

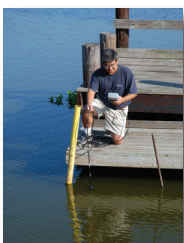
LOUISIANA Agriculture

Vol. 54, No. 4, Fall 2011
Published Since 1957

Assuring Our Future Through Scientific Research and Education

*Water
Resources*





ON THE COVER: Y. Jun Xu takes measurements at the University Lakes in Baton Rouge. Read the story on page 17. Photo by Johnny Morgan

LSU AgCenter is committed to water quality

Y. Jun Xu

In 2011, Texas experienced a severe drought that state officials declared as the worst on record. Sustained dry, hot conditions caused fires and damage to the ranching and farming industry, as well as placed a strain on the state's recreational hunting and fishing sector. It has been estimated that the drought has cost Texas \$5.2 billion in lost crops and livestock. The drought killed much of the grass used for grazing and, as a result, many Texan ranchers may be forced out of business. Meteorologists predict the drought conditions may continue well into next spring and summer. Some claim continuing drought conditions will persist in Texas for the next 15 years.

During the same time, Texas's neighbor, Louisiana, had a vast amount of water traveling down the Mississippi River. The historic 2011 Mississippi River spring flood required the opening of the Morganza and Bonnet Carre Spillways in Louisiana. Billions of gallons of water were diverted from the Mississippi River into the Atchafalaya River Basin, which posed a serious flood threat to communities, making many people temporarily relocate to higher ground.

Imagine aqueducts that conveyed these waters from Louisiana to Texas. Imagine the nutrient-rich waters being used to irrigate the millions of acres of dried farming land and to feed the millions of thirsty livestock in Texas rather than contributing to the Gulf of

Mexico Dead Zone. Imagine the riverwater diversion system continuing to work in 2012, 2013, and many years beyond. What economic benefits would that bring to citizens of Texas and Louisiana?

Like petroleum and natural gas, water is a precious natural resource of Louisiana. However, nature's gift has not been fully valued by Louisianians. Although there is an abundance of water in the state, we face a number of water-related issues that affect our environment, the state's long-term economy and our well-being.

This issue of Louisiana Agriculture magazine contains articles from 48 researchers and extension specialists at the LSU AgCenter. These papers present some of the results gained from their research activities in a wide range of topics including water availability and quality, their effects on crop and fisheries production, riverine nutrient and sediment sources, wetland restoration, saltwater intrusion, stormwater protection, wastewater treatment, best management practices for protecting water quality, and water resources education programs. It is our hope that through this publication, the people of Louisiana will not only be shown our commitment to creating and broadening the knowledge of effective utilization and protection of our state's water resources, but also will be inspired to join us in the efforts. ■

Y. Jun Xu, Associate Professor, School of Renewable Natural Resources, LSU AgCenter, Baton Rouge, La.

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What's New

Crawfish study in mesocosms begins

A system to test various aspects of crawfish biology and culture has recently been completed at the South Unit of the Rice Research Station in Crowley.

A series of 12 fiberglass tanks (each 12 feet in diameter and 5 feet high) were set up to provide many of the amenities of earthen crawfish aquaculture ponds, albeit with the ability to exercise greater control over some of the key variables affecting growth and production.

The outdoor tanks contain soil, planted crops of rice (forage for crawfish), supplemental aeration, and individual water inlets and outlets. When stocked with known numbers and sizes of crawfish, the tanks will serve as semi-natural mesocosms conducive to research that would be difficult or impossible to conduct in ponds.

The first research trial to be conducted in these mesocosms is under way. The objectives of this research are to obtain more comprehensive data on the relationship of crawfish growth to water temperature and to ascertain cumulative degree-day (DD) requirements for crawfish. Like the DD-50 model for rice, which uses cumulative degree-days to determine time to various growth stages in rice, the data generated from this study will relate cumulative degree-days to growth of crawfish and more precisely the degree-day requirements necessary for hatchlings to reach the minimum market size of 15 grams or 30 count per pound.



A series of 12 fiberglass tanks have been set up at the South Unit of the Rice Research Station in Crowley to study crawfish. Photo by John Sonnier

This information will be useful for crawfish aquaculture managers that want to more accurately predict time to harvest based on peak periods of young-of-the-year recruitment. This information could also be used as a diagnostic tool for assessing reproductive trends and population dynamics.

■ Ray McClain

Birders flock to south Louisiana

THORNWELL, La. – Birdwatchers from 23 states and two countries converged on rice fields in Jefferson Davis Parish to get a glimpse of the small, elusive bird called the yellow rail.

The Yellow Rail and Rice Festival, which was Oct. 27-30, drew 123 participants. For many of the birders, the event was their first chance to check another species off their lists.

The birds are easy to spot flying out of rice fields in late October and early November as farmers harvest their second-crop rice. Kevin and Clarence Berken, farming brothers in the Thornwell community, hosted the birdwatchers in their fields and let them ride their combines to see the birds. When a rail was spotted, Berken beeped the horn on his combine to alert the onlookers standing on the field's edge.

"This is a real treat," said Bob Loomis, of Virginia Beach, Va., who came to the festival with his wife. "We're having a good time."

Loomis said he had lost count of the number of rails he had seen flying

out in front of Kevin Berken's combine. "They skim and glide into the rice. As soon as they hop up, they are back down."

Joan Hewlett and Ann Beaulieu, both of upstate New York, said the related sora rail passes through New York, but it resides there in the marshes.

The Berkens used the festival as a chance to let visitors know about rice farming and their contribution to creating habitat for waterfowl.



Birdwatcher Joan Hewlett, of New York, scans a rice field being harvested by farmer Kevin Berken near Thornwell, La. Photo by Bruce Schultz

Kevin Berken said the visitors also were given bags of rice provided by farmer Jimmy Hoppe and Falcon Rice Mill. Apparently, that gesture made a positive impression.

"When I shop, I usually buy Tex-mati rice, but now I'll be looking for Louisiana rice," Hewlett said. "I like rice better than potatoes."

Keith Hawkins, of Little Rock, Ark., walked alongside the combine to get a close-up view of the birds as they flew out of the rice about to be harvested. Mud was caked on his pants from a misstep, and he wasn't sure how many rails he had spotted. "Eight or maybe more," he said. "I lost count. That was fantastic."

Bill Vermilion, a member of the Lafayette-based conservation group the Gulf Coast Joint Venture, was working at the festival as a facilitator to help birders.

"Birdwatchers can go all their lives and not see this bird," Vermilion said. "It prefers to run, and it takes something like a combine to make it fly."

Vermilion said the migrating bird spends the winter in Louisiana, and the northern Great Plains is its usual breeding grounds.

Audubon Society member Dave Patton,



Birdwatchers perched on a combine harvesting rice look for a small bird, the yellow rail, in a field in Jefferson Davis Parish. The bird is rarely seen, but it is often observed flying out of a rice field as the crop is being cut. Photo by Bruce Schultz

of Baton Rouge, said four bald eagles flew over Kevin Berken's field when the field trip started.

Patton said the group included birdwatchers from the casual to the intense, but they all found Louisiana abundant in varying species. "We have a lot of birds here that we take for granted."

This was the festival's third year. Kevin Berken said the festival began after Patton brought birdwatchers to the area to see the rails four years ago. He said he allowed them to walk his fields, and he offered them a ride on his combine.

Once LSU ornithologists Donna Dittman and Steve Cardiff became involved, the idea gained considerable traction, and word spread nationwide in the birding community, Berken said.

Berken said the festival provides the chance for birders to see the beneficial effects of rice farming on wildlife. "You can't buy air time for a message like that to get out the word that rice farming creates good habitat."

Appreciation for rice cultivation is becoming more widespread, said Steve Linscombe, director of the LSU AgCenter Rice Research Station.

"This just confirms that people from throughout the U.S. are realizing the contribution that rice farming makes toward the wildlife environment," Linscombe said. "Here

in Louisiana, we often take this for granted. But particularly in periods of dry weather like we have now, a rice field can be an oasis for bird life."

The event shows how agriculture can be used to draw tourism to the state, said LSU AgCenter agritourism coordinator Dora Ann Hatch. ■ **Bruce Schultz**

Field day shows dairy business from 'cow to cone'

For an urban university, it may be a well-kept secret that some of the best dairy products in Louisiana are produced on the LSU campus.

Those who attended a dairy field day, which was dubbed "From Cow to Cone," on Nov. 2 were shown what happens at the campus dairy and the creamery – from feeding young calves to making ice cream.

"There's been a working dairy on this campus since 1904, when four cows were bought from the University of Missouri," said Gary Hay, director of the School of Animal Sciences.

Those cows were shipped down the Mississippi River on a barge and started what is now a full-time dairy that milks nearly 100 cows twice every day, Hay said.

At the dairy, the group toured the milking parlor and was shown how the operation works with most of its labor provided by students.

"We wanted to show them the work that we are doing in disease prevention and calf growth and management," Hay said.

At the creamery, the group saw how ice cream and cheese are made and participated in a taste test of milk to see if they could tell which of three samples had an oxidation problem that affects the flavor.

"In the creamery, we're developing functional foods, which are dairy foods with enhanced nutritional qualities," Hay said. "We also are doing some research with product shelf life to make products last a little bit longer."

The campus dairy represents a truly unique marriage between the LSU AgCenter and the LSU College of Agriculture, said John Russin, LSU AgCenter vice chancellor for research.

"Our research interacts with graduate student training," Russin said.

■ **Johnny Morgan**



Chuck Boeneke, LSU dairy science professor, prepares milk for a taste test during the "From Cow to Cone" dairy field day on the LSU campus on Nov. 2. Two of the samples were identical, but a third had an oxidation problem, which affects the flavor. Photo by Johnny Morgan

Keep Louisiana's water resources plentiful and good

D. Allen Rutherford

Louisiana's rivers and streams (66,294 miles), natural lakes and human-made reservoirs (1,078,031 acres), fresh and tidal wetlands (5,550,951 acres), and estuaries (4,899,840 acres, where freshwater mixes with saltwater), combined with Louisiana's territorial waters cover over a third of the state's land area.

Water quality describes the chemical, physical and biological properties of water. It embodies many complex characteristics including temperature, dissolved oxygen and other gases (e.g., carbon dioxide, nitrogen, hydrogen sulfide), sediment levels, salinity, acidity, nutrients (nitrogen and phosphorus), as well as bacteria and other organisms that live in water. These characteristics are each dependent on local conditions such as geology, the terrain and topography, local drainage patterns, weather, and, of course, human influences. Interactions among the complex characteristics of water and the complexity of local conditions and influences determine the limits of how water can be safely used or simply enjoyed. For most of us, we just want to know if our water is safe for drinking or swimming and suitable for our plants and animals.

Louisiana's topography is a diverse patchwork of both upland and bottom-land forests, pastures, prairies and savannahs, marshes, swamps, and coastal waters. This naturally decorated landscape is interlaced with thousands of miles of rivers, streams, lakes, reservoirs, wetlands and estuaries. Including Louisiana's territorial waters, our water resources cover over one-third of the



Intercoastal water way. Photo by Y. Jun Xu



Freshwater marsh. Photo by Y. Jun Xu

state's area. Home to some of the world's most diverse flora and fauna, this breadth of natural resource diversity is reflective of our state's abundance of water resources. It's no wonder our state is known as a sportsman's paradise.

The importance of uncontaminated groundwater (water stored beneath the surface) for agriculture, forestry, human consumption and the environmental health of our ecosystems cannot be underestimated. Pesticides, herbicides, fertilizers, sediments and other chemicals often run off terrestrial areas into the nearby water bodies, where they can

adversely affect aquatic life, the quality of drinking water, and, ultimately, limit our quality of life. Over the last century and a half, all aquatic ecosystems have been impacted as human population and cultural activities have increased across Louisiana's landscape.

The LSU AgCenter's mission is to provide research-based information to improve the quality of life and economic well-being for Louisiana residents. To fulfill this mission, AgCenter scientists study economically important crops (forestry, sugarcane, rice, soybeans, cotton, etc.), livestock and aquacultural spe-

cies (poultry, horses, beef, farm-raised fishes, etc.), and other natural resources (wildlife, freshwater marine fisheries, recreational hunting and fishing, etc.). The goal is to improve and enhance both their quantities and qualities. The value of plant agriculture (\$6.4 billion), animal agriculture (\$2.6 billion) and natural resources (\$2.6 billion) is significant and critical to the economy of our state. Each of these valuable commodities is intimately dependent on an abundant and clean supply of water.

The AgCenter also has a stated focus on the health and safety of our biological environment, which requires examining the effects on water quality of all agricultural-related activities with the goal of maximizing production while minimizing damage. It is our duty to help conserve, protect, restore and maintain the state's water resources.

The articles in this issue give an excellent look at the diversity of ongoing research and extension efforts by AgCenter scientists. Several research studies examine water quality issues and best management practices and strategies associated with specific commodities (rice, Saichuk and Gauthier, page 35; sugarcane, Viator *et al.*, page 18; forestry, Bryant-Mason and Xu, page 9; aquaculture, Romaine *et al.*, page 32).

Other studies identify and pose solutions to runoff associated with land-based activities. These include the effects of runoff from agricultural activities on water quality in adjacent water bodies (agricultural watersheds, Selim *et al.*, page 22; erosion control to prevent sediment inputs, Weindorf *et al.*, page 24; impacts of animal waste, Wang and Gaston, page 16; fertilizer runoff on levees, Beasley *et al.*, page 14).

Several studies examine novel solutions to treating water to improve its quality (ornamental plants and storm-water runoff, Chen and Bracy, page 20; rice hulls as a biological filter, Davis *et al.*, page 28) and water-use efficiency (efficient irrigation, Sheffield and Girouard, page 30).

Additionally, two research articles examine ecosystems with large-scale water quality issues unique to Louisiana (Atchafalaya Basin, Kaller and Kelso, page 12; Gulf of Mexico, hypoxic dead zone, Xu *et al.*, page 8). Retired state climatologist Jay Grymes gives us an update on



Measuring stream flow in Flat Creek. Photo by Y. Jun Xu

climate conditions and the recent drought (page 26).

Finally, we are given a synopsis of ongoing extension efforts that help public understanding of AgCenter past and present water quality research (LeBlanc *et al.*, page 33). This extension-related article includes a clear explanation of newly proposed numeric nutrient criteria for water bodies, a demonstration project quantifying the ability of submerged aquatic vegetation to reduce nutrient levels, an update of the BMP manual in addition to an educational program designed for horse owners and producers, and an overview of a partnership program with Shell Oil Company that is designed to educate public school teach-

ers on an array of water quality issues and concerns.

We hope this issue of Louisiana Agriculture magazine gives you a good overview of how AgCenter scientists are focused on addressing the important water-related issues of our time. We are continually faced with many complex and ongoing challenges to our natural resources, but we are committed to the task. We believe that well-designed research and tireless extension can make a substantial difference. ■

D. Allen Rutherford, Professor and Director, School of Renewable Natural Resources, and Interim Head, Department of Biological & Agricultural Engineering, LSU AgCenter, Baton Rouge, La.



Lake Chicot. Photo by Y. Jun Xu

Nutrient Removal

from Atchafalaya during 2011 flood

April Bryant-Mason and Y. Jun Xu

The Mississippi-Atchafalaya River carries a large quantity of nutrients, making Louisiana's estuarine and coastal waters highly productive for commercial fisheries. However, excessive riverine nutrients, especially nitrate nitrogen, have caused algal growth and the consequent oxygen depletion in the summer over the past two decades. This condition, also known as hypoxic dead zone, exerts not only long-term ecological impacts, but also economic damage from lost fisheries income.

As the hypoxic dead zone in the northern Gulf of Mexico continues to grow, alternative means to reduce nutrient loads from the Mississippi River to the Gulf are being sought. One of the options is to divert the nutrient-rich water to the river corridor and floodplain wetlands in the lower Mississippi-Atchafalaya River Basin. It is unclear how much nitrate reduction this would cause.

The Mississippi River flood of 2011 required the opening of the Morganza Spillway to divert the flood water into the Atchafalaya River Basin. This event offered a unique opportunity for investigating nitrate transport and retention in this large river swamp basin. During this flood event, LSU AgCenter scientists collected water samples for nitrate analysis at three locations on the Atchafalaya River, using Simmesport as the input and Wax Lake Outlet and Morgan City as the output. In addition, measurements of water temperature and dissolved oxygen were taken at these locations. This data collection design was to quantify mass inflow, outflow and the retention rate of nitrate in the Atchafalaya River Basin during the extreme flood event.

Nitrate Concentration and Transport

From May 15 to July 20, nitrate concentration in the Atchafalaya River was lower at the outlets than at the input. The concentration change was inversely correlated with the flood discharge, with the lowest nitrate concentration occurring at the peak flow and the highest concentration occurring approximately one month later as the river flow receded. While the concentration fluctuation at Simmesport is mainly dependent on the Mississippi River water, the concentration change at Morgan City represents additional influences from the basin.

During the 10 weeks of the 2011 flood, a total of 107,034 tons of nitrate entered and 103,066 tons of nitrate left the Atchafalaya River. The nitrate transport during such a short period of time represents approximately half of the average annual nitrate load in the Atchafalaya. Because the Atchafalaya River discharge represents about 32 percent of the total Mississippi River's flow during the flood, the Mississippi River main chan-



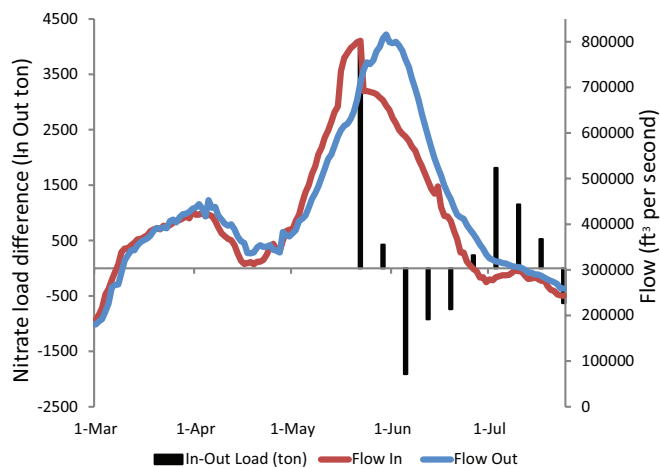
A river corridor and forest wetland in the Atchafalaya Basin. Photo by Y. Jun Xu

nel would have discharged 219,029 tons of nitrate, assuming the concentration at Simmesport represents that in the Mississippi River. The total nitrate transported from the Mississippi-Atchafalaya system during this flood would amount to 322,095 tons of nitrate, which is about 31 percent of the annual nitrate input to the Gulf.

Atchafalaya River Nitrate Retention

The Atchafalaya River Basin acted as a small sink for nitrate, retaining nearly 4 percent of the nitrate entering the basin during the 2011 flood. Although there were some weeks in early June that the basin released nitrate, nitrate was retained in the basin during the flood recession (Figure 1). Timing of this flood later in the season may have allowed for higher denitrification or permanent removal. Because denitrification is dependent both on lack of oxygen and presence of the required biological community, warmer water favors these conditions in holding less oxygen while being high enough to support a biological community.

Figure 1. Average daily inflow (Simmesport and Morganza Spillway) and outflow (Wax Lake and Morgan City) from the Atchafalaya River. Nitrate retention/export bars indicate the difference between the weekly nitrate load input and output.



Flow paths in the Atchafalaya Basin are not fully understood and are apt to become even more convoluted in large floods. Intensive sampling results show that the flood diverted an extraordinarily large quantity of nitrate to the Atchafalaya River, and that this swamp river basin with high connectivity to its floodplains functioned as a nitrate sink, which is unlike the findings of previous studies. Despite the magnitude of the flood and the potential for the Atchafalaya Basin to reduce nitrate load, only 4 percent of nitrate was retained. Further testing will help determine if the nitrate change is from temporary storage (assimilation) or permanent removal (denitrification), which will be helpful for predicting riverine nitrate transport and transformation in floods of this magnitude. ■

April Bryant-Mason, Graduate Student, and Y. Jun Xu, Associate Professor, School of Renewable Natural Resources, LSU AgCenter, Baton Rouge, La.

Acknowledgments

The authors acknowledge funding from McIntire-Stennis and thank the U.S. Geological Survey Louisiana Water Science Center for providing river discharge data. The authors also thank Abram DaSilva for field assistance.



The Morganza Spillway Highway 190 bridge before, above, and after the spillway opening. Photos by Y. Jun Xu

Forestry Best Management Practices

and stream water dissolved oxygen

Y. Jun Xu, Abram DaSilva and April Bryant-Mason

Dissolved oxygen (DO) is an important indicator for water quality in surface water bodies. Like most terrestrial organisms, fish and many other aquatic organisms are adapted to a narrow range of DO concentrations. While oxygen concentration in the atmosphere stays relatively constant, DO concentration in water can vary because of a number of physical, chemical and biological factors.

Stream water temperature, turbulence and the amount of organic matter in the water all affect how much DO is present. The solubility of oxygen in water is inversely related to water temperature. Turbulence increases the rate of reaeration, which is the rate that oxygen moves from the atmosphere into solution when the DO concentration is below saturation. Respiration by aerobic organisms, decomposition of organic matter and chemical oxidation are all processes that consume oxygen from water.

In Louisiana, high average temperatures, sluggish stream-flow resulting from the flat landscape and high organic content found in the majority of streams combine to cause low DO concentrations. Currently, about half of the state's watersheds are listed as impaired for the low DO levels in their water bodies. While the current acceptable DO minimum is 5 milligrams per liter, LSU AgCenter researchers found that many streams in forested areas of northern Louisiana were below this standard. Stream oxygen depletion is a pervasive problem in many Louisiana streams.

Because of the low DO levels found in many Louisiana's forested streams, there is a concern that timber harvest in these areas can further exacerbate this condition. Although forestry best management practices (BMPs) are widely implemented in Louisiana, it is not clear if the practices can prevent further DO degradation in the streams that are already under DO stress. To fill this knowledge gap, AgCenter researchers began an intensive monitoring study on stream DO changes in 2006 in the Flat Creek watershed, an area representative of the flat forested landscape in much of Louisiana.

From 2006 to 2010, AgCenter researchers monitored changes in stream DO in two monitoring intensities – monthly measurements at three harvested sites and 15-minute continuous measurements at one harvested site. At each harvested site, researchers installed two monitoring locations – one upstream above the harvested area and another downstream below the harvested area. Timber harvest was conducted during the summer and fall of 2007.

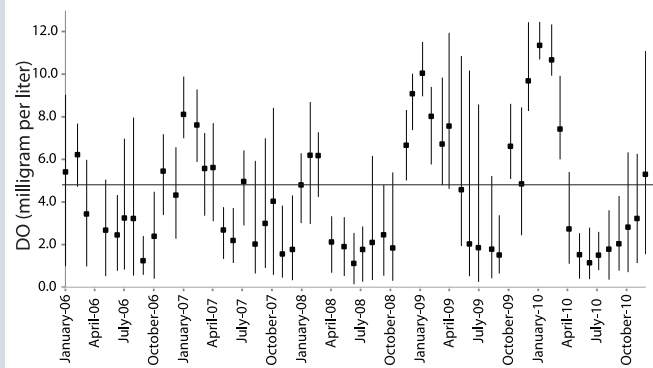
(continued on page 10)



Many streams in Louisiana show low dissolved oxygen because of the gentle topography, organic-rich stream substrate and high temperature. These students are taking measurements as part of LSU AgCenter research. Photo by Y. Jun Xu

The five-year study shows that Louisiana's current forestry BMPs can maintain existing stream DO levels through minimizing stream temperature increases and excessive intrusion of harvest residue. Neither water temperature nor organic carbon concentrations were changed by the timber harvest. At two of the harvested sites, no change in DO levels was found between the upstream and downstream sites. At one harvested site, DO increased slightly downstream of the harvested site, which can be attributed to increased surface runoff and the resulting increased turbulence.

Figure 1. Seasonal dissolved oxygen variability from 2006 to 2010. Squares represent the means, and lines show the ranges between maximum and minimum values from multiple stream locations in a low-gradient forested watershed in central Louisiana.



Large seasonal variation in DO levels exists in the studied streams. Based on the findings, an attainment of 5 milligrams per liter DO standard seems to be unrealistic for many forested streams that are already classified as DO-impaired in this region (Figure 1). The goal of the Louisiana Department of Environmental Quality is to determine the best attainable criteria. Therefore, the attainment standard applied to this region should be adjusted accordingly to account for seasonal load allocations for DO. A more appropriate goal is 3 milligrams per liter for the summer months and 5 milligrams per liter for the remaining months. ■

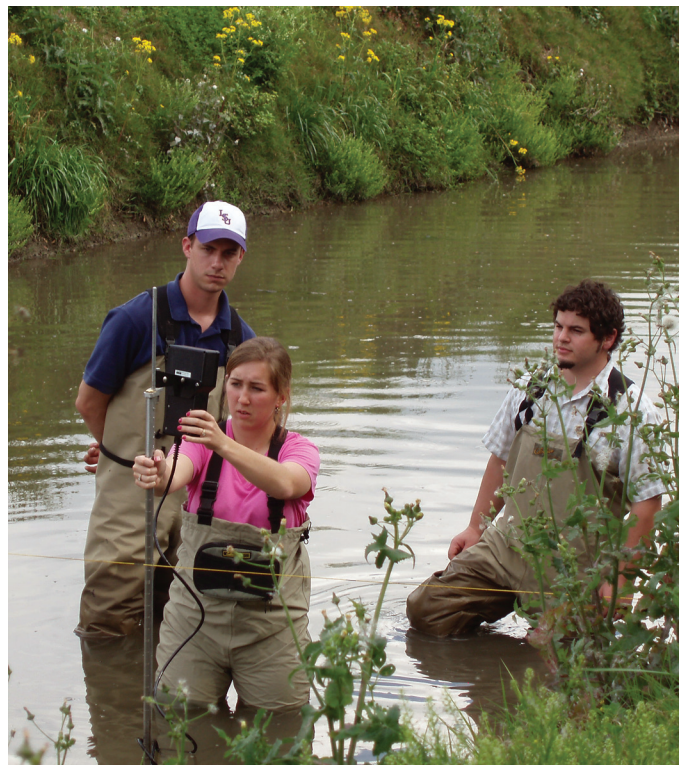
Y. Jun Xu, Associate Professor; Abram DaSilva and April Bryant-Mason, Graduate Assistants, School of Renewable Natural Resources, LSU AgCenter, Baton Rouge, La.

Riverine Sediment and the Louisiana coast

Y. Jun Xu and Timothy Rosen

About 40 percent of the nation's coastal wetlands are in Louisiana and include contiguous freshwater wetlands, contiguous brackish wetlands, and low and high salt marshes. These natural ecosystems are highly productive and serve as critical nursery areas for Gulf of Mexico sea life, ensuring a thriving marine and fisheries industry. However, Louisiana coastal wetlands are disappearing at an alarming rate. Since the 1990s the land loss rate has been estimated to be between 9,884 and 13,838 acres each year, and over the previous 50 years, land loss rates have exceeded 14,826 acres per year. Total land loss since the 1930s has been more than 1.2 million acres. This loss represents 80 percent of the coastal wetland loss annually in the entire continental United States.

The factors that have contributed to the rapid wetland loss along Louisiana's coast include land subsidence, sea level rise, coastal erosion and reduction in riverine sediment loads. Coastal Louisiana is built on sediment, and many wetlands in the region depend on sediment supplies from the inland rivers (Figure 1). Information on the quantity and distribution of the



Students measure river flow in LSU AgCenter research. Photo by Y. Jun Xu

Figure 1. Major river systems supply sediments to coastal Louisiana.

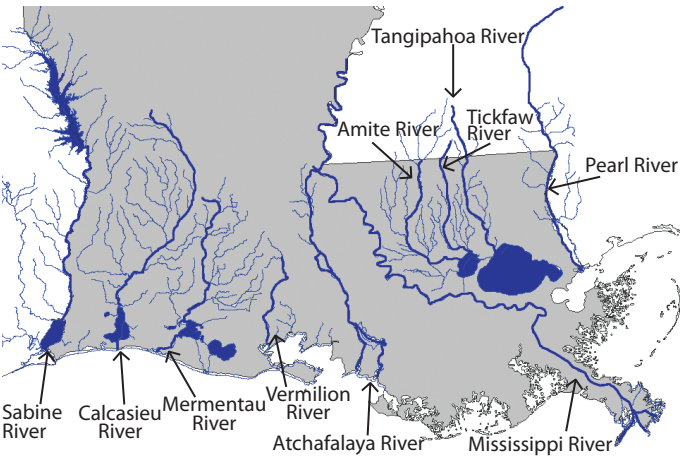


Table 1. Average annual discharge and total suspended solids deliveries of 10 major rivers in coastal Louisiana.

Section	River	Total Sediment (tons)
Lake Pontchartrain	Pearl	438
	Tangipahoa	56
	Tickfaw	20
	Amite	155
Mississippi-Atchafalaya	Mississippi	139,718
	Atchafalaya	59,073
Chenier Plain	Vermilion	47
	Mermentau	44
	Calcasieu	52
	Sabine	235

supplies is therefore important for policy makers to develop effective resource management strategies for regional sediment management.

Over the past several years, LSU AgCenter scientists have conducted studies to quantify long-term total yields of suspended solids from 10 major rivers entering the Gulf of Mexico from Louisiana (Figure 1). The rivers supply sediments to three coastal sections. From east to west these are Lake Pontchartrain fed by the Pearl, Tangipahoa, Tickfaw and Amite river systems; the Mississippi-Atchafalaya River Delta; and the Chenier Plain fed by Vermilion, Mermentau, Calcasieu and Sabine River system.

On average, these rivers deliver a total of 200 million tons of sediment to Louisiana’s coast annually while the Mississippi-Atchafalaya river system alone delivers 198 million tons of sediment (Table 1). This sediment delivery is approximately 180 times more than all other eight rivers combined. All these rivers show a seasonality of high sediment yield in the spring and low sediment yield in the summer and early fall. The sediment discharges are crucial resources, and further studies are under way to explore an environmentally sustainable, economically feasible concept of maximizing the benefits of the riverine sediments, while maintaining navigation and flood control in coastal Louisiana. ■

Y. Jun Xu, Associate Professor, and Timothy Rosen, Graduate Student, School of Renewable Natural Resources, LSU AgCenter, Baton Rouge, La.



Calcasieu River. Photo by Timothy Rosen



Vermilion River. Photo by Timothy Rosen

Water Depth

enhances quality, provides fish refugia in the Atchafalaya River Basin

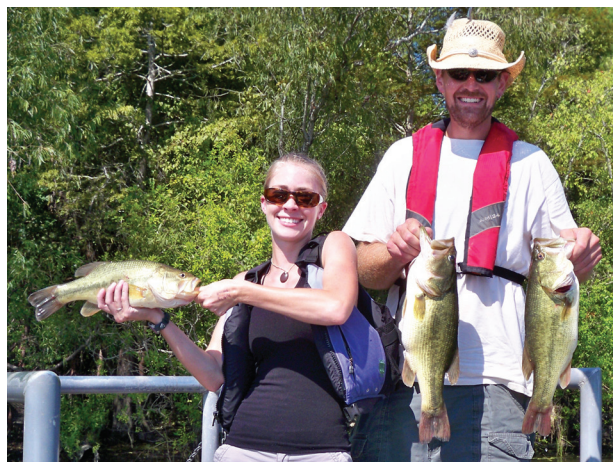
Michael D. Kaller and William E. Kelso

As the largest bottomland hardwood swamp ecosystem in the United States, the Atchafalaya River Basin offers a tremendous diversity of terrestrial and aquatic habitats that support many economically and recreationally important activities including oil and gas extraction, shipping, farming, timber harvesting, hunting, and commercial and recreational fishing. Although diverse and productive, the Atchafalaya River Basin has been increasingly altered over the last century by a number of natural and human-related factors. For example, the hydrology has been affected by the closure of distributaries (river branches) from the mainstem river and erection of levees. Also, the ecology has been invaded by several exotic aquatic plants, such as hyacinth, hydrilla and salvinia. Like much of the Gulf Coast, the Atchafalaya River Basin has been impacted by the passage of several hurricanes, notably Andrew (1992), Ivan (2004), Katrina and Rita (2005), and Gustav (2008). Although the physical damage resulting from passage of a nearby storm may be minimal, the short-term and long-term effects on aquatic habitats and organisms can be significant.

The storm track of a hurricane plays a vital role in the severity of its effects

on marine and freshwater communities. The strong winds associated with hurricanes that pass near the Atchafalaya River Basin can significantly affect aquatic communities and result in extensive fish kills. Hurricanes Andrew and Gustav passed directly over south central Louisiana as Category 3 and Category 2 storms, respectively, resulting in estimated fish kills of more than 100 million fish each. For most of these storms, the most likely causes of Atchafalaya River Basin fish kills have been the mixing of oxygen-deficient bottom water throughout the water column, as well as the release of highly toxic hydrogen sulfide from bottom sediments. As the water column turns over, fish have no time to adapt to decreasing dissolved oxygen levels, resulting in widespread suffocation. Water is classified as hypoxic when dissolved oxygen levels drop below 2 milligrams per liter, at which point most fishes tested so far experience an oxygen debt and become stressed. Measurements taken after the passage of recent hurricanes indicate that dissolved oxygen levels of less than 0.4 milligrams per liter were common throughout the affected area.

The occurrence of toxicity-related mortality from hydrogen sulfide can be inferred from the presence of spotted, longnose and alligator gar among the moribund fishes because these species can gulp air and use their swim bladders for respiration when dissolved oxygen levels decline. In addition to short-term mortality caused by rapid dissolved oxygen decline and release of hydrogen

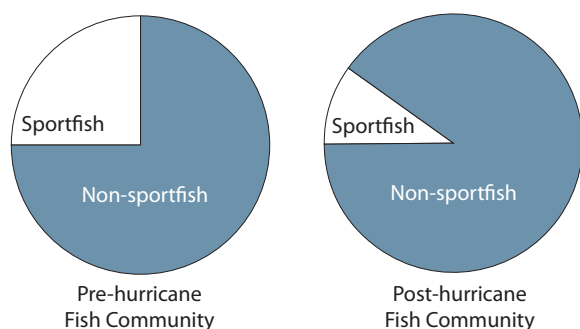


School of Renewable Natural Resources graduate student Alexandra Fitzgerald, left, and research associate Brad Trumbo display some typical East Grand Lake largemouth bass. Photo by Michael D. Kaller

sulfide, high levels of precipitation in the Atchafalaya River Basin watershed can increase water levels to the point where large floodplain areas become inundated. In late summer, the stagnant water on the floodplain quickly warms, which promotes decomposition of organic material and strips oxygen from the water. As this water moves back into the canals and bayous from the floodplain as water levels recede, dissolved oxygen levels can remain depressed for days to weeks, extending the period of poor water quality.

Within the Atchafalaya River Basin, the southeastern portion – bounded to the north by I-10, to the south by Morgan City, to the west by Atchafalaya River levees and to the east by the East Protection Levee – is managed as the East Grand Lake Water Management Unit (WMU). The WMU contains some of the most popular and productive Atchafalaya River Basin recreational and commercial fishing destinations in Bayou Sorrel and Bayou Postillion. The East Grand Lake WMU bore the brunt of recent hurricanes because its southerly location did not allow for wind speeds or storm surges to abate over land. To study the immediate and long-term effects to fish and water resources in East Grand Lake, LSU AgCenter scientists deployed recording water quality probes prior to Gustav's landfall. The data collected suggested that, indeed, during Hurricane Gustav, the dissolved oxygen levels declined severely during and immediately after the storm. Monitoring efforts following the passage of Hurricane Gustav suggested poor water quality was widespread immediately

Figure 1. The average proportion of recreationally important sport fish declined in sampling following the passage of hurricanes Katrina and Rita.



following the storm. The flushing of this poor water from the Atchafalaya River Basin began in the north and moved southeast, resulting in East Grand Lake sustaining some of the longest periods of poor water in the Atchafalaya River Basin, from August 31 through October 6, 2008.

Fish sampling in the East Grand Lake WMU in 2009 revealed low numbers and diversity of fish, presumably because of low dissolved oxygen caused by Hurricane Gustav. Importantly, fish numbers and diversity have been low in this region since hurricanes Katrina and Rita compared to data from 2000-2005, suggesting the 2005 hurricanes had a similar effect. Similar water quality data are not available for hurricanes Andrew, Ivan, Katrina or Rita. However, comparisons of sport fish abundance in the years before (2000-2005) and after hurricanes Katrina and Rita (2006-2007) suggest substantial reductions in recreational fishes in the WMU after passage of these hurricanes, possibly through suppression of dissolved oxygen (Figure 1). Therefore, because fish kills can occur when dissolved oxygen is suppressed, it is reasonable to assume that the reduced fish numbers following Hurricanes Katrina and Rita were the result of low dissolved oxygen.

LSU AgCenter research also indicates that many fishes survive hurricane impacts and thrive in lower Grand Lake. Fish sampling in 2011 suggest

fish numbers may be recovering and fish that survived the hurricanes appear to be in good condition (see photos). The concept that fish that survived a bottleneck in population numbers would have excellent growth and condition is termed a compensatory response. Fish exhibit indeterminate growth, unlike mammals, and may continue to grow throughout their lives given adequate food, space and release from predation. When competition with other fish and predation pressures are reduced, the compensatory response is often increased growth and better overall condition. Evidently, the large, well-conditioned fish in recent sampling, many of which are old enough to have been alive during Hurricane Gustav, suggest the successive hurricanes did not affect all fish equally in the East Grand Lake WMU. Research in the neighboring Lake Verrett system by Nicholls State University indicates that fish only need access to small areas of good water during poor water events to survive and maintain populations.

Lower Grand Lake is one of the deeper areas of the Atchafalaya River Basin, and AgCenter research suggests that deeper water in the Atchafalaya River Basin is more resistant to turnover, depression of dissolved oxygen and release of hydrogen sulfide. For example, AgCenter scientists demonstrated that an area in lower Grand Lake with 1 meter greater depth would support 1.1 milligrams per liter more dissolved oxygen than a comparable shallower area in other parts of the Atchafalaya River basin. Although the entire Atchafalaya River Basin and within it the East



Dead fish in East Grand Lake north of Morgan City collected in slack water areas following the passage of Hurricane Gustav. Photo by Michael D. Kaller

Grand Lake WMU are accumulating sediment and converting from water to land, lower Grand Lake is deeper and holds more oxygen averaging 0.4 meter deeper and supporting a mean of 5.4 milligrams per liter dissolved oxygen compared to a mean of 4.7 milligrams per liter in other parts of the Atchafalaya River Basin. Therefore, it is possible that fish found in deeper waters with higher dissolved oxygen survive the hurricanes and subsequent periods of poor water. Although deep water and higher dissolved oxygen refugia may not be the only reason for fish survival and subsequent success, the concept seems reasonable based on water quality measurements taken throughout the Atchafalaya River Basin over the past decade.

In conclusion, the lower Grand Lake represents one of the Atchafalaya River Basin's most productive and most resilient regions. Although located in the path of several hurricanes over the past 20 years, the lower Grand Lake continues to support strong recreational and commercial fishing opportunities, as well as supporting the bottomland hardwoods and swamp emblematic of the Atchafalaya River Basin. AgCenter research suggests that water depth is an important component to the productivity of the lower Grand Lake and, further, that water management activities in the East Grand Lake WMU focus in part on maintenance of deeper areas as storm refugia for Atchafalaya River Basin fishes. ■

Michael D. Kaller, Assistant Professor, and William E. Kelso, F.O. Bateman Distinguished Professor and Associate Director, School of Renewable Natural Resources, LSU AgCenter, Baton Rouge, La.



School of Renewable Natural Resources graduate students Brett Miller, right, and Devon Oliver display some East Grand Lake largemouth bass sampled in 2011 in exceptionally good condition. Photo by Michael D. Kaller

Nitrogen and Bermudagrass Establishment on Levees

Jeffrey S. Beasley, Robert Burwell Jr., Ron E. Strahan and Gregg C. Munshaw

Flooding from Hurricane Katrina has resulted in federal and state mandates to raise levees in New Orleans and surrounding parishes. Levees are constructed from heavy soils compacted into embankments to reduce water infiltration and prevent flooding. As a result, levees are susceptible to surface runoff from intense rainfalls during and after construction. In the case of levees, these earthen structures border water bodies with little to no buffer zones to trap off-site nutrient and sediment movement.

To reduce erosion and maintain structural integrity, grass establishment on levees, referred to as soft armoring, is standard. However, during establishment, levees are more susceptible to nutrient and sediment losses via surface runoff into water bodies compared to mature grass swards. Nitrogen and phosphorus contamination of surface waters via runoff has been shown to significantly contribute to eutrophication, a process involving algal blooms and water-oxygen depletion and subsequent deterioration of surface water quality.

A common practice by levee construction contractors is to accelerate grass establishment using water-soluble nitrogen at seeding. However, water-soluble nitrogen is extremely susceptible to off-site movement. One factor that should affect nitrogen losses to surface runoff is the type of nitrogen fertilizer applied. Application of slow-release nitrogen fertilizers could reduce nitrogen losses during surface runoff while providing sufficient nitrogen to accelerate grass growth to limit erosion during establishment.

To test the effect of nitrogen fertilizers on grass establishment and surface runoff losses, runoff trays (see photos) were installed on the Bonnet Carré Spillway levee near LaPlace, La., in 2008 and 2009. Within each runoff tray common bermudagrass was seeded and fertilized with 50 pounds of nitrogen per acre

from a water-soluble nitrogen or slow-release nitrogen with unfertilized trays serving as controls. In 2008, urea was the water-soluble nitrogen fertilizer and sulfur-coated urea was the slow-release nitrogen applied. The second year, urea and sulfur-coated urea were replaced by ammonium nitrate as the water-soluble nitrogen fertilizer and urea-formaldehyde as the slow-release nitrogen applied. All fertilizers were applied at seeding with the exception of ammonium nitrate, which was applied as a split-application at seeding and 35 days after seeding, once grass coverage exceeded 50 percent. This was done to assess the effect of nitrogen application timing on nitrogen losses.

During bermudagrass establishment natural rainfall was collected, and rainfall simulations were performed. Rainfall simulations were conducted three times in 2008 and four times in 2009. For each runoff event, measurements included the time until runoff occurred, total runoff volume and bermudagrass coverage. Water samples were collected

for nitrogen and sediment analyses for 70 days in 2008 and 56 days in 2009. All water samples were analyzed for ammonium and nitrate concentrations and sediment. To simplify the presentation of the results, nitrogen data for ammonium and nitrate were combined and presented as total nitrogen.

Nitrogen-fertilized bermudagrass established the fastest at over 90 percent for both urea and sulfur-coated urea, compared to 75 percent coverage for unfertilized bermudagrass 70 days after seeding. In 2009, nitrogen fertilizer had a similar effect on bermudagrass growth with 89 percent coverage for unfertilized and 95 percent coverage for fertilized bermudagrass at 56 days after seeding. Nitrogen has been shown to accelerate grass growth and improve characteristics such as density, shoot growth and root growth, factors that can retard runoff. However, bermudagrass establishment was comparable for slow-release nitrogen fertilizers and water-soluble nitrogen fertilizers. Similarities in bermudagrass growth between fertilizers may be due to



Trays used for surface runoff collection. Photo by Robert Burwell Jr.

southern Louisiana's subtropical climate, which allowed faster nitrogen release of slow-release fertilizers for greater grass uptake and growth.

Increases in bermudagrass cover led to greater runoff resistance. For example, the onset of runoff was delayed up to 538 seconds with over 90 percent bermudagrass cover compared to 10 percent bermudagrass cover. Stoloniferous grasses such as bermudagrass develop dense canopies that slow water flow and increase infiltration to delay runoff from occurring and reduce runoff volumes. Runoff volumes decreased from 12 gallons at less than 20 percent bermudagrass cover to 2 gallons at 90 percent bermudagrass cover in 2008. In 2009, runoff volumes followed a similar pattern with a four-fold reduction in runoff volume 56 days after seeding compared to 14 days after seeding. Decreasing runoff volumes from increasing bermudagrass cover suggests bermudagrass affected the soil's infiltration capacity. Scientists have long attributed reductions in runoff severity from grassed areas to a combination of dense vegetation and increased rooting.

Although runoff is not directly detrimental to water quality, surface runoff has been identified as a major mode of transport for sediment and dissolved nutrients. Surface runoff is not only an environmental concern but also a threat to levee structural integrity. Therefore, practices to accelerate grass establishment post-construction to attain higher grass coverage for greater runoff resistance must be evaluated to assess environmental costs versus benefits. Among them are the benefits of nitrogen fertilization on grass growth versus potential nitrogen losses during establishment.

Given the positive effect of nitrogen fertilization on bermudagrass establishment, nitrogen fertilization should not only lead to faster bermudagrass establishment but also to decreased erosion. Although sediment losses were much higher in 2008 than 2009, due to a slope difference of 33 percent to 23 percent and slightly faster bermudagrass establishment in 2009, the pattern of higher bermudagrass coverage decreasing sediment loading was observed in both years. Once 95 percent bermudagrass coverage was present, sediment losses were reduced to 95 percent in 2008 and 85 percent in 2009. However, total sedi-

ment losses for the establishment periods did not differ across nitrogen fertilizers.

Even though nitrogen fertilizers accelerated bermudagrass establishment, if no benefit occurs concerning erosion, the costs of potential nitrogen losses from surface runoff must be accounted. Nitrogen losses were highest for all fertilizers following initial surface runoff events. At 14 days after seeding in 2008, two natural rainfall events resulted in nitrogen losses from sulfur-coated urea and urea-fertilized bermudagrass accounting for 82 percent and 75 percent of the total nitrogen lost during the 70-day establishment period. Again in 2009, nitrogen losses were highest during initial rainfall with 60 percent and 75 percent of total nitrogen lost from urea-formaldehyde and ammonium nitrate, respectively, for the 56-day establishment period.

In the second year of the study, water-soluble nitrogen was applied as a split application to test whether nitrogen losses would be reduced with greater bermudagrass nitrogen uptake. However, nitrogen losses were similar to losses observed when fertilizers were applied at 14 days after seeding. Regardless of fertilizer type, nitrogen losses were highest with the initial runoff after application and declined for subsequent rainfalls.

Although delaying the second application of ammonium nitrate did not reduce total nitrogen losses, it did affect total nitrogen losses. Bermudagrass fertilized with water-soluble fertilizers, urea and ammonium nitrate, resulted in 72 percent greater nitrogen losses in 2008 and 86 percent greater nitrogen losses in 2009, compared to unfertilized bermudagrass. However, the effect of slow-release nitrogen fertilizers on nitrogen losses from runoff varied, depending on the type of slow-release nitrogen applied. Sulfur-coated urea resulted in the highest total nitrogen losses compared to the control, whereas total nitrogen losses from urea did not differ from the control.



Surface runoff study at Bonnet Carré Spillway. Photo by Robert Burwell Jr.

Only urea-formaldehyde accelerated grass establishment without significantly increasing total nitrogen losses from unfertilized grass during the establishment period.

In this study, all nitrogen concentrations in surface runoff exceeded the concentration reported to accelerate eutrophication and favor detrimental algal growth. The majority of nitrogen lost from runoff occurred from rainfalls immediately post-nitrogen applications for all fertilizers. Large initial runoff losses from fertilized bermudagrass emphasize the inability of plant densities less than 50 percent to shorten the period of greater runoff susceptibility by faster growth from nitrogen fertilizers to create a more resistant bermudagrass cover.

Under the conditions tested, there was no benefit from nitrogen fertilization at seeding on levee embankments to increase erosion resistance. However, levees typically receive fertilization only during establishment. Therefore, benefits of increased bermudagrass growth would not be realized. Of course, if less fertile clay were used for levee construction, nitrogen applications could have a more significant impact on grass establishment. Alternate solutions such as mulches or fertilizer application timing could reduce nutrient and sediment loading. ■

Jeffrey S. Beasley, Assistant Professor; Robert Burwell Jr., Graduate Student; and Ron E. Strahan, Associate Professor, School of Plant, Soil & Environmental Sciences, LSU AgCenter, Baton Rouge, La.; and Gregg C. Munshaw, Associate Professor, Department of Plant and Soil Sciences, University of Kentucky, Lexington, Ky.

Land-Applied Animal Waste and Water Quality

Jim J. Wang and Lewis Gaston

The mantra of the environmental movement reads – Reuse, Reduce, Recycle. In this regard, the ancient farming practice of land application of animal waste is an environmental trifecta – excreta is reused as a fertilizer, thereby reducing the application of inorganic fertilizer while recycling organic matter back into the soil. However, the adage “all things in moderation” also applies. High rates of animal waste application to land or long-term application of high rates may lead to runoff or seepage of nutrients into streams, lakes and rivers and change the aquatic ecology for the worse.

Application of animal waste as fertilizer has been traditionally based on its nitrogen content, which is typically the most limiting nutrient for crops. However, animal waste contains many other nutrients, and they are not balanced with nitrogen in proportion to crop needs. In particular, the concentration of phosphorus is typically much higher than needed so that continual land application of animal waste tends to build up soil phosphorus. The result may be greater phosphorus loss (Figure 1), which could be a problem because phosphorus is typically the nutrient most limiting to algal and aquatic plant growth in freshwater. In addition, the loss of organic substances from animal waste could be also a concern because they generally enrich biological oxygen demand in the receiving water bodies.

Poultry is the largest animal agriculture enterprise in Louisiana and had a gross farm value of more than \$800 million in 2010, most of which came from the 900 million pounds of broilers produced. A byproduct was about 200,000 tons of poultry litter. Dairy waste from confinement systems amounts to about 100,000 tons per year. To better ensure this amount of animal waste fertilizer does not become a nutrient source for water eutrophication, producers use a nu-

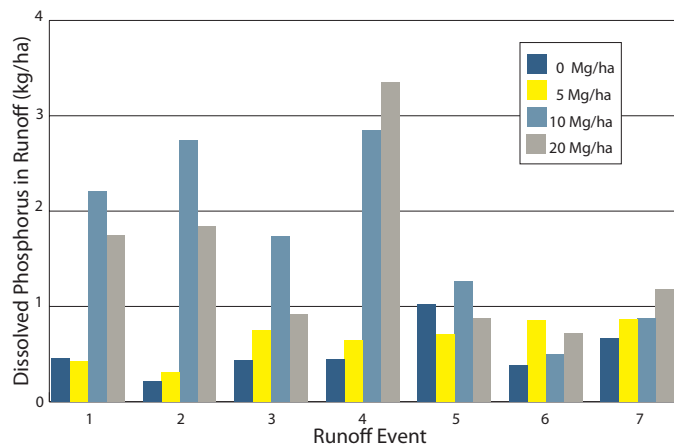
trient management plan. One aspect of it is the P-index – a simple assessment of the risk that some phosphorus in the fertilizer and already in the soil will be lost into nearby water bodies. The P-index used in Louisiana considers source factors such as amount of fertilizer applied, level of soil phosphorus, and loss factors such as soil permeability and slope. However, many factors affect nutrient conservation, and the ability to accurately predict the fate of fertilizer phosphorus and soil phosphorus is far from perfect. LSU AgCenter scientists are making efforts to improve it. In addition, LSU AgCenter scientists have developed a tool called the soil suspension turbidity test to account for particulate phosphorus in surface runoff based on simple turbidity measurement. This method works well especially for more eroded soils.

Furthermore, many different approaches for reducing potential phosphorus loss are being examined. These include:

- Amending the animal waste or the soil with substances that decrease phosphorus solubility.
- Using hay harvest to phytoremediate high phosphorus soil.
- Variable rate application depending on the spatially variable capacity of soil to retain added phosphorus.
- Alternative uses of animal waste fertilizer as in pine plantations and with potential bioenergy grasses.

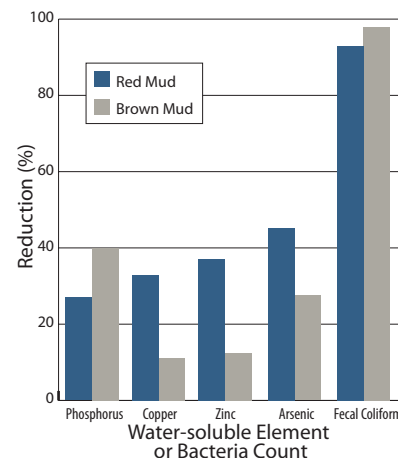
One promising approach to reducing the loss of soluble nutrients and contaminants is to change the chemistry of ani-

Figure 1. Loss of phosphorus in runoff from pasture plots at the Calhoun Research Station. Poultry litter at the rates shown was applied before runoff event 3. Plots had been amended at these rates annually for five years previously.



mal waste and waste-amended soils by use of certain additives. This approach appears to have a broad spectrum of benefits, not only reducing the solubility and release of nutrients and organic materials in general but also specific organic substances such as veterinary antibiotics sometimes found in animal waste.

Figure 2. Percent reduction in water-soluble elements leaching out from manure and fecal coliform counts in poultry litter treated by iron/aluminum-rich red mud and calcium-rich brown mud at 22 percent as compared to nontreated poultry litter.



Both pure chemicals and some industry byproducts such as bauxite-refining residues, known as red and brown mud and containing iron and aluminum oxides, have been investigated. These amendments can strongly adsorb phosphorus as well as trace metals such as copper and zinc, immobilizing them into slowly released forms. Initial results showed that both red mud and brown mud decrease the leachability of nutrients and trace metals found in poultry litter and cattle manure. Brown mud showed strong reduction in water-soluble phosphorus, whereas red mud had strong

reduction in water-soluble trace metals. In addition, bauxite residue reduced the survival rate of fecal coliform by 93 percent and 98 percent in poultry litter. See Figure 2.

Adding red mud to phosphorus-rich, manure-affected soils decreased phosphorus leachability by an average of 88 percent. Red mud also significantly decreased the leachability of trace metals and carbon and reduced five-day biological oxygen demand.

The effects of alum, montmorillonite and red mud amendments on reducing the runoff of tylosin, a commonly used

veterinary antibiotic, from poultry litter were also investigated. Both alum and especially montmorillonite significantly reduced tylosin in runoff from small plots whereas red mud had no effect.

The results of this research demonstrate that different techniques and approaches can be used to manage animal wastes as well as animal waste-affected agricultural soils to minimize their potential impact on water quality. ■

Jim J. Wang, Professor, and Lewis Gaston, Associate Professor, School of Plant, Environmental & Soil Sciences, LSU AgCenter, Baton Rouge, La.

Research tracks changes at University Lakes

Trying to keep the University Lakes in Baton Rouge clean and healthy is a goal of LSU AgCenter researcher Yi Jun Xu, associate professor in the School of Renewable Natural Resources.

For the past three years, Xu has used funds from the Louisiana Board of Regents Equipment Enhancement Fund to study the lake's health.

"When the project began in 2008, the focus was on two areas – enhanced teaching in water resources and to provide sophisticated, state-of-the-art equipment for surface water research," Xu said.

Xu and his graduate students receive measurements of the dissolved oxygen, pH and water temperature every 15 minutes from equipment in the lake. He said his data can be used by state agencies and others interested in water quality.

"I have a piece of equipment on a floating platform that sends data from the lake in real time to my computer," Xu said. "We always know what's going on with the lake."

Over the years, the lake has become more shallow, and Xu believes it will become a swamp unless something is done fast.

"A major problem the lake is experiencing right now is pollution and sediment buildup," Xu said.

Until funds are available for dredging, the public and residents of the lake need to be aware of what's getting into the lake.

"You would be surprised at some of the things we find in the lake," Xu said. "We see anything from bottles to tires to refrigerators."

Xu realizes the importance of the lake to LSU as a symbol when entering campus and says everything possible must be done to keep the lake healthy.

"This is really important research because so many people use the lake and we need to make sure that it stays healthy and something we can be proud to show off," Xu said. ■ **Johnny Morgan**



This yellow monitor is in the middle of the LSU lake; the other monitor, top photo, stands near the bridge on Stanford Drive. Photos by Yi Jun Xu

Influence of Soil Salinity on Sugarcane

Sonny Viator, Jimmy Flanagan, Andrew Granger, Blair Hebert, Barton Joffrion, Ben Legendre and Rick Louque

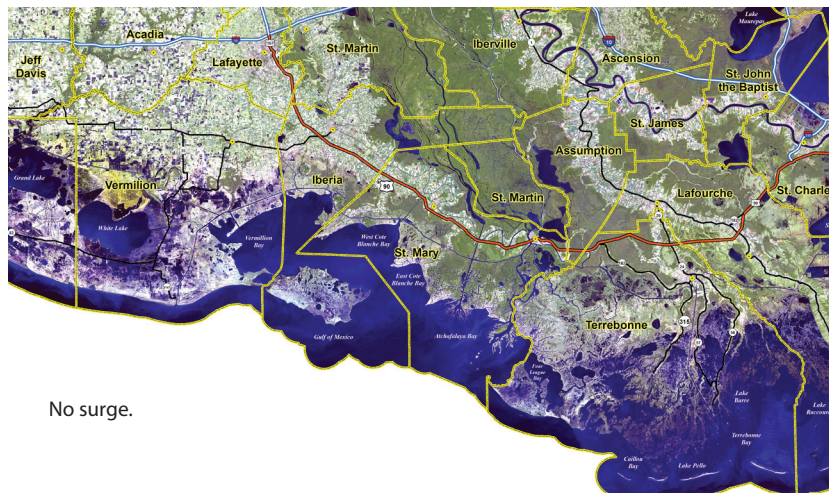
Tidal surges from hurricanes Katrina, Rita, Gustav and Ike deposited enormous amounts of salt in the sugarcane fields of coastal Louisiana in a period of active tropical weather from 2005 to 2008. To gain an appreciation of the effects of salinity on sugarcane production, LSU AgCenter scientists conducted a survey to measure soil salinity levels at sites in the parishes most affected by the storms – Iberia, St. Mary, Terrebonne and Vermilion. An initial survey was accomplished in October 2005 after Katrina and Rita. The survey revealed soil salinity levels ranging from 268 to 4,329 ppm. Published reports suggest sugarcane is moderately sensitive to salt, with the damage threshold for sugarcane estimated to range from approximately 640

to 1,200 ppm of salt in the soil. Several survey sites had salinity above the damage threshold. Because of the enormity of the salinity problem, a decision was made to continuously monitor salinity over time and attempt to associate salinity level with sugarcane yield. A total of 60 single-row, 25-foot-long plots were established along the coast. These geo-referenced sites were sampled for soil salinity at the time of establishment and at harvest of the following crop. Cane yield in tons per acre was estimated from multiplying stalk number times stalk weight, and sugar yield was estimated by multiplying pounds of sugar per ton times tons per acre. No attempt was made to evaluate the direct damage to sugarcane caused by wind, tidal surge or salinity,

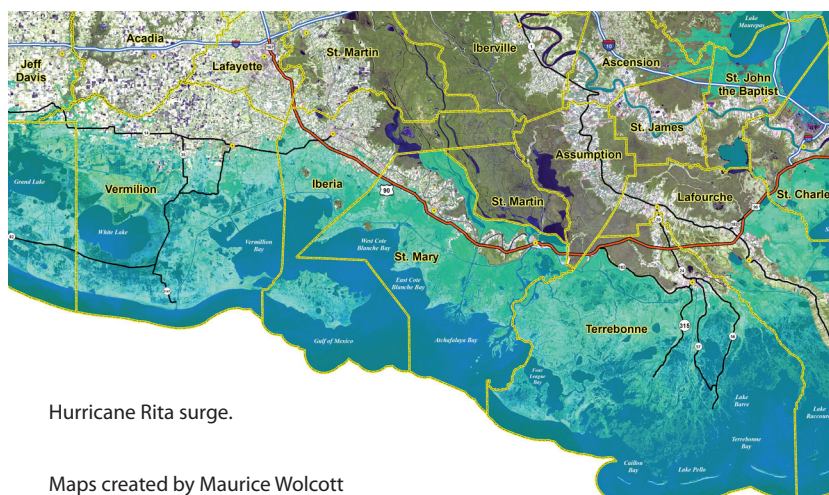
but only the effects of soil salinity on the performance of the subsequent crop in the production cycle.

By the time plots were harvested in the fall of 2006, rainfall was sufficient to leach much of the salt from the root zone. Averaged over all the plots, salinity decreased by almost two-thirds from the time of the survey to the harvest season. Consequently, cane and sugar yields were generally satisfactory. High salinity remained at a few sites, and it is believed these persistent high levels are due to proximity to salty water subject to tidal movement and a high water table.

Another soil salinity survey was conducted in October 2008 after hurricanes Gustav and Ike. Salinity levels and resultant effects on sugarcane yield were similar to that found for the earlier storms. While observations have been offered concerning the effects of soil salinity on sugarcane yield, the evaluation process was made difficult because the conventional methodology of using unsalted control plots for comparison purposes was not possible. Also, differential rainfall amounts and the direct effects of the flood waters served as confounding effects across the many locations from which data were collected. While the storm surges are not inconsequential, the sugarcane industry should be somewhat comforted in the knowledge that the effects of soil salinity on sugarcane crops produced subsequent to the deposition of salt are generally benign, except in areas where salinity is recalcitrant. For more than 200 years the sugarcane industry has survived the aftermath of countless tropical storms primarily because Louisiana's high rainfall serves to mitigate the damage to sugarcane caused by soil salinity. ■



No surge.



Hurricane Rita surge.

Maps created by Maurice Wolcott

Sonny Viator, Professor, Iberia Research Station, Jeanerette, La.; Jimmy W. Flanagan, Extension Agent, St. Mary Parish; Andrew L. Granger, Extension Agent, Vermilion Parish; Blair Hebert, Extension Agent, Iberia Parish; B. Barton Joffrion, Extension Agent, Terrebonne Parish; Ben Legendre, Head, Audubon Sugar Institute, St. Gabriel, La.; and Rick Louque, Extension Agent, Assumption Parish

Wetland Restoration

with agricultural techniques

Andy Nyman

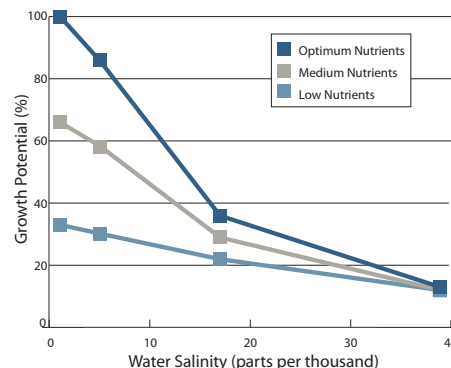
Managing and restoring coastal wetlands requires knowledge of wetland conditions and the factors creating the desired conditions. Flooding stress, nutrient starvation and salinity stress are the most likely suspects in wetlands that have higher loss rates or appear less productive than typical wetlands. Diagnosing the cause depends primarily on information inferred from plant species growing in the wetlands. The dominant species and the species richness can be used by many wetland managers to infer levels of salinity stress and flooding stress, but not nutrient limitation. Even with salinity stress and flooding stress, experts may disagree about which is more important at a particular site. Coastal wetland managers and restoration planners could benefit from new tools to help them objectively diagnose factors limiting plant growth.

LSU AgCenter scientists have been working to modify a technique that farmers use to diagnose their crops so that marsh managers and restoration planners can similarly diagnose coastal wetlands. Farmers and home gardeners can clip leaves from their fields and lawns, send the leaf tissue to the LSU AgCenter's Soil Testing and Plant Analysis Laboratory, and a few weeks later receive a diagnosis of the factors most likely to be limiting plant production. Plant analysis diagnoses nutrient deficiency, toxicity and imbalance of major and micro-nutrient elements of more than 90 crops and lawn plants. Numerous scientists have studied these plants under known conditions of nutrient deficiency or toxicity and then identified a chemical consequence of those conditions in the leaf tissue. Until now, such information did not exist for coastal wetland grasses.

The research focused on *Spartina patens*, also known as saltmeadow cordgrass, which occurs from fresh to saline marshes but dominates intermediate and brackish marshes. Work began with experimental projects growing saltmeadow cordgrass under a range of known flooding, nutrient and salinity conditions in

the greenhouse and the field. The health of those plants and the chemical make-up of their leaves were used to develop chemical signatures of flooding stress, nutrient starvation and salinity stress. Fifteen elements and various combinations of ratios of those elements were considered when trying to identify chemical consequences of flooding stress, nutrient deficiency and salinity stress. Identifying a signature of flooding stress was simpler because flooding stress apparently is unaffected by salinity stress and nutrient starvation. Identifying signatures of salinity stress and nutrient starvation was more complex, however, because those factors interact in such a way that growth is limited by salinity even when nutrient content is high.

Work continued with field studies designed to challenge the chemical signatures developed from the experimental work. Study sites included Four League Bay, which is southeast of Morgan City, over to Calcasieu Lake, which is south of Lake Charles. Public lands involved were the Cameron Prairie National Wildlife Refuge, Rockefeller Refuge and Marsh Island Refuge. Private landowners also cooperated including Miami Corporation. Most of the field study sites were within a mile or two of a sensor operated by the Louisiana Office of Coast-



Salinity stress prevents *Spartina patens* from utilizing available nutrients. The ocean's average salinity is 3.5‰ or 35 ppt.

al Protection and Restoration, which records water level and salinity hourly. More importantly, salinity and nutrient levels were measured in water collected from the study plots where saltmeadow cordgrass health was measured. The field challenges revealed that the new technique accurately identified salinity stress and nutrient limitation. The flooding stress indicator appeared to work but could not be tested rigorously because the water level recorder data did not accurately reflect flooding and drainage conditions at the sampling sites. Thus, while marsh managers and restoration planners can confidently use the new tool to diagnose nutrient starvation and flooding stress, the flooding stress indicator is not yet ready for use. Additional field work is planned that will incorporate adjacent study plots and water level recorders. ■

Andy Nyman, Associate Professor, School of Renewable Natural Resources, LSU AgCenter, Baton Rouge, La.



Vanessa Tobias, graduate student, harvests the biomass of *Spartina patens* grown in the marsh organs at Rockefeller Wildlife Refuge. Photo by Andy Nyman

Plants remove nutrients from runoff

Yan Chen and Regina Bracy

Population growth and urbanization over the last century have raised concerns about stormwater runoff and the environmental impact of the pollutants it may carry, such as fertilizer from home lawns and recreational turf areas. Studies on impaired Mississippi River watersheds have found excess nutrients, such as nitrate–nitrogen and soluble reactive phosphorus, in stormwater runoff from urban areas. These pollutants degrade water quality and contribute to algal blooms and fish kills in downstream reservoirs.

In Louisiana, permits and other authorizations issued by local, state and federal agencies regulate stormwater runoff. Ordinances and rules established by local municipalities provide additional guidance for stormwater management. A variety of treatment technologies, such as constructed wetlands, swales or retention ponds, are being implemented. To meet increasingly rigorous federal and state regulations, significant nitrogen and phosphorous reductions are necessary to improve water quality before water is discharged from these retention structures.

A few wetland plants have been recommended for stormwater mitigation based on their role in natural wetlands. However, most of these plants are hard to find at local nurseries. On the other hand,

noninvasive ornamental plants that are readily available from the ornamental industry may have similar or even better mitigation ability than native wetland plants.

A nutrient recirculation system was designed and used to assess the ability of ornamental plants to remove nutrients from stormwater runoff. This system comprises refill and reservoir tanks, circulating tubing, growth tubs and covers, and pH and temperature sensors. Treatment solutions mimicking stormwater runoff are circulated within the closed system. Daily water use by the plants can be measured because water loss is only from plant uptake and minor evaporation. Concentrations of nitrate and phosphorus in the solution can also be measured to evaluate the test plants' abilities to remove nutrients from stormwater. This system compared nutrient-removal abilities of ornamental canna, iris, calla lily and dwarf papyrus with those of the wetland plants arrow arum, pickerelweed and bulltongue arrowhead. In these experiments, the recirculating system was filled with a nutrient solution with total a nitrogen concentration of 11.3 parts per million (milligrams per liter) and a phosphorus concentration of 3.1 parts per million to simulate high levels of nutrient contaminations in stormwater.

Among tested plants, Australia canna had the greatest daily water use, total biomass and total tissue contents of nitrogen and phosphorous. The amount of nutrients canna removed from the system was higher than pickerelweed, a wetland plant often

Table 1. Total water consumption and N and P recovery rates by the nutrient-recirculating units planted with ornamental or wetland plants averaged from six experiments. Experiments lasted 65 days on average. Each unit was planted with six plants of a species.

Species	Total water consumption (gallons/unit)	Nutrient recovery rate (%)	
		N	P
Canna Australia	157	98	92
Pickerelweed	117	88	82
Bulltongue arrowhead	78	90	82
Dwarf papyrus	74	85	71
Calla lily	30	35	27
Iris Golden Fleece	27	32	26
Arrow arum	34	32	39

recommended for wastewater treatment. Golden Fleece iris had higher tissue nitrogen concentrations than canna but produced much lower biomass, thus lower total nitrogen removal. The units planted with canna removed 99 percent of the nitrogen and 92 percent of the phosphorus compared with those planted with iris (32 percent nitrogen and 39 percent phosphorus) and arrow arum (32 percent nitrogen and 26 percent phosphorus) (Table 1). Units planted with dwarf papyrus had a similar nutrient recovery rate as pickerelweed, but much less total nitrogen and phosphorus were removed as a result of less water consumption (Table 1).

Based on these results, canna Australia, pickerelweed, arrowhead and dwarf papyrus were selected and planted in floating wetlands (also called floating islands) in the stormwater retention pond at the Hammond Research Station. Results suggest that when ornamental plants are used for water treatment, the benefits can be both aesthetic and environmental. The floating systems increased mitigation capacity and provided efficient nitrogen and phosphorous removal for this small treatment structure.

Ornamental canna are recommended to be used as mitigation plants in urban stormwater treatment areas such as retention ponds, constructed wetlands and vegetated waterways. Canna is a nonin-



Ornamental canna Australia and dwarf papyrus being evaluated for the ability to remove excess nutrients from stormwater in a nutrient-recirculating research system. Photo by Yan Chen

vasive perennial plant adaptive to wide soil and water conditions. It allocates the majority of its biomass to shoots. It can be harvested regularly and offers consistent removal of biomass along with nitrogen and phosphorous from the treatment system.

More research is being planned to evaluate other potential landscape plants, such as ornamental grasses, for stormwater mitigation. The ultimate goal of this research project is to provide landscape designers and municipal planners with a variety of ornamentals that can effectively work as living filters as well as beautify our landscapes. ■

Yan Chen, Associate Professor, and Regina Bracy, Professor, Hammond Research Station, Hammond, La.



Planted floating islands set out in a retention pond at the Hammond Research Station. Photo by Yan Chen

LaHouse serves as model for sustainable home landscape

In addition to being the showplace for home building ideas, the LSU AgCenter's LaHouse in Baton Rouge also serves as a model for a sustainable home landscape.

The house is designed with hurricanes and hot summers in mind, but also provides ideas for those interested in landscaping and home vegetable gardening, according to Kyle Huffstickler, LaHouse landscape coordinator.

"For us, sustainable simply means minimal impact on whatever you're doing," Huffstickler said. "LaHouse has seven basic principles that we follow when carrying out our sustainability plan at LaHouse. The most important on that list is having the right plant in the right place."

No matter how beautiful a plant looks at the nursery, you must plant it in the right conditions and tend to its needs properly for it to be beautiful at your house, Huffstickler said.

"Choosing the proper size plant for your area will prevent future problems like being too close to your home or interfering with driveways, walkways or power lines", he said.

One way to do this is by introducing plants such as Louisiana Super Plants and other select species that are suitable to Louisiana's growing conditions.

"We use as many native species of plants that are conducive to our growing conditions as possible," he said.

When working in a sustainable landscape, one of the first things you should do is collect a soil sample. "Don't guess, soil test," Huffstickler said, adding that soil should be tested every three years.

"You don't want to keep adding more elements to the soil such as potassium and phosphorus, which may already exist in the soil," Huffstickler said. The soil pH must be determined because most ornamental and vegetable plants prefer a soil pH of 6 to 7.

Maximizing mulch, fertilizing appropriately, recycling yard waste and managing yard pests and attracting wildlife are all considerations in the LaHouse sustainable landscape.

Water consumption also is a vital consideration in his landscaping plans. This involves the protection of surface waters and wetlands.

"When LaHouse was built, there was a cistern built beside the house to catch the water from the gutters to be used to water plants on the grounds," he said. "We also have a retention pond beside the vegetable garden that we can pump water from if needed. We want to minimize the amount of water we use as much as possible."

LaHouse is across the street from the new LSU Alex Box baseball stadium and is open Monday through Friday from 10:00 a.m. to 4:30 p.m. for the public to come and see what the sustainability programs look like both inside and outside LaHouse. ■ **Johnny Morgan**



Kyle Huffstickler is the landscape coordinator at LaHouse. Photo by Johnny Morgan

Watershed Water Quality

Effect of Best Management Strategies

H. Magdi Selim, Chang Yoon Jeong, Allen E. Arceneaux and Richard L. Bengtson

The quality of water resources is a major concern in Louisiana and nationally. Surface and subsurface water quality depends in large part on human activities in the surrounding areas. Management strategies that reduce the potential for contamination are the key to quality of water resources. Bayou Wikoff in south Louisiana (Figure 1) was chosen by the Louisiana Department of Environmental Quality (DEQ) for intensive watershed-level monitoring and best management strategy implementation. The implementation process will allow DEQ to determine whether the management strategies

being recommended for nonpoint-source pollution reduction do, in fact, reduce the pollutant load to the water body by 30 percent to 50 percent. The major goal of this water quality study is to quantify control measures for reducing contamination of sediment, nitrogen, phosphorus and dissolved organic carbon.

The project area is the Bayou Wikoff sub-watershed, which is representative of the type of land use that exists within the upper portion of the Bayou Plaquemine Brule watershed (Figure 1). The major land-use is agricultural production, specifically sugarcane and pasture. A

total of seven sites were instrumented and include pastures sites, sugarcane sites and a control or pristine site.

The pasture sites include one continuous grazing site, which represents a traditionally managed pasture at maximum recommended stocking rates, supplemental feeding, winter seeding and fertilization, and minimum tillage. The second pasture site consists of a deferred rotational grazing system wherein duration, intensity and frequency of grazing were managed to enhance nutrient cycling. Therefore, we regard this management strategy as minimum input and reduced grazing pressure compared to the higher stocked continuous grazing site.

The sugarcane sites were side-by-side where one tract was selected for implementation of the standard practice of

burning prior to or following harvest. The second site was a no-burn strategy to achieve nonpoint-source reductions in sediments and nutrients.

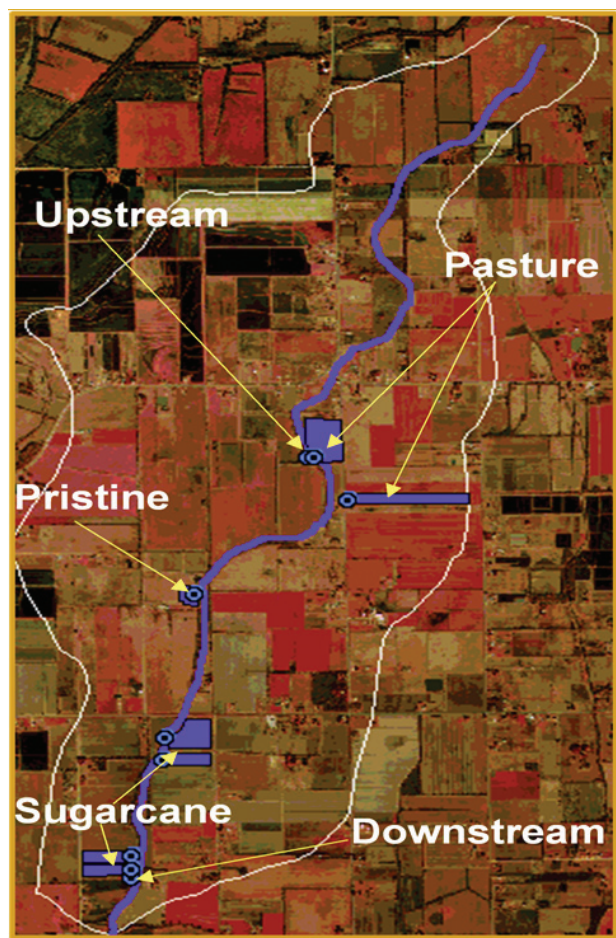
In addition, we carried out in-stream monitoring of water quality in Bayou Wikoff at two locations – an upstream location not influenced by the various treatments and a downstream location where the cumulative effects of all management treatments in Bayou Wikoff could be assessed.

To quantify the impact of best management strategies in the watershed, a minimally disturbed site was identified as the pristine site to obtain an expected level of natural background nonpoint-source loading. This site was identified as a control. It was a minimum-input tree farm wherein sapling trees of various species were grown within dense indigenous grass vegetation and heavy mulch applications at the tree base. The grassed areas are not grazed and only infrequently mowed. Effluent samples from this site and all instrumented sampling sites were activated by rainfall that produced runoff events.

Pasture Sites

Results of sediments or total solids in the effluent from the rotational grazing site were significantly lower compared to the continuous grazing site. A reduction of total solids in the effluent of 79 percent was achieved when rotational rather than continuous grazing was the farming practice. Sediment losses or total solids losses from pastures sites were calculated based on runoff volume associated with each runoff event over the drainage area from each field. Losses of total solids at the pasture sites were nearly 40 percent higher under continuous grazing than under rotational grazing. The concentrations of suspended solids were not significantly different for the two grazing sites. However, the concentration of dissolved solids showed significant differ-

Figure 1. Aerial photograph of Bayou Wikoff project area. White lines indicate drainage area, thick blue line indicates Bayou Wikoff, and all instrumented sites are identified.



ence in two pasture lands. The amount of losses of suspended and dissolved solids exhibited similar trends with dissolved concentrations. Moreover, the turbidity from the two pasture lands showed a similar pattern with the results of the suspended solids.

The concentration of total phosphorus was significantly lower for rotational grazing than for continuous grazing. The dissolved phosphorus followed a similar trend. Dissolved phosphorus was significantly lower when rotational grazing was the management practice. Therefore, the loss of phosphorus in the effluent was 74 percent higher under continuous grazing than under rotational grazing.

Pristine Site

The pristine site was considered a control site because management operations are restricted to mowing, mulching and clearing of drains throughout the year. Based on results from the pristine site, there is strong evidence that the presence of grass cover on the soil surface throughout the year minimized sediment losses and erosion. Based on mean comparison of total solids from the pristine site, it was not significantly lower



Pasture site where measurements are being taken. Photo by H. Magdi Selim

from the continuous grazing site. Moreover, total phosphorus losses from the pristine site were significantly lower than those from the rotational and continuous grazing pasture sites.

Downstream and Upstream Sites

The concentrations of total solids from the downstream site of Bayou Wikoff were significantly higher than from upstream. Moreover, suspended, dissolved and volatile solids as a fraction of the total solids also showed higher concentrations in water samples from the downstream location when compared to concentrations from the upstream site.

Goals Achieved

- A reduction of sediment losses in the runoff of 79 percent was achieved when rotational rather than continuous grazing was the farming practice.
- A reduction of total phosphorus losses of 74 percent was achieved when rotational rather than continuous grazing was the farming practice.
- Total phosphorus losses from the pristine site were significantly lower than those from the rotational and continuous grazing pasture sites. ■

H. Magdi Selim, George and Mildred L. Caldwell Professor of Soil Science; Chang Yoon Jeong and Allen E. Arceneaux, both Research Associates, School of Plant, Environmental & Soil Sciences; and Richard L. Bengtson, Professor, Department of Biological & Agricultural Engineering, LSU AgCenter, Baton Rouge, La.

Acknowledgments

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Sugarcane site showing flume, rainfall gauge, solar panel and water sampler. Photo by H. Magdi Selim

Using Composted Mulch for Highway Embankment Erosion Control

David C. Weindorf, Noura Bakr, Allen E. Arceneaux, Yuanda Zhu and H. Magdi Selim

Runoff from highway rights-of-way can be difficult to manage. Following extended rainfall duration and short periods of high intensity rainfall water, seepage on sloping soils commences and becomes the dominant mechanism that initiates runoff and erosion. As seepage on sloping surfaces increases in velocity, its kinetic energy compounds its erosive power, and the runoff is capable of carrying soil particles off-site as suspended sediment. The Louisiana Department of Environmental Quality (DEQ) has cited many instances where suspended sediments have caused reductions in surface water quality. These suspended sediments are due in many cases to unabated erosion of exposed soils in construction areas and failed erosion control measures.

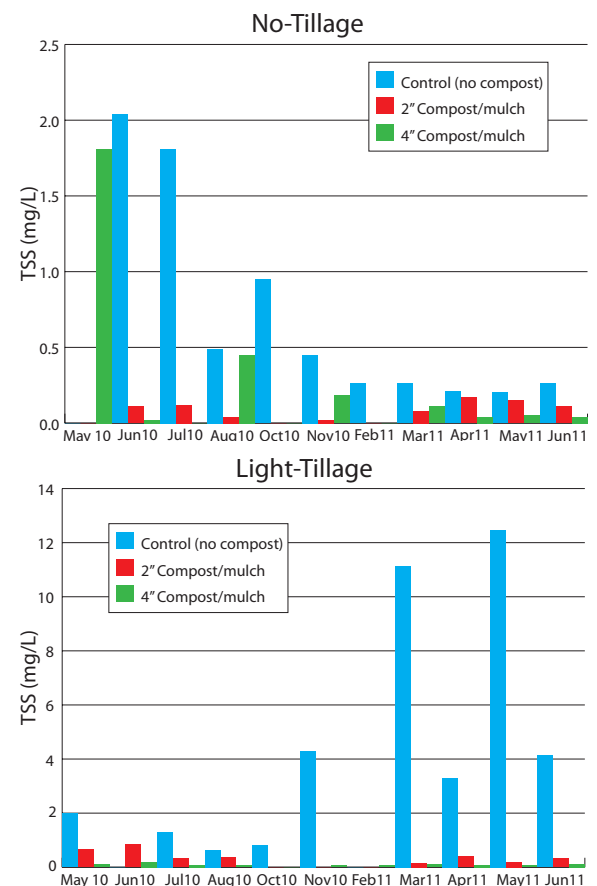
Combatting soil erosion on highway rights-of-way requires novel, multidisciplinary approaches that evaluate the issue from vegetative, soil and engineering standpoints. Recent studies by the Texas Department of Transportation and the Texas Transportation Institute have shown that the use of compost/mulch can provide superior conditions for vegetative establishment and longevity in highway rights-of-way while minimizing erosion. The idea is relatively simple: instead of burning trees as highway construction proceeds, those trees are

ground into a mulch material and mixed with organic-rich compost. The compost/mulch mixture is placed onto highway rights-of-way with a large blower truck. Grass seed mixtures can easily be added to the mix. Compost is known to provide a substantive nutrient stream to newly emergent vegetation, while the larger mulch particles settle and interlock to arrest erosion. The compost/mulch blanket absorbs the kinetic energy of falling raindrops, energy which would cause soil particle detachment in otherwise exposed soils. Furthermore, the compost/mulch blanket slows water movement across the surface, again limiting the erosive power of the water. Compost is also known to facilitate additional moisture retention, which would benefit vegetative vigor in hot, dry summer months.

Evaluation of this technique in Louisiana was initiated in early 2010 with the establishment of several test plots along Interstate 49 in Rapides Parish and Highway 61 in West Feliciana Parish. Researchers at the LSU AgCenter, Louisiana Department of Transportation and Development (DOTD) and DEQ worked collaboratively

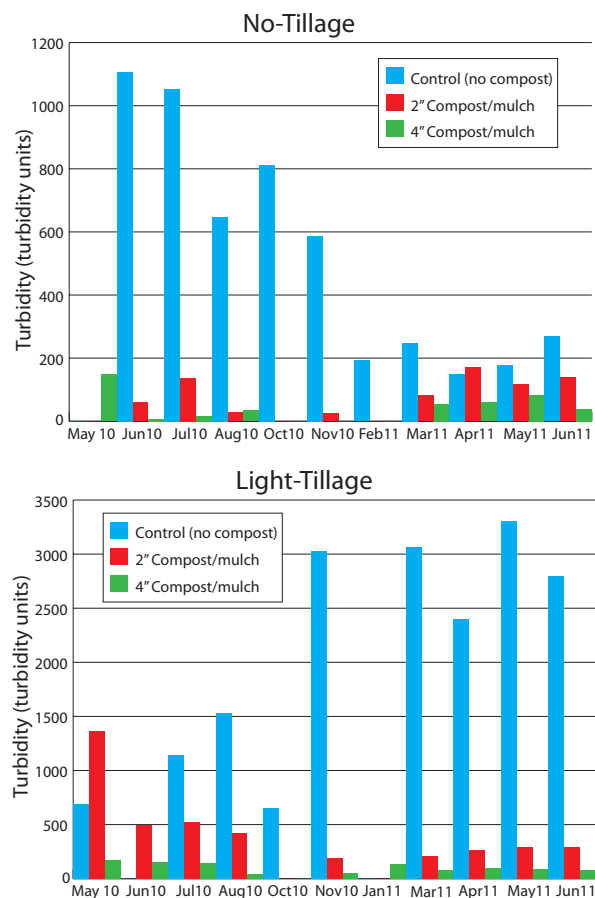
to establish test plots in new construction areas and established rights-of-way where active erosion was present. Plots were bounded with steel edging and subjected to three conditions: control (no compost/mulch), 2-inch compost/mulch and 4-inch compost/mulch. Other variables included surface application versus incorporation via tillage, variable slopes and variable soil textures. The steel-edged plots led into H-flumes for collection of runoff. Evaluated parameters included turbidity, total suspended solids, pH, salinity and elemental data. Soil moisture and temperature sensors were placed in each plot to monitor soil condi-

Figure 1. Total suspended solids of different compost/mulch treatments using no-tillage versus light-tillage applications in central Louisiana. Months with no data indicate there was not enough precipitation to generate runoff.



Sediment generated by control plots with no compost/mulch (left) and 4 inches of compost/mulch application (right) in test plots along I-49 in Rapides Parish. Photo by David C. Weindorf

Figure 2. Turbidity results of different compost/mulch treatments using no-tillage versus light-tillage applications in central Louisiana. Months with no data indicate there was not enough precipitation to generate runoff.



Compost/mulch application to test plots along I-49 via blower truck in Rapides Parish. Photo by David C. Weindorf

compost/mulch treatments and control. Compost/mulch applications of 4 inches yielded exceptionally low turbidity across both tilled and nontilled plots.

Results from the no-tillage control plot produced the highest temperatures in the summer months and lowest temperatures in the winter months as a result of no surface coverage in that plot and exposure to direct

sunlight. In the winter months, the application of 2 inches or 4 inches of compost/mulch helped to keep soil temperatures warmer than control plots. These results were expected because the high heat capacity and low thermal conductivities of the mulch, when compared to mineral soils, result in warmer winters and cooler summers and less overall temperature fluctuations near the soil surface over time. However, the most dramatic benefit of compost/mulch to soil temperature/moisture was the substantially higher moisture contents afforded to compost/mulch plots as compared to the control plots. Because of the unique physical properties of the mulch material, increased water retention along with decreased surface evaporation depends on the thickness of the applied mulch layer. This additional moisture is extremely important in hot summer months because additional moisture will help to sustain newly establishing vegetation. In

drought years where consecutive weeks of no rainfall can lead to emergent seedling mortality, the additional soil moisture retained via compost/mulch application can literally mean the difference between vegetative life and death.

The use of compost/mulch in highway right-of-way rehabilitation fosters numerous benefits, including reductions in total suspended solids, reductions in runoff turbidity, moderated soil temperatures and additional soil moisture retention. The project is scheduled to conclude in 2012 with the construction of two demonstration plots at highway rest stops in northern and southern Louisiana. A specification for the use of compost/mulch for highway right-of-way stabilization and revegetation is being developed for use by DOTD. Its adoption and widespread implementation in the state will foster improvements in surface water quality and highway slope stability that will be realized for years to come. ■

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Acknowledgments

The Louisiana Department of Environmental Quality, the Louisiana Department of Transportation and Development, the U.S. Forest Service, the U.S. Composting Council and the U.S. Environmental Protection Agency.

tions continuously. Rainfall was documented via tipping bucket rain gauges.

With the exception of one 4-inch compost/mulch plot immediately following installation (May 2010), all control plots showed considerably higher total suspended solids than compost/mulch treatment plots (Figure 1). Furthermore, total suspended solids under light tillage conditions increased in control plots with time (Figure 1).

Turbidity (a measure of the cloudiness imposed by soil particles suspended in water) results indicated that within one year of plot construction, the highest values were found in runoff from light-tillage and no-tillage control plots (i.e. no compost/mulch added). The application of 2 inches or 4 inches of compost/mulch substantially decreased turbidity in runoff (Figure 2). Between no-tillage versus light-tillage applications, the turbidity of light-tillage plots was considerably higher than no-tillage plots across all

Precipitation Patterns Over the Bayou State

John M. "Jay" Grymes III

With an annual statewide-average rainfall of approximately 60 inches per year, only Hawaii receives more rain on an average statewide basis. Louisiana's proximity to the Gulf of Mexico is the primary source for the state's rains and makes her just slightly wetter than her central Gulf Coast sisters, Mississippi and Alabama – and notably wetter than Florida.

A review of Louisiana's statewide-average rainfall dating back to the 1890s shows a number of interesting trends and patterns. Probably the most interesting feature of Louisiana's rainfall history is the large variability in annual totals, with statewide annual rains ranging from less than 40 inches to more than 80 inches over the past 120 years. Year-to-year differences of 10 inches or more are common throughout the record, with more than a dozen occurrences when back-to-

Statewide annual rainfall over the next several years may tend to be normal to below-normal for the Bayou State.

back yearly rains differed by more than 20 inches (roughly one-third of the average annual total)! Even for a state where rainfall is normally in generous supply, such year-to-year variability can be a challenge for planning and management purposes and can play havoc with the natural environment.

Over the course of the state's annual rainfall series, there has been a modest increase of roughly 10 percent in statewide rainfall, which is a signal of climate change for the Bayou State. The long-term increasing trend is partly the result of an unusually high occurrence of dry years (by Louisiana standards) at the be-

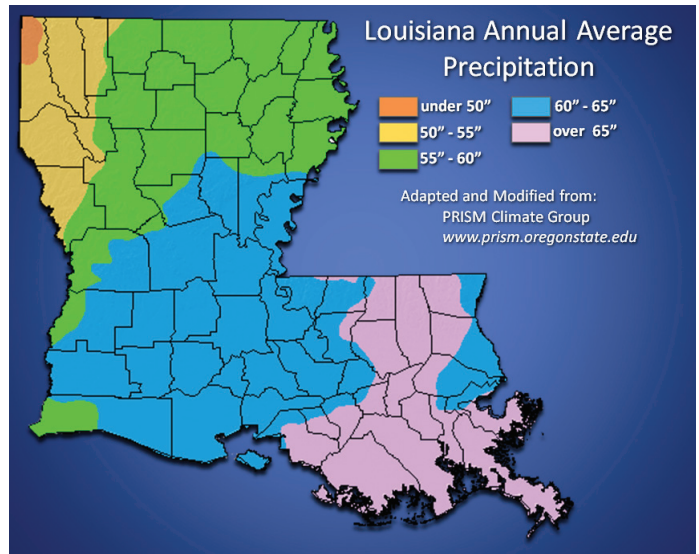
ginning of the series (roughly 1895-1920) and a more recent run of wetter years (roughly 1980-1997). Note, however, that after the nearly two-decade run of wet years near the end of the 20th century, many of the recent years have swung back to being drier than the long-term average.

The period from the 1920s into the 1940s was significantly wetter than the previous decades for Louisiana, while the decades of the 1950s and 1960s saw a modest decline in annual totals. Then the state experienced another upswing in rainfall. Indeed, the decades of the 1980s and 1990s are among the wettest decades of the entire time series. But the most recent years, beginning with the mega-drought of 1998-2000, have tended to be on the dry side.

Researchers have yet to identify a causal mechanism for this apparent oscillation in annual rainfall over time, but should this multiple-decade trend hold true, statewide annual rainfall over the next several years may tend to be normal to below-normal for the Bayou State as a whole.

Even as a wet state, annual average rainfall for Louisiana displays a rather marked gradient, ranging from more than 70 inches per year, on average, over sections of the Florida Parishes to less than 50 inches in the state's northwestern corner (Figure 1). Few states have such a wide range in mean annual totals, and those that do are typically much larger, mountainous states where orograph-

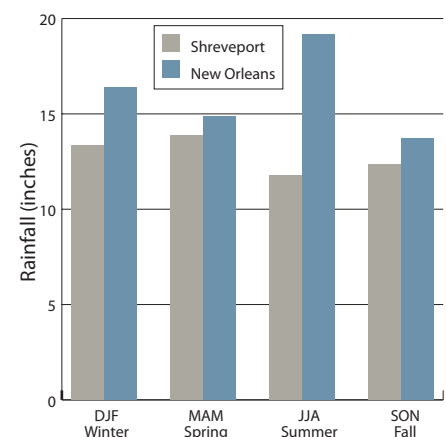
Figure 1. Louisiana average annual rainfall distribution.



ics enhance local or regional rainfall variability.

Many assume that Louisiana's north-to-south rainfall gradient is a result of the impact of tropical systems on the coastal parishes. Without doubt, Louisiana is one of the nation's hot spots for tropical weather, with impacts by roughly 100 tropical systems (tropical storms

Figure 2. Seasonal average rainfall at Shreveport and New Orleans. Data provided by the LSU Southern Regional Climate Center (NOAA).



Louisiana would greatly benefit from an active and fully-integrated statewide climate-monitoring program.

and hurricanes) over the past 150 years. While tropical systems undoubtedly have a greater influence on the southern half of the state, the decreasing gradient of annual rainfall is largely a product of the summer season “sea breeze” showers, those bands of rains that drift inland from the Gulf but tend to “rain themselves out” before reaching the northern half of the state.

Figure 2 shows the average seasonal rainfall for Shreveport and New Orleans. Note that average rainfall is greater in New Orleans for all seasons, but the largest difference by far occurs during the summer, when New Orleans’ rains average more than 7 inches above those for Shreveport.

For much of the year, average rainfall across the state is sufficient to meet local evapotranspiration (ET) and environmental moisture demands. But in the heat of the summer, ET typically outpaces rainfall for the northern parishes, whereas rains across the southern parishes are often sufficient to meet most or all of the regional moisture demands. Undoubtedly, it is this warm-season rainfall gradient that defines many of the differences encountered across the state in terms of natural vegetation and agricultural practices (including irrigation).

When Mother Nature is behaving, Louisiana rains maintain our luscious green landscapes and forests, supply copious runoff for our wetlands, and keep many a farmer, forester and cattle producer happy. But being wet has its price. When we get too much of a good thing, flooding follows. Louisiana’s blessing is occasionally a curse in disguise because the Pelican State ranks among the top states in the nation when it comes to per-capita flood losses, and that excludes losses attributed to Katrina, Rita and the many additional tropical impacts. In fact, while tropical weather can produce enormous amounts of surge and flood damage, the vast majority of flood events

in Louisiana come during the winter and spring seasons, when rainfall can far exceed evapotranspiration rates and the environment’s water-holding capacities.

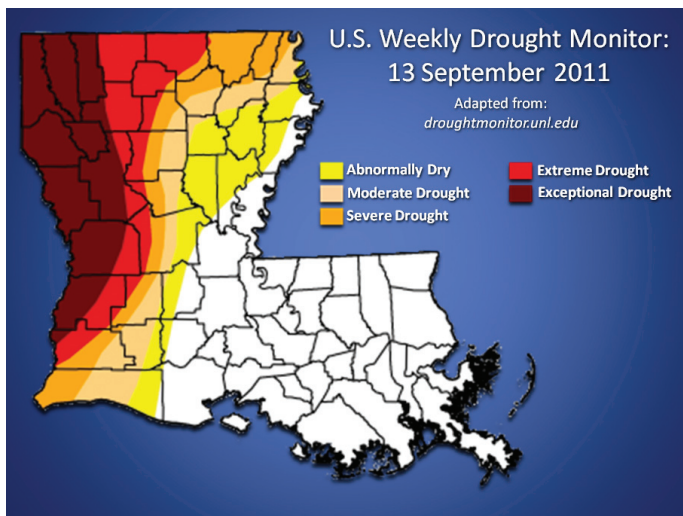
At the other extreme, and often more difficult to manage, is the drought threat. With floods, you see them coming. They can be measured with rain and river gauges. In most cases, they can be quickly assessed in terms of their economic impacts. Most floods can be viewed as meteorological events, prompted by relatively short-term weather anomalies.

Drought, on the other hand, is more insidious. It slowly evolves and can be difficult to quantify, especially in the early stages. Drought sometimes requires months of deficient rainfall before any effects become apparent. What makes drought an even more difficult problem is that it is often sector-specific. What is a drought for a sugarcane or rice farmer may be fine weather for other types of agricultural activities. In addition, as was so evident during 2011, drought severity can vary considerably over relatively small distances.

Louisiana’s drought status at the end of the 2011 summer serves as a prime example: the U.S. Weekly Drought Monitor shows a dramatic drought gradient across Louisiana (Figure 3), reflecting the uncommon and critical nature of rain and soil-moisture shortages over many western parishes during much of 2011. Yet nearly half of the state was essentially drought-free during the late summer and early fall of 2011, thanks in a large part to July rains and a tropical storm named Lee.

Louisiana’s mid-September 2011 drought status is an excellent reminder that even a relatively small state can experience periods of drastic environmental differences simply as a function of spatial and temporal difference in local and regional rainfall.

Figure 3. U.S. Weekly Drought Monitor for Louisiana, 13 September 2011.



The bottom line: Substantial variability in annual, seasonal and spatial rainfall is readily evident in the Bayou State’s climatic record.

And given the added uncertainties introduced to the state’s future in the face of climate change theory, the importance of forestry and agriculture in the state’s economy, and the invaluable resources of our coastal wetlands, Louisiana would greatly benefit from an active and fully-integrated statewide climate-monitoring program. A successful weather- and climate-monitoring program would incorporate the resources of the wide variety of data-gathering networks within the state and provide a convenient interface for access to these data. But data delivery is only one part of a comprehensive climate-monitoring program. Data-driven, user-friendly tools – tools defined by the user community – would be available through a Web-based interface to provide enhanced, value-added decision-making applications for farmers, researchers and resource managers. In Louisiana, the AgCenter’s LAIS (Louisiana Agricultural Information System) and the LSU Southern Regional Climate Center have made great strides in this direction, but so much more remains to be done. ■

John M. “Jay” Grymes III, Climatologist (retired), Department of Biological and Agricultural Engineering, LSU AgCenter, Baton Rouge, La.

Rice Hulls for Wastewater Treatment, Nitrogen Oxidation

Troy F. Davis, Ron E. Sheffield, Brian D. LeBlanc, Chandra Theegala, Jake Farlow and Steven G. Hall

Aquaculture is a nearly half-billion dollar per year industry in Louisiana. Many aquaculture systems include water filtration to protect fish and maintain water quality, enhancing productivity and the environment. Biological filters are effective in using natural bacteria to remove ammonia from aquatic systems such as aquaculture or waste management systems. These bacteria must grow on some medium, which could include microbeads, floating or sinking beads, sand or other materials. This study investigated the use of rice hulls as an organic medium for this purpose and found them to be effective in this task.

Growth media for biological filters are described by surface area available for bacteria to grow on, or specific surface area, expressed in terms of square feet per cubic foot. Media with higher specific surface areas provide better nitrification and filtration because a medium with a large surface area has more room for bacteria to grow and provides more contact points between bacterial coatings, called biofilms, and the filter solution.

For these experiments, rice hulls used as the growth medium had a specific surface area of around 1,130 square feet per cubic foot. The shape of rice hulls is also ideally suited for bacterial growth. Rice hulls also have relatively low carbon content, 40 percent by dry weight; they do not rot easily and thus remain effective in the biofilter for long periods.

Rice hulls are readily available in bulk as a byproduct of rice farming. All of these factors combined make them a suitable biological filter growth medium. The overall research goal was to investigate the efficacy of using rice hulls as an organic nitrification medium in biological filters. Specific objectives were to evaluate:

- The effectiveness of a trickling biological filter under high nitrogen loading without clogging.
- The viability and effectiveness of rice hulls as a biological growth medium in wastewater treatment systems.
- The biological filter's ability to completely oxidize ammonia to nitrite to nitrate.

To evaluate the effectiveness of rice hulls as a growth medium for nitrifying bacteria, three lab-scale tests were run: a five-day test with synthetic wastewater, a 10-day test with synthetic wastewater, and a 10-day test with dairy parlor wastewater treated by a phosphorus removal process.

The lab-scale tests used six small-scale biological reactors that consisted of three main components: the main reactor body, the filter media basket and the circulation pump with spray nozzle (Figure 1).

The reactors were constructed using 20-inch sections of a 14-inch-diameter PVC pipe. The bottoms of the reactors were sealed with sections of ¼-inch-thick PVC sheet, with holes drilled in the center to allow for connection to the recirculating pumps. Each reactor held five gallons of wastewater.

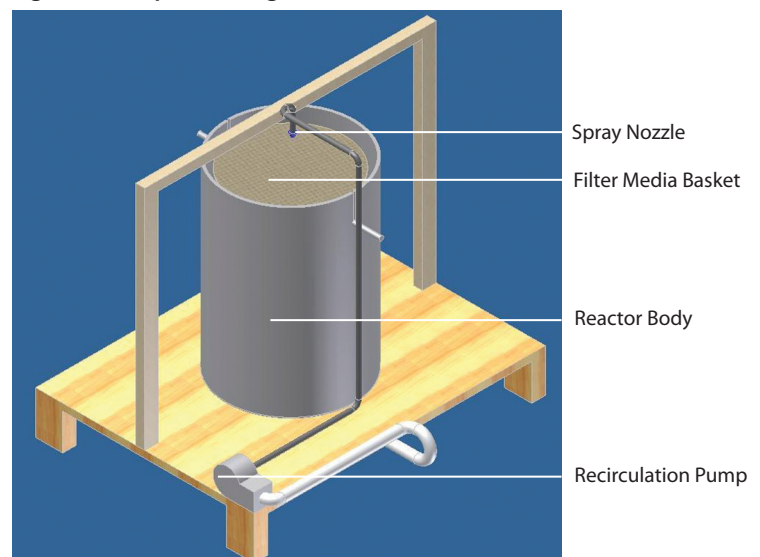
The filter media baskets were constructed using 3-inch-long sections of 12-inch-diameter PVC pipe with a threaded rod

inserted through the center of the basket to allow it to be rotated to prevent clogging. It was essential to provide unimpeded flow through the medium to ensure the most efficient and effective nitrification possible. On each side of the basket, wire mesh prevented rice hulls from leaving the basket, which hung 3 inches above the surface of the wastewater.

Recirculation pumps were connected to the reactor spaces at the bottom and pumped the wastewater up above the filter media baskets. The pumps had a pumping capacity of 190 gallons per hour, resulting in a recirculation time of about three minutes. The wastewater was pumped through nozzles with a spray diameter of approximately 12 inches. To provide an even and equal distribution of water across the top of the filter medium, the inlet water was forced through spinner nozzles.

Two solutions tested were synthetic wastewater with a concentration of ammonia of 50 milligrams per liter. The third material was from a dairy parlor.

Figure 1. Complete biological reactor



In the first test, samples were taken from each reactor every six hours for five days after the initial filling of the reactors. The samples were stored in a freezer to reduce the biological activity so that ammonia, nitrite and nitrate concentrations would more accurately represent the concentrations in the biological reactors at the time of sampling.

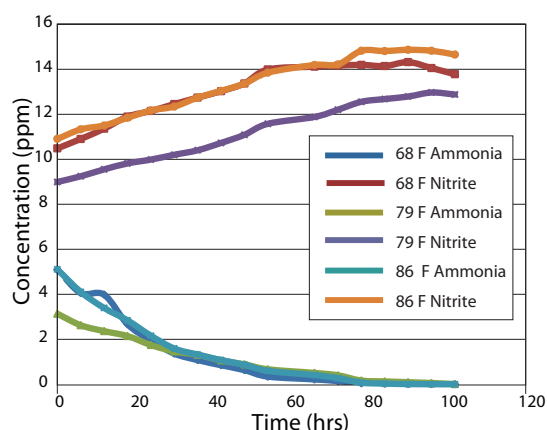
The second lab-scale tests also used the synthetic wastewater. Samples were taken every 12 hours for a 10-day period after initial filling. The samples were stored in a freezer until they could be tested.

The final lab-scale tests used dairy wastewater that had undergone a phosphorus treatment. Samples were taken every day for 10 days and stored in a freezer.

All samples were tested using the same procedure.

In the five-day lab-scale test, the initial concentrations of ammonia were much lower than expected because of improper mixing of the synthetic wastewater. Figure 2 displays the graph of the ammonia and nitrite concentrations

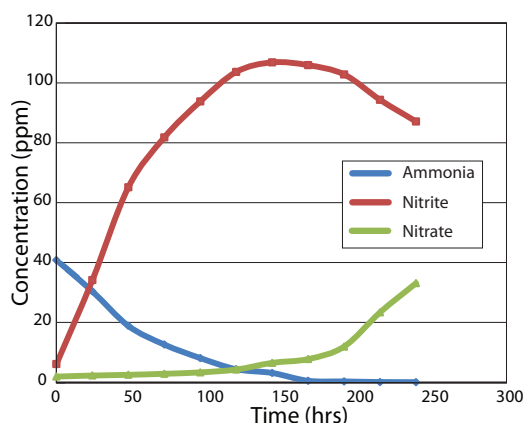
Figure 2. 5-Day Lab-Scale Synthetic Wastewater Test



recorded during the five-day lab-scale test using synthetic wastewater at each temperature. Because of problems with the thermometers, temperature variations were only used in the five-day lab-scale experiments.

In the 10-day lab-scale test, initial ammonia concentrations were lower than projected but were closer to the target goal of 50 milligrams per liter than the

Figure 3. 10-Day Lab-Scale Dairy Parlor Wastewater Test



five-day synthetic wastewater test. Ammonia oxidation began at the beginning of the experiment and continued until the seventh day, when ammonia levels became too low to detect.

In the 10-day dairy parlor wastewater experiment, the initial ammonia values ranged from 39.43 parts per million to 42.54 parts per million. Figure 3 displays the graph of the ammonia, nitrite and

nitrate concentrations recorded during the course of the 10-day lab-scale test using phosphorus-treatment effluent.

Complete oxidization of ammonia into nitrate did not occur in the time frames examined during this study. However, the purpose of oxidizing ammonia into nitrite was to convert the ammonia into a stable form of nitrogen that would not volatilize and be lost from the wastewater to the atmosphere. Typically, high concentrations in nitrite may mean that the bacterial population is no longer alive and that the filter is on the verge of failure. But in this instance, the presence of high nitrite concentrations immediately after ammonia concentrations dropped indicates that a partially mature biofilm was present in the filters.

The inoculation techniques of the rice hulls prior to experimentation offer an explanation to why mature biofilms had not developed on the rice hulls. Each batch of rice hulls was inoculated for two months prior to experimentation in hopes

of achieving a mature biofilm. Because nitrite oxidation did occur at the end of the both of the 10-day lab-scale tests, it is evidence that a mature biofilm was beginning to develop. Had the experiments continued, a fully matured biofilm would have eventually developed, causing both the ammonia and nitrite levels to decrease to near zero and the nitrate levels to increase.

The trickling biological filter did not fail or clog due to fouling over the duration of the entire study. This demonstrates that trickling filters can be used for wastewater treatment processes that exhibit high ammonia concentrations

once the organic solids are removed. Rice hulls were found to be a viable biological filter growth medium. The availability and durability of rice hulls make them a cheap, long lasting filter medium, while their shape, large surface area and resistance to bacterial degradation make them an effective bacterial growth medium.

Collectively, trickling biological filters that use rice hulls as a bacterial growth medium can effectively oxidize ammonia into a stable form, inhibiting volatilization and conserving nitrogen. Once the nitrogen is conserved into a stable form that will not off-gas into the atmosphere, land application can be more effective and efficient in terms of crop utilization and needs. The results achieved in both the 10-day synthetic wastewater and the 10-day dairy parlor wastewater tests are favorable for continuing the research with a pilot-scale field evaluation of a hanging-basket, trickling filter.

Rice hulls may be useful for farmers and aquaculturists alike as a medium for biological filters. ■

Troy F. Davis, former graduate student, and Ron E. Sheffield, Associate Professor, Department of Biological & Agricultural Engineering; Brian D. LeBlanc, Extension Specialist and Roy & Karen Pickren Professor, W.A. Callegari Environmental Center, Baton Rouge, La.; Chandra Theegala, Associate Professor, Jake Farlow, student, and Steven G. Hall, Associate Professor, Department of Biological & Agricultural Engineering, LSU AgCenter, Baton Rouge, La.

Irrigation Pump Efficiency Testing

Ron Sheffield and Ernest Girouard

Most agricultural producers who irrigate are using older diesel power units and old wells where upgrading to newer wells and diesel engines or electric motors needs to be technically and economically evaluated. Over the past several years we have seen tremendous swings in the cost of crude oil and diesel fuel. These higher fuel costs dramatically increased the cost of irrigating crops in Louisiana.

Irrigators need a mechanism by which to evaluate the condition of their pumping systems. With the current high diesel cost, this information is crucial in

In the spring of 2009, the AgCenter began working with the Natural Resources Conservation Service and Texas Agri-Life Extension to learn about hands-on irrigation well pumping-plant efficiency tests and evaluated several diesel and electric pumping plants in southwest and northeast Louisiana. These tests were used to estimate the average cost of operating irrigation systems and to evaluate the need to conduct further irrigation pumping-plant efficiency tests in Louisiana.

The initial tests found that diesel-powered pumping systems on southwest-

The goal of the Louisiana Irrigation Well Pump Efficiency Testing Program is to conduct irrigation pumping plant efficiency tests and demonstrate their effectiveness to rice producers.

ing unit. With proper operation, maintenance or replacement of system components, the cost per acre-inch could range from \$0.95 to \$1.51, and the cost over a typical 1,200-hour pumping season could range from \$4,199 to \$6,911. In a third of the units tested, farms could save nearly \$16,000 per year by making appropriate changes to their irrigation pumping systems. With the price fluctuations seen during the summers of 2008 and 2011, the cost savings per pumping plant will only become more evident.

Electric pumping systems on wells in southwestern Louisiana were found to have an average efficiency of 39.7 percent to 40.5 percent with a potential standard efficiency of about 65 percent. The cost of irrigating, assuming \$0.06 per kilowatt-hour, was found to range from \$1.18 to \$1.44 per acre-inch irrigated and an hourly cost range of \$5.35 to \$7.45 per pumping unit. It is estimated that through proper operation, maintenance or replacement of system components, a range of \$1.38 to \$1.66 per acre-inch irrigated or \$2,155 to \$4,025 over a typical 1,200-hour pumping season could be realized.

A pumping system's efficiency is calculated by comparing the amount of fuel used with the amount of water pumped. This efficiency can change due



Nich Kenny, of Texas Agri-Life Extension, demonstrates how to install a torque cell on a diesel-powered irrigation pump.

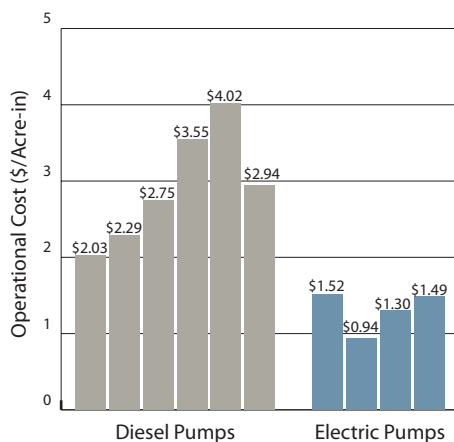
determining the profitability of switching to an electric motor or investigating the rebuilding of existing diesel power plants. Additionally, producers need such analyses when applying for federal grant funds from a Resource Conservation and Development program to assist electrical infrastructure or the Natural Resources Conservation Service to assist with well replacements.

ern Louisiana wells with water depths of 70 feet to 130 feet were found to have an average efficiency of about 16 percent with a 25 percent potential standard efficiency. The cost of irrigating an acre-inch of water (27,154 gallons) with a 3,000-gallon-per-minute pump and \$2-per-gallon fuel, was found to be from \$2.62 to \$3.24 with an hourly cost ranging from \$9.48 to \$13.54 per pump-

Factors for estimating pumping efficiency

Information	Test	Notes
Depth to Water <i>feet</i>	Open well access port	Depth of water can be estimated by recent and reliable well drillers' records.
Irrigation Discharge <i>gallons per minute</i>	Flowmeter	Ultrasonic flowmeters are preferred; however, several less expensive, less precise options are available.
Diesel Fuel Use <i>gallons per hour</i>	Fuel flowmeter	New fuel meters allow for accurate measurement of fuel use over short operation times.
Output Horsepower <i>rpm and horsepower</i>	Torque cell	Torque cell allows for greater evaluation of engine performance to quantify if problems are associated with the power unit, the pump or the well.

to the depth of water being pulled from a well, the condition of an engine and the rate the motor is turning. The calculated performance is then compared with the performance of the motor under perfect,



Variability of operating costs per acre for 10 wells in southwest Louisiana.

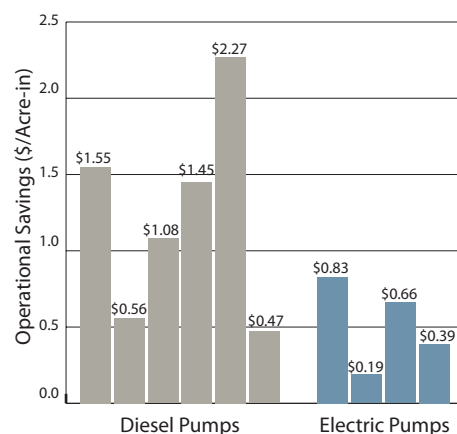
laboratory standards. Typically, electric pumping systems will have a 75 percent to 85 percent overall efficiency, and diesel-powered pumps will have between 18 percent and 35 percent efficiency, depending on the age and care of the engine.

To calculate a system's pumping efficiency, several pieces of information are needed. If this information cannot be collected, assumptions can be made to estimate efficiency. However, great care needs to be taken to make appropriate assumptions to prevent a gross

over- or under-estimation of the system's performance.

Funds from the Louisiana Rice Research Board and the LSU AgCenter supported a trailer equipped with the necessary equipment to conduct further irrigation evaluations in southwest Louisiana. A grant from the U.S. Department of Agriculture and NRCS in 2011 will fund additional pumping-system evaluations in Louisiana over the next two years.

The goal of the Louisiana Irrigation Well Pump Efficiency Testing Program is to conduct irrigation pumping-plant efficiency tests and demonstrate their effectiveness to rice producers. To demonstrate this novel and specialized energy-focused conservation practice, 250 irrigation well pump efficiency tests will be conducted during 2012 in areas largely over the Chicot and Mississippi



Variability of potential cost savings per acre for 10 wells in southwest Louisiana.

Alluvial aquifers in southwest Louisiana. Following each efficiency test, the irrigator will be provided with a set of technical evaluations and recommendations on changes that can be made to the operational settings of the pumping equipment to optimize energy, financial and water resources.

If the operational efficiency is found to be extremely low, specialized spreadsheets will identify the cost/return of rehabilitating the existing system compared with converting to a different power system, such as from a diesel to an electric pump. Field days for rice producers will demonstrate a pump test and present the general results and effects of well efficiency tests on water and energy conservation as well as on farm profitability.

The project also will develop a group of private, third-party auditors who will be trained to conduct irrigation pump efficiency tests in the future. To educate the auditors, the LSU AgCenter has joined with irrigation specialists from across the southern United States to develop a national Irrigation Pump Efficiency Testing Manual. The manual will be composed of how-to fact sheets and reference guides for specialized irrigation spreadsheets. These spreadsheets will be invaluable to auditors and producers for interpreting, comparing and summarizing the data collected during the on-farm pump efficiency tests so they can be easily understood and digested and their recommendations implemented.

Producers can then use this information when applying for federal grants or loans to convert from diesel to electric power units or when replacing a well. The AgCenter also will provide direct technical assistance through an interactive website and blog to assist auditors and conservation professionals as they encounter difficult situations and help them stay abreast of the latest news and technology related to energy and water conservation topics in Louisiana. ■

Ron Sheffield, Associate Professor, Department of Biological & Agricultural Engineering, Baton Rouge, La., and Ernest Girouard, Coordinator, Louisiana Master Farmer Program, W.A. Callegari Environmental Center, Baton Rouge, La.

Water Resource Use

in Louisiana Aquaculture

Robert P. Romaine, W. Ray McClain and C. Greg Lutz

Water is an essential resource for aquaculture. No single factor influences the success of aquaculture operations more than the availability of good-quality water. Aquaculture is one of Louisiana's major animal industries and, its \$326 million contribution to the state's economy makes it an important part of Louisiana's agriculture. The Louisiana aquaculture industry includes more than 2,000 diverse operations throughout the state, including production of crawfish, catfish, alligators, oysters, tilapia, bait-fish, soft-shell crawfish and crabs, ornamental fish, baby turtles and a variety of freshwater game fish and other minor species. Crawfish production typically accounts for slightly over half of the farm-gate value of Louisiana's aquaculture crops.

In commercial aquaculture facilities, water use is directly related to effluent discharges. Greater water use results in greater water volumes being discharged, and this can potentially have a negative effect on receiving waters. Contributions of water to an aquaculture operation include precipitation, runoff, seepage inflow and the addition of surface water or groundwater through management, including filling ponds, flushing for oxygen management or replacing losses from evaporation and seepage. Water consumed in aquaculture includes water lost to evaporation, discharge and seepage; withdrawal of surface water or groundwater; and water removed in the biomass of harvested aquatic animals.

Water requirements for Louisiana aquaculture operations vary greatly depending on the type of culture system. Flow-through systems that require large volumes of water are not used commercially in Louisiana. Recirculating aquaculture systems, which are used on a limited scale for alligator, tilapia and bait-minnow farming in Louisiana, are minor consumers of water because the water is continuously recycled through mechanical and biological filters. Wa-

Table 1. Comparison of water consumption for selected crops with those for farm-raised crawfish and channel catfish.

Crop	Annual water consumption (inches)
Corn	34.6
Cotton	34.6
Soybeans	31.5
Alfalfa Hay	42.1
Rice	48.4
Catfish	51.2 to 86.6
Crawfish	70.1 to 79.9

ter consumption is significant in crawfish and catfish farms that use outdoor earthen ponds, and these are dominant in Louisiana aquaculture. Water consumption in ponds varies widely depending on the frequency of water exchange and pond drawdowns (minor in catfish farming; significant in crawfish farming).

The amount of water consumed in crawfish and catfish farming is higher than for typical agricultural crops (Table 1), but aquacultural products generally have higher economic value per unit weight. Crawfish farming is Louisiana's largest aquaculture industry with 184,000 acres in cultivation, so it will be used here to illustrate water consumption. About 11 percent of the water withdrawn from the Chicot aquifer system in southwest Louisiana is used for crawfish farming, compared with about 65 percent used for crop irrigation, principally rice. Water is required to fill crawfish ponds and replace losses from evaporation and levee seepage during the fall, winter and spring production season. Additional water is often used to flush ponds to maintain sufficient oxygen levels for crawfish.

AgCenter research has shown the total amount of water

required to maintain a typical rice-field crawfish pond at near full-flood depth of 12 inches, from October flood-up through mid-June drawdown, is about 91 inches. About 40 percent of this water requirement will be supplied by precipitation, but the balance (60 percent) must be provided by surface water or groundwater. Of the 91 inches of water used, 68 inches will be consumed by evaporation and by transpiration by plants (Table 2). Effluent discharged during an average crawfish production cycle is 23 inches with end-of-season pond drawdown (37 percent), non-intentional discharge from precipitation overflow, excess pumping and levee breaks (29 percent), normal levee seepage (22 percent) and oxygen management (12 percent) accounting for the water releases (Figure 1).

The LSU AgCenter, with partners from government and industry organizations, has developed voluntary environmental best management practices (BMPs) for all of Louisiana's aquaculture commodities. BMPs result in reduced water consumption and lower levels of nutrients, sediments, and organic matter being discharged into the state's waters. These recommended practices are outlined in two new LSU AgCenter publications, *Aquaculture Environmental Best Management Practices* and *Crawfish Environmental Best Management Practices* (see back cover). These manuals provide guidance for the selection, implementation and management of practices that help growers conserve soil and protect water and air resources.

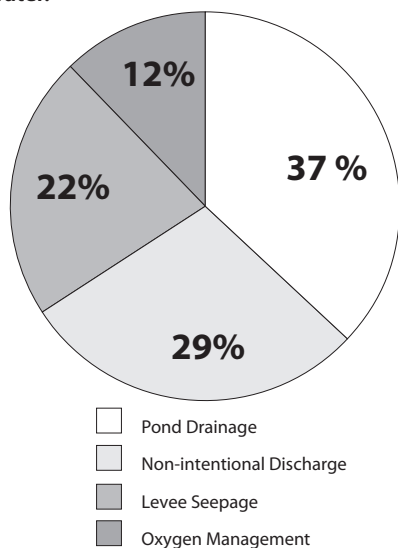
Several BMPs can be implemented to improve water use efficiency in earthen ponds. These include:

- Not flooding crawfish ponds earlier than recommended by AgCenter guidelines to minimize evaporative loss.
- Practicing active rodent control and

Table 2. Water budget for rice-crawfish aquaculture ponds, southwest Louisiana, October through June.

Water Inputs	Water Quantity (inches)	Water Losses	Water Quantity (inches)
Precipitation	36.7	Evaporation and Transpiration	67.9
Groundwater Withdrawal	54.6	Effluent Discharge	23.4
Total	91.3	Total	91.3

Figure 1. Effluent discharged, by source, from rice-crawfish aquaculture ponds. Total effluent released is 23.4 inches of water.



compacting levees in all ponds to minimize seepage loss.

- Maintaining 4 to 6 inches of storage volume in ponds to prevent or minimize overflow following heavy rains and to conserve rainwater, thus reducing pumping costs and water use.
- Avoiding frequent water exchanges (flushing) to maintain high levels of water quality except under the most extreme conditions to reduce consumption and pumping costs.
- Holding water in ponds before releasing it at season's end to allow natural processes to assimilate waste, thereby reducing potential pollutant loads in effluents.

Often, aquaculture ponds can be managed to reuse water for other purposes. For example, tailwater (effluent) discharged in spring and summer from crawfish ponds can be used to irrigate and replenish water in rice fields, which are planted in mid-March through April.

Water use in aquaculture is essential, but wise use and management not only conserve the resource and protect the environment, they also reduce the cost of production and potentially increase profit margins. ■

Robert P. Romaine, Professor, Aquaculture Research Station; W. Ray McClain, Professor, Rice Research Station, Crowley, La.; C. Greg Lutz, Professor, Aquaculture Research Station, Baton Rouge, La.

Water Resources Extension Programs

Brian LeBlanc, Carol Franze, Ron Sheffield, Vinicius Moreira and Bobby H. Fletcher Jr.

The LSU AgCenter conducts extension programs to inform Louisiana citizens about water resources and ecosystem policy, protection and conservation. One such program involves informing people about a recent announcement by the U.S. Environmental Protection Agency to establish numeric nutrient criteria for Florida water bodies under the 1972 Clean Water Act. This announcement has created concern in Louisiana and other states. The Clean Water Act aims to protect the nation's waters from a wide array of impairments and requires the adoption of water quality criteria sufficient to protect designated uses.

Numeric criteria establish measurable limits for the concentrations of specific pollutants such as nitrogen and phosphorus or other quantitative indicators of water quality, such as temperature. Water quality standards are usually established by individual state agencies such as Louisiana's Department of Environmental Quality (DEQ) with oversight by the EPA. If the state and EPA cannot agree, the EPA administrator has authority to supersede the state and establish water quality standards if the agency determines such actions are necessary to meet the requirements of the act.

Louisiana and many other states have historically used narrative criteria for nutrients. A few years ago Florida began exploring the use of numeric criteria for nutrients and began the process of testing and trying to establish workable limits for nutrients and the

associated costs of implementation. In 2009, the EPA concluded that based on available data, information and trends, Florida's narrative nutrient criteria alone were not sufficient to protect designated uses.

The EPA also concluded that numeric nutrient criteria, and not narrative criteria, were necessary to meet the requirements of the Clean Water Act. The EPA determination in Florida is being challenged in federal court by the state of Florida and other groups. The outcome of this case could have wide-ranging implications for Louisiana. As a result of this uncertainty, most states, including Louisiana, are exploring the adoption of numeric criteria for nutrients in surface



Plant mats float below the surface at the Hammond Research Station. Photo by Carol Franze

waters. AgCenter extension specialists are informing state officials and agricultural and natural resource leaders about the situation in Florida and the implications of adopting nutrient numeric criteria in Louisiana.

Plant Mats for Cleaner Water

LSU AgCenter extension specialists have developed a project aimed at cleaning water through the use of plant mats.

(continued on page 34)



Vallisneria americana, a submerged aquatic plant native to Lake Pontchartrain, above, is planted in coconut-fiber mats in predator-proof cages and placed 18 to 20 inches below the water surface in a freshwater pond on the Hammond Research Station. Photos by Carol Franze

Vallisneria americana, a submerged aquatic plant native to Lake Pontchartrain, is planted in coconut-fiber mats in predator proof cages and placed 18 to 20 inches below the water surface in a freshwater pond on the Hammond Research Station. The goal is to measure the amount of nutrients the vegetation removes from the pond and to grow and sustain populations of this threatened species for transplanting into suitable habitat in and around Lake Pontchartrain.

The project includes bimonthly water sampling to measure a variety of water-quality parameters above and below the vegetated areas. 4-H Clubs and other student groups will be involved in transplanting these plants into the lake and nearby tributaries. In addition, these groups and their teachers will be taught how to grow these plants in green-

houses or freshwater ponds and the role and function of these plants in the ecosystem. The multi-year project is funded by the Pontchartrain Basin Restoration Program.

Horses and Water Quality

Extension specialist and agents have collaborated to develop an educational program for horse owners and horse farm proprietors to encourage the voluntary adoption of strategies that can reduce polluted stormwater runoff from their land. The program was developed in response to increased concerns by DEQ that some of the sediment, bacteria and nutrient loads entering water bodies in the Lake Pontchartrain Basin were from the high numbers of horses and horse farms in the basin. Although the genesis of the program was out of concern for the potential pollutants emitted

from equine operations, the program is generic enough to be used in any Louisiana watershed. AgCenter collaborators on this project are part of a seven-state research and extension project NE1041, "Environmental Impacts of Equine Operations."

Best Management Practices and Master Farmer Program

LSU AgCenter water resources and commodity specialists and researchers have recently rewritten commodity-based environmental best management practices manuals.

These manuals are used extensively in the Master Farmer Program. These manuals are critical to maintaining producer options for voluntarily implementing pollution-reduction management strategies that support the state's nonpoint pollution reduction plans. See the back cover for a listing of these manuals.

Project with Shell

LSU AgCenter extension specialists have developed an educational program for science teachers and students as a result of a relationship developed with the Shell Oil Company. Shell recently constructed a deep-water robotics training facility in Robert, La., and the company approached the AgCenter about ecological and water-quality maintenance of its deep-water impoundment. Stemming from that relationship, Shell agreed to provide equipment and supplies for educational programs that will consist of wetlands education, water-quality testing and results interpretation, organism identification and ecological function, and fisheries population assessment and management. Specialists are developing curricula to be used with the 4-H Youth Wetlands Program. ■

Brian D. LeBlanc, Associate Professor and Roy and Karen Pickren Professor of Water Resources, LSU AgCenter and Sea Grant, Callegari Environmental Center, Baton Rouge, La.; Carol Franze, Area Agent, Southeast Region, Hammond, La.; Ron Sheffield, Associate Professor, Department of Biological & Agricultural Engineering, LSU AgCenter, Baton Rouge, La.; Vinicius Moreira, Associate Professor, Southeast Research Station, Franklinton, La.; Bobby H. Fletcher Jr., Assistant Professor and Southeast Region Director



Plant mats are submerged at the Hammond Research Station. Photo by Carol Franze

Water Quality in Rice Production

Johnny Saichuk and Stuart Gauthier

Saltwater intrusion into rice production has been a cause for concern in southwest Louisiana for decades. But storm surges from recent hurricanes coupled with recent droughts have brought this problem to the forefront.

Rice is considered a salt-sensitive crop, yet rice varieties have not been selected for salt tolerance. Today's varieties are similar in salt tolerance to the varieties of nearly 50 years ago.

Rice farmers have learned to measure the amount of salt in water before they use it for irrigation to avoid short-term crop injury and long-term soil contamination. The most commonly used tool to indicate the degree of salt content of water is a conductivity meter. The more salt the water contains, the easier it is for electricity to flow through it.

Rice at all growth stages can tolerate water containing 600 parts per million (ppm) of sodium. As the plants grow, their tolerance also increases. Irrigation water containing 1,300 ppm may be harmful to seedlings but is usually tolerable at later growth stages. Levels above 1,300 ppm begin to harm rice in varying degrees until they reach a fully toxic level of around 5,000 ppm. These figures assume a single application of water at this level. Repeated application has a cumulative effect, both on the plants in the short term and on the soil in the long term.

Following Hurricane Rita, the LSU AgCenter conducted extensive soil testing to determine how much salt remained in the soil once the tidal surge had subsided. In many cases, salt levels in the soil were too high for normal rice growth, and some farmers were unable to plant a crop the following summer. Research conducted at the Rice Research Station in Crowley resulted in the recommendation to avoid planting rice where salt levels were above 750 ppm.

After Hurricane Ike in 2008, a select number of sites were visited again to determine if there had been a cumulative effect of the salt deposition from Hurricane Rita combined with Ike. Each site was sampled from October 2008 until November 2009. One site was a control

where inundation did not occur. Approximately 65 inches of rain fell on the area during the test period.

When sampled in October 2008, seven of nine sites that had been flooded showed salt levels above 2,000 ppm (Figure 1). At one site located near the Vermilion River, salt levels dropped quickly from a high around 2,000 ppm to 500 ppm a month later. This was attributed to the already saturated soil at the time of flooding, the short time the flood remained on the field, and ample supplies of fresh water that helped to flush the salt out of the system. The most heavily flooded areas required several months of rainfall to achieve the same decline in salt levels in the soil.

One phenomenon observed during the sampling period was the rise and fall of salt levels in the soil. The changing levels indicated salt migrated with the water in the soil profile. In saturated soils, salt is fairly evenly distributed, causing dilution and lower readings. As moisture evaporates from the soil, salt tends to accumulate near the surface. If sampled at that time, the reading would likely be high. If rainfall occurs, especially if it is heavy over a short time, however, ac-

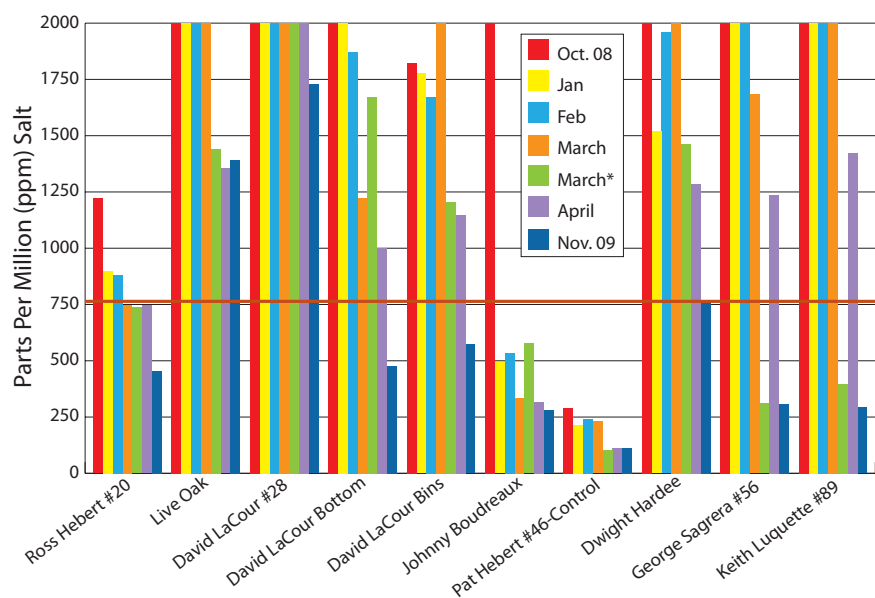
cumulated salts can be flushed from the field. Slow, steady rain resulting in little runoff from the field will simply move the salt back down into the soil profile.

Another characteristic of salt is that it is randomly distributed in a field with some areas showing high levels and others much lower levels. The uneven distribution is often seen in seedling rice planted into affected fields where odd patterns of seedling injury can be observed.

Reclamation of soils in these situations is lengthy and often expensive. Studies of different techniques revealed the most effective method is to work the field in a flooded state (on silt loam soils that have a subsurface hard pan), allow the field to stand for a couple of weeks, then release the water. This procedure can be repeated to hasten the recovery. Some farmers simply let Mother Nature take care of things. Rainfall is the best treatment for the problem because water draining from the fields carries dissolved salt back to its source. ■

Johnny Saichuk, Rice Extension Specialist, Rice Research Station, Crowley, La.; and Stuart Gauthier, Extension Agent, Vermilion Parish

Figure 1. Scheduled salinity soil test in Vermilion Parish at sample locations.



*Second March sample pulled after 4 inch rainfall

Inside:

As the dead zone in the Gulf of Mexico grows, alternative means to reduce nutrient loads from the Mississippi River are being sought. See page 8.

Water depth enhances the quality and provides a good place for fish to grow in the Atchafalaya River Basin. See page 12.

Scientists work to establish bermudagrass on levees to prevent runoff. See page 16.

Storm surges bring salt on the land for growing sugarcane (see page 18) and rice (see page 35).

A study to restore wetlands uses agricultural techniques. See page 19.

Composted mulch can control highway embankment erosion. See page 24.



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Best Management Practices

Most of the water in Louisiana's waterways comes from rainfall runoff. As this runoff travels across agricultural lands, it can carry with it soil particles, organic matter and nutrients, such as nitrogen and phosphorus. To help farmers prevent too much of these nutrients getting into waterways, the LSU AgCenter has developed a series of publications on management practices. Five of these BMP publications, as they are called, are available in PDF form at www.LSUAgCenter.com. Go to **Publications>Catalog>Crops & Livestock>Best Management Practices**



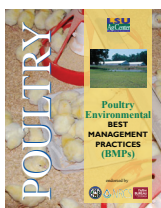
Sugarcane Environmental Best Management Practices

If properly implemented – with appropriate incentives, where needed – the practices described in this manual will help improve water quality without placing unreasonable burdens on the sugarcane industry, which is a major contributor to the Louisiana economy.



Crawfish Environmental Best Management Practices

When surface waters are used for crawfish production, the water leaving the ponds is of equal or better quality than when it was pumped in. Nonetheless, discharge of pond water into surrounding watersheds has been cited by some as the primary environmental concern with crawfish farming.

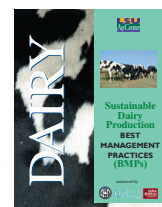


Poultry Environmental Best Management Practices

This manual is a guide for the selection, implementation and management of those practices that will help poultry farmers conserve soil and protect water and air resources. Poultry is Louisiana's most valuable animal commodity and contributed \$1.6 billion to the economy in 2010.

Sustainable Dairy Production Best Management Practices

Dairying, by its nature, requires specific practices to conserve and protect soil and water resources. Best management practices are an effective and practical means of reducing point- and nonpoint-source water pollutants at levels compatible with environmental quality goals.



Aquaculture Environmental Best Management Practices

BMPs for aquaculture enterprises are a specific set of practices used by growers to reduce the amount of soil, nutrients, pesticides and microbial contaminants entering surface water and groundwater while maintaining or improving productivity. This manual is a guide for management practices that will help growers conserve soil and protect water and air resources.



Equine Water Quality Education Series

This series of nine fact sheets informs horse owners and the technical specialists who work with them about the potential water-quality effects from horse farms and highlights practical management practices that can be used to reduce these effects. Go to **Publications>Catalog>Environment>Water Quality**.

