

Given sufficient time and incentives students can and will discover that none of the integers 11, 111, 1111, 1111, etc. is a perfect square. Using modulo 4 arithmetic, this conjecture is not difficult to prove making it a theorem, indubitably true forever. Not all conjectures are created equal. Students are also able to provide copious inductive evidence that combining the processes of multiplying any odd positive integer by 3 and adding 1, and dividing any even positive integer by 2, always seems to dead end in the sequence 1, 2,4, 1,2, 4, 1,2,4, 1,2,4, etc. However, this conjecture, despite the best efforts of the mathematical community, has not been proven. Is there a pedagogical approach that lends itself to helping students in substantive ways to follow the yellow brick road to provable conjectures, and not venture off into the Land of the Giant of Despair where dragons and nearly unprovable conjectures lurk?

### Environmental Science

THE EFFECTIVENESS OF WETLAND MITIGATION BANKS IN THE LOWER RAPPAHANNOCK WATERSHED THROUGH MAPPING AND CREATION OF A SINGLE DATABASE. Brittany A. Baker, Michael L. Bass, Earth and Environmental Sciences, University of Mary Washington, Fredericksburg, VA. Wetlands are a precious environmental resource that provide habitat, prevent pollutants and excess sediments from entering large water ways, and control storm surge. Wetlands may be destroyed in the process of commercial, residential and infrastructure development. Federal regulation requires that these wetland losses must be mitigation, through wetland mitigation banking. Wetlands mitigation banking creates a large area of wetland acreage where portions, measured in credits, are sold to those who have destroyed wetland areas. In the United States Army corps of Engineer's Norfolk district, there are several wetland mitigation banks. Information about each of these banks may be obtained on their RIBITS database. On this database, however, it is difficult to compare attributes of different wetland mitigation banks within the same service watershed. The purpose of this study is to explore the effectiveness of the wetland mitigation banks that service the Lower Rappahannock Watershed by creating a single database for easy comparison and visualizations that may drive future wetland mitigation bank development decisions.

IMPACTS ON TWO STREAMS CAUSED BY DEVELOPMENT IN THE CELEBRATE VIRGINIA NORTH PROJECT. Katherine Vrobel, Earth and Environmental Science Department, University of Mary Washington, Fredericksburg, VA. This study observed and assessed damage to streams located within the Celebrate Virginia North development in Stafford County, Virginia. Research was conducted at seven stations located on England run and the Unnamed Tributary streams. Assessments were made based on the study of the macrobenthic communities, water chemistry comparisons (such as nutrients, dissolved oxygen, conductivity, alkalinity, and water hardness) before and after rainfall, suspended load in the stream water, and grain size analysis in the water column and sediment. This study consisted of a number of methods: Water quality was assessed by determining the abundance and diversity of macrobenthic organisms, which included the Hilsenhoff Family Biotic Index (HBI) and the total percent of insect orders Ephemeroptera, Plecoptera, and Trichoptera

(%EPT) in the biotic community. Water chemistry data, such as dissolved oxygen, conductivity, and temperature, were determined using the YSI Model 85 multimeter. Samples of streams water were collected to determine nutrient levels, alkalinity, hardness, and particle size; particle size was ascertained with a Coulter counter, and water quality was assessed using LaMotte chemistry kits. Total dissolved solids and total suspended solids were determined by filtering samples from each stream before and after rain, and a grain size analysis was conducted on sand that had accumulated in Stream 5's bed. Results indicate that stream quality is declining rapidly due to the large influx of sediment from the nearby development, which is adversely affecting water quality and smothering macrobenthic communities. A negative relationship is present between the embedment in the macrobenthic habitat caused by sediment erosion from the development activities and the health of the streams' macrobenthic communities.

**MONITORING THE STORMWATER MANAGEMENT PONDS OF CENTRAL PARK AND DEVELOPMENT OF AN OFFSITE WETLAND MITIGATION PROGRESS.** Katherine Oldham and Michael L. Bass, Earth and Environmental Science, University of Mary Washington, Fredericksburg, VA. When Silver Company built the commercial complex of Central Park in the 1990's, 6.9 acres of the wetlands were destroyed. The EPA requires that the equivalent area of destroyed wetland has to be reconstructed. In compliance with the Clean Water Act, wetlands were constructed in two areas; benches around the storm water management ponds located within Central Park, and an off-site constructed wetland in Spotsylvania County. The off-site wetland was impacted by nearby developments. The storm water management ponds receive runoff from Central Park while the off-site wetland receives runoff from a new housing development. Water chemistry tests were performed on both sites, testing for nitrate, phosphate, total alkalinity, total hardness and pH levels. Temperature, dissolved oxygen, and conductivity were measured with an YSI multi meter. The nitrate, phosphate, total alkalinity and total hardness were performed in the lab using LaMotte testing kits. Samples were taken before major rainfall as well as after storm events in order to examine the impact of runoff from the development. Identical water chemistry tests were performed on the off-site constructed wetland as well as a nearby natural wetland. In addition to water chemistry tests, a survey of woody stems was done on the off-site wetland in order to determine the number of woody stems per acre. The wetland was divided into two sections, and each section was marked off in 100 foot increments with string. 20 foot squares were constructed on either side of the 100 foot markers to create a grid. Within each square the number of woody stems over one foot in height were counted and classified. In addition, wetland professional Bill Sipple aided in identifying herbaceous plant species and creating a list of those species. Soil cores were taken along the 100 foot markers in order to assess the hydric soil prevalence which is substantial.

**COMPARING CLIMATE RESPONSES IN TWO TREE SPECIES OF MOUNT VERNON, VA.** Brittany Miller & Daniel L. Druckenbrod, Biological and Environmental Sciences Dept., Longwood University, Farmville, VA 23909. This research investigates the relationship between tree growth and precipitation for two

common long lived species in the eastern deciduous forest. Using tree ring cores of select Mount Vernon Virginia pine (*Pinus virginiana*) and white oak (*Quercus alba*) collected in June 2008, we crossdated annual ringwidths with divisional climate data overlapping back to the year 1895. Significant correlations were found between precipitation and tree ring growth using COFECHA, ARSTAN, and DendroClim 2002 programs in conjunction with precipitation data from the National Oceanic and Atmospheric Administration. It was determined that June's precipitation was most important to Oak growth, and May and prior September precipitation was most important to Pines.

FOREST COVER CHANGE OF HISTORICAL MOUNT VERNON FROM 1793 TO 1994. Heather M. Carty & Daniel L. Druckenbrod, Biological and Environmental Sciences Dept., Longwood University, Farmville, VA 23909. During European settlement the forests were heavily logged and farmed, stripping the majority of all the forest lands in eastern North America (Foster and Motzkin 1998). However, by the mid 19th century with the rise of the Industrial Revolution, the decline of agriculture, and forest use the forests of North America have increased in area and in age (Foster and Motzkin 1998). This means that currently in the United States there is more forest cover than there has been since European settlement. Although this may be the case for the entire eastern seaboard, this study hypothesizes that the current forest cover of Mount Vernon is smaller than during George Washington's era due to human impact and development. The conclusions from this research support the hypothesis. The forest cover of Historical Mount Vernon has decreased since Washington's era. This GIS project uses a survey of Mount Vernon drawn by George Washington, a Civil War topography map, a 1933 topography map, and current aerial photos of Mount Vernon. All illustrate forest cover for its time period and use the Universal Transverse Mercator NAD 1983 coordinate system (zone 18). The two historical maps and the 1933 topography map were georeferenced against the aerial photos. George Washington's hand drawn map is the most accurate map that was georeferenced to the aerial photo, the 1933 topography map was the second most accurate, and the Civil War Map had the largest error. After overlaying all three maps with the aerial photo only 44 Acres of Washington's original 2,300 Acres of forest land remains consistently forested.

A PROPOSAL TO ESTABLISH A NATIONAL MUSEUM OF ENVIRONMENTAL SCIENCE. Richard S. Groover, J. Sargent Reynolds Community College, Richmond, VA. It is proposed that a National Museum of Environmental Science be established at a four-year institution in Virginia. Such a museum should include a small public exhibit on environmental science issues, an environmental persons Hall-of-Fame, a collection of first edition books on the science of the environment, up-to-date reports on environmental conditions, working documents from those persons who advanced the science and concerns about the environmental issues, artifacts from early environmental movement activities, and audio-visual interviews with early pioneers of the environmental movement and environmental science. The Museum physical plant would include a library, storage space for artifacts and documents, staff office space and a meeting facility for symposia.

**BASLINE WATER QUALITY ASSESSMENT USING BENTHIC MACROINVERTEBRATES IN HIATT AND LICK RUNS, OPEQUON CREEK WATERSHED, FREDERICK COUNTY, VIRGINIA.** Marie R. Dahl<sup>1</sup>, Jared B. Davis<sup>1</sup>, Andrew G.M. Fisher<sup>1</sup>, L. Brandon Millholland<sup>1</sup>, J.W. Pangle<sup>2</sup>, Sean G. Robertson<sup>1</sup>, Jeremy D. Tovar<sup>1</sup>, & Woodward S. Bousquet<sup>1</sup>, <sup>1</sup>Environmental Studies Department, Shenandoah University, Winchester, VA 22601 and <sup>2</sup>Opequon Creek Targeted Watershed Grant. In 1996, the Virginia Department of Environmental Quality placed Opequon Creek in Frederick and Clarke Counties on its Impaired Waters List because it failed to meet water quality standards for aquatic life and *E. coli* bacteria. Shenandoah University student researchers sampled benthic macroinvertebrates (BMIs) at six locations in the Hiatt-Lick Run subwatershed of Opequon Creek in May and October 2008. Methods and analysis conformed to the EPA's Rapid Bioassessment Protocols (RBPs) and the Virginia Stream Condition Index (VSCI) manuals, respectively. The VSCI is an eight-metric index based on the biodiversity, pollution tolerance and ecological niches of the BMIs collected in each sample. The mean VSCI score for the 11 samples was 43.5 on a 100-point scale, an overall water quality rating of "moderately stressed". VSCI scores for 8 samples fell into the severely or moderately stressed category, 2 were rated fair, while only 1 was rated good. This study provides provide baseline data and a sampling framework to evaluate proposed watershed improvements under the TMDL (Total Maximum Daily Load) Implementation Plan for Opequon Creek.

**LOST CRAB-LOST CULTURE: ENVIRONMENTAL AND CULTURAL CHANGES RELATED TO THE FRESHWATER CRAB, *POTAMON* IN GREECE.** Eugene G. Maurakis<sup>1,2,3</sup> and David V. Grimes.<sup>3</sup> <sup>1</sup>Science Museum of Virginia, 2500 W. Broad St., Richmond, VA 24542, <sup>2</sup>Biology Dept., University of Richmond, VA 23173, <sup>3</sup>VA Dept. of Environmental Quality, Richmond, VA 23060. Objectives are to generate phylogenetic relationships and biogeographic hypotheses of four freshwater crab species of *Potamon* in Greece; and comment on the need to protect their habitat. *Potamon* in the Balkan peninsula and islands in the Mediterranean region is a monophyletic group composed of two main clades: Clade 1 (*P. fluviatile* and *Potamon algeriense*) and Clade 2 (*P. ibericum* and its sister group composed of *Potamon rhodium* and *Potamon potamios*). Vicariant events (e.g. marine transgression and regression, orogeny, volcanism) are hypothesized as major factors shaping distributions of *Potamon* species in the region. We recommend an increase in environmental education and communication among older and younger generations, agriculturalists, politicians, policy writers, land developers and economists to create an understanding for the need to protect land and aquatic environments that harbor unique species and the potential benefits for economic activities such as ecotourism.

**BASELINE FOR CLIMATE CHANGE: MODELING FISH SPECIES DIVERSITY IN WATERSHEDS.** Eugene G. Maurakis<sup>1,2,3</sup>, Summer Schultz<sup>1</sup>, and David V. Grimes<sup>1</sup>. <sup>1</sup>Science Museum of Virginia, 2500 W. Broad St., Richmond, VA, 23220, <sup>2</sup>Biology Dept., University of Richmond, and <sup>3</sup>Dept. of Environmental Science and Policy, George Mason University. Objectives are to model fish species richness, diversity and evenness in watersheds of Quantico Creek (a pristine undisturbed

drainage) and Cameron Run (a highly developed urban drainage) using biological (e.g. macroinvertebrate richness and abundance, allochthonous detritus concentration), and physio-chemical factors (e.g. pH, temperature, stream order, width, depth, current, flow, elevation, gradient, river km, substrate composition, land use, and human population per intra-drainage stream order area. To date, 30 species of fishes representing 10 families, including *Channa argus*, the snakehead fish, have been collected from 23 sampling sites over a 6-month period of the two-year study. Funded by U.S. Department of Energy grant DE-FG0208ER64625.

GIS GAP ANALYSIS OF FRESHWATER AQUATIC RESOURCES (FAR) AND FRESHWATER PROTECTED AREAS (FPA) IN GREECE. David V. Grimes<sup>1</sup> and Eugene G. Maurakis.<sup>2,3,4</sup>, <sup>1</sup>Virginia Department of Environmental Quality, 4949 – A Cox Rd., Richmond, VA 23060, <sup>2</sup>Science Museum of Virginia, 2500 W. Broad St., Richmond, VA 24542, <sup>3</sup>Biology Dept., University of Richmond, VA 23173, and <sup>4</sup>George Mason University. Objectives are to quantitatively inspect overlays of FAR and FPA to determine their percent coincidence; Describe the current level of FAR protection in Greece; and Develop practicable recommendations for increasing FAR protection. Spatial analysis of ring buffered FPA, intersected with collection point data for freshwater fishes and the freshwater crab *Potamon sp.* (FAR), was used to determine the frequency of occurrence of FAR relative to the distance of collection from FPA. Pearson correlation coefficients indicate there is little correlation between the frequency of FAR collection and the distance of the collection point from FPA. Targeted sampling of FPA is needed to determine if FPA in Greece are providing the requisite levels of protection for FAR, particularly fishes listed as extinct, critically endangered, endangered, threatened or vulnerable. We recommend targeted sampling of FPA, urban, rural, resort, agricultural and other land use areas as well as the inclusion of other environmental and anthropogenic variables into a GIS GAP analysis of FAR in order to fully identify their protection needs and environmental quality indicator status.

### **Materials Science**

(Met with Astronomy, Math & Physics)

### **Microbiology and Molecular Biology**

(Met with Biology)