Spring 2011
BSES Senior Research Symposium

27 April, 2011

INDIANA UNIVERSITY
BLOOMINGTON

NOTES

Spring 2011 BSES Senior Research Symposium

27 April, 2011
7:00 -9:00 PM
Geology Building, Room S201

7:00-7:05		Welcome, introductory remarks, and awards
7:05-7:20	Jordan Schnell	Effect of Removing the ENSO Variability from the Global Mean Temperature Record
7:20-7:35	Anwar Alsanea	Ground water model for Huntertown, Allan County, IN.
7:35-7:50	Paola Areana	Immunogenetics: Steps toward an oral vaccine to relieve stress on salmon fisheries.
7:50-8:05	Jade Marks	Sulfur concentration and isotopic signature of lichen species, Bullion Mine; Basin, MT
8:05-8:20	Rebecca Goldstein	Macroinvertebrate Communties at Sycamore Creek, Central Indiana.
8:20-8:35	Melissa LoFaso	Social Barriers Associated with Community Gardens
8:35-8:50	Stephen Strong	Relations between Air and Water Temperature and Stream Flow and their Implications for the Spread of Whirling Disease (Myxobolus cerebralis) in the Willow Creek Watershed, Montana
8:50-9:05	Janelle Steffen	Current Trace Metal Fluxes in Wet Deposition for the BATS region.
9:05-9:20	Jeremy Degler	$\delta^{18}O$ and $\delta^{13}C$ Isotopic Analysis of Lodgepole Pine (Pinus contorta) Tree Rings and Their Evaluation as Local or Regional Climate Records, Upper North Willow Creek Drainage, MT

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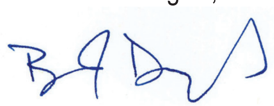
BSES Spring Research Symposium

I welcome you to the Spring 2011 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 the Fall 2007 of the academic year 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



BSES Program Committee:
Ben Brabson, Physics; Keith Clay, Biology;
Scott Robeson, Geography; Flynn Picardal, SPEA

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BSES AWARDS

SENIOR ACADEMIC ACHIEVEMENT AWARD

To be announced

Awarded in recognition of achievement of the highest academic record among the senior class.

GEOL G329 SCHOLARSHIPS, SPRING 2010

Deiss Scholarship:
Rachel Irving

Judson Mead Scholarships:
Jeffery Brown
Tyler Pietrykowski
Daniel Top
Jacob Rowland
Melissa LoFaso

Preliminary numerical experiments involving water-table recharge in a glacial aquifer system.

Anwar Alsanea

Advisor: Greg Olyphant, Geological Sciences

This study is a pilot study of a numerical experiment based on geospatial distribution of glacial aquifers to understand the groundwater conditions. The aquifer studied is the Huntertown aquifer in Allen County, IN. The geology of this aquifer is complicated due to the glacial deposits from the late Wisconsin glacial. The numerical difference model used is the groundwater flow model by Freeze in 1971 with Van Genuchten's equations incorporated. Two scenarios were used for the glacial deposit geology, the undifferentiated and the variable model. These models only ran for 7 days. The results of both runs show different responses at each observation point. There are 10 observation points. The variable run showed more difference in the water tables of observation points. It is concluded that including spatially distributed details of the surficial geology shows a representative way to show the conditions of groundwater in a glacial aquifer. Further numerical experiments based on this pilot study are planned.

Figure 1. A map showing Allen County, IN

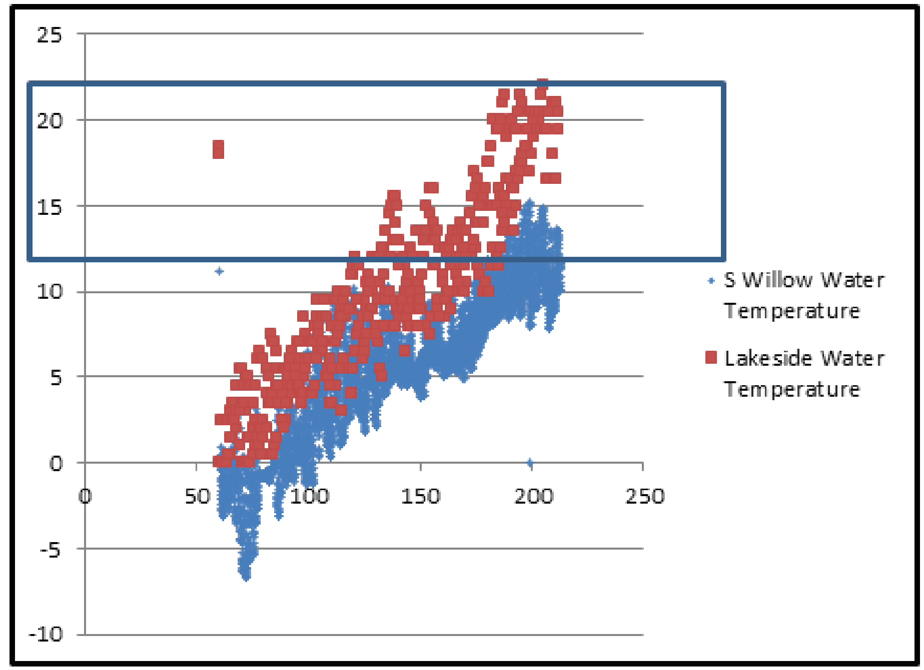


Figure 2 - Mean water temperatures (°C) at Lakeside gauging station (4925ft) and South Willow Creek gauging station (6000ft). Blue box indicates medium to high infection risk temperature zone (12-22°C).

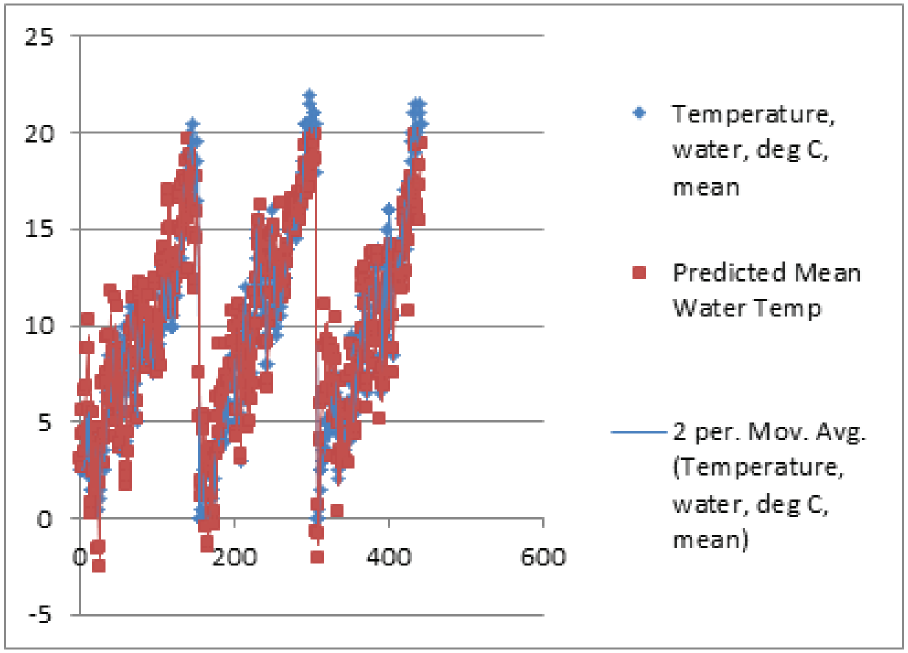


Figure 1. Predicted values for mean daily water determined using water-air temperature relationship compared to actual water temperature values at the lakeside gauging station near Harrison, MT. Values were predicted with and mean error of +/-1.8°C

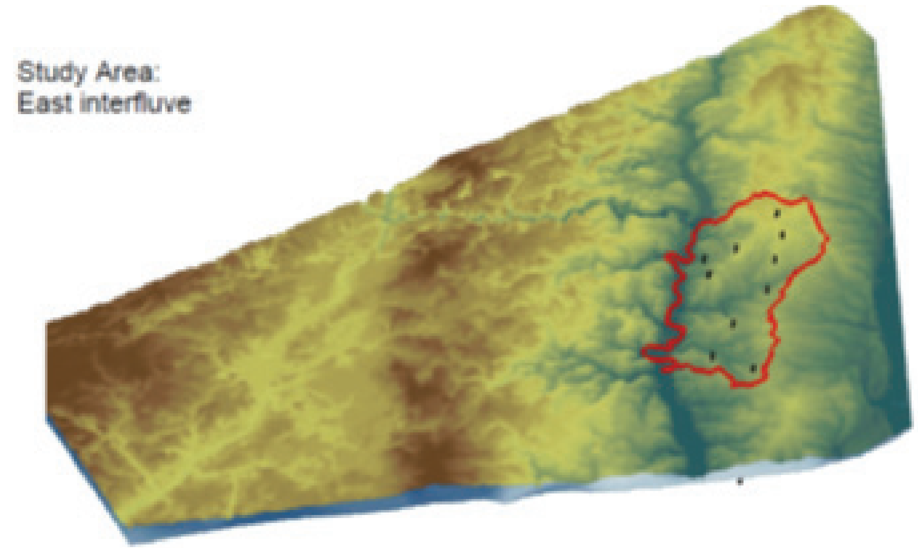
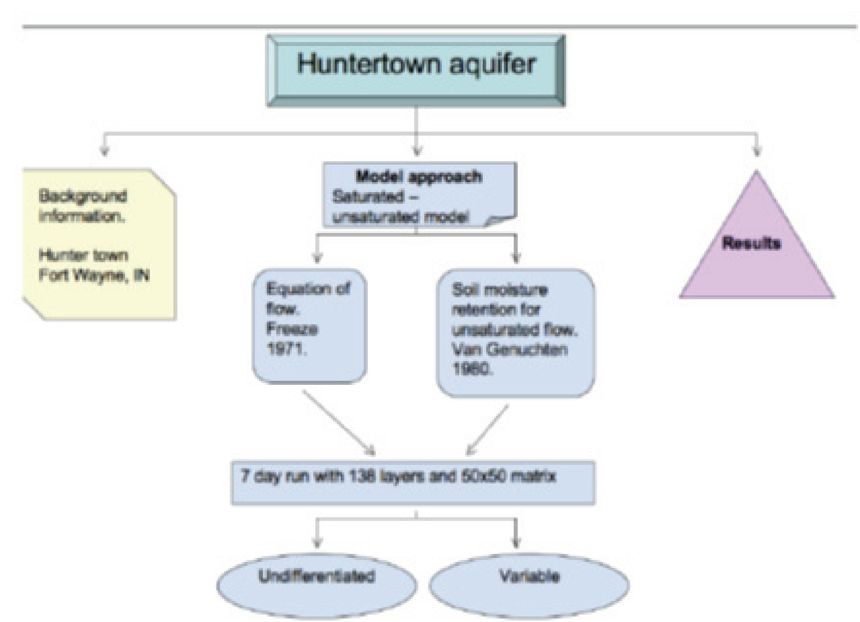


Figure 2. A GIS 3D topographic map showing Huntertown aquifer. The study area is outlined in red, with ten observation points.



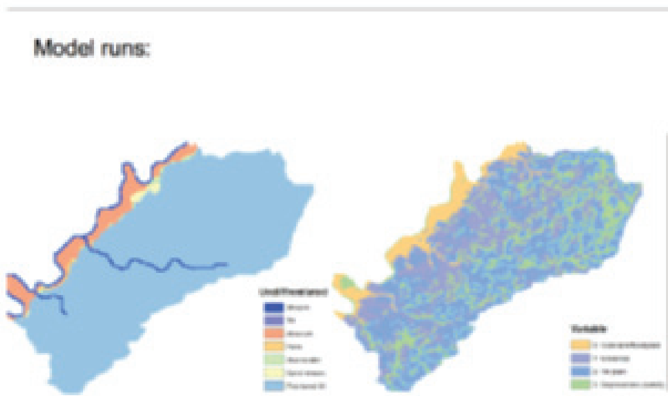
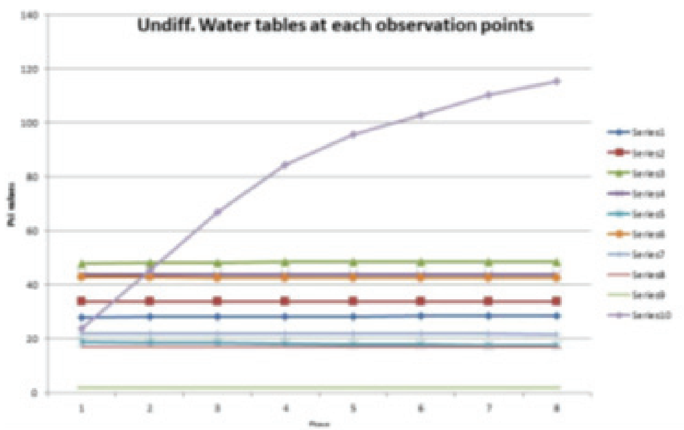
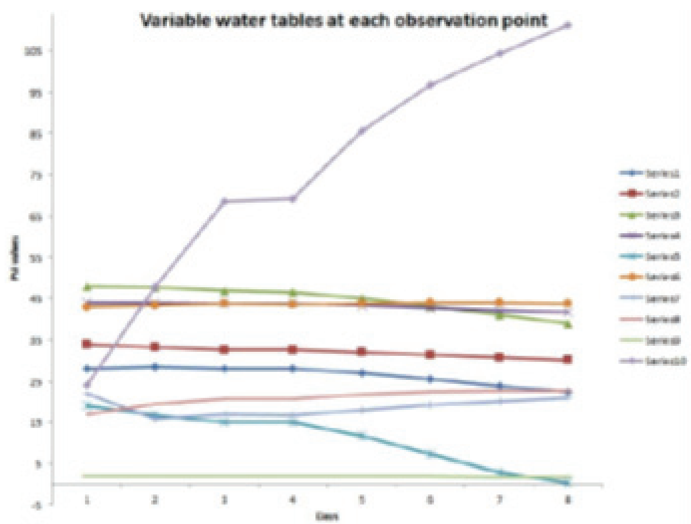


Figure 3. The study area maps with the two model scenarios and geology.





Relations between Air and Water Temperature and Stream Flow and their Implications for the Spread of Whirling Disease (Myxobolus cerebralis) in the Willow Creek Watershed, Montana

Stephen Strong

Advisors: Bruce Douglas [Geological Sciences] and Kevin Ellett [Indiana Geological Survey]

Myxobolus cerebralis, the parasite which causes whirling disease in salmonoids, threatens native trout populations in 25 states and continues to spread. Infection rates of the parasite are dictated by steam conditions, with much of it being controlled by water temperature. This study aims to create models allowing the prediction of daily stream temperatures from meteorological conditions at various points over the extent of the Willow Creek watershed in Western Montana and use these stream temperatures to predict the relative risk of infection. Linear relations were examined between daily stream temperature and air temperature, net radiation, and discharge; correlations between ground air temp and minimum water temperature and 3m air temperature and maximum water temperature were found to be strongest (R^2 values of 0.885 and 0.737). A linear model was used to predict daily minimum, mean and maximum water temperatures from daily air temperature values as well as the relation between water temperature and elevation (fig 1). A risk assessment was then conducted using the daily mean water temperature and range producing a value on a 1-3 scale (low, medium, or high risk). The risk assessment was performed for the lakeside site (elevation 4925ft) and at the South Willow Creek gauging station (elevation 6000ft)(fig 2). Both sites reach the high risk temperature zone with the lower elevation site reaching critical temperatures in mid-May and the higher site in mid-June.

Based upon the established relationship between temperature and elevation the stream would be unlikely to exceed high risk temperatures above 7500ft. Since the vast majority of the watershed is below 7500ft and therefore subject to high infection risks each summer whirling disease should be considered in water resources management decisions in the area.

Estimated annual trace metal fluxes (Table 1) are comparable to reported data for Fe (14.0 nM cm^{-2} y^{-1}), but are much higher than the most recent data seen for Cu or Mn fluxes (0.30 nM cm^{-2} y^{-1} for Cu and 0.75 nM cm^{-2} y^{-1} for Mn) from wet deposition to the Sargasso Sea area.

Enrichment factors, given by the equation:

$$EF = \frac{\left(\frac{TM}{Fe}\right)_{Sample}}{\left(\frac{TM}{Fe}\right)_{Crust}} \quad (1)$$

Enrichment factors close to the value one are expected for crustal matter, while enrichment factors ranging up to the 100's show enrichment, presumably from anthropogenic materials. Figure 2 shows enrichment factors over the course of this study. Copper was highly enriched compared to aluminum and manganese. This data also showed two events that showed extremely high copper enrichment (enrichment factors of 305 and 326). By analyzing back trajectories, it is evident that air masses from these rainfall events were fast moving, arriving from across the United States, which further supports the theory for anthropogenic enrichment.

Table 1: Estimated yearly trace metal fluxes of Al, Cu, Fe and Mn to the Sargasso Sea.

Element	Flux (nM/cm^2/y)
Al	43.66
Cu	0.59
Fe	10.74
Mn	1.45

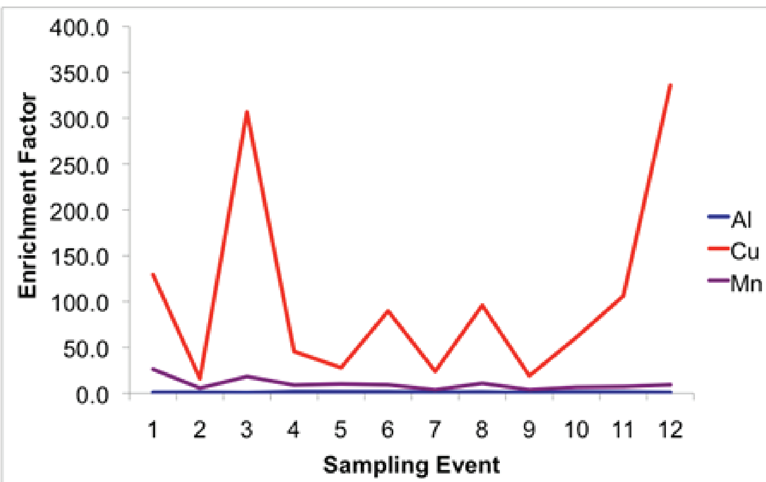


Figure 2: a. Enrichment factors of Al, Cu and Mn compared to Fe across the 12-week study period.

Immunogenetics: Steps toward an oral vaccine to relieve stress on salmon fisheries.

Paola Areana

Advisor: Vitalia Henriquez [Pontifica Universidad Catolica de Valparaiso]

One of the major problems with fisheries is disease that infects portions of the populations that are meant for harvesting. Piscirickettsia salmonis is such an infectious disease that affects the salmon in fisheries of southern Chile and other locations around the world. Currently there are slow and impractical immunizations for these bacteria including injection and immersion. Another form of immunization that is still developing is oral vaccinations.

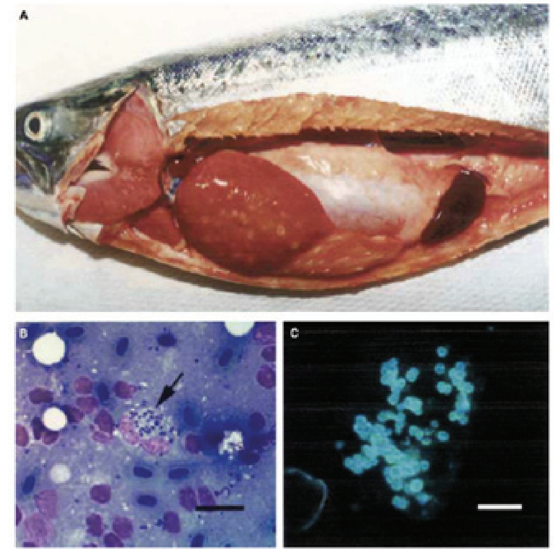


Figure 1. Internal signs of piscirickettsiosis in coho salmon and detection of the bacterium. (A) A juvenile coho salmon with the more chronic form on the disease with circular opaque discolourations evident in the liver. (B&C) Stained smears from the kidney of a coho salmon with piscirickettsiosis; (B) Giesma stain with arrow showing intracellular bacteria (bar = 20μm); (C) positive indirect fluorescent antibody test showing individual bacteria (bar - 5μm). Fryer and Hedrick 2003)

Sergio Marshall and Vitalia Henriquez run a genetics and molecular immunology lab of the PUCV biological institute in Curauma Chile. The lab works to create an efficient oral vaccine that can be used to inoculate the salmon cultivated in the fisheries of southern Chile. Their goal is to transform the DNA of microalgae to express an immunogenic gene and cause the immune system to react against P. salmonis. This method would create a cheaper and more efficient vaccination that is easy to handle and administer without stress to the fish.

The purpose of this study is to explore an immunogenic gene named ChaPs that was found within the bacterial plasmids. Experiments showed promising results in vitro for creating an oral vaccine for fish infected with P. salmonis using transformation into micro algae. However, before continuing to in vivo experiments we wanted to decipher whether there are one or two copies of this gene within the plasmids using the chemiluminescence southern blot technique. During my time in Chile the final development stages of the southern blot were inconclusive due to improper materials.

$\delta^{18}O$ and $\delta^{13}C$ Isotopic Analysis of Lodgepole Pine (Pinus contorta) Tree Rings and Their Evaluation as Local or Regional Climate Records, Upper North Willow Creek Drainage, MT

Jeremy Degler

Advisors: Erika Elswick and Peter Sauer

Tree ring cellulose has been used in the past as a way to estimate past climates (Buntgen, 2011), and can support data which comes from a number of different climate proxies. Carbon and oxygen isotope data from the tree rings can be analyzed in regards to climate trends throughout the lifespan of the tree. The α-cellulose is being extracted from samples of annual growth rings from Lodgepole Pine (Pinus contorta) tree cores taken near Mason Lake, within the Indiana University Willow Creek Demonstration Watershed in Montana. The cores are separated into individual years, and then digested using a process derived from Loader et al. (1997) in which the lignin and hemicellulose are extracted, leaving only the α-cellulose behind. This purified cellulose is then introduced to the mass spectrometer to determine the $\delta^{18}O$ or $\delta^{13}C$ isotope composition. The pines incorporate carbon from CO_2 during photosynthesis at a regional scale, and the oxygen originates from CO_2 and snowmelt. There are two separate cores from the Mason Lake area; methodology was tested on one to ensure that accurate and reliable data was produced, and the other will chiefly comprise the main study. The annual $\delta^{18}O$ and $\delta^{13}C$ isotope data obtained from the Lodgepole cores will be compared to the past 200 years of existing regional data found in the Palmer Drought Severity Index (PDSI) (NOAA, 2011) and the past 72 years of local discharge data from USGS discharge monitoring station 06035000 at Willow Creek, MT (USGS, 2011). As the USGS data is concerned with stream discharge derived from available snowmelt on a local, watershed scale, and the PSDI data is a regional average from four datasets with a total geospatial range of 2.5°, it is important to compare this difference in scale to the isotope analysis from the Mason Lake Lodgepole cores. The purpose of this research is to determine whether or not stable isotope proxies from the Lodgepole cellulose have any direct correlation with either discharge data caused by annual snowmelt as seen in the data from the USGS discharge or with the PSDI data. These two proxies act on separate scales, and it will be determined whether the O or C isotopic tree ring data more closely represents the existing proxies.

Current Trace Metal Fluxes in Wet Deposition for the BATS region.

Janelle Steffen

Advisors: Lisa Pratt [Geological Sciences], Danilo Dragoni [Geography] and Vicky Meretsky [SPEA]

Atmospheric aerosol deposition is an important source of nutrients and trace metals to the open oceans. These depositions affect ocean productivity, carbon sequestration, and chlorophyll concentrations, ultimately affecting overall phytoplankton community structure. It has been shown that wet and dry atmospheric aerosol depositions contribute to trace metal levels in the western North Atlantic significantly more than either fluvial or deep-sea particle fluxes. Bermuda (Figure 1a), located in the Sargasso Sea, receives both anthropogenic and natural atmospheric aerosols. From May-September, the easterlies bring in terrestrial aerosols from Southern Europe and the Sahara of Northern Africa, while from October- May, the westerlies arrive to Bermuda from across North America. Aerosols arriving from these different locations differ in chemical characteristics. Aerosols collected during the summer months show Cu/Al ratios resembling crustal matter, while those collected during the late fall and early spring show enriched Cu/Al ratios. These seasonal composition changes along with a relatively high oceanic mixing rate alter copper surface levels significantly throughout the year.

Figure 1: a. The location of Bermuda in the North Atlantic Ocean. b. Bermuda, showing the sampling locations—Tudor Hill Tower and the Bermuda Institute of Ocean Sciences (BIOS).

Every week, a bulk rainwater sample was collected and placed in 2-60 mL bottles for duplicate and frozen until analysis. All samples were collected at the Tudor Hill Sampling Tower (Location, Figure 1b) using a automated wet-only collector. The rainwater samples were then run in a Graphite Furnace Atomic Absorption Spectrophotometer (GFAAS) to find the concentration levels of Al, Cu, Fe and Mn. These values were used to calculate weekly trace metal fluxes (nM cm^{-2}) and yearly estimated trace metal fluxes (nM cm^{-2} y^{-1}). The mean Al, Cu, Fe and Mn concentrations were 299 nM, 4.02 nM, 73.7 nM and 9.92 nM respectively. It is notable that Fe and especially Al concentrations are an order of magnitude greater than either Fe or Cu concentrations, with mean Al, Cu, Fe and Mn fluxes following the same trend.

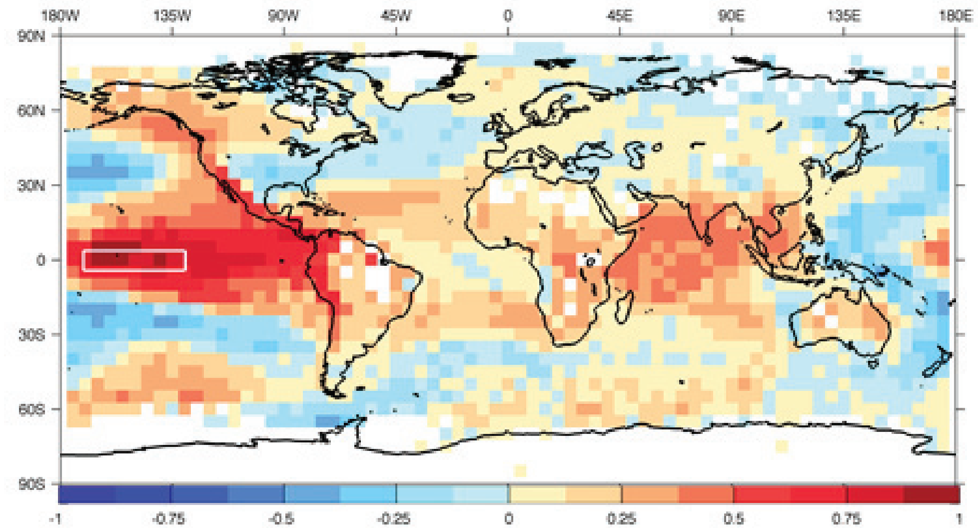


Fig. 3 Correlation between HadCRUT3 temperatures with ENSO anomalies for all months in years (1950-2010). The white rectangle denotes the Niño 3.4 region.

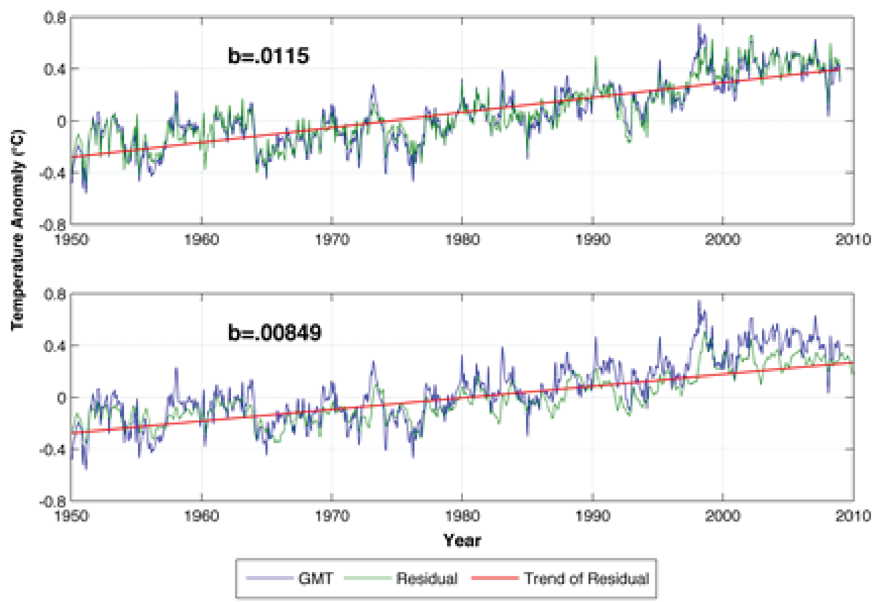


Fig. 8 Comparison of the methods used in (Thompson et al. 2009) (top panel) and this study (bottom panel).

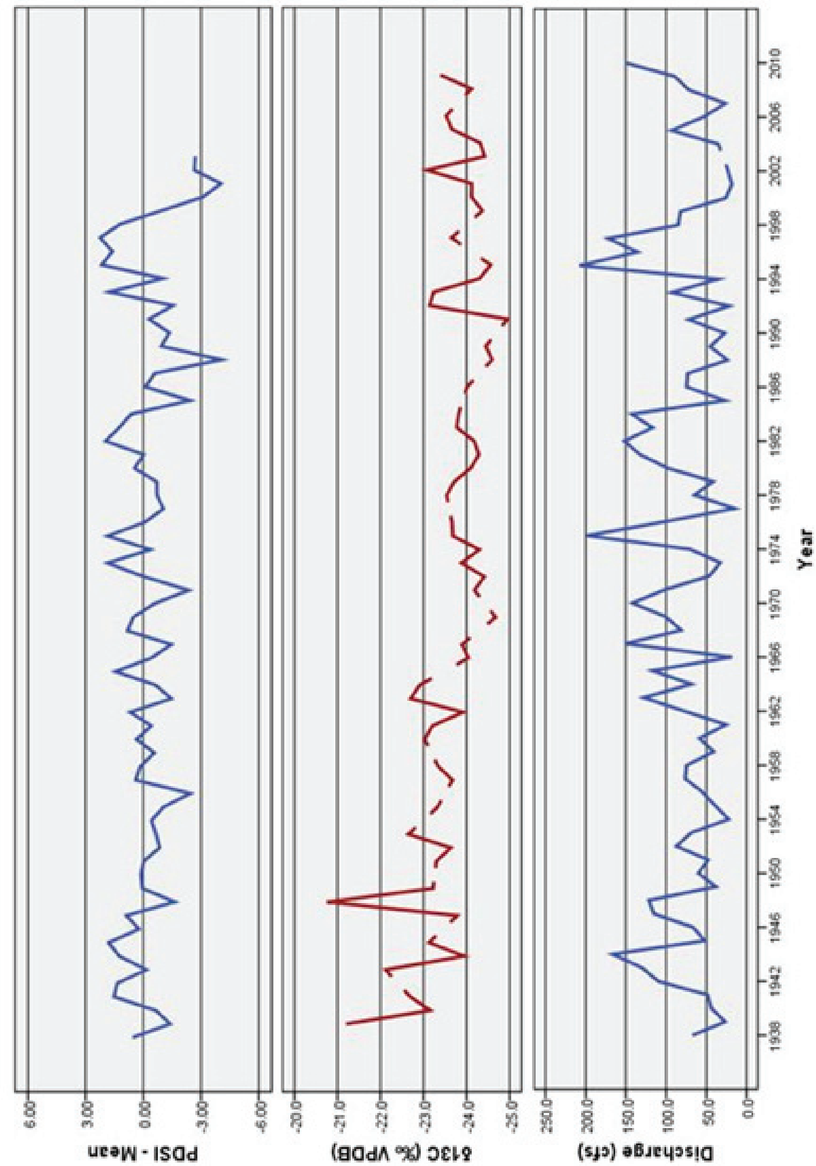


Figure 1. Palmer Drought Severity Index (mean value of 4 stations located across Southwestern MT), $\delta^{13}C$ values of annual growth rings of a Lodgepole pine (Mason Lake, MT), and mean summer discharge data from a USGS station (Willow Creek, MT) spanning from 1938 to 2010.

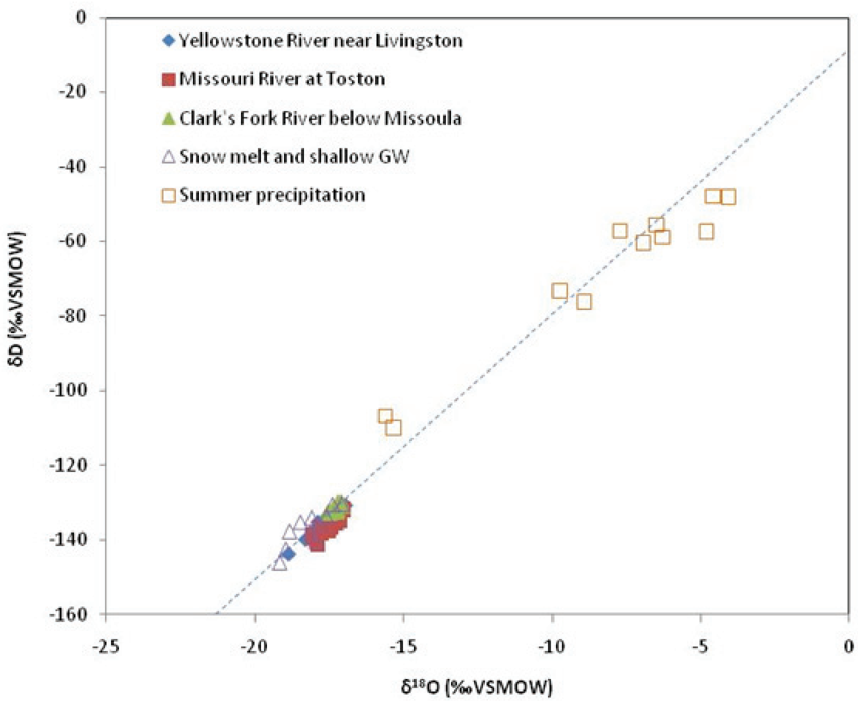


Figure 2. δD and $\delta^{18}O$ plotted against the meteoric water line (MWL) for three rivers located near the study site. The δD and $\delta^{18}O$ values of Willow Creek snowmelt and summer precipitation show that the majority of water availability in the area is provided through annual snowmelt.

Identifying and Removing the El Niño Southern Oscillation Variability from the Time Series of Global-Mean Surface Temperature and its Regional Implications

Jordan L. Schnell

Advisor: Scott Robeson, Geography

Global-mean surface temperatures consist of both natural and anthropogenic variability. This study attempts to identify one source of natural variability, the El Niño-Southern Oscillation (ENSO) and also shows the regional influence this signal has on temperature. The correlation between ENSO and surface temperature anomalies for each 5° by 5° grid box is calculated using simple linear regression analysis over the period January 1950-December 2010. Significant positive correlations were found in the area where El Niño's effect on SSTs is greatest, the western coast of both North and South American, and also the Northern Indian Ocean. When looking at the correlations of North America on a calendar month basis, three areas that have been identified in previous studies emerge and agree with their conclusions. The area south of Florida extending east is an area with high positive correlation. Another area of strong correlation is the western edge of North America. While they identified the area of Northwest North America to be a region with strong correlation, our analysis shows a more consistently strong correlation in Southwest North America, especially during winter months. However, the Northwest North American region does show strong correlation in late winter and spring months. The third identified is Eastern Canada which shows near-zero correlations for all calendar months. After removing the variability of ENSO from each gird box's temperature record, and subsequently calculating a residual global-mean temperature, much less variability is seen. On the regional scale however, temperature records of areas with large positive correlations alter significantly while areas with near-zero correlations remain relatively unchanged.

fractions of sulfur in the lichen specimens are yet to be determined. AAS analyses detected trace amounts of cadmium, copper, zinc, lead, and chromium in the thallus of all lichen specimens. These concentrations vary between species and with distribution across the field area. Preliminary data does not confirm the extent to which the lichens growing near the Bullion Mine were affected by anthropogenic disturbance. However, sequential extractions and S purification, followed by measurements sulfur isotopic compositions will enable a more accurate assessment of the usefulness of lichens as indicators of biological incorporation of contaminant elements in isolated and remote mining operations. A geospatial analysis of heavy metal concentrations will serve to confirm potential metal sources and to explain the observed variations between species.

Works Cited:

Batts, Judith E., Lisa J. Calder, Barry D. Batts. 2004. Utilizing stable isotope abundances of lichens to monitor environmental change. *Chemical Geology*. 204, 345-368.

Brodo, Irwin, Sylvia Duran Sharnoff, Stephen Sharnoff. Lichens of North America. 2001. Yale University Press.

Fey, David L., Stanley E. Church, and Christopher J. Finney. 2000. Analytical Results for Bullion Mine and Crystal Mine Waste Samples and Bed Sediments from a Small Tributary to Jack Creek and From Uncle Sam Gulch, Boulder River Watershed, Montana. Open-File Report 00-031. On-line Edition. US Geological Survey.

Metesh, John. Jeff Lonn, Ted Duaime, Robert Wintergerst. 1994. MT Bureau of Mines and Geology Open File Report No. 321 Abandoned and Inactive Mines Program. Deerlodge National Forest. Vol.1. Basin Creek Drainage. MBMG

Project Title: Macroinvertebrate Communties at Sycamore Creek, Central Indiana

Rebecca Goldstein

Advisor: Jeff White , SPEA

Rapid Bioassesment Protocols (RBPs) use biological indicators, such as macroinvertebrates, to infer stream water quality (Barbour *et al.* 1999) Chemical and physical sampling can also be used to classify water quality (Barbour *et al.* 1999). This study investigated the results of the macroinvertebrate indexes at two sites (SC and BR) in the Sycamore Creek Watershed in central Indiana (Figure 1). Macroinvertebrate samples were collected using a D-net 5 jab method for 5 weeks in winter 2011. Water chemistry and physical samples were collected bi-weekly for a year. Macroinvertebrates were analyzed using 4 indexes (Table 1). Assemblage amongst the two sites was measured (Figure 2) and results showed the taxa at each site were similar ($p < 0.05$), but the abundances were significantly different ($p > 0.05$). Results implied BR had lower water quality than SC. Differences between SC and BR in terms of physical and chemical parameters were not significantly different ($p < 0.05$). A study by McCabe and Gotelli (2000) showed that disturbance regimes cause two sites to have similar taxa with different abundances. Their results correlated well with this study. This study implies that ecological theory plays an overarching role and must be accounted for when using RBPs.

Barbour, M.T., J. Gerritsen, B.D. Snyder, and J.B. Stribling. (1999) Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates and Fish, Second Edition. EPA 841-B-99-002. U.S. Environmental Protection Agency; Office of Water; Washington, D.C.

McCabe, D. J. and Gotelli, N. J. (2000) “Effects of disturbance frequency, intensity, and area on assemblages of stream macroinvertebrates” Oecologia 124:270–279. Aquatic Biodiversity II Developments in Hydrobiology 180: 379-390,

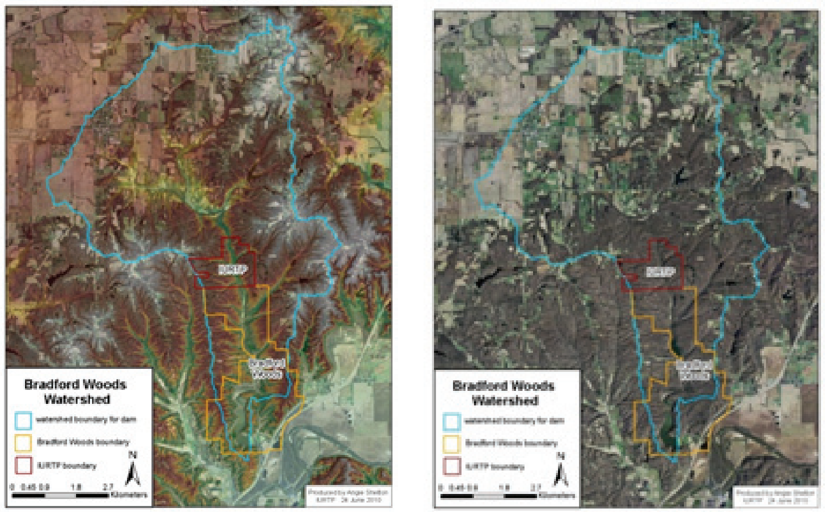


Figure 1: Watershed Maps of Sycamore Creek. These maps show the topology (A) and land used (B) within the watershed. The watershed is 34.02 Km2 and 95% of the land is covered by oak hickory forest. The sites are marked with black dots. The top dot is SC, bottom is BR.

Table 1: Macroinvertebrate index results. All results for SC imply low amounts of pollutants in the stream. At BR all results indicate that there is some organic pollution affect the stream. The results are consistent for each site, but different between the sites.

Index		SC	BR
HFBI	Value	3.09	4.78
	Interpretation	Organic Pollution unlikely	Some Organic Pollution present
ICI	Value	364.6	23±2.1
	Interpretation	Above Acceptable level for stream. Indicates little to no pollution present	Below Acceptable level for stream Indicates some pollution present
%EPT	Value	77.32	16.73
	Interpretation	High quality water	Low quality water
%Chironomidae	Value	15.04	68.34
	Interpretation	High Quality water	Low Quality water

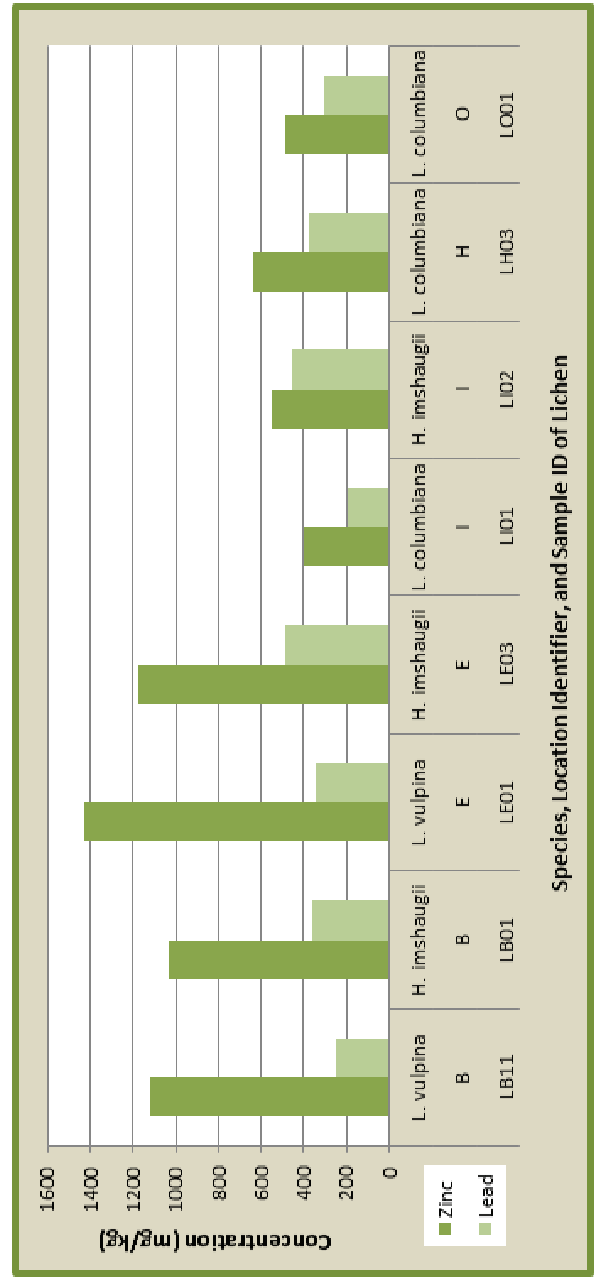


Figure 3: Concentration of zinc and lead (mg/kg or ppm) in eight lichen specimens from five different sample locations. Concentrations determined by atomic absorption spectroscopy on an AAnalyst 800. Data plotted from left to right in order of increasing radial distance from the center of the field area. Lichens collected from Bullion Mine, Jefferson Co. Montana. July 2011. Analyzed April 2011.

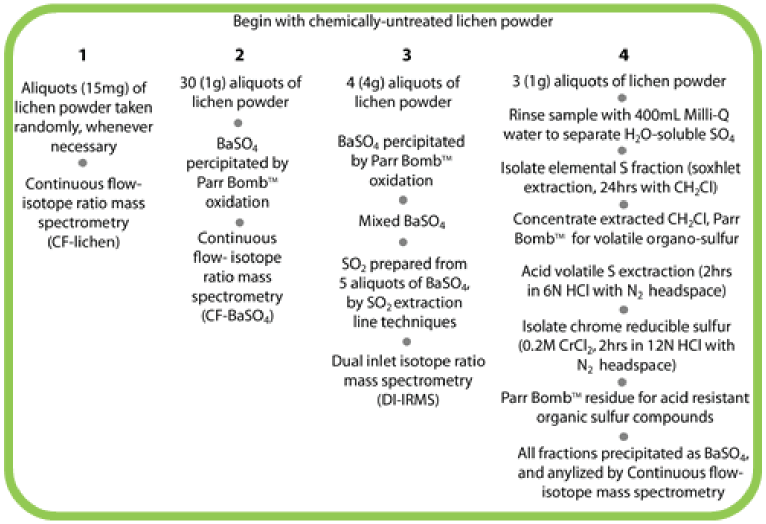


Figure 2: Four methods for extracting S from the lichen tallus. Methods 1-3 are described in Yun (2004). Method 4 is modified from Lefticariu (2006). Methods 1, 2, and 4 are used in this study. Figure adapted from Yun 2004.

Twenty-six samples, consisting of six different lichen species, were collected from eleven living trees at radial distances of 300-800 feet from the center of Bullion Mine. Sampling sites were chosen within a roughly radial pattern, as allowed by disturbance and abundance of lichen. Lichens were identified using chemical tests, the investigation spore structure under a dissecting microscope, and by examining the structure of fruiting bodies. Unpulverized specimens were analyzed on an Eltra CS-2000 carbon-sulfur determinator to provide preliminary data on C/S ratios in different lichen species. Three methods were used to extract sulfur from the lichen thallus; direct input into a CE Instruments EA 110 elemental analyzer, oxidative combustion via Parr® Oxygen Bomb, and sequential sulfur extraction. Three samples were selected for sequential extraction, which allows for the removal of various oxidation states of sulfur though a series of wet chemistry techniques. Sequential extraction uses both organic solvents and strong acids to liberate the sulfur. Twenty-three samples were oxidatively combusted in a Parr® Bomb stainless steel reactor. Sulfur released during oxidative combustion was recovered as barium sulfate and analyzed for $\delta^{34}S$ using a Finnegan MAT 252 isotope ratio mass spectrometer. Eight samples were analyzed for heavy metal concentration using an AAnalyst 800 Atomic Absorption Spectrometer.

Preliminary C/S ratios suggest that these lichen specimens do not contain abnormally high concentrations of sulfur for biological material. The dominant chemical

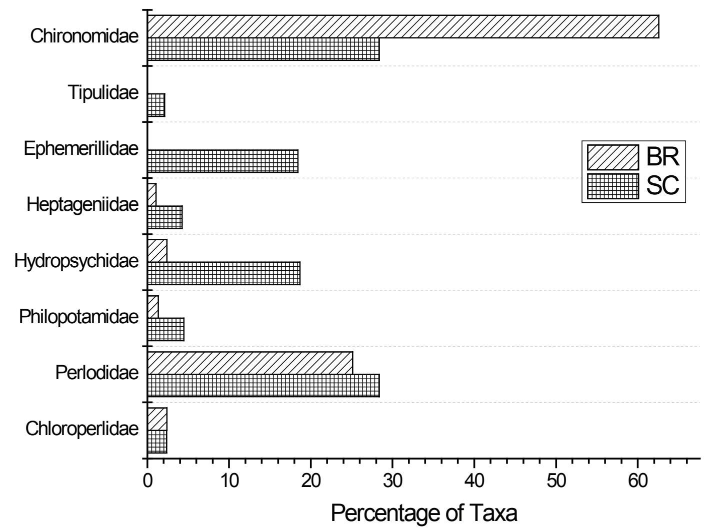


Figure 2: The percentage of taxa in the sample for taxa that represented over 1% of the sample. This figure shows that in comparison to other taxa at BR Chironomidae is dominant (68%). At SC Chironomidae, Perlodidae Ephemerillidae and Hydropschidade dominate almost evenly.

Table 3: Analytes measured in laboratory. Average or median (pH) is shows, along with the sample number and the significance. Samples that were not above the detection limit were not included in the average or the t-test. Only pH and DOC were significantly different between SC and BR. NH4-N and Alkalinity were not included because of low sample numbers.

	SC	BR	N (SC)	N (BR)	Significantly Different?
NO_3-N (mg/L)	1.444±0.802	1.059±0.816	30	30	no
TDN(mg/L)	1.089 ±0.383	0.846±0.467	24	22	no
SRP (μg/L)	10±4	8± 4	16	19	no
DOC(mg/L)	2.487±0.639	1.809±0.397	24	24	yes
DO (mg/L)	12.00	12.00	2	2	no
Conductivity (μS)	509 ±136	477 ±110	28	28	no
pH	8.36	8.20	22	22	yes
Temp. (°C)	11.81± 8.50	11.50 ± 8.00	28	28	no
Turbidity (NTU)	1.83±.87	2.46 ±1.16	26	26	no

Social Barriers Associated with Community Gardens

Melissa LoFaso

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Community gardens are not exclusively defined by a cultivated area for crops; they are an essential part of a community where the benefits are limitless. Establishing communal gardens beautify neighborhoods, improve the quality of life for users, provide nutritious organic foods, reduce reliance on commercially brought products, decrease family food budgets, and conserves resources among others. Essentially gardens help create opportunities to educate community members on healthy lifestyles, while providing a facilitator for neighborhood and public development. Although community gardens are meant to stimulate social interaction among its members, often gardens are faced with ignorance, lackluster interest, or unwillingness to simply try something new. To prevent these problems and create successful gardens it is important to learn how to interact with a community to get them interested in being a part of a growing trend among cities.

As mentioned, a lack in enthusiasm for participating in gardens is a main concern for the success of a garden. Focusing on some of Bloomington's local community gardens, I was able to collect data referring to the amount of users and food produced by each garden. After evaluating and comparing the data to Bloomington statistics, it has given me evidence that there are social barriers even within sustainable cities such as Bloomington. Repeatedly individuals misunderstand the influence gardens can have on themselves, making them unwilling to try something new and learn about maintainable resourcing. It takes strong leadership and passion to start a garden and have it continue sustainably into the future. To reduce these social barriers, we will explore ways to overcome these obstacles. Main ideas are to create farmers market, offer free classes, and promote garden education in schools. With stronger influences on individuals in the community, community gardens can become the sole providers for fresh produce in many areas.

Sulfur Content and Isotopic Composition of Lichen Species. Bullion Mine; Basin, MT

Jade A. Marks

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Lichens are useful indicators of environmental impact due to their tendency to accumulate trace metals into their bodies (thalli) and their ability to go dormant under adverse conditions (Brodo, 2001). Changes in species richness and distribution, stable isotopic compositions of carbon and sulfur, and heavy metal concentrations within the lichen thallus can vary temporally and spatially with industrialization, disturbance, and associated contamination (Batts, 2004). This research project involves an exploratory analysis of sulfur concentration, sulfur ($\delta^{34}S$) isotopes, and heavy metal concentrations in six common lichen species collected at an abandoned precious metal mine in central Montana. Results will help to evaluate the potential of lichens as bioindicators for human disturbance in remote mountainous areas.

The field site for this project, Bullion Mine, is a reclaimed mine in the Basin Mining District; Jefferson County, Montana. Bullion was mined intermittently for gold and silver from 1897 to 1955. The ore body contains a variety of metallic sulfides including pyrite, galena, sphalerite, tetrahedrite, and arsenopyrite, as well as an abundance of quartz and siderite (Fey, 2000). The weathering of these minerals releases sulfur into the environment, which can be traced using stable isotopes. In 1999 Bullion became a Superfund National Priorities List site with initial cleanup being completed in 2002. The site is still actively monitored by the Environmental Protection Agency (Metesh, 1994).

Figure 1: Photograph of lichen species Letharia columbiana collected at Bullion Mine, Jefferson Co, MT. July 2010. One of six lichen species analyzed in this study.