Maryland Water Resources Research Center Annual Technical Report FY 2012

Introduction

During Funding Year 2012, the Maryland Water Resources Research Center supported a variety of research and outreach activities that address the diversity of water issues in the State and the Chesapeake Bay Region. Although very different in their research focus and tasks, two new projects funded this year shared a common theme: the effects of past development and management decisions on current water quality: one study examined the remobilization of sediments trapped by milldams of the mechanical-water-power era; the other launched an investigation of the hydro-ecological effects of mosquito ditching in tidal wetlands. Two graduate students received summer fellowships: a watershed-scale investigation on Nitrogen storage, transformation, and transport in upland forests; and a laboratory-scale study of resistance and sensitivity of organisms to toxics in forest stream versus agricultural ditch water. Commemorating the 40th Anniversary of the Clean Water Act, our annual Maryland Water Symposium featured “Clean Water Connections: Law, History, Science & Communities.”

Research Program Introduction

A University of Maryland project was selected for support under the IWR/NIWR program, beginning in 2012:

- The Effectiveness of a Computer-Assisted Decision Support System Using Realistic Interactive Visualization as a Learning Tool in Flood Risk Management, Bahram Momen (Environmental Science & Technology, University of Maryland, College Park)

With 104B funding, the Maryland Water Resources Research Center supported three research projects and two graduate student summer fellowships in Funding Year 2012:

- Quantifying remobilization rates of legacy sediment from Maryland Piedmont floodplains, Andrew Miller (Geography & Environmental Systems, University of Maryland, Baltimore County)
- Ecohydrology of ditch-drained coastal marshes, Brian Needelman and Andrew Baldwin (Environmental Science & Technology, University of Maryland, College Park)
- An Innovative Learning Tool in Communicating Flood Risk Management, Bahram Momen (Environmental Science & Technology, University of Maryland, College Park) – a supplement to the IWR/NIWR award listed above.
- Multixenobiotic resistance (MXR) induction in amphipods (Hyalella azteca) by agricultural ditch sediment and water (Graduate Fellowship), Ryan Gott (Entomology, University of Maryland, College Park, Advisor: William Lamp)
- Forest N retention in the Chesapeake Bay watershed: A role in water quality restoration? (Graduate Fellowship), Robert Sabo (University of Maryland Center for Environmental Science – Appalachian Laboratory, Advisor: Keith Eshleman)

One 104B project funded in FY 2011 continued this year:

- Relating pollutant and water quality parameters to landuse in a subwatershed of the Choptank River watershed, Alba Torrents (Civil & Environmental Engineering, University of Maryland, College Park) and Cathleen Hapeman (USDA Agricultural Research Service, Beltsville, Md.)

Relating pollutant and water quality parameters to landuse in a subwatershed of the Choptank River watershed

Basic Information

Title:	Relating pollutant and water quality parameters to landuse in a subwatershed of the Choptank River watershed
Project Number:	2011MD238B
Start Date:	6/1/2011
End Date:	5/31/2013
Funding Source:	104B
Congressional District:	5th Congressional District
Research Category:	Water Quality
Focus Category:	Non Point Pollution, Surface Water, Water Quality
Descriptors:	
Principal Investigators:	Alba Torrents, Cathleen Hapeman

Publication

1. Nino de Guzman, Gabriela T., Cathleen J. Hapeman, Kusuma Prabhakara, Eton E. Codling, Daniel R. Shelton, Clifford P. Rice, W. Dean Hively, Gregory W. McCarty, Megan W. Lang, Alba Torrents, 2012, Potential pollutant sources in a Choptank River (USA) subwatershed and the influence of land use and watershed characteristics, Science of the Total Environment, 430, 270-279.

Progress Report for the period 3/01/12 through 2/28/13

Project: 2011MD238B

Project Title: Relating pollutant and water quality parameters to landuse in a subwatershed of the Choptank River watershed

Principal Investigator(s): Alba Torrents and Cathleen Hapeman

Problem and Research Objectives

The Choptank River, a tributary of the Chesapeake Bay, is surrounded by various agricultural practices and has been under scrutiny for impaired water quality. The majority contributor to the poor water quality of this river is speculated to be these agricultural facilities and farms, particularly the husbandry operations. According to the Environmental Protection Agency's Guidance for Federal Land Management in the Chesapeake Bay Watershed, agriculture is responsible for approximately 43% of nitrogen (N), 45% of phosphorus (P), and 60% of the sediment loads released into the Bay. Of this, approximately 17% of N and 19% of P load comes from chemical fertilizers, and 19% of N and 26% of P load comes from manure. About 60% of land use in the Choptank River watershed is devoted to agriculture, producing corn, soybean, wheat, and barley; much of this supports small- and medium-sized animal feeding operations, mostly poultry with some dairy and horse husbandry. Manure from poultry houses is routinely used as a fertilizer on agricultural fields. Though mitigation practices have been put in place to control runoff from the agricultural fields and husbandry lots, surface water pollution still occurs. Potential pollutants from these agricultural activities, especially poultry farming, include sediment, pesticides, nutrients, antibiotics, heavy metals, and non-indigenous microorganisms.

The main objective of this study was to survey a small section of a subwatershed in the Choptank River watershed and determine if a single poultry operation has a measurable effect on the surrounding environment. We are particularly interested in the impacts water quality. Water samples are tested for arsenic, nitrogen, phosphorus, *E. coli* and *Enterococcus* as bacterial indicators of contamination/natural reservoirs, antibiotics, and pesticides. Water quality parameters, such as pH, temperature, and conductivity are also measured at each site

Specific tasks performed during this reporting period are:

1. Address comments and revised a manuscript submitted for publication.

2. Evaluate the possible use of artificial sweeteners and MESA as nutrient and pollutant fate indicators in the Choptank River.

3. Develop analytical methods for the use markers and analysis of archival samples.

Graduate student Gabriela Nino de Guzman (Civil and Environmental Engineering, UMCP) completed manuscript revisions while being funded by another project. This work clearly illustrated the need to be able to identify and distinguish between urban and agricultural nutrient sources and assess fate processes. Furthermore, our data suggested that N and P have different sources and/or presumably have different delivery mechanisms. Compounds that behave similarly to the nutrients and are unique to one source can be used to distinguish between the various anthropogenic aquatic inputs to the river. A new MS student, Lucia Geis, conducted an in-depth literature review in the use of urban and agricultural chemical markers. We have identified MESA {2-[2-ethyl-*N*-(1-methoxypropan-2-yl)-6-methylanilino]-2-oxoethanesulfonic acid}, a metabolite of the extensively-used herbicide metolachlor, as an ideal agricultural tracer. Sucralose is an artificial sweetener that is recalcitrant in the waste treatment process, and is an excellent source indicator of urban waste. We are currently working on the optimization of liquid chromatography - mass spectrometry (LC-MS) analysis to include MESA and sucralose, looking to develop a high throughput analysis and possibly improving identification by including more transitions and using ion ratios as qualifiers. Sample extraction techniques are being tested for sucralose and will be further validated by determining sensitivity, dynamic ranges, accuracy, precision, limits of quantification and lowest calibration limits. Ultimately, the method will be used to analyze the archive samples and further discern sources and processes.

Publication:

Science of the Total Environment 430 (2012) 270–279

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journal homepage: www.elsevier.com/locate/scitotenv

Potential pollutant sources in a Choptank River (USA) subwatershed and the influence of land use and watershed characteristics

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Quantifying remobilization rates of legacy sediment from Maryland Piedmont floodplains

Basic Information

Title:	Quantifying remobilization rates of legacy sediment from Maryland Piedmont floodplains
Project Number:	2012MD262B
Start Date:	7/1/2012
End Date:	8/31/2013
Funding Source:	104B
Congressional District:	07
Research Category:	Climate and Hydrologic Processes
Focus Category:	Geomorphological Processes, Sediments, Non Point Pollution
Descriptors:	
Principal Investigators:	Andrew Miller

Publication

1. Donovan, M. and A.J. Miller. Quantifying remobilization rates of legacy sediments from Maryland Piedmont floodplains. Poster presentation, Amtrak Club (Mid-Atlantic Geomorphology Conference), Johns Hopkins University, May 17-18, 2013.

Progress Report:
2012MD262B
Quantifying remobilization rates of legacy sediment from Maryland Piedmont floodplains

1. **Narrative Summary**
   a. **Problem and Research Objectives**

Sediment has long been recognized as a critical pollutant affecting water quality and habitat in Chesapeake Bay. Recently the U.S. EPA issued a "pollution diet" for the Bay in the form of a Total Maximum Daily Load (TMDL) document that includes a mandate for a 20 percent reduction in the mass of sediment reaching Chesapeake Bay (U.S. EPA, 2010). The TMDL document assigns 17 percent of the total sediment load reaching the Bay to sources in Maryland, many of which are closer to the Bay than more remote parts of the watershed. A key element of the TMDL involves the use of Watershed Implementation Plans that will involve state and local jurisdictions in decisions about how to limit sources and delivery of pollutants, including sediment. Thus every jurisdiction will need access to sound scientific understanding of the sources, transport and delivery of sediment in order to make appropriate decisions. As Smith et al. (2011) and Walter and Merritts (2011) point out, successful strategies for managing sediment delivery to downstream sources require a better understanding of sediment budgets and processes acting on key parts of the landscape than has generally been the case.

Numerous studies document that land use causing accelerated upland soil erosion leads to storage of sediment in the watershed both as colluvium and through aggradation of river valleys (Gilbert, 1917; Happ et al., 1940; Trimble, 1975, 1981; Costa, 1975; Knox, 1972, 2006; Phillips, 1991; James, 1991; Herman, 2001). The Piedmont physiographic province has the lowest natural long-term denudation rates among the provinces of the Chesapeake Bay watershed, accounting for the deep weathering profiles that have been preserved in much of the landscape, but also has the highest contemporary sediment yields as a result of historical land-use disturbance (Gellis et al., 2009). Much of the sediment mobilized by historical disturbance is currently stored in the form of "legacy" sediments as floodplain deposits dating from the period of intensive agriculture between the late 18th and the early 20th centuries (e.g. Jacobson and Coleman, 1986). A large fraction of the historical sediment stored in floodplains is in the silt and clay size ranges, which are considered more important contributors to degradation of habitat and water quality in Chesapeake Bay. There are major questions related to remobilization and delivery of stored sediment to receiving waters (Wolman, 1967, Meade 1982, Jacobson and Coleman 1986) and its effects on habitat loss and environmental degradation in Chesapeake Bay (Langland and Cronin, 2003; Merritts et al., 2011). Managers are concerned about whether a major part of their focus in meeting TMDL requirements should be devoted to managing streambank erosion to limit the remobilization of legacy sediments (Robert Summers, Secretary, Maryland Department of Environment, personal communication, April 2010).

Although the issue of legacy sediment has been familiar to geomorphologists for many years, recent interest in the topic has been spurred by a study suggesting that almost all of the historical alluvium stored in valley bottoms of the mid-Atlantic Piedmont region was trapped behind mill dams that were pervasive throughout this landscape (Walter and Merritts, 2008). The dams' locations have been mapped and there are indeed a large number of them, as they formed the power grid of that time. Most of these dams were breached many years ago but their deposits remain mostly in place and they are considered a major potential source of sediment. It has been argued that previous geomorphic understanding of the nature of Piedmont streams was almost entirely an artifact of the influence of mill dams; that under current circumstances the upland sources are largely decoupled from processes associated with streambank erosion and increased suspended sediment loads in streams; that entrenchment and remobilization of mill dam deposits is a more important source of sediment than upstream sources including those associated with the impacts of urbanization on stormwater, soil erosion, and headwater channel enlargement; and that wetland restoration by removal of historic millpond sediment is a potentially effective strategy for ecosystem renewal (Walter and Merritts; Merritts et al., 2011). These suggestions are intriguing and have policy implications but the ideas need to be tested further by other investigators. For example, recent evidence from a study in the Difficult Run watershed in the Virginia Piedmont (Hupp et al., 2013) suggests that historic mill dams are associated with some legacy sediment deposits but do not exert a controlling influence on the basin-scale balance of stored legacy sediment or on floodplain dynamics.

This project seeks to quantify rates of remobilization of legacy sediment from Piedmont floodplains over a multiple-decade time period, and to assess the relative importance of deposits stored upstream of mill dams by comparison with other sites where the influence of mill dams is not present or is considered minimal. The work plan includes the following research objectives:

1. Identify and characterize historical legacy sediment deposits in Piedmont floodplains within Baltimore County, and develop a sampling scheme for quantifying remobilization rates of legacy sediment across a range of stream orders and drainage areas.
2. Identify floodplain sites with and without historic mill dams and develop a stratified sampling scheme for comparison of legacy sediment remobilization rates to assess the relative importance of mill-dam deposits as a source of legacy sediment.
3. Carry out field reconnaissance to verify bank heights and channel dimensions derived from LiDAR digital elevation data.
4. Collect and analyze field samples for bulk density and particle-size analysis to be used in quantifying the mass of sediment remobilized from selected study sites.
5. Compare LiDAR digital elevation data (collected for Baltimore County in 2005) with stream bank lines and center lines from 1950’s-60’s topographic maps (compiled at 1:2400 scale) to quantify changes in channel location, volumes of erosion and deposition, and net remobilization of legacy sediment from Baltimore County floodplains.
6. Calculate mass balance for legacy sediment remobilization across the range of study sites and use resulting data to estimate net contributions to regional sediment budgets.

Given the limited funds and duration of this project, which is being used to support work by a UMBC graduate student working on a M.S. thesis, the results that are generated will not account for changes in floodplain storage associated with overbank deposition and therefore represent only one component of the watershed sediment budget. These results will be interpreted within the context of the literature characterizing sediment budgets in watersheds throughout the region in order to assess the relative importance of legacy sediment and mill-dam sources.

b. Methods

i. Site selection

Multiple criteria were considered when selecting a set of sites (Figure 1) suited to represent the distribution of streams across Baltimore County. Historical archives of dam locations were imported into ArcMap in order to determine whether a stream reach was under the influence of a dam. The distribution of stream orders was then determined for the streams containing mill dams, along with the entirety of streams across Baltimore County. Additional criteria such as lithology, land use, and slope characteristics were compiled as secondary traits to assist in determining which sites would be best suited for comparisons. Subsequent to determining whether stream reaches displayed characteristic geomorphic features of dam absence or presence, field examinations and documentation were used to confirm the suitability of each site.

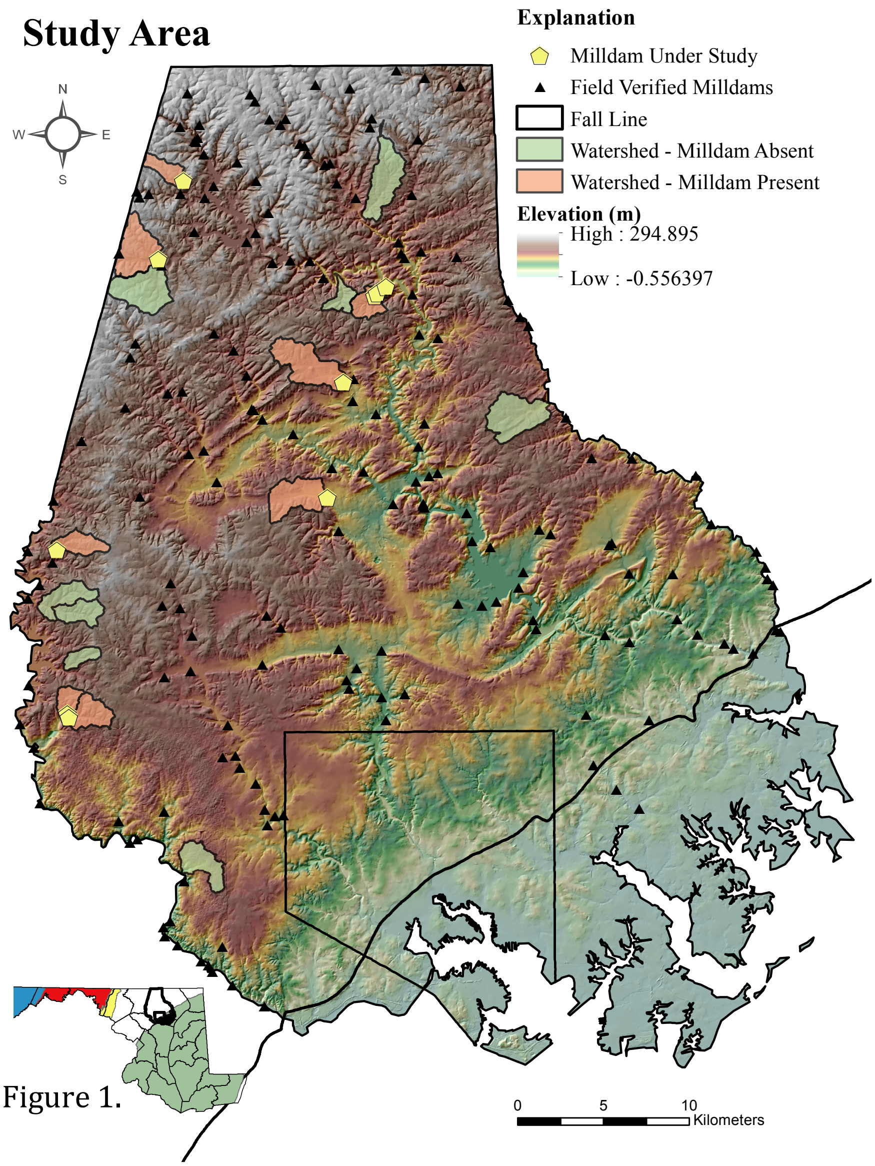

Figure 1.

ii. Field reconnaissance

Field reconnaissance has proven to be an ongoing process in order to determine (1) the absence/presence of a historic mill dam, (2) the location and depth of legacy material along streams, (3) the changes in bank height and stratigraphy along streams, especially near dam locations, (4) the diagnostic criteria for labeling stratigraphic layers as pre- or post-settlement (5) the suitable and representative locations for sampling material classified as pre- and post-settlement material. All potential sites were examined for these characteristics, and were discarded or selected as a site with or without a dam. Visual observations and sample data were recorded in a field notebook and backed up with photographs and GPS locations for the observations. Each site was also characterized by the stream length, which was established based on limitations in historic data accuracy, anthropogenic alterations to the landscape/channel, or lack of an established floodplain. Upon establishing all of these characteristics and evaluating each site, to date, 21 sites have been chosen, 11 of which contain dams, while 9 are believed to be outside the influence of historic dams. The details of these sites are available in Table 1.

iii. Field sample collection

Multiple streambank samples were taken from reaches along each stream where the material could be distinguished as pre-settlement or legacy sediment. Distinguishing samples provided a means to establish characteristic densities and grain size distributions of the different streambank layers along with sediments deposited in point bars. Of the 122 samples taken so far, all have been weighed for their density, while 20 have been sieved for grain size distributions. The

Mill dam	Stream Order	Area (km²)	Study Length (km)	No Mill dam	Stream Order	Area (km²)	Study Length (km)
Panther Branch	3	3.04	2.10	Mingo Branch	3	2.05	2.10
Keysers Run	3	3.10	1.25	Cooks Branch	3	3.12	2.6
Piney Run @ Trenton Mill Dam	4	5.22	2.11	Piney Run @ Mt. Zion Road	5	21.16	2.02
Little Piney Run @ Dark Hollow Rd.	4	3.21	2.15	Western Run @ Mantua Mill Road	6	84.38	2.5
Little Falls @ Keeny Mill	4	8.23	3.6	Norris Run	3	5.6	2.8
McGill Run @ Byerly	3	2.66	2.1	McGill Run @ Butler Road	3,4	16.2	2.9
Piney Run @ Mantua Mill Road	5	30.5	1.9	Jones Falls @ Park Heights Avenue	3,4	18.4	2.31
Fourth Mine Branch	4	6.34	1.26	Chimney Branch	3,2,1	1.77	Entire watershed
Buffalo Run @ Buffalo Run Road	3	7.53	3.46	Blackrock Run @ Ridge Road	2		
Western Run @ Thornton Mill Dam	6	158.88	4.1	*First Mine Branch @ Stablersville Road*	*4*	*11.8*	2.28
Powell's Run	3,2,1	1.82	Entire watershed				

Table 1. List of sites currently selected for evaluation.

number of samples per site ranged from 4 to 22, the lower end resulting from lack of clearly exposed streambanks. Each sample was taken by extracting a core of 200 cm^3 from the bank, as seen in figure 2b. For each sample the following was recorded: (1) the height of the sample, (2) the primary color (using a Munsell chart), along with any interlaced colors, (3) the texture based on touch, (4) any potential compaction of sample and (5) a preliminary label of Presettlement, Legacy Sediment, or Point Bar. Despite some locations with very easily distinguished boundaries

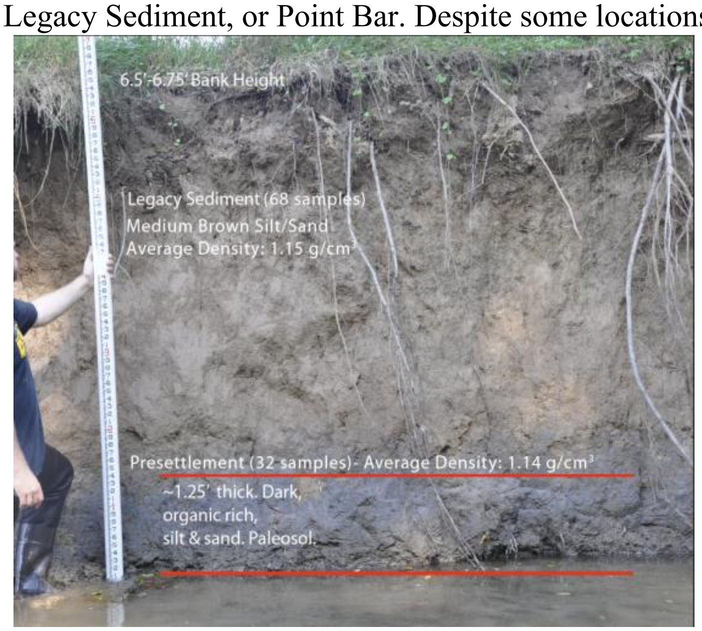

Figure 2a (above): Easily identified boundary between pre- and post-european material. Figure 2b (right): Ambiguous sequence of streambank strata. Note sampling tubes in bank.

(Figure 2a), a variety of profile compositions have been found across the field sites, such as that seen in Figure 2b. In cases such as these there is no simple way to classify the material. Methods are being developed to assign potential labels to the various layers.

Upon sampling sediments in the field, each was placed in a plastic bag, labeled, and transported back to either the USGS or UMBC labs, where it was dried at temperatures ranging from 85-115°C. Samples were weighed after drying for a minimum of 12 hours, at which point the density was determined by dividing the mass by the volume of the sample. Samples were then stored in sealed plastic containers until it was possible to sieve for particle size distributions. Wet sieving was performed in a sink with stacked sieves ranging from 16.0 to 0.063 mm diameter. Once material had finished filtering through each sieve, it was dried in the oven and weighed to determine the amount of material for each particle size. Sieved samples were at least 50.0 grams, with scrape samples and duplicates to validate the accuracy of the sample size and procedures.

iv. GIS analysis of channel changes through time

In order to characterize the location of the historic stream channels, scanned images of Baltimore County 1:2400-scale topographic maps were georeferenced in ArcMap and channel banklines were manually digitized from the channel edges depicted on the maps. In some cases, a single line was drawn on the historic maps, in which case the median channel width of the current channel was assigned as a buffer around the historic stream line. Current channels were delineated manually for each stream length using a combination of satellite imagery, hillshade, slope, and curvature grids. Local peaks and troughs in values of curvature, which is the derivative of slope, can be used to locate the edge of a channel or base of a streambank where other sources fail in doing so. To date, 18 of 21 historic topographic maps have been georeferenced, while 15 have had their channels vectorized and visually compared to the current channels. Manually delineating the current channels has been completed for seven sites, with cumulative lengths ranging from 2.1 to 3.5 km. For six of the seven sites, the entire mass of sediment remobilized has been calculated.

Calculating the mass of sediment remobilized consists of six main steps:

1. Overlay historic and current channels to generate the areas of erosion and deposition along each reach.
2. Establish the top of bank elevation (red dashed lines in Figure 3) and the adjacent channel bed elevation (blue dashed lines in Figure 4), in order to allocate these values to surrounding cells.

3a. Within the areas of erosion, subtract the allocated bank height values and actual elevation for each DEM pixel. Because each cell is 1 m^2, the difference in height is also the volume eroded (illustrated in Figure 3).

3b. Within the areas of deposition, subtract the actual elevation values and channel bed elevation for each DEM pixel. Because each cell is 1 m^2, the difference in height is also the volume deposited (illustrated in Figure 3)

4. Multiply these values by the bulk density of material they represent to determine the mass of erosion/deposition.
5. Multiply the mass values by percent fine-grained (silt+clay) sediment derived from laboratory samples for comparable materials.
6. Sum the amount of erosion and deposition along the reach, determine the difference to

obtain the net change for an entire site, and calculate net mass of fine-grained sediment derived for each site.

Within Figure 3, the cross section on the right is a vertical slice along transect A-A' in the cartoon at the left. The vertical dashed brown lines indicate the channel boundary derived from the historic topographic map, and the vertical green lines are the locations of the channel edges as delineated from the 2005 LiDAR data. The red dashed line extending across the top represents the 'bank height' elevation of the legacy surface, and the blue dashed line along the bottom represents the minimum stream channel elevation. These elevations are used to estimate volumes of erosion and deposition for the cross sections. The area between the vertical dashed lines was part of the channel when the topographic map was made and therefore the inset stippled area represents net deposition as the channel migrated to the left. The area between the old left bank and the new left bank (15 m to 4 m on the x-axis) was eroded but was then partly filled in by continued point-bar accretion, hence there are areas of erosion and deposition between within this part of the cross-section. In this example, the higher "legacy" surface is gradually being replaced by the lower inset surface as the channel migrates and our mass-balance calculations will account for both gross and net change. The visualization shown here is a simplified form of a more complex pattern that occurs at many of our study sites.

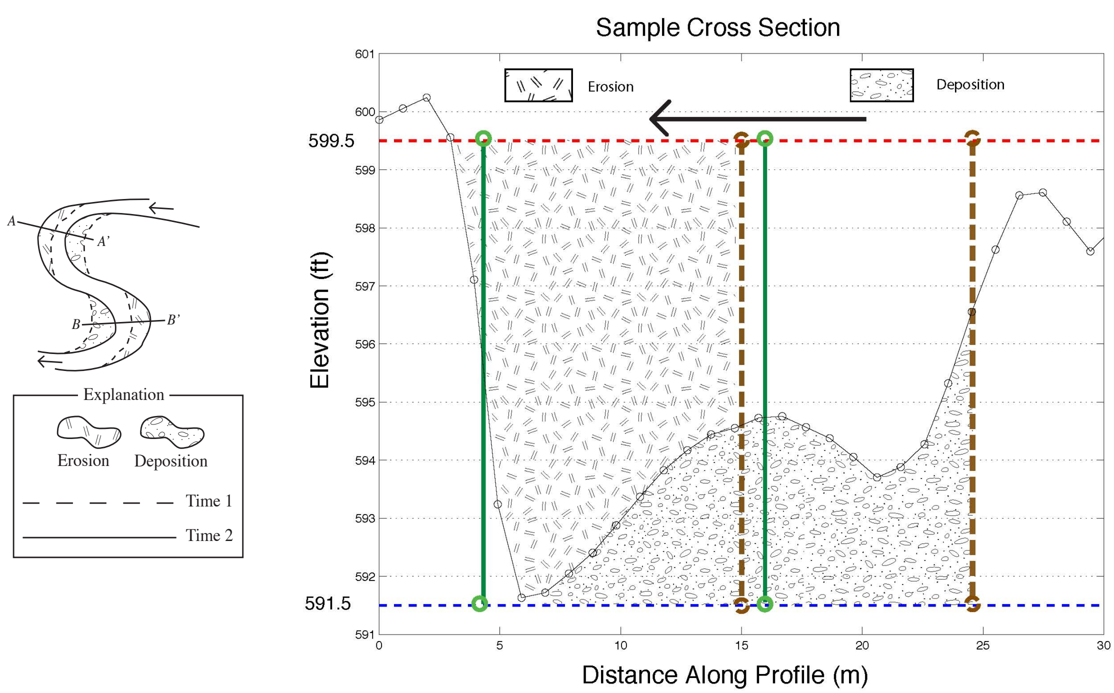

Figure 3. Aerial and plan form conceptual views of lateral migration demonstrating erosional, depositional, and areas of no change for a given stream cross-section. The cross section on the right represents A-A'.

In order to understand the error involved in quantifying the mass of sediment remobilized, we have bracketed the range of variation associated with the measurements and methods used. Bracketing and error quantification was completed for sediment density ranges, grain size distributions, horizontal accuracy of historic channel boundaries, channel width estimations, and the vertical accuracy of LiDAR DEMs. The total range of possible values will be established based on these sources of error. The final estimates of error will be reported based on the standard deviation or 25th and 75th percentiles of these ranges. The current results do not reflect the error or uncertainties, as the majority of work has focused on establishing suitable methods and determining the primary causes of error.

c. Principal findings

As field work, laboratory analysis and GIS analysis are all still in progress, we have only preliminary results to report here. Ongoing work over the remainder of summer 2013 will allow us to complete remaining field and laboratory work. Remaining data analysis and discussion will be completed as part of Mitchell Donovan's M.S. thesis work during the Fall 2013 semester.

Average Lateral Migration						
Buffalo Run	Keysers Run	Mingo Branch	Panther Branch	Piney Run @ Trenton	Western Run @ MM	Rate
4.90	5.05	4.95	4.15	6.76	8.02	Meters / 44 Years
0.11	0.11	0.11	0.09	0.15	0.18	m/yr

Site	Stream Order (1-7)	Area (km²)	Stream Length (km)	Net Erosion (Mg/year)	Net Erosion (Mg/km/year	Gross Erosion (Mg/km/year)	Gross L.S. Erosion (Mg/km/year)
Western Run @ Mantua Mill Road	6	84.38	2.6	817.89	314.57	1,021.19	714.83
Mingo Branch	3	2.05	2.1	260.10	123.86	305.53	183.32
Piney Run @ Trenton Mill Dam	4	5.22	2.11	916.60	434.41	743.61	483.35
Keysers Run	3	3.1	3.4	247.70	72.85	373.74	250.41
Panther Branch	3	3.04	2.1	517.46	246.41	376.26	252.10
Buffalo Run	3	7.53	3.46	409.01	118.21	301.85	105.65

Table 2. Summary of preliminary lateral migration rates and mass of sediment eroded from 6 study sites.

The majority of bulk density values obtained thus far for Pre-European sediments and soils range from 0.95 to 1.23 g/cm^3, with an average of 1.18 g/cm^3. Legacy sediments had a similar average bulk density of 1.12 g/cm^3, with 50% of values falling between 1.05 g/cm^3 and 1.20 g/cm^3. The bulk density of lateral accretion deposits varied between 1.20 g/cm^3 and 1.45 g/cm^3, with an average of 1.30 g/cm^3.

As illustrated above in Table 2, preliminary results for mass erosion rate have been obtained for 6 sites. The rates are similar to those found in Hupp et al. (2013). Additionally, lateral migration-rate estimates fall within the range found by Evans et al. (2003) and Rhoades et al. (2009), suggesting that data sources and methods developed for this study are both reasonable. Assessment of remobilization rates is in progress for the majority of sites, however, given the time required to assess each stream reach, quantification of remobilized sediments has yet to be calculated for the remaining sites. Figure 4 illustrates the position of channel banklines from the historic Baltimore County topographic maps superimposed on 2005 channel topography for a section of the Western Run valley.

Radiocarbon dates are being used to test our working assumptions about the distinction between legacy sediment and presettlement material visible in floodplain exposures. Through support provided by Milan Pavich of the U.S. Geological Survey, a radiocarbon date has been determined for a wood sample taken from beneath the horizon identified as a paleosol at the Keysers Run study site. Based on the ^{14}C age, determined at the Center for Accelerator Mass

Spectrometry (CAMS), Lawrence Livermore National Laboratory, Livermore, California, the sample dated to 934 years B.P ± 30 years. Additional samples have been submitted for other sites and are waiting to be processed. Walter and Merritts (2008) obtained ^{14}C dates for 2 pieces of wood from the presettlement layer beneath the Western Run floodplain, dating them at 240 and 250 (± 40) years B.P. Additional dates of 319 and 400 B.P. were cited for Whitemarsh Run on the east side of Baltimore County.

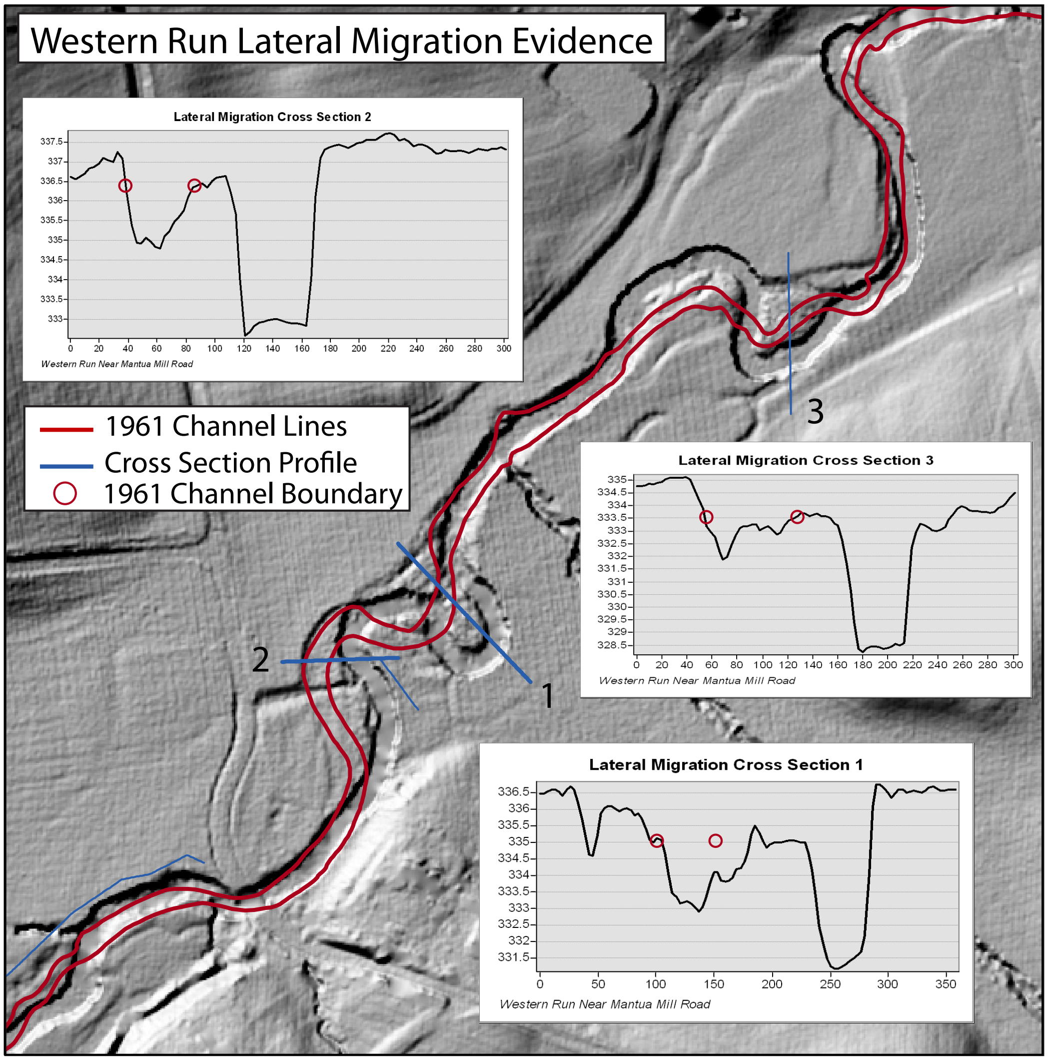

Figure 4. Comparison of 1961 and 2005 channel locations along Western Run near Mantua Mill Road.

d. Significance

It is premature at this stage of the research to attribute significance to the findings collected thus far, other than to note (as mentioned above) that the preliminary lateral migration rates and mass estimates per km of stream bank are consistent with results presented by other authors working in the mid-Atlantic region. The broader significance of this work is that it will contribute to our knowledge base about the relative importance of remobilized legacy sediment as a component of Piedmont watershed sediment budgets, and that it will allow us to characterize the relative importance of mill-dam deposits as a sediment source compared with other sites lacking mill dams. Field reconnaissance within some of our study watersheds extends to the most upstream locations where floodplain formation is observed, and we therefore plan to extrapolate our results across stream orders to characterize the mass of legacy sediment remobilized from floodplains throughout the drainage network.

The results of this research are expected to contribute to ongoing discussions about management policies designed to mitigate or limit sediment contributions from tributary watersheds in the Chesapeake Bay drainage. Stream restoration practices, funded by tax dollars, are frequently justified based on the assumption that they will contribute to the mitigation of watershed sediment and nutrient loads. Excavation of legacy sediment stored behind historic mill dams in Piedmont floodplains is now under consideration as a policy option in Pennsylvania, as was discussed at the 2012 Legacy Sediment workshop at Franklin & Marshall. Yet the relative importance of mill-dam sediment as a contributor to problems in Chesapeake Bay has not yet been firmly established across the region, and there is a need for more information. The design of this project, incorporating data from multiple watersheds at different scales and with a 40-50 year time base for characterizing erosion rates, will contribute information that should help inform the discussion about policy alternatives to be pursued in Maryland.

2. Publication citations associated with the research project

There have been no publications associated with the work up to this point. A poster was presented at a recent conference of geomorphologists from throughout the mid-Atlantic region. In addition Mitchell Donovan recently attended the *EarthCube Geochemistry, Biogeochemistry, and Fluvial Sedimentology Workshop* in Boulder, CO where this project was discussed informally with an international group of earth scientists. A publication will be submitted to a refereed journal shortly after completion of the Master's Thesis. Possible journals include Geomorphology, Earth Surface Processes and Landforms, Journal of the American Water Resources Association, or Water Resources Research.

Citation: Donovan, M. and A.J. Miller. Quantifying remobilization rates of legacy sediments from Maryland Piedmont floodplains. Poster presentation, Amtrak Club, Johns Hopkins University, May 17-18, 2013.

3. Number of students supported (with MWRRC funds and required matching funds)

MWRRC funds have provided support for one M.S. student and two undergraduate research assistants. Mitchell Donovan is currently enrolled as a M.S. student at UMBC under the supervision of Andrew Miller and he is carrying out the bulk of the research. The first undergraduate research assistant, Andrew Bofto, is pursuing a career in environmental engineering. He has aided in all aspects of the project, including fieldwork, laboratory measurements, and ArcMap analyses. We are in the process of hiring a second part-time undergraduate assistant to aid with the processing of sediment samples and GIS work during June and July 2013.

3. Notable achievements and awards resulting from the work.

Mitchell Donovan was awarded NSF support to attend the EarthCube workshop in Boulder, CO in April 2013. He also received support from UMBC to attend a Legacy Sediment workshop at

Franklin and Marshall College in Spring 2012. Due to the current phase of research no other awards or notable achievements have resulted from the work to date. However, in the course of attending the EarthCube workshop, the Amtrak Club conference, the Southeastern Friends of the Pleistocene field conference, and a locally hosted trip visiting field sites associated with this project, colleagues from other research institutions have expressed interest in the results anticipated from this research. Researchers Dorothy Merritts, from Franklin & Marshall College, along with Milan Pavich of the U.S. Geological Survey in Reston have traveled to Baltimore County to visit the field sites with us and to exchange ideas and suggestions. Milan has arranged for radiocarbon dating of samples taken from multiple field sites to aid the interpretation of geomorphic features in the field. Allen Gellis of the U.S. Geological Survey MD-DE-DC Water Science Center is a member of Mitchell's thesis committee and has also participated in multiple field trips and provided useful guidance on a range of technical topics. Verbal and written communication with other researchers provides ongoing feedback and suggestions to improve the work.

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An Innovative Learning Tool in Communicating Flood Risk Management

Basic Information

Title:	An Innovative Learning Tool in Communicating Flood Risk Management
Project Number:	2012MD270B
Start Date:	1/12/2012
End Date:	8/31/2013
Funding Source:	104B
Congressional District:	MD-005
Research Category:	Social Sciences
Focus Category:	Education, Management and Planning, Floods
Descriptors:	
Principal Investigators:	Bahram Momen

Publications

There are no publications.

Progress Report:
An Innovative Learning Tool in Communicating Flood Risk Management
2012MD270B

Dr. Bahram Momen and V.B. Olsen

I. Summary

This grant supplements 2012MD299S "The Effectiveness of a Computer-Assisted Decision Support System Using Realistic Interactive Visualization as a Learning Tool in Flood Risk Management," (USGS Award No. G12AP20058). The two linked projects are advancing the field of flood risk management by using technology to bridge the gap between science and decision-making. We are testing the effectiveness of a computer-assisted decision support system (DSS) that uses realistic interactive visualization in combination with collaborative learning to (1) increase stakeholders' knowledge of flood risk, (2) increase stakeholders' knowledge of risk-reduction options, and (3) initiate action to reduce risk.

This grant supports the training of a team of undergraduate and graduate students in GIS, HAZUS Flood Risk Analysis, and meeting facilitation; and provides funds for the student team members to travel to data-collection communities to conduct pre-workshop interviews and data-collection workshops. Specifics are listed under Student Support, below.

Findings and Significance
Reported in details in the Progress Report for 2012MD299S.

II. Outreach and Publications

Publications are listed in 2012MD299S Progress Report

III. Student Support

Grant covered travel per diem to GIS training in HAZUS for Floods at the FEMA Emergency Management Institute, Emmetsburg, Md., for Ph.D. candidate, V. B. Olsen.

Grant covered travel, lodging and per diem to present project introductions to potential data-collection communities and conduct exploratory interviews with key leaders in the communities for:

Undergraduates:
1. Alison Karp
2. Maureen Kelly

Masters:
1. Michael Riedman
2. Xiaoyu Bi Murtha

PhD:
1. V. Beth Kuser Olsen

Grant covered travel and meals for pre-data-collection workshop preparation and data-collection workshops for three communities for:

Undergraduates:
1. Alison Karp
2. Maureen Kelly

Masters:
1. Michael Riedman
2. Xiaoyu Bi Murtha

PhD:
1. V. Beth Kuser Olsen
2. Quentin A. Stubbs

Students listed above who are not listed on the USGS Award no. G12AP20058 progress report:
Undergraduate: Maureen Kelly
Masters: Xiaoyu Bi Murtha
PhD: Quentin A. Stubbs

IV. Notable Achievements

The students supported by this grant completed extensive GIS training and Meeting Facilitator training.

Ecohydrology of ditch-drained coastal marshes

Basic Information

Title:	Ecohydrology of ditch-drained coastal marshes
Project Number:	2012MD282B
Start Date:	9/1/2012
End Date:	8/30/2013
Funding Source:	104B
Congressional District:	5
Research Category:	Climate and Hydrologic Processes
Focus Category:	Hydrology, Wetlands, Ecology
Descriptors:	marsh ditching, restoration, field observations
Principal Investigators:	Brian Needelman, Andrew Baldwin, Paul Leisnham

Publication

1. Lundberg, Dorothea J.; Needelman, Brian A.; 2012. Ecohydrological linkages of Eastern Shore Maryland coastal marshes: A two part assessment on the conditions of parallel ditched marshes (Poster presentation). Geological Society of America, Nov 4-7, Charlotte, NC.

Title: Ecohydrology of ditch-drained coastal marshes (2012MD282B).

Type: Completion report

1. Narrative summary

Problem and Research Objectives: Marshes are among the most productive and valuable habitats in the Chesapeake Bay and Atlantic Coast. In 1912 extensive ditching of coastal marshes began within New Jersey to control mosquitoes. Marsh ditching was originally restricted to low metropolitan areas until 1933 when it was expanded with relief labor as an organized result of the economical depression. Then in 1938, similar mosquito control activities similar to New Jersey begun in other coastal States, bringing the total area of marshlands ditched along the Atlantic Coast to approximately 560,000 acres, which represents 90% of original Atlantic Coast marshes lying from Maine to Maryland (Bourn and Cottam 1950).

The effects of ditching on the hydrological regime and ecosystem services of coastal marshes have not been widely determined; nor have the effects of the hydrologic restoration of these systems. This study was performed as the first year of a longer-term hydrologic study of these systems. The long-term goal is to assess ecohydrological processes operating in ditched drained marshes as well as the effects of restoration on Atlantic Coast and Chesapeake Bay marsh ecosystems. The main objectives of the long-term study are to identify and compare pre-restoration, post-restoration, and natural unaltered unditched site characteristics; determine restoration hydroecological effects; and identify site variables that could be used to predict the success of future restoration projects.

Three paired marsh systems of ditched and unditched marshes were used in this study and one overall reference site. The paired sites were selected to be in the same general marsh area where topography, vegetation, and tidal patterns were similar yet spatially separate. Data collection included hydrological and ecological properties such as ditch intensity, water table fluctuations and interaction with surfacewater, salinity profiles, and vegetation composition.

It was hypothesized that the hydrological pathways of shallow overbank flooding and infiltration will be dominant at the unditched sites whereas shallow lateral subsurface and conduit flow within ditches will be dominant in the ditched sites. It was also hypothesized that the distribution of plant communities and soil characteristics would be correlated with geomorphologic and hydrologic conditions. Four comparison scenarios are being used to identify the presence or absence of trends with hydrological and ecological parameters within pairs of (1) unditched versus ditched, (2) ditched versus restored, (3) unditched versus restored two types of unditched (reference site Monie and paired unditched sites), and (4) reference (Monie Bay reference site) versus unditched (paired).

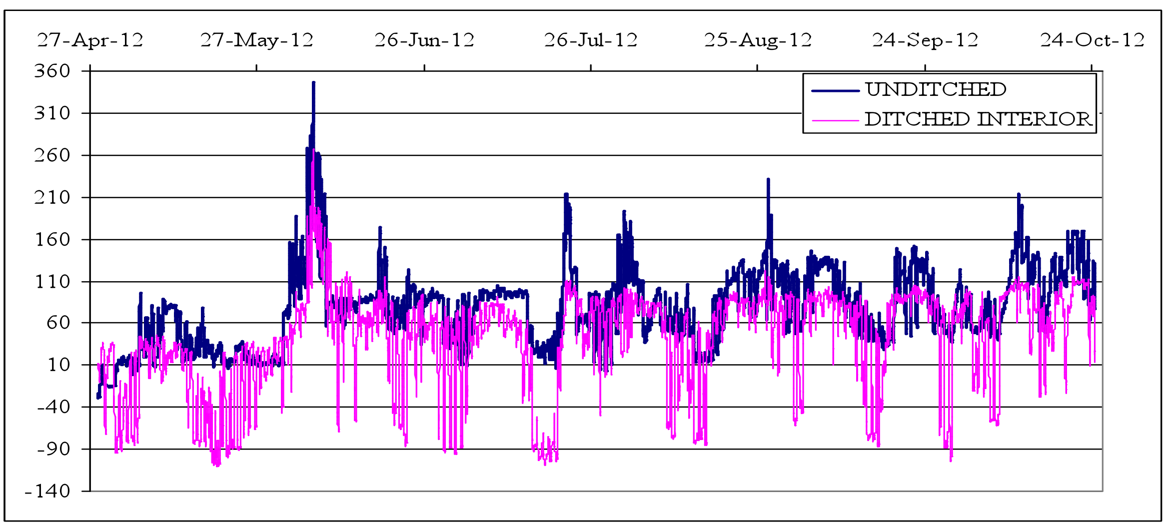
Methods: Water table fluctuations are currently being monitored by wells equipped with data loggers recording every 15 minutes and located within 3 main transects; 50 meters from source, 120 meters, and than approximately 350 meters. Transects run laterally from a dominant ditch, with the first well located in the dominant ditch and additional wells on each side at the midpoint between ditches and in the adjacent ditches. Vertical and horizontal flow paths will be determined through well data logger values. Piezometer purchase and installations occurred during the summer of 2012. Piezometers are currently being used to determined vertical stratification of the water table. To measure vertical stratification, piezometer slotted portions were placed in the ground at depths of 5-20 cm, 20-50 cm, and 50-80 cm.

Water quality parameters sampled in main tidal channel, ditches, and ponded surface water will begin in 2013 and will consist of dissolved oxygen, salinity, temperature, pH, suspended sediment, ammonium, nitrate, and phosphate. All measurements will be sampled at each well location. Additionally we installed salinity loggers to determine the salinity profiles laterally and vertically at various depths using piezometers. Hand sampling will occur once per month for a year. A soil water sample will be extracted using a syringe attached to a stainless steel sampling tube. The water collected is placed in an antioxidant buffer of equal volume. 5 mL of each (buffer and sample) will be used. The sample container will be capped, recorded, and returned to the laboratory for analysis within 24 hrs.

Allocation of funds: The MWRRC funds allowed us to conduct hydrologic, vegetation, and mosquito data collection during 2012 and to add salinity probes. Water quality parameters were postponed until summer 2013 when hydrological networks have been clearly identified so beneficial placement of water sampling can be completed.

Principal findings: Results in this report are preliminary, as we are continuing to collect and analyze data.

These preliminary graphs show two wells in a paired system; one unditched well compared to one well in the associated ditched marsh but located in the interior section of the marsh between two ditches. Graph 1 shows the time series for approximately 7 months with no major storms (hurricanes). Note that the y-axis is not scaled because we have not finalized our data calibrations at this time.



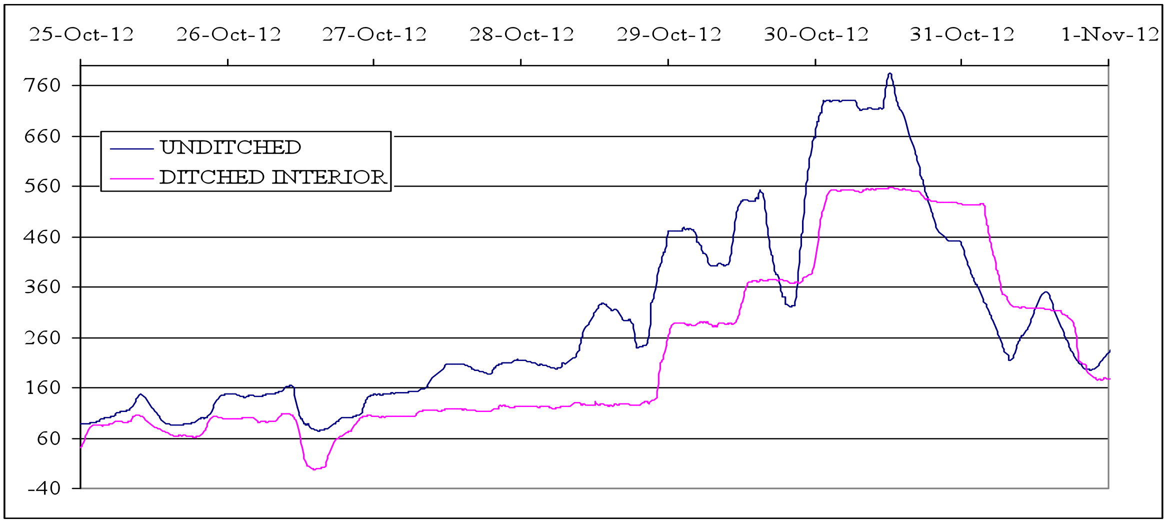
Graph 1

Graph 1: When comparing unditched marshes to ditched interior marshes, unditched marshes show:

- A larger magnitude of tidal influence above the marsh surface

- Water table elevations having a greater percentage of time at and above the marsh surface
- Larger responses to storm events
- Less magnitude and frequency in dropping of water table elevations

Graph 2 shows the time series for approximately 8 days before and after Hurricane Sandy.



Graph 2

Graph 2: Comparing unditched marshes to ditched interior marshes, unditched marshes show:

- A larger magnitude of surface water
- A gradual buildup of surface water over time
- A quicker, more dramatic return to baseflow levels

Significance: This project is the initiation of a strong hydrological and ecological component of a larger study of the socio-ecological system of the Deal Island Peninsula Marshes and Communities. This study is a collaboration between academic, federal, state, county, non-governmental, and community institutions and individuals. Continued hydrological and ecological data collection will allow us to provide key scientific information to the stakeholders involved in this project as they attempt to increase the resilience and prosperity of this system to stresses such as sea-level rise through collaborative investigations of marsh management and restoration options, heritage, and flooding. This project will also involve the development of outreach and K-12 educational materials.

References:

Bourne, W.S., and C. Cottam. 1950. Some biological effects of ditching tidewater marshes. Research Report 19. U.S. Fish and Wildlife Service. 30 pp.

2. Associated citations

Lundberg, Dorothea J.; Needelman, Brian A.; 2012. Ecohydrological linkages of Eastern Shore Maryland coastal marshes: A two part assessment on the conditions of parallel ditched marshes. Geological Society of America, Nov 4-7, Charlotte, NC.

3. Number of students involved in project

Undergraduate: 3
Ph.D: 1

4. Notable achievements and awards

The preliminary data and equipment acquired through this grant helped to secure grant # NA09NOS4190153 from the National Estuarine Research Reserve System Science Collaborative, operating by a cooperative agreement between the University of New Hampshire and the National Oceanic and Atmospheric Administration. This grant has allowed for continued hydrological and ecological data collection.

Multixenobiotic resistance (MXR) induction in amphipods (Hyalella azteca) by agricultural ditch sediment and water (Graduate Fellowship)

Basic Information

Title:	Multixenobiotic resistance (MXR) induction in amphipods (Hyalella azteca) by agricultural ditch sediment and water (Graduate Fellowship)
Project Number:	2012MD285B
Start Date:	3/1/2012
End Date:	2/28/2013
Funding Source:	104B
Congressional District:	MD 5
Research Category:	Water Quality
Focus Category:	Toxic Substances, Agriculture,
Descriptors:	
Principal Investigators:	Kaye Lorraine Brubaker, William Lamp

Publications

There are no publications.

Effects of agricultural ditch and forest stream sediment and water on multixenobiotic resistance (MXR) in freshwater amphipod (*Hyalella azteca*)

Ryan C. Gott
Department of Entomology, University of Maryland, College Park, MD 20742
Questions or requests for the full report can be sent to: rcgott@umd.edu

Progress report for the Maryland Water Resources Research Center

Multixenobiotic resistance (MXR) is a transport protein-mediated efflux process through which a wide variety of organisms excrete a broad spectrum of both endogenous toxins and exogenous contaminants. Certain chemical species can act as inhibitors of this process, increasing sensitivity of organisms to other toxins. The effect of field-obtained water and sediment on MXR can reflect the presence or absence of these sensitizing chemicals. Amphipods (*Hyalella azteca*) were exposed to treatments containing sediment and water collected from either an agricultural ditch or a forest stream in both a bioassay and an assay using an MXR dye substrate to assess levels of MXR (Table 1). Average change in mass per amphipod and percent survival within each replicate of each treatment were measured in both assays. Water samples were taken daily and measured for fluorescence of the dye from each treatment in the MXR assay.

	Stream sediment	Ditch sediment
Stream water	SS	DS
Ditch water	SD	DD

Table 1: Treatments resulting from factorial combination of factors. Factors were sediment and water. Both factors had two levels referring to their origin, ditch and stream.

Amphipods exposed to stream water and stream sediment in combination had significantly lower survival (Table 2) and average change in mass per amphipod ($P<0.05$) (Figure 1) as shown by ANOVA and Dunnett's multiple mean comparison test using the lab control as the control treatment. No significant differences in average change in mass or survival were found in the MXR assay. MXR activity measured as fluorescence of a dye transport substrate in water samples was consistently highest in treatments containing sediment from the agricultural ditch and lowest in treatments containing sediment from the stream (Figure 2).

Treatment	Average percent survival	High	Low
LC	96.67	100	90
SS	46.67*	60	30
SD	86.67	90	80
DS	90.00	100	80
DD	83.33	100	70

Table 2: Average percent survival of amphipods in the bioassay. The highest and lowest percent survivals from the three replicates of each treatment are also given. Survival in the SS treatment was significantly lower than in the LC control, denoted by * (Dunnett's test, $\alpha=0.05$, $P<0.05$). All treatment name abbreviations refer to the factorial treatment combinations from Table 1.

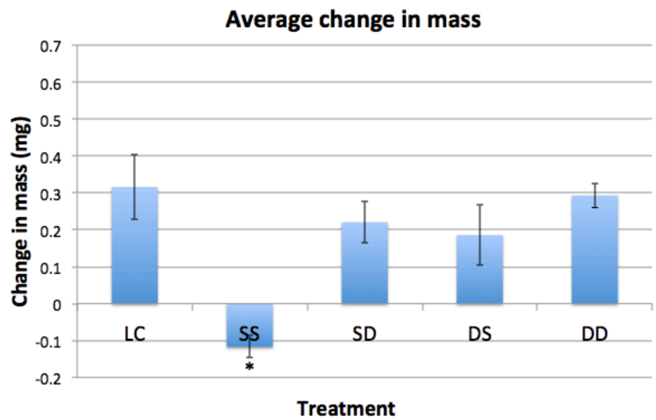


Figure 1: Average change in mass per amphipod in the bioassay. All treatments except SS saw an increase in mass, though none were significantly different from the LC control (Dunnett's test, $\alpha=0.05$, $P>0.05$). The SS treatment had a significant decrease in mass compared to LC, denoted by * (Dunnett's test, $\alpha=0.05$, $P<0.05$). All treatment name abbreviations refer to the factorial treatment combinations from Table 1.

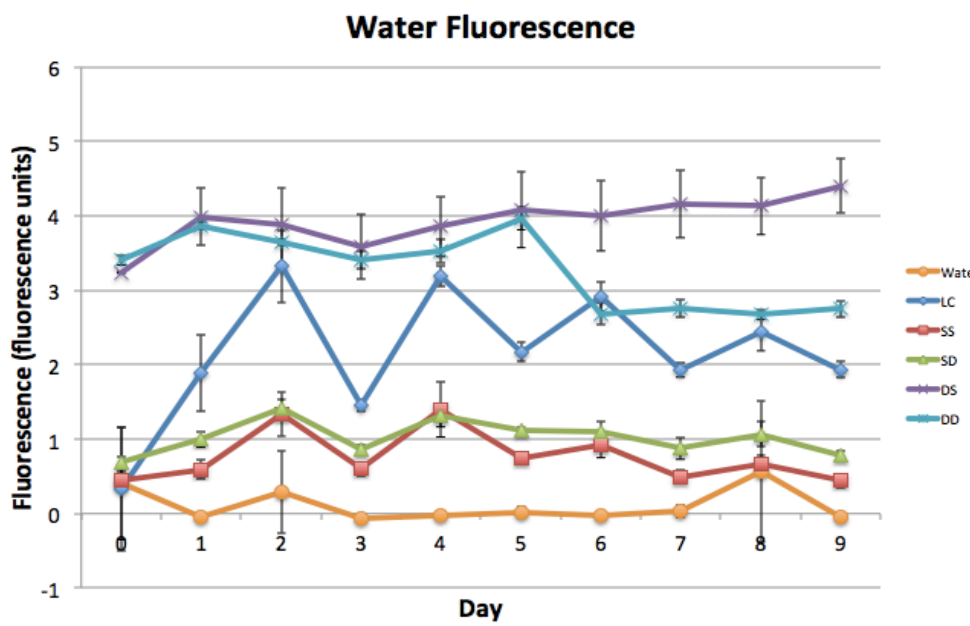


Figure 2: Water fluorescence levels of all treatments over ten days. There was a significant interaction between treatment and time (repeated measures analysis, $\alpha=0.05$, $P<0.05$). Treatments containing ditch sediment started with and maintained higher fluorescence levels on each day of the experiment. Treatments containing stream sediment maintained lower fluorescence levels compared to other treatments on each day. Dechlorinated water, the negative control, maintained the lowest fluorescence each day. Rhodamine B at 0.052 M concentration (not shown) served as a positive control and had a fluorescence level around 10,000 fluorescence units. All treatment name abbreviations refer to the factorial treatment combinations from Table 1.

The bioassay revealed a significant loss of mass in amphipods exposed to the SS treatment, which was theoretically a microcosm of the forest stream. The SS treatment also had significantly lower survival. These results suggest that the amphipods may not tolerate the stream as well as expected. The stream water may have very different water chemistry or contain either a toxic contaminant that the amphipods are sensitive to or a chemosensitizer that blocks P-gp activity, creating a build up of other chemicals to beyond their threshold concentration. All of these possibilities would result in lowered fitness of the amphipods, including lower mass gain or even mass loss and lower survival. The treatments containing agricultural ditch sediment, which were expected to behave as the SS treatment did, showed no decreased fitness parameters. This would suggest that the agricultural ditch is actually either free of toxins, has them at only very low levels, or contains nutrient contamination that enhances growth.

In the MXR assay, there was a significant overall treatment effect on change in mass, so we can see from Figure 2 that treatments containing a component (water or sediment) from an agricultural ditch did seem to have a greater positive mass change, though the changes were not significantly different when compared to the lab control. This may be due to high concentrations of nutrients from fertilizers associated with agricultural field runoff. Also the change in mass and the survival of amphipods in the SS treatment were not significantly different from the lab control, a result opposite to the bioassay. Of course these differences may be due to chance or error. However, they may also represent a change in MXR activity. The only difference between the SS treatments of the bioassay and the MXR assay was the presence of rhodamine B dye in the amphipods. Rhodamine B is a known substrate for the P-glycoprotein (P-gp) pump responsible for the MXR mechanism. What is not known, however, is if rhodamine B has a further upstream effect on the *mdr* gene that encodes P-gp. Rhodamine B, if it is a gene inducer, could have induced transcription of more P-gp, creating more protein available to export whatever contaminant was present in the SS treatment that lowered the fitness of amphipods in the bioassay. There is also evidence from the water fluorescence readings that argues against this hypothesis. The treatments containing stream sediment (SS and SD) consistently had the lowest fluorescence readings each day of the experiment except on Day 0. If the P-gp gene had been induced, we would expect there to be more rhodamine B in the water and thus higher fluorescence in the SS and SD treatments. Instead the highest fluorescence levels were in treatments with ditch sediment (DS and DD), with fluorescence on some days being significantly higher than in the lab control. This may indicate that something in the ditch sediment fluoresces at wavelengths similar to rhodamine B.

As a whole these two experiments suggest that monitoring for chemicals that are chemosensitizers of P-gp is not as simple as a traditional bioassay. The transport activity of P-gp has to be monitored with a known P-gp substrate, but the introduction of this new chemical may itself affect the level of MXR, changing the true signal. An alternative is monitoring the transcription levels of the P-gp *mdr* gene. Instantaneous rates of gene transcription and P-gp levels can be obtained without introduction of further chemicals to the test organisms. Sequencing of the *mdr* gene in amphipods and development of PCR primers is the next logical step. PCR can then be used along with existing quantitative structure-activity relationships (QSARs) to construct broad classes of contaminants that function as either gene inducers or repressors. Then P-gp mRNA levels in field-obtained specimens can be compared against lab raised cultures and interpreted in terms of levels of these contaminants. The relationship, if any, between a contaminant being a P-gp inhibitor/chemosensitizer and/or an *mdr* gene inducer or repressor will also be examined. This new MXR assay can be optimized in the lab before applying it to a broader field-based experiment.

Forest N retention in the Chesapeake Bay watershed: A role in water quality restoration? (Graduate Fellowship)

Basic Information

Title:	Forest N retention in the Chesapeake Bay watershed: A role in water quality restoration? (Graduate Fellowship)
Project Number:	2012MD286B
Start Date:	3/1/2012
End Date:	2/28/2013
Funding Source:	104B
Congressional District:	MD 6
Research Category:	Water Quality
Focus Category:	Non Point Pollution, Hydrology, Geochemical Processes
Descriptors:	
Principal Investigators:	Kaye Lorraine Brubaker, Keith N. Eshleman

Publications

There are no publications.

Forest N retention in the Chesapeake Bay watershed: A role in water quality restoration?
Summary of Summer 2012

The majority of the summer was dedicated to the TNEF watershed (tributary to Nef Run) along the crest of Dan's Mountain near Frostburg, MD. This 3.1 ha watershed is made up of a 30 yr. old mix deciduous forest which supports an ephemeral stream that tends to run dry in the summer and freeze over in the winter. Surprisingly this watershed was declared N-saturated a decade ago after an intensive four year N-budget study. The forest displayed high leaching of IN, especially in the form of NO3-N, and elevated nitrification rates relative to mineralization. IN export from this watershed in 2004 was an astounding 18.4 kg/ha with a flow weighted concentration of 2.79 mg L^{-1} ((Castro et al. 2007)). This site was identified as a prime candidate to revisit since IN inputs from wet deposition has relatively declined over the past decade regionally (Eshleman en prep).

Year	Flow-weighted NO_3-N concentration (mg/L)	Stream water NO_3-N export (kg-N/ ha yr)	Wet Deposition IN (kg-N/ ha yr)	Total Precipitation (mm)	Stream water runoff (mm)	Water Yield %
2000	2.12	4.44	4.78	933	209	0.22
2001	2.20	4.16	9	1072	189	0.18
2002	3.09	5.32	6.29	944	172	0.18
2003	2.46	15.02	7.54	1399	610	0.44
2004	2.79	18.35	5.51	1341	657	0.49
2012	**0.91**	6.81	4.7*	1021	745	0.73

Table 1: Displays the flow-weighted NO_3-N concentration, NO_3-N export, NO_3-N inputs from wet deposition, and water budget for TNEF from 2000-2004 and 2012 water years.
*Nutrient data for 2012 only available up to June 20th, the rest of the water year's samples still need to be processed.

The 2012 water year for TNEF possibly indicates that this N-saturated forest has responded dramatically to the declining inputs of NO_3-N. This response indicates that further adjustments of our understanding of N-dynamics within temperate forest needs to be further refined. It should be noted however, that TNEF never truly froze over this past winter and our autumn gave the stream an earlier start in the water year than what is usual for the watershed. Our intense sampling, however captured a variety of flow regimes which should have adequately characterize the IN export of the stream (n=40). Another year of data should offer confirmation of our currently observed trends. These declines coincide with the regional observation of NO_3-N loads and flow-weighted concentrations throughout the region, though TNEF's response seems to be much more dramatic (Eshleman en prep.).

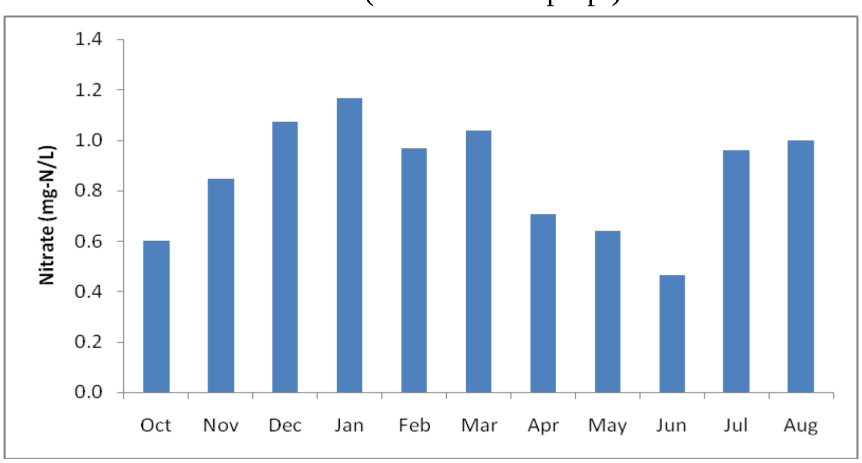


Figure 1: Displays the monthly flow-weighted concentrations of NO_3-N throughout the 2012 water year.

Isotopic Analysis

Our Central Appalachian Isotope Facility (CASIF) has recently developed the methods and equipment to carry out isotopic analysis for δN^{15}, δO^{17}, and δO^{18} of nitrate using the denitrifier technique. The δO^{17} data will be especially useful because it is a conserved tracer of atmospheric nitrate deposition in streams (Michalski et al. 2004). The δO^{18} signal is sometimes lost due to fractionation effects from biotic processes. Overall our lab is one of the few institutions in the country that are capable of carrying out this method and will be capable of quantitatively assessing the proportion of atmospheric nitrate in streams. Samples (n=40) for this project are planned to be run over the next month, along with next year's samples.

Soil Mineralization/Nitrification Complex

Year	2000	2002	2012
Mineralization (NH_3-N kg/ha)	61	101	47*
Nitrification ($N0_3$-N kg/ha)	50	97	30*
MIN/NIT Ratio	0.82	0.96	0.63

Table 2: Presents the net nitrification, mineralization, and mineralization to nitrification ratio for the years of 2000, 2002, and 2012.

*2012 numbers are only based on May and June net rates (July, August, September, and October) still needs to be run.

Buried bag techniques assessed net nitrification and mineralization rates within three permanent plots within the TNEF watershed. The year 2000 was the end of abnormally dry period throughout the region which suppressed mineralization/nitrification in the soil. In 2002 the mineralization to nitrification ratio was extremely low, which is a symptom of N-saturation. In 2012, current data indicates that the mineralization to nitrification ratio has dropped significantly (~0.88 to 0.63), however the rest of the summer samples need to be processed. As the 2012 summer progressed, soils became progressively drier which should depress high early summer mineralization/nitrification rates. The rest of the summer samples will be processed in November, which will provide more definitive answers to the effects of decrease IN deposition on the soil mineralization/nitrification complex.

Future Directions

As mentioned previously soil and isotopic samples still need to be processed this fall. This data will aid in effectively explaining the declining trends of NO_3-N in forested watersheds throughout the east coast. Our intensive stream sampling of TNEF and monthly samplings of the Appalachian Lab's study watersheds throughout the Appalachians will continue. Nitrate isotopic analysis will also soon be carried out at our CASIF for our other study watersheds which have not been elaborated in this report (Black Lick, Deep Run, Big Run, Terrapin Run, and Herrington Run). Another initiative of this project is to carry out a nitrogen availability survey of our forested watersheds utilizing the ^{15}N signature in tree rings. Recent observations of declining N-availability, even in the face of chronic elevated inputs of IN indicate that ecosystem recovery may play a large role in N retention(McLauchlan et al. 2007). All in all, this summer's project has yielded an extraordinary data set that has prompted a larger research initiative throughout the Chesapeake Bay Watershed.

Works Cited

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McLauchlan, Kendra K., Joseph M. Craine, W. Wyatt Oswald, Peter R. Leavitt, and Gene E. Likens. 2007. "Changes in Nitrogen Cycling During the Past Century in a Northern Hardwood Forest." *Proceedings of the National Academy of Sciences* 104 (18) (May 1): 7466 –7470. doi:10.1073/pnas.0701779104.

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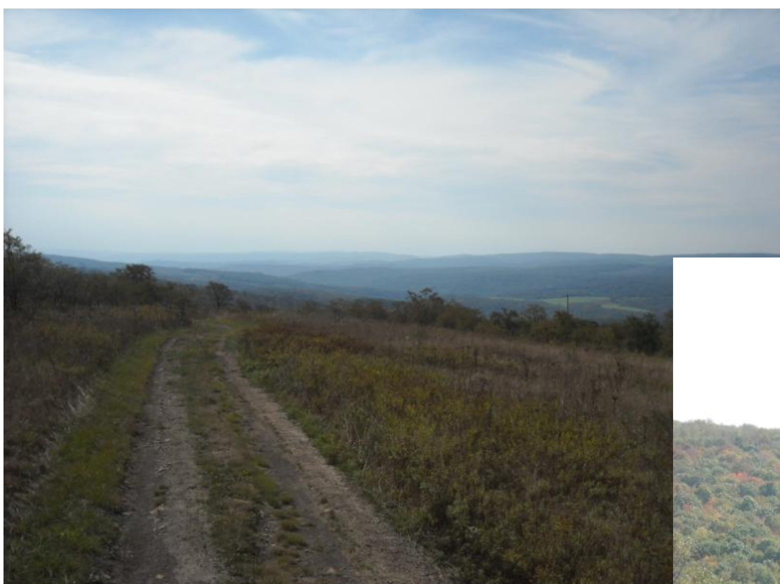
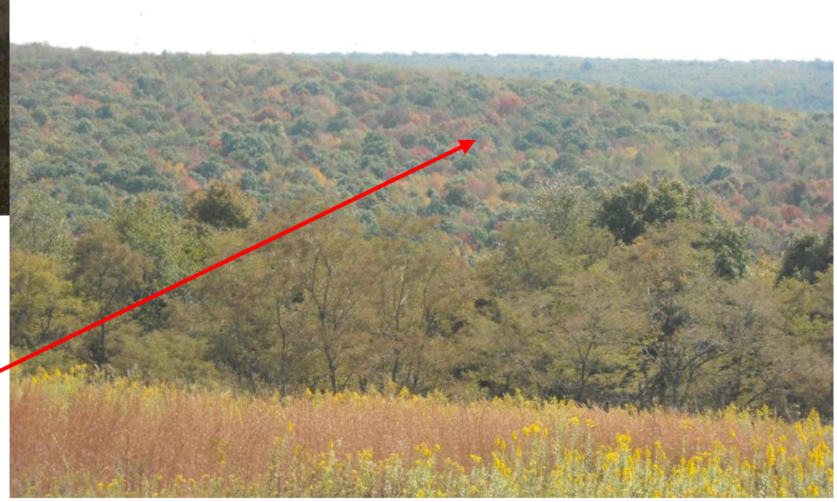
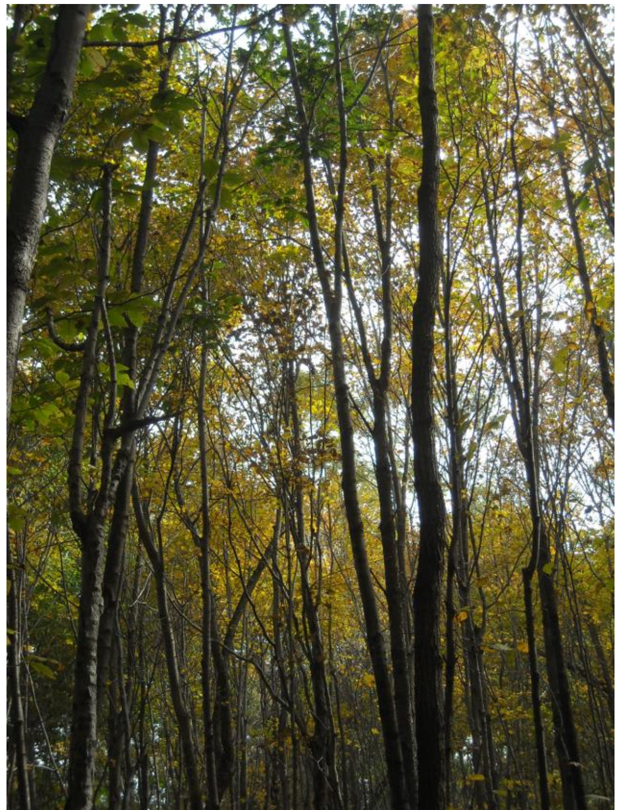
Photo Journal

TNEF is a 3.1 ha, 100% forested watershed situated on the western slope of Dan's Mountain. It was declared N-saturated in the early 2000's after an intensive four year N-budget study led by the Appalachian Lab. The trail to access the site traverses a reclaimed surface mine site and affords views of Frostburg and the Alleghany Plateau. A precipitation collector has been established near TNEF since the early 2000's, nutrient analysis of the rain restarted in the 2012 water year.



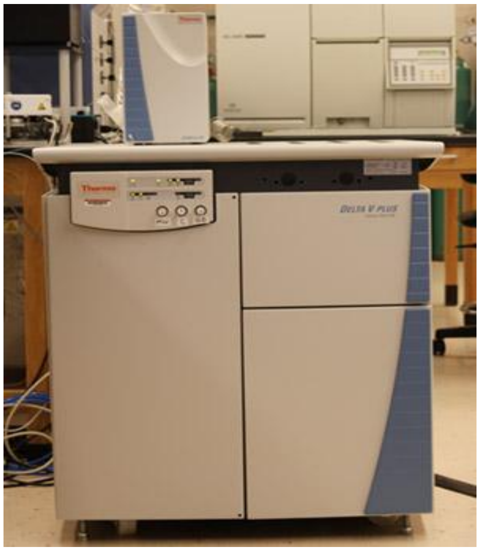


The tributary to Nef Run (TNEF) watershed is an aggrading mixed deciduous forest that supports a small ephemeral stream.



We maintain continuous flow measurements throughout the year and maintain a water budget for TNEF. This strict water accounting allows us to estimate the load and flow weighted concentration of nutrients leaving the watershed. By recording the inputs from precipitation and the outputs from the stream, we can develop an N-budget based on our nutrient data.

The ephemeral nature of TNEF means that the stream bed tends to be dry a good amount of the summer due to ET demand! As revealed by the photos a high density of stems of beech, sugar maple, birch, and cherry dominate the watershed. The stream falls along a straight slope at a relatively steep gradient.



We can construct an input/output budget of a watershed but the more challenging aspect is explaining the black box of N-flux in forest. Questions swirl about how forest retain and expel N from the system. There is a myriad of pathways and reservoirs within a forest. In my research, I am exploring what is suspected to be two of the main determinants of nitrate inputs into forest, atmospheric deposition and nitrification. My buried bag techniques look at the mineral and decayed forest floor layers to assess how much N these layers are producing.

With my water samples I can identify how much atmospheric N is present in the water column by using isotopic analyses. These methods should shed light on how forests maintain N-scarcity even in the face of chronic deposition. I hope my data can aid the Chesapeake Bay clean-up and ensure high-quality and sustainable water resources for the future!

USGS Award no. G12AP20058 The Effectiveness of a Computer-Assisted Decision Support System Using Realistic Interactive Visualization as a Learning Tool in Flood Risk Management

Basic Information

Title:	USGS Award no. G12AP20058 The Effectiveness of a Computer-Assisted Decision Support System Using Realistic Interactive Visualization as a Learning Tool in Flood Risk Management
Project Number:	2012MD299S
Start Date:	3/1/2012
End Date:	11/30/2013
Funding Source:	Supplemental
Congressional District:	MD 5
Research Category:	Social Sciences
Focus Category:	Management and Planning, Models, Floods
Descriptors:	Decision Support System
Principal Investigators:	Bahram Momen, Kaye Lorraine Brubaker

Publications

1. Olsen, V. Beth Kuser, Cynthia McCoy, and Bahram Momen. "HAZUS Flood Risk Analysis: Regional vs Local Data," Poster Presentation, University of Maryland Bioscience Day, College Park: PS 35 Environmental Science: November 27, 2012.
2. Olsen, V. Beth Kuser, Cynthia McCoy, and Bahram Momen. "HAZUS Flood Risk Analysis: Regional vs Local Data," Poster Presentation, University of Maryland Marine, Estuarine, and Environmental Science Graduate Program 2012 Colloquium, Institute of Marine and Environmental Technology: PS 26: October 19, 2012.

Progress Report for 2012MD299S
The Effectiveness of a Computer-Assisted Decision Support System Using Realistic Interactive Visualization as a Learning Tool in Flood Risk Management
(USGS Award no. G12AP20058)
Dr. Bahram Momen and Beth Olsen

I. Summary

Problem and Research Objectives

This project is advancing the field of flood risk management by using technology to bridge the gap between science and decision-making. We are testing the effectiveness of a computer-assisted decision support system (DSS) that uses realistic interactive visualization in combination with collaborative learning to (1) increase stakeholders' knowledge of risk, (2) increase stakeholders' knowledge of risk-reduction options, and (3) initiate action to reduce risk. This method is called the "Stakeholder-built" DSS. We are comparing the "Stakeholder-built" DSS to the standard method developed and presently used by the Federal Emergency Management Agency (FEMA).

Table 1: Overview of Risk Communication Methods (Treatments)

Attributes	**HAZUS DSS Method**	**Stakeholder-built DSS Method**
Stakeholders complete pre-survey & interviews	X	X
Facilitator introduces stakeholders to flood risk factors and risk-reduction options	X	X
Stakeholders engage in collaborative learning using a computer-assisted decision support system	X	X
Model-building requires memory-intensive (expensive) hardware	X	
Model-building is performed by a GIS-trained technician	X	
Stakeholders use their own computer hardware to access free cloud-stored software		X
Stakeholders engage in realistic interactive visualization, building their own model		X
Stakeholders complete post-survey & interviews	X	X

Research Objectives and Associated Hypotheses:

Objective I: Test the effectiveness of two collaborative learning methods using computer-assisted decision support systems, one that uses realistic visualization teaching methods and one that does not, and determine whether or not there is a significant difference among the methods at communicating flood risk.
Hypothesis I: The stakeholders' knowledge of flood risk will be significantly greater using the Stakeholder-built DSS Method as compared to the HAZUS DSS Method as indicated by post-survey results.

Objective II: Test the effectiveness of the two methods at communicating options for risk reduction and determine whether or not there is a significant difference among the methods.
Hypothesis II: The stakeholders' knowledge of flood risk reduction options will be significantly greater using the Stakeholder-built DSS Method as compared to the HAZUS DSS Method as indicated by post-survey results.

Objective III: Test the effectiveness of the two methods at initiating risk reduction actions and determine whether or not there is a significant difference among the methods.
Hypothesis III: The stakeholders' intentions to take action to reduce flood risk will be significantly greater using the Stakeholder-built DSS Method as compared to the HAZUS DSS Method as indicated by post-survey results.

Demographic Differences in Access to and Effectiveness of DSS Collaborative Learning in Flood Risk Communication
To test the effectiveness of the Stakeholder-built and HAZUS DSS methods in communicating flood risk and risk-reduction strategies, we are visiting Federal Emergency Management Agency (FEMA) Region III communities participating in the digitized Federal Insurance Rate Maps (DFIRM) updates. These communities may not represent the demographic attributes of all stakeholders in this region. Within participating communities, barriers to attending the meetings and/or learning using the DSS collaborative methods may exist for certain groups. Factors that can influence participation rates and/or perceptions of risk include household income, home ownership, ethnicity, educational attainment, English as a second language, age, and gender. Because these demographic factors may influence the results of our study, we are conducting a qualitative analysis of the composition of meeting participants. If representation favors certain demographic groups over others, we will adjust our scope of inference accordingly.

Methods

Overview of Design for Qualitative Analyses
Comparison of Community Attitudes toward Flood Risk and the Perceived Need to Initiate Flood Risk Reduction Strategies
Prior to the scheduled DFIRM meetings, we are identifying key informants in each community and conducting exploratory interviews to identify cultural nuances and/or community-wide experiences that may influence the quality or content of responses received during the study.
Demographic Differences in Access to Flood Risk Communication

Using demographic information supplied by participating stakeholders, we are identifying patterns that may indicate bias in FEMA DFIRM meeting representation. The following will be included in our analysis:

1. Gender
2. Household income
3. Ethnicity
4. English as a second language
5. Education
6. Age
7. Age and household income interaction
8. Home ownership

Overview of Experimental Design for Quantitative Analyses

The two treatments are the Stakeholder-built and HAZUS DSS methods. To detect the treatment effect, we are using a non-equivalent control group design. Each stakeholder (sub-sample) is given a survey before treatment begins (pre-test variable to be used as a covariate in the analysis) and an identical post-treatment (post-test, which is the response variable). An Analysis of Covariance (ANCOVA) and multivariate analyses will be performed as needed to remove the effect of pre-test or other covariates.

We are assessing responses from at least six communities in FEMA Region III participating in DFIRM updates. These are our experimental units. We chose these meetings because the DFIRM meeting agenda will serve as an introduction to our topic. With the DFIRM update completed, stakeholders in these communities are primed for the prospect of insurance rate reductions and are therefore likely to be open to information about their flood risk and risk-reduction options, which include, but are not limited to, flood insurance.

Meeting Protocol

1. Introduce to the stakeholders the concept of flood risk analysis and explain how that differs from historical flood data.
2. Divide stakeholders into small groups of three to twelve individuals, ideally grouped with those living closest together. For the Stakeholder-built DSS Method, include at least one computer-savvy person in each group.
3. For each group, model the community's highest historical storm surge using the treatment assigned:
   a. HAZUS DSS Method - GIS technicians enter this data and run the scenario in advance of the stakeholder meeting.
   b. Stakeholder-built DSS Method – stakeholders use their own hardware and link to Google Earth™ maps and the National Flood Hazard Layer (NFHL) application. Using the data provided and the Google Earth™ drawing tool, they build a model showing the relationship between their home location and past storm surge data. Members of the group assist one another in building their model.
4. Each group discusses flood risk to their homes based on their model.
5. Model the most recent risk analysis shown on FEMA DFIRMs and re-emphasize how risk calculations differ from historical data.
6. Model the 'worst-case scenario' for flood risk based on predicted changes in sea level rise and increases in extreme precipitation events. If exploratory interview responses indicate the community is interested, discuss this in the context of climate change.

7. Each group discusses the pros and cons of maintaining the status quo in flood risk management.
8. Each group considers alternatives based on risk reduction options presented by the meeting facilitator.
9. Each group decides which risk-reduction options, if any, they recommend the community and/or individual stakeholders implement and how they recommend the implementation be accomplished. The group prepares an informal presentation of their recommendations and presents their ideas to the whole.
10. An inter-group discussion weighs the merits of each group's recommendations and comes to a consensus on the best set of recommendations to follow.
11. Wrap-up the meeting by summarizing the conclusions of the group, thanking the participants for their time, and reminding them to complete the post-survey before leaving.

Demographic Differences in Access to Flood Risk Communication
We are identifying patterns that may indicate bias in demographic representation in this study. There are three reasons for identifying demographic biases: (1) to determine if the representation in each treatment group is similar, (2) to adjust the scope of inference to include only those demographic groups represented in our study, and (3) to determine if community meetings participants are a true representation of the community as a whole. To determine this, we are comparing U.S. Census Bureau and municipal census information to the demographics of the participants in the flood risk management meetings.

Findings

1. The Federal Emergency Management Agency (FEMA) developed a model to be used as a computer-assisted decision support system, enabling vulnerable communities to make informed decisions about flood risk management: the Multi-hazard Loss Estimation Methodology (HAZUS-MH). The HAZUS-MH default information is compiled based upon best available National data sources and is accurate on a regional scale. HAZUS-MH is designed to accept local, higher resolution, data. We examined the City of Alexandria, Virginia as a case study and asked: Is a model that uses local data, referred to as a Level 2 analysis, cost-effective as compared to a Level 1 analysis, which uses regional data, in terms of informed decision-making that will lower community costs during a flood? In most locations, the Level 2 analysis shows more precise 1% annual flood risk, a.k.a. the 100-year floodplain, delineations. Most calculated losses are very similar in both analyses. However, building repair and replacement costs are substantially higher, by approximately 33 ½ million dollars, in the Level 2 analysis.
2. We compared the use of each computer-assisted decision-support system (DSS), HAZUS and Stakeholder-built, to determine how efficiently each modeled flood risk on the campus of the University of Maryland by training a team of five undergraduates with little or no GIS experience to use both DSS methods. The simplicity of the Stakeholder-built DSS was found by the team to be its best characteristic. The small learning curve allowed them to quickly delineate flood danger zones. Elevation and coordinates allow users to map a floodplain using USGS stream gauge data and Google Earth ™ available on the Internet and accessed from inexpensive personal computers. Training and use of HAZUS was found to be time consuming and difficult to master for the inexperienced users.

3. Our preliminary findings show that FEMA Region III flood risk management workshop participants are older, better educated, more likely to be female, more likely to have a higher income, and more likely to own their home than the census data indicate for the community demographics. Ethnically, Latinos are underrepresented as compared to the census data.

Significance

1. We conclude that the building information in HAZUS-MH Level 2 justifies the cost of the contracted risk analysis team as compared to a Level 1, regional data, HAZUS analysis.
2. If a GIS user is interested in seeing a basic visual outline of flood danger zones and not a damage report or economic losses, the Stakeholder-built method is a quicker and simpler method than HAZUS. However, the Stakeholder-built method does not provide information on economic losses.
3. Traditionally, federal agencies communicate flood information to the public through town-hall community meetings using computer-assisted decision support systems (DSS) to model risk scenarios. Past studies show that within the participating communities, certain segments of the population may be underrepresented at the meetings. Factors that may influence individual participation rates include household income, home ownership, ethnicity, education, age, and gender. We compared U.S. Census Bureau and municipal census demographic data to self-reported demographics provided by participants in flood risk management meetings to address whether or not the participants were a true representation of the community. These results indicate that to disseminate flood risk information to all segments of the population, other methods need to be developed for reaching males, young adults, the less educated, those of Latino-descent, and those who rent their homes.

II. Publication

PRESENTATIONS:

Abdissa, Aman, Geoffrey Chan, Yevheniya Kupchyk, Derek Lam, and Marianne Varkiani (2013) Flood Risk Management at University of Maryland: A Comparison of HAZUS vs. Google™ in Flood Damage Analysis, University of Maryland, College Park, Maryland.

McCoy, Cynthia, Beth Olsen, Bob Pierson, and Farhad Tavassoli (2012). Damage Estimate Analysis for Alexandria, Virginia, FEMA Emergency Management Institute, Emmitsburg, Maryland.

SCIENTIFIC POSTERS:

Abdissa, Aman, Geoffrey Chan, Yevheniya Kupchyk, Derek Lam, and Marianne Varkiani. "Comparison of HAZUS vs. Google Earth™ in Flood Damage Analysis: University of Maryland" Maryland Day, College Park, Maryland: April 27, 2013.

Olsen, V. Beth Kuser, Cynthia McCoy, and Bahram Momen. "HAZUS Flood Risk Analysis: Regional vs Local Data" University of Maryland Bioscience Day, College Park: PS 35 Environmental Science: November 27, 2012.

Olsen, V. Beth Kuser, Cynthia McCoy, and Bahram Momen. "HAZUS Flood Risk Analysis: Regional vs Local Data" University of Maryland Marine, Estuarine, and Environmental Science Graduate Program 2012 Colloquium, Institute of Marine and Environmental Technology: PS 26: October 19, 2012.

III. Students supported

Undergraduates:

1. Alison Karp
2. Aman Abdissa
3. Geoffrey Chan
4. Derek Lam
5. Marianne Varkiani
6. Yevheniya Kupchyk

Masters: Michael Riedman
PhD: V. Beth Kuser Olsen

IV. Notable achievements

The students supported by this grant completed extensive GIS training. The undergraduates and Masters student completed three modules in the ESRI ArcGIS 10^{TM} and eleven modules in ESRI^{TM} HAZUS online training. The Ph.D. student completed the FEMA Emergency Management Institute "HAZUS for Floods" course.

Information Transfer Program Introduction

The Maryland Water Resources Research Center's information transfer program in Funding Year 2012 consisted of sponsoring our 11th annual Maryland Water Symposium. More details are provided in the specific project report.

Maryland Water 2012 - Symposium

Basic Information

Title:	Maryland Water 2012 - Symposium
Project Number:	2012MD283B
Start Date:	3/1/2012
End Date:	2/28/2013
Funding Source:	104B
Congressional District:	MD 5
Research Category:	Not Applicable
Focus Category:	Education, Law, Institutions, and Policy, Economics
Descriptors:	
Principal Investigators:	Kaye Lorraine Brubaker

Publications

There are no publications.

The 2012-13 Maryland Water Symposium focused on Environmental Law and the Social Sciences. Marking the 40th anniversary of the Federal Water Pollution Control Act Amendments of 1972 – better known as the Clean Water Act (CWA) – the symposium provided an overview of the CWA's enactment, implementation, and status. Speakers with expertise in sociology, anthropology, and economics contributed their perspectives on how communities are affected by, and respond to, environmental challenges and proposed or prescribed solutions.

The Symposium is usually held in the Fall of the Funding Year. It was postponed to February 2013 this year due to schedule constraints.

Over 80 individuals from the University of Maryland, other universities, and the broader community registered for the Symposium. Unfortunately, due to restrictions on attendance at training events associated with the Federal budget sequestration, some interested individuals were unable to attend.

The Symposium agenda is included on the following page.

Clean Water Connections

Law, History, Science & Communities

2012-13 Water Resources Symposium

Monday, February 25, 2013
8:30 a.m. – 3:00 p.m.

Adele H. Stamp Student Union
Benjamin Banneker Room
University of Maryland, College Park

8:30 a.m.	**Gathering and Refreshments**
8:50 a.m.	**Welcome and Introduction** Kaye L. Brubaker, Ph.D., Director, Maryland Water Resources Research Center
9:00 a.m.	**The Clean Water Act 1972: A New Law for an Enduring Problem** Betsy Mendelsohn, Ph.D., Director, Science, Technology & Society programs of College Park Scholars and the University Certificate, University of Maryland, College Park
9:40 a.m.	**Implementing the Clean Water Act in the Chesapeake and Mid-Atlantic Region: Stories from the 1990's and 2000's** Jim May, LL.M, J.D., B.S.M.E., Professor of Law and Co-Director, Environmental Law Center, Widener University
10:20 a.m.	**Break**
10:40 a.m.	**The Clean Water Act at 40: Current Status in the Courts, in Congress, and at EPA** Joanna B. Goger, Esq., Lecturer, Environmental Science and Policy Program, University of Maryland
11:20 a.m.	**A Case Study of Stakeholder Response to Harmful Algal Blooms and Nutrient Management in the Chesapeake** Elizabeth Van Dolah, M.A.A., Research Assistant, and Shirley Fiske, Ph.D., Research Professor, Department of Anthropology, University of Maryland
12 noon	**Luncheon**
1:00 p.m.	**Understanding Environmental Stewardship** Dana R. Fisher, Ph.D., Associate Professor, Department of Sociology, and Director, Program for Society and the Environment, University of Maryland
1:40 p.m.	**Economics and the CWA: Getting the Incentives Right** Doug Lipton, Ph.D., Associate Professor, Department of Agriculture & Resource Economics, and Coordinator, Maryland Sea Grant Extension Program, University of Maryland
2:20 p.m	**Group Discussion: Research needs and opportunities for collaboration**
3:00 p.m.	**Adjourn**

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USGS Summer Intern Program

None.

Student Support					
Category	**Section 104 Base Grant**	**Section 104 NCGP Award**	**NIWR-USGS Internship**	**Supplemental Awards**	**Total**
Undergraduate	5	0	0	6	11
Masters	4	0	0	1	5
Ph.D.	3	0	0	1	4
Post-Doc.	0	0	0	0	0
Total	12	0	0	8	20

Notable Awards and Achievements

The preliminary data and equipment acquired through 2012MD282B, "Ecohydrology of ditch-drained marshes," helped to secure grant # NA09NOS4190153 from the National Estuarine Research Reserve System Science Collaborative, operating by a cooperative agreement between the University of New Hampshire and the National Oceanic and Atmospheric Administration. This grant has allowed for continued hydrological and ecological data collection.

Publications from Prior Years

1. 2007MD143B ("Responses of Species-Rich Low-Salinity Tidal Marshes to Sea Level Rise: a Mesocosm Study") - Articles in Refereed Scientific Journals - Sharpe, Peter J. and Andrew H. Baldwin, 2012, Tidal marsh plant community response to sea-level rise: A mesocosm study, Aquatic Botany 101, 34–40, http://dx.doi.org/10.1016/j.aquabot.2012.03.015
2. 2008MD171B ("Microbial nitrogen sequestration in detrital-based streams of the Chesapeake Bay watershed under stress from road-salt runoff.") - Articles in Refereed Scientific Journals - Swan, C. M. & C. A. DePalma. 2012. Elevated chloride and consumer presence independently influence processing of stream detritus. Urban Ecosystems 15(3):625-635.
3. 2010MD229B ("Occupational and Community Exposure to Antimicrobial-Resistant Bacteria and Antimicrobials Present in Reclaimed Wastewater ") - Articles in Refereed Scientific Journals - Rosenberg Goldstein R.E., S.A. Micallef, S.G. Gibbs, J.A. Davis, X. He, A. George, L.M. Kleinfelter, N.A. Schreiber, S. Mukherjee, A. Sapkota, S.W. Joseph, and A.R. Sapkota. 2012. Methicillin-resistant Staphylococcus aureus detected at four U.S. wastewater treatment plants. Environmental Health Perspectives 120:1551–1558
4. 2010MD229B ("Occupational and Community Exposure to Antimicrobial-Resistant Bacteria and Antimicrobials Present in Reclaimed Wastewater ") - Dissertations - Rosenberg Goldstein, Rachel E., 2013. Antibiotic-resistant bacteria in wastewater and potential human exposure through wastewater reuse, PhD Dissertation, Maryland Institute for Applied Environmental Health, University of Maryland School of Public Health, College Park, Maryland, 198 pages.
5. 2010MD229B ("Occupational and Community Exposure to Antimicrobial-Resistant Bacteria and Antimicrobials Present in Reclaimed Wastewater ") - Conference Proceedings - Rosenberg Goldstein, R.E., S.A. Micallef, A. George, A. Sapkota, S.G. Gibbs, S.W. Joseph, and A.R. Sapkota. 2010. Reductions of methicillin-resistant Staphylococcus aureus and vancomycin-resistant Enterococcus spp. at a U.S. tertiary wastewater treatment plant, in American Society for Microbiology, 110th General Meeting, San Diego, CA.
6. 2010MD229B ("Occupational and Community Exposure to Antimicrobial-Resistant Bacteria and Antimicrobials Present in Reclaimed Wastewater ") - Conference Proceedings - Rosenberg Goldstein, R.E., S.A. Micallef, A. George, A. Sapkota, S.G. Gibbs, S.W. Joseph, and A.R. Sapkota. 2010. Evaluating occupational exposures to antibiotic-resistant bacteria from wastewater reuse, in Water and Health: Where Science Meets Policy 2010 Conference, University of North Carolina at Chapel Hill, Chapel Hill, NC.
7. 2010MD229B ("Occupational and Community Exposure to Antimicrobial-Resistant Bacteria and Antimicrobials Present in Reclaimed Wastewater ") - Conference Proceedings - Rosenberg Goldstein, R.E., S.A. Micallef, A. George, A. Sapkota, S.G. Gibbs, S.W. Joseph, and A.R. Sapkota. 2011. Survival of methicillin-resistant Staphylococcus aureus in Secondary Treated Wastewater, in American Society for Microbiology 111th General Meeting, New Orleans, LA.
8. 2010MD229B ("Occupational and Community Exposure to Antimicrobial-Resistant Bacteria and Antimicrobials Present in Reclaimed Wastewater ") - Conference Proceedings - Rosenberg Goldstein, R.E., S.A. Micallef, A. George, A. Sapkota, S.G. Gibbs, S.W. Joseph, and A.R. Sapkota. 2011. Assessing an alternative water source: Evaluation of methicillin-resistant Staphylococcus aureus in secondary treated wastewater used for spray irrigation in Nebraska, in Water and Health: Where Science Meets Policy 2011 Conference, University of North Carolina at Chapel Hill, Chapel Hill, NC.
9. 2009MD200B ("Correlating Nutrient, Pesticide, and Bacteria levels in the Choptank River--Summer Fellowship") - Articles in Refereed Scientific Journals - Guzman, G., C. Hapeman; K. Prabhakara; E.E. Codling, D.R. Shelton, C. Rice, W.D. Hively, G.W. McCarty, M.W. Lang, and A. Torrents. 2012 Potential pollutant sources in a Choptank River (USA) subwatershed and the influence of land use and watershed characteristics, Science of the Total Environment, 430, 270-279. DOI: 10.1016/j.scitotenv.2012.03.056.

10. 2009MD199B ("Role of Invertebrate Bioturbation in Phosphorus Retention of Agricultural Ditch Soils--Summer Fellowship") - Articles in Refereed Scientific Journals - Leslie, A.W., R.F. Smith, D.E. Ruppert, K. Bejleri, J.M. McGrath, B.A. Needelman, and W.O. Lamp. 2012. Environmental factors structuring benthic macroinvertebrate communities of agricultural ditches in Maryland. Environmental Entomology 41: 802-812.
11. 2008MD176B ("Summer Fellowship: Investigating the Fate and Persistence of dichloroacetamide herbacide safeners in model environmental systems") - Articles in Refereed Scientific Journals - Sivey, John; Lynn Roberts, 2012, Abiotic reduction reactions of dichloroacetamide safeners: Transformations of "inert" agrochemical constituents, Environmental Science and Technology, 2012, 46(4), 2187-2195.
12. 2008MD176B ("Summer Fellowship: Investigating the Fate and Persistence of dichloroacetamide herbacide safeners in model environmental systems") - Articles in Refereed Scientific Journals - Sivey, John and Lynn Roberts, 2012, Abiotic reduction reactions of dichloroacetamide safeners: Transformations of "inert" agrochemical constituents, Environmental Science and Technology, 2012, 46(4), 2187-2195.
13. 2008MD176B ("Summer Fellowship: Investigating the Fate and Persistence of dichloroacetamide herbacide safeners in model environmental systems") - Dissertations - Sivey, John, 2011, Abiotic Redox Reactions of Chloroacetamide Herbicides, Safeners, and Structural Analogs in Natural and Engineered Systems, Ph.D. Dissertation, Department of Geography and Environmental Engineering, Whiting School of Engineering, Johns Hopkins University, Baltimore, Maryland, 323 pp.
14. 2010MD209B ("Leaching of Heavy Metals from High Carbon Fly Ash--Stabilized Soils in Highway Embankments") - Articles in Refereed Scientific Journals - Cetin, B., A.H. Aydilek, and Y. Guney, 2012, Leaching of Four Trace Metals from High Carbon Fly Ash Stabilized Highway Base Layers, Resources, Conservation and Recycling, 58, 8-17.
15. 2010MD209B ("Leaching of Heavy Metals from High Carbon Fly Ash--Stabilized Soils in Highway Embankments") - Conference Proceedings - Cetin, B. and A.H. Aydilek, 2012, Environmental Suitability of Fly Ash Amended Highway Embankment Construction, in Proceedings of Geocongress, ASCE, Oakland, CA, 9 pp. (CD-ROM).
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