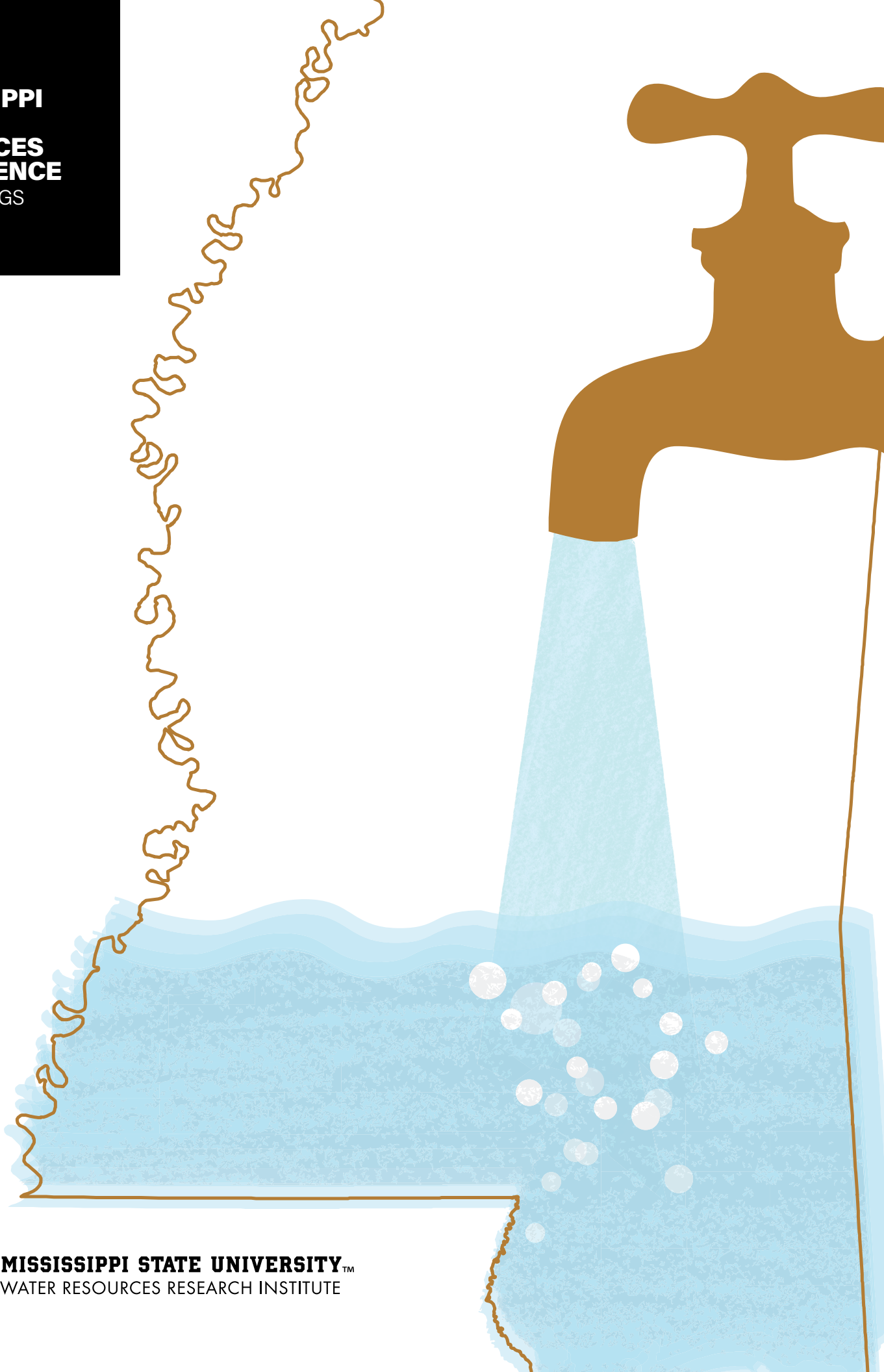
2019

MISSISSIPPI WATER RESOURCES CONFERENCE

PROCEEDINGS



MISSISSIPPI STATE UNIVERSITY™
WATER RESOURCES RESEARCH INSTITUTE

2019
MISSISSIPPI WATER RESOURCES CONFERENCE
PROCEEDINGS

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POSTER SESSIONS

Experimental Study of the Performance of the N,N'-di (Carboxymethyl) Dithiocarbamate Chelating Resin in Removing Heavy Metals from Oilfield Waste Water

AL OTMI M., MIRABOLGHASEMI M.

High concentrations of heavy metals in oilfield waste water pose serious health and environmental risks. These risks can be partially managed by waste water treatment for repurposing. Treating oilfield waste water at large volumes remains a challenge due to the high concentration of heavy metals and their variety. In this study, we examine the capability of the N,N'-di (carboxymethyl) dithiocarbamate chelating resin in removing divalent heavy metal ions. We also test the effect of the presence of multiple types of ions and hydrocarbon content on the adsorption of each metal. The resin is synthesized following a multi-step procedure outlined in the literature. We verified the accuracy of the synthesis procedure by comparing the removal of single metal ions (Pb, Cu, Ni) measured in the lab, with the values reported in the literature. Next, the performance of the resin is tested in terms of metal removal efficiency as a function of time, for solutions of two metal salts. We expect to observe hindered adsorption due to the competition between the ions. The concentration of metals are measured by solution conductivity measurement and Raman spectroscopy. This study quantifies the metal removal power of the N,N'-di (carboxymethyl) dithiocarbamate chelating resin under various conditions. This information is useful for comparing various methods of oilfield waste water treatments based on their efficiency and operational costs.

A Geospatial Inventory of Surface Water for Irrigation in the Big Sunflower River Watershed

BROCK M.L., TAGERT M.L., PAZ J.O., KRUTZ L.J.

The Delta is the center of agricultural production in the state of Mississippi. This region harbors a humid climate with approximately 55 inches of rainfall per year. However, seasonal variability in precipitation with only 30% of rainfall occurring in the growing season requires the use of irrigation systems to meet crop water needs. As groundwater has been the predominant water source for irrigation, extensive pumping of the Mississippi River Valley alluvial aquifer has led to concerns over the sustainability of groundwater. On-farm water storage (OFWS) systems have been implemented in different areas throughout the Delta as a conservation practice to mitigate nutrient runoff and address water quantity concerns. These systems consist of a tailwater recovery ditch that collects irrigation and rainfall runoff and conveys the water to a storage pond for reuse. Using surface water as an alternative to or in conjunction with groundwater shows promise of releasing the strain on groundwater sources in certain areas. Through this project, an inventory and analysis of OFWS systems in the Big Sunflower River Watershed (HUC 08030207) is being conducted using high-resolution imagery and geospatial technologies such as ERDAS IMAGINE image analysis software. In the inventory, storage ponds and tailwater recovery ditches are delineated and simplified into polygons to create functional shapefiles of existing OFWS systems. Preceding years are then evaluated to discover the rate of construction of OFWS systems in the Big Sunflower River Watershed in response to various factors.

Characterization of Runoff Water Quality from Established BMP Soybean Production Systems

BRYANT C.J., KRUTZ L.J., LOCKE M.A., STEINRIEDE JR. R.W., SPENCER G.D.

Recent regulation has placed even greater pressure on agricultural producers to implement non-point source pollution controls on production fields. The most commonly adopted controls are on-farm best management practices (BMPs) which aid in reducing off-site transport of sediment and agro-chemicals in runoff water. In 2004 a long-term study site was established in the Mid-Southern USA at the Delta Research and Extension Center in Stoneville, MS on a Dubbs silt loam. This study site is used to evaluate off-site transport from furrow-irrigation events under varying BMPs. Experimental units are hydrologically separated from one another and instrumented to mass balance the off-site transport of water, sediment, and agrochemicals. In 2015 the site was transitioned into continuous soybean (Glycine max) production. Treatments included conventional tillage/winter fallow (CT/WF), reduced tillage/winter fallow (RT/WF), reduced tillage with in row sub-soiling (RT/SS), reduced tillage with a cereal rye (Secale cereal) cover crop (RT/RC), reduced tillage with a tillage radish (Raphanus sativus) cover crop (RT/TR), zone tillage/winter fallow (ZT/WF), and zone tillage with a tillage radish cover crop (ZT/TR). Total solids transport was reduced by at least 17% when using a zone tillage system or including sub-soiling or a cereal rye cover crop in a reduced tillage system. Compared to the regional standard RT/WF orthophosphate transport was reduced by at least 35% with a tillage radish or cereal rye cover crop. Including either cover crop or sub-soiling in a reduced tillage system reduced total Kjeldahl nitrogen transport by at least 20%. This data indicates that runoff water quality can be improved through adoption of BMP based soybean production system.

Bottom-Up Effects of Leaf Litter Conditioning on Snail Physiological Rates

GLISSON L.C., DICKINSON G.K., RANKIN A.A., HALVORSON H.M., ATKINSON C.L.

The relationship between food quality and physiological rates is crucial in understanding how invertebrates respond to their environment via bottom-up effects. We investigated the feeding habits of the snail Planorbella trivolvis by altering the microbial conditioning of Typha latifolia leaf litter. We conditioned litter in either a light or dark environment and at high or low nutrient availability to give us four combinations of food quality to assess snail physiological feeding processes. During the two-week feeding study, we measured consumption, egestion, excretion (ammonia, phosphate, dissolved organic carbon, and total nitrogen), survivorship, and instantaneous growth rates. We predicted that the snails would exhibit compensatory feeding, where organisms increase their ingestion of low nutrient food to reach their nutritional requirements. Therefore, we hypothesized that consumption and egestion rates would be increased in low resource quality litter and higher growth rates of snails would be observed in higher quality litter. Our results show that instantaneous growth rates were twice as high in light treatments and consumption rates were four times higher in low nutrient treatments. When examining ammonia excretion rates, significant increases were found in the low nutrient/light treatments and high nutrient/dark treatments. Our results suggest that invertebrates exhibit compensatory feeding to reach their nutritional requirements and prefer higher quality food to maximize growth rates.

The Spatiotemporal Variation of Groundwater Level and Response to Landuse Change in the Big Sunflower River Watershed

HAN Y., FENG G., OUYANG Y., LIU Z., JENKINS J.N.

The Big Sunflower River Watershed (BSRW) groundwater was heavily used for irrigating crops. Cotton, soybean, corn and rice account for 64% of the total area in BSRW and their irrigation water use is 0.5, 0.7, 0.9 and 3.0 feet/acre, respectively. The landuse had a huge change and groundwater levels has been decreased over 1 meter from 2003 to 2013. However, the annual rainfall of BSRW in 2003 and 2013 was similar(52.6 and 54.2 inch). The purpose of this study was to study the spatial variation of groundwater level and the relationship between landuse change and groundwater level variation in 2003 and 2013. We applied the semi-variation function model and Kriging interpolation technique to produce BSRW's groundwater level isogram maps in 2003 and 2013. The differences of groundwater level between 2013 and 2003 were spatially displayed across the BSRW. The landuse map of BSRW in 2003 and 2013 were used to obtain the changes of land use patterns and area. The transition matrix of landuse types with respect to different change range of groundwater depth between 2003 and 2013 will help us to understand the relationship between groundwater level and landuse. Our results showed that the planting area of cotton and corn changed dramatically from 2003 to 2013 and groundwater level in BSRW decreased rapidly from northeast to southwest, sunflower county was the center of groundwater decline. The change trend of planting patterns from cotton to corn and soybean had no obvious relationship with groundwater change, but the change from grass/pasture to woody wetland/forest had an effect on groundwater level change.

Iron-Precipitation in Mississippi Streams from Discharge of Iron-Rich Groundwater: Characterization and Modeling

HERATH H., DAVIDSON G., O'REILLY A., WIDANAGAMAGE I.

Some streams in northern Mississippi experience extensive precipitation of ironminerals on bottom sediments and plant matter, resulting in diminished photosynthetic production and biological diversity. At two streams, one with visible iron-precipitates and one without, two shallow wells were installed along a groundwater flow path toward each stream. Both streams and wells were sampled for water quality. Physicochemical parameters such as pH, water temperature, conductivity and dissolved oxygen were measured in-situ. Titrations were performed to measure in-situ alkalinity. Total Fe concentration in the water was also measured in the field using a photometer. Major and minor ion concentrations were measured at both locations and possible mineral phases were identified using geochemical modelling software (PHREEQC-3.4.0-12927). Some groundwater samples showed elevated levels of NO3-, Al, As, Na, and P. Hardness at one site is soft-moderate while at the other it varies from soft to hard. Water overall can be classified as dominantly Ca-Cl. Generally, all groundwater significantly exceeded the U.S. Environmental Protection Agency secondary drinking water standard of 0.3 mg/L for Fe. The concentration of Fe tends to decline along the groundwater flow path exhibiting an inverse relationship with pH and dissolved oxygen. Fe is depleted in both streams due to prevailing oxidizing conditions which promote transformation of Fe(II) to the less soluble Fe(III). All waters at both sites are supersaturated with respect to hematite, goethite, gibbsite, K-mica and kaolinite. Based on geochemical modeling, Fe precipitation is favored in both streams. However, iron-oxyhydroxides are only visually observed in one stream. Explanations for the absence of observed precipitates in the second stream may be related to differences in stream size. In the larger stream, greater dilution of groundwater discharge occurs (lower measured Fe), and higher discharge rates may retain precipitated minerals in the water column to flush them downstream.

Investigating Variables Which Could Affect Unionid Abundance and Biodiversity

KUNBERGER J.M., VAN EE B.C., ATKINSON C.L.

Freshwater mussels (order Unionoidea) are crucial to the health of freshwater ecosystems, as they filter water and excrete easily consumable materials. Due to drought, pollution, and development of river systems, Unionids are imperiled with over half considered endangered and many already extinct. Despite their importance and the pressing threat of more extinctions, research into Unionid habitat selection is limited, with only a handful of scientists working on pinpointing the factors that determine Unionid presence and success. This research would be valuable in determining how to detect potential areas of Unionid success and to predict impacts on certain populations, which would both aid in management and reintroduction efforts. In this study we surveyed six sites in the Sipsey River, which is known for its high Unionid diversity and abundance, and investigated variables at three spatial scales to determine which factors could be relevant in Unionid habitat selection. During the survey, we collected quadrat-level data at each site, including mussel abundance and biodiversity, pH, temperature, flow, and sediment characteristics. We also collected site-level data, including active channel width, seston quantity, discharge, and hyporheic flow. Lastly, through the use of remotely-sensed imagery and GIS operations, we determined watershed extent, distance upstream, vegetation, and land use for each site as landscape-level data. We then performed statistical analyses to determine which factors would best explain abundance and biodiversity at these sites.

Systematic Water Use Efficiency in Maize-Soybean Rotations: The Impact from Climate Change and Cover Crops

LI Y., TIAN D., FENG G., FENG L.

Climate change influence hydrological processes in agricultural systems, which may lead to inefficiency of systematic water use efficiency (sWUE). Cover crops can be potentially considered as a strategy to improve systematic water use efficiency for mitigating the effects from climate change. However, the potential effects of cover crops on sWUE have not been studied under future climate scenarios. In this study, the hybrid Root Zone Water Quality Model version 2 (RZWQM2) model was calibrated using 5 years (2013-2017) field data. The calibrated model was used to simulate historical and future crop yields, evapotranspiration, seepage, and runoff under the cover crop and non-cover crop scenarios in Pontotoc, Mississippi using historical observations and future climate projections under two Representative Concentration Pathways (RCPs) 4.5 and 8.5 from statistically downscaled outputs of ten GCMs (General Circulation Models) from Coupled Model Inter-comparison Project - Phase 5 (CMIP5). The impacts of cover crops and climate change on maize-soybean rotation systems are analyzed using the model simulations under different scenarios. The results indicated that cover crop decreased the annual seepage respectively 13.7% during 2020 to 2049 and 11.4% during 2050 to 2079 under RCP4.5, by 16.1% and 14.7% under RCP8.5. Compared with the no cover crop management, the sWUE under cover crop management were improved respectively by 3.4% during 2020 to 2049 and 1.8% during 2050-2079 under RCP4.5, and by 3.1% during 2020 to 2049 and 1.5% during 2050-2079 under RCP8.5 for maize but not much for soybean. The results of relationships between climate extreme indices and crop model output variables suggest that the practice of cover crops can reduce the negative feedback effect of high temperature and plays a certain buffering role by improving evapotranspiration in extreme weather.

Increase in Plant Available Water Holding Capacity of Soils Amended by Biochar

LI Y., FENG G., TEWOLDE H., ADELI A., REGINELLI D.

Biochar as a soil amendment has been increasingly advocated for its effects on improving soil water holding capacity and soil health. To date, little information was found regarding impact of biochar amendment on plant available water holding capacity of dominant soils in Mississippi State. The objective of this study was to investigate whether and how much biochar addition at various rates could improve plant available water holding capacity of dominant soils in the state of Mississippi. Laboratory (Incubation) and field experiments were conducted to measure soil bulk density (BD), total porosity (TP), field capacity (FC), permanent wilting point (PWP), soil moisture characteristic curve (SWRC), saturated hydraulic conductivity (Ksat), and infiltration rate (IR). Then the plant available water holding capacity of soils amended by biochar will be calculated to evaluate the effect of biochar addition on the water use efficiency in Mississippi State.

The results are expected to provide fundamental guidance for growers, university extension and NRCS personnel, and policymakers to amend biochar for improving water use efficiency of different soils in Mississippi State.

Assessing the Environmental and Educational Value of an Agricultural Stream Restoration

MCCRARY A., BAKER B., BURGER L.

Agriculture is the predominant source of today's environmental challenges, including the degradation of water resources. With a majority of land in the United States being designated for agricultural use, water resource conservation has become a significant topic of interest for federal and state natural resource agencies. Through the U.S. Environmental Protection Agency's Section 319 Program and the Mississippi Department of Environmental Quality, Mississippi State University is conducting a stream restoration project within its agricultural research properties in Oktibbeha County, Mississippi. This study will evaluate the impacts of the restoration on the impaired stream in an agricultural landscape. Water sampling during storm-runoff events will be conducted to test for changes in microbial, nutrient, and sediment concentrations pre- and post-restoration. Stream flow will also be monitored to assess the volume of water flowing during comparable storm events and calculate the total volume of nutrients and sediments lost from the landscape during events. In addition to these water monitoring activities, a regional survey of Cooperative Extension Service agents with agriculture and natural resource responsibilities will be conducted to assess the need for in-service training on water resource conservation topics. Both water quality monitoring and survey data will be used to evaluate the creek restoration's environmental impact and value as a demonstration site for future stakeholder training in water resource conservation.

Control of Chinese Privet as a Part of the Water Resources Management Plan for the Redbud-Catalpa Creek Watershed

PALMER T., SCHAUWECKER T.

As a part of the Undergraduate Research Scholars Program at Mississippi State University, we investigated the control of the highly invasive shrub Chinese privet (*Ligustrum sinense*) in the Catalpa Creek Watershed. The goal of our research is to provide management personnel with Standard Operating Procedures (SOPs) for invasive species management. We will also provide a cost-benefit summary for each of the methods for decision-making purposes. Our research compares three methods thought to best control the privet in the field: Cut Stump, Hack and Squirt, and Basal Bark Application methodologies. Eighteen cross sections of the upper reaches of Catalpa Creek, all located on the HH Leveck Research Farm, were sampled for privet cover in 2017. Using this data as a starting point, a privet treatment method was randomly assigned to each of 18 stream cross sections to implement the methods. The Cut Stump method was implemented by cutting through the circumference of the privet 12" or below on the trunk and then immediately applying a 3:1 solution of water and 41% glyphosate. The second method implemented is known as Hack and Squirt, and required a machete or sharp tool to cut around the circumference of the privet 12" or below on the trunk and then immediately applied a 1:1 solution of water and 41% glyphosate. The final method that we implemented was called the Basal Bark method. With this method, we applied a 20% triclopyr herbicide solution with an oil-based surfactant to the bottom 12" of the trunk. Once we had applied the herbicide, we gathered all the cuttings for future use as waddles to help control erosion on another site. For this presentation, we give preliminary results of treatment outcomes based on early spring growth.

“One-Pot” Method for Collection and Preparation of Microplastic

SCIRCLE A., CZIDZIEL J., LI L.

In microplastic analyses, one of the most commonly encountered challenges is how to avoid sample contamination and minimize losses during sample preparation steps. Contamination can be addressed through a combination of vigilant laboratory cleanliness and conscious decisions on materials used and worn during analysis, and losses can be minimized by decreasing transfer steps. However, there still exists a very real chance of contamination, carry-over, or loss events which limits any conclusions drawn. Here, we describe a “One-Pot” method which minimizes sample contamination and avoids transfer losses and carry-over events by keeping a sample in the same jar it was collected in until the sample is placed on a microscope slide for analysis (this includes sample preservation, storage, digestion, density separation, and dye-staining steps). Furthermore, this method uses relatively inexpensive and easily purchased or assembled materials such as canning jars and wire screens. Overall, the “One-Pot” improves reliability of microplastic analyses, particularly for the smaller size fraction (less than about 0.5 mm) which are more prone to contamination and transfer losses.

DSS Based BMPs Effectiveness Impacts and Evaluation of Water Quality at Yazoo River Sub Basin

SHABBIR M.

The web based support systems are one of the emerging interdisciplinary study with the motivated challenged and opportunities. It focuses on the tool and design implementation of web based support systems and various other human activities. With the emergence of web technologies and web based support system, various support system has been extended from single machine to a single computer system user. The recent advancements of technologies such as water quality management practices (BMPs) and low impact development practices (LID) are reducing the amount of adverse influences on urban areas. The objective of this study is to evaluate the effectiveness in sub basin watershed with the (L-THIA) web application, a DSS (Decision support system) based integration web based programs and geographic information system (GIS) for intended to support decision makers who need information regarding BMPs and LID effectiveness practices on water quality and land uses changes. In agriculture field, decision-making perception for used land, which can include changes in agricultural uses in an area or adaptation to non-agricultural uses. However, DSS is targeted to beginner should provide additional functionalities to help understanding the results. L-THIA model estimates the long term average yearly runoff for the land use types in required watershed based for long term climate data, soil and land use data for that area. By using more than sixteen years of daily precipitation data in daily runoff calculation alongside with curve number method, L-THIA gives long term effects, rather than an extreme year or storm event impact. These development can support and guide consumers in verdict creation and increase consumer's ability to understand the land use changes on water quantity and quality. Keywords: L-THIA, DSS, BMPs, LID, Soil data

Runoff and Transportation in Conservation Management Systems Under Simulated Rainfall

SPENCER D., KRUTZ J., LOCKE M., RAMIREZ-AVILA J., HENRY B., GOLDEN B.

Mid-southern, USA silt loam soils are characterized by poor soil structure, increasing their susceptibility to crusting and erosion. Cover crops may improve soil structure through the addition of organic matter thereby increasing infiltration and reducing erosion. Studies were established in Stoneville, MS in 2017 and 2018 to determine the effects of four cover crops on aggregate stability, infiltration, and nutrient and sediment transport under simulated rainfall. Experimental design is a randomized complete block with four replications. Treatments include a reduced till/no cover (as a control), reduced tillage with cereal rye (*Secale cereal L.*), reduced tillage with Austrian winter pea (*Pisum sativum L.*), reduced tillage with tillage radish (*Raphanus sativus L.*), reduced tillage with crimson clover (*Trifolium incarnatum L.*), and no till/no cover. Results including soil quality parameters, infiltration, and nutrient and sediment transport will be presented.

Determining Ecosystem Function and Thermal Thresholds of Freshwater Mussel

VAN EE B.C., ATKINSON C.L.

Consumers play a significant role in the uptake, transformation, and storage of nutrients and organic matter in aquatic ecosystems. By creating hotspots of bioavailable nutrients consumers can stimulate ecosystem processes essential to the natural functioning of a system. In addressing the impacts of global climate change it is imperative to understand how these consumer driven processes might be altered under current climate predictions, though this can often be difficult due to the species-level traits relevant in these processes. For consumers, such as freshwater mussels, which are already experiencing drastic declines, studies into ecosystem function can also provide valuable information for conservation efforts. In our study we investigated how physiological rates relevant to ecosystem functions vary across temperatures in multiple species of freshwater mussels. We measured filtration rate (capture of chlorophyll), metabolism (O2 consumption), excretion rate (release of ammonia and phosphorus), and biodeposition rate (release of solid waste) at a range of temperatures (10, 20, 30°C) for 11 species of freshwater mussels native to the Sipsey River, AL. Using the measured rates, we investigated species-level differences in organic material capture and nutrient release between species. Pairing this with survey data from the Sipsey River, we calculated the filtration capacity of freshwater mussel communities at different times throughout the year. We also used these data to examine the thermal tolerances of freshwater mussel species. By estimating at which temperature these species metabolism shift between anabolism (net gain of energy) and catabolism (net loss of energy), we determined when species growth is inhibited by temperature. The higher the temperature this shift occurs at, the more thermally tolerant a species is considered. Using this information we can estimate which species would be lost first as a result of warming and the potential losses to ecosystem function.

The Use of Lumped Parameter Modeling to Determine Groundwater Age of the Mississippi River Valley Alluvial Aquifer

WACASTER S.R., KNIERIM K.J., KINGSBURY J.A., KILLIAN C., BUSSEL A., KRESS W., O'REILLY A.M.

Groundwater from the Mississippi River Valley Alluvial (MRVA) aquifer supplies water primarily for irrigation and domestic uses in the Mississippi Alluvial Plain (MAP), so understanding how water quality influences availability is critical for states relying on this important resource. Additionally, deeper aquifers such as the Sparta aquifer are used for public drinking-water supply and there are questions about hydraulic interaction between the aquifers. Surface-derived contaminants are more likely to affect groundwater that contains a greater fraction of young water, so determining groundwater age is important when assessing groundwater availability within the context of water quality and how it might change over time. In the MRVA aquifer, 39 wells were sampled from July to December 2018 for inorganic constituents and age-date tracers. Local-scale groundwater studies have been conducted in the MRVA aquifer, but a regional characterization of groundwater age is needed to gain a better understanding of recharge processes and how water quality varies with groundwater age. This research will determine groundwater age of the MRVA aquifer, which underlies a large portion of the MAP extent, using a lumped parameter model using age-tracer data (tritium, helium, sulfur hexafluoride, and carbon-14) collected by the U.S. Geological Survey (USGS). These calculated ages can be used to better estimate recharge for the water budget of the MAP area, which in turn will aid in model predictions of future groundwater availability. Groundwater ages from the Sparta aquifer will be used to assess groundwater interaction between the aquifers where confining units are absent. Preliminary analysis of tritium data collected for this project from samples in the MRVA aquifer indicate that about half of the locations sampled contained little to no young groundwater (defined as younger than 1950). This suggests portions of the MRVA aquifer are being recharged very slowly, thus causing a longer-term imbalance of recharge and withdrawals.

Microplastics in the Mississippi River System

CIZDZIEL J., SCIRCLE A.

Microplastic (MP) concentrations along the northern Gulf of Mexico are among the highest levels reported globally. The most likely source of the plastic pollution is the Mississippi River (MR) which drains much of the central portion of the USA. Yet, surprisingly little is known about the concentrations, types, sizes, and loadings of MPs in the MR and its major tributaries. This lack of data is hindering our understanding of the magnitude and sources of the problem. Because the MR is an intricate system of waterways, tributaries, and commercial routes, an in-depth spatial study is needed to fully assess MP pollution in the system. Our research aims to systematically quantify the concentrations and loads of MPs in the MR system, and characterize their shapes, size distribution, and chemical composition in the MR system—a source of drinking water to over 18 million people. We used Nile Red dye to stain the MPs and fluorescence microscopy to count them, as well as vibrational spectroscopy to the identity the plastics. The morphology of the MPs was dominated by fibers (~75%), followed by fragments (~23%) and beads (~2%), with the proportion of fragments increasing slightly moving down the river. The concentration of MPs is relatively low for smaller tributary rivers (Tennessee and Yazoo) and higher in larger tributaries rivers (Ohio and Missouri), with the later having higher concentrations than the MR itself. Counts and loads of MPs generally increased down the main stem of the MR until past New Orleans, where loads declined, possibly due to deposition with slowing water. Sites near population centers (e.g. Memphis) had higher MP concentrations. Overall, this work is an important first step to assess possible relations between MPs levels and characteristics with sources and different watershed attributes.

Establishment of a Riparian Buffer Along the Constructed Levees of Catalpa Creek

LANG D., MADDOX V.

Riparian buffers along streams that have been channelized to facilitate developments provide filtration of sediments. Their implementation needs to be coordinated with remediation of storm water diversion structures upstream such as constructed wetlands and containment ponds. Constructed levees have been implemented to control floods and to create usable lands for agriculture and other human activities. A constructed levee tends to limit flood plain overflows and it interferes with natural stream ecosystem function. Floodplain overflows deposit alluvium to redistribute upstream sediments dislodged by natural and man-made activities such as from agricultural fields or from impervious surfaces created by construction projects. The constructed levee system of Catalpa Creek originates near its headwaters on the campus of Mississippi State University continues onto the Leveck Animal Research Center into Sessums, MS through Oktibbeha County. These levees and other improvements have created experimental research and educational facilities on the Leveck Animal and Foil Plant Science Research Centers of the Mississippi Agricultural Experiment Forestry Station (MAFES). Waters of Catalpa Creek flow through Oktibbeha County under US 82 through Lowndes County into the Tombigbee River near Columbus, MS. The original channelized levee system provided flow of storm waters from an agricultural landscape historic to the foundations of the Mississippi Agricultural College founded in 1862 as a Land Grant Institution. As Mississippi State University developed into a major comprehensive university, lands that had infiltrated much of the storm water was now covered with buildings and other impervious surfaces such as parking lots. Storm water flow from MSU and neighboring private developments have increased the flood potential of downstream soil resources from "Occasional" to "Frequent". Channelized levee banks constructed in the mid-1930s reached a stable equilibrium down to the Selma Chalk streambed. The Marietta soil has a stable silty clay regolith layer above the Selma chalk (limestone) that has formed a stable erosional environment. Only the constructed levee portion has been subject to erosional bank scours at constructed nick points such as intruding pipes or at bridges. These scours have increased and will continue without abatement of excessive storm water flows from MSU and neighboring private developments as Catalpa Creek seeks to establishment a new equilibrium. A vegetative buffer by itself will not suffice. An alternative vegetative plan would be to cease mowing along the narrow exotic grass strips and allow natural vegetation to volunteer. Strategically located release points would alleviate excess flow in the main channel of Catalpa Creek and its West Catalpa Creek tributary. This will reduce mowing costs and suppress exotic grasses that rely on abundant sunshine and nutrients released by mowing. Two studies with native species volunteering nearby Catalpa Creek will be presented. These indicate that Andropogon sp. will readily volunteer and that most volunteer species are native (> 80%; 11 of 14 were natives).

Estimating the Optimal Water Requirement for Soybean Production in the State of Mississippi

LI X., FENG G.

Determining the optimal water amount required for soybean production is a critical step to optimize irrigation management. Previous studies mainly used field experimental data or simulation data from process-based crop growth models. But results based on those data are not always applicable to the real world production fields. This study uses the actual historical data of dryland soybean production from the state of Mississippi to estimate the soybean water response. Given that the precipitation is the only source of water supply, rainfalls are generally random across years, this dataset can be viewed as a natural experiment of soybean water response. Soybean yield data are collected from the USDA RMA (Risk Management Agency) for 76 out of the 82 Mississippi counties spanning the period 1991 to 2014. Precipitation data are obtained from the PRISM (Parameter-elevation Relationships on Independent Slopes Model) Climate Data at 4 km grids and then aggregated to county level. A piecewise nonparametric quantile regression is utilized to estimate how the potential soybean yield changes with precipitation level. Our interest is the conditional quantiles (upper 99%, 95%, and 90%) of yields rather than the mean yields. That is because at a given precipitation level, the yields can still be limited by other growing factors such as temperature, disease, pest, weed, management, technology, and so forth. The more useful information for producers is what maximum yields can be possibly achieved under a certain amount of water supply, given that all other factors are properly managed. The results show the potential soybean yields first increase with precipitation, and reach maximum at the range of 800-1000 mm. After that, the potential yields decrease when precipitation further increases. At low precipitation level, such as under 400 mm, the potential yields are around 35 bu/ac. With adequate precipitation, such as 800 mm, the potential yield can reach up to 55 bu/ac. But excessive precipitation causes potential yields to drop again. The optimal precipitation also varies with temperature. In cooler years (average daily temperature below 23°C) the optimal precipitations are around 700 mm, while in warmer (average daily temperature above 23°C) the optimal precipitations are slight above 800 mm. Those findings provide useful guidelines for optimal irrigation water requirements for Mississippi soybean production.

Characterizing Phosphorus Fractionation in Delta Soils

STEVENS E., YASARER L., LOCKE M.A., TAYLOR J.

As a historical floodplain of the Mississippi River, MS Delta soils are anticipated to have high natural nutrient content. In addition, years of farming and fertilizer applications have altered natural nutrient compositions and potentially created a legacy storage of soil phosphorus on agricultural land. As phosphorus-rich sediment erodes and is transported throughout the landscape, it may be stored in ephemeral drainage paths, ditches, and retention ponds, where it could potentially release phosphorus into the overlying water. This study is the first step in a series of analyses and experiments to characterize and quantify legacy soil phosphorus in a variety of land management types within a Delta watershed. Soil and sediment samples were taken from two locations in five different environments: cropland, Conservation Reserve Program (CRP) land, ditches, riparian forest, and a sediment retention pond. Sampling locations within these land types were chosen based on low elevation and the potential to experience ephemeral flow or elevated soil moisture throughout the year. Samples were taken in triplicate to total 30 samples, which were each homogenized in the laboratory. A series of sequential phosphorus extractions were then performed on field-moist, dried, and flooded samples. Extractions involved: water-soluble fraction, labile P (KCl), aluminum and iron- bound P (NaOH), calcium-bound P (HCl), and total P. The field-moist samples were processed immediately, while the dried samples were air-dried for several weeks, ground, and sieved to less than 2mm. Both field-moist and dried samples were extracted in aerobic environments. The flooded samples involved sampling field-moist soil/sediment into a jar with 70mL of overlying water and incubating at 24C for about 50 days to obtain anoxia. Flooded samples were then extracted in an anaerobic environment for the water-soluble and labile fractions. This analysis will help to understand how the hydrologic conditions in these different environments affect P fractionation, which can influence mobility and reactivity with overlying water.

STREAM HEALTH ASSESSMENT AND RESTORATION

Evaluation of Spatial and Temporal Variation in Stream Water Quality: A Case Study for a Mississippian Urban Headwater

RAMIREZ-AVILA J., ORTEGA-ACHURY S., SCHAUWECKER T., CZARNECKI J., MARTIN J.

Evaluation of spatial and temporal variation of water quality and identification of pollution sources is very important for effective implementation of watershed management actions/plans. Water quality monitoring data were collected from more than 40 monitoring stations along the main stream and tributaries of the Catalpa Creek between 2017 and 2018. Water quality distribution and characteristics of each stream is evaluated by conducting multivariate statistical analysis for 9 water quality parameters (i.e. temperature, dissolved oxygen, total suspended solids, total nitrogen, total phosphorus, total dissolved solids, pH, turbidity and electric conductivity). Results are expected to indicate if monitoring sites with high levels of pollution are directly affected by the direct contribution of urban or agricultural areas, the differences in type of riparian vegetation, occurrence of in-stream processes and/or seasonal variation of baseflow and stormflow rates. Impairment of waterbodies will be determined based on the study results, and priorities for water quality improvement, items required for watershed management implementation, will be determined for efficient water quality management in terms of future watershed management.

Abiotic Parameters Dictating Community Composition and the Ecological Functions of Freshwater Mussels

ATKINSON C., VAN EE B.

Animal aggregations can lead to localized hotspots of nutrient and material flux in streams. Yet, the abiotic characteristics driving the spatial structure of these hotspots due to species-specific preferences remain a mystery. Historically, unionid mussels dominated benthic biomass in many river ecosystems, but have undergone extensive declines. We examined reach-scale physical attributes of sites encompassing a gradient of mussel densities, evaluated quadrat-scale abiotic variables, and the role various species play in nutrient (C, N, P) sequestration and regeneration. We sampled mussels and abiotic variables at 1,218 quadrats, measured tissue nutrient composition and excretion and biodeposition rates of 11 species across 12 reaches in the Sipsey River, Alabama. Using geostatistical analyses, species distributions and their associated ecological functions were mapped and models were developed to examine species distributions and species' roles in recycling and storing nutrients. These models were used to examine species-specific roles in reach- and quadrat-scale nutrient recycling and storage. Our results demonstrate that mussels are important to nutrient dynamics through nutrient regeneration and the creation of storage hotspots, but their significance varies with distribution, species composition, and abiotic context.

Investigating the Effect of Habitat Availability and Stream Morphology on Macroinvertebrate Demographics in Red Bud/Catalpa Creek of Northeastern Miss

RICHARDSON B., MUSSER S., ORTEGA-ACHURY S., RAMIREZ-AVILA J., MARTIN J.

Rapid bioassessments using macroinvertebrates is one of the most popular ways to gather large amounts of data on stream health in a very short amount of time. A wide variety of indices have been developed to score and weight macroinvertebrate communities for the purposes of evaluating water quality, and many of these are state- or region-specific. However, the use of these indices can often bias results toward better water quality when taken at face-value, as the presence of only one individual of a certain group or species can significantly raise the water quality score of many indices. This study investigated the macroinvertebrate demographics of Red Bud/Catalpa Creek in northeastern Mississippi. The Pollution Tolerance Index (PTI) of the sampled stream reaches reported, almost exclusively, an "excellent" rating. However, community abundances showed that many samples were dominated tolerant taxa while the most intolerant taxa (indicators of good water quality) were represented by 1 or 2 individuals. Community analysis also showed that many stream reaches were vacant, or nearly so, of important functional groups such as scrapers and predators. The absence of these functional groups is likely due, in part, to the absence of adequate habitat and other resources. In one study stream, forested riparian vegetation is restricted to approximately a 200-m section in the upper reaches while the rest of the stream is flanked by thick grasses and invasive shrubs. This restriction of forest vegetation reduces the availability of sufficient food resources for shredders in downstream sections of the stream. The results of this study highlight the importance of ecological metrics and community demographics in the evaluation of stream health. Water quality and stream health indices using macroinvertebrates should be used to support these results of these metrics, not supplant them.

The Role of Riparian Vegetation Type in Stream Water Quality Conditions

MUSSER S., GRAFE J., ORTEGA-ACHURY S., RAMIREZ-AVILA J.

Stream health can be significantly affected by the type and characteristics of riparian zones along stream corridors. Research is focused on the identification and assessment of habitat, water quality, and flood hazard processes along the main channel and tributaries of Catalpa Creek. Research results would be used to support the implementation of the management plan for this watershed. A study is in progress to compare forested and grassed riparian zones on tributaries within the Catalpa Creek Watershed, in order to better understand their effects on stream water quality and health. Water quality is monitored weekly for parameters such as temperature, dissolved oxygen, pH, and turbidity. Grab samples are also collected and tested for quantification of total suspended solids and nutrients. Temporal and spatial differences in water quality, including changes in temperature, dissolved oxygen levels, and suspended solids will be assessed to determine how they are affected by seasonal changes (i.e. fall and winter) and the riparian zone characteristics (i.e. forested and grassed). Preliminary results indicate poorer stream health in grassed regions than forested regions. Overall, results would strengthen the case for properly maintaining and improving forested riparian zones to provide benefits in water quality and stream health in the Catalpa Creek.

Developing Regional Curves for Stream Restoration in Mississippi

RAMIREZ-AVILA J., ORTEGA-ACHURY S., MARTIN J., RICHARDSON B.

A long term stream assessment and restoration program is needed in Mississippi and developing Regional Curves is a critical first step toward achieving this goal. This project aims to provide validated tools to aid practitioners and Federal and State agencies in the design, evaluation and implementation of more effective stream and wetland restoration and mitigation projects in Mississippi. Main goal and project tasks will be achieved by using a combination of methods including remote sensing, field reconnaissance, detailed data collection, laboratory analysis and modeling. Project tasks include identification of stream reference reaches to conduct geomorphological and biological assessment and surveys within the Tombigbee River Basin, a representative area for the East Gulf Coastal Plain Physiographic Section and the Coastal Plain Province in Mississippi. Geomorphic and biological surveys will be related to drainage area to develop the Regional Curves and biological community references, respectively. Proposed Regional Curves will be compared to available Curves for the Coastal Plain Province in Alabama, Florida and Georgia. Stream restoration designs for an existing non-functional stream will be developed using both, the new proposed Curves and those from outer state. The new tools are expected to improve stream assessments and designs increasing the effectiveness of stream restoration projects.

UAV-EMERGING TECHNOLOGIES IN COASTAL PROCESSES

A Market Accessibility Study for the Inland Waterway System in Mississippi

PURYEAR S.

In order to find a good beginning point for this study, multimodal freight plans in neighboring states and in Mississippi have been reviewed to determine the level of knowledge about Mississippi's inland waterway assets from a state agency's perspective. In order to assess the accessibility for each port, a quantification method has been investigated and determined. Data and information for calculation are collected and processed currently. An exercise of building a multimodal network has been finished. Network data and impedance evaluation methods have also been investigated and determined. Future network configuration measures have been investigated and determined, including network centrality measurements.

In Mississippi, different entities have conducted studies on port development and its economic impact. It is clear that the port authorities need well established marketing strategies and plans to expand market and request funding. Some reports collected profile data about each port, although in different level of details. Important information about port capacity, throughput, efficiency, and commodity type are lacking. UAVs and portable scanning equipment are being coupled to provide accurate scans and input to simulations of inland port infrastructure and operations.

The ports included in this study are: Yellow Creek, Port Itawamba, Port Amory, Port Aberdeen, Lucas Port at West Point, Lowndes Co. Port, Rosedale Port, Greenville Port, Vicksburg Port, Claiborne Co. Port, Natchez-Adams Co. Port, Yazoo County Port, Bienville Port, Gulfport Port, and Pascagoula Port.

Evaluating the Effectiveness of Large-Scale Living Shoreline Projects at Restoring Fringing Marshes

MARTIN S., TEMPLE N., PALINO G., CEBRIAN J., SPARKS E.

In the wake of the Deepwater Horizon oil spill, large-scale breakwater projects have been constructed to restore and conserve marshes across the northern Gulf of Mexico. These breakwater projects are often termed living shorelines, due to the perceived increase in productivity around the breakwaters and within the fringing marsh shoreward of these structures. However, evaluations of the effectiveness of breakwaters at preserving natural shorelines are limited. To evaluate the effectiveness of large-scale breakwaters at protecting or restoring marshes in high wave energy environments, we conducted experimental plantings and a shoreline monitoring program landward of six year old breakwaters (OBW), recently constructed breakwaters (RBW), and reference no breakwater sites (NBW) along Bon Secour Bay, AL. The OBW, RBW, and NBW complexes cover 0.6km, 3km, and 1.2km of consecutive shoreline, respectively. Within the OBW and NBW sites, eight replicates of planted (4m2 of nursery grown S. alterniflora sods planted in checkerboard pattern), natural stand, and no vegetation treatments were randomly distributed throughout each site. Within the RBW sites, an additional planted design was also established (clumped plantings), yielding four shoreline vegetation treatments. Each plot was visited quarterly with a suite of vegetative measurements taken, including: percent coverage, species diversity, biomass, porewater DIN, and soil organic matter. Additionally, the perimeter of all of the natural S.alterniflora patches within each site was field mapped using an RTK GPS and validated with drone imagery to compare S.alterniflora area across breakwater treatments. Preliminary results indicate a positive effect of breakwaters beginning 5 years after construction on naturally colonized S.alterniflora, but no effect on planted vegetation using the fixed monitoring plot data. However, to date, the RTK GPS and drone imagery have shown no discernable effects of the breakwaters on enhancing shoreline vegetation. If these trends continue throughout the duration of the monitoring, they will show that large-scale breakwaters could have marginal effects of preserving and enhancing fringing marsh vegetation in high wave energy environments.

Remotely Sensing Sediment Tracers

LINHOSS A., CZARNECKI J., SAMIAPPAN S.

Tracking the movement of sediment in water is important for understanding the rate of coastal erosion and deposition. This understanding is critical for designing sustainable and resilient coastal infrastructure. Sediment tracers are one of few field techniques that can be used to track coastal erosion and deposition. Traditional sediment tracing methodologies involve recovering sediment samples and extracting the tracer material either by hand (particle by particle) or using magnets. This is an effective but time intensive and costly process.

This project explores the use of low altitude remote sensing to measure the concentration of sediment tracer in order to understand and track coastal sediment movement. Sand was mixed with various concentrations of fluorescent and magnetic sediment tracer. Samples were placed in containers, outdoors during daylight hours. An unmanned aerial system fitted with a hyperspectral sensor flew over the samples to collect reflectance data. The images were processed to detect the concentration of tracer in each sample. The results from the processed images were compared to the known concentrations. Preliminary results show that, at the plot scale, remote sensing is a promising technique for measuring sediment tracer concentrations. Future work will involve testing the method in field conditions along the Mississippi coastline.

Best Practices and Lessons Learned in using Low-Cost Unmanned Aerial Vehicles for Assessing Erosion

CZARNECKI J., RAMIREZ-AVILA J., LINHOSS A., SCHAUWECKER T., HATHCOCK L.

Unmanned aerial vehicles (UAV) are promoted as an efficient, low-cost tool for aerial survey. This includes not only traditional aerial photography, but also creation of digital surface models. The process, referred to as "structure from motion", has received attention in recent years as a replacement for other field survey techniques such as LiDAR and terrain laser scanning. We collected UAV images with large overlap between successive images over a two-year period to perform structure from motion analysis and monitoring of erosion. The goal of this research effort was to determine the limitations to the technology and the accuracy obtainable. The output of this research effort was best practice guidance for new users of the technology. As a summary of our results, we concluded that UAV images are capable of providing spatially-explicit, fine- to medium-temporal scale data. The output was advantageous for hydraulic models, offering more detailed channel geometry, as well as guidance on friction coefficients. The biggest impediment to accuracy was dense vegetative cover.

ROW CROP WATER MANAGEMENT

Soil Health Management Practices for Improving Rain Water Use Efficiency to Stabilize Dryland Soybean Yield

FENG G., REGINELLI D.

Soil health management is essential for sustainability of agricultural production system. Cover crop, manure and biochar have been widely applied for improving soil organic carbon (SOC). However, no consistent results were found whether and how much increasing SOC could improve water holding capacity of different soils. We conducted both field and simulation studies to determine impact of cover crop and amendment of poultry litter and biochar on SOC, soil water content at field capacity (FC) and water use efficiency (WUE). The results revealed that average annual percolation under the wheat cover crop system was decreased by 11%, over 8 decades as compared with the plots without cover crop. Soybean yield and water use efficiency (WUE) were increased by 4% and 9% in the cover crop-based cropping system. Growing a winter wheat cover crop between harvest and planting of soybean improved soil organic carbon by 15%. Application of poultry litter increased SOC ranging from 0.6 to 2.6%. A significant positive linear relationship was found between total carbon (TC) and FC of silt and silty loam soils as TC exceeded 1%. We found that a 1% increase in soil TC can improve soil water holding capacity by 13%. For different soil textures, a strong linear positive relationship was found in coarser soils (clay <20%). The soils from Brooksville had higher carbon content (mean value, 1.59%) and higher FC (34.64%) partly due to manure application than unmanured soils from Stoneville (TC of 0.92% and FC of 30.40%) in Mississippi State. We suggest soil carbon should be increased over 1% by applying manures and biochar or by other means to improve soil water holding capacity and overall soil health.

Increasing Mid-Southern USA Furrow-Irrigation Efficiency through In-Field Cultural Practices

BRYANT C.J., KRUTZ L.J., LOCKE M.A., STEINRIEDE JR. R.W., SPENCER G.D.

Declines of the Mississippi River Valley Alluvial Aquifer are currently unsustainable and require changes to current irrigation practices to ensure irrigated agricultures longevity. However, many environmental and economic factors prevent adoption of systems more efficient than the current furrow-irrigation method. Therefore, methods must be developed to increase the application efficiency of current irrigation systems. This study was established in Stoneville, MS to determine the effects of varying tillage systems with and without cover crops on furrow advance time, runoff volume, and irrigation application efficiency in continuous soybean (Glycine max) production. Treatments consisted of conventional tillage/winter fallow (CT/WF), reduced tillage/winter fallow (RT/WF), reduced tillage with in row sub-soiling (RT/SS), reduced tillage with a cereal rye (Secale cereal) cover crop (RT/RC), reduced tillage with a tillage radish (Raphanus sativus) cover crop (RT/TR), zone tillage/winter fallow (ZT/WF), and zone tillage with a tillage radish cover crop (ZT/TR). Furrow advance time was increased by at least 18% by switching to either zone tillage system or a RT/RC system. Utilizing CT/WF or RT/WF soybean production systems increased runoff volumes by at least 41% while reducing irrigation application efficiency by at least 24%. These data indicate that switching to conservation based soybean production systems that include either zone tillage or a cover crop can reduce runoff water volumes and increase application efficiency of Mid-Southern USA furrow-irrigation systems.

Factors Affecting In-Filed Soil Moisture

HODGES B.C., TAGERT M.L., PAZ J.O., REGINELLI D.

There have been numerous studies on soil moisture as it pertains to irrigation in Mississippi, but more work is needed in the agricultural region known as the Blackland Prairie, located in the northeastern part of Mississippi. Here, an increasing number of producers are showing an interest in irrigation. It is not economical to access groundwater over most of the region due to the depth of the aquifer, so many producers use surface water for irrigation. Sprinkler irrigation is the primary application method, to accommodate the changing topography across the landscape. Soil moisture sensors have been shown to conserve water usage while maintaining yields on irrigated fields, helping to better time irrigation applications with crop water needs. However, more work is needed to determine the ideal number of sensor sets needed over a given area and the best placement of sensors within a field. There are many variables that can affect soil moisture including topography, soil type, and the variability of vegetation. This study is being executed on a 15-ha soybean field under sprinkler irrigation near Brooksville, MS, in the Blackland Prairie region. A 55-m grid was placed over the field, resulting in 44 sample locations; Watermark Granular Matrix soil moisture sensors were installed at 12- and 24-inch depths at each sampling point. The sensors were wired to data loggers, which recorded soil tension measurements hourly. Plant height and leaf area index (LAI) were measured weekly from June 29 through August 17, 2018. Soil texture was measured for each grid point, showing a relatively homogenous field with a silty clay loam as the dominant soil type. Results show spatial differences in soil moisture over time, with more variability when the soil profile is drier.

Contrasting Evaportransporation Requirements of Staple Row Crops in the MS Delta

ANAPALLI S.S., REDDY K.N., KRUTZ J.

Aquifers all around the world, that took millions of years to fill are being depleted due to unsustainable water withdrawals for crop irrigation. The Mississippi (MS) Delta, one of the most important agricultural production regions in the USA, relies mostly on water from the MS River Valley Alluvial Aquifer for irrigation needs. Soybean represents about 53% of the irrigated area, while the remaining shared between other crops and aquaculture. Pumping water from this shallow aquifer beyond its natural recharge levels has already resulted in significant aquifer declines, threatening the future of irrigated agriculture in the MS Delta. Accurate information on crop evapotranspiration demands (consumptive water requirements; ET) of staple crops in the MS Delta is essential for developing environmentally and economically sustainable water management practices. We quantified ET of corn (a C4 crop) and soybean and cotton (C3 crops) in a predominantly clay soil under humid climate in the Lower MS Delta using the eddy covariance method. In 2017 season, corn, soybean, and cotton fixed 31331, 23563, and 8856 kg ha-1 of CO2 in exchange for 483, 552, and 367 mm of ET, respectively. Crop durations were 120, 135, and 137 days, respectively for corn, soybean, and cotton. Maximum LAI and average grain yield produced were 5.5 and 12772 kg ha-1, 5.5 and 4777 kg ha-1, and 3.0 and 1260 kg lint ha-1, respectively, for these crops. The seasonal net ecosystem exchange (NEE) of CO2 estimated for cotton was 72% less than corn and 62% less than soybean. Estimated average daily ET of corn was 4.0 mm, soybean was 3.9 mm, and cotton was 3.0 mm. The ecosystem water use efficiency in these three cropping systems were 53, 43, and 24 kg CO2 ha-1 mm-1 of water. The WUE in grain production of corn was 26 kg ha-1 mm-1 and soybean was 9 kg ha-1 mm-1 of water. Results of this investigation can help in adopting crop mixtures that are environmentally and economically sustainable, conserving limited water resources in the region.

Irrigation Water Use Efficiencies of Twin-Row vs. Single-Row Soybean in the Humid Mississippi Delta

PINNAMANENI S.R., ANAPALLI S.S., REDDY K.N., FISHER D.K., BELLALOUI N., SUI R., BOYKIN D.L.

In the humid climate of the Mississippi (MS) Delta, high intra-seasonal variability in the rainfall received during the critical periods of crop growth often makes irrigation necessary to maximize crop yields. Farmers in this region, generally, meet their crop irrigation water demands by pumping water from the shallow MS valley alluvial aquifer underlying this region. However, water withdrawal beyond the aquifer's natural recharge levels is resulting in significant groundwater-level declines, thereby threatening future water availability. A field study was initiated in the summer of 2018 to compare the water use efficiencies between twin-row and single-row planted soybean (Glycine max L.) cropping system under varying irrigation levels in a Dundee silt loam soil in the humid climate of MS Delta. The soybean was planted on ridges spaced 102 cm apart and furrow irrigated. In the twin-row plantings, soybean was planted in two rows of 25 cm apart on a 102 cm center. The experimental design used in this study was a split-plot with irrigation as main unit and row spacing as subunit, replicated six times. Irrigation levels were full irrigation (FI), half irrigation (HI), and rainfed (RF). Irrigations were scheduled based on soil water measurements. Twin-row planting had a significant impact on grain yield over single rows in all the irrigation treatments (5.03 t ha-1 vs. 3.01 t ha-1 RF; 5.70 t ha-1 vs. 3.84 t ha-1 HI and 6.14 t ha-1 vs. 5.06 t ha-1 FI). Similarly, seed test weight increased considerably due to irrigation: 14.76 g RF vs. 16.29 g HI vs. 17.79 g FI in single rows and 14.76 g RF vs. 16.67 g HI vs. 17.48 g FI in twin rows, respectively. Nutritional quality was assessed using a standardized near-infrared reflectance (NIR) diode array feed analyzer protocol. Significant enhancement in the levels of seed protein, palmitic acid, aspartic acid, glycine, methionine was observed in FI and HI while sucrose levels were elevated in the rainfed soybean. The growers can consider transitioning to twin row system of soybean production with alternate row irrigation during critical periods of crop growth for enhanced water use efficiency and crop profitability.

AQUATIC ECOSYSTEM FUNCTION

The Influence of Submarine Groundwater Discharge on the Quality of Mississippi Coastal Waters: Example of Hypoxic Events in Summer 2016 and 2017

SANIAL V., SHILLER A., MOORE W.

The quality of the Mississippi Sound and Bight ecosystem, and as a consequence of economic activities such as tourism and fisheries, is directly affected by land-derived chemical elements. Rivers supply large amounts of allochthonous nitrogen that impact the ecosystem by stimulating primary production, which sometimes leads to coastal eutrophication as well as harmful algal blooms. The Mississippi Sound and Bight, located to the east of the Mississippi River Delta, experience hypoxia that is often attributed to nutrient-rich Mississippi River waters. However, oxygen isotopes show a limited influence of the Mississippi River waters in the Mississippi Bight in spring and summer 2016, but rather a dominant freshwater source originating from local rivers with much lower nutrient concentrations. Therefore, we hypothesize that there is likely an additional factor, namely submarine groundwater discharge (SGD), that significantly impacts the quality of Mississippi coastal waters by playing a role, in particular, in hypoxia. SGD is a hidden pathway for the transfer of chemical substances (such as nutrients, metals, and pollutants) from the land to the coastal ocean. Unlike rivers, SGD is difficult to monitor due to its diffuse nature, which limits the use of direct physical measurements. Tracing techniques, measuring geochemical species such as radium isotopes (Ra) that are naturally enriched in groundwater, constitute a powerful tool to assess the extent of SGD influence in the coastal zone. Hypoxic Mississippi Bight bottom waters in summer 2016 were enriched in Ra, but also in barium (Ba), and nutrients that cannot be accounted for sediment diffusion or river inputs, which suggests the presence of SGD. Spatial distribution in bottom water concentrations of certain dissolved trace elements (e.g., Mn, V, REEs) also suggests spatial differences in fluxes of species from the sediments are affected by bottom oxygen. Further evidence of SGD comes from the increase of Ra associated with a rise in nutrients and methane in coastal Mississippi Sound waters shortly after a Jubilee event in July 2017.

Submarine Groundwater Discharge (SGD) in the Mississippi Sound and its Potential Links to Hypoxia

MOODY A., SHILLER A.M., SANIAL V.

Submarine groundwater discharge (SGD) in the Mississippi Sound is an understudied component of nutrient and trace metal cycling. Submarine groundwater discharge is the combined flow of freshwater from aquifers and the recirculation of seawater through sediments that occurs along the coastline and across the continental shelf. In July 2017, a low oxygen (less than 2 mg/L) event occurred in the Mississippi Sound causing a "jubilee" event, where large masses of demersal organisms came towards shore. We collected water samples at five locations along Mississippi beaches and analyzed them for chemical species typically enriched in SGD (e.g., Ra isotopes, Ba, methane). During this period of low oxygen there were increased groundwater signatures, suggesting a correlation between the hypoxic conditions and groundwater release. Dissolved methane (CH4) and 224Ra (half life = 3.66 d) were significantly higher than what we observed during more normal conditions. The high levels and short half lives of both indicators suggest that there was a recent release, and nearby source, of groundwater. Historically, low oxygen events have been observed in the Sound, so it is important to understand what causes them. Our results suggest that understanding the origins and forcing factors for local SGD may be an important aspect of predicting and managing hypoxia in the Sound. In order to determine if SGD may enhance or lead to hypoxia in the Mississippi Sound, an ongoing time series along the coastline has been collecting radium, nutrients, barium, and oxygen data. In order to understand if there are spatial components of SGD, radon surveys are also being conducted throughout the Sound. Preliminary results indicate that SGD is highest along the coastline. However, more work is needed to determine the sources and impacts of SGD within the Mississippi Sound.

Microplankton Trophic Dynamics in the Northern Gulf of Mexico

BOYETTE A.D., CRUZ V.J., GRAHAM W.M.

Improved understanding of microplankton (< 200 µm) community dynamics and trophic connectivity between primary producers and heterotrophic protists is central to plankton ecology and water quality studies. Despite their ecological significance in structuring aquatic ecosystems, there is limited knowledge on phytoplankton-microzooplankton trophic interactions in the northern Gulf of Mexico (nGOM). Here we describe the microplankton community structure using a morphological based functional group (MBFG) approach to classify microplankton images obtained from imaging in-flow technology (FlowCAM®), primary production (photosynthesis-irradiance curves, P-E), and phytoplankton apparent growth and mortality (dilution experiments) within inner shelf surface waters of the nGOM during two seasons (fall, spring). Additionally, we evaluated the importance of protist grazers, particularly ciliates, as predators on phytoplankton. Phytoplankton biomass was dominated by diatoms in both seasons, with average chlorophyll a (3.8 mg m-3) more than twice that of fall (1.7 mg m-3). Needle-like (Pseudo-nitzschia sp.) and cells with setae (Chaetoceros sp.) were the predominant diatoms, whereas small (<20 µm) cryptophytes, prymnesiophytes, and Heterocapsa sp. dinoflagellates comprised more than 80% of the flagellate community in both seasons. Aloricate choreotrichid ciliates (Strombidium sp., Strombilidium sp.) were the primary microzooplankton grazers, though >50% of the ciliates were mixotrophic the Mesodinium rubrum. Phytoplankton potential production (0.01 x 0.38 gC m-3d-1) and apparent growth (0.01 x 2.53 d-1) were greater in spring, although highest maximum photosynthetic rates (PBmax = 34.07 g C g Chl-1 h-1) were measured in fall. Microzooplankton consumed ~ 40% phytoplankton biomass and > 65% of the daily primary production. The ratio of microzooplankton grazing to phytoplankton growth (m:µ) averaged 1.14, suggesting that microzooplankton grazing is an important top-down control on phytoplankton biomass in this system.

Ecological Agriculture Application with Winter Flooding

FIRTH A., BAKER B., BROOKS J., DAVIS J.B., IGLAY R., SMITH R.

Rice is the staple food for more than half of the world's population and has the ability to support more people per unit of land area than wheat or corn, as rice produces more food energy and protein per hectare than other grain crops. However, with the human population projected to reach 8.5 billion by 2030, there are major concerns about the sustainability of rice production practices because of its major contribution to water pollution and soil degradation. Thus, there is a need to identify sustainable production practices that minimize environmental damage, while also remain economically feasible. This study investigated a potentially sustainable rice production system in the Mississippi Alluvial Valley (MAV) that uses ecological principles to enhance environmental quality and economic gain at the field scale. It was hypothesized that the annual flooding of rice fields to create water bird habitat would benefit soil health, and in turn water runoff, providing agronomic benefits to the farmer alongside environmental benefits. Two rice farms were selected that applied different management regimes during the winter: conventional fallow fields and winter flooding. Soil microbial diversity and nutrient content were quantified and compared for a measure of overall soil health. Measured soil health variables linked flooded fields and high bird activity with more nutrient and microbial activity. Evidence from the investigation provided justification for future research, to develop a framework for other producers within the MAV to adopt similar management methods, ultimately improving the overall integrity of soil, water, and environmental quality as well as the farmer lifestyle.

GROUNDWATER RECHARGE & SUPPLY

The State of Groundwater Assessment in Alabama

GUTHRIE G.M.

The Geological Survey of Alabama (GSA) Groundwater Assessment Program has two priorities in support of the development of a state-wide water management plan. The first priority is to monitor the state's groundwaters by: (1) conducting bi-yearly water level sampling, (2) expanding the real-time and continuously monitored well network, and (3) developing a GIS-based well database. The second priority is to utilize information from the initial assessment report entitled "Assessment of Groundwater Resources in Alabama 2010-2016", published as GSA Bulletin 186 in 2018, in conjunction with new data to develop a comprehensive integrated and calibrated water model for the state that will incorporate groundwater, surface water, land use, water use, and climatic data. Alabama's water resources are distributed in diverse settings, so the model will be a composite of subareas defined by HUC-8 boundaries rather than a singular state-wide model. The modeling process will utilize pilot projects representative of the state's aquifers to develop procedures that will be used in subsequent modeling of comparable aquifer environments. Two pilot projects have been initiated: the north Alabama Wheeler Lake HUC-8 and the west Alabama Middle Tombigbee-Choctaw HUC-8, representing the Appalachian Plateau and Gulf Coastal Plain aquifers, respectively. Future pilot projects will focus on basins located in the Valley and Ridge and Piedmont areas of the state. The model is being developed to allow responsible parties to make water-related and policy decisions in response to changing water stresses.

Estimation of Groundwater Recharge by Chloride Mass Balance (Cmb) in the Southwestern United States

MUKHERJEE A., HOLT R.M., O'REILLY A.M.

Groundwater recharge is defined as water flux across the water table from the unsaturated to saturated zone. Recharge is a critical factor in groundwater resource management in arid and semiarid regions and often the most difficult component of the hydrologic cycle to quantify. Recharge is very small in arid and semiarid regions and thus needs to be carefully and accurately estimated. The objective of this study is to calculate recharge in the arid and semiarid areas of the southwestern United States using the chloride mass balance (CMB) method based on numerical simulation. Estimation of recharge using a natural tracer such as chloride (Cl) has the significant advantage of increased sensitivity at lower recharge rates. The HYDRUS 1D computer code was used to simulate water flow and solute transport for four sites: High Plains (HP), Eagle Flat (EF), Hueco Bolson (HB), and Amargosa Desert (AD). The entire unsaturated zone, extending from land surface to water table, was simulated at each site in this simplified modeling approach. Assigned conditions are assumed to be representative of long-term average conditions, circumventing the diurnal and seasonal variation of complex water flux dynamics, especially in the upper part of the domain near the surface. All Cl profiles are bulge shaped with low concentrations near land surface, increasing to peak concentrations at depth assumed to be root zones, and then decreasing to a more or less constant concentration with depth. Recharge fluxes were calculated based on Cl concentrations beneath the bulges. Recharge rates calculated using the CMB method from the four sites are 3.67 mm/yr for HP, 0.03 mm/yr for EF, 0.1 mm/yr for HB, and 8.64 mm/yr for AD, which represent <1%, <0.01 %, <0.05 %, and 8% of mean annual precipitation of each respective site.

Groundwater Recharge from Oxbow Lake-Wetland Systems to Alluvial Aquifers

GRATZER M., DAVIDSON G., O'REILLY A.M., RIGBY J.R.

Knowing recharge rates and understanding recharge mechanisms are crucial to managing water resources. Groundwater recharge from oxbow lake-wetland systems to alluvial aquifers is poorly understood. The aim of this study is to determine whether Sky Lake, an oxbow lake-wetland system in northern Humphreys County, Mississippi, provides significant recharge to the Mississippi River Valley Alluvial Aquifer (MRVAA). To answer this question, we monitored lake-wetland stage and groundwater levels in the wetland and around the entire lake-wetland system from December 2016 to October 2018. Our analysis indicates that Sky Lake provides significant recharge to the MRVAA, based on a groundwater ridge located beneath the lake, groundwater responses to surface-water changes, and a higher correlation between groundwater level and lake stage than between groundwater level and rainfall intensity. Possible recharge mechanisms include preferential flow paths created by tree limbs and roots buried in the wetland sediment as well as coarse-grained point bar deposits near the east side of the lake. Oxbow lakes are created as river meanders and tend to have forested wetlands in the Lower Mississippi River Valley. Therefore, the recharge observed at Sky Lake likely occurs at other oxbow lakes. Similar studies could be carried out at these other lakes, monitoring lake-wetland stage and groundwater levels over time to test whether these lakes significantly recharge the alluvial aquifer.

Assessment of Vadose-Zone Recharge Wells in the Mississippi River Valley Alluvial Aquifer as an Artificial Recharge Method

KWAK K., O'REILLY A.M., RIGBY J.R.

Increasing concerns regarding depletion of groundwater in the Mississippi River Valley alluvial aquifer in the Delta region of Mississippi have led to a need to augment natural recharge. Infiltration basins are often one of the simplest means of artificially recharging aquifers. However, the Delta has a layer of clay and silt at the surface, so it is a better idea to use vadose-zone recharge wells that are not limited by the surficial layer of fine soils. The purpose of this study is to use full-scale field testing to assess the feasibility of using vadose-zone wells for artificial recharge of the Mississippi River Valley alluvial aquifer by using a combination of field, laboratory, and computer simulation techniques.

An initial field test indicated each of two vadose-zone wells could intake 100 to 170 m3/day by gravity flow. Eight soil samples were collected from the site and their saturated hydraulic conductivities (Ksat) and wetting/draining curves will be determined using falling head permeability test, METER Hyprop, and hanging water-column method. An axisymmetric model was developed using VS2DTI software from the USGS. The simulations were run with a range of Ksat and porosity (n) values. The results of the simulations show that head changes at the nearest monitor well are likely to be smaller with a greater ratio of Ksat/n and vice versa. A final full-scale field test will be performed by simultaneously running multiple (up to four) vadose-zone wells. A three-dimensional variably saturated flow model will be developed to analyze the final test. This research will provide understanding of the hydraulic properties controlling vadose-zone wells and operation of the artificial recharge system. As most alluvial aquifers have similar geological settings as the Delta, results are expected to be relevant to other areas.

COASTAL PROCESSES

Further Developments of the Hydrodynamic/Water Quality Model for Oyster Restoration in the Western Mississippi Sound

ARMANDEI M., LINHOSS A.

The development of a hydrodynamic and water quality model for the Western Mississippi Sound is addressed here. The hydrodynamic part of the model simulates flow, salinity, and temperature. The hydrodynamic part of the model is also the driving mechanism for nutrient transport. The water quality part of the model simulates the physical, chemical, and biological characteristics of Western Mississippi Sound. The model has been developed using the Visual EFDC program that links the hydrodynamic model to the water quality model. A computational grid has been generated consisting of 4 layers, each having 3000 cells. The input data for the hydrodynamic model are; water level, water temperature, salinity, precipitation, solar radiation, wind speed, wind direction, air pressure, and air temperature. The input data for the water quality model are; dissolved oxygen, nutrients (such as Carbon, Nitrogen, Phosphorus and their compounds) and Algae. The simulation time period is from Jan 1st, 2009 to Dec 31st, 2017. The hydrodynamic part of the model is finalized, whereas the water quality part is still being calibrated. The model will be used to identify the most appropriate locations for oyster bed restoration and cultch deployment in the Mississippi Sound.

Assessment of Marsh Terraces Performance in Coastal Louisiana U.S. using Multi-Temporal High-Resolution Imagery

OSORIO R.J., LINHOSS A., DASH P.

Coastal Louisiana is facing wetland loss and land cover change. Their marshes are drowning due to land subsidence and sea-level rise. Marsh terraces are one of the many techniques that can be applied for wetland restoration by reducing wave energy in the northern Gulf of Mexico. Marsh terraces are segmented ridges of soil that are built in inland, shallow coastal ponds. They are designed to increase marsh area, dissipate wind driven waves, and encourage marsh expansion. Marsh terraces have been implemented for almost 30 years; however little research has been conducted to determine their effectiveness.

The objective of this study was to assess the change in marsh terrace area over time through remote sensing and change detection analysis. This analysis was conducted using 1-meter resolution imagery from the National Agriculture Imagery program (NAIP) from 2003 until 2017 from five Louisiana coastal Parishes. Marsh terrace sites of at least 10-14 years old were selected randomly within each Parish. Results show more cumulative deposition than erosion in marsh terraces. These results also show that terraces, which have adjacent channels, and thereby an external supply of sediment, show more deposition compared to terraces within enclosed lakes. In the future, the results obtained from this study will be also related with terrace design and environmental factors to understand which features influence marsh terraces erosion or deposition, determine trends in marsh terrace performance and possibly understand which design is most effective when accomplishing their restoration goal.

Comprehensive Review of Plans, Priorities and Efforts for Land Conservation Along the Gulf of Mexico Coast

LINHOSS A., EVANS K., SAMIAPPAN S., LIU J., ROBERTS J., SHAMASKIN A., ASHBY S.

This study reviews past, current, and future land conservation priorities in the Gulf of Mexico coastal region. The review catalogs an extensive list of projects and plans proposed and implemented at federal, state, county, and city levels with direct ties to land conservation during the past 20 years. Five conservation goals proposed by Gulf of Mexico Restore Council were used as a framework for grouping the identified conservation plans and projects. The goals are: 1) Restore and Conserve Habitat, 2) Restore Water Quality, 3) Replenish and Protect Living and Marine Resources, 4) Enhance Community Resilience, and 5) Restore and Revitalize the Gulf Economy. A series of five charrettes were conducted with stakeholders in the coastal states to validate the catalog and add missing projects and plans. A geospatial web tool has been developed as part of this work to allow for identification and exploration of plans in the region. This review also investigates the associations between the Restore goals and conservation priorities among states and different geographic extents. The review suggests that (across the different states, and geo-extents) there is a considerable dependence between the focus of conservation plans and the geo-extent the plan originated. This study is the first large-scale regional assessment of conservation planning efforts across governmental and non-governmental organizations encompassing all ecosystem types in the Gulf of Mexico. This comprehensive analysis at the Gulf Coast Region level is vital to understand the key factors that may drive conservation efforts, as well as identify potential gaps in conservation planning efforts. A holistic understanding of the origin of conservation plans and their relationship with respect to Restore Council conservation goals can be useful in understanding and aligning conservation planning efforts to funding opportunities associated with Restore goals.

Science-Based Land Conservation Prioritization Framework: An Overview

SAMIAPPAN S., LINHOSS A., EVANS K., ROBERTS J., LIU J., SHAMASKIN A.

The overwhelming consensus among the conservation experts is the immediate requirement for an efficient data-driven science-based geospatial conservation prioritization tool that can help guide or optimize the dollars spent on land conservation. In this work, we propose a framework for conservation prioritization that enables integration of 1) openly available peer-reviewed data from federal and state agencies, 2) the priorities and values identified in local and regional plans with those identified by stakeholders representing local and regional agencies and organizations. The framework developed as part of this work is implemented as a web geospatial tool. In this work, a multi-criteria decision analysis method is adapted for a conservation decision support problem. The tool was developed and tested with five conservation goals proposed by Gulf of Mexico Restore Council were used as a framework for grouping the identified conservation plans and projects. The goals are 1. Restore and Conserve Habitat, 2 Restore Water Quality, 3. Replenish and Protect Living and Marine Resources, Enhance Community Resilience, and Restore and Revitalize the Gulf Economy. A series of five charrettes were conducted with stakeholders in the coastal states to validate the developed tool and get feedback. The goal of this project is to develop science-based land conservation planning tools that can help the Gulf Coast Ecosystem Restoration Council members to identify and evaluate potential land conservation projects and strategies.

DAM SAFETY

Managing the State's Inventory of Dams

MYERS D., WATTS J.

The Dam Safety Division of the Office of Land and Water Resources (OLWR) within the Mississippi Department of Environmental Quality (MDEQ) is tasked with regulating dams within the state to protect downstream lives and property. The original inventory of dams was completed in the early 1970s prior to the passage of legislation in 1978 creating a state dam safety program. This inventory was updated during the early years of the program but did not undergo any major updates until 2013. To expedite the process of updating the inventory, the program created Geographic Information Systems (GIS) tools to automate many of the steps used to locate and properly classify dams. Information will be presented on the evolution of the state's inventory of dams, the number and beneficial uses of dams, the GIS tools and procedures created, and ongoing efforts to improve and maintain the inventory to better protect the public.

The Regulatory Process of Inspections and Compliance

KING P., CUMMINGS A.

The State of Mississippi requires that high and significant hazard dams are inspected annually. While owner inspections are allowed, at least every 5th year the owner must hire a licensed professional engineer to perform the inspection. These inspections help the Mississippi Department of Environmental Quality (MDEQ) Dam Safety Division assess the condition of each dam and identify needed repairs. The Dam Safety Division assists dam owners in identifying critical repairs to safely maintain their dams and to comply with State regulations. If the required actions are not taken, enforcement procedures are necessary. MDEQ has broad authority to take necessary actions to get deficient dams into compliance, such as imposing penalties to draining the lake and breaching the dam. This presentation will focus on the inspection process and explain the methods used to ensure all high and significant hazard dams are compliant with State Regulations.

Dam Decommissioning

ATKINS J.

The Mississippi Department of Environmental Quality (MDEQ) Dam Safety Program is responsible for regulating dams across the State of Mississippi. Excluding NRCS watershed dams, over 90% of the dams regulated by the Dam Safety Program are owned by private entities, such as individual citizens, homeowners association, etc. If a dam is reclassified from low hazard to high or significant hazard, the cost to bring the dam into compliance with the regulations can often exceed the financial ability of the dam owner. In these cases, owners sometimes choose to drain and breach the dam. Information will be presented on the processes and procedures utilized by the Dam Safety Division to have a dam safely breached and removed along with some case studies of dam removals.

Emergency Action Plans (EAPs) vs Actual Dam Events

GRAHAM Q.

All high hazard dams in the state are required to have an Emergency Action Plan (EAP). The EAP contains procedures for detection, notification, and evacuation in the event of an incident or failure at a dam. The goal of the EAP is to have a plan in place which will allow for a rapid response so that efforts can be made to intervene and prevent the failure or to evacuate residents downstream in order to prevent loss of life. However, dam failures don't always go according to the plan. Information will be presented about EAPs and the information they contain as well as case studies on real life responses at dam failures and incidents and how they compare to the EAP process.

DSS-WISE Web: A Web-Based Automated Modeling, Mapping and Consequence Analysis Tool for Improving Dams Safety in the USA

ALTINAKAR M., MGGRATH M., RAMALINGAM V.

The National Inventory of Dams (NID) includes the records of more than 90,000 dams classified in three hazard classes: high-hazard (HH), significant hazard (SH) and low-hazard (LH). Although required by law, 17.1% of 15,498 HH dams and 13.1% of 11,883 SH dams do not yet have an emergency action plan (EAP). Moreover, some of the existing EAPs are outdated or do not meet the standards set by FEMA and/or the individual states. About 65% listed in the NID are privately owned, but the safety of the dams is under the responsibility of the states. Unfortunately, many dam owners do not fully understand their personal liability in case of a failure and/or may not have the funds to hire professional services of an engineering company to establish an EAP. The state dam safety offices needed a reliable and accurate tool for dam-break modeling to track the hazard classification of their dam portfolio, which may change based on downstream development, and to provide up-to-date EAPs.

Funded by FEMA through a sole-source contract, NCCHE developed a web-based, automated two-dimensional dam-break flood modeling and mapping tool called DSS-WISE Lite, which is accessed through DSS-WISE Web secure web portal. The DSS-WISE Web portal was released on November 8, 2016. A graphical user interface with a map server assists the user to set up simulations quickly and efficiently by responding to a small number of questions. The input files needed for the numerical model are automatically prepared using various national data layers, such as NID, USGS 1/3 arc-second digital elevation model (DEM) tiles, National Levee Database (NLD), National Land Cover Database 2011 (NLCD2011), and National Bridge Inventory (NBI). Resampled at the user-specified resolution (20 to 200 ft.), the DEM serves as a regular Cartesian computational grid. The levees from NLD and the estimated reservoir bed topography are burned into the computational grid. The simulation engine uses a shock-capturing upwind scheme to solve the conservative form of full dynamic shallow-water equations discretized over the complex topography using finite-volume method and handles mixed-flow regimes, wetting and drying and discontinuities, such as jumps or traveling positive waves. The results can be viewed on a map server on the Status and Results page of DSS-WISE Web and downloaded onto the user's computer for further analysis. Recently, a post-processing module called DSS-WISE HCOM was released under DSS-WISE Web to provide an estimation of the human consequences of the dam-break floods based on the results of DSS-WISE Lite simulation. This module provides flood danger maps for different categories of population and the evolution of nighttime and daytime population at risk (PAR) by hazard classes using LandScan USA data layers developed by Oak Ridge National Laboratory.

This presentation briefly presents the capabilities of the DSS-WISE Web portal, which is being used by 730 users from numerous federal agencies and 35 state dam safety offices. As of mid-February 2019, the system handled 13,836 simulation requests and performed 10,623 dam-break flood simulations for more than 3,000 dams. The computational performances of the DSS-WISE Lite system, which returns 85% of the simulation results to the user within 30 minutes, has made it an extremely valuable real-time emergency management tool. Exampled of the use of DSS-WISE Web as a tool for preparedness and emergency response planning are discussed.

WHAT IMPACTS YOUR DRINKING WATER?

The Southeastern Partnership for Forests and Drinking Water

MORGAN R., WEISMANN K.

The USDA Forest Service (USFS) and the US Endowment for Forestry and Communities are collaborating with several Southeastern states on the Southeastern Partnership for Forests and Water (the Partnership). This initiative began in 2012 when South Carolina Rural Water Association conducted a high-level, collaborative, multi-state meeting in Greenville South Carolina among state drinking water and forestry agencies, associations and conservation groups. The gathering provided information about the importance of drinking water and forest lands, forestry and drinking water perspectives, and creative financing tools for drinking water protection (referred to as source water protection) in forested watersheds. The initiative recognizes that healthy forests benefit source water quality and quantity. Stewarding, enhancing and maintaining healthy forests in key Southeastern drinking water source watersheds is necessary due to increasing population growth and urbanization in the Southeast, which is resulting in forest fragmentation, forest losses, and a decline in forest health. The purpose of the initiative is to maintain healthy watersheds that provide safe, reliable drinking water, healthy forests, and strong local and regional economies. After the initial meeting in South Carolina the Partnership was formalized. Eight southern states including Alabama, Arkansas, Florida, Georgia, North and South Carolina, Texas and Virginia are now actively involved Partnership. This presentation will discuss the goals, strategic plan and activities of the Partnership along with initial results from state efforts. Attendees at the presentation will acquire appreciation of the value of collaboration between the forestry and drinking water sectors, how the Partnership has operated, and what outcomes may be realized through collaborative projects.

Mississippi Private Well Characteristics and Well Owner Demographics

BARRETT J.R.

Mississippi citizens who acquire their drinking water from private wells do not have the luxury of knowing the quality of their drinking water on a regular basis unless they are making the effort to have their water screened and tested. Without knowing and understanding the safety of drinking water, private well owners do not know if and when treatment is needed. Approximately 88% of Mississippi citizens are served by one of the 1,100(+/-) public water systems which provide safe reliable water under the regulatory guidance of the Mississippi State Department of Health-Bureau of Public Water Supply. Private well owners are free to own, operate, and maintain their wells because there is no regulatory oversight. For some private well owners, this freedom is welcome but others want to know the quality of their drinking water and best practices for proper maintenance.

No demographic data about private well owners has been compiled since the 1990 census. Since the inception of Mississippi State University Extension's Mississippi Well Owner Network, demographic data has been collected and workshops have allowed private well owners the opportunity to have their well water screened for bacteria. This presentation will compare demographic data of current private well owners with those from the 1990 census as well as compare to overall Mississippi demographic data. Private well characteristics are also gathered when a well owner has their water screened for bacteria. Characteristics may prove beneficial when analyzed against the presence of bacteria to assist well owners in making improved decisions on the treatment or introduction of treatment to their well water. The concluding data can be utilized to better understand and serve Mississippi private well owners.

This study should be of interest to representatives of local municipal water systems, local communities, and rural water associations for potential expansion of their water systems. The regulatory oversight of public water systems should promote and produce a safer drinking water supply for Mississippi residents. The study should also be of interest to private well owners as they navigate life obtaining their drinking water from an unregulated source.

Teaser: Approximately 12% of Mississippians derive their drinking water from a private well and are unaware of the quality of their drinking water. The Mississippi Well Owner Network has created a venue to educate and inform private well owners about their private well and offering bacteriological screening of the well water. Regardless of location or age of a private home well, the water quality should not be assumed or not known.

The Value of On-Site Wastewater in Mississippi

WELCH D.

The 2010 US Census lists approximately 50% of the population of MS as living in “rural” areas. The vast majority of the homes & businesses in these areas are served sewer by on-site wastewater treatment and disposal systems. This presentation will focus on the economic and societal value of serving areas with sewer that might not otherwise be habitable. It will also focus on the potential costs and issues associated with malfunctioning on-site wastewater disposal systems and issues that currently face the Mississippi State Department of Health in regulating the usage of on-site wastewater treatment and disposal systems. There will also be a focus on the attitudes of the wider public as it relates to on-site wastewater treatment and disposal.

Lead Contamination in Drinking Water and Associated Housing Characteristics in the Mississippi Delta

WILLETT K.L., OTTS S.S., WOO L., FRATESI M.A., HAGGARD R., JANASIE C., THORNTON C., RHYMES J.

This project aimed to create an atmosphere of community and inclusion in order to inform and influence a major public health issue, namely lead contamination of drinking water. Community-based participatory research enabled an assessment of residential drinking water supplies in the Mississippi Delta. We partnered with multiple community organizations to test lead concentrations in drinking water and survey residents about their housing characteristics. Through variously styled community events, drinking water from 215 homes in Mississippi were analyzed for pH and lead concentrations, representing a 74% bottle return rate. The highest concentrations were associated with a targeted private well owner event. Detectable lead concentrations were found in 61% (n = 122) of samples ranging from 0.06 to 14.3 ppb. Of the 122 samples with detectable lead, 9 exceeded 5 ppb. Participants from these homes were provided a certified sink filter. The pH of the waters ranged from 5.84 to 9.13. Five of the nine samples with lead concentrations > 5 ppb had pH < 7 suggesting a correlation between acidic water leaching lead from pipes. Letters were sent to each participant notifying them of their water results. Demographic data collected from the participants were correlated with U.S. Census tract data, which allowed us to determine at-risk areas. Outcomes of this research include a system for determining the best community engagement methods for collecting samples and the best methods for identifying at-risk areas. By involving members of the community in the project, we spread awareness and provoked action in order to minimize lead exposure. Ultimately, this project has helped safeguard public health because survey and sampling results contributed to assessment of the risks of lead contamination in Mississippi and guided scalable research and outreach efforts to minimize lead exposure through use of filters and/or behavioral changes. Supported by USGS-MSWRRI.

Private Well Disinfection: Similarities and Disparities Among State Level Protocols

BARRETT J.R.

Citizens who acquire their drinking water from private wells do not have the luxury of knowing the quality of their drinking water on a regular basis unless they are making the effort to have their water screened and/or tested. Approximately 90% of American citizens are served by a public water system which provides safe, reliable water under the regulatory enforcement of their state primacy agency. Private well owners are free to operate and maintain their wells because there is no regulatory oversight. For some private well owners, this freedom is desired but others want to know the quality of their drinking water.

If bacteria is found in a private well, the standard response is to have the well disinfected or shock chlorinated. The concept of making an effort to kill bacteria in a well is known by multiple terms to explain the process of using chlorine to disinfect. There may also be different causes or events that necessitate well disinfection. Well disinfection may also be performed by the well owner or a well contractor. Regardless of the cause or demand for well disinfection, there needs to be a uniform process to rid the well of bacteria. State level protocols have many variations of the fundamental steps in well disinfection.

This study should be of interest to state primacy agencies, private well owners, private well contractors, and anyone affiliated with private well disinfection. Studies show the magnitude of difference between public water system and private well bacteriological sample results. Private wells have a significantly higher number of sample results with presence of bacteria. Private wells being generally shallow in depth and possessing no continual disinfection lend to their susceptibility. The expansion of public water systems increases drinking water regulatory oversight which should promote and produce a safer drinking water supply for all citizens. This study will look to lay out a framework for well disinfection and display the lack of consistency among current state level protocols.

HYDROLOGIC DATA COLLECTION & ANALYSIS

Economic Benefits of Hydrologic Data Collection

RUNNER M.

Evaluation of 1-Day–1% AEP Rainfall Depths in Mississippi

KRONKOSKY B.C.

In Mississippi, the Federal Emergency Management Agency (FEMA), National Flood Insurance Program (NFIP), insures ~64,000 policies that total ~$16M dollars (9/30/2017 FEMA statistics)—in aggregate (since 1978), Mississippi has contributed to ~60,000 insurance claims that have exceeded $3B dollars. In almost all instances NFIP "base flood" flood plains are delineated using 1-day–1% rainfall depths (100-year floodplain). In 2013, the National Oceanic and Atmospheric Admiration (NOAA) released "NOAA Atlas 14—Precipitation-Frequency Atlas of the United States, Volume 9, Version 2,"—the most current source for establishing 1-day–1% rainfall depths for Mississippi (and other neighboring states). In addition to Atlas 14, there are seven other studies, dating as far back as 1917, which define 1-day–1% rainfall depths for Mississippi.

In this investigation, we present a detailed review of these rainfall depths (5 of the 7 studies) using Mississippi county centroids (88 counties). Homogeneous statistical tests are utilized to show differences amongst these estimates, which indicate most estimates are within 10%. It is also shown these studies are bound by each other's standard error, indicating these estimates are statistically indistinguishable (within margin of error). These results suggest 1-day–1% rainfall depths (for Mississippi) have not significantly changed in over 100 year of research, and that methods used 100 years ago produce near identical results as modern-day studies (e.g. Atlas 14).

Attendees will be presented with a breadth review of these historical studies and detailed comparison of their estimates. The objective is to demonstrate that newer research should not necessarily supplement historical practice unless there are significant differences. This calls to question…is newer better, or are we over complicating how 1-day–1% rainfall depths are prepared.

Status and Trends of the USGS Streamgaging Program in Mississippi

RUNNER M.

Making Civic Engagement More Accessible and Measurable

COSSMAN R.E., ZIOGAS I.

Regulatory agencies, grant-making foundations, and those with an interest in the environment recognize both the value of, and need for, civic engagement, however it is defined. For example, regulatory agencies recognize that once they move their focus, and resources from a designated area, there is still the need for sustained environmental stewardship at that site. In our EPA-funded study we explored how civic engagement was defined and viewed, how "success" was measured and how environmental outcomes were quantified. Now we pivot to how can we make the civic engagement process more accessible, and how can we measure impact and how can we nurture sustainability.

Generally, we found that "civic engagement" (as it relates to environmental issues) is poorly defined, the process is inadequately understood, and there is a lack of metrics by which to measure impact or success. These finding starkly illustrate both the current gaps in the field as well as the need to develop operational definitions and metrics. Both regulatory agencies, who expend public funds, and private foundations, are in serious need of metrics that can measure outcomes and accountability.

We offer three actionable recommendations towards developing actionable Environmental Civic Engagement (ECE) measurements:

(1) The creation of an "umbrella" organization, or center, that will facilitate interdisciplinary discourse and cooperation with funding agencies and government authorities on the subject of ECE.
(2) The development of a clear and concise programmatic research agenda.
(3) Establishing a common repository of ECE-driven data.

Moving forward we hope to develop a collaborative research agenda with the input and support of regulatory agencies and private foundations.

The purpose of this project was threefold: first, we aimed to collect, inventory, and promote measures focused on capacity for civic engagement for agricultural and water management; second, we set forth to create a collaborative network comprised of academics, policymakers, and stakeholders, which would openly discuss issues surrounding civic engagement and environmental stewardship; third, we attempted to collect new data on civic engagement in order to enhance our understanding of the phenomenon. Our five major findings can be summarized as follows:

First, we were unable to identify the existence of robust, concise, and generalizable civic engagement indicators and data. Any past attempts to develop such measures are either limited in scope or geographically restricted.

The term "civic engagement" has been widely used to denote a multi-dimensional range of activities and participants without a clear scholarly consensus on its meaning, definition, and operationalization. Although it was first introduced by Putnam (1993) in his seminal work *Making Democracy Work*, over the past 25 years "civic engagement" has gained popularity among the public, media, scholars, and policymakers alike, despite its conceptually ambiguous and ontologically convoluted nature. During this period, the concept of civic engagement has evolved from its original minimalist definition of a politically

engaged citizenry (Putnam 1993) to a buzzword used to describe "describe activities ranging from bowling in leagues to watching political television shows, writing checks to political advocacy groups, and participating in political rallies and marches" (Berger 2009: 335).

In our review of the civic engagement literature we identified several overlapping – and at times competing – theoretical perspectives. In political science, civic engagement captures social and political actions by individuals or groups towards the improvement of society (Berg 2013). Under this paradigm, civic engagement incorporates volunteerism and political involvement towards a fuzzy definition of "political change." In psychology it pertains to "individual and collective actions designed to identify and address issues of public concern [...] such as working in a soup kitchen, serving on a neighborhood association, writing a letter to an elected official or voting" (APA 2018; also Battistoni 2002). Sociologists view civic engagement as a nexus of collective efforts to achieve a well-defined goal within a well-specified plane of interactions, in which the community, rather than the individual, is the theoretical focal point (Ehrenhalt 1996). Yet, certain political theorists contend that civic engagement is merely an irrelevant symptom of an active citizenry and civilian involvement that should be receiving less scholarly attention than civil society and social capital (Barber 2004; Cohen and Arato 1994; Putnam 2000). It is important to note that outside the confines of social sciences there has been sparse engagement with the phenomenon of civic engagement.

In order to avoid conceptual stretching and confusion, for the purposes of this study we have restricted our research to a particular aspect of civic engagement, namely environmental civic engagement (ECE), which we define as *organized activities performed by individuals towards their perceived improvement of environmental conditions*, particularly as it relates to efforts directed towards addressing nutrient reduction, non-point source pollution, and hypoxia in watersheds belonging in the wider Mississippi-Atchafalaya River Basin (MARB) area. An important element embedded in our definition is that such activities should result in an absolute net material cost to the individual(s) engaged, but an overall positive expected utility as to rationally justify involvement. The decision to act is contingent on a pervasive perception of a "problem" that is a direct component of the decision-making calculus of the individual(s) involved. Under these conditions we, therefore, capture both latent volunteerism and coordinated actions, while we comfortably exclude attempts that seek long-term engagement rents and tangible compensation.

Shifting our focus to ECE in specific, we noticed that relevant research has recently attracted greater scholarly attention. We reviewed 58 articles and reports that contemplate environmental stewardship. During our review we found that scholars are using multiple terms to analyze behaviors falling under the wider ECE conceptual umbrella. Indicatively, some of these constructs are "community-based natural resource management (CBNRM)," "collaborative natural resource (or watershed) management," "sustainability-centered environmental engagement," and "grassroots ecosystem management" to name just a few. Although the terms may sound different, their analytical scope is largely similar as they all refer to collaborative behaviors that aim to improve environmental conditions.

A large part of this literature is concerned with developing models that explain "capacity," which is considered a necessary precursor—and in some cases a robust predictor—to ECE. The common themes across these capacity building models are: a) individual characteristics (e.g. knowledge about issues, leadership traits, organizational skills); b) community characteristics (e.g. established networks, past collaborative experiences, issue-linkages); and c) the structure of opportunities (e.g. perceptive local governance, availability of resources, economic conditions). A particularly informative model of community capacity specifically addressing watershed management is offered by Davenport and Seekamp (2013: 1105; adapted by Foster-Fishman et al. 2001). This model (Graphic 1) visualizes how member engagement, relational networks, organizational development, and programmatic coordination cumulatively interact to lead to sustainable ECE.

Second, the primary reason behind the lack of such indicators can be attributed to the absence of a programmatic agenda guiding data collection

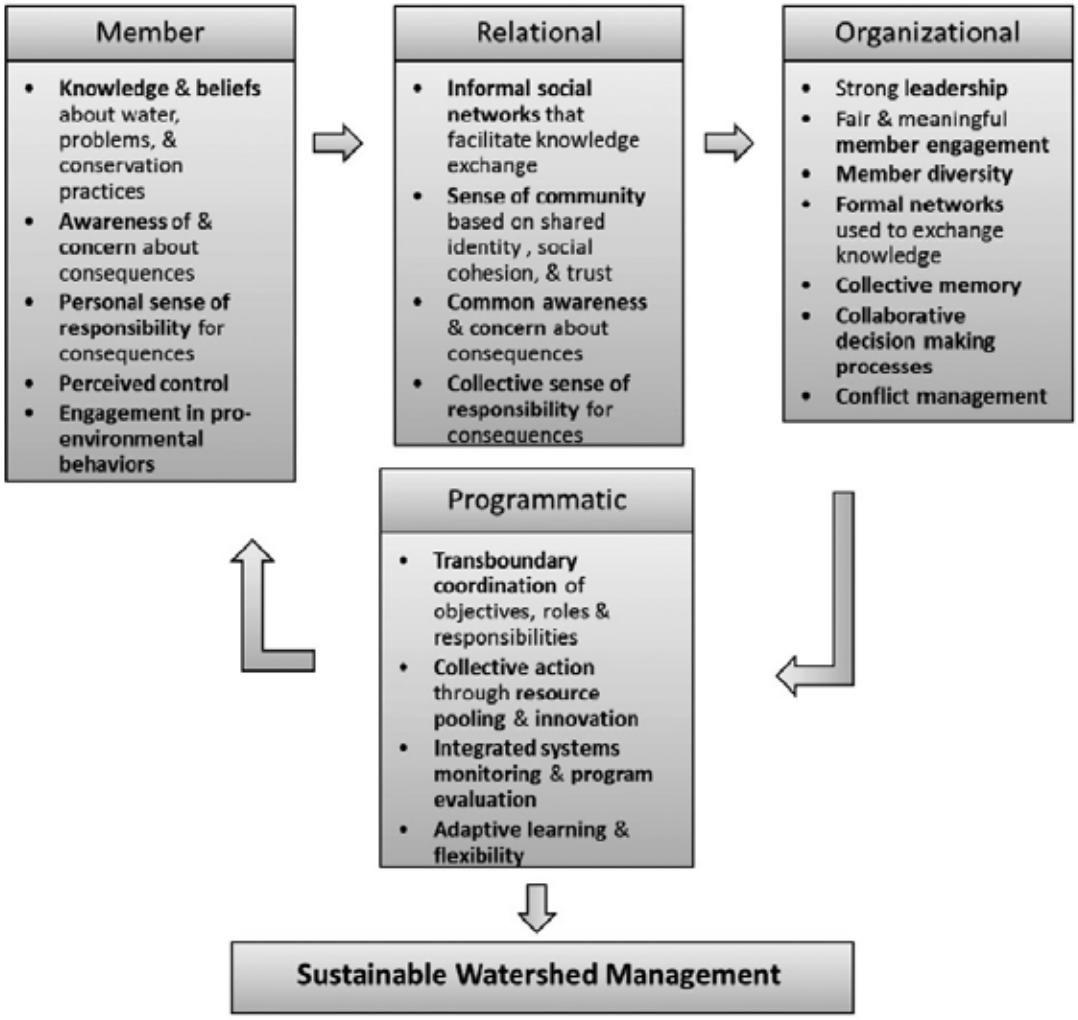

Figure 1. A Community Capacity Model (Davenport and Seekamp 2013: 1105)

efforts and the associated lack of resources that are necessary to maintain those. Despite the availability of tools and methods and the voluminous literature on civic engagement, during our extensive review of "white" and "grey"[1] literature we were surprised to find out that attempts to comprehensively evaluate empirical hypotheses are scarce. We were furthermore unable to identify any systematic efforts to collect primary data on ECE or develop relevant indicators. Some of the reasons behind the absence of such measurements are purely theoretical or methodological, such as the fact that environmental stewardship can encompass a variety of behaviors, the problematic quantification of civilian involvement, disagreements over the most appropriate unit-of-analysis, the absence of commonly acceptable operationalization of traits and attributes, and the lack of a cohesive causal process. The absence of an interdisciplinary programmatic agenda, along with the logistics associated with creating a robust community of practice, are also impeding the thorough examination of ECE causes, determinants, and outcomes. That said, perhaps the single most important barrier to data collection and the creation of reliable ECE indicators has been the monetary cost combined with a lack of funding agencies willing to sponsor such initiatives. Just

[1] "White" literature refers to published peer-reviewed research, while "grey" denotes literature other than peer-reviewed (e.g. reports, working papers, executive summaries etc.).

to offer a single representative example, the Pew Research Center estimates that a simple dual-frame telephone interview survey of 1,500 subjects, constituting a true-random sample of the population, costs $100,000.[2] For most researchers and practitioners of ECE this amount is prohibitive, more so if it were to be part of a repeated panel survey project. For these reasons ECE researchers have, for the most part, relied on self-reporting surveys and structured interviews with restrictions in sample size and issue-linkages.

A number of empirical studies focus on assessing, building, and maintaining community capacity as a precursor to ECE. Evidence suggests that the proximity of a rural community to an area of environmental concern, along with the emotional attachment it has developed to the territory surrounding it, predicts the community's attitudes towards stewardship more accurately that sociodemographic variables (Vorkinn and Riese 2001; cf. Brown, Raymond, and Corcoran 2015; Buta, Holland, and Kaplanidou 2014; Raymond, Brown, and Weber 2010). Building on these findings, Brehm, Eisenhauer, and Krannich (2006) contend that community attachment, common identity, and trust and respect among members create conditions conducive to grassroots involvement as they increase the capacity for action. Local governance also plays a role; the likelihood of success of these initiatives seems to be influenced by the willingness of local authorities to alert, educate, and encourage the public to get involved and develop a sense of ownership of their physical environment (Shandas and Messer 2008). Local governance may also facilitate cooperation between cross-cutting networks, while it has the ability to provide technical support and assistance in evaluating goals and progress (Fleeger and Becker 2008). However, Wagner and Fernandez-Gimenez (2009) caution against assessing ECE via social capital and community capacity. As their study reveals, collaborative involvement heavily depends on the quality of outcomes. If observed outcomes following a community project fail to meet expectations, the chances such an attempt will be repeated decrease, meaning that social capital may only affect the initial drive to action without ensuring longevity of involvement.

At the individual level empirical analyses are mostly concerned with personal traits or characteristics and their effect on attitudes and views towards ECE. Specifically, pro-environmental behaviors (PEBs) seem to be motivated by an individual's proclivity towards sustainability and their ability to comprehend the complexity of natural systems (Carfora et al. 2017). Individuals also appear to be motivated to act when they have already developed pro-environmental self-perceptions and identities, like considering themselves to be "vegetarian" or "recyclers" (Nigbur, Lyons, and Uzzell 2010; Trudel, Argo, and Meng 2016). Political attitudes and social networks may push individuals to solidify or reject such identities, since people express an innate tendency to emulate behaviors they observe with greater frequency (Brick, Sherman, and Kim 2017). In all, both capacity and identity are crucial to engagement; however, although the literature provides a framework of understanding how capacity can be expanded to assume PEBs, it does not explain how one develops her identity or changes it after its initial adoption (Steg et al. 2014; van der Werff, Steg, and Keizer 2013).

Third, members of our established network, particularly those representing funding agencies, are extremely interested in the development of indicators that would allow them to assess community capacity for civic engagement and evaluate the prospects of success given appropriate resource allocation.

As the primary sources of ECE funding, foundations were extremely interested in the development of metrics that would allow them to assess the feasibility and success prospects of ECE efforts. Moreover, contacted foundation representatives were very receptive to the idea of community capacity building through education and experimental initiatives. In fact, two of the foundations we contacted talked extensively about their attempts to develop civic engagement indicators internally, albeit unsuccessfully. The reason behind their interest in efficient assessment metrics is simple: return to investment is high when funding is allocated to environmental stewardship efforts with a high likelihood of achieving their stated objectives, attracting participants, and maintaining operations for longer periods of time. In the

[2] According to http://assets.pewresearch.org/wp-content/uploads/sites/12/old-assets/pdf/cellphone-peoplepress.pdf.

words of a foundation representative: "we want to know whether our funds are appropriately utilized, and so far we have no clue on how to make such judgements."

These interviews highlighted two important aspects of ECE in practice, outside the analytic microscope of academic literature. First, no entity has developed nor is using civic engagement indicators or has a comprehensive plan to develop such metrics for that matter. Although such a toolset would be immensely valuable in promoting and evaluating ECE, there exist significant barriers to obtaining relevant metrics. Among those the most obvious one is the cost associated with developing indicators and administering the instruments necessary for data collection and refinement. Absent significant external funding or collaborative effort, no party denoted interest in unilaterally undertaking such a project. Second, as most of our partners highlighted, ECE is so complicated that even if we assume availability of resources, they would not know where to start. Should the development of an ECE suite of indicators begin with measuring community or individual capacity? If yes, how would that project be structured and implemented? Should the focus be on environmentally troubled areas only and, if yes, what would the selection criteria for those be? What is the scale of the phenomenon that should be measured? Should isolated activism and/or volunteerism factor into the metrics? Is the primary objective to understand how ECE is caused or is it to understand how it succeeds? What should be considered as evidence of success?

Fourth, our model of civic engagement (presented herein) and the data we collected through semi-structured interviews suggests that civic engagement data should be collected on the individual level, thus reinforcing the calls for systematic collection efforts.

Specifically regarding the data collection effort, our primary interest should be in obtaining accurate individual-level data that includes personal attitudes towards environmental stewardship, beliefs towards activism, leadership skills etc. Along these observations, we should also be interested in subjects' socioeconomic background, education, age, and other relevant controls, as to make our data externally valid. Moreover, our data should be combined with geographic elements and local water quality indicators in order to be across-case comparable. These collected data should not capture a snapshot in time; to the contrary, they should be part of a repeated (i.e. longitudinal) panel that will afford us the opportunity to measure change over time and compare it with relevant natural effects.

In that respect, to obtain the data we require in order to develop ECE metrics we propose for the creation of a three-step project. The first step is to develop and administer comprehensive surveys with a truly random population sample in targeted areas along the MARB, whose selection needs not be randomized. Those areas need to include both urban and rural communities in order to assess quantitative differences between the frequency and propensity of ECE behaviors. Surveys need to be designed in a manner that captures individual tendencies, character traits, personal attitudes, socioeconomic features, perceptions about the environment, normative predispositions, and behaviors associated with activism widely construed. An ideal number of administered surveys would be 4 per MARB state, while the sample size for each survey should not be smaller than 150 respondents. Given that this is intended to be a longitudinal tracking project, survey need to be repeated in regular intervals (e.g. every 3 years), which will allow us to observe and quantify changes in attitudes and behaviors given similar external stimuli. It is important to note that, to ensure the collected data hold under methodological scrutiny and validity concerns, the survey instruments need to be the same no matter what their targeted population is, and they need to be administered to all selected samples concurrently. Surveys that are repeated every 3 years in MS versus surveys repeated every 7 years in AR will eventually present us with systematic irregularities and prevent us from across-case comparisons.

Beyond acquiring quantifiable individual-level data through surveys, the second step of this operation should be devoted to obtaining qualitative data focusing on community capacity. This effort should target the selected areas and conducted via strictly structured interviews. The purpose is to gauge the capacity of a community to undertake environmental action and develop a sense of environmental ownership. Under this frame of mind, interviewers

should ideally set up interviews with identified community leaders and local government representatives in order to assess whether an understructure of civic engagement exists. Such interviews serve a dual purpose. First, they supplement surveys as they capture unobserved community-wide qualities. Second, they allow us to map civic engagement networks, present or latent, that could be activated or cultivated in the future. As with the surveys, structured interviews should be regularly repeated as to evaluate measurable changes in capacity, both within and between communities.

In order to develop civic engagement indicators, a new multistep project of systematic data collection needs to be initiated. Such a project requires the administration of panel surveys, performing structured interviews, and obtaining physical data on water quality. Combined, those three data sources will provide us with the necessary tools to evaluate progress, as well as to predict and prescribe solutions to pressing environmental issues. Ultimately, this data toolset will allow for a horizontal dissemination of available information to researchers, community leaders, and policymakers alike, leading to collaborative efforts in assessing and promoting ECE behaviors.

Fifth, given the above, our recommendations are the following: maintain and expand the collaborative network created by this project, develop a programmatic research program on ECE measures, and establish a common repository of ECE-driven data.

(1) The creation of an "umbrella" organization, or center, that will facilitate interdisciplinary discourse and cooperation with funding agencies and government authorities on the subject of ECE. In order to develop measurements, there first needs to exist agreement on what exactly is being measured. This could be achieved by establishing a new collaborative effort, housed at an academic institution. This center would be tasked with being the central node in a network of scientists, funders, and policymakers, providing them with guidance and facilitating coordination.[3]

(2) The development of a clear and concise programmatic research agenda. A major part of the difficulties with understanding the root causes and measuring the impact of ECE relates to a confusion around the concept itself. We propose the creation of a programmatic agenda that is designed to identify specific research areas. Developing and maintaining an agenda (and corresponding theoretical advancements or findings) under a single roof would be beneficial to incentivizing scientific cooperation.

(3) Establishing a common repository of ECE-driven data. Equally important to the above is the ability of interested parties to access, evaluate, and validate available data, as well as a hub for the collection of new data. This could begin with the very simple step of compiling a list of active GEGs in a single state, which would be expanded to include other states, relevant agencies, and potential ECE funding sources. Although such basic information is extremely important to scholars and policymakers alike, there have not been any efforts towards that end to date. The ultimate goal would be to create a research hub where publicly available data on ECE—drawn from surveys, interviews, or experiments—would be maintained.

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[3] An example of such a collaborative effort could be considered the NSF's Research Coordination Network.

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Climate Extremes and Cover Crop Influence Yields and Water Use of a Maize-Soybean Cropping System

LI Y., TIAN D., FENG G., FENG L.

Climate extreme events in the forthcoming decades are most likely to affect agriculture production and water consumption. Cover crops could be potentially considered as a strategy to mitigate the negative effects of climate extremes. However, extreme climate events were not well determined, and how will the cover crop affect each water balance component under different climate extreme conditions has not been fully explored in Mississippi State. In this study, future climate data were projected under two Representative Concentration Pathways (RCPs) 4.5 and 8.5 from statistically downscaled outputs of ten GCMs (General Circulation Models) provided by Coupled Model Inter-comparison Project - Phase 5 (CMIP5). A variety of diagnostic methods were used to determine extreme temperature, heavy precipitation, and drought based on data in the past (1956-1985), present (1986-2015), and future (2020-2049 and 2050-2079). Then the calibrated and validated model, Root Zone Water Quality Model version 2 (RZWQM2), was applied to simulate crop yields, evapotranspiration (ET), seepage, and runoff under historical and projected future climate extreme conditions for cover crop and non-cover crop scenarios in Pontotoc, Mississippi. A set of climate indices were calculated using daily data during growing season to investigate relationships of climate indices, crop yield and water balance components. The effect of cover crop on crop yield, ET, runoff and percolation under different climate extreme conditions in a Maize-soybean Rotation cropping system will be presented and discussed.

DNF Shallow Ground Water Monitoring Wells

JOHNSON D.R.

In 2010 the USACE established 25 groundwater monitoring wells in Delta National Forest and Twin Oaks Wildlife Management Area. Each well extends approximately three feet into the ground. The intent was to determine the depth and duration of soil saturation in a bottomland hardwood forest. The hydrology component of wetlands can be satisfied by the saturation of the top foot of soil during a continuous 21 day period during the growing season. Well locations were sited based on historical stage and duration data. Wells were placed in locations that had a flood frequency from 1 year to 50 year intervals, and an annual continuous duration from one to 28 days. The observed periods of soil saturation differed significantly from the flood duration, and ranged from zero to 250 days per year. Most sites were saturated for more than 50 days per year. This study shows that these wetlands are classic BLH wetlands, where the major source of moisture comes from winter rains. The infrequent out of bank flooding augments the available moisture.

Theory-Guided Data-Driven Modeling of Groundwater Levels in an Alluvial Aquifer

ABROKWAH K., O'REILLY A.M.

Groundwater is an important resource that is extracted every day because of its invaluable use for domestic, industrial, and agricultural purposes. The need for sustaining groundwater resources is clearly indicated by declining water levels and has led to increasing demand for modeling and forecasting accurate groundwater levels. In this research, results of wavelet analysis-artificial neural network (WA-ANN) data-driven models for simulating groundwater levels are compared to the results of aquifer water levels simulated using physics-based MODFLOW models. That is, we compare the results of each model to understand how WA-ANN model results relate to real physical hydrogeologic properties, e.g. hydraulic conductivity (K) and specific storage (Ss), with the objective of using physical principles (theory) to guide development of data-driven models. These techniques are explored by modeling groundwater levels in a synthetic alluvial aquifer system consisting of a river and an unconfined aquifer, two confined aquifers, and confining layers separating each aquifer. A synthetic time series representing daily values of recharge to the unconfined aquifer, with seasonal and shorter time-scale periodicity, is used as the forcing function. Properties of K and Ss for aquifers and confining layers as well as river properties are assigned assumed values in the MODFLOW model. Simulated water levels from MODFLOW at an observation well in each aquifer are then modeled again with a WA-ANN model for each well by using various decomposition levels of the discrete wavelet transform (DWT). The DWT is used to decompose the recharge time-series data into various levels of approximate and details wavelet coefficients, which are then used as inputs for the WA-ANN models. The results for the various DWT decomposition levels of the WA-ANN models are then compared to the simulated water levels and hydrogeologic property values of the MODFLOW model. Based on this comparison, potential relationships are identified between the characteristics of the various decomposed wavelet levels of the WA-ANN models and the hydrogeologic properties of the MODFLOW model. The resulting knowledge of the underlying physics manifest by the WA-ANN models, inferred by comparison with a physics-based model, ultimately produces theory-guided data-driven models, imparting science-based consistency and interpretability into data science models.

Alabama Groundwater Monitoring Using NGWMN

ARNOLD A.C.

Using the USGS National Groundwater Monitoring Network (NGWMN) framework document, Geological Survey of Alabama (GSA) staff are currently evaluating observation wells throughout the State to place them into subnetworks of background, suspected or documented changes in water-level elevations. The NGWMN's primary mission is to provide a national online map/data interface to address regional groundwater questions focused on principal aquifers. The GSA staff measure static water levels in observation wells bi-annually. These April and October measurements represent seasonal variation of wet and dry conditions. Many GSA observation wells have recorded water-level elevations for over forty years. The overall approach is to define areas with clusters of high-volume pumping wells. Groundwater use data supplied by the Alabama Office of Water Resources (OWR) provides locations for wells extracting >100,000 gallons per day, chiefly for municipal, agricultural and industrial uses. Within areas of significant groundwater use, GSA will evaluate the observation well network for potential aquifer drawdown. Five areas have tentatively been identified as background that are not affected by intensive groundwater withdrawal. Background areas are situated in low-yielding aquifers of the Cumberland Plateau or Piedmont region, with few major supply wells. The primary areas being evaluated for suspected changes due to groundwater withdrawal are Gulf Coastal Plain, Valley and Ridge, and Highland Rim aquifers. No areas have been classified as documented changes. Future studies will include analyses of available pump test data and delineation of water-level trends in major Alabama aquifers within these areas.

Numerical Studies of Ground Water Flow near a Partially Penetrated Well and an Alluvial River

FANG J., JIA Y., OZEREN Y., RIGBY J.R.

The Mississippi Delta is a productive agricultural area in the United States, the agriculture, however, heavily relies on groundwater. In the last decades, the ground water table has experienced a significant drawdown. The current way of using groundwater is not sustainable. This problem has drawn attention of water resource management agencies and research community.

In this study, a newly developed 3D groundwater model, CCHE3D-GW, was used to analyze this problem. The model is verified using analytical solutions including a stream depletion case considering the effects of both pumping and surface water charging from a stream (Butler et al. 2001). Several scenarios with different ratios between the conductivity of streambed and aquifer were simulated. The agreements between the simulation results and the analytical solutions verified the model.

The model was then applied to the pumping tests of a USDA project in Money, Mississippi. The pumping site is very close to the Tallahatchie River and the relations between the pumping and the surface water charging is studied. The complex conditions of the aquifers, river morphology, and sediment bed have been incorporated in the numerical model and preliminary simulation results have been obtained. Additional study is in progress. The results will be reported in the conference.

Estimation of a Probable Maximum Precipitation and Probable Maximum Flood with associated Frequency: Blakely Mountain Dam

MOREE D.

Blakely Mountain Dam controls flow on a 1,105 square mile watershed and is located upstream of Hot Springs, Arkansas. In order to better understand the hydrologic risks associated with the dam, the following items are being performed to increase confidence in the probable maximum flood for Blakely Mountain Dam and its assigned frequency. An outline of the methodology used to complete each process will be presented, with a focus on the creation of probable maximum precipitation dataset and the routing of the event to the dam.

- Preform a Site-Specific Probable Maximum Flood Analysis and compare with the standard HMR 51/52 Methodology. Use Sensitivity analyses to determine upper, lower, and best estimate.
- Create hydrologic model (HEC-HMS) with adequate calibration and validation. Calculate peaking factors to account for added runoff volume
- Complete a survey of dam and spillway crest. Use 2-dimensional modeling to validate rating curves for spillway and am overtopping.
- Create a reservoir routing model (HEC-ResSim) with the ability to model downstream flow constraints. Validate the mod
- Perform a paleoflood analysis to extend the effective record length of the reservoir inflow data, and increase confidence in estimates of extreme flood probability
- Gather historical flood records dating back to 1800's and incorporate the historical records and the paleoflood information into the inflow volume-frequency curve using HEC-SSP.
- Compare the inflow volume-frequency curve to the regional precipitation-frequency curve from NOAA Atlas 14 to see if the estimated return periods for the PMP and PMF are consistent.
- Update the stage-frequency curve using a Reservoir Frequency Analysis Tool (RMC-RFA) with the new volume-frequency curve.
- Use the stage-frequency curve to assign a reoccurrence frequency values to Spillway, Top of Dam and PMF elevations.

WATER QUALITY

Distributions of Dissolved Trace Elements in Mississippi Coastal Waters: Influence of Hypoxia, Submarine Groundwater, and Episodic Events

HO P., SHILLER A.

A multi-year (2007-2011) chemical time series of eight stations in the western Mississippi Sound and northwestern Mississippi Bight was undertaken to examine the factors affecting the distributions of trace elements in this estuarine-coastal system. Key findings include the frequent development of bottom water hypoxia in this part of the Bight during late spring and summer, the likely contribution of submarine groundwater discharge (SGD) to the material flows (i.e., Ba, V and nutrients), and the effects of episodic events (i.e., tropical storms, cold fronts, the opening of the Bonnet Carr Spillway) on trace element distributions. A variety of trace metals (i.e., Ba, Mn, V and Cs) in Mississippi Sound surface waters were largely regulated by the temporal and spatial variations of riverine sources. For instance, in fall and winter, high concentrations of dissolved Mn at the most nearshore stations followed by a sharp decline in concentrations offshore, are indicative of Pearl River influence in the Mississippi Sound. Cs-rich water coming from St. Louis Bay is evident in the Mississippi Sound, but not observable in Mississippi Bight.

In hypoxic bottom waters, enriched Mn and Ba as well as depleted V were commonly observed. Consideration of the mass balances of dissolved Ba and V suggests that SGD can be a significant contributor to the chemical mass balance in this region, not just for certain trace elements, but for nutrients, too. Interestingly, a seasonal change in the direction of the V flux from the sediments suggests that the chemical conditions (i.e., pH, E_H, and/or DOC) of the groundwater are changing. During the study period, the Bonnet Carr Spillway was opened in April 2008 and May 2011. The spillway discharges Mississippi River water to Lake Pontchartrain and ultimately to our study area, which is supported by the observation of an extended freshwater signal and low Cs across the Mississippi Sound and Bight during these two spillway openings. Important remaining questions from this study include the extent to which SGD and/or Mississippi River water are necessary for establishment and maintenance of hypoxia in the Mississippi Bight and the reasons for the seasonal change in the direction of the sedimentary V flux.

Mobile Water/Wastewater Treatment Systems Developed by the Army Engineer Research and Development Center

MEDINA V.F., GRIGGS C., WAISNER S.

The U.S. Army Engineer Research & Development Center has developed and studied a variety of mobile water and wastewater treatment systems to address the needs of the military. These technologies also have applications for civilian purposes, such as providing for small rural communities, treatment of contamination and industrial wastewater, and disaster response. This project will discuss four projects, and will explore how these can be adapted for civilian use.

The first project was the development of the Deployable Aerobic Aqueous Bioreactor (DAAB), a mobile wastewater treatment system developed to support military operations. The DAAB is a membrane bioreactor that is designed to start up quickly thanks to special cultures of microorganisms designed to seed the reactor. It is a unique modular design that allows the system to be easily upgraded in increments of 250 men.

The second project was the exploration of anaerobic digestion to treat both food and black water generated at base camps during military operations. Base camps typically generate large amounts of food waste, which can be very difficult to manage. Our study showed that anaerobic digestion can treat food wastes along with toilet waste, and generate useful energy, up to 30% of the needs of the base camp. This could result in fewer resupply missions, saving money and lives.

The third project is a grey water (shower, laundry, and food waste wastewater) treatment project that is currently in progress. This process uses a novel, low energy reverse osmosis process coupled with a membrane bioreactor to treat grey water to allow total reuse of the water in an energy efficient manner. Testing at Camp Shelby in Mississippi is currently in progress.

The last project is the development of the Decontamination Effluent Treatment System (DETS), which is the first ever system designed to treat decontamination water. The DETS is designed to treat highly contaminated water that may contain very toxic constituents and achieve effective treatment every time. And, it is fully mobile. The DETS proved to be so effective that new uses are now being explored, including for the treatment of perfluorinated compounds, fracking fluids, and for disaster response.

The Presence of Dissolved Iron in Ground and Surface Waters of the Yazoo Basin

TRAN G., JOHNSON D.

The U.S. Army Corps of Engineers (USACE) is assisting the Agricultural Research Service (ARS) in the design and construction of a pilot groundwater injection project in Leflore County, MS. The project will have a single withdrawal well and two injection wells. One aspect of the assistance the Corps consists of obtaining all applicable permits for the wells from MS Department of Environmental Quality (MDEQ). Because the well will require periodic back flushing to remove biofouling of the gravel pack surrounding the well, a National Pollutant Discharge Elimination System (NPDES) permit is required. The permitting process identified iron as a potential contaminant of concern. Groundwater samples obtained from sites close to the injection site had dissolved iron concentrations which exceeded the chronic aquatic life criteria (CALC) for iron (1.0 mg/l). The USACE has designed a water treatment plant to remove the iron, but use of such a plant may affect the viability of a large scale implementation of injection project to restore the declining alluvial aquifer. As the Mississippi Delta has more than 20,000 existing irrigation wells, which discharge excess irrigation water in the Delta's lakes and streams, the USACE conducted a study to determine if there are any indications of existing iron contamination of surface waters. The USACE obtained all available ground and surface water data from the United States Geological Survey National Water Information System (USGS NWIS) database. The average concentration of iron in groundwater is 600 ppb, and is more than 50 times greater than the average surface water concentration. Occasional surface water samples did exceed the ALC, but these instances were extremely infrequent.

The Use Drop Pipe Inlet Structures in the Big Sunflower Watershed Basin as a BMP for Erosion Control

JOHNSON B.S., JOHNSON D.

The Flood Control Act of 1944 provided authority to the United States Army Corps of Engineers (USACE) to implement actions to enhance flood control in the Upper Mississippi Delta through the use of channel improvements along the major tributaries within the Big Sunflower Watershed Basin. During the same timeframe significant areas of forestland were cleared to make way for the growing demand of agricultural production. Local drainage districts were formed to improve drainage. These drainage districts often dug numerous ditches, many of which were often hydraulically oversized. As a result, these oversized ditches provided for conditions conducive to significant headcutting in the channels and on the adjacent land. These combined actions significantly increased the runoff and flow rates in the available channel system which in turn caused excessive erosion of the land adjacent to the primary channels. In an effort to counter these aggressive erosional features taking place throughout the basin, USACE was charged with developing a number of best management practices (BMPs) to address the resulting erosion. One of these BMPs is the construction of drop pipe inlet structures. USACE has completed approximately 100 of these BMPs in the Big Sunflower Basin and plans to complete many more to counter the persistent problem.

Microplastics in the Mississippi River System

CIZDZIEL J., SCIRCLE A.

Microplastic (MP) concentrations along the northern Gulf of Mexico are among the highest levels reported globally. The most likely source of the plastic pollution is the Mississippi River (MR) which drains much of the central portion of the USA. Yet, surprisingly little is known about the concentrations, types, sizes, and loadings of MPs in the MR and its major tributaries. This lack of data is hindering our understanding of the magnitude and sources of the problem. Because the MR is an intricate system of waterways, tributaries, and commercial routes, an in-depth spatial study is needed to fully assess MP pollution in the system. Our research aims to systematically quantify the concentrations and loads of MPs in the MR system, and characterize their shapes, size distribution, and chemical composition in the MR system - a source of drinking water to over 18 million people. We used Nile Red dye to stain the MPs and fluorescence microscopy to count them, as well as vibrational spectroscopy to the identity the plastics. The morphology of the MPs was dominated by fibers (~75%), followed by fragments (~23%) and beads (~2%), with the proportion of fragments increasing slightly moving down the river. The concentration of MPs is relatively low for smaller tributary rivers (Tennessee and Yazoo) and higher in larger tributaries rivers (Ohio and Missouri), with the later having higher concentrations than the MR itself. Counts and loads of MPs generally increased down the main stem of the MR until past New Orleans, where loads declined, possibly due to deposition with slowing water. Sites near population centers (e.g. Memphis) had higher MP concentrations. Overall, this work is an important first step to assess possible relations between MPs levels and characteristics with sources and different watershed attributes.

EMERGING & INNOVATIVE TECHNOLOGIES— UNMANNED AIRCRAFT SYSTEMS USE IN WATER RESOURCES

Project Efficiency: Advantages of UAS Technology in Civil and Environmental Engineering

LAWSON J., PARRISH J.

The use of unmanned aircraft systems (UAS) in civilian and non-military sectors has skyrocketed over the past several years with predictions of exponential demand for UAS and related services in the coming years. In this era of disruptive innovation, rapid advances in UAS technology along with implementation of the FAA's 2016 UAS guidelines have boosted the economic development landscape on multiple levels. More UAS and associated features are being produced by manufacturers than ever before, and remote pilot certifications are on the rise. Utilization of UAS technology in the environmental and engineering fields has gained momentum as the capabilities of UAS applications are becoming abundant and more site-specific.

What was once seen as too great of a risk to undertake is now considered a valuable investment by environmental and engineering firms. Professionals are increasingly employing certified remote pilots and creating their own UAS divisions. Improved data collection rates and accuracy, lower number of safety risks and costs, and numerous compatible data processing platforms are marked advantages that current UAS technologies allow. Further, UAS software is compatible with global positioning systems and can be manipulated to form 3D models and a surfeit of other outputs. These factors are just a few of the reasons UAS technology is preferred over traditional labor-intensive methods.

The versatility of UAS operations over water and unsafe, rugged terrain is ideal for enhancing and accelerating projects such as inspecting inlet and outfall structures at wastewater treatment facilities and detecting leachate leaks at solid waste facilities. A few other examples of areas benefitting from UAS technology include dam spillway condition assessments, erosion monitoring, and natural disaster evaluations involving flooding events. From the water resources standpoint, opportunities are boundless for how UAS technology has and will continue to benefit the environmental and engineering fields.

Evaluating the Use of sUAS-Derived Imagery for Monitoring Flood Protection Infrastructure

DIETZ E., YARBROUGH L.D.

In the U.S. there are approximately 33,000 miles of levee. This includes 14,500 miles of levee systems associated with U.S. Army Corps of Engineers programs and approximately 15,000 miles from other states and federal agencies. More than 14 million people live behind levees and associated flood prevention infrastructure. Monitoring and risk assessment are an on-going process, especially during times of flood conditions. The historic events such as those in the City of New Orleans with Hurricane Katrina in 2005, Red River floods of 2009 and 2011, Ohio River flooding of 2018, the 2017 California Floods have profoundly impacted lives and communities. Climate change and increasing population are likely to make flooding events more frequent and costly. As new technologies emerge monitoring and risk assessment can benefit to increase community resiliency.

In this research, we investigate the use of the structure from motion photogrammetric method to monitor positional changes in invariant objects such as levees, specifically, I-walls. This method uses conventional digital images from multiple view locations and angles by either a moving aerial platform or terrestrial photography. Using parallel coded software and accompanying hardware, 3D point clouds, digital surface models, and orthophotos can be created. By providing comparisons of similar processing workflows with a variety of imaging acquisition criteria using commercially available unmanned aerial systems (UAS), we created image sets multiple times of a simulated I-wall at various flight elevations, look angles, and image density (e.g. effective overlap). The comparisons can be used for sensor selection and mission planning to improve the quality of the final product. The results can optimize current equipment capabilities with respect to client expectations and current FAA limitations.

Exploitation of UAS to Analyze River Flooding

MOORHEAD R., DYER J., VAN COOTEN S.

Unmanned aircraft systems (UASs) have been shown to be cost-effective and efficient data collection platforms for high-resolution and/or real-time imagery. NOAA's River Forecast Centers (RFCs) have stated that some of their top priorities for UAS applications for RFC operations are rapid response images to document extent of inundation to verify flash flooding, flood inundation maps, and enabling production of flood maps for more locations. The lack of data over river reaches that are difficult to access and/or a large distance from population centers degrades overall river forecast accuracy. This is especially true if the river reaches with poor elevation data are known to exhibit complex hydraulic conditions such as backwater flow during high water events. In such cases, not only do real time data and images provide improved accuracy in river flow speed and direction, but also aid in quantifying the amount of potential storage along the river reach during flood events.

Such backwater processes are known to occur along the Yazoo River in western Mississippi, which is in the operational area of the Lower Mississippi River Forecast Center (LMRFC). More specifically, the backwater areas of interest in this study are along the Yazoo River and the contributing tributaries of the Big Black and Sunflower River. The LMRFC forecasts for this area are based on river gauges near Belzoni and Yazoo City along the Yazoo River, near Bovina and Bentonia along the Big Black River, and near Anguilla and Sunflower along the Sunflower River. These points all lie in areas with minimal changes in relief. This area is of great interest and concern to NOAA, USGS, and USDA due to the frequency and severity of flooding and the associated major economic and societal impacts.

This presentation will cover our work on establishing CONOPS, the data collected, and preliminary assessments of the value of the UAS-collected data in river forecasting. The initial phase of the study is being conducted in the area around the Greenwood, Mississippi airport.

Planning to Integrate Small Unmanned Aerial Systems (sUAS) into Your Current Data Acquisition Workflow? The State of the Technology: Highlights, Case Studies, Pitfalls, and Future Trends

YARBROUGH L.D.

They are in the news. You see them in the workplace as well as with recreational hobbyists. They have been the cause of occasional airport closures. I will present an overview of the current state of the technology and discuss examples from current and past projects to explore the many uses of small unmanned aerial system (sUAS), commonly called drones. From the perspective of remote sensing and aerial imaging, the recent explosion of the sUAS has a long, well-established foundation dating back to the mid-1800s when wet glass daguerreotypes were set aloft with balloons and kites. Mississippi, too, has had a long history of developing sUAS technology in research, teaching and application. Key aspects of mission planning, flight operations, safety protocols, data curation, data analysis and product development are all interdependent and are developed from the needs of the end-user or client. I will discuss the regulatory environment and flight restrictions that may affect your choice of sensor, payload needs, and size of sUAS. From commercially-available, to a custom bird and ever-increasing selection of sensor payloads, the future trend quite literally has the sky as the limit.

UPDATE ON USGS BASELINE FLOWS RESTORE PROJECT

Freshwater Delivery to the Gulf of Mexico: An Analysis of Streamflow Trends in the Southeast US from 1950-2015

RODGERS K.D., ROLAND V.L., HOOS A.B., KNIGHT R.R.

The U.S. Geological Survey and U.S. EPA are collaborating to assess the climatic, physiographic, and anthropogenic factors driving spatial variability and temporal trends in the freshwater delivery to the Gulf of Mexico. The timing and magnitude of fresh water delivery influences terrestrial and aquatic communities, changing community composition and altering habitats necessary to support indigenous life. Streamflow at 139 stream gaging stations in the southeastern United States were analyzed from 1950 to 2015 to determine if climatic oscillation, spatial correlation, and variability in the streamflow indicated significant increases or decrease for the period of record. This study examined spatial and temporal patterns in seasonal and monthly mean daily streamflow and for quantiles of streamflow. Three primary methods were used to analyze streamflow trends including: 1) the non-parametric Mann-Kendall trends test to identify monotonic change, 2) cluster analysis to determine if trends in streamflow were regional in nature, and 3) Quantile-Kendall analysis to identify trends over the period of record. Results from our analysis have identified significant trends in monthly and seasonal streamflow values as well as significant trends over the entire flow regime.

Seasonal and Annual Salinity Trends in the Mississippi Sound in Response to Extreme Weather and Freshwater Inflow, 1995-2018

SWARZENSKI C.M., RODGERS K.D., MIZE S.V.

The U.S. Geological Survey and U.S. Environmental Protection Agency have begun a preliminary assessment of seasonal and annual salinity trends in the Mississippi Sound, an area that extends from Mobile Bay in Alabama to Bayou Rigolettes in Louisiana. On the south, the Sound is separated from the Gulf of Mexico by a series of barrier islands. These islands allow the exchange of water between the Gulf and Mississippi Sound through a series of tidal passes. The Pascagoula and Pearl Rivers along with a few smaller rivers locally introduce the majority of freshwater into the Sound. Freshwater may also enter the Sound through Lake Pontchartrain during openings of the Bonnet Carre spillway. Extreme weather events such as tropical storms and heavy rainfall further influence salinity.

Annual and seasonal trends in salinity and freshwater inflow from local watersheds are being evaluated using Kendall-Tau analysis. Stations from Mobile Bay, the Mississippi Sound and the nearshore waters of eastern coastal Louisiana are included. Not surprisingly, salinity in the Mississippi Sound, and by extension, water-quality are controlled by the timing and quantity of freshwater input and the rate of lateral exchange of water along the coasts of Alabama, Louisiana, and Mississippi. Salinity is a determining factor for productivity in estuarine waters and understanding the factors that control salinity variability are fundamental to understand biological functioning and health, as well as, source water partitioning in the Mississippi Sound.

An Interactive Data Visualization Tool for Exploring the Causes and Extent of Streamflow Alteration Across the Lower Mississippi and Gulf Coast Region

WALKER J.D., KNIGHT R., LETCHER B.

The U.S. Geological Survey Lower Mississippi-Gulf Water Science Center and the U.S. Environmental Protection Agency are performing a comprehensive assessment of streams that flow into the Gulf of Mexico. The goal of this assessment is to assist resource managers in identifying and prioritizing opportunities for flow restoration and thereby protect and replenish valuable coastal water resources. This assessment will generate numerous large and complex datasets including geospatial basin characteristics and streamflow statistics that reflect the magnitude, timing, trend, and degree of alteration for freshwater delivery to the Gulf. To make these datasets accessible to decision makers and other researchers, we developed a web-based data visualization tool called the Interactive Catchment Explorer for the Lower Mississippi Gulf (ICE-LMG).

ICE-LMG was built using the ICE framework, which is a generalized web application platform developed as part of the Spatial Hydro-Ecological Decision System (SHEDS) and is designed for exploring large environmental datasets and model outputs. ICE utilizes modern web technologies and numerous free and open source software (FOSS) libraries to provide an engaging user experience through a high degree of interactivity and responsiveness. The ICE framework has been applied to projects across the country including stream temperature and trout occupancy model predictions for the Northeast and Mid-Atlantic U.S. and a climate vulnerability assessment of endangered fish species in the northern Rocky Mountains.

The ICE-LMG web application will provide a map-based interface for viewing spatial patterns of basin characteristics, streamflow statistics, and various metrics of flow alteration across the Gulf Coast region. The base map will be coupled to interactive histograms that show the distributions of selected variables and can be used to filter the dataset by applying single- or multi-variate criteria through a technique called cross filtering. Using this technique, users can interactively explore spatial and temporal patterns of each variable, as well as understand the correlations between the variables.

This presentation will describe the motivation and approach to developing the general ICE framework and its application to the Lower Mississippi-Gulf region. We will then demonstrate how ICE-LMG can be used to explore datasets and develop a better understanding of the causes and extents of streamflow alteration across this region. By making the results of this study available to local and state decision makers through an engaging user interface, it is our hope that ICE-LMG will serve as a valuable decision support tool for facilitating flow restoration efforts and stimulating further research.

Putting Flow-Ecology Relationships into Practice: A Decision-Support System to Assess Fish Community Response to Water-Management Scenarios

NEBIKER S., CALDWELL C., KNIGHT R.

Understanding the relationship between the ecological health of a stream and its flow is critical for resource managers to develop effective water management plans that address multiple and often conflicting uses throughout a river basin. Since management objectives must be considered in a basin-wide context, it is important to conduct regional analyses of the relationship between streamflow and riverine ecosystems that account for differences in physiography, land use, and topography. Further, for the flow-ecology recommendations to be scientifically credible, they must be derived from measured data. However, the effort required to do these analyses on a regional scale, let alone on an individual river segment, can be prohibitive.

Throughout the eco-flow assessment process, decision makers must be involved so as to promote collaboration between stakeholders and to identify the trade-offs between varying management strategies. To that end, it is helpful to (a) distill the underlying analysis down to the most ecologically-relevant flow criteria so that flow-management models can quickly generate results and (b) distill the resulting environmental metrics down to an easily understood concept like fish diversity, i.e., number of fish species. For decades, the integration described above has been elusive. This presentation introduces a framework to operationalize flow-ecology relationships into decision-support systems of practical use to water-resource managers, who are commonly tasked with balancing multiple competing socioeconomic and environmental priorities. We illustrate this framework using a case study from the Tennessee River Basin—one of the most ecologically diverse basins in the United States—whereby fish community responses to various water-management scenarios were predicted in a partially-regulated river system at a local watershed scale. The water-allocation modeling framework used—OASIS—is flexible, transparent, and allows for quick screening of management scenarios which positions it to be used in a collaborative setting with watershed stakeholders.

DELTA WATER QUALITY I: LAKES AND AQUATIC ECOLOGY

Demystifying Denitrification in Mississippi Delta Lakes

TAYLOR J.M., LIZOTTE R., OCHS C.

Denitrification (DNF) is a biologically-mediated mechanism that converts nitrate (NO_3-N) to di-nitrogen (N_2) gas and potentially removes excess N from intervening waterbodies distributed across the Mississippi Delta landscape. Despite its considerable influence on N cycling and potential mitigation potential as an ecosystem process, very little information is available on denitrification rates in Delta water bodies. We use two different approaches to measure DNF with data collected from two different Delta habitat types: a bayou within the Delta interior (Roundaway Lake), and historic river meander cutoff of the lower Mississippi River (Desoto Lake). Results indicate that significant DNF occurs within Delta lake habitats and rates are governed by organic matter and N availability. Sediment core incubations from Roundaway Lake indicate DNF rates increase with increasing N availability and were enhanced by crop organic matter transported from adjacent agricultural fields. Connectivity with the Mississippi River during spring flooding resulted in high N enrichment in Desoto Lake. After the river receded and separated from the lake, NO_3-N concentration decreased with corresponding increases in N_2 gas concentrations in the hypolimnion, indicating that denitrification can play a significant role in N removal within off channel habitats of the river. Information on factors that influence DNF in Delta waterbodies can improve models of N cycling and export within Delta watersheds as well as identify potential management strategies for enhancing DNF and N mitigation within the region.

Linking Agricultural Best Management Practices with Eutrophication and Oxygen Stress

LIZOTTE R.E., YASARER L., LOCKE M.A.

Intensive row-crop agriculture in the Mississippi Delta have well-documented impacts on lakes in the region. Eutrophication resulting from nutrient loads (nitrogen and phosphorus) in runoff directly affect lake productivity and dissolved oxygen. Agricultural best management practices (BMPs) supported by the USDA Natural Resources Conservation Service (NRCS) can be implemented by land users to help protect and improve water quality. Although NRCS supported BMPs are primarily used to control soil loss, erosion and associated sediment loads in runoff, these same practices have the added benefit of reducing nutrient loads. The current study attempts to assess the effects of BMPs on lake eutrophication and associated oxygen stress in two Mississippi Delta lake watersheds. Beasley Lake watershed (BL) in Sunflower County has multiple integrated BMPs (16.9% watershed acreage) including edge-of-field vegetated buffers, conservation reserve areas and constructed wetland habitats. In contrast, Roundaway Lake watershed in Coahoma County has a few isolated BMPs (2.3% watershed acreage) including conservation reserve areas and a constructed wetland habitat. During May-September 2018, biweekly water quality variables comprising soluble orthophosphate (PO_4-P), total phosphorus (TP), nitrate nitrogen (NO_3-N), total Kjeldahl nitrogen (TKN), chlorophyll a (total algal biomass), phycocyanin (cyanobacteria biomass), and weekly diel surface dissolved oxygen (DO, 0.3 m at 15 minute intervals) were measured. Nutrient data showed BL had significantly lower concentrations of TKN ($p < 0.001$) and TP ($p = 0.003$) than RL. Mean summer TKN in BL and RL were 1.098 and 1.581 mg/L, respectively, and mean summer TP in BL and RL were 0.079 and 0.147 mg/L, respectively. However, mean summer NO_3-N ($p = 0.416$) and PO_4-P ($p = 0.836$) concentrations were not significantly different between BL (0.024 mg NO_3-N/L and 0.021 mg PO_4-P/L) and RL (0.061 mg NO_3-N/L and 0.023 mg PO_4-P/L). Mean summer total algal biomass (36-58 g/L) and cyanobacteria biomass (30-102 g/L) were both significantly lower in BL relative to RL ($p < 0.010$). Concomitantly, frequency of summer DO stress (as DO < 4 mg/L in hours per week) was significantly lower ($p = 0.010$) in BL (3.4 hours per week) than RL (37.6 hours per week). Correlation and regression analyses indicated associations with increased BMPs, decreased total nutrient inputs, corresponding decreased algal biomass, and decreased DO stress during summer of 2018. Results clearly indicated BL, in the presence of more intensive BMPs, was significantly less eutrophic and less oxygen stressed than RL during summer conditions.

Seasonal Sediment Accumulation Rates in Beasley Lake, MS

WREN D.G., TAYLOR J.M., RIGBY J.R., LOCKE M.A., YASARER L.

Recent sedimentation rates are useful for quantifying the effects of changing watershed conditions on soil erosion; however, typical geochronological methods for dating sediments are limited in temporal resolution. We used sediment traps to measure short-term sediment accumulation rates in Beasley Lake, Mississippi, a natural oxbow lake whose watershed has a mix of agricultural and forested land. Precipitation data from a local Soil Climate Analysis Network (SCAN) site and water quality measurements from Beasley Lake were used to explain patterns in sediment deposition rates. We found that sediment accumulation in the traps was highest in the summer, while the highest rate of runoff occurred in late winter and early spring. The delay between fine sediments entering the lake and deposition in the traps prevented the detection of changes in watershed erosion within seasons; however, sediment traps were shown to be useful for inferring changes in watershed erosion rates on annual timescales. Our findings contribute new understanding of the interactions between suspended sediments, algal biomass, and water chemistry in a natural oxbow lake and provide support for using sediment traps to measure intra-annual variability in sedimentation rates in oxbow lakes

Characterizing Legacy Phosphorus Storage and Release from Beasley Lake Sediments

YASARER L., MARTIN H., LOCKE M.A., TAYLOR J., LIZOTTE JR. R.E., STEVENS E.

Agricultural soils in the Mississippi Delta are notoriously rich in legacy phosphorus. Due to high erosion rates, nutrient-rich soil often ends up in Delta lakes and water bodies. However, few studies have been conducted to quantify the phosphorus stored in these sediments and to estimate potential fluxes in lake environments. This study represents a starting point for characterizing legacy phosphorus in aquatic environments in the Delta utilizing sediment and data collected from Beasley Lake, an oxbow lake in an agricultural watershed that has been studied by the USDA-ARS since 1995. Twelve sediment cores were collected from two locations: six from the littoral zone (depth = 1.5 m) and six from the limnetic zone (depth = 2.8 m). Cores were incubated for two weeks with either aerobic or anaerobic treatments. Sediment samples were also taken from each lake coring site and chemical and physical characterization, sequential phosphorus extractions, and phosphorus isotherm analyses were performed. Results from the experimental incubated cores demonstrated average phosphorus fluxes of 0.77 and 1.72 mg/m^2/day under aerobic conditions and 15.26 and 22.33 mg/m^2/day under anaerobic conditions from the littoral and limnetic zones, respectively. Results from the sediment characterization demonstrated that Beasley Lake sediments are indeed storing a large amount of phosphorus (P), up to 279 g-P per g dry sediment. Yet, results of the isotherm analysis suggest the sediments have the potential to adsorb up to 3200 g-P per g dry sediment under oxygenated conditions. These results suggest that Beasley Lake has a large pool of available phosphorus, but still has the potential to store more under oxygenated conditions. With anaerobic conditions this phosphorus may be released into the water column where it could stimulate algal growth. Dissolved oxygen (DO) conditions near the sediment interface in Beasley Lake have been measured since May 2018 and will be continuously measured to understand seasonal DO patterns. The combination of experimental analysis of phosphorus release and field observation of lake conditions will help provide a deeper understanding of aquatic nutrient cycling in Beasley Lake and potentially other Delta water bodies.

DELTA WATER QUALITY II: MEASURING AND MODELING AGRICULTURE RUNOFF

Does the Sudden Influx of Broiler Production Impact Nearby Surface Water Quality?

MOORE M.T., LOCKE M.A.

The United States has the largest broiler chicken industry in the world. Arkansas (1 billion head) and Mississippi (740 million head) are two of the five top broiler producing states. Although poultry is the largest agricultural commodity for both Arkansas and Mississippi, until recently, large-scale broiler production has generally been limited to a small number of clustered counties within each state. In 2014, an industry partner invested $165 million in two northeast Arkansas counties for a significant poultry complex, and by 2017, hundreds of new chicken houses were built within the Current, Upper Black, and Lower Black River watersheds. These were areas new to the broiler chicken industry, as most broiler production had occurred in the middle and extreme northwestern parts of the states. Water quality issues of high levels of phosphorus and nitrate in the Illinois River Basin in northwestern Arkansas had raised the concern of possible surface and ground water contamination by an overwhelming number of chicken houses. In northeast Arkansas, the primary rivers within these watersheds (Current and Black) provide surface water for recreation and agricultural needs. Aquatic diversity is high, and several endangered freshwater mussel species are present in these watersheds. Because of the potential concern for water quality impairment by the sudden influx of chicken houses, a small-scale evaluation began in December 2016 on a six- acre recreation pond immediately downstream of newly constructed chicken houses. Seasonal water quality and sediment sampling are underway for basic physicochemical parameters, nutrient, and pesticide concentrations. Water quality trends will be examined and discussed, along with opportunities and suggestions on research collaborations to ensure continued agricultural commodity production is harmonized with the surrounding natural resources.

Effect of Land Management on Surface Runoff Water Quality in Beasley Lake Watershed

LOCKE M.A., LIZOTTE JR. R.E., YASARER L., BINGNER R.L., MOORE M.T.

Assessing best management practices in the landscape is needed to better understand their potential to mitigate sediment and nutrient loss in runnoff. Runoff and sediment and nutrient losses in Beasley Lake Watershed were monitored from 2011 to 2017. Landscape management in monitored catchments included areas under row crops with (CropBuff) and without (Crop) edge-of field buffers and under the Conservation Reserve Program (CRP). The study demonstrated that edge-of-field vegetated buffers and conservation reserve can be integral components in an agricultural landscape to reduce topsoil loss and transport of nutrients downstream concomitantly mitigating water quality impacts on rivers and lakes. Overall, efficacy in mitigating runoff losses of soil and nutrient resources, significant within-lake processes may limit the effectiveness of land management in improving downstream water quality. Results from this study should be providing additional information to improve and sustain water quality and overall environmental quality using combined conservation practices.

Management Practice Impacts on Runoff and Sediment Loads in the Upper Sunflower River Watershed

BINGNER R.L., MOMM H.G., PORTER W.S., YASARER L., ELKADIRI R., ABER J.

The Mississippi River alluvial floodplain is one of the most productive agricultural regions in the United States and the Upper Sunflower River watershed is an important part of this region. Over the past decade, land-use patterns in the Upper Sunflower River watershed have shifted to include more corn and soybean cropland and less cotton. In addition, irrigation adoption has increased from approximately 26% of the watershed in 2001 to 43% in 2015. This study uses the USDA Annualized Agriculture Non-Point Source (AnnAGNPS) watershed pollution modeling technology to assess the impacts of these land-use and irrigation changes on runoff and sediment loads in the Upper Sunflower River watershed. Modeling simulations demonstrated that the increase in irrigation adoption increased runoff during the irrigation season, while conversion of cotton to corn and soybean cropland reduced average annual suspended sediment loads. These results provide a starting point for understanding watershed sensitivity to changes in crop and irrigation management practices.

Management Practices to Improve Infiltration and Decrease Nutrient Transport Under Furrow

SPENCER D., KRUTZ J., LOCKE M., RAMIREZ-AVILA J., HENRY B., GOLDEN B.

Furrow irrigation and sealing silt loam soils contribute to a low irrigation application efficiency in Mid-Southern, USA corn production systems. Cover crops may improve irrigation application efficiency and interest in incorporating cover crops into Mid-Southern, USA production systems has risen in recent years. Studies were established in Stoneville, MS in 2017 and 2018 to determine the effects of four cover crops on corn grain yield, irrigation application efficiency, irrigation water use efficiency, and sediment and nutrient transport. Experimental design is a randomized complete block with four replications. Treatments include a reduced till/no cover (as a control), reduced tillage with cereal rye (*Secale cereal L.*), reduced tillage with Austrian winter pea (*Pisum sativum L.*), reduced tillage with tillage radish (*Raphanus sativus L.*), reduced tillage with crimson clover (*Trifolium incarnatum L.*), and no till/no cover. Except for cereal rye and Austrian winter pea, yield was decreased from 2017 to 2018 up to 47%. No till/no cover and tillage radish decreased runoff volume from 2017 to 2018 by 24.8 and 12.3%, respectively. No till/no cover also increased furrow advance time. Sediment and nutrient transport results will also be presented.

GROUNDWATER MANAGEMENT

An Exploratory Study of Introducing Common Property-Based Management for the Sustainable Groundwater use in Mississippi

KO J.

Underground water levels have dropped in Mississippi over the last two decades, because most municipalities have depended on groundwater for their tap water sources and irrigations for large-scale cash crop—cotton, corn, soybean farming also have depended on groundwater in the State of Mississippi. The natural resource is regarded as private property and reporting of water use is not required in state. Currently the voluntary reporting of groundwater withdrawal has remained at ten percent and the State of Mississippi is in a legal dispute with Tennessee over the groundwater near the state border to secure more groundwater. These cases show well serious challenges in designing programs for stabilizing water table in aquafer, and for sustainable water use in the State. Elinor Ostrom (co-recipient of the Nobel prize in economics in 2009) and her associates have developed theoretical and empirical studies of common property-based management for natural resources, including aquafer. Western States, which had adopted private property as fundamental right in their state water policies, have increasingly adopted the common property-based management in managing their watersheds and aquafers over the years. For example, Arizona designates the areas experiencing rapidly depleting groundwater as Active Management Areas and mandates estimation of safe-yield and preservation of groundwater for future use. The proposed study examines differences between private property-based and common property-based managements and explores potential changes in Mississippi from the cases of water management in the Western States, if adopted.

Case Studies of Rapid Dam Breach Modeling During Flood Events

CROSBY W.

The USACE Modeling Mapping and Consequences Production Center (MMC) provides hydraulic modeling, mapping and consequence analysis for USACE dams in support of the USACE Dam Safety and Critical Infrastructure Protection and Resilience (CIPR) Programs. The MMC has developed processes, tools and standards for creating dam breach hydraulic models for use in emergency action plans (EAP), during real-time flood events, and in support of the Corps Dam Safety and Security programs. The MMC-developed standards have been used to provide dam failure modeling for over 500 USACE dams and multiple flood events, involving over 1000's of stream miles throughout the continental U.S. and Alaska. The MMC also provides Flood Inundation Modeling support during real-time flood events with its Flood Inundation Modeling Cadre (FIM). The mission of the FIM Cadre is to assist districts when called upon to run real-time hydraulic models, prepare forecast inundation maps, and develop consequence estimates for significant flood events. Since supporting the flooding efforts during the 2011 flood of record on the Mississippi River and the 2011 flood on the Missouri River, the FIM Cadre has been called in to support multiple flood events across the nation, including support during some hurricanes.

This presentation will provide case studies where the MMC FIM Cadre has supported flood inundation modeling during flood events. The presentation will primarily focus on dam break analysis during hurricanes. In 2015 the MMC performed a dam break analysis in South Carolina during Hurricane Joaquin. Additionally, MMC performed 2 dam break analysis during Hurricane Matthew in 2016. The MMC FIM Cadre has also performed numerous levee breach analysis during flood events.

Projection of Climate Change Impact on Groundwater Resources in the Upper Yazoo River Watershed, Mississippi

OUYANG Y., JIN W., FENG G., YANG J.

Groundwater depletion due to anthropogenic activities is an issue of water resource concern worldwide, while climate change adds the uncertainties to this concern. Currently, very few efforts have been devoted to projecting the impact of climate change on groundwater resources in forest and crop lands in Mississippi, which is crucial to water resource managers and farmers in the region. In this study, we modify the USGS's MERAS (Mississippi Embayment Regional Aquifer Study) model to assess the impact of potential climate change on groundwater flow and level in the Upper Yazoo River watershed (UYRW), Mississippi. This watershed consists of two major land uses: one is the forest land and the other is the crop land. Three simulation scenarios were developed in this study. Scenario 1 is a base scenario with the input parameter values similar to those of MERAS model. Scenarios 2 and 3 are the same as Scenario 1 except that Scenario 2 increased while Scenario 3 decreased the groundwater recharge rates by 1 and 2%. The latter two scenarios were developed based on our observations of the past 100 plus years' rainfall trends. In general, the impact of climate change on groundwater flow in the UYRW was primarily through its impact on groundwater recharges due to the changes in rainfall events. Simulation results showed that a 2% increase in groundwater recharge rate increased average groundwater head by 0.39 ft after 21 years, whereas a 2% decrease in groundwater recharge rate decreased groundwater head by 0.36 ft after 21 years. Furthermore, a 2% increase in groundwater recharge rate increased groundwater volume by 201,401 ft^3/y after 21 years, while a 2% decrease in groundwater recharge rate decreased groundwater volume by 185,909 ft^3/y after 21 years. Impacts of climate change through its impacts on groundwater recharge due to rainfall change were discernable. Further study is therefore warranted to apply the same approach to estimate impacts of climate change on groundwater resources for the entire Mississippi Embayment Regional Aquifer by combing the MERAS and HSPF models using the Integrated Hydrologic Model.

Hydrogeologic Thresholds Affect Groundwater-Surface Water Interactions of the Big Sunflower River at Sunflower, Mississippi

O'REILLY A.M., HOLT R.M., DAVIDSON G.R., PATTON A., RIGBY J.R., BARLOW J.

At a site near Sunflower, Mississippi, observations of Big Sunflower River stage and adjacent groundwater level indicate a disproportionately larger response in groundwater level above a certain stage elevation. This suggests the river contributes water to the aquifer at a higher rate above a threshold that defines high-stage versus lower-stage periods. This is in contrast with the common assumption of a linear relation between river leakage and water-level difference between the river and aquifer. Heterogeneity in the riverbed or near-field geology can impart such a threshold effect on groundwater-surface water (GW-SW) exchange. Variations in the texture of riverbed sediments and lithologic variations in underlying geology are examples of common heterogeneities. Hydrologic interaction with these heterogeneities leads to distinct types of behavior that switch when river stage or groundwater level rises above or falls below the interface.

A simple dynamic water-balance (linear reservoir) model was developed to investigate this phenomenon at the study site on the Big Sunflower River. Four conceptual models, each of which consists of a perched aquifer that receives recharge from the riverbank and loses water to the underlying Mississippi River Valley alluvial aquifer, were tested: homogenous riverbank and aquifer lithology, two-layer riverbank and homogenous aquifer lithology, two-layer riverbank and two-layer aquifer lithology, and homogenous riverbank and two-layer aquifer lithology. Models were run using hourly observed river stage, calibrated to a 382-day period of water-level measurements in a nearby well, and rerun for the entire 1,278-day period of record. All models matched observed groundwater levels reasonably well, with a maximum root-mean-square error (RMSE) of 0.46 m. However, the heterogeneous models matched high-stage events substantially better than the homogeneous model, with the best performance (RMSE of 0.27 m) by the model incorporating threshold effects controlled by both two-layer riverbank and two-layer aquifer lithology. Substantial flow occurs through both the upper riverbank, representing about 30% of the flow through the lower riverbank, and the upper aquifer, representing about 25% of flow through the lower aquifer.

These results illustrate the importance of considering threshold effects on GW-SW interactions. Regional-scale, numerical, groundwater models typically do not incorporate threshold effects, because the causative heterogeneities exist at a scale smaller than a single grid cell. Models such as those developed here can be incorporated into numerical groundwater models to better simulate intra-cell processes that cannot be effectively modeled at the regional scale.

USGS MAP PROJECT

Estimating Irrigation Water Use in the Mississippi Alluvial Plain, 1999-2017: Aquaculture and Irrigation Water-Use Model (AIWUM) Version 1.0

WILSON J., PAINTER J., TORAK L., KRESS W.

Water use is a critical and often uncertain component of quantifying the water cycle and securing reliable and sustainable water supplies. Recent water-level declines in the Mississippi Alluvial Plain, especially in the Mississippi Delta, pose a threat to water sustainability. Currently, the U.S. Geological Survey (USGS) Water Availability and Use Program Mississippi Alluvial Plain Water Availability Study is developing a hydrologic decision-support system to help manage water resources in this area, one of the most productive agricultural regions in the Nation.

To improve water-use estimates needed as input to the hydrologic decision-support system, an aquaculture and irrigation water-use model, Aquaculture and Irrigation Water-Use Model (AIWUM) 1.0, was developed and compared to other reported and estimated irrigation water-use values within the study area for 1999-2017. AIWUM 1.0 is primarily driven by annual flowmeter data provided by the Mississippi Department of Environmental Quality's Delta Voluntary Metering Program as well as historical flowmeter data from the Yazoo Mississippi Delta Joint Water Management District. The model quality incorporates remote sensing and flowmeter data and outputs monthly estimates at a fine spatial (100 meters) and temporal (monthly) resolution used directly in the Mississippi Embayment Regional Aquifer Study (MERAS) groundwater model 2.1.

Results indicate annual total irrigation water-use estimates ranged from about 3 to 9 billion gallons per day and a majority of the irrigation water use was applied to soybeans (52%), followed by aquaculture and rice (26%), other crops (10%), corn (8%), and cotton (4%). Comparisons indicate that annual total irrigation water-use estimates from AIWUM 1.0 generally were smaller than all other sources of water-use data, but within the Mississippi Delta the total annual water use is approximately equal between AIWUM 1.0 and the MERAS groundwater model 2.1.

This and other models included in the decision-support system are developed in Python and interconnected, resulting in a dynamic, instead of the traditional static, model. This approach allows models to quickly evolve as better data are available (e.g., additional flowmeter data, improved remote sensing data), providing the current best estimates of water resources to cooperators and the public. Future planned work includes (a) determination of irrigation rates based on machine learning and geostatistical methods using daily precipitation and temperature data and regional irrigation water-use from flowmeter data, (b) improved classification of crop type and irrigated versus unirrigated lands, (c) back- and forecasting estimates from 1890-2100, and (d) establishment of a public-facing, real-time irrigation water-use model.

Two-Method Prediction Divergence of Water Level for the Mississippi River Valley Allluvial Aquifer to Inform Observational Network Review

ASQUITH W.H.

Information gaps can be detected by quantifying statistical efficacy in estimation of phenomena such as groundwater levels at unmonitored locations for the Mississippi River Valley alluvial (MRVA) aquifer located within the Mississippi Alluvial Plain (MAP), south-central United States. Multi-agency water-level networks containing wells screened in the MRVA aquifer collect data in space (horizontal and vertical dimension) and time. Groundwater levels are also influenced by a given hydrogeologic framework (aquifer geometry and properties), well construction, local and regional pumping histories, and contexts of seasonal recharge and discharge. One common stakeholder inquiry concerns identification of information gaps. To quantify information gaps, a two-method approach for water-level prediction is proposed. Two statistics of interest were spring 2018 maxima (March-May) and fall 2018 minima (September-November) based on use of water-level data collected during these same months from 2014-2018 with prediction made for 2018. Spring maxima represent maximum seasonal aquifer recovery, whereas fall minima represent maximum aquifer drawdown attributable in part to irrigation demands. Data included for this study were computed from 1,411 unique wells for which 6,304 measurements (discrete or daily mean) were available. Our focus is not on the estimation of water levels per se but on the divergence between estimates using two methods (generalized additive models [GAMs] and support vector machines [SVMs]). Spatial coordinates, land-surface altitude, MRVA aquifer bottom altitude, and year were used as predictor variables. GAMs and SVMs are powerful estimation methods in their own right, but by their radically different mathematics, perform differently as extrapolation increases when predictions are increasingly made away from hyperspace of predictor variables and not necessarily away from spatial coordinates. GAMs can have curvatures away from the global mean, but SVMs must curve back to the global mean. Throughout the MAP and aligned to the 1-kilometer National Hydrogeologic Grid (NHG), absolute differences between GAM and SVM predictions were computed. Spatial depiction of the results on the NHG are shown for the entire MAP as well as for subdivision-specific GAM and SVM computations for the Boeuf, Cache, Delta, Grande Prairie, and St. Francis subdivisions. Various local areas in the MAP can be seen with large GAM-SVM divergence, and hence these areas have potential information gaps, indicating the need for additional water-level monitoring. Stakeholders are thus provided information on which to judge allocation of future resources in monitoring of the MRVA aquifer.

Mapping the Variability of Specific Conductance in Groundwater of the Mississippi River Valley Alluvial Aquifer

KILLIAN C., BUSSELL A., KNIERIM K., KINGSBURY J., WACASTER S., KRESS W.H.

The Mississippi River Valley alluvial (MRVA) aquifer is the uppermost aquifer underlying the Mississippi Alluvial Plain (MAP) and spans portions of eight states within the Mississippi Embayment. The MRVA aquifer supplies most of the groundwater used for irrigation throughout the MAP. Water-quality conditions in parts of the aquifer may limit the availability of groundwater for irrigation, public supply, and domestic use. To better understand and map the water resources of the MAP, the U.S. Geological Survey (USGS) designed an Airborne Electromagnetic (AEM) survey to map resistivity of hydrologic units at the regional scale. Mapping resistivity changes of hydrologic units will help identify the primary drivers that influence groundwater quality in the MRVA aquifer. To accurately interpret the AEM survey data and the changes in resistivity, the spatial and vertical distribution of groundwater specific conductance throughout the aquifer needed to be delineated. This study compared newly collected and existing historical specific conductance and chloride data from over 1,500 existing wells and cooperatively funded water-quality monitoring sites screened in the MRVA aquifer to changes in geomorphology, recharge rates, and well depth. The results from this study will support threedimensional machine-learning models of specific conductance and recharge-rate estimates as a part of characterizing the water-budget components in the MAP. Results will also help to predict aquifer salinity across the region and help to characterize areas where possible upwelling from deeper saline units may impact the availability of fresh water in shallower aquifers.

Using Machine-Learning Models to Predict Concentrations of Nuisance Constituents in Groundwater of the Mississippi Embayment

KNIERIM K., KINGSBURY J., HAUGH C.

Machine-learning methods were used to map groundwater quality, including specific conductance (SC), total dissolved solids (TDS), and chloride, in the Mississippi River Valley Alluvial aquifer (MRVA) and the Claiborne aquifers of the Mississippi Embayment regional aquifer system. The MRVA aquifer is used widely for irrigation and locally for public supply, and high concentrations of chloride and iron can limit groundwater use. The middle Claiborne and lower Claiborne aquifers of the Mississippi Embayment are largely confined with few water-quality concerns, but higher salinity zones occur with depth as groundwater becomes more mineralized. Explanatory variables, including surficial spatial datasets (such as soil properties and land use), groundwater-flow model output (such as groundwater flux and age), and well characteristics (such as depth to screened interval) were used in boosted-regression tree models to predict SC and chloride concentrations throughout the aquifers at depth zones used for drinking water supply. TDS concentrations (which has a secondary maximum contaminant level of 250 g/L) were modeled using the correlation between SC and TDS. Surficial explanatory variables were attributed to individual wells using a 500-meter buffer, which for confined aquifers likely does not reflect the recharge zone for groundwater to the well. However, predicted values of hold-out data (not used to train the model) were in good agreement with observed values for SC models ($r^2 = 0.62$). Important predictors included surficial variables such as land-surface elevation, landscape geomorphology, well position within the aquifer system, and land use. In particular, land-surface elevation may be a good indicator of whether the well screen was located in a confined or unconfined area of the aquifer system. Therefore, mapping groundwater quality across a confined aquifer system using surficial datasets is possible, and predicted concentrations were improved when groundwater-model variables were included as explanatory variables in machine-learning models.

Recent Hydrogeologic Investigations at Shellmound MS for the Groundwater Transfer and Injection Project

RIGBY J.R., KRESS W., MINSLEY B.

The USDA is conducting a pilot study to investigate the potential for a managed aquifer recharge project to augment recharge to the Mississippi River Valley Alluvial Aquifer (MRVA). The conceptual design of the project proposes to use riverbank filtration to capture water from the Tallahatchie River for direct injection in the aquifer. The USGS Mississippi Alluvial Plain (MAP) project, as part of a larger regional effort, in collaboration with USDA has contributed extensive high-resolution geophysical investigations to the characterization of the hydrogeology of the project area including Airborne Electromagnetic (AEM) surveys, surface Nuclear Magnetic Resonance (NMR), and towed time-domain electromagnetic surveys (tTEM). The Resolve AEM survey provides the best composite image of the aquifer available to date and at a higher resolution than any previous method. The high-resolution airborne survey mapped an area 15 km by 30 km north and west of Greenwood, MS. Flight lines were oriented east-west and separated by 250m. The AEM provides a spatially extensive data set to help interpret the thickness of the MRVA, the elevation of the aquifer top and bottom, and the nature of material lying above and below the aquifer. The AEM survey results for the study area show the bulk of the MRVA between 10m and 45m below land surface. An extensive electrically conductive unit begins to appear broadly at 40-50 m below land surface in the eastern half of the project area though it is cut by a large-scale channel-like feature of electrically resistive material extending to depths of approximately 80 m below land surface. In the western half of the project area moderately resistive material extends deeper than in the eastern half suggesting the appearance of subcropping Tertiary units in contact or nearly in contact with the MRVA. The AEM survey has also provided extensive data on the electrical properties of the top 10 m of sediment below land surface commonly referred to as the confining layer of the MRVA. This layer is shown to be highly heterogeneous, suggesting that areal recharge from precipitation may also be spatially heterogenous and vary substantially. Results from near-surface methods gives a still higher resolution picture of the upper sediment layers but broadly agrees with results of the high-resolution AEM survey. These methods will be further compared with other geophysical methods and core logs to outline the evolving conceptual framework of the study area for the managed aquifer recharge project.

Geophysical Data Integration for the Shellmound Inset Groundwater Flow Model of the Mississippi Alluvial Plain

GUIRA M.N., PETERSON S.M.

The U.S. Geological Survey Mississippi Alluvial Plain project is updating groundwater models of the Mississippi Embayment and Mississippi River Valley Alluvial aquifer to provide key information and decision support for stakeholders through a decision support system. Groundwater withdrawals from the Mississippi River Valley Alluvial aquifer sustain agricultural production in the Shellmound, Mississippi area, but groundwater declines have heightened concerns about long-term sustainability of the resource and led to consideration of artificial recharge or other water management activities. To support evaluation of the effects of potential water management activities in the Shellmound area, aquifer characteristics derived from high-resolution airborne electromagnetic surveys (AEM) are being integrated into a groundwater flow model. The Shellmound model area is about 1000 square kilometers covering part of northwestern Mississippi.

Aquifer characteristics derived from the AEM data at multiple resolutions will be objectively evaluated through automated groundwater model calibration, for example, using 1 layer to represent the alluvium as opposed to ten. Each model will use the same hydrologic input data and be calibrated against equivalent calibration targets. Subsequent comparison between model calibration data and simulated outputs for variously-resolved groundwater flow models will provide information about the level of detail in the vertical discretization that most improved the Shellmound Inset groundwater flow model. The comparison will also provide information about the maximum level of detail in the vertical discretization that can be supported from the AEM and supporting data available for model calibration.

Substitution Between Groundwater and Other Inputs in Irrigated Agriculture in the Mississippi Alluvial Plain: An Economic Analysis

ALHASSAN M., LAWRENCE C., PINDILLI E.

The Mississippi Alluvial Plain (MAP) region consists of parts of Mississippi, Arkansas, Illinois, Kentucky, Louisiana, Missouri, and Tennessee and relies on the Mississippi River Valley Alluvial Aquifer (MRVAA) for approximately 90 percent of its irrigation water. Irrigated agriculture is the main source of economic activity in this region, with regional economic impact of more than $11 billion from production of major commodities in 2017. However, groundwater levels in the underlying aquifers have declined due to long-term excess pumpage over inflows. These declining groundwater levels result in decreases in well yields, and reduction of water in storage in the aquifers to meet future demands and sustainable use.

To support decision making regarding groundwater availability and use in the region, this study examines relationships between groundwater, labor, fertilizer use, and irrigation systems (furrow and center pivot) as the main inputs in the production of the major crops (corn, cotton, rice, and soybeans) in the region. In general, understanding relationships between groundwater and other inputs in agricultural production helps decision makers in sustainable management of groundwater. Our study also investigates how changes in water budget components impact input groundwater use in the region. This study employs a translog cost function, a type of econometric model, to analyze the production relationships between the inputs. The model relies on a large dataset of input prices, outputs of corn, soybeans, cotton, and rice, and the hydrologic characteristics of the underlying aquifer. We use 2017 county-level data from USDA-NASS, Crop Enterprise Budgets and Planning Budgets from the University of Arkansas and Mississippi State University, and a combination of observation and model-based hydrologic data. Our preliminary results using state-level data show an inelastic price elasticity of demand for groundwater and inelastic cross-price elasticities of demand between groundwater and the other inputs.

Models Supporting Decision Making: The USGS Mississippi Alluvial Plain Project

HUNT R.J., PINDILLI E.J., FIENEN M.N., KRESS W.H.

The US Geological Survey (USGS) is commonly asked to provide science to inform societal decision-making, including numerical models. Twentieth Century workflows emphasized paper reports and or single discipline information to those charged with making decisions. Such workflows are ill suited for today's decisions, especially those involving adaptive management or large uncertainties. Moreover, as stakeholders have grown accustomed to near instant access to information such as real-time weather forecasts, water-resource support systems have not kept pace. This is the context within which local stakeholders initiated the USGS Mississippi Alluvial Plain (MAP) project in 2016. From its inception, effort was dedicated to formulating a new approach of applying USGS models to decision support involving: 1) dynamic, sophisticated hydrologic-economic model integration, 2) reusable script-based model construction modules; 3) automated conduits that move new field data to the model; 4) high-throughput computing to update calibration and uncertainty outputs; 5) fast-running surrogate models; and 6) web-services suitable for feeding decision-support systems designed by others. The overarching goal is to provide responsive, consistent, and seamless high-quality science even as the decision-making landscape evolves. Challenges to this vision include building an approach that encompasses moving projection targets, ensuring scientific reproducibility, developing a common technology and language across a large, multidisciplinary team, and robust script design extensible for new data types and numerical code updates. However, by the end of the MAP project we believe the workflow and supporting documentation developed will have transferability to many areas outside the MAP.

BIOLOGY, ECOLOGY, AND MANAGEMENT OF AQUATIC AND WETLAND PLANTS

Experimental Evaluation of Herbicides for Chemical Management of Nuisance Native Aquatic Plants

ERVIN G.N., TURNAGE G., CALHOUN K.

Resource managers of public lands, such as national wildlife refuges, manage their lands not only for the resident fish and wildlife species, but also for patrons who utilize those resource areas. Occasionally, the dominance of problematic native plant species interferes with the intended uses of these areas. One example of this is when dense growth of aquatic vegetation blocks access to or effective use of waterbodies. In Mississippi and adjacent states, native plant species, such as Nelumbo lutea or Limnobium spongia, sometimes reach nuisance levels; however, few methods are currently known that allow the control of problematic native plant species such as these.

Our work is aimed at evaluating several chemicals for their potential to manage these plants in a way that mitigates their negative impacts on recreational use, while also minimizing potential negative impacts on water quality and desirable native plant species. We are conducting mesocosm studies to evaluate six systemic herbicides and one contact herbicide (at two dosage levels each) for their potential to control four target plant species (the above-mentioned two plus *Nymphaea odorata* and *Brasenia schreberi*).

During the first 3 weeks after treatment (WAT), we observed rapid response to some of the herbicides and dosages being evaluated. At that point, all three modes of action included in the study had shown at least 50 percent mortality on all four of the species included in the study, with only two chemical species combinations not reaching 50 percent mortality within 3 weeks. In fact, 2,4-D, Glyphosate, Triclopyr, and Flumioxazin all caused 50 percent mortality of three of the species during the first week, with other chemicals causing 50 percent mortality of the fourth species within the first WAT. At 8 WAT, we still saw continued control of all species except fragrant water lily, based solely on leaf count data. Additionally, we found that, although some herbicides caused a pulse of nitrate concentrations at 4 weeks after achieving 50% mortality, those nutrient concentrations recovered to levels comparable to untreated tanks over the ensuing 4 weeks. We did not find any other evidence of potential negative impacts on water quality in any of the treatments.

Torpedograss Vontrol via Submersed Applications of Systemic and Contact Herbicides

TURNAGE G., WERSAL R., MADSEN J.

Torpedograss (*Panicum repens*) is a perennial invasive aquatic plant species native to South America that is spreading across the southeastern US. Torpedogass can survive in terrestrial and aquatic environments rooted to hydrosoil or form large floating islands (tussocks) that can limit human and wildlife uses of waterbodies. Portions of tussocks can break off, float away, and start new torpedograss infestations in other locations thereby making the problem worse. Limited data exist concerning submersed chemical control (herbicides) methods that are effective at controlling torpedograss. This work was conducted to investigate short- and long-term submersed chemical control options of torpedograss grown in outdoor mesocosms near Starkville, MS. Nine herbicides labeled for use in aquatic environments and a non-treated reference were evaluated. Eight weeks after treatment (WAT), harvested plants were separated into root/rhizome and shoot/leaf tissues, placed in labeled paper bags, dried in a forced air oven for five days at 70C, then weighed. None of the herbicides significantly reduced root/rhizome tissues for torpedograss eight WAT, however penoxsulam, topramezone, flumioxazin, and carfentrazone-ethyl had reduced root/rhizome tissue by 52 WAT (57%, 64%, 97%, and 62% reduction, respectively). Triclopyr, diquat, flumioxazin, and carfentrazone-ethyl had reduced shoot/leaf tissue at eight WAT (57%, 47%, 98%, and 49% reduction, respectively). At 52 WAT, penoxsulam, topramezone, flumioxazin, and carfentrazone-ethyl had reduced shoot/leaf tissues by 49%, 66%, 97%, and 57%, respectively. While no herbicide treatment reduced root/rhizome biomass below pre-treatment levels, flumioxazin did reduce shoot/leaf tissues below pre-treatment levels. This work suggests that submersed applications of penoxsulam, topramezone, flumioxazin, or carfentrazone-ethyl can provide long-term control of torpedograss populations.

Survey of Aquatic Plant Species in Mississippi Waterbodies

SHOEMAKER C., TURNAGE G.

Mississippi has significant water resources that, many times, are impaired by invasive aquatic and wetland plant species. These plants can impact water quality (DO, pH, turbidity, etc.) such that native flora and fauna are negatively affected. Infested waterbodies can then act as source populations to introduce non-native vegetation to other waterbodies in the region thereby worsening the problem. The likelihood of being a source population increases if a waterbody has a high frequency of boat traffic. Many times small waterbodies that have significant amounts of boat traffic are overlooked due to the size of the waterbody. Approximately 192,050 acres of MS are covered by small waterbodies (<100 acres) which is greater than the five largest reservoirs in the state combined (117,840 acres; Ross Barnett, Sardis, Grenada, Enid, and Arkabutla reservoirs). The state has a greater number (>160,000) and density (1 per 0.51 mi^2) of small waterbodies than any other state in the MidSouth (MS, AL, AR, TN, LA, and GA) region. Many waterbodies in the state that receive the highest amount of traffic are those owned and managed by the state of MS (MDWFP), federal agencies (USFWS, USFS, or USACE), or private entities. The purpose of this work was to survey small and medium sized waterbodies (100 - 7,500 acres) for the presence of invasive or problematic aquatic vegetation as no statewide survey of these waterbodies in MS has been conducted within a single growing season. In total, 42 waterbodies were surveyed between June-July 2017 and were spread throughout most major geophysical regions of Mississippi. Only four waterbodies in this survey had plant assemblages entirely composed of only native aquatic plant species while 38 (90% of surveyed waterbodies) had at least one non-native aquatic plant species. Of the 105 plant species observed, 15 were non-native (14% of surveyed plants). Alligatorweed (*Alternanthera philoxeroides*) and torpedograss (*Pancium repens*) were the most widespread non-native species in the state. Brittle naiad, wild taro (*Colocasia esculenta*), water hyacinth (*Eichhornia crassipes*), and Cuban bulrush (*Oxycaryum cubense*) are of concern as they have the ability to rapidly colonize any waterbody in which they are introduced. The results of this survey are useful in implementing early detection, rapid response (EDRR) management options on populations of non-native aquatic plant species in Mississippi, specifically small isolated populations, before they spread to other sites. This survey highlights the need for repeated monitoring throughout Mississippi in order to know which waterbodies are impacted by aquatic invasive plants and the severity of each infestation.

Potential Management Options for Controlling Giant Salvinia (*Salvinia molesta* D.S. Mitchell)

SARTAIN B.T.

Giant salvinia is a highly invasive floating aquatic fern that is spreading across the southern United States. It is an aggressive competitor that reproduces asexually through fragmentation, allowing it to easily spread to surrounding water bodies. Giant salvinia growth is rapid and biomass can double in 36 hours under optimal conditions; allowing it to form dense mats of plant material that can completely cover a water body. Due to its rapid growth and ability to form large extensive mats, water resources have been impacted immediately after the initial infestation. Dense plant growth impedes navigation, irrigation, and recreational use of water resources, leading to not only environmental impacts, but economic impacts and public health concerns. These negative impacts have led to situations where giant salvinia needs to be intensively managed to limit its growth and spread to surrounding water bodies. Chemical, biological, physical/mechanical, and integrated control methods are all potential management options available for controlling giant salvinia. Selecting the proper management option is dependent on a number of factors including: management goals and objectives, the size of the infestation, site characteristics, the primary uses of the infested water body, available budget, and proximity to sensitive plant and animal species. This presentation provides an overview of the current management options for controlling and limiting the spread of this species.

WATER RESOURCES CHARACTERIZATION AND USE IN NORTHEAST MISSISSIPPI

Comprehensive Approach to Characterizing Groundwater Resources Throughout Mississippi

BANKS J.

The Office of Land and Water Resources (OLWR) is charged with conserving, managing, and protecting the water resources of Mississippi. Sufficient spatial coverage of water level monitoring within a short period of time is critical to the characterization of an aquifer. The Monitoring Branch of the Water Resources Division developed a comprehensive plan to provide OLWR with a detailed view of water levels in the state's major drinking water aquifers by starting in the northeast corner of the state and working to the south and west. Work to measure these water levels throughout Mississippi is being accomplished as efficiently as possible by utilizing all staff in the Branch to focus on monitoring in one area at a time. This work also accomplishes the Monitoring Branch goals of characterizing available water resources in prioritized municipal areas throughout the state each fiscal year. The prioritized areas being studied for fiscal year 2019 are the Ripley aquifer, the Coffee Sand aquifer, the Eutaw-McShan aquifer, and the Gordo aquifer, which are drinking water sources for much of northeast Mississippi, including the cities of Starkville, Amory, and New Albany.

Overview of Groundwater Resources in Northeast Mississippi

BRISTER A.

The Monitoring Branch of the Office of Land and Water Resources (OLWR) within the Mississippi Department of Environmental Quality (MDEQ) is tasked with monitoring the state's groundwater and surface water resources so that the resources can be put to beneficial use while also being protected. A survey of groundwater levels was completed in 2018 in the Paleozoic and Cretaceous aquifers, which are utilized in twenty counties in the Northeastern area of the state. Water levels were collected by a team of geologists and engineers using methods involving steel and electric tapes from which new potentiometric maps, hydrographs, and cross-sections were created. Changes in water levels across the area of investigation are identified and quantified with areas of significance being highlighted and further investigated. This information is utilized by the Permitting, Certification, and Compliance Division of OLWR to inform the management and permitting of the use of groundwater and surface water resources.

Overview of Surface Water Resources in Northeast Mississippi

HENLEY L.

Mississippi water law (§ 51-3-1) calls for the conjunctive use of both surface water and groundwater so that, to the fullest extent possible, the ground and surface water resources within the state shall be integrated in their use, storage, allocation and management. The Monitoring Branch of the Water Resources Division in the Office of Land and Water Resources (OLWR) at the Mississippi Department of Environmental Quality (MDEQ) characterizes both surface and groundwater resources to inform permitting decisions. There is a large amount of surface water available for use in northeast Mississippi, primarily the Tennessee Tombigbee Waterway, which is a man-made waterway comprised of river, canal, and divide sections that encompasses approximately 234 navigable miles between the Tombigbee River at Demopolis, Alabama and the Tennessee River at Pickwick Lake. Authorized by Congress in 1946 as a means of commercial navigation, construction was completed for the project in 1985. In addition to being used for commercial navigation, the Tennessee Tombigbee Waterway is used for recreation, fishing, a habitat for wildlife, and a source of water for several cities, towns, and industries.

Management of Water Resources in Northeast Mississippi

SORRELL K.

The Office of Land and Water Resources (OLWR) is responsible for the management of the water resources in Mississippi. § 51-3-1 of the Mississippi Code requires that the water resources of the state be put to beneficial use to the fullest extent of which they are capable, that the waste or unreasonable use, or unreasonable method of use, of water be prevented, that the conservation of such water be exercised. In order to achieve this, the Permitting, Certification, and Compliance Division of OLWR utilizes water availability and use data to determine the viability of new groundwater and surface water withdrawal points, allowed permitted volumes for new and existing groundwater and surface water withdrawal permits, and restrictions on permitted uses. Both surface water and groundwater are used in Northeast Mississippi to meet the demand of multiple beneficial uses.

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