Cary Institute of Ecosystem Studies

Research Experiences for Undergraduates

2017 Student Abstracts

Johnathan Clementi (Marist College): Determinants of Sex Ratio of Bluegill (*Lepomis macrochirus*) across Changing Fishery Landscapes in Northern Wisconsin

The sex ratio of a population can be indicative of the reproductive fitness. Throughout lakes in Northern Wisconsin, increases in dissolved organic carbon (DOC) levels and fishing pressure have been shown to influence fish life history characteristics. A comparative study of bluegill (*Lepomis macrochirus*) across lakes ranging in DOC and fishing pressure was conducted to examine the ecological influences on the sex ratios of bluegill. To assess sex ratio, we sampled 25 lakes using fyke nets from late May to late June 2017. Although DOC and fishing pressure have been shown to influence other life history traits such as maximum size and productivity, we found no definite correlations between sex ratios and DOC or fishing pressure. However, sex ratios in seventeen lakes were greater than 1:1. Twelve of those lakes were heavily male skewed and ranged from two to nine males to each female. Skewed sex ratios may have implications for the management of recreational fisheries. As males begin to dominate populations, sneaking strategies and sex-specific angling practices may increase, selecting for smaller fish.

Mikayla Domingo (Oregon State University): Effects of Diluted Wastewater Concentration on the Hudson River Estuary

Wastewater continues to be a significant input of water, carbon, and nutrients to the Hudson River. In the past, the effects of large amounts of wastewater have been well-documented, but current effects of more dilute wastewater on river functioning have not been considered. Therefore, we focused on examining how varying concentrations of wastewater affects the bacteria and phytoplankton communities in the Hudson River. To do this, Hudson River water samples were amended with amounts of wastewater spanning the relative inputs observed in the system. To quantify the bacterial response, we measured oxygen consumption, the dissolved organic matter concentration, nutrient concentrations, and the optical properties of dissolved organic matter over time. The phytoplankton response was determined through the accumulation of chlorophyll a. Overall, we saw that the addition of wastewater added nutrients and novel sources of dissolved organic matter, but it did not drastically affect the growth of bacteria and phytoplankton communities in the Hudson River. This could be the case for a variety of reasons. One being that wastewater treatment plants are doing a good job of treating wastewater before releasing it into our waterways. Another being that the Hudson River already receives a fair amount of treated wastewater so additional wastewater inputs does not have a large impact on the system. Wastewater continues to add household chemicals, pharmaceuticals and certain indicator bacteria to our waters, but it is not causing the serious negative effects seen in previous decades.

Sophia Skoglund (St. Olaf College): Developing a Model for Lake Ice Phenology using Satellite Remote Sensing Observations

Parallel to the warming climate, historical data have shown that temperate freshwater lakes are freezing over later and thawing earlier. This shift in timing, and the resulting shorter duration of seasonal ice cover, may impact ecological processes, negatively affecting aquatic species and the quality of water we drink. In order to better understand the trends in changing ice cover, it is important to have long-term records for lakes. The traditional method of gathering these data is by observation, but such records of temperate lake ice cover are lacking. However, satellites provide remotely sensed data with which we may be able to approximate the dates of ice-on and ice-off for many years over a variety of lakes. The goal of this study has been to build a model of ice phenology using remote sensing data and to compare the output with observed ice histories. Methods to translate surface temperature readings from MODIS (Moderate Resolution Imaging Spectroradiometer) satellite instruments into ice-on and ice-off dates were developed for observations of Lake Auburn, Maine. Day and night surface temperatures from MODIS Aqua from 2002 to 2017 were utilized. The results revealed that approximations for ice-off dates were more accurate than ice-on dates. The analogous comparison of observed and remotely sensed ice cover duration showed relative agreement with a correlation coefficient of 0.46. The model shows promise for estimating ice-on, ice-off, and ice cover duration for hundreds of northern temperate lakes.

Deresha Porter (Louisiana State University): Measuring Interest in Science and Science Self-Efficacy Among Youth Living in an Urban Environment

Minority groups are highly underrepresented in a range of science careers and make up a particularly small portion of environmental careers. The purpose of this study was to investigate a number of factors that may have an influence on the resulting underrepresentation in science. The Parks & People Foundation (PPF), an environmental stewardship organization based in Baltimore City, offers environmental internship opportunities to Baltimore City youth through their program BRANCHES. Within the program, middle and high school aged students have the opportunity to participate in ecological research or environmental stewardship activities. Science self-efficacy and interest in science were evaluated in 10 of the BRANCHES students, five of which partook in the research group and five of which partook in a stewardship group. Survey results of the 10 students showed a range of interest in science and science self-efficacy, regardless of their BRANCHES group. Interview results showed that a number of factors including valuation and understanding of science, education, support, and experience had varying amounts of influences on the students' interest in science and science self-efficacy. While I expected to observe more differences in the students, survey and interview results showed that many of the students shared similar levels of interest and confidence in science but varying levels of education, support, and experience, regardless of their BRANCHES group.

Margot Shrift (Kutztown University of Pennsylania): The Potential of Satellite Imagery to Retrieve Chlorophyll a and Water Clarity Data for the Assessment of Lake Water Quality

Lake water quality is declining nationwide and has become a tremendous point of interest due to lakes' sensitivity to the changing environment. Lakes and reservoirs are important not only because we depend on them for drinking water, food, and recreation, but also because they reflect and support the ecological state of the surrounding ecosystem. Remote sensing (RS) data from satellite observations may offer a reliable alternative to in-lake observations of water quality. RS data have provided the ability to

efficiently study many oceans or terrestrial system over space and time. Fresh water bodies, especially small, nutrient poor lakes, however, have only recently been assessed using remote sensing technology; few models exist to interpret these fresh water systems. This study focuses on the potential of utilizing Landsat 8 satellite imagery to predict chlorophyll-a and Secchi disk transparency values from Lake Auburn, Maine, an oligo-mesotrophic lake which is the primary source of drinking water for Lewiston/Auburn and has had increasingly toxic algae blooms. Several combinations of Landsat bands were analyzed to obtain the most reliable prediction of in-lake chl-a and Secchi disk values. The results reveal that a specific combination of bands 5 and 4 for chl-a and bands 3 and 2 for Secchi disk transparency show the most promising formulas with respective 0.57 and 0.74 correlations coefficients. However, there has been a trend of poor satellite sensitivity to low chl-a values. The resultant algorithms show promise for utilizing RS data to estimate past, present, and future water quality for a large array of low-nutrient lakes in northern North America, and thereby to gain a better understanding of our vital fresh water resources.

Alex Page (North Carolina A&T State University): Determining Scavenger Presence in Temperate Forests on Northeastern America

Scavenging is a crucial ecosystem service which allows nutrient materials to be recycled and reused within a community; scavenging may also limit the presence of harmful pathogens. The purpose of this study was to observe the scavenger guild that exists on the Cary Institute property and understand how these scavengers affect carcass removal. Non-invasive camera traps were set with chicken carcasses at four separate sites within the Cary property with 4 replicates per site. The cameras took pictures of the various species which visited the bait. Our team sequentially measured the chicken carcasses at 3 intervals to determine how much scavenger activity and carcass consumption occurred over time. The camera trap photos were then collected and analyzed to determine which species were present at each site, and for what amount of time they were present at the bait. This allows us to evaluate which species contribute the most to consumption of carcasses through time. Based on preliminary results, American turkey vultures (*Carthartes aura*) and coyotes (*Canis latrans*) were the most abundant scavengers visiting the carcass site.

Elena Prado-Ragan (Knox College): Efficacy of Various Plant Compounds as Larvicides against *Aedes albopictus*

Yearly estimates from the Center for Disease control report that over 1 million people die worldwide due to mosquito borne illnesses, making the mosquito the most dangerous animal on the planet. As climate change progresses however, alterations in precipitation patterns and warming global temperatures have encouraged a boom for soft bodied arthropods and in turn have increased the likelihood for transmission of all mosquito vector borne diseases. Current strategies for combating mosquitoes have remained the same despite this expected increase in disease transmission. Focus has greatly remained on repellants, though these chemically based compounds do nothing to kill mosquitos, only temporary deter the mosquito from its blood meal. This study however, aims at developing a larvicide--killing the mosquito before it reaches adult potential. Four plants common in North America were tested against first instar *Aedes albopictus* larvae. C*hrysanthemum indicum, Erigeron pulchellus, Nepeta cataria* and *Cichorium intybus* plant leachates served as habitats for *Ae.albopictus* larvae for a

period of 24 hours, and mortality rates were recorded thereafter. Results indicate that *Chrysanthemum indicum* and *Erigeron pulchellus* have the most potential as being a future derivative for a plant based larvicide based on multiple trials at various concentrations. Relying on plants instead of chemically based compounds replaces the need for chemical and plastic manufacturing, eliminates the chance for synthetic chemical ingestion, and provides an option for individuals from all socioeconomic backgrounds. Further, if flowers are planted in home gardens for future use, this will encourage pollinators while also actively reducing mosquito populations in local sites.

Abigail Lewis (Pomona College): Nutrient Limitation of Phytoplankton at Varying Depths in a Stratified Lake

Anthropogenic increases in global nitrogen (N) and phosphorus (P) cycling have led to increased loading of N and P in aquatic systems and subsequent toxic phytoplankton blooms. However, the issue of which nutrient (N, P, or both) is the limiting factor for freshwater phytoplankton productivity remains hotly debated. In this study I investigated differences in nutrient limitation between phytoplankton that inhabit the epilimnion (1m depth), metalimnion (5m depth), and hypolimnion (15m depth) of Lake Minnewaska, NY, using a one-week, *in situ* microcosm incubation and four nutrient treatments (control, N, P, N+P). Phytoplankton from all depths demonstrated co-limitation by N and P, while phytoplankton from 15m also showed a significant, though weaker, response to P alone. To test the effect of changing light conditions on nutrient limitation, I repeated the incubation using three light treatments on phytoplankton from a depth of 5m. The type of nutrient limitation did not differ between light treatments. These results challenge conventional theory that P limitation dominates freshwater lakes, in addition to suggesting potential for depth-based differences in nutrient limitation.

Abigail McCrea (Oberlin College): Effects of Vegetation and Competition on Development of Vector Species

Mosquito-borne diseases are increasingly affecting public health with urban areas seeing changes in distribution and an increase in incidence of vector-borne pathogens. Anthropogenic influences are changing resource availability in the aquatic breeding habitats of mosquitoes and in turn are affecting larval development. Leaf detritus and the associated chemical makeup of these habitats inform levels of competition among mosquito larvae and affect adult mosquito life history traits that influence disease transmission. This study investigated how differences in vegetation chemistry among plants commonly found in urban yards (grass, oak) and vacant lots (ailanthus, catalpa) present in rearing habitats affected development and emergence amongst *Culex pipiens* and *Aedes albopictus* larvae. In this laboratory experiment, these larvae were reared in aquatic environments with varying levels of nitrogen and different plant species typical of managed and unmanaged urban areas. This allowed us to explore how land use affects competition between the two vectors and to discover how this in turn affects larval development and survivorship as well as adult body size. Our findings suggest that resource availability is determined by detritus inputs to containers and that nutrients from these inputs determine the level of competition, survivorship, and the adult wing size of the mosquitoes. *Ae. albopictus* pupation rates varied significantly across species treatments but adult size was greater when reared in treatments with higher nitrogen plants. *Cx. pipiens* pupation rates were consistent across treatments, yet adult size was greater when reared with plants believed to leach higher nitrogen.

Byron Birss (Southern Oregon University): The Development of Children's Scientific Curiosity, and Why School Should Be More Like Summer Camp.

The future of this planet is dependent upon our ability to raise children into stewardship-minded adults. Positive environmental ethics develop from regular childhood contact and play in nature, and by encouraging their natural curiosity through exploration and discovery of the natural world. This research assessed the development of children's scientific curiosity at summer camp, and how that progression may be influenced by their pre-existing environmental actions, attitudes, and beliefs. Students in the Cary Institute Eco-Discovery Camp from 2nd - 7th grade were the test subjects for this research. Using a take-home survey and pre-post questionnaires, we determined the effect of attending camp on various aspects of children's scientific curiosity, and their preferred methods of expressing that curiosity. These measures identify how children's perceptions may extend beyond direct camp experiences into the broader context of scientific curiosity, and how the environmental learning that takes place at home influences the development of their curiosity at camp.

Celestina Wright (Oberlin College): Modeling the Temperature- and Nutrient-Dependence of Larval Development Rate, Egg-to-Adult Survival, and Adult Size in *Culex* Mosquitoes

Better understanding mosquitoes is the mission of many concerned with disease transmission and global public health. The larval life stage is of particular interest because larval rearing conditions can influence the developmental process and subsequent effects can carry over into adulthood. Both nutrient type and temperature are essential factors in this stage that fluctuate in natural environments: nutrient availability has been observed to influence development time, survival, and resulting adult body size and, because mosquitoes are ectotherms, their biological processes depend on external temperature. We explored how life history traits, specifically egg-to-adult survival, larval development rate, and adult size, respond to a range of temperatures and whether these responses differ between natural and artificial nutrient regimes. We collected data from published laboratory studies reporting these life history traits for *Culex* mosquitoes at various temperatures, and under natural and artificial nutrient regimes. We then fit linear and nonlinear (unimodal) models to data for each trait and their corresponding nutrient categories to determine the best fit model. Our findings indicate that all three traits are temperature-dependent in different ways, thus challenging the conventional population growth formulae that incorporate them without regard to their temperature-sensitivity. Our results encourage more studies to use natural nutrient regimes and reveal the need for more laboratory experiments to be conducted at thermal extremes, especially the thermal maxima, for a better understanding of how these traits respond at critical thermal thresholds.

Jennifer Nieves (Montclair State University): Chestnut Oak (*Quercus prinus*) Response to Browsing Pressure by White-Tailed Deer: Implications for C and N Allocation

Overabundant white-tailed deer (*Odocoileus virginianus*) populations threaten potential forest regeneration in many parts of the Northeast. Growth reductions in forest plants associated with high herbivory have been attributed to limitations in C, N, and carbohydrate storage in various plant parts. To assess the potential for regrowth of forests subjected to long-standing deer herbivory, this study evaluated the tissue chemistry, biomass accumulation, and ages of chestnut oak *(Quercus prinus)* seedlings growing in locations with different deer densities. I compared low, medium, and high

herbivory intensities with the tissue chemistry of plants protected in 25 year old deer exclosure plots. Seedlings of similar height located at plots with higher herbivory were older, had greater total biomass, and had greater non-structural carbohydrates in roots compared to stems. In deer exclosure treatment plots, differences in the tissue chemistry of plants between fenced and unfenced plots were insignificant for all plant parts at all herbivory intensities. This study suggests that future forest regeneration will depend on deer management strategies including the time that regenerating plants will need to be protected in accordance with previous herbivory intensities.

Melisa Bohlman (University of Arizona): Relative Stability of Nitrogen in Soil Organic Matter Depends on Sources of Input

The nitrogen (N) cycle in temperate hardwood forest soils in the northeastern United States was closely examined to explore how different forms of N inputs affect the dynamics of soil organic matter (SOM) formation and stability. Despite years of receiving elevated levels of pollutant N from atmospheric deposition, recent inorganic N concentrations in forest stream runoff have been declining. To better understand N storage in forest soils, we conducted a ^{15}N tracer study to compare how the stability of N in recently formed soil organic matter differs between N that is derived from decomposed plant organic material (representing the primary source of N inputs to soils in most undisturbed forests) versus N that is deposited in the inorganic form as nitrate (NO_3^-; representing the dominant N form coming from atmospheric deposition). We hypothesized that inorganic N (In-N) incorporated into soil organic matter will be more stable and will be lost from the mineral-associated organic matter (MAOM) fraction at a slower rate than N derived from plant matter decomposition (O-N). Contrary to this hypothesis, we found that, N derived from NO_3^- in soil organic matter exhibited greater rates of loss while soil organic matter with the isotopic label from O-N appeared more stable over a two-week time period. These findings will contribute to a broader understanding of how atmospheric deposition of N is affecting the soil N cycle in forests.

2016 Student Abstracts

Jonah Boucher (Hamilton College): Assessing the Effectiveness of Landsat 8 Chlorophyll-a Retrieval Algorithms for Regional Freshwater Management

Predicting algal blooms has become a priority for municipalities, businesses, and citizens. Remote sensing (RS) offers solutions to the spatial and temporal challenges facing existing lake monitoring programs that rely primarily on high-investment *in situ* measurements. Techniques to remotely measure chlorophyll-a (Chl-a) as a proxy for algal biomass have been limited to large water bodies in particular seasons and Chl-a ranges. This study explores the relationship between in-lake measured Chl-a data in Maine and New Hampshire and Chl-a retrieval algorithms. Landsat 8 images were obtained and required atmospheric and radiometric corrections. Six indices including the NDVI and KIVU algorithms were tested to validate their applicability on a regional scale on ten scenes from 2013-2015 covering 169 lakes. In addition, more robust novel models were also explored. For late-summer scenes, existing algorithms accounted for nearly 90% of the variation in in-situ measurements, however, we found a significant effect of time of year on each index. A sensitivity analysis revealed that rainfall in the region as well as a longer time difference between *in situ* measurements and the satellite image increased noise in the models. The quantification of these confounding influences points to potential solutions such as

incorporating remotely sensed water temperature into models as a proxy of seasonal effects. Novel models built to fit particular scenes reduced this variability, but they required more satellite band inputs that do not yet have a clear ecological relevance. These results suggest that RS could be an effective and accessible tool for monitoring programs at the regional scale. Although they are subject to some of the limitations of traditional monitoring imposed by the weather, high-resolution satellites like Landsat 8 provide a promising opportunity for protecting freshwater resources.

Saba Saberi (University of California, Berkeley): Scanning from the Sky: Using Remote Sensing to Estimate Freshwater Gross Primary Production

Lakes contribute to local and regional climate conditions, cycle nutrients, and are viable indicators of climate change due to their sensitivity to disturbances in their water and airsheds. Utilizing spaceborne remote sensing (RS) techniques has considerable potential in studying lake dynamics as it allows for coherent and consistent spatial and temporal observations as well as estimates of lake functions without in situ measurements. However, in order for RS products to be useful, algorithms that relate in situ measurements to RS data must be developed. Estimates of lake metabolic rates are of particular scientific interest since they are indicative of lakes' roles in carbon cycling and ecological function. Currently, there are few existing algorithms relating remote sensing products to in-lake estimates of metabolic rates and more in-depth studies are still required. Here we use satellite surface temperature observations from Moderate Resolution Imaging Spectroradiometer (MODIS) product (MYD11A2) and published in-lake gross primary production (GPP) estimates for eleven globally distributed lakes during a one-year period to produce a univariate quadratic equation model. The general model was validated using other lakes during an equivalent one-year time period (R2=0.76). The statistical analyses reveal significant positive relationships between MODIS temperature data and the previously modeled in-lake GPP. Lake-specific models such as those for Lake Kentucky (USA), Rotorua (New Zealand), and Rotoiti (New Zealand) showed stronger relationships than the general combined model, pointing to local influences such as watershed characteristics on in-lake GPP in some cases. These validation data suggest that the developed algorithm has a potential to predict lake GPP on a global scale.

Jaelyn Bos (University of Maryland, Baltimore County): Comparing Submerged and Emergent Tidal Marshes as Sources and Sinks of Colored Dissolved Organic Matter

The Hudson River's tidal marshes produce, transform, and export dissolved organic matter, yet the factors controlling dissolved organic matter export from marshes to the Hudson River remain incompletely understood. We measured absorbance and fluorescence of colored dissolved organic matter (CDOM) in water taken from interchange points at four Hudson River marshes: two marshes dominated by submerged "low" marsh and two marshes with spatially mixed low marsh and emergent "high" marsh. Water samples taken at the submerged marsh interchanges had significantly higher humification index (HIX) values than the mixed marsh samples ($p < 0.001$) and lower ratios of protein-like CDOM to humic-like CDOM ($p < 0.001$). We also conducted an ex-situ experiment by submerging sediment cores taken from high and low marsh in water from the Hudson River's main channel and taking samples every hour for three hours. Linear regression models predicted increase in the ratio of protein-like to humic-like CDOM over time for the water exposed to high marsh sediment cores with a significance level of $p < 0.1$ but not the water exposed to low marsh sediment cores. These results indicate functional differences in CDOM export between low marshes and mixed marshes and suggest possible ecological consequences for loss of high marsh with sea level rise.

Maria Moya (University of Puerto Rico, Aguadilla): Factors Affecting the Occurrence of Larger Terrestrial Vertebrates in a Northeastern Forest

Food preferences and habitat selections remain important to understanding the distribution of animals. In this study we focus on quantifying the factors affecting the distribution of the several large vertebrates found on the Cary Institute for Ecosystem Studies' property. The study examines both abiotic and biotic variables and assesses their relative significance in determining the distribution of focal species. The species that were studied include: white-tailed deer, Eastern coyotes, grey squirrels, wild turkeys and raccoons. The data were collected using trail cameras during the fall seasons in 2014 and 2015. Generalized linear models, generalized mixed models and Pearson correlation statistics were used in order to study the relationship between the occurrence of the species and the different resource variables (eg. habitat type, distance from water and the presence of other species). Generalized mixed models allowed us to analyze the data for the years 2014 and 2015 both separately and combined. Our analyses show that the distribution of deer, squirrels, and raccoons were positively correlated to a specific habitat type in at least one of the years. Coyotes and turkeys were found to be consistently and negatively correlated to distance from water. With the exception of the raccoon, the abundance of all species was correlated with coyote abundance. Our analysis shows that resource selection studies can be used to improve the understanding of the distribution of animals in a community.

Andrew Nunn (University of Evansville): Hemlocks Under Attack: Hemlock Woolly Adelgid, Elongate Hemlock Scale, and Fungal Entomopathogens

Invasive forest pests have become an increasing problem in forests globally. Locally, much focus has been towards addressing the problem of hemlock wooly adelgid (*Adelgis tsugae*) and its damage to eastern hemlock (*Tsuga Canadensis)* stands. However, another invasive pest, elongate hemlock scale (*Fiorina externa*), is present locally and has been impacting hemlock stands as well. At Mohonk Nature Preserve in New Paltz, NY 98 understory hemlock trees were assessed across ten 1-acre plots throughout the 8000 acre preserve for infestation levels of elongate hemlock scale, hemlock wooly adelgid, and measures of tree health. The presence of a fungal pathogen (*Metarhiziopsis microspore*is) of elongate hemlock scale was also measured. Across the preserve, density of elongate hemlock scale was found to be the primary factor in declining hemlock trees. The fungal pathogen of elongate hemlock scale was not found to be directly correlated with density of the insect, suggesting that environmental conditions may be more influential in prevalence of the disease rather than host density. Interestingly, this pathogen was negatively associated with hemlock wooly adelgid suggesting that conditions favoring hemlock wooly adelgid may in fact be similar conditions that the fungus struggles to survive. At Mohonk Nature Preserve, elongate hemlock scale seems to be the primary contributor to hemlock decline rather than hemlock wooly adelgid, suggesting that in areas where both pests are present management decisions should focus on both pests for the greatest chance at success.

Elizabeth Cole (University of Illinois at Urbana-Champaign): Salamanders on the Move--How Global Trade Can Alter Forest Salamander Distribution

Hemlock woolly adelgid (HWA; *Adelges* tsugae) infestation is causing an increase in eastern hemlock (*Tsuga Canadensis*) mortality rates throughout the eastern United States. In many instances black birch

(*Betula lenta*) replaces fallen hemlock, which can potentially alter forest structure and forest floor characteristics because of its high water usage. Salamanders are extremely sensitive to changes in the environment and may be affected by the loss and replacement of eastern hemlock. This study looked at how hemlock loss and replacement by black birch alters salamander habitat, if at all, and how those changes translate to the salamander community. If replacement by black birch favorably alters the microenvironment salamanders require for survival, then their population should be higher in birch dominated areas. Alternatively, if replacement by black birch negatively alters salamander habitat, then more salamanders should be found in hemlock dominated areas. Two transects were created in six different hemlock plots and birch thickets, and within each plot, soil and leaf litter measurements were taken, canopy openness was assessed, and salamander and invertebrate abundance was recorded. Salamander and invertebrate abundance was greater in hemlock plots than birch thickets, although the difference was not significant. All other environmental variables were not significantly different between plot types. Structural differences between the plot types could be influencing salamander distribution, as salamanders may prefer areas with lower stem density.

Bobbetta Davis (SUNY New Paltz): The Influence of Plant Composition on Mosquito Population Growth and Survival

Mosquitoes are known to spread diseases like Zika and West Nile viruses. These viruses are transmitted when the mosquito, a vector, carrying the virus drinks the blood of a host animal. Blood meals are only taken by female mosquitoes in order to reproduce, however all mosquitoes depend on plants early in life. Mosquito larvae consume plant detritus in aquatic habitats and adult mosquitoes feed on plant nectar. Although some plants are known to repel adult mosquitoes, little is known about how different plants consumed during the larval stage affect survival and emergence of adult mosquitoes. The main objective of this study was to study the effects of different plant communities on mosquito growth and survival. We set up ovitraps in Poughkeepsie City at sites including vacant lots with unmanaged plant communities and in managed, residential neighborhoods to monitor where female mosquitoes lay eggs. We then evaluated population growth and survival of larvae in water with urban plants from either unmanaged vacant or managed residential lots, collected in Poughkeepsie, NY. We found that mosquitoes were more likely to lay eggs in sites with unmanaged plant communities. However, mosquito larvae reared in unmanaged plant water had significantly greater mortality and were less likely to emerge as biting adults. Overall, mosquitoes have a tendency to lay more eggs in vacant lots, surrounded by invasive plant species, but seem to live longer in the presence of ornamental plants.

Yashoma Boodhan (The City College of New York): Interacting Effects of Light and Pharmaceuticals on Stream Biofilms

Pharmaceuticals and personal care products (PPCPs) are detected in streams and water supplies worldwide, and are known to affect biofilms. The algae, bacteria, and fungi that make up biofilms are important contributors to the stream ecosystem because they maintain water quality by regulating excess nutrients and serve as a food source for consumers. Although there has been recent research on the effects of PPCPs on biofilms in aquatic ecosystems, the cumulative effect of different levels of light intensity and a pharmaceutical mixture has not yet been examined. To investigate the interacting effects of light and a mixture of PPCPs, we conducted two experiments – one in artificial streams testing biofilm colonization on artificial substrates and one in a natural stream using pharmaceutical diffusing substrates (PhaDS) – and quantified the response of stream biofilms by examining chlorophyll-a (chl-*a*),

gross primary production (GPP), community respiration (CR), and algal pigment diversity. For both experiments, we found a significant difference in chl-*a* concentrations between open and shaded streams, but in an opposite direction of our initial hypothesis. From the PhaDS experiment, we found a significant effect of light on GPP, and significant effects of light and pharmaceuticals on CR. We saw that pharmaceuticals increased CR in stream biofilms, which reduces the energy available to consumers of biofilms. Chl-*a* concentrations in open versus shaded streams indicate that there might be other factors, like the composition of biofilm communities, to consider. Our results indicate that pharmaceuticals and altered light intensities have the potential to alter normal stream biofilm processes which can affect the organisms that depend on biofilms for energy, and the overall water quality of our freshwater streams.

2015 Student Abstracts

Catherine Kagemann (Indiana University): The Effects of Amphibian Presence and Predation on Mosquitoes

Due to their importance as vectors of human diseases such as West Nile, dengue, and malaria, extensive scientific research has been done to examine the factors regulating mosquito populations. Mosquito larvae are aquatic, and often share habitat with other species including amphibians. However, it is not well known whether amphibians regulate mosquito populations. Amphibian populations are declining globally due to many factors including habitat destruction, infectious diseases, and climate change. If amphibians influence mosquito survivorship, for example, by reducing the rate at which mosquitoes lay their eggs or through direct predation of mosquito larvae, then the decline of amphibians worldwide could increase mosquito populations. We conducted a series of experiments to examine whether amphibian presence and predation of mosquitoes has a significant effect on mosquito populations. Specifically, I investigated whether the presence of 2 amphibians affected the rate at which mosquitoes lay their eggs**.** I also examined whether 2 species of amphibian prey upon mosquito larvae at different rates and whether the sizes of the amphibians affected consumption rate. Salamander larvae consumed mosquito larvae at a much higher rate than the frog tadpoles. Based on the number of mosquito eggs laid in containers containing salamanders, salamander larvae do not contribute to lowering mosquito population densities in areas where mosquito habitats are predominated by vernal pools. It is currently being determined whether the salamanders affect the viability of the eggs laid in the containers. Although at a much lower rate, frog tadpoles also consumed mosquito larvae. Though predation rates were very different between salamander and frog larvae, both tadpoles and salamander larvae could have significant effects on the survivorship of mosquito larvae, and may ultimately be important contributor to overall mosquito population density.

Kayla Smith (Mt. Holyoke College): Predicted Effect of Climate Change on Mosquito Species *Culex pipiens* and *Aedes albopictus*

Mosquito species *Culex pipens* and *Aedes albopictus* are important vectors for viral diseases such as West Nile Virus (WNV), yellow fever, and Dengue fever among others. As such, these species are a public health concern and frequently studied by ecologists. While much is known about their disease transmission capabilities and population dynamics, comparatively little is known about the impacts of current and impending climate change. Global climate change due to anthropogenic production of CO_2

is widely recognized by scientists. The predicted climate patterns have the potential for serious increases in dangers to human health. There have been a few studies predicting the increase in mosquito populations and therefore increases in mosquito transmitted viruses. Many studies have established that mosquitoes develop faster in warmer temperatures, provided it remains in their thermal limit. This study aims to better understand how mosquito development and population growth responds to the expected increases in both mean temperature and variability in future climate. To test mosquito population response to climate, I simulated the predicted increase in temperature and diurnal variation in environmental chambers. Physiological responses of the mosquitoes were monitored from first instar stage to adult emergence. Competitive relationships among the two species were also monitored. Species success and fitness were determined by date of pupation, date of adult emergence, wing length of adults and adult mass.

Lara Chodelski (Oregon State University): The Language of Veeries....

Songbirds have a numerous repetoire of calls, the function of which is unknown in many species. As calls have a function, we expect that there are patterns in the way Veeries use calls to communicate. In some species, song-matching (singing the same song type back to another male) is used in aggressive interactions. In our study, we experimentally tested whether veeries used call-matching using a playback study. We created 20 minute long call tracks that we played to wild veeries to collect their response, and then tested for call-type matching by Chi-squared statistical analysis.

Erik Arndt (Whitman College): A Nitrogen Budget for the Mara River Basin, East Africa

Nitrogen is a key nutrient in ecosystems worldwide, but also has the capacity to be a potent pollutant. In this study, we developed a nitrogen budget for the Mara River Basin in East Africa and examined the effect of wildlife populations on inputs, flux, and retention rate in the river. We estimated nitrogen inputs to the watershed using the net anthropogenic nitrogen input (NANI) method. We estimated N flux using regression modeling in the USGS load estimation program LOADEST. We applied these methods to two distinct portions in the watershed—an upstream area (2,454 km^2) bounded by site 1, with major human inputs and low wildlife populations, and a downstream area (6497 km^2) bounded by site 3, with proportionately less human influence and much more wildlife. NANI results show that nitrogen inputs for both sites came primarily from human and livestock consumption (67-71%). Because very little N is imported to the basin, consumption is indicative of the mining of soil N stocks. Atmospheric deposition and biological fixation of N both contribute 12-19% of the total basin N, while fertilizer application accounts for ~1%. The LOADEST model results show that riverine N flux accounts for less than 1% of the total inputs at both site 1 (51.3 kg N day^{-1}, SE=22.0) and site 3 (157.9 kg N day^{-1}, SE=39.3), meaning 99% of the total N inputs were retained in the river, with marginally more retained upstream of site 1. At less than 1%, the fraction of riverine N export in the Mara Basin is much lower than elsewhere in the world, including the Lake Victoria Basin as a whole (16%) and watersheds in the USA and Europe (25%). Our estimate of retention rate could be improved by bettering our estimates for livestock populations and other human driven factors in the basin for the NANI model, and by including flood pulse data and increasing sample size for our LOADEST flux estimate. This study indicates that although wildlife populations increase dramatically between sites 1 and 3, they have a minimal effect on N retention rate in the Mara River. Human populations are therefore the main drivers of N loading and flux in the basin, with mining of soil N being the largest anthropogenic contributor. Careful management of human and livestock waste must be considered to

reduce and prevent pollution of the Mara River. In addition, cropland management strategies may be necessary to prevent excess soil N depletion and further environmental and economic problems.

Amanda Herzog (Wheaton College): Effects of Urban Chemical Stressors on Stream Biofilm Growth and Function

Pharmaceuticals are frequently detected in surface waters, yet little is known about their effects on aquatic ecosystem structure and function, especially in relation to other chemical stressors common in urban streams (e.g., road salt and nutrients). Using artificial streams, we measured stream biofilm response to a gradient of urban chemical stressors (UCS; including salt, dissolved organic carbon, nitrate, and phosphate), and a pulse addition of a cocktail of 8 pharmaceuticals. Streams were exposed to the UCS treatments throughout the 4 week experiment and to the pharmaceuticals for the final 2 weeks. In addition, we translocated biofilms colonized on fritted glass disks in streams without UCS to streams with the highest concentration of UCS, and vice versa, and measured their responses to UCS and pharmaceuticals. Prior to the addition of pharmaceuticals, gross primary production (GPP) increased with increasing exposure to UCS, while community respiration (CR) was higher in both the high and no UCS treatments than in the low and medium UCS treatments. Over time, GPP and CR of the translocated disks became more similar to the streams they were translocated into. Disks translocated from the highest UCS treatments to treatments without UCS showed a significant initial drop in CR after the addition of pharmaceuticals. Because biofilms are hotspots of biogeochemical activity and support higher trophic levels in streams, it is important to understand how chemical stressors may change the function of this essential component of stream ecosystems.

Hannah Talton (North Carolina A&T State University): A Natural Control for a Natural Nuisance

Many diseases are transmitted by mosquitoes, making them a deadly nuisance. Most mosquitoes are controlled by the application of pesticides, but due to the harm pesticides cause, organized vector control programs are looking for biological agents to control mosquito populations. Larval dragonflies eat larval mosquitoes and share the same habitat, thus dragonflies are of interest when looking for a natural control agent for mosquitoes. This experiment test predation, choice, and oviposition and the role each might play in controlling mosquito populations. Predation rates of dragonfly nymphs on *Aedes japonicas* were studied in laboratory conditions. *Sympetrum striolatum* nymphs were found to predate on *Aedes japonicas* mosquito larvae at first and fourth instar stages. Predation on the mosquito larvae was found to be statistically significant with a P- value < .0001. A large number of mosquito larvae were eliminated within three hours, suggesting that dragonflies may have potential as control agents. The oviposition experiment was conducted under field conditions in 3 gallon containers with 16 replicates comparing controls (no dragonfly nymph) with an experimental treatment with a single free-swimming dragonfly nymph. Results showed that even with a dragonfly larva present, females still oviposited. The predation choice experiment determined if the presence of alternative prey would interfere with dragonflies' predation on mosquitoes. Bloodworms were preferred by *Sympetrum striolatum* dragonflies over mosquitoes. Thus dragonfly nymphs could be good biological control of Aedes mosquitoes, especially since oviposition of mosquitoes takes place even with dragonfly nymphs present. However, they may not be as effective if alternative prey are abundant.

Laura Block (Bowdoin College): Songbird Communication: Structure and Function of Veery Calls

Veeries (*Catharus fuscescens*) are a species of North American thrush with a large repertoire of calls that they use to communicate with one another. In this study I examined correlations between the acoustic structure and the social function of veery calls to gain insight into the behavioral role of calls in this species. I identified three common call categories (named veer, chatter, and peu) and compared their acoustic features to determine which calls propagate well in veery habitats and which attenuate the most over distance. I used acoustic structure data to create a quantitative and qualitative method of categorizing veery calls, and conducted two experiments: a sound transmission experiment to test how the three calls degrade over distance in veery habitat, and a playback experiment to examine how veeries respond to each of the three calls. Of the three call types tested, the veer call transmitted the best across veery habitat, followed by the peu call. The chatter call degraded the most of the three. When exposed to playback stimuli, veeries generally responded with calls that had a similar acoustic structure and therefore a similar ability to propagate. My categorization of veery calls can be used as a method to identify and analyze veery calls in future work, and the results of the sound transmission and playback experiments demonstrate a correlation between call structure and function. This correlation is an important step into discovering the function of various veery calls and prompts many future questions about how and why birds vocalize.

Dillon McQuade (Central Connecticut State University): Investigating the Effects of Drugs and Urban Chemical Stressors on Aquatic Macroinvertebrates in Artificial streams

Drugs (prescription and over-the-counter pharmaceuticals) are found in many urban aquatic systems around the world, but little is known about the ecological effects of drugs, and even less is known about the effects of multiple drugs on aquatic ecosystems. Drugs may also have varying effects depending on the environment it enters (i.e., their effects may be context dependent). We examined the effects of drugs along a gradient of urban chemical stressors (UCS; including salt, dissolved organic carbon, nitrate, and phosphate) on aquatic macroinvertebrates. We used artificial streams to simulate a gradient of water chemistry quality, including a control (no drugs or UCS), a reference treatment (only drugs), and a low, medium, and high UCS treatment for a total of 5 treatments. After two weeks of UCS treatment, we exposed invertebrates and biofilms to a mixture of 8 drugs. Before drug exposure, UCS had no significant effect on insect emergence, although the low UCS treatment had the lowest emergence, suggesting the low nutrient addition may have had a positive effect on the food resource for the aquatic larvae. After drug exposure, the reference treatments had significantly higher emergence than the control and all UCS treatments suggesting that the effects of drugs on emergence is context dependent. Investigating the effects of drugs on macroinvertebrates is important because they support higher trophic levels and are an important link between stream and terrestrial ecosystems.

Michelle Victoria (St. Edward's University): Can Chytrid Spores be Filtered Out by Invertebrates?

The primary factor in current global amphibian declines and extinctions is believed to be *Batrachochytrium dendrobatidis* (Bd), a chytrid fungus that causes chytridiomycosis, a fatal fungal disease affecting amphibians. A recent confirmation of Bd in Ithaca, NY by Lenker et al. may predict the spread of Bd in the state of New York. We know water fleas, rotifers, and planaria feed on chytrid

zoospores, but we do not know if other filter feeding invertebrates do the same. My study attempts to confirm whether or not invertebrates prey on Bd zoospores, significantly decreasing Bd abundance in the environment. The invertebrates were placed in water containing zoospores and the difference in zoospore density was calculated using a hemoytometer. I use Trypan blue dye, a novel method of identifying dead zoospores, to calculate viable zoospore density. Tadpole infection rates were quantified in relation to the micro invertebrate in the water using quantitative PCR. The micro invertebrates in this study are mosquito larva, freshwater clams, bloodworms, and water fleas. They are all found in local vernal pools along with amphibians. This study would reveal previously unknown interactions between certain micro invertebrates and Bd zoospores using more precise methodology for quantifying zoospore viability and infection strength.

Cheyene Keniston (California State University of Sacramento): A Rise in Sea Level & Heavy Metal Bioavailability

Global climate change is being accelerated because of many anthropogenic reasons. This contributes to many ecosystems alterations throughout the world. Warmer temperatures and melting sea ice are two factors that contribute greatly to sea level rise, which is causing salt-water intrusion into many ecotones. The Hudson River wetland ecosystems will potentially experience this salt intrusion phenomenon. Salinity is increasing within tidal freshwater wetlands, altering these important ecosystems and their functionality. Wetlands along the Hudson River have also historically experienced high levels of heavy metal pollution; therefore, the sediments have stored heavy metals. The questions that I addressed are: 1) Will an increase in water salinity within the Tivoli wetlands draw stored lead out of the sediment? 2) Will the increase in salinity affect the lead absorption properties of the sediment? My hypothesis is that an increase in water salinity at the Tivoli wetlands will displace the lead stored in the sediment, increasing the heavy metal concentrations in the water and also decreasing the sediment's capacity to absorb lead from the overlaying water. Through a manipulative experiment, I tested the effects of multiple saline and lead solutions on Tivoli wetland sediment cores. There was not a significant increase of lead, within the overlaying water, that leached out of the sediment exposed to different salinities. Although all sediment cores continued to have lead absorption properties after the saline soak, there was a significant relationship between an increased saline water level and less absorption of lead from the overlaying water. This implies that an increase in salinity could contribute to lower uptake levels of lead pollution from wetland sediments.

Solomon Ajasin (Vassar College): Decomposition and Denitrification in Natural vs. Artificial Ponds and Riparian Areas

The increase in urban land cover over the last 50 years has had detrimental effects on the environment. With an increase in nitrogen levels as well as other chemicals in the environment, ecosystems are suffering from the adverse effects of these pollutants. In addition, the destruction of forests and natural habitats has displaced some of the natural functions unique to these ecosystems. As a result, humans have found ways to replace processes such as the regulation of runoff water. These measures, otherwise known as storm control measures (SCM); seek to mimic natural ways of controlling runoff water. Nonetheless, the deposition of pollutants in these urban fixes to nature has caused changes in the organisms that live in these artificial environments and the processes that they perform. One of the most important of these processes is decomposition, the process by which microorganisms and invertebrates consume organic matter and releases nutrients such as nitrogen to the environment.

We quantified the differences between natural and artificial ponds and riparian zones with regards to decomposition, invertebrate abundance and microbial biomass and activity related to nitrogen cycling. We sampled between artificial and natural ponds and riparian zones in the Baltimore, MD USA metropolitan area. We expected higher rates of decomposition due to an accumulation of detritivores as a result of a limited supply of nutrients. We found significant differences in leaf decomposition and macroinvertebrate abundance between the natural riparian and artificial riparian areas. In addition, there was evidence of a difference in nitrification rates, mineralization rates, microbial biomass N, Soil NO2/NO3 levels for the artificial riparians and ponds. However, there was a general lack of statistical support for differences in Soil TIN, Soil NH4, respiration, and microbial biomass C between natural and artificial environments.

2014 Student Abstracts

Jessica Mailhot (University of Vermont): Whose Nest is Best? The Allometry of Habitat Creation by Nest-Building Birds and Implications for Secondary Nester Conservation

Ecosystem engineering is extremely important to ecosystem stability because it allows for a great degree of interspecies reliance through habitat creation. Allometry (how body size influences behavior) can reveal the driving forces behind ecosystem engineering. Bird nests are one example of how allometry may determine the degree to which a species creates habitat in its ecosystem. This study observes the nesting behavior of over 300 nest-building species. By comparing body size to nest volume of birds in 4 nests shape categories, it is possible to discern which species, nest types, and body sizes are the most important to an ecosystem's biodiversity and stability through the creation of habitat. Many bird species use the abandoned nest of others to raise their young. These secondary nesting species rely on primary species for nests that are the proper relative size, maximizing the functional efficiency to both fit and protect their eggs, young, and themselves. Because secondary species cannot guarantee a perfectly sized nest, they must strategically choose from those already constructed by primary species. This study reveals secondary nest choice strategy, nest type importance, body size importance, and the dynamic relationship between primary and secondary nesters. Results can be used to focus conservation efforts on the most keystone species and to monitor ecosystem stability.

Julie Jung (Williams College): Consider the Chipmunk; Reconsider the Road: How Road Noise Affects Eavesdropping Systems in Eastern Chipmunks

The ability of a forager to gain information about its surrounding environment may influence its decision of where and how long to forage (Brown 1988, Valone and Giraldeau 1993). Typically eastern chipmunks, *Tamias striatus*, eavesdrop on the alarm calls of birds in the Paridae family such as eastern tufted titmice, *Baeolophus bicolor,* and black capped chickadees, *Poecile atricapilus,* to gather clues about predation risk in the surrounding area. This information helps them decide how long to continue foraging. Thus, the giving-up density (GUD) or the amount of food left over when the chipmunk decides to stop foraging is an indication of the animal's patch use behavior and perception of predation risk. Road noise, however, can interfere with the chipmunk's eavesdropping systems and consequently affect their cost-benefit analysis of foraging. The purpose of this research is to measure giving-up densities (GUDs) of chipmunks in the presence of different alarm calls with and without

background road noise to quantify the consequential changes in perceived predation risk. We find that chipmunks that perceive a

greater risk from road noise increase vigilance and cease risky behavior faster as a result, leaving more food behind and yielding a greater giving-up density.

Amy Colorado (University of Rochester): Eel or No Eel: The Hudson River Eel Project's Influence on Career Path Choices

Citizen science projects give participants hands on experience and exposure to different areas of science making science more accessible to the public. The Hudson River Eel Watch Project (Eel Project) led by the scientists and educators with the NY State Department of Education is a citizen science project that monitors the ecology of the American Eel through tributaries along the Hudson River extending from New York City to Albany. Select Eel Project participants (26 HS & College students) from the Fall Kill site in Poughkeepsie were interviewed by Cary Institute staff to gain knowledge about their interest in science and the project, and the project's effect on their attitudes toward science and the environment. A follow up phone interview was administered to four participants to delve more into their personal goals, academic experience, and social environment to see the influence of these factors on their academic goals and subsequent career choices. The participants of the Eel Project are a diverse group that includes traditionally underrepresented youth in the sciences, particularly in Environmental Sciences. Most of the students were motivated to learn about eels and participate in the project for individual reasons rather than for social ones. Leading motivators were "fun" and because they "enjoy it," whereas factors such as "influenced by others" were less important. The largest number of participants indicated that the Eel Project increased their environmental awareness of their local ecosystem, while fewer indicated an influence on their motivation to pursue a career in science. The follow-up phone interviews reinforced the significance of role model influence on a student's academic paths as well as familial support of their academic and career choices.
These findings will help the Eel Project create a more effective framework to recruit participants and have a deeper understanding of the factors that influence student academic and career choices that may be applicable to other citizen science projects in general.

Tiquasha Thompson (SUNY- ESF): Breeding Behavior of the Invasive *Aedes japonicus* Mosquito

Due to their many negative effects on human health, mosquitoes are one of the most valuable insects to study. My research is on the invasive, Asian Rock Pool Mosquito (*Aedes japonicus*) and how it's breeding behavior is influenced by predator presence, resource quality, and habitat location. One of the ways to decrease mosquito presence is through monitoring of possible larval habitats, which is why understanding where mosquitoes lay eggs (oviposition) is important. *Ae. japonicus* was found to oviposit around three times more often in habitats placed near a human dwelling versus in forest habitat. The presence of a larval predator, salamander nymph, reduced oviposition and resulted in fewer larval mosquitoes ($p<0.05$). A treatment with increased resources in the form of leaf 'tea' had no significant effect on oviposition. Most interestingly, when predator presence and high resource quality were combined, the predator effect was eliminated. The presence of the predator had less of a negative impact on oviposition when resources were increased, although the mechanism behind this interaction is unknown. In a subsequent predation study, all larvae added to the predator treatment were

consumed in 3 days. However, only 53% of the larvae were consumed in the combined predator-increased resource treatment. Results of this study demonstrate that both resource availability and predator presence may be important tools in managing everyone's least favorite insect.

Patrick Reineke (DePauw University): Body Mass, Bioturbation and Biogeochemistry: How Ecosystem Engineers Control Sediment Microbial Processes

There are many different ecosystem engineering species that function as bioturbators in a variety of environments. Bioturbation involves the removal of soil or sediment through digging or burrowing. This physical modification of the ecosystem is a function of allometry, or the relationship between body size and intrinsic species characteristics. Previous research on allometry has indicated that the size of a species can predict the amount of soil or sediment that a species moves. However, little research has extended allometry beyond the proximal physical modification of the environment to species extrinsic effects on the environment. My research addresses how the size of a bioturbator and its surrounding abiotic environment can control microbial processes by regulating the input of oxygen into the sediment. This is important because if we can combine an understanding of how the biogeochemical processes and abiotic factors limit or promote a particular reaction, with the understanding of the effects of species on the processes and abiotic conditions, we can very well predict the biogeochemical effects of a species in relation to its size. This information can then be easily applied to managing microbial processes in the sediment and conserving crucial aquatic environments around the world in a very fundamental way.

Emily Hughes (Mount Holyoke College): Learning about Decomposition in the Cary Ecology Camp

Young students are not usually taught about decomposition during their elementary school education. However, several substantial studies have suggested that younger children are capable of showing sophisticated levels of understanding after just a few lessons, and that this provides a significant advantage in subsequent learning. This study explores learning patterns among participants of the 2014 Cary Institute Summer Ecology Camp. To observe the sophistication of camper learning, data was collected from four weeklong sessions of the camp. Campers created their own decomposition storyboards both Monday and Thursday to show pre- and post-camp understanding. Participating campers also completed a take-home survey and some were randomly selected for interviews. A learning progression coding scheme was used to analyze the collected data. General trends over the course of the week showed a relative increase in campers' understanding of decomposition. In particular, campers demonstrated a far more sophisticated level of reasoning about the role of decomposing organisms after their time at camp. However, the ability for some campers to learn more than others often depended on a variety of outside factors, including age, previous camp experience, and interest in ecological topics.

Lorraine Dargis (SUNY New Paltz): The Effects of Traffic Noise on Veery Singing Behavior

We are so attuned to the sounds of our daily lives that it may be difficult to envision the effects of our sound on the natural ecosystem. However, the anthropogenic sounds that accompany highly populated urban environments, such as noise from cars and traffic, can alter vocal communications between animals, in particular, the vocal communication of songbirds. Interferences in their communication can decrease the likelihood of successful mate selection

and breeding, resulting in overall decreases in species richness, or population density. Other studies have confirmed that anthropogenic noise can alter the frequency and structure of different species' songs, as well as biodiversity patterns; therefore, we set out to examine the effects of this acoustically challenging environment on local species. Veeries (*Catharus fuscescens*) were selected for their timid nature and complex song with the expectation that they would be most representative of species sensitive to acoustic disturbances. We examined Veery songs in forest and wetlands habitats with no road noise and compared to song samples taken from forested "phantom road" sites where we played recorded traffic noise. The forest control site had a general trend of lower bottommost frequencies when compared to the wetland control site and the two forest roads sites. Additionally, one wetland-habitat control site contained considerably more masking events by other bird species, suggesting a greater avian biodiversity. However, this is most likely due to differences in habitat area rather than traffic road noise disturbance. The considerable amount of masking at the wetlands site could also explain why the site did not follow the expected lower frequency trend as the control site. These results are altogether statistically non-significant and are most likely due to a very small sample size (n =3). This preliminary study points towards a few interesting patterns that could be further analyzed in future experiments and useful for later conservation efforts.

Lily Mastrodimos (Bard College): The Influence of Host Preference and Larval Habitat on Mosquito Diversity

With over twenty species identified on the Cary Institute grounds, mosquitoes are one of the most common pests in the northeast. As juveniles, mosquitoes live in small or temporary bodies of water. Once they are grown, they primarily consume nectar. Only during oviproduction will female mosquitoes ingest blood, making them ideal vectors for pathogens that cause diseases such as encephalitis and malaria. Mosquitoes may take blood from a number of different organisms, and the species they bite are important determinants of whether or not mosquitoes are a problem for humans. Mosquitoes survive in various types of habitats from cities to wetlands, and it is likely that animal species richness influences the spatial distribution of mosquito species across habitats. In sites around the Cary Institute campus, CDC Light Traps and containers of dry ice were used to collect adult mosquitoes in different habitats over 6 weeks. To assess host species diversity, point counts were completed and "hair snares" were placed near traps. We found 23 species of mosquitoes in communities ranging from 9 species at our most human- influenced site to 15 and 16 species at a wetland and forested field site. This talk examines how these mosquito communities vary with host composition and why this might be important for understanding disease risk in the Hudson Valley.

Curt McConnell (Ithaca College): Quantifying Sediment Methanogenesis from Plant Habitats in a Tidal Hudson River Wetland

Wetlands are the largest natural source of global methane emissions, which are principally derived from methane-generating macrophyte beds. Methane is either vented directly from the plant roots or released from anaerobic methanogenic archaea by the fermentation of organic matter. Methane is a potent greenhouse gas so it is important to identify high methane emitting macrophyte communities and to quantify methane production. In this study we analyzed microbial methanogenesis rates from four different macrophyte sediment beds in the tidal Hudson River's Tivoli Bay wetlands. Native *Vallisneria americana* and *Typha angustifolia* as well as the invasive

Trapa natans and *Phragmites australis* were studied. The rate of net methanogenesis and carbon dioxide release from macrophyte sediment cores were compared. We found that respiration rates varied significantly among the species. On the other hand, we found a wide range in methanogenesis rates among individual cores but no consistent differences among plant types. Local sediment attributes such as organic content, porewater dissolved organic carbon or oxygen penetration may account for high variability in methane release. By comparing the variation in methane and carbon dioxide emissions among plant species and sediment properties, we can better assess the impact of wetlands on the greenhouse gas budget.

Vanessa Ehrenpreis (The University of Virginia): The Peculiar Case of Personal Values, Knowledge, and Attitudes toward Earthworms

The narrative that earthworms are "good" has dominated ecology education for decades. Few people are aware that earthworms are exotic from Europe and Asia and are harmful to northern forests; even fewer people change their attitude toward earthworms once they learn this information. This study examined the factors that contribute to an individual's attitude toward earthworms, and how those factors are used when discussing earthworm processes and impacts. Personal values, experience, and knowledge were assessed to give a broad representation of what shape's an individual's attitudes. We found that scientific professionals had more sophisticated systems-based accounts and used these to acknowledge the potential negative effects of worms. Hobbyists and manual professionals (e.g. gardeners, farmers, etc.), on the other hand, gave more phenomological accounts and used these to reinforce the idea that worms are "good." Individuals who were aware of the negative impacts of worms tended to exhibit ecocentric and biocentric values. These findings indicate the need to develop targeted education programs about earthworms and forest ecology, and invasive species management in order to reach different audiences.

Rodolfo Villegas (California State University, Long Beach): Give Me Room to Breathe: The Role of Ventilation in Fossorial Burrow Construction

Fossorial organisms create burrows for shelter and feeding purposes. When Dr. Jones and a former Cary student conducted a study investigating the allometric relationships between burrowing organisms and their burrows, they hypothesized that the length of the burrow would scale metabolically (the organism digs until it obtains enough food) while the cross-sectional area would scale to the organism's body geometry (the organism's body must fit in the burrow). Surprisingly, they found that cross-sectional area super-scaled to its volume, three dimensions, instead of its cross-sectional area, two dimensions. The focus of my project is explaining why fossorial organisms expend so much more energy constructing their burrows than we first hypothesized. The underground environment in which these fossorial organisms live usually demonstrates high carbon dioxide concentrations and low oxygen concentrations. I hypothesized that this excessive cross-sectional area is created in order to increase ventilation in their burrows. In order to determine if ventilation could explain the super-scaled cross-sectional areas I mined the literature for ventilation models that could be applied to burrows. The results of my experiment could expose a very interesting evolutionary constraint explaining why we do not see any large fossorial organisms.

Giovanna Tomat-Kelly (The College of New Jersey): Riparian Links and Nitrogen Sinks: How Riparian Connectivity and Invasive Plants Influence Nitrogen Cycling within Urban Riparian

Zones

Riparian ecosystems are important nutrient sinks that are useful in preventing excessive nitrogen loading into aquatic ecosystems. The primary mechanism of N removal in riparian ecosystems is denitrification, an anaerobic microbial process that converts inorganic nitrate into N gas. The process is carried out primarily by heterotrophic bacteria, and is optimized in the oxygen poor and carbon rich environments that are characteristic of wetland and riparian ecosystems. Unfortunately, increasing urbanization has lead to a suite of degrading effects in riparian ecosystems including hydraulic disconnection, erosion, drier soils and increased vulnerability to exotic plant invasions. The objective of this study was to determine how hydrologic disconnection affects the ability of urban riparian ecosystems to function as N sinks. Soil samples collected from urban riparian zones in Baltimore were analyzed for denitrification potential, potential net N mineralization and nitrification, soil moisture, and ion concentrations. Denitrification was found to be significantly higher in the connected DR2 site compared to the more disconnected HHR1 site and the strongly eroded and incised DR5 site. Differences in denitrification potential were strongly correlated to differences in soil nitrate pools across sites. Differences in soil nitrate pools were not the result of differences in internal N-cycling across sites, and were likely the result of varying exposure to nitrate rich stream water. Thus, it appears that more connected riparian sites have a greater potential to function as N-sinks. These results suggest that urban riparian restoration efforts should focus strongly on increasing connectivity to streams.

2013 Student Abstracts

Keyanna Millinger (Barnard College): Pharmaceutical and personal care products (PPCPs) are a long list of chemicals that are used for medical and cosmetic purposes. With improper disposal of PPCPs through incomplete degradation by humans, animals, and wastewater treatments plants (WWTPs), trace amounts enter into urban waterways and other aquatic environments. The occurrence of these chemicals has led to negative ecological implications, with changes in species physiology and composition in population-level dynamics. The pharmaceutical diphenhydramine has been shown to have negative impacts on stream fish and invertebrates. In this study, the effects of diphenhydramine on prey-avoidance behaviors, mortality rates, emergence rates, species composition and species abundance were examined. Prey-avoidance behaviors were observed for 25 to 50 minutes for approximately three to five days in experimental mason jars. Mortality rates, emergence rates and species composition and abundance were measured in the artificial stream facility located at Cary Institute. Prey- avoidance behaviors were not adequately measured due to experimental confounds. This led to no observed significance in prey-avoidance behaviors. However, species mortality, emergence, composition and abundance were significantly lower in the treatment stream (6 mg/L) than in the control streams. This suggests that diphenhydramine has a toxic effect on stream invertebrates, and may lead to high levels of invertebrate mortality.

Mary R .Ellis (North Park University): Mosquito-borne diseases have become of great concern in the world today, as many are re-emerging. This has prompted an interest in better understanding what factors drive or control mosquito populations. One promising bio-control agent of mosquitoes is through the use of mosquito predators as a way of controlling the population. A predator of mosquitoes that has not been researched fully is the dragonfly. The following research examined the influence of dragonfly larvae on several different aspects of a mosquito's lifecycle. This study was done in two

parts, first by performing biweekly field surveys of semi-permanent, intermittent, and ephemeral pools. Secondly, experimental mesocosms were done with mosquito larvae both with and without dragonfly larvae present. Mesocosm experiments were done to test the survival, development rate, and reproductive behavior of mosquito larvae (*Aedes* and *Culex*) in the presence of dragonfly larvae (*Tetragoneuria*). Dragonfly larvae were only found to be present in the semi-permanent and intermittent ponds. It was also found that the semi-permanent and intermittent ponds had significantly lower adult mosquito emergence. The results of mesocosm experiments identified dragonfly larvae being able to eat large numbers of mosquito larvae in very short periods of time, but dragonfly larvae did not seem to have a significant effect on the development rate of mosquitoes. Ovipositing behavior of mosquitoes did not seem to be affected by the presence of dragonfly larvae. These results suggest that dragonfly larvae could play a role in the regulation of mosquito populations.

Joshua Rieskamp (Centre College): Many passerine (songbird) species communicate using numerous distinct song types, which are comprised of smaller elements called notes. In addition to variation among species, individuals of the same species often vary in terms of the number of song types they use as well as the notes that make up their song types (collectively called a bird's song repertoire). For many songbird species, song repertoires have not been adequately described. One such species is the veery (*Catharus fuscescens*), a migratory thrush known for its complex song. Several pioneering studies provided valuable information about veery song repertoires, but more recent studies are lacking. In the present study, we set out to provide an updated description of the veery song repertoire using a sample of natural focal recordings containing 1752 songs sang by 56 male veeries on the grounds of the Cary Institute in 2009. We generated sonograms of these recorded songs to visually categorize each song according to song type. We also recorded the number and structure of notes, and compared songs both within and among the repertoires of individuals. We found that male veeries sang from 1 to 3 distinct song types, with an average of 1.4 song types ± 0.76. On average, songs contained 5.0 notes ± 0.026 with a minimum of 2 and a maximum of 11. Most male veeries (59%) used only a single distinct song type; however, within each song type, all males made slight modifications through the repetition, deletion, or re-arrangement of notes to produce many variations of that song type. This differs from classic study species with well-studied repertoires such as the song sparrow, in which individuals sing discrete song types that do not vary much within song type. The results of this study provide the basis for future research investigating when and why veeries use modified variations within song types.

Elizabeth de la Reguera (Dickinson College): Urban lawns often receive greater nitrogen inputs than natural systems and can have significant nitrogen losses to the environment. Nitrogen can be lost into the air in the form of nitrous oxide (N_2O) and into the water as nitrate (NO_3^-). However, it has been shown that nitrogen can be tightly cycled in residential lawns, which may contribute to high rates of retention that minimize losses to the environment. Still, many lawns have compacted subsoil and thin layers of topsoil and there is concern that these "bad" lawns may not cycle nitrogen as efficiently and have significant hydrologic or gaseous loss. Within these lawns, the compacted subsoil maybe acting as an impervious surface which leads to water and nitrogen ponding between the sod and subsoil which creates an anaerobic environment, which stimulates gaseous losses. Another possibility instead of ponding within the system is if the water and nitrogen are unable to penetrate the subsoil, they may instead run-off or leach, resulting in a significant hydrologic loss. This study, therefore, sought to determine if lawns with compacted subsoil support higher rates of hydrologic and/or gaseous nitrogen losses than lawns with more "natural" soil profiles. Denitrification potential along with other related variables (potential net nitrogen mineralization and nitrification,

microbial biomass carbon and nitrogen content, inorganic nitrogen pools, organic matter, microbial respiration) were measured in plots that received a subsoiling and compost addition treatment to remediate compacted subsoil, unremediated "reference" plots, swales (wet drainage ways) located between treatment plots, and from a "good" reference plot. Denitrification potential was highest in the swales compared to the reference, compost, and unremediated plot. The composted site had the lowest nitrate pool and nitrification rate, along with negative mineralization rate. The data suggests that there is microbial immobilization (retention) taking place in the composted site (microbes are converting inorganic N [nitrate and ammonium] into organic N). The unremediated plot and swales had more denitrification, suggesting that compaction on these "bad" lawns may be preventing hydrologic losses of nitrogen by facilitating gaseous losses.

Maria Schletzbaum (Washington University in St. Louis): Mosquito-borne disease is (re)emerging worldwide and is becoming an increasing public health threat, particularly in urban areas. However, many factors influencing larval dynamics (and thus disease risk from adults) are still unknown. This study will evaluate how different levels of nitrate and the sequence of larval hatching in container habitats influence the competitive interactions between *C. pipiens* and *A. albopictus* larvae. The effect of early hatching of one cohort of a species on a second, later, cohort of the same or different species or an effect of nitrate level on these two species could help us understand mosquito species compositions on a smaller spatial scale and aid in predicting and evaluating potential disease risk. The study found that nitrate levels may alter the competitive interactions between the two species resulting in differing degrees of mosquito emergence, which may have implications for disease risk in urban environments.

Rebekah Petroff (Allegheny College): *Phragmites australis* is a non-native species of wetland reed grass, found throughout much of Eastern United States, growing in many different types of environments. In the Hudson River estuary, *Phragmites* grows in water from above Albany to the edge of the Atlantic. Previous research has shown that *Phragmites* is genetically varied to better thrive in these differences of salt concentration in habitats. Although this shows how adaptable the genetic code can be, little is known about the possible variances in the epigenome. The epigenome consists of a series of markers that exist above the DNA. These markers alter the expressed traits of an organism by either silencing or activating a particular gene, instead of changing the gene itself. Epigenetic markers that alter the expression of traits in an organism are essential to the way an organism or population operates, thrives, or fails in any one particular environment. Despite these markers not being the central control of expression in organisms, learning about their functionality and manner of operation is essential for future understanding of ecological genetics. This research investigated the extent to which *Phragmites* growing in diverse salt concentrations varied in both the genome and epigenome. Seven sites throughout the Hudson River watershed were sampled. DNA from each of these sites was extracted from plant tissue and variances were diagnosed via AFLP and MS-AFLP techniques. These techniques are able to reveal which sections of the genome or epigenome a group of organisms may or may not share. Thus far, procedures are still underway to produce initial results.

Katherine Trudeau (Smith College): The Cary Institute's Evidence- and Reasoning-Based Critique and Inquiry Framework, is geared towards helping high school students learn to use data as evidence to make and evaluate arguments. A premise for this work holds that if students can become skilled at *making* arguments then they should be better able to *critique* arguments. Few students will progress to careers that involve day-to-day data processing, but almost all will be bombarded with science-related

issues in the media and in life. For this reason, evidence-based critique is crucial to being a scientifically and ecologically-literate citizen. Other studies have shown that the way to create interesting lessons is to relate the lessons back to the students and create a sense of urgency for obtaining certain knowledge and skills, since learners engage or do not engage depending on how they see relevance. The Data Exploration in Ecology Project (DEEP) developed lesson modules that were thought to be relevant and interesting. This study focused on two of the DEEP modules: 1) salt pollution and 2) hydrofracking. We aimed to discover whether there was a difference in interest and learning between the road salt pollution module and the hydrofracking module.

Despite living in the northeast and experiencing road salt every winter, students found hydrofracking more interesting as well as more relevant. Likewise, students constructed more sophisticated arguments in relation to the hydrofracking module. However, limitations in the experimental design indicate that their increased sophistication could be a result of many different variables outside of their perceived relevance. Students' opinions in relation to the modules were more objective when studying road salt and more polarized when studying hydrofracking. Students were less aware that they were constructing value-based arguments in the hydrofracking module, which leads to new questions regarding the role of values when engaging students with highly motivated issues in the science classroom.

Nikola Alexander (Vassar College): Body-mass scaling (allometry) is an approach to predicting species characteristics from their body size. It has been widely used to investigate the intrinsic characteristics of organisms. There are virtually no studies investigating the relationships between species body size and extrinsic, physical environmental modification by species, i.e. ecosystem engineering. In one of the first such studies, I compiled a literature-based dataset of 32 species that substantially modify the physical environment by digging for food. The resulting pits, mounds, and other structures can have large effects on soil and sediment characteristics, nutrient and water dynamics, and habitat for other species. I collected data on the *per capita* 'engineering' rate of physical modification (PCER), the frequency of these activities, and the dimensions of the associated structures. Using reduced major axis regression I analyzed the degree to which body mass could account for variation in soil and sediment turnover by these species. I hypothesized that PCER would be driven by metabolic rates, and, according to metabolic theory, should scale with an exponent of 0.67-0.75. Analyses across 10 orders of magnitude of body mass and diverse taxa (worms to whales) indicate that the rate of soil/ sediment movement super-scales with body mass with an exponent significantly greater than 1, and that body mass accounts for most of the rate variation ($R^2=0.91$). Dig volume scales significantly with body mass, as do the component variables of cross-sectional area and depth. Dig volume is the primary contributor to rate. This implies that the rate of excavation by such species is primarily driven by their geometry (biomechanical constraint), not metabolic rate. I will illustrate how the resulting models contribute to our understanding of ecosystem engineering and may have practical application by improving and simplifying estimation of soil and sediment turnover.

Emily Baker (Mount Holyoke College): The role of many mosquito species as disease vectors has created a great need for a better understanding of the factors that influence their occurrence and abundance. While the presence of standing water is known to be a habitat for mosquitos to lay eggs in and emerge from, the dry depressions of ephemeral pools may also play an important role in maintaining mosquito populations. Many species of mosquitos lay eggs that can remain viable within leaf litter and soil long after all water has disappeared. Additionally, certain species are known to lay

eggs on dry surfaces of areas likely to be inundated by water. Therefore, mosquito eggs may already be present in the dry leaf litter of ephemeral pools, ready to hatch and emerge upon re-flooding. This study examined the leaf litter within five temporary forested pools on Cary Institute property in order to determine the location and abundance of mosquito eggs, and to determine how this egg bank changes throughout the summer and after longer periods without re-flooding. Larval samples were also collected from each pool during the periodic wet phases for comparison. Leaf litter samples were collected during June and July from multiple locations within the pools. The samples were soaked in water, and the emergent mosquitos were counted and identified to species. In general there was a lot of variability in the numbers of larvae that hatched from samples both within and between pools, with 0 to 2152 eggs hatching per square meter. The data reveal an increase in the number of mosquitos after longer periods of temporary pool absence and a seasonal increase in the abundance of eggs deposited throughout the summer. Mosquitos within the genera of *Psorophora*, *Ochlerotatus*, *Anopheles*, and *Aedes* were present within the samples, of which most can be aggressive human biters. Understanding the dynamics of the egg banks within these temporary pools is important in order to better predict fluctuations in mosquito populations and design more effective management strategies.

Rachael Tylock (Mansfield University of Pennsylvania): Healthy coral reefs have a balance of growth and erosion, and imbalance threatens these biodiversity hotspots. Although storms erode coral, most erosion is caused by species that eat or live in coral (e.g. bacteria, urchins, and parrot fish). Among the most important of these bio-eroding species are encrusting sponges that also erode rock and shells. Predicting sponge erosion rates has proved challenging. Current models estimate erosion using percent cover and additional variables (e.g. sponge, substrate, sponge age, water depth, temperature, and location). I compiled a data base from 7 published studies that reported the growth and erosion rates for 6 species. In all, the data base includes 25 independent measures of growth and erosion rates each spanning two orders of magnitude and also includes the listed additional variables. Analysis shows that sponge growth rate strongly predicts erosion rate and that additional variables have no detectable influence. At high growth rates of ca. 100cm^2/year, sponges erode 40g of substrate a year, and sponges must grow at least 2cm^2/year to erode ca. one gram. The two-dimensional geometry of sponges shows that surface area growth rate can estimate erosion rate. In comparison to a model based on percent sponge cover, the growth rate model is simple – additional variables do not affect the erosion rate – and makes different predictions (e.g. erosion rate can increase, decrease, or stay the same at constant cover over time, whereas current models predict constant erosion rates). The new model could readily be used by managers to help assess coral reef health. The findings contribute to a growing body of work at the Cary Institute (including data bases of pit diggers, burrowers, and other coral bio- eroders) that shows how allometry – body size or growth rate relationships – can estimate ecosystem engineering effect magnitudes across a diversity of species.

Jason Lopiccolo (Humboldt State University): Informal or outdoor ecological education programs are effective ways of increasing environmental literacy in students. The Young Environmental Scientists' Network (YES-Net) Stream Ecology Unit is an effort by the Education Department of the Cary Institute of Ecosystem Studies to increase the environmental literacy of middle school students. In the spring of 2013, six middle schools participated in YES-Net. The unit is composed of four in-class lessons in stream macroinvertebrate ecology and phenology and one lesson at a stream where the students collect, separate, and count the number and abundance of macroinvertebrate taxa.

Students completed mirrored pre- and post-assessments yielding a total of 116 matched assessments. Responses were coded and assigned a value based on answer sophistication and correctness. Students

self-reported their interest in a number of questions in two categories, interest in data exploration and interest in nature exploration. Correlations were sought between the various measures of student interest and answer correctness. While students made significant ($p < .05$) gains in both learning and self-reported interest in working with data, there was no significant relationship between any measure of student interest and learning gains. Interest in nature exploration was high in both the pre- and post-assessments and did not change significantly. The failure to find a relationship between learning and interest may be due to student interest in nature exploration being sufficiently high in both assessments as to not have impeded learning. Alternately, though there were significant gains in data exploration interest, the assessment did not provide an appropriate vehicle for the determining learning gains in data exploration. However, the gains in student interest in data exploration from the Stream Ecology Unit may be important for subsequent learning, especially in using data.

2012 Student Abstracts

Emily Waters (Hampshire College): The large increase in impervious surface cover due to urbanization leads to "flashier" storm flows and increased runoff. This altered hydrology causes channel incision in urban stream channels and lower water tables in the riparian (next to the stream) zone. In turn, these physical changes alter many stream processes, including denitrification. Denitrification is the anaerobic microbial process that transforms nitrate (NO_3^-) to N_2 gas. It is particularly important, as it is one of the primary sinks of nitrogen, and excess nitrogen loading can lead to eutrophication and hypoxia in coastal areas. We might expect there to be more sources of nitrogen from exurban areas than urban areas, as exurban land use is often agricultural, with substantial fertilizer runoff, and houses in these areas are on septic tanks, which are another large nitrogen source. Depending on the extent of these nitrogen sources, and on the availability of carbon, denitrification will either be carbon or nitrogen limited. This study, therefore, sought to determine if denitrification in riparian zones and streams was limited by carbon or nitrogen and whether these limitations varied over an urban to exurban gradient. Denitrification potential and a suite of related variables (microbial biomass carbon and nitrogen content, potential net nitrogen mineralization and nitrification, microbial respiration, inorganic nitrogen pools) were measured in riparian soils and stream sediments in four different watersheds (urban, suburban, exurban, and forested reference) in and around Baltimore, MD. Denitrification potential in both the urban and exurban forested riparian soils were significantly higher when carbon was added but not when nitrogen was added suggesting denitrification in these riparian soils was carbon-limited. We also found significantly higher denitrification potential in the exurban riparian soils than the other sites which did not differ. This suggests that despite the large nitrogen loading into all of the streams, they are effectively denitrifying some of this load. Further, these results show that stream restoration efforts should focus on bringing more carbon into these systems, which should result in even higher denitrification rates.

Rachel Doery (SUNY-Oneonta): In 2011, educators at the Cary Institute of Ecosystem studies created an online module designed to teach middle school students about the acorn connection interaction web that involves Lyme disease (Notin, Schneider, McLean, & Rubbo, 2010). The overarching goal of the module is to expand students' thinking about interactions within an ecosystem and allow them to grasp the idea of multi-step connections between organisms. To measure their understanding, 304 seventh grade students completed surveys before and after participating in the module. The students also completed a feedback survey to measure their overall enjoyment of the module (Notin, Schneider, McLean, & Rubbo, 2010). Content analysis was used to compare the levels

of sophistication and complexity of student responses before and after their completion of the module. Initial results imply that the module was successful in its goals: the majority of the students did learn from the module. In the fourth question of the multiple choice section, 34 students answered correctly in the pre survey compared to 168 in the post survey. Question 2 of the open-ended response section exhibited an increase of more sophisticated answers from the pre surveys to the post surveys. Initial results from the feedback surveys imply that the Lyme module was enjoyable for the students. Out of a total of 134 students who completed this survey, 54 agreed or strongly agreed that the module was fun, 36 were undecided, and 40 disagreed or strongly disagreed. When asked if they thought the module was interesting, 95 students agreed or strongly agreed, 17 were undecided, and 17 disagreed or strongly disagreed. Further analysis will be completed on the remaining survey questions to determine students' learning for each survey question and the feedback surveys will be fully analyzed to determine students' enjoyment of the module and if it impacted their learning.

Shelby Servais (Mount Saint Mary's University): Pharmaceutical and personal care products (PPCPS) are any products used by individuals for health or cosmetic reasons or products used for veterinary purposes. Trace amounts of PPCPs can be found in aquatic ecosystems entering through wastewater effluent, septic systems, factory effluent, and agricultural runoff. This study examined the effect that two pharmaceuticals, ciprofloxacin and diphenhydramine, have on the gross primary production (GPP) and community respiration (CR) of stream biofilm in Wappinger's Creek, NY. We found no significant response of biofilm to diphenhydramine or ciprofloxacin (10, 25,100, and 100 ng) after 4 or 24 hours of exposure. We deployed Pharmaceutical Diffusing Substrates (PhaDS) for 7-10 days to examine longer term exposure with four treatments: control, 0.015 M of diphenhydramine, ciprofloxacin, and a mixture of the two. The response of biofilms were estimated on four substrate types: pre-colonized sponges or disks to target established biofilm, and new sponges or discs to target newly colonized biofilms with heterotrophic biofilms being more prevalent on sponge substrates.

In Ciprofloxacin significantly decreased CR on pre-colonized sponges. Diphenhydramine significantly decreased GPP and CR on pre-colonized disks. The combination of the two PPCPs lead to a significant decrease in GPP of the biofilm on the pre-colonized disks, and a significant decrease in CR of the biofilm that settled on both the new and pre-colonized sponges. It appears that ciprofloxacin more strongly affects the heterotrophic biofilm community, while diphenhydramine more strongly affects both components of the community, especially when biofilms had not been previously exposed (i.e., pre-colonized discs). This suggests streams that have never been exposed to PPCPs may be negatively impacted by these two compounds.

Rebecca Erickson (University of Minnesota, Morris): The invasive hemlock woolly adelgid (*Adelges tsugae*, HWA) is threatening stands of eastern hemlock *(Tsuga canadensis)* all along the east coast. The adelgid leads to progressive decline in tree vigor and eventual mortality, capable of killing a single tree within 4 years of initial infestation. Changing environmental conditions such as increasing temperatures and less consistent rainfall patterns will undoubtedly affect vegetation, but the impacts of such changing conditions on HWA have not been studied in detail. Further, the effects of HWA-induced needle loss and resulting increased light entering the canopy and lower branches are not understood either. There is also reason to believe that higher infestation densities could lead to quicker death, so understanding factors that influence settlement and development in HWA is crucial to understanding infestation and mortality risks for remaining hemlock stands. This study will investigate site location and light availability as factors that may impact HWA settlement, either directly or indirectly. Branch samples were collected twice and analyzed to determine a settlement density and

developmental classification. Linear mixed models and ANOVAs were used to determine that samples in the sun had significantly faster development that those in the shade, though the light variable was not a significant predictor of settlement density. Branches with later development classifications had significantly higher settlement, as did samples at the Tea House site compared to the Fern Glen site.

Alma Ramirez (Universidad Metropolitana, PR): *Trapa natans*, commonly known as water chestnuts, is an invasive aquatic plant native from Eurasia introduced to the Hudson River in the late nineteenth century. Since then, it has been changing the preexisting submerged ecosystems by forming floating mats of leaves that block entering light and cause oxygen depletion, sometimes within hours depending upon the river's tides. Organisms that depend on oxygen, light or both have been threatened by *T. natans*. Therefore, the important question is: what percentage of entering light is needed to support a submerged ecosystem? This research hypothesizes that a submerged ecosystem will have a higher rate of dissolved oxygen and organism survival with a higher percentage of light entering. To test this, we controlled the percentage of light entering in each of 11 different tanks and measured the temperature, dissolved oxygen, as well as the growth and survival of several organisms. So far, the results suggest that at least temperature and dissolved oxygen depend on the percentage of light entering the ecosystem.

Jane Li (Skidmore College): The relationship between an organism's body size and the magnitude of its effects as an ecosystem engineer was investigated for species eroding coral reefs. A preliminary database of 34 species was compiled from the literature and allometric scaling was used to quantify the relationship between body mass and annual erosion rate over 14 orders of magnitude of body mass and 13 orders of magnitude of erosion rate. Based on metabolic theory, the null hypothesis was that bioeroder body mass would relate to coral erosion rate with a scaling exponent of 0.67-0.75. Analysis showed a scaling exponent significantly greater than 0.75, but not statistically different from 1. Large-bodied species (e.g. parrotfish) do not erode more grams of coral per gram of body mass than small species (e.g. cyanobacteria); both are equivalent. The ability of small body sized species to forage for high quality food more selectively than large bodied species may account for the observed scaling exponent greater than 0.75. The scaling relationship has important implications for coral reef management. Coral reefs are threatened, along with the high levels of marine biodiversity they support. Monitoring reef health amidst this complexity is a challenge, but may be simplified by the finding that gram for gram, bioeroding species are equivalent. Given that organism size and abundance is not difficult to obtain, whole reef erosion rates may be more readily estimated. This study appears to be the first to apply allometry beyond the organism to the study of their extended environmental influence.

Stephanie Dunn (Bard College): Lyme disease was first associated with tick bites in the 1970s. In the 1980s, it was confirmed that the bacterial agent *Borrelia burgdorferi* causes Lyme disease in humans. Thirty years later, it is now an emerging infectious disease raising concerns for public health. Studies have since generated knowledge of the various host species and factors involved in the Lyme disease system, their relationships, and what this means for human health. The white-footed mouse (*Peromyscus leucopus*) has been identified as the principal reservoir host for *B. burgdorferi*. In the past, research of disease systems has focused on single pathogens. Recently, studies have begun to focus on the relationships among multiple pathogens in individual hosts. This study applies the concepts that disease dynamics involve multiple interacting factors and a host organism's response to coinfection is comprised of a system of tradeoffs. The investigation includes an in-depth analysis of a

subset of the multiple parasites that may simultaneously infect the white-footed mouse. Specifically, this study focuses on the potential impact of helminth infection on the transmission of *Borrelia burgdorferi*. Past research has provided evidence that helminth infection plays a role in the population dynamics of *Peromyscus*. This study applies these findings to the parasite populations involved in the host species *P. leucopus.* The main hypothesis is that *P. leucopus* reservoir competence will vary with anthelminthic treatment. In order to illuminate a relationship between helminth infection and reservoir competence, I used the anthelminthic drug, Levamisole Hydrochloride (Prohibit™) to treat white-footed mice. Ultimately, the comparison of reservoir competence in treatment and control groups provides insight into the role of coinfection and disease transmission in the principal reservoir host of the Lyme bacterium.

Brian Becker (Oberlin College): Due to their role as pest species and vectors of disease, mosquitoes play an important role in decisions regarding public health and in mosquito control and management efforts. Despite this fact, factors governing mosquito production in highly urbanized matrices remain largely unknown. A number of mosquito species have been shown to thrive in human-created habitats such as containers, sewers, and catch basins, yet there is still little information on the mechanisms by which the physical environment alters abundance and composition. Even less attention has been paid to studying the effects of urban decay on mosquito ecology. I examined the effect of roofless abandoned buildings, a common symptom of urban decay, on mosquito production in Baltimore, Maryland. In particular, blocks within the highly impoverished Franklin Square neighborhood and higher-income Union Square neighborhood were sampled during four nights of adult trapping in late July and early August 2012. Though preliminary larval sampling within the neighborhoods suggested that these abandoned buildings played a role in mosquito production, findings from the adult trapping showed more mosquitoes within the Union Square block, which contained a lower level of roofless abandoned buildings. Further, these results suggest that other landscape factors may play a more important role in determining mosquito abundance in urban areas.

Claire Nemes (University of Maryland, College Park): The veery *(Catharus fuscescens)* is a neotropical migratory songbird species that breeds on the Cary Institute grounds. Males use a variety of acoustically complex vocalizations during the breeding season, particularly during territorial defense and mate attraction. In previous years, Cary researchers have determined that male veeries use two vocalizations, dubbed whisper calls and no-intro songs, more frequently during agonistic encounters with rival males and have hypothesized that these may serve as signals of aggressive intent. This year's research was designed to build upon the previous investigations and determine whether these vocalizations indeed signal a bird's intent to escalate the conflict. We used a playback experiment wherein we presented territorial males in the field with two acoustic stimuli: one "control" recording of unmanipulated song, and one "treatment" recording that was altered to contain both whisper calls and songs missing the introductory note. In comparison to the pre- and post-playback periods, where no vocal stimuli were used, males uttered more whisper calls and no intro songs during both control and treatment playback. In addition, they spent more time in close proximity to the speaker during both of these playback periods, which is generally considered a reliable measure of aggression. Both whisper calls and no-intro songs were correlated with amount of time spent within 10m of the speaker across all four periods. However, we found no significant difference in veery responses to the control versus treatment playbacks, indicating that this species may use additional behaviors that we were not able to simulate during this experiment in order to signal aggressive intent.

Ian Hetterich (Bard College at Simon's Rock): The Hudson River is very heavily used. Large freighters move goods up and down the river to the many cities that have grown on its banks. Recreational boating and fishing are prevalent, and many parks have been established on its shores. These shorelines are heavily used and modified by humans, yet they are not very well understood. As borders between aquatic and terrestrial environments they are home to many creatures and interactions between species that can occur nowhere else. Yet it is painfully unrealistic to imagine that human use of the Hudson will do anything but increase in the future.
If we are to preserve the shoreline's ecological function while compensating for human use it is imperative that we learn more about its workings. The goal of this research was to investigate a very small portion of those workings, particularly the relationship between the shoreline vegetation and the exposure of the shoreline. The variable of exposure is essentially the physical abuse the shoreline is put through by waves, currents, tides, and boat wakes. Five sites were sampled on Cruger Island; these sites were selected because they appeared to vary along the spectrum of exposure. While the relationship might be intuitive our study of shorelines is still in its early stage and studies like this must be conducted. Not only to obtain information but to try and develop good methodology.

Max Mossler (Arizona State University): With the overall health of the environment rapidly declining – mostly due to human behaviors, solving the problem of nature deficit disorder and getting more children interested and aware of nature could be paramount to improving the environmental health of our planet. To solve the problem, education must play a role. How does education play a role in increasing environmental affect? Simply teaching knowledge does not work, but studies suggest that a hands-on environmental education experience would increase a child's affective attitudes towards nature and thus increase their pro-environmental behaviors. In this study, the relationship between emotion and knowledge of concrete and abstract ecological concepts learned at an ecology-based summer education program will be explored using high and low familiarity as a comparative factor along with a control. Examining the difference between abstract and concrete ecological concepts could also be useful in studying the environmental affects in children towards human-created ecological problems – as some are concrete (i.e. pollution) and some are abstract (i.e. climate change).

2011 Student Abstracts

Kristen Sloyer (Millersville University of Pennsylvania): West Nile Virus was first introduced to the United States in 1999 in New York City. Since then, viral and vector distributions have been on the rise with thousands of reported human cases each year, especially in urban environments. This high risk of disease could be explained by many of the changes to landscape which occur with urbanization. One such potential explanation presented by this research investigates the idea that urban environments facilitate the introduction of invasive mosquito species, either by increases in temperature or invasive detritus input. This hypothesis was tested by conducting a larval competition experiment between the invasive *Oc. japonicus* and the native *Oc. triseriatus*. Species interactions were recorded for when each species was kept in separate mesocosms as well as both species in the same mesocosm with a constant density of 40 mosquitoes. Mosquitoes were given either *Quercus alba* (White Oak) or *Ailanthus altissima* (tree of heaven) at concentrations of 1.0g/l or 2.0g/l as their primary nutrient source as well as rearing temperatures representing urban and rural temperatures. In the results, it was seen that *Oc. japonicus* was able to outcompete *Oc. triseriatus* under lower food

concentrations regardless of temperature. Replacement of *Q. alba* with *A. altissima* as primary food source sped up emergence rates but also increased larval mortality. These results suggest that urban influences have an effect on the success of native mosquito species under resource competition.

Noelle Martinez (University of New Mexico): The largest single crop in the United States happens to be turf grass; it covers 1.9% of the land area. Many lawn owners add fertilizers and pesticides to their yards in order to maintain appearance, which causes concern since nitrogen (N) laden fertilizers may be polluting our watersheds as nitrates (NO_3^-) or emitting nitrous oxide (N_2O, a greenhouse gas) into the atmosphere. Lawns may actually provide ecological benefits and previous research suggests that they have a great ability to retain N; but we do not know exactly why they retain N. Which is why we asked if location (front yard vs. back) or age of neighborhoods controls variability in lawn nitrogen environmental performance. We also asked, what regulates nitrification (a process that produces NO_3^-) and N_2O production, and why is there so much carbon (C) at depth in the soil profile? We expected higher amounts of nitrates and N_2O in front yard lawns due to higher amounts of nitrogen fertilizer application. In lawns that have higher nitrification rates, we expected to see low amounts of roots. Also, we anticipated higher C amounts with high amounts of roots at depth. In order to test our hypotheses we collected soil samples to 1meter depth from residential lawns in three neighborhoods in Baltimore, MD. We quantified root biomass and soil carbon and NO_3^- levels and measured N_2O production and potential net mineralization and nitrification rates. We found no significant differences in nitrification, N_2O, or NO_3^- between front and back yards or in different neighborhoods. Nitrification was low everywhere, with no correlations between nitrification or NO_3^- and other variables. There was also no correlation between roots and carbon at depth, but there was a significant positive correlation between soil wetness and N_2O. These results suggest that the high N retention observed in previous studies is widely distributed in the Baltimore area, likely due to active growth and N uptake by lawn grasses. Further research is needed to confirm the mechanisms behind this retention. The source of carbon at depth also remains uncertain, as roots do not appear to be the source of C at depth; leaching of dissolved organic carbon (DOC) from the surface might be important. The relationship between soil wetness and N_2O suggests that overwatering might increase the flux of this greenhouse gas.

Oscar Azucena (Humboldt State University): Concern over the widespread use of road salt, as a road deicer, throughout the northeastern United States and documentation of increasing levels of Chloride in streams has fueled interests to not only use less road salt but to also increase the use of alternative road deicers. The environmental effects of alternative deicers especially, potassium acetate (KA), calcium magnesium acetate (CMA), and Magic Salt, has not been as extensively studied as road salt. This research seeks to answer three questions, how are alternative deicers affecting biochemical oxygen demand (BOD) in a local rural New York stream for summer and winter temperatures?, how are alternative deicers moving through soils?, and is soil respiration affected by alternative road deicers? BOD was assessed by taking stream water from Wappinger Creek in Millbrook, NY and exposing it to simulated road runoff concentrations for both winter and summer temperatures. Soil cores filled with the most common soil in Dutchess County were irrigated 10 times with 4 rain events having road run off concentration of the alternative deicers and road salt. Soil respiration (DIC) was measured along with, dissolved organic carbon (DOC), chloride, and Ca, Mg, K, and Na.

Biochemical oxygen demand was observed to be drastically increased by both KA and CMA. While road salt and and Magic Salt had little to no effect on BOD. Results for soil respiration yielded highly significant results ($p=0.00027$) with CMA and KA having the highest respiration rates. Results for DOC measurements in soil leachates were highly significant ($p=0.00211$) with CMA having the highest yield of DOC. Measurements of higher absorbance from soil cores treated with CMA and KA suggest that the higher DOC results were due in part to increased biological activity. Results for chloride were similar to previous soil core studies investigating road salt in soils. Ca, Mg, K, and Na results showed that the major cations were moving rapidly through the soil cores and were not being retained on exchange sites

Arwen Milroy (Adams State College): Worldwide pharmaceutical and personal care products (PPCPs) are present in surface waters at a range of different concentrations. In order to assess the impact that chronic exposure to low concentrations of PPCPs has on ecosystem function, we examined the *in-situ* growth of stream biofilms. We examined the effects of eight concentrations (10^{-8}, 10^{-7}, 10^{-5}, 10^{-4}, 10^{-3}, $2.5x10^{-3}$, $5x10^{-3}$, and $1.5x10^{-2}$ M) of diphenhydramine, ciprofloxacin, and caffeine on biofilms in Wappingers Creek, NY. For each treatment, equal numbers of fritted glass and cellulose substrates were used to distinguish between autotrophic and heterotrophic biofilm components. We measured both changes in dissolved oxygen after exposure to light and dark treatments to calculate gross primary productivity (GPP) and respiration, as well as extracted chlorophyll *a* in order to quantify biofilm biomass.

We found that biofilm chlorophyll *a* did not vary significantly relative to controls in any of the three assays. GPP did not vary significantly with exposure to caffeine or ciprofloxacin; however, the 10^{-7}, 10^{-5}, 10^{-4}, and 10^{-3} M treatments of diphenhydramine reduced GPP by an average of 50% compared to controls. Average respiration of all treatments on cellulose substrates was reduced by half when exposed to diphenhydramine, and by 70% when exposed to ciprofloxacin. Concentrations of ciprofloxacin at 10^{-5} M and higher reduced respiration by 55% compared to controls. Respiration of biofilms exposed to caffeine increased on average by 30% relative to controls. Our findings suggest that biofilm GPP and respiration are more sensitive indicators of PPCPs than chl *a*. Because biofilms are a basal food resource, reduced function caused by chronic exposure to low concentrations of PPCPs may have detrimental effects on higher trophic levels in stream ecosystems.

Jillian Guenther (Vassar College): Do you know where your energy comes from? The route of your water once it goes down the drain? Are you willing to change your behavior to protect the environment? Questions like these are rarely addressed in typical US curricula; they are also ill- suited for nationally standardized tests because of their local nature. Yet knowledge of basic amenities and an understanding of environmental processes is the right of every citizen. Environmental literacy through place-based education has the potential to allow students to connect course content to their daily lives and give them an opportunity for active participation in their local community. This study examined student knowledge and attitudes toward environmental topics and behaviors during the first two years of the locally focused Eco- Initiative Project in the Rhinebeck Central School District in New York. Students in grades K-12 were given surveys at the end of the 2010 and 2011 school years to collect data on their knowledge and attitudes about the local environment. Older students were also asked about the environmental behaviors they can individually and communally take part in. 1,497 student responses were coded to answer two primary research questions: How does student knowledge about their local environment vary across grades and sexes? How do student attitudes and willingness to change behavior vary across grades and sexes? Preliminary trends in certain topics suggest that there

are no significant differences between male's and female's responses; there may also be downward trends in accurate responses about the local environment as grade level increases. However, willingness to change behavior increases in the second year of the program. These analyses will provide insight into the effects of a place-based environmental education program. The localized nature of the program and the assessments lends itself to a unique education and research opportunity that can inform environmental literacy programs in the future.

Olivia Santana (Calvin College): In 2007, over 254 million cars traveled the roadways of the United States and the numbers only continue to increase. Road systems are a major part of our country and although people may think their actions have no effect, even a rural suburban area like Millbrook, NY is influenced. On average, 9528 cars per day drive on the segment of the Taconic State parkway surrounding the Cary Institute property while 4999 cars travel along the Route 82 segment. Acoustic competition occurs when one sound interferes with another sound being heard causing a break in communication. This is a problem for many organisms such as the Veery (*Catharus fuscescens*), a neotropical migrant from Brazil who comes to the northeast to breed. When noise from another source interferes with the Veery singing their song, communications cannot occur leading to cross-breeding or no mating at all.

In this study, we examined competition in Veery songs due to human-created noises such as traffic. Songs were recorded within 3 different categories: near traffic areas, a natural creek and quieter woodland areas. The files were analyzed and the best files were chosen based on song quality and amount of data. Trends indicated that the Veery song length could be affected by traffic noise. The declining Veery population could be detrimental to the balance of the ecosystem as Veeries are insect eaters and disperse seeds. Creating buffer zones might help keep human interference from affecting bird and other animal communication.

Kira Gilman (Bard College): Garlic mustard (*Alliaria petiolata)*, an invasive plant species, is found in areas that overlap with the presence of a disease vector, the blacklegged tick (*Ixodus scapularis*). Because garlic mustard is known to kill entomopathogenic fungi, which serves as a naturally occurring arthropod population control, it is possible that without this control agent, ticks have a better chance of summer survival. This study aims to determine if garlic mustard impacts tick survival through the reduction of entompathogenic fungi. If garlic mustard increases tick survival rates, tick-borne disease may continue to increase. Thus, further colonization of the invasive herb could potentially pose a greater threat to human health. Conversely, if garlic mustard hinders tick survival, the continuing spread of the herb may decrease rates of infection by tick-borne disease.

Matt Trentman (Manchester College): Nitrate and other nutrients can be harmful to aquatic ecosystems at high concentrations. Above average concentrations have been known to occur when flow is increased; especially in watersheds with large amounts of fertilization or areas that are located downstream of wastewater treatment plants. Historic data from Wappinger Creek suggests that nitrate may be added from alternative sources during instances of high flow in this area.

Golf courses create the perfect conditions for non-point source pollution, which is often a source of nutrient loading in streams during rain events and high flow periods. A small stream at the Millbrook Golf and Tennis Club, outside Millbrook, NY, is a tributary of Wappinger Creek; it contains many vegetated buffer strips and runs through two small ponds. During the summer of

2011 the buffer strips and ponds were analyzed for their potential to remove nutrients. Lysimeters were placed in 3 buffer strips at equal intervals perpendicular from the stream in order to determine how nutrient concentrations changed as groundwater traveled through the vegetation and soil. Denitrification enzyme assays (DEA) were also conducted at each buffer strip and in pond sediments to determine if the potential exists for microbial denitrification. Water samples were collected at both baseline and storm flow levels throughout the reach of the stream to determine how nutrient concentration changed at different points. Preliminary data suggests nutrient removal especially as the stream flows through the pond.

Alexandra Rodriguez (University of Puerto Rico): Lyme disease, a zoonosis cause by the spirochete bacterium *Borrelia burgdorferi* is transmitted by the blacklegged tick *Ixodes scapularis*. Risk of human exposure to this and other tick-borne diseases is related to the density of blacklegged ticks, but little is known about what controls tick abundance in nature. Ticks are sensitive to desiccation, and might use leaf litter as protection from hot, dry conditions. Some species of earthworms remove leaf litter and could potentially reduce this protection. We hypothesized that tick abundance would be inversely correlated with earthworm abundance. To test this hypothesis we sampled earthworm density from 126 small plots distributed in 42 forested sites throughout Dutchess County. Each site was also sampled for the population density of the nymphal stage of the blacklegged tick. This study will present data that examines possible correlations between earthworms and ticks, potentially mediated by earthworm effects on leaf litter thickness. Results will be interpreted in light of possible effects of earthworm populations on risk of human exposure to Lyme disease.

Arial Shogren (Vassar College): *Tsuga canadensis* (eastern hemlock) is an important and beautiful part of the Northeastern forest community. In addition to providing unique habitat for plants, birds, and mammals, hemlocks help to moderate temperatures, regulate stream flow, and provide aesthetic beauty to our distinctive landscape. Since the 1980's, populations of this tree species have been rapidly declining due to infestations of a small, aphid-like exotic insect, *Adelges tsugae* (hemlock wooly adelgid) that feeds on the stored sugars at the base of a tree's needles. The adelgid can kill hemlocks quickly, often within 3 to 4 years, with some populations surviving longer. Some studies suggest that the presence of multiple stressors on infested trees may affect how quickly a tree succumbs to the pest. This study in particular examined the affect of a water deficit on infested trees by observing response measures of tree health on those with and without experimentally imposed drought - using plastic skirts around a tree's trunk to prevent water from saturating the soil and roots. Counts of adelgid density and measures of photosynthesis from trees with and without plastic skirts were compared. Trees experiencing "drought" and heavier infestation were predicted to exhibit a more negative response to stress than other trees, though no significant response was observed. Still, understanding the links between drought and infestation will be critical for predicting future forest response to a changing climate.

Ayah Badran (University of Vermont): Environmental issues are becoming part of our daily lives, and as a society we are continually faced with making decisions. Issues such as clean energy, pollution, and climate change are relatively complicated and require a combination of social and environmental solutions. In order to participate in decision-making processes surrounding such issues, the public needs to be equipped with the tools necessary to do so. Environmental education is one of the many areas taking on this task, by providing students with the scientific knowledge and skills they need to make informed decisions. The overall goal of this project was to gain an understanding of how students use

science in making environmental decisions, what sources of evidence they rely, and how these factors affect the decisions they make. About 150 high school students and 1st year undergraduate students in NY and NJ participated in this study by completing a citizenship activity in class. The responses to the activities were then collected, coded for particular themes (such as source, evidence use…) and analyzed. So far, with analysis still in the preliminary stages, the data seems to suggest that there is a relationship between how students use science and what decisions they make.