UNIVERSITY OF PENNSYLVANIA

SCHOOL OF ARTS AND SCIENCES

DEPARTMENT OF EARTH & ENVIRONMENTAL SCIENCE

COLLEGE OF LIBERAL AND PROFESSIONAL STUDIES

ENVIRONMENTAL BIOLOGY ABSTRACTS

LAND USE AND WATER QUALITY IN BANGLADESH AND BHUTAN

Bryan Currinder (2017)

Readers:
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The freshwater systems of Bhutan and Bangladesh offer marked contrasts in anthropogenic disturbance, surrounding land uses, watershed population density, and benthic macroinvertebrate ecology. However, they share a lack of published research on water quality monitoring, specifically in regard to biological monitoring with benthic macroinvertebrates. With their high diversity, high abundance, and spectrum of pollution tolerances, study of benthic macroinvertebrates is an inexpensive yet powerful tool for monitoring freshwater health. In November 2015, the Stroud Water Research Center performed physical, chemical, microbiological, and macroinvertebrate sampling at 18 stream sites in western Bhutan, with sites representing a variety of surrounding land uses and disturbance levels. In August of 2016, the author and a fellow Penn MES student (Naimul Islam) performed a second round of sampling at 11 sites in Bhutan, and a first round of sampling at 10 sites in Bangladesh, using both quantitative collection techniques as well as less technical citizen-science techniques. After extraction and identification to the taxonomic level of family, macroinvertebrate taxa were compared across land uses and in relation to collected physico-chemical and microbiological metrics. In Bhutan, significant changes in macroinvertebrate taxa were correlated with changes in upstream versus downstream condition, as well as with monsoon versus post-monsoon sampling times. In Bangladesh, the citizen-science collection technique of leaf packs selected overwhelmingly for Chironomidae and thus could not distinguish between upstream and downstream conditions, necessitating an in-field or lab modification of the technique for future use. Given each country's direct interests in maintaining clean, functioning freshwater systems, both Bangladesh and Bhutan – and much of South Asia – are ripe for the implementation of both citizen-science and technical biomonitoring techniques that connect communities and public officials to measures of water quality and stream condition.

DEVELOPING AND INTEGRATING AN URBAN FARM CURRICULUM FOR HIGH SCHOOLS

Tasnim Aziz (2016)

Readers:

Sally McCabe, Pennsylvania Horticultural Society
Tom Brightman, Longwood Gardens
Sarah Willig, Earth & Env Science, University of Pennsylvania

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Urban farming is an increasingly popular form of land use in highly populated areas at risk of becoming food deserts. With the ailing health of the growing population and disengagement of the youth from science, implementing a gardening curriculum can be an effective way to meet the needs of the community while simultaneously providing context for and relevancy of science in the students' lives. Much existing urban farm education takes place in the elementary school level, with very little at the high school level. Urban farms, if maintained, can have positive impacts on grades, knowledge, attitude, and behavior for learners of all age group (Williams & Dixon, 2013). I collaborated with the Pennsylvania Horticultural Society to study how they implement community gardens in high schools of Philadelphia. I also interviewed teachers from schools that promote urban farming in Philadelphia to learn about their accomplishments and challenges, synthesize the lessons learned and make them available for other stakeholders and interested parties.

THE ENVIRONMENTAL BENEFITS OF TREES ON AN URBAN UNIVERSITY CAMPUS

Corinne G. Bassett (2016)

Readers:

Jason Henning, The Davey Institute and USDA Forest Service
Sarah Willig, Earth & Env Science, University of Pennsylvania

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The University of Pennsylvania is situated on a rapidly growing and highly urbanized campus that, as of the summer of 2015, contained over 6,000 trees. Trees play an important ecological role within the urban environment, as well as support improved public health and provide aesthetic benefits to cities (Nowak et al. 2008; McPherson et al., 2003). This capstone project used the United States Department of Agriculture Forest Service's software, i-Tree Eco, to quantify the ecosystem benefits that the University of Pennsylvania urban forest conveys to its community. Field research teams collected data on location and tree canopy size for 4,086 trees on 160 acres in the core of the Philadelphia campus during the summer of 2015. Trees within the Core Campus were estimated to store a total of 1,576,717 lbs. of carbon and prevented $51,871 in building heating/cooling energy costs. This project will give Penn Facilities and Real Estate Services decision makers a more complete assessment of the value of their urban trees to inform future tree management practices and create a precedent for ongoing urban forestry research efforts at Penn.

ACOUSTIC ANALYSIS OF COASTAL MIGRATORY PATTERNS IN DELAWARE BAT POPULATIONS

Sarah Deutsch (2016)

Readers:

Sarah Willig, Earth and Env Science, University of Pennsylvania
Holly Niederriter, Delaware Division of Fish and Wildlife

Information gained from research efforts into coastal bat migration could aid in the reduction of bat fatalities caused by wind turbines, especially during autumn migration (Cryan et al., 2014). Tree bat species of North America are largely migratory, capable of flying distances of over 100 km in search of better foraging area or to avoid harsh weather (Cryan, 2003). The use of acoustic technology in order to survey for bat presence is a valuable tool that has been used by a number of researchers to gain knowledge of coastal bat movements. Acoustic data collected by the Delaware Division of Fish and Wildlife (DFW), from three different coastal sites within the State was analyzed from 2012 - 2014. Activity was measured by the number of bat calls that were recorded per night throughout an entire year of data collection. General trends of increases in activity during the early fall and decreases in activity at the onset of November can be observed at two of the coastal sites. Data collection at the third site was too limited for these years to draw conclusions about patterns of movement. The average temperatures and wind speeds during days of peak fall activity were also analyzed in order to observe the effect of weather on bat activity. Low average wind speeds generally occurred on days when higher activity was measured at night. Higher average temperatures were also found to occur on these days, but average temperatures on peak fall nights that occurred later in the season were lower than those that occurred earlier. Further investigation of other weather factors affecting coastal movement would be useful in the future, as well as complete species analysis of the types of bat species occurring on nights of peak fall activity.

EVALUATION OF IRON FRACTION AND PRECIPITATE SIZE IN AN MSW INCINERATION ASH LEACHATE REMEDIATION POND IN LOWER MERION, PENNSYLVANIA

Ian Dombroski (2016)

Readers:
David Vann, Earth & Env. Science, University of Pennsylvania
J. Anthony Sauder, Pennoni Associates

A municipal solid waste incinerator ash landfill in Lower Merion, Pennsylvania began operation in 1921, and has been leaching iron from groundwater seeps since before its closure in 1977. The high levels of iron released into Glanraffan Creek by the seeps prompted PADEP to list the creek as a Section 303(d) impaired water, prompting the creation of a Total Maximum Daily Load (TMDL). In 2005, township engineers built a retention basin with passive aeration to allow iron from the seeps to settle out and comply with the TMDL. However, during winter months and high flow events, short circuiting lead to non-compliant effluent. To prevent short circuiting, baffles with vertically offset flow-through openings were installed in the basin. Installation of the 1st baffle curtain decreased effluent iron concentrations. Two additional baffles, however did not further decrease concentration, but did decrease variability. This project looked to evaluate dissolved vs. suspended iron and floc size behind each baffle to understand how iron is being removed from the system and why the additional baffles did not reduce effluent iron concentration. To do so, iron fraction in each baffle chamber was determined via filtration and ICP-AES. Floc size distribution was found with laser diffraction particle size analyses. It was found that total and suspended iron were significantly higher behind the first baffle, but equal in the remaining baffle chambers. Dissolved iron is effectively oxidized by inlet cascade aeration and remains at low levels throughout the basin. Median floc size was significantly smaller behind the 1st baffle than in the rest of the system. These results suggest that the first baffle concentrates small iron flocs, allowing for increased floc growth and settling; and thus increased iron removal. Iron concentration beyond the first baffle is too low for further significant floc growth. Flocs that escape the first chamber in the 50-150 μm range do not continue to agglomerate and settle at significant rates, and may move through the system along with dissolved iron. This study begins to quantify successful iron removal in a basin with vertically offset flow-through baffles and indicates that this system may be useful in other leachate remediation scenarios.

MONITORING GROWTH AND SUCCESS RATES OF A RIPARIAN CORRIDOR PLANTING AT A LEGACY SEDIMENT SITE

Amanda Dunbar (2016)

Readers:
Sarah Willig, Earth & Env Science, University of Pennsylvania
Bernard Sweeney, Stroud Water Research Center

Recent studies suggest that planting seedlings along stream banks containing thick deposits of legacy alluvial sediments results in low survivorship of the plants. This low survivorship is being used to support a concept that legacy sediments need to be removed before riparian areas are planted in order for the restoration effort to be successful. In this study, growth and survivorship data were collected for seedlings planted at densities of 400 seedlings per acre as part of a riparian reforestation effort on a site with thick legacy sediments in Franklin Township, Pennsylvania. Study plots with the wettest conditions were treated with herbicide for the first year and results indicate herbicide application is not necessary for increasing survivorship under those conditions. After five years of growth across all plots, tree seedling survivorship was 60% or ~240 seedlings per acre. No strong patterns or differences were found in tree height across all species or within any single species. These results indicate that growth and survivorship was not greatly affected by legacy sediments. Therefore, the time and expense of removing legacy sediments seems unnecessary for riparian reforestation. Rather, each riparian planting site needs to be managed according to its unique attributes.

ASSESSING HABITAT QUALITY FOR MIGRATORY LANDBIRDS IN SOUTHEASTERN PENNSYLANIA

Alison V. Fetterman (2016)

Readers:
Robert J. Smith, University of Scranton
Lisa Kiziuk, Willistown Conservation Trust

Declines of migratory landbird populations in North America have often been attributed to habitat loss on the breeding and wintering grounds. However, fewer studies have reflected the importance of the migratory period and the conservation of stopover habitat. During the migratory period birds experience extreme energy demands as they encounter obstacles such as predator avoidance, inclement weather, resource competition, navigation of unfamiliar habitats, and finding suitable food resources to refuel and continue on their journey. Identifying areas of adequate habitat for migratory landbirds is essential for their survival, which challenges conservation planning to focus on land connectivity throughout their migratory period. This study examined the use of habitat through capture rates, and fitness consequences, by evaluating rates of mass change, of landbirds using Rushton Woods Preserve (RWP), located in Newtown Square, Pennsylvania, during fall migration. Results demonstrate 1) high capture rates compared to other study sites, 2) most individuals using the site are young hatching year birds, and 3) all species either gained or maintained mass. Although these results demonstrate that RWP provides important stopover habitat for many migrating landbirds in the fall, this site may not be a high quality refueling area for some species.

IDENTIFICATION OF SMALL MAMMALS AND PREY DENSITY DURING NSWO MIGRATION AT RUSHTON WOODS PRESERVE

David Groff (2016)

Readers:
Lisa Kiziuk, Willistown Conservation Trust
Sarah Willig, Earth & Env Science, University of Pennsylvania

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Northern Saw-Whet Owls (*Aegolius acadicus*, NSWO) banding records collected between 2012 and 2015 from the Rushton Woods Banding Station located in southeastern Pennsylvania were analyzed in combination with small mammal activity to understand how NSWO's respond to prey availability across four different habitats during fall migration. A large number of NSWOs were banded at Rushton Woods Preserve in 2012, during an irruptive year. According to banding records this is known to occur once every 3 to 5 years. Comparisons between NSWOs captured and small mammal activity reveal that NSWO capture rates do not correlate to prey activity within the Rushton Woods Preserve. Although more study is needed, this project could be replicated at other Project Owlnet banding stations as a tool for answering ecological questions regarding NSWO fall migration and prey availability.

NON-CROP PLANT COMMUNITIES OF RUSHTON FARM AND PRESERVE: SURVEYING THE WEEDSCAPE

Katherine Pflaumer (2016)

Readers:
Fred deLong, Willistown Conservation Trust
Sarah Willig, Earth & Env Science, University of Pennsylvania

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Plant community composition in areas of Rushton Woods Preserve and Rushton Farm (a 6-acre organic farm at the entrance to the preserve) in Newtown Square, PA, were surveyed to examine potentially beneficial and detrimental interactions between cultivated and natural areas (for example, the potential of surrounding natural areas to serve as staging grounds for agricultural weeds). Plant communities were largely distinct; although some crossover did occur between non-crop plants from the farm ("weeds") and plants in "natural" (edge, meadow, and wildflower) habitat, dominant species largely differed between habitats based on management regime. Finer-scale studies of weed distribution and further research on potential ecological benefits of introduced species (which dominated in farm habitat) will give a better picture of the potential benefits of farm habitat to wildlife, as well as the potential threat of agricultural weeds repopulating from specific non-farm habitats.

BEST MANAGEMENT PRACTICE FOR USING ANTI-BIRD NETTING ON TREE SHELTERS WHEN ESTABLISHING RIPARIAN FOREST BUFFERS

Katherine Ridella (2016)

Readers:

Bernard W. Sweeney, Stroud Water Research Center
Sarah Willig, Earth & Env Science, University of Pennsylvania

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Reaches of streams with riparian forest buffers generally have higher water and habitat quality and healthier stream ecosystems than deforested stream reaches. Riparian forests provide a number of ecosystem services to the stream. These include, among others, filtering out unwanted substances from overland runoff before they enter the stream, stabilizing banks to prevent erosion, providing shade and cooler temperatures to prevent the growth of harmful bacteria, and providing woody detritus as habitat for stream biota. As such, many watershed restoration projects involve the planting of trees and other vegetation along deforested stream reaches. Seedlings are often fitted with tree shelters to protect them from herbivore browsing (especially by deer), invasive plants, and physical threats such as desiccation or overbank flooding. Tree shelters are necessary but can be controversial because birds, especially Eastern bluebirds (*Sialia sialis*), sometimes enter, get trapped, and die in tree shelters while searching for suitable nesting sites. Anti-bird netting can be installed on the top of shelters to prevent bird entry. However, the netting can cause stem deformities and weakness due to entanglement in the net as stems emerge from the top of the shelter. So far, there is no "best practice" for installation of the netting to eliminate or reduce this effect. This study explores six different approaches for installing anti-bird netting and evaluates their success in terms of successful retention of the netting, healthy stem development, bird deterrence, and seedling survivorship and growth and provides a prescription for successful deployment of netting on tree shelters used in riparian reforestation. This study shows that to avoid the above problems, anti-bird netting should be pulled far enough onto the shelter to create a flat netted surface across the top, leaving a "silver dollar" sized opening for seedling emergence. Application of duct tape with UV-inhibitor is the best method for assuring that the net stays attached to the tree shelters in wind-prone areas.

CULTIVATING A SUSTAINABLE LANDSCAPE: A COMPARATIVE ANALYSIS OF THE AGRICULTURAL PRACTICES AND IMPACTS OF THREE FARMING SYSTEMS IN EASTERN PENNSYLVANIA

James Robert Dickinson (2015)

Readers:

Fred de Long, Willistown Conservation Trust

Lisa Kiziuk, Willistown Conservation Trust

The global population is growing rapidly and is expected to reach 9.6 billion by 2050. This growth will put increased pressure on the world's agricultural resources with cereal demand expected to be 50% higher in 2030 than it is currently. The two most commonly accepted methods for meeting future food demand are agricultural intensification and expansion. The trend in agricultural intensification over the last century has seen large increases in crop yields, however it is also often associated with severe environmental degradation. This study aimed to assess whether intensive agricultural systems are the only answer to meeting the food needs of future generations or whether more sustainable alternatives exist.

Three farm types were examined in Chester County, Pennsylvania. They included a small scale organic farm using agro-ecological methods (SS Farm), a medium scale diversified farm adopting some sustainable agricultural methods (MS Farm) and a large scale industrial farm that operates a typical intensive agricultural operation (LS Farm). A range of economic and ecological variables were examined including the use and cost of pesticides, fertilizer, water, equipment, plastic mulch, GMOs and cover crops. Abundance and diversity of pollinator crops and invertebrates were recorded as a proxy for biodiversity.

The results of the study indicated that the LS Farm not only performed the worst environmentally but also economically. It was the only farm to make a loss rather than a profit, which is an indication of the reliance that intensive agricultural systems have on the farm subsidy system. Both the MS and SS Farms made profits, with the MS Farm performing better economically and the SS Farm performing better environmentally. Despite the MS Farm supporting greater biodiversity than the LS Farm, it supported significantly less than the SS Farm. The additional profit per acre made by the MS Farm is unlikely to be sufficient to compensate for the loss of the ecosystem services provided by the additional biodiversity on the SS Farm. This study provides evidence to refute the commonly held idea that more ecologically conscious agricultural operations are less profitable or economically unviable.

THE PRESENCE AND FUNCTIONALITY OF AMMONIA OXIDIZING BACTERIA AT THE CONSTRUCTED WASTEWATER TREATMENT WETLAND AT THE JOHN HEINZ NATIONAL WILDLIFE REFUGE

Keith Lewy (2015)

Readers:
David Vann, PhD., Penn Earth and Env Science
Karen Hogan, PhD., Penn Biology Department

The vast majority of research has been done on constructed treatment wetlands (CTWs) that are outdoors, but very little work has been done on indoor systems. Previous work on the indoor CTW at the John Heinz National Wildlife Refuge focused on whether the lack of floral diversity in the system would negatively impact its ability to remove various chemical parameters, but despite their great importance in bioremediation in these systems the microbial communities in CTWs have never been studied. Thus, through culture and DNA-based techniques the presence and functionality of ammonia oxidizing bacteria was examined in various points of the treatment system. In addition, the overall ability of the treatment system to filter out nitrogenous compounds was measured, to demonstrate how its functionality may have changed over the multi-year period since the last study. Water chemical testing revealed that there was a functional shift observed in each section of the treatment system, with much higher levels of ammonium leaving the first aerobic section than before and with the second anaerobic section now eliminating seemingly all forms of nitrogenous compounds. Functional assays indicated though that ammonia oxidizing bacteria were both present and functional in the first section, with results much stronger than those for the second section. Data generated from metagenomic assays from both sections revealed the presence of certain bacterial phyla, which offer insight into the underlying physical and chemical properties of the system on the whole. Due to the significant impact of microorganisms on CTW function and the scarcity of data on the subject, these findings provide a strong foundation for future research.

PREDICTING OCCUPANCY OF SELECT UPLAND BOREAL FOREST BREEDING BIRDS IN RESPONSE TO STAND-REPLACING FIRES IN JACK PINE-BLACK SPRUCE FORESTS IN NORTHEASTERN MINNESOTA

Michael McGraw (2015)

Readers:

Alan Haney, PhD., University of Wisconsin
Stephen Applebaum, Applied Ecological Services
C. Dana Tomlin, PhD., Penn School of Design

Occupancy models for 9 songbird species that breed in the upland boreal forests of northeastern Minnesota were created using a combination of new and previously collected data in the Boundary Waters Canoe Area Wilderness (BWCAW). The models will be tested via random sampling in June 2015. Shrub and tree cover densities revealed the best correlations to bird presence/absence. Isolating upland boreal forest sites disturbed by fire from other disturbance types (blowdowns and logging) revealed distinct trends sufficient to model occupancy at the landscape scale. Further analysis is needed to verify the accuracy of these models.

BEST PRACTICES FOR ESTABLISHING RIPARIAN BUFFERS WITH TREE SHELTERS

Katherine Ridella (2015)

Readers:
Bernard W. Sweeney, PhD, Stroud Water Research Center
Sarah Willig, PhD, Penn Earth and Env Science

Freshwater streams with riparian buffers are shown to have higher water quality and healthier stream ecosystems. Riparian vegetation provides a number of services to the stream system including filtering out runoff before it flows into the stream, stabilizing banks to prevent erosion, providing shade and cooler temperatures to prevent the growth of harmful bacteria, and providing woody detritus for stream organisms. As such, many watershed restoration projects will involve the planting of trees and other vegetation along deforested streams. Typically, planted seedlings are fitted with plastic tree shelters to protect the seedlings from deer browsing, invasive plants, and physical threats such as desiccation or overbank flooding. Such tree shelters have proven somewhat controversial among the birding community because birds, especially blue birds, sometimes will try to build nests in the protective shelters. These birds become trapped and die. In some cases, the shelters can also deform or weaken saplings. More recently, conventional practices prescribe the addition of netting on top of tree shelters to prevent birds from entering. So far, there are no instructions for best practices on how to use the netting. This study explores four different approaches for installing the netting and will evaluate their success in terms of durability, bird deterrence, and tree survival to provide a prescription for successful tree shelter use.

INVESTIGATION THE INTERACTION OF GLUTAREDOXIN SYSTEM ON VIRULENCE GENE EXPRESSION IN *VIBRIO CHOLERAE*

Ao Zhang (2015)

Readers:

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Richard V. Pepino, Earth & Env Science, University of Pennsylvania

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Many factors, such as oxygen and osmolarity, in both aqueous environment and host intestine influence the virulence gene expression in *Vibrio cholerae,* which is the pathogen that is responsible for the serious diarrheal disease-- cholera. Most cells contain glutaredoxin system that can use the reducing power of glutathione to catalyze disulfide reductions with proper reaction agents. Two genes—*grxA* and *grxB*, of *V. cholerae* are hypothesized to encode reductase belonging to glutaredoxin system. Studies show that AphB, a virulence activator, is normally oxidized in aqueous estuaries and uses a dithiol mechanism to switch into active form under oxygen limited conditions (Liu *et al.*, 2011). This project aimed to investigate whether *grxA* and *grxB* encode reductases that are responsible for the switch of AphB. Results from single knockouts showed that neither *grxA* nor *grxB* alone influenced the activity of AphB. Mutant with *grxA* and *grxB* double knockout also showed no effects on AphB activity. However, both single and double knockouts showed some growth phenotype under treatment with reactive oxygen species (ROS)—hydrogen peroxide and cumene hydroperoxide. The results indicated that *grxA* and *grxB* are important for *V. cholerae* to maintain normal growth under oxidative stress caused by ROS but these two genes may not be directly responsible for virulence expression. It is likely that other factors together with GrxA and GrxB control the successful expression of virulence factors in *V. cholerae.*