a significant research project. It is also a time to remember those students who have gone before and to inspire those students who will come after.

One of the cornerstones of the BSES degree program is the opportunity for students to undertake a significant research project at the end of their undergraduate experience. The efforts of students finishing their research in May, 2004 are reported in this volume. The dedication of both the students who completed this research and the faculty members who mentored these young scientists must be applauded. All of these individuals have proven their dedication to the pursuit of scientific learning through their participation in this process. There are also a large number of additional individuals who need to be recognized including the graduate students, research scientists, and technical support personnel who play significant roles in the nurturing of these young scientists. For these contributions we are grateful; without support from the Bloomington research community, the scientific endeavors of BSES students could not be as successful as they have been.

I am proud to be a part of this process.

Dr. Bruce J. Douglas, Director

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Salamander Population Study at Griffy Woods Preserve

Kevin Allison
Advisor: Vicky Meretsky

Salamanders are recognized as good environmental indicators giving insight into the healthiness of a forest. Amphibians have permeable skin that is susceptible to air-borne toxins, and polluted water affects the soft, gelatinous eggs and the aquatic tadpoles. This population study was conducted on a ridge largely within the Indiana University Teaching and Research Preserve's Griffy Woods property. Portions of the study area are on lands managed by Bloomington's Park and Recreation Department. The deciduous hardwood forest in this area is undergoing secondary succession in response to clearing for agriculture during the late 19th and early 20th centuries. Woodland salamander species have different habitat requirements that may be met in different parts of the study area. In particular, soil moisture generally is lower on south-facing than on north-facing slopes. The study area is an east-west ridge with north- and south-facing slopes. Five 200-meter transects composed of 40 cover objects each were laid out parallel to the ridge along the top of the ridge, the middles of the sides, and along the bottom of the north-facing slope. Because the south-facing slope of the main study ridge was too steep for safe work, the south-facing slope of the parallel ridge to the north was used to sample that habitat. Each fourth cover object was sampled every 7-10 d during September 2 to November 25, 2003. I measured total length of salamanders found under cover objects and then released the salamanders. I found a total of 109 salamanders during 14 site visits. Five salamander species were encountered: *Desmognathus fuscus*, *Eurycea bislineata*, *Plethodon cinereus*, *Plethodon d. dorsalis*, and *Plethodon glutinosus*. There were significantly fewer ($p < 0.05$) individuals found on middle of the south-facing slope than on the north-facing middle and bottom transects; no other two-way comparisons were significantly different.

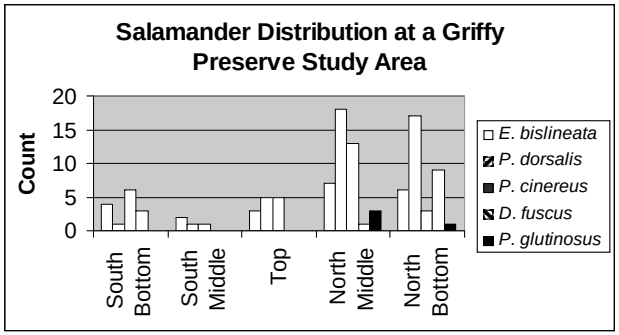


Figure 1: Graph shows the distribution of the 109 individual salamanders spanning five species at Griffy Lake Nature Preserve sampled from Sept. 2 to Nov. 25 of 2003.

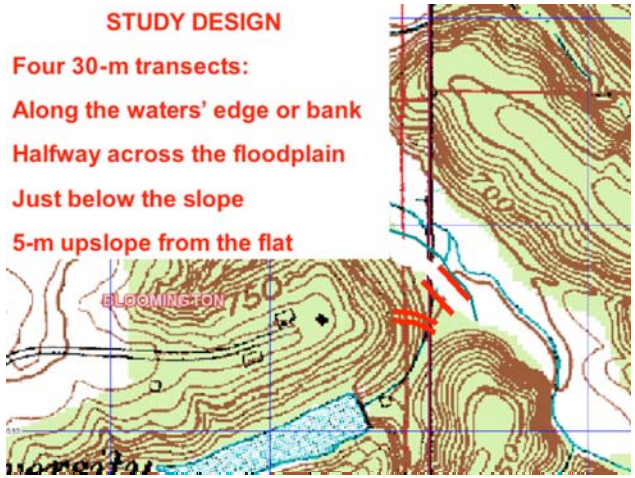
Plethodon glutinosus was only found on north-facing transects; *Desmognathus fuscus* was found on north-facing transects and on the bottom transect of the south-facing slope. The remaining 3 species were found on all 5 transects. In future analyses, I will examine distribution of these species among the transects for signs of habitat preference.

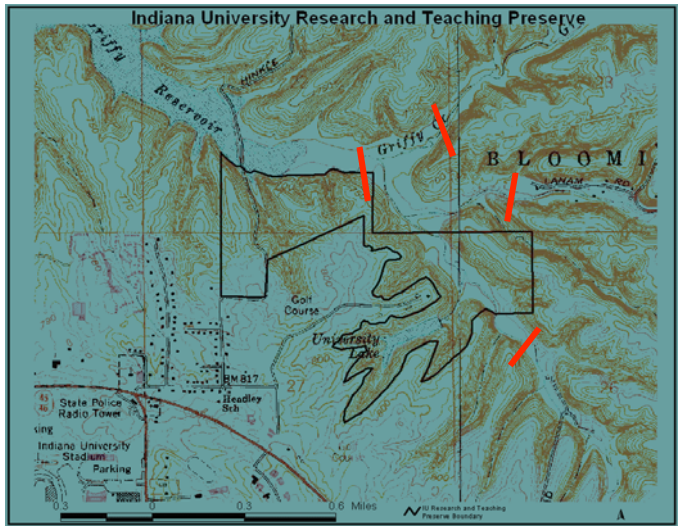
I will also analyze salamander counts in relation to rainfall during the study. However, due to the need to moisten cover objects later in the study, and to a change in practice (later in the study, we flipped cover objects before rainstorms to remoisten them), this analysis will be difficult. The data I collected and analyzed in this study will serve as baseline data for salamander populations on forested ridges at the Griffy Woods property. As the forest matures, later surveys may reveal changes in the salamander community.

Invasive Plants in the Griffy Creek Riparian Corridor

Jen Cleland
Advisor: Vicky Meretsky

Invasive plants can be introduced to ecosystems in a variety of ways. After introduction, some plants are unable to survive in a new environment, but others thrive. The invasive plants that are introduced to disturbed, open areas with plenty of nutrients and light thrive. Being highly adaptable to specific conditions, like soil moisture and light in disturbed areas or early successional forests, allow the invasive plants to reproduce and spread quickly. In a new environment, the invasive plants lack predators and enemies, and this gives the plants an advantage over native species, allowing the invasive plants to out-compete the native flora. This threatens the survival of native plant communities, and threatens the native wildlife's habitat and food sources. Invasive plants disperse throughout an ecosystem using birds, wind, and rivers to transport their seeds and propagules. My study area includes the riparian floodplains surrounding the first and second order sections of Griffy Creek, immediately above Griffy Lake, as well as the outflow of University Lake – a first order tributary of Griffy Creek. The stream collects run off from residential areas and the Indiana University Golf Course, which could be a source of invasive plant seeds and propagules. The stream is also an agent of dispersal and creates habitat for invasive plants. The riparian area also acts as a dispersal agent to invasive plants. The banks along the creek provide the invasive plants with a disturbed habitat with plenty of light, and can promote the spread of seeds and propagules. The riparian floodplains in my study area were *Platanus occidentalis* and *Juglans nigra*. The understory of the floodplain forest was often open, but in some sites, the understory was thick with invasive species. I assessed the presence of the invasive plants in the floodplains of the Griffy Preserve and near by areas. Floodplains were classified by width. Small floodplains were up to 75 meters wide, medium floodplains were 76 – 150 meters wide, and large floodplains were 151 meters and wider. Locations for transects will be selected randomly for those categories occurring frequently throughout the study area. However, categories that only occur once or twice throughout the study area will not be randomly chosen. They will be specifically chosen to ensure each category is included in the study. I laid 30 meter transects parallel to the creek across the floodplain, at the base of the uplands, and 5 meters beyond the base of the upland. At each meter along the transect I recorded the presence of invasive plant species. Invasive plants were considered present if they were found rooted in the plot, or hanging over the plot. The invasive plants found in the floodplains included *Alliaria petiolata*, *Berberis thunbergii*, *Ligustrum vulgare*, *Lonecera japonica*, *Lysimachia nummularia*, and *Rosa multiflora*. The most abundant invasive plants in



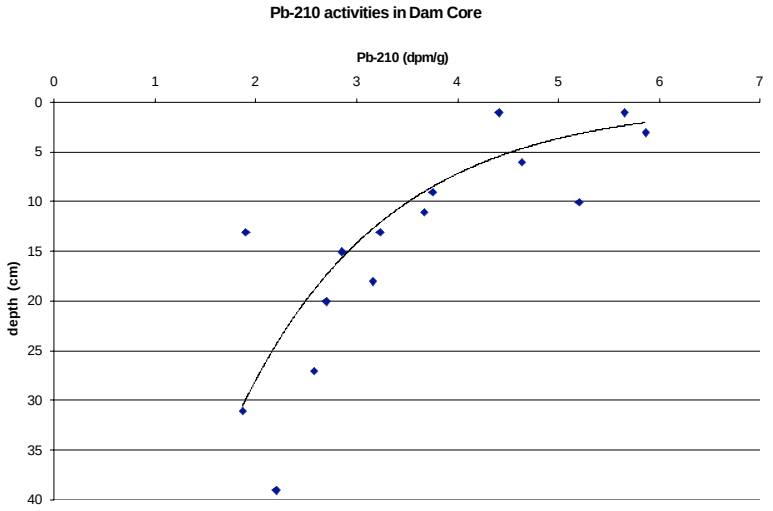


the transects were *L. vulgare*, *L. japonica*, and *R. multiflora*. Plots containing invasive plants will be compared to those lacking invasive plants. The presence of invasive plants within each floodplain category will be compared to the other two categories.

An Investigation of carbon, nitrogen, and sediment loading at Griffy Reservoir, Bloomington, IN

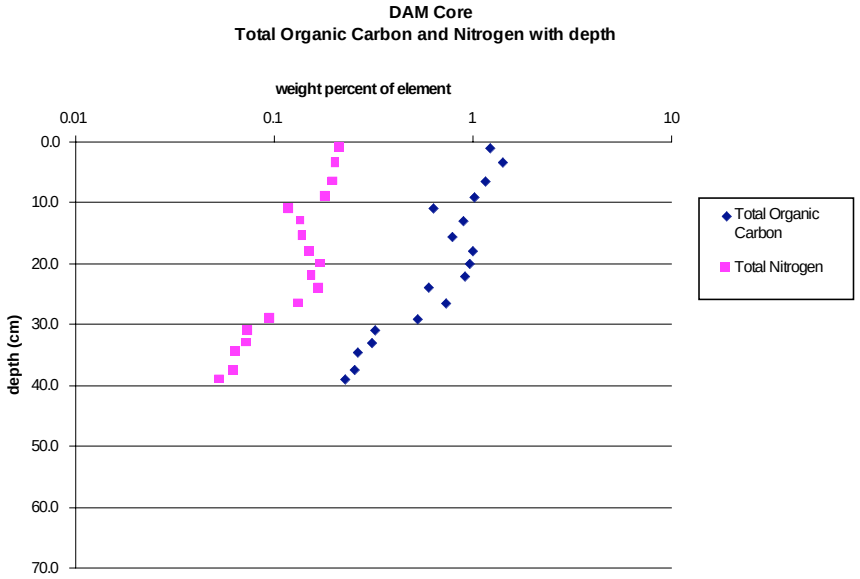
Megan M. Hill
Advisor: Erika Elswick, Geological Sciences

It was hypothesized that since the creation of Griffy Reservoir in 1924, sediment and nutrient loading rates have increased due to increased development in the watershed. We investigated the rate of sediment loading and the distribution of grain sizes, total carbon, total organic carbon, and total nitrogen in the sediments of Griffy Reservoir, Bloomington, IN. Three sediment cores and eight pairs of grab samples (an early spring set and a late summer set) were collected from the lake and creek flowing into the lake, respectively. The cores were dated using visual observations and radiometric dating techniques of Cs-137 and Pb-210. Weight percents of total organic carbon, total carbon, and total nitrogen were determined using elemental analyzers. The data suggest that the sedimentation rate is greatest near the inflow into the lake (7.95mm/yr) and decrease with distance from the inflow to a minimum rate of 3.75mm/yr near the dam. Sediment grains appear to be normally distributed such that larger grains are preferentially deposited first, near the inflow, and small grains are preferentially deposited later, near the dam. The data show organic carbon makes up most of the total carbon in the system and that total organic carbon values range from 0.2 -3% in the cores and .06-6% in the grab samples. Nitrogen values ranged from 0.05-0.25% in the cores and 0.05-.45% in the grab samples. Both carbon and nitrogen showed decreasing concentrations with increasing depth in the cores. The pattern of decrease of nitrogen mimics that of carbon, and it is suggested that nitrogen buried in the sediments is organic nitrogen transported with organic carbon. Furthermore, nutrient concentrations were generally higher in the late summer samples than in the early spring samples suggesting a seasonal variation in the input of carbon and nitrogen into the system. Overall, the data suggest that the rate of sediment and nutrient loading into Griffy Reservoir has remained fairly constant over the past 80 years.



Pb-210 activity in the Dam core. The data tend to follow exponential-type decay indicating a steady accretion rate. Pb-210 data represents 4 half-lives, so the accretion rate calculated should be close to the actual accretion rate after 5 half-lives.

Total nitrogen and total organic carbon with depth in the Dam Core. Nitrogen concentration mimics total organic carbon concentration.



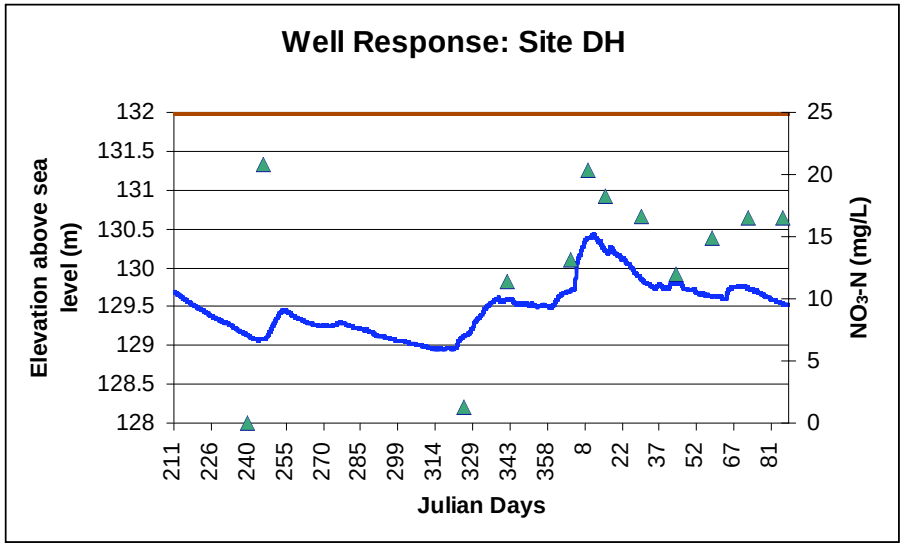
An Evaluation of Nitrate Transport in Sandy Soils at a Confined Feeding Operation

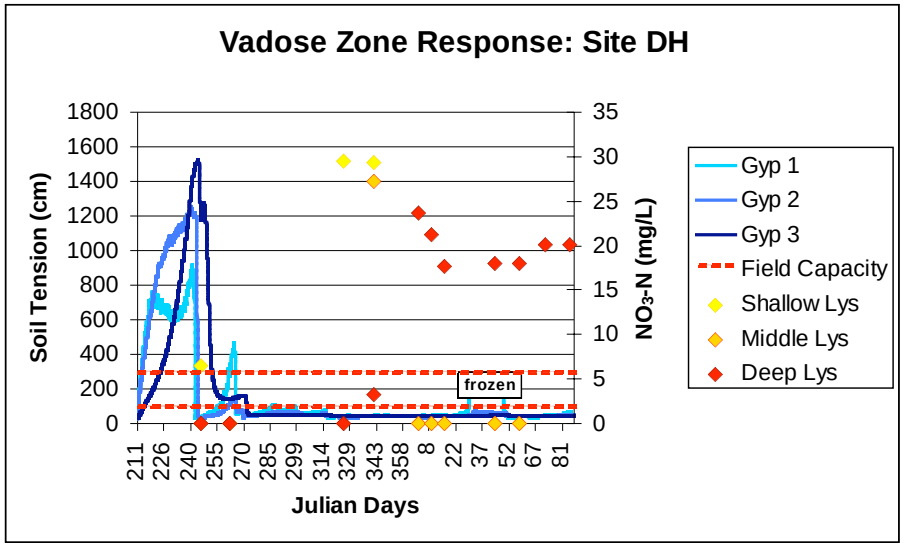
Anna Makowski
Advisor: Greg Olyphant, Geological Sciences

Several Confined Feeding Operations (CFOs) are operating in southwestern Indiana where ground water may be very sensitive to contamination because of highly permeable soils and a shallow water table. The potential sensitivity of this hydrogeologic setting to ground-water contamination warrants a thorough investigation of the effective limits of current management practices. It is our hypothesis that nitrate migration through the unsaturated zone is a result of gravity drainage, induced by rainfall, infiltration, and snowmelt. Such events typically occur early and late in the growing season when nutrients cannot be utilized to promote plant growth. The current project, which is supported by the U.S Environmental Protection Agency's Clean Water Act Section 104(b)(3) program, is aimed at empirically evaluating this hypothesis. Our approach involves continuously monitoring hydrologic conditions and frequent water sampling that will allow development of a detailed hydrochemical budget for the waste-application fields in the area of concern.

This study is being conducted near Washington, Daviess County, Indiana. Three representative sites are simultaneously monitored: two on agricultural fields that receive animal-waste (in this case, turkey manure) applications (sites DW, DH) and the other on a field that receives commercial fertilizers (site DL, a control site). The field instrumentation was installed in late July 2003, and hydrologic and micrometeorological monitoring has been continuous since then. Biweekly visits to each of the three sites provide an opportunity to take additional measurements such as soil-moisture profiles and field chemistry, collect water samples from the soil column and water table, and calibrate the monitoring equipment. The water samples are analyzed in the field for specific conductivity, dissolved oxygen, pH, and oxidation-reduction potential (Eh). The samples are then returned to the lab, where they are analyzed for nitrate as nitrogen, nitrite as nitrogen, ammonia as nitrogen, chlorine, phosphate, and potassium. The results presented here involve only nitrate as nitrogen (NO3–N).

Nitrate levels at DL are significantly lower than those at DW and DH. Preliminary results show a correlation between recharge events and nitrate levels in the vadose zone and groundwater. Overall, nitrate levels in the saturated zone are lower in the summer, and higher in the late fall and early winter. This trend is probably linked to the increase in recharge associated with the annual hydrologic cycle. Nitrate concentrations in the vadose zone also reflect gravity drainage. Nitrate levels peak in the shallow vadose zone first. The middle and deep lysimeters respond sequentially in response to the downward migration of the wetting front.

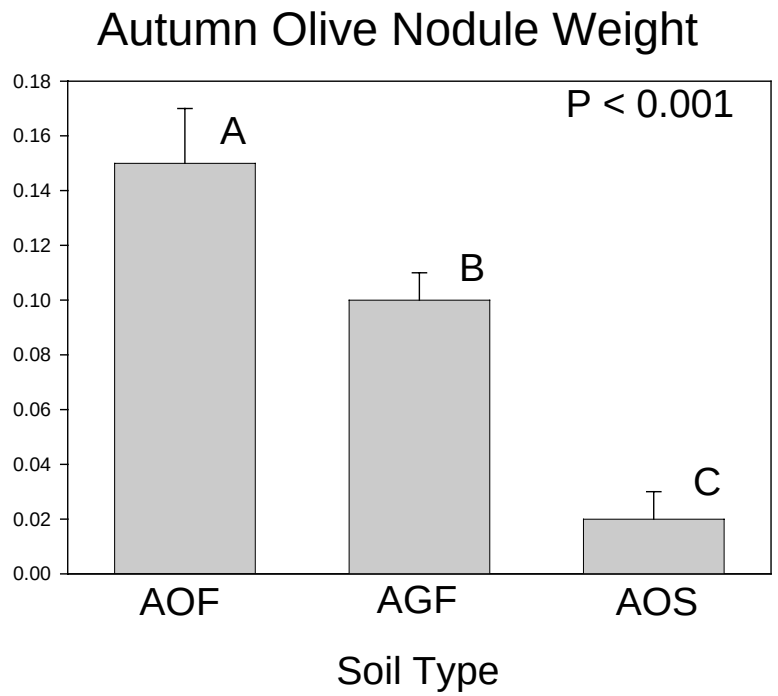




The Role of Symbiosis with *Frankia* on the Invasiveness of the Shrub *Elaeagnus umbellata*.

Rebecca Utley
Advisor: Dr. Keith Clay

The objective of this research is to test the role of a symbiotic bacterium in limiting the spread of an invasive shrub. *Elaeagnus umbellata,* Autumn-olive, is a deciduous shrub that was introduced to the U.S. from East Asia in 1830 for re-vegetation of disturbed areas, food and cover for wildlife, and as wind and soil erosion preventive measures. It escaped cultivation and has become one of the most problematic invasive plants in eastern North America. *Elaeagnus'* symbiotic relationship with the actinomycete genus *Frankia* contributes to its success. *Frankia* colonizes the roots of *Elaeagnus*, forming coralline roots containing actinorhizas. N-fixation occurs in the actinorhizas and gives *Elaeagnus* the ability to establish in N-deficient soils. The specific objectives of this research were to determine 1) if *Frankia* is present in various soil communities, 2) how its degree of presence or absence affects the ability of *Elaeagnus* to establish in those areas, and 3) how that establishment changes the nitrogen composition of the surrounding soil. Cuttings of young stems were dipped in root growth hormone and placed in sterile potting soil in order to develop *Frankia*-free roots. The first experiment tested the presence or absence of *Frankia* for soil from two areas, one with an abundance of *Elaeagnus* and the other an open field without *Elaeagnus*. Half of the soil from the *Elaeagnus* field soil was sterilized; the other half was left as a control. 25 rooted cuttings were planted in each of the three soil types, and the speed of root colonization and the number of actinorhizas indicate the density of *Frankia* in the soil. In the second experiment, 25 cuttings were placed in six different soil types covering a successional gradient to determine which areas are more susceptible to invasion by *Eleaegnus*. Dry biomass weight of the plants was compared by soil type and found to be statistically significant for each experiment. Plants in soil taken from an area with a presence of *Eleaegnus* had greater total and nodule biomass values than plants in *Eleaegnus*-free soils. Areas with a greater density of *Frankia* in the soil are more susceptible to invasion by *Eleaegnus*. Establishment of one *Eleaegnus* plant in an environment has a positive feedback response in which it increases the growth of *Frankia*, in turn increasing *Frankia*'s availability for other *Eleaegnus* plants. Thus, this creates a snowballing effect and allows for more invasion by *Eleaegnus*.



Precipitation composition trends in the Ohio River Valley

Karin Kvale
Advisor: Sara Pryor, Geography

According to the EPA, regulation of sulfur and nitrogen by the Clean Air Act and subsequent amendments resulted in decreases in emissions of 33 and 15% respectively between 1983-2002. However, due to non-linearities of the atmospheric chemistry of these gases, emission reductions need not be linearly related to decreased concentrations of the oxidation products in precipitation. Hence, I analyzed weekly average wet deposition data from six National Atmospheric Deposition Program/National Trends Network (NADP/NTN) locations in and around the state of Indiana (Figure 1) between the dates January 1985 and December 2002 to examine spatial variability of precipitation amount
and composition and the magnitude and potential causes of temporal trends. Application of a student t-test for the difference in means and examination of the probability distribution of weekly precipitation indicates the northern three sites (IL11, IN41 and IN20) experience a higher frequency of low precipitation amounts and lower annual total precipitation amounts. Ionic concentrations in precipitation also exhibit statistically significant spatial variability, and in accord with previous research, due to the quasi-exponential dependence of ion concentrations on precipitation amount, the northern sites exhibit a greater frequency of highly concentrated samples. Overall, annual average sulfate concentrations in precipitation decreased and average of 54% from 1985-2002. Over the same time period, nitrate concentrations decreased and average of 14%. Ammonium concentrations exhibited spatial differences, with increases at the southern sites and decreases at the northern sites and an overall increase of 5% (see Figure 2).

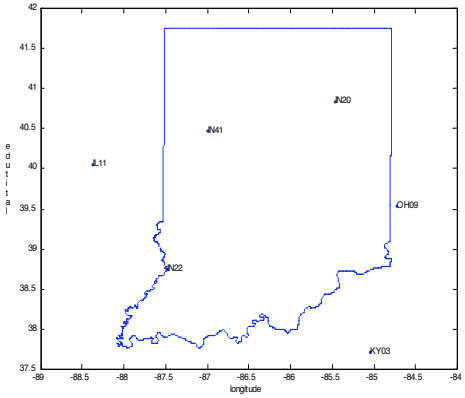
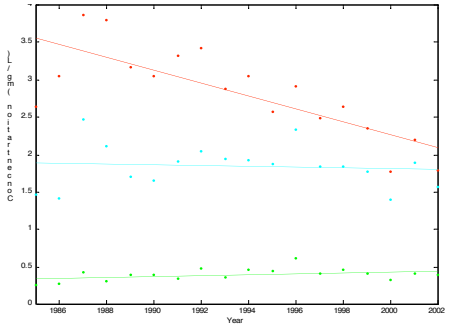


Figure 1. Ohio River Valley NADP/NTN sites selected for analysis. Sites were chosen based on spatial distribution and length of operation.

Previous research has demonstrated that variations in synoptic-scale meteorology can significantly impact temporal variability of air quality parameters, and this combined with the strong influence of precipitation amount on ionic concentrations led to the hypothesis that some of the temporal trends in precipitation composition may be attributable to meteorological variability rather than emission controls. Analysis of annual precipitation amount at the NADP/NTN sites indicates a high degree of inter-annual variability and some evidence of temporal trends. Hence, weekly ionic concentration data were assigned synoptic types developed by Polderman and Pryor (2004) to identify which synoptic types are associated with highly concentrated precipitation. The annual frequencies of these synoptic types were then examined for evidence that they exhibited trends within the data record. The results indicate that some of the types did exhibit significant changes in annual frequency and hence that meteorological effects may be confounding the trends in ion concentrations.

To further test this hypothesis least squares linear regression equations were developed for annual mean precipitation composition based on only a time index. As an example, the variance was 0.6 for sulfate concentrations at IN22 indicating that 60% of the variance of annual mean sulfate concentration in precipitation at this site may be attributed to a downward trend (and by association emission controls). However, when annual precipitation is added as an addition predictor variable the variance explanation increases to 0.75, indicating that the inter-annual variability of precipitation amount offers additional explanation for variations in annual precipitation chemistry. My presentation will summarize the research and discuss some of the difficulties in 'declimatizing' air quality data sets for meteorological variability.

Figure 2. Ionic mean annual concentration time series for IN22, 1985-2002.



The response of twelve prairie plant species to AMF isolated from a remnant prairie and an old field community

Elizabeth Porter
Advisors: Peggy Schultz and Jim Bever, Biology

The soil community plays an important role in the maintenance of diversity in a plant community (Bever *et al* 1997). One component of the soil community is arbuscular mycorrhizal fungi (AMF). AMF transfer soil nutrients to associated host plant roots in exchange for carbon. The relationship between AMF species isolated from prairie and old-field communities and their ability to promote the growth of prairie plants was explored. Specifically, we chose to evaluate the response of twelve prairie plant species that represent four families (Grass, Legume, Lily, and Composite) and a range of successional stages (early and late) to AMF collected in old-field and prairie environments in a greenhouse study. We expected that early successional plants would grow best in sterile soil or in soil inoculated with *S. fulgida* or *G. claroideum*, which were collected from old-field sites at the Kankakee Sands. We further expected that late successional plants would have greater biomass in live soil than sterile soil but grow best in the soil inoculated with *S. pellucida* or *G. claroideum*, which were collected from prairie sites. We found that the Legume, Lily, and Composite families were not sensitive to the soil treatments and therefore saw no growth differences between the infected plants and non-infected plants. This result is surprising and counter to preliminary results on these species. The growth of these plants may have been limited by the high level of P found in the Kankakee Sands soils and by root crowding. The Grass family demonstrated a growth difference within soil treatments and by successional stage. The grasses generally grew better with AM fungi. The late successional grasses responded best to *S. fulgida* collected from the old field, while the early successional grasses responded best to *G. claroideum* collected from the prairie site. The results of this study indicate that different grasses from different successional stages have a variety of responses to AMF.

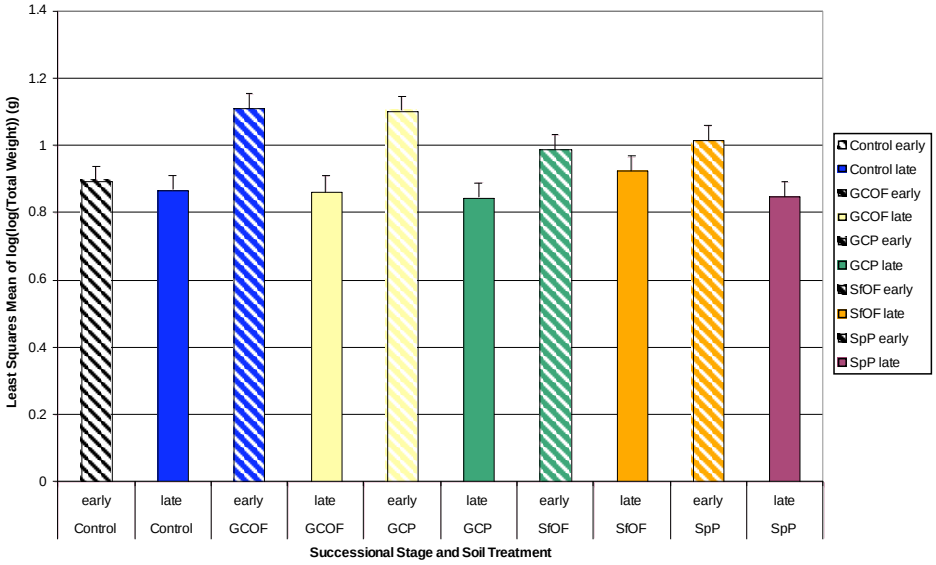


Figure 1. This figure demonstrates that the grasses grew better in live soil than sterile soil and that within the live soil treatments, the early successional grasses grew better than the late successional grasses. This figure represents the log(log(Total Weight)) of the Grass family evaluated within successional stage and soil treatment. Error bars show SE.