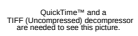
COASTAL RESTORATION AND ENHANCEMENT THROUGH SCIENCE AND TECHNOLOGY

PROGRESS IN UNDERSTANDING COASTAL LAND LOSS AND RESTORATION IN LOUISIANA: The W. Alton Jones Foundation Report Revisited

River Oaks,
Lafayette, LA
12-13 April 2005



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National Oceanic and Atmospheric Administration,
U.S. Army Corps of Engineers
U.S. Geological Survey
Louisiana Governor's Applied Coastal Science Program

Welcome to the second CREST Science Symposium, which is being held in the heart of Louisiana's Cajun country in Lafayette.

In 1994 the W. Alton Jones Foundation sponsored a report titled "Scientific Assessment of Coastal Wetland Loss, Restoration and Management in Louisiana." This benchmark report focused attention on understanding the underlying processes that drive landscape change and its consequences. These processes provide both the primary opportunities for restoration and constraints on what can be accomplished through management. This symposium revisits the issues raised in 1994 and assesses progress toward and even beyond the recommendations of the report. The focus will be on recent insights into the causes and mechanisms of land loss, the consequences of the rapid changes during the 20th century, and approaches to predicting the outcomes of system-scale restoration efforts.

We welcome the support received from the University of Louisiana at Lafayette and our sponsors the U.S. Geological Survey, NOAA, the U.S. Army Corps of Engineers, and the Louisiana Governor's Office for Coastal Affairs through their Applied Coastal Science Program.

Conference Timetable

Tuesday 12 April, 2005

08.00 Registration and mounting of posters

08.45 Welcome Denise Reed (UNO) Chair of CREST Technical Advisory Board
Bob Stewart (ULL) Vice-President for Research, ULL

09.00 Setting the scene:past, present and future perspectives from the 1994 W. Alton Jones report *William Nuttle* (Eco-Hydrology)

Session 1: Stepping into the Unknown: Trends, Thresholds and Surprising Changes in Coastal Dynamics (Moderator: Denise Reed).

09.30 Height modernization activities along the northern Gulf of Mexico. *David Zilkoski* (NOAA National Geodetic Survey)

10.00 Brown marsh forensics: causes for sudden salt marsh dieback in coastal Louisiana. *Irv Mendelssohn* (LSU), *S. Faulkner, R. Gambrell, M. Hester, Q. Lin, K. McKee, T. Michot, R. Schneider, E. Swenson, C. Swarzenski, and R. Twilley*

10.30 Break

10.45 The supply side of coastal restoration: what sediment is available in the lower Mississippi River? *Mead Allison* (Tulane)

11.15 Constraining the timing and magnitude of historical subsidence and wetland loss in south-central Louisiana. *Julie Bernier* (Environmental Careers Organization) *Robert Morton, John Barras*

11.45 Louisiana's Science Working Group on coastal wetland forest conservation and use: process and findings. *Stephen Faulkner*, (USGS National Wetlands Research Center), *W. Conner, R. Keim, S. King, J. Chambers, J. Day, E. Gardiner, M. Hughes, K. McLeod, C. Miller, J. Nyman, and G. Shaffer*.

12.15 Lunch.
Lunchtime speaker: *Sherwood Gagliano* (Coastal Environments Inc.) Reflections on Louisiana's coastal restoration movement.

13.30 The role of very large, infrequent diversions in the formation, maintenance and restoration of the Mississippi delta. *Paul Kemp* (LSU), *Don Davis, Clint Willson, John Day, Enrique Reyes*

14.00 Progress in understanding coastal land loss and restoration in Louisiana:" a legal perspective, ten years later. *Michael Wascom* (LSU), *James Wilkins*

14.30 Break

15.00 Panel discussion: "The Status of Science in Coastal Restoration" Panel convenor: Len Bahr, Louisiana Governor's Office for Coastal Affairs.

Panellists include: David Biedenharn (USACE), Ehab Meselhe (ULL), Robert Twilley (LSU), Joe Suhayda (LSU, retired), and John Lopez (USACE).

16.30 Poster viewing session, with refreshments
18.30 Evening reception: ULL Alumni Center

Wednesday 13 April, 2005

Session 2: What are we learning from using science in restoration? (Moderators: William Nuttle and Doug Meffert).

08.30 The U.S. Geological Survey's NASQAN Mississippi River monitoring program. *Arthur Horowitz* (USGS, Atlanta)

09.00 Advanced coastal circulation modeling – Mississippi River delta and surrounding waters. *Cheryl Ann Blain* (Naval Research Laboratory, Stennis)

09.30 The social science of coastal habitat restoration. *Shirley Laska* (UNO)

10.00 Predicting the effect of management actions on vegetation response: challenges and data limitations for conceptual and simulation models. *Jenneke Visser* (LSU)

10.20 Break

10.40 Mississippi River basin restoration and the restoration of the Mississippi delta. *John Day* (LSU) and *Bill Mitsch*

11.00 A review of the brief history of terraces. *Andy Nyman* (LSU Ag. Center) and *Megan La Peyre.*

11.20 Louisiana Barrier Island and Shoreline Protection and Restoration: Tactics, Strategies, Adaptive Management, and Future Directions. *Shea Penland* (UNO)

Nutirent dynamics related to river diversions: pelagic and benthic fluxes and phytoplankton community response. *Johannes Rick* (ULL), *Silke Rick and Robert Twilley*

12.00 Questions posed by a review of two hydrologic restoration projects in the Barataria hydrologic basin. *Bill Good* (Louisiana Geological Survey)

12.30 Lunch
Setting the Science Agenda
Introductory remarks to stimulate discussion from *John Day* (LSU, Chair of the NTRC panel reporting on the LCA proposal) and *Jean Cowan* (Louisiana Department of Natural Rsources)

13.00 Breakout into working groups
The aim of the working groups is to set an agenda for science as applied to coastal restoration along the northern Gulf coast. Facilitated breakout groups will identify key uncertainties that can be used to frame the strategic plan for the CREST program and others funding science in support of coastal management and restoration.

14.00 Report back from discussion groups

14.30 Break

14.45 Panel discussion: Reactions to discussion group reports. Agency representatives will be asked to give their views on the findings of the working groups.

16.00 Summing up: What have we learned to guide the next decade of restoration science? *Don Boesch* (U. Maryland and Chair, W. Alton Jones Committee)

16.45 Conference closes

SETTING THE SCENE: PAST, PRESENT AND FUTURE PERSPECTIVES FROM THE W. ALTON JONES REPORT

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From our present, enlightened perspective the report sponsored by the W. Alton Jones Foundation on the scientific basis for the restoration of Louisiana's coastal region appears fairly mundane. Even at the time it was written, ten years ago, the report offered little more than a somewhat conservative statement of consensus. Yet this was enough to hasten a shift in perspective on what techniques should be employed to slow degradation of Louisiana,s coastal wetlands. Good science is fundamentally a subversive activity, and that is how the W. Alton Jones report was initially received. Recommendations in the report anticipated a further shift in perspective that is still occurring at present.This is that restoration projects must be conceived on a coast-wide scale to be effective, and this requires new analytical tools to support planning and evaluation of restoration activities.Today, we have a much better appreciation than was possible ten years ago for the implications of climate change and the impacts of human activities both on the coast and in the Mississippi watershed.Using the W. Alton Jones report as a benchmark, it is possible to anticipate a further change in perspective about what is really at stake in the restoration of Louisiana's coastal resources.

HEIGHT MODERNIZATION ACTIVITIES ALONG THE NORTHERN GULF OF MEXICO

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NOAA, National Ocean Service

A variety of processes in the coastal areas of Louisiana and neighboring Gulf Coast states create a spatially-challenged environment subject to many types of underground and surface movement which can cause both subsidence and uplift – in a nonlinear fashion. A combination of soil compaction, water and oil extraction, rerouting of waterways, faulting, and other causes creates vertical changes -- at variable rates -- at benchmarks throughout the region.

NOAA's National Geodetic Survey (NGS) has made a continuous effort in the Coastal areas of Texas, Louisiana, and Mississippi, to provide a reliable National Spatial Reference System (NSRS). NGS' efforts have ranged from periodic re-leveling of various segments of the NSRS to the more recent use of Global Positioning System (GPS) technology as a monitoring tool. These efforts have usually involved the cooperation and assistance of State, Parish, local, and other Federal agencies, especially the U.S. Army Corps of Engineers. A key to the NGS approach is the use of the North American Vertical Datum of 1988 (NAVD88) as the reference frame in measuring changes in heights.

Analysis of historical elevation data in conjunction with "modern" re-measurement of survey marks is being used to develop models, tools and procedures for establishing up-to-date, accurate heights; to better understand the complex dynamics of the land; and to monitor changes in elevations.

Our latest observations and analysis indicate that accurate rates for certain periods or epochs can be determined but cannot be accurately extrapolated into the future. A major part of this effort includes the use of the National Continuously Operating Reference Stations (CORS). As more CORS are established by the Louisiana Spatial Reference Center, the monitoring of changes will become more accurate, but the area will always need a slightly different approach than more stable areas. There is no guarantee that the subsidence rates and current elevations will remain constant over time. As a result, elevations along the northern Gulf Coast must be constantly monitored, analyzed, and updated.

BROWN MARSH FORENSICS: CAUSES FOR SUDDEN SALT MARSH DIEBACK IN COASTAL LOUISIANA

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Extreme weather events, which are predicted to increase in frequency during the 21st century due to global climate change, are significant disturbances to ecosystems. Knowledge of the mechanisms determining environmental impact is a necessary first-step for scientifically based mitigation and restoration of affected habitats. A record-setting weather event in the spring/summer of 2000, resulting in severe drought, high temperatures, and unusually low coastal water levels, coincided with the dieback and stress of ca. 157,000 ha of tidal marsh in Louisiana. Although this weather anomaly was likely the ultimate cause for the extensive dieback, the proximate cause for plant impact was not apparent. An interdisciplinary, multi-investigator research program was designed to evaluate the cause(s) of this unique event. Field, laboratory and greenhouse investigations assessed the influence of abiotic factors (hydrology, soil drainage, precipitation, acidity, salinity, moisture, and metals) and biotic controls (fungal pathogens and snails) on plant and soil chemical responses that could provide insight into causation. Although the dieback was certainly the result of multiple, interacting factors, insufficient soil moisture, in conjunction with soil physico-chemical status, likely resulted in soil oxidation, acidification, and metal toxicity. Higher than normal salinities may have also exacerbated plant osmotic stress induced by low plant water availability. Fungal pathogens, which were associated with affected plants, could have become more virulent during drought stress.

THE SUPPLY SIDE OF COASTAL RESTORATION: WHAT SEDIMENT IS AVAILABLE IN THE LOWER MISSISSIPPI RIVER?

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Department of Earth & Environmental Sciences, Tulane University

A series of studies have been conducted in the lower Mississippi River since 1999 with the overall focus of examining the channel floor as a sediment source for coastal restoration in Louisiana. Recent workshops have examined the possibility of long-distance pipelines extracting Mississippi River sediment for marsh creation or to capture sand for barrier island renourishment. Although technically feasible, their success is dependent on a thorough understanding of location, volume and quality of sediments available on the channel floor. River diversion design also needs to be optimized to maximize capture of particulates. Our efforts to date have focused on two major issues: defining the freshwater and estuarine mechanisms that trap and store suspended particles on the channel floor and examining the nature of bedload sand transport. The latter includes the need to understand variations in sand volume/quality, and the rate of replenishment of these reservoirs in the event of sand mining. Our work shows that the "active" sediment sheet on the channel floor is relatively thin (zero to meters) and is underlain by highly consolidated relict strata that may be available as a larger, non-replenishable, sediment source for elevation-building projects. These relict deposits are a combination of fluvio-deltaic units incised by the river, and alluvial deposits created by the present river channel and rendered relatively moribund by artificial levee confinement.

CONSTRAINING THE TIMING AND MAGNITUDE OF HISTORICAL SUBSIDENCE AND WETLAND LOSS IN SOUTH-CENTRAL LOUISIANA

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[1]The Environmental Careers Organization, [2]USGS Center for Coastal and Watershed Studies, [3]USGS National Wetlands Research Center

Extensive wetland losses have occurred in coastal Louisiana during the last half century, with estimated rates as high as 75 to 100 km^2/yr. Analysis of historic aerial photographs and satellite images suggests that the most rapid wetland loss and collapse of the delta plain occurred during the late 1960s and 1970s. Since 1956, the emergent land area at five wetland-loss hotspots in the Terrebonne-Lafourche region of the Mississippi River delta plain has, on average, decreased by 45 to 50%.

A land-water classification was developed from the historic imagery. A comparison of the classified water area with water-level records from several nearby tide gauges suggests that the derived land-loss rates are sensitive to changes in regional water levels. Fluctuations in local water levels introduce about ±5% uncertainty in determining the relative amount of land vs. water area. Despite this uncertainty, the most recent wetland-loss rates are substantially lower than the peak rates that occurred in a five- to ten-year period after 1969.

Formerly emergent marshes at the wetland-loss hotspots are now submerged beneath water that averages 0.5 to 1.0 m deep. Correlation of the shallow subsurface stratigraphy shows that land subsidence has been the primary physical process contributing to wetland loss. Subsequent erosion of the submerged delta-plain marsh has been relatively minor at most of the hotspots.

The widespread and nearly simultaneous collapse of marshes across the Mississippi delta plain appears to be an unprecedented event in the recent geological record. Average historical rates of subsidence, determined from analysis of leveling surveys conducted by the National Geodetic Survey between 1965 and 1993, range from 8 to 12 mm/yr. In contrast, average rates of subsidence inferred from radiocarbon dates range from 1 to 5 mm/yr over the last 5000 years.

LOUISIANA'S SCIENCE WORKING GROUP ON COASTAL WETLAND FOREST CONSERVATION AND USE: PROCESS AND FINDINGS

S.P. Faulkner[1](sfaulkner@usgs.gov), W.H. Conner[2], R.F. Keim[3], S.L. King[3,4], J.L. Chambers[3], J.W. Day[5], E.S. Gardiner[6], M.S. Hughes[3], K.W. McLeod[7], C.A. Miller[3], J.A. Nyman[3], and G.P. Shaffer[8]
[1]USGS National Wetlands Research Center; [2]Baruch Institute of Coastal Ecology & Forest Science, Clemson University; [3]Louisiana State University Agricultural Center; [4]USGS Louisiana Cooperative Fish and Wildlife Research Unit; [5]Louisiana State University; [6]Center for Bottomland Hardwood Research, USDA Forest Service Southern Research Station; [7]Savannah River Ecology Lab, University of Georgia; [8]Southeastern Louisiana University

Although some 2 million acres of forested wetland occur throughout Louisiana, over half are located in the Deltaic Plain. Large- and small-scale hydrologic and geomorphic alterations have caused the complete loss of some coastal wetland forests and reduced the productivity and vigor of remaining areas. In response to the continuing loss and adverse impacts to Louisiana's coastal wetland forests, a Coastal Wetland Forest Conservation and Use Science Working Group (SWG) was formed to provide the Governor with information and guidelines for the long-term utilization, conservation, and protection of Louisiana's coastal wetland forest ecosystem, from both environmental and economic perspectives. The process of engaging scientists, resource managers, and stakeholders in this effort is described along with the findings of the SWG.

REFLECTIONS ON LOUISIANA'S COASTAL RESTORATION MOVEMENT

Sherwood M. Gagliano (sgagliano@coastalenv.com)
Coastal Environments Inc.

Louisiana's coastal restoration movement is based upon the belief that natural and human induced changes along the coast have degraded landforms and the renewable resource rich natural systems, and that the degradation threatens property, quality of life and safety of the coastal inhabitants. It follows that some of the damage can be repaired and/or restored through human intervention. The roots of the restoration movement can be traced to the post-Civil War era of navigation improvement and flood control along the Lower Mississippi River and its tributaries. During the same period there was interest in freshwater diversions for enhancement of oyster growing conditions in the coastal estuaries. The movement has progressed through five stages: (1) flood control and navigation (1865-1969); (2) the coastal zone management act stage (1969-1981); (3) the state trust fund stage (1981-1991); (4) the Breaux Act stage (1990-1999); (5) the Coast 2050 (1999 – 2002); and the America's Wetland stage (2002 – present).

The movement has a large following and has developed its own social and political structure. There has been a procession of advocates, elected and appointed public officials, research scientists, engineers, planners, concerned citizens, and many others, who collectively make up "the coastal restoration community," engaged in a public dialog regarding what must be done and how it can best be accomplished. An eyewitness account of some of the issues and players during the past three decades will be given.

The magnitude of the restoration undertaken has been identified and a plea has been made to the nation for assistance in saving America's Wetlands. We are now faced with the challenges of further testing and applying basic scientific and engineering concepts, making wise decisions on expenditure of billions of tax dollars, and creating an administrative structure that is capable of accomplishing the mission, with sufficient checks and balances to control expansion and to maintain equity and integrity.

The potential for a multiuse coastal zone that will serve the state and the nation into future centuries remains the prize that brings together individuals with diverse talents, and ideas in a common effort.

THE ROLE OF VERY LARGE, INFREQUENT DIVERSIONS IN THE FORMATION, MAINTENANCE AND RESTORATION OF THE MISSISSIPPI DELTA

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Hundreds of lower Mississippi River crevasses occurred in the first two centuries of settlement, suggesting that this may once have been an important mechanism in the transfer of river sediments to deltaic wetlands. Before man intervened, crevasses opened and closed naturally. Erosion and aggradation occurred locally during high water and rarely precipitated more significant river course changes when outflow channel enlargement and elongation was favored. Historical crevasses form a backdrop for the design of modern delta diversion projects. The human tragedy and ecological recovery associated with historical crevasses is also part of the cultural heritage and influences public response to proposals for new diversion projects today. We are using historical and geological data to estimate rates of overbank sediment transfer along the lower Mississippi prior to levee construction, and a combination of numerical and physical modeling techniques to assess the rates of sediment introduction that could be expected from modern, controlled lower Mississippi River crevasses.

"PROGRESS IN UNDERSTANDING COASTAL LAND LOSS AND RESTORATION IN LOUISIANA"- A LEGAL PERSPECTIVE, TEN YEARS LATER

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While the W. Alton Jones-funded research presented in the special issue of the Journal of Coastal Research addressed scientific and technical issues of coastal land loss and restoration in Louisiana, no one could have anticipated legal issues that were lurking in the shadows. Subsequent to the report, these issues arrived, necessitating, for example, two amendments to the state Constitution to address such issues.

As Louisiana's coastal restoration identified in Coast 2050: Towards a Sustainable Louisiana (COAST: 2050) and the Louisiana Coastal Assessment report (LCA) have developed over the past ten years, it is clear that anticipating and addressing legal and land use management affects of these efforts may be as important in reaching desired goals as the scientific and technological efforts.

Already we have seen the somewhat shocking result of lawsuits seeking compensation for damage to oyster leases due to the Caernarvon Diversion which were finally denied, after much consternation, by the Louisiana Supreme Court. Also, in the past ten years, publicly-funded coastal restoration projects have led to legal conflicts not easily addressed by the Louisiana Civil Code and Louisiana Constitution concerning issues of land loss from erosion; private reclamation rights; the ownership of accreted land resulting from large scale, publicly-funded projects, particularly on Isle Dernieres.

Among other coastal restoration legal issues that may need to be addressed, for example, are the adverse affects of freshening of coastal waters on businesses other than oyster farming; changes in flooding patterns as coastal geography is altered; and the need for obtaining flowage, comprehensive and conservation easements and/or fee title from private landowners as a result of river diversions.

This presentation will discuss these unanticipated legal issues that have arisen/are anticipated to arise from publicly-funded coastal restoration projects in Louisiana to complement scientific and technological aspects.

THE U. S. GEOLOGICAL SURVEY'S NASQAN – MISSISSIPPI RIVER MONITORING PROGRAM

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In 1994, the USGS National Stream Quality Accounting Network (NASQAN) was redesigned from an occurrence and distribution to a flux-based (annual) water-quality monitoring network. The revised program provides data on discharge, suspended sediment concentration (SSC), and the concentrations of a variety of dissolved and suspended sediment-associated chemical constituents.

The Mississippi River Basin suspended sediment and associated constituent monitoring subnetwork initially consisted of 15 sites but currently contains 17. Comparison of annual suspended sediment fluxes between the 1980 and 2002 water years indicates that the 1993 Mississippi River flood substantially altered the interrelation between discharge and SSC throughout much of the river, as well as its main tributaries. Hence, despite a slight increase in annual discharge for the same period, post 1993 annual suspended sediment fluxes are some 35% lower than pre-1993 levels. Initial annual flux calculations involving NASQAN as well as other data indicate that suspended sediment fluxes increase some 48% between Melville and the two distributary outlets (Wax Lake and Morgan City) of the Atchafalaya River.

Total rather than total-recoverable suspended sediment-associated trace element and nutrient concentrations are determined by direct analysis of material dewatered from large-volume whole-water samples. Elevated Zn levels were detected in the Ohio River Basin and elevated Hg levels were detected in the Tennessee River; the former may affect the mainstem Mississippi River, whereas the latter probably do not. Site-specific intra- and inter-annual chemical variations are small relative to SSC and discharge. The concentrations, hence the annual fluxes, for suspended sediment-associated phosphorus (P) and organic carbon (OC), were markedly higher than those determined using the more traditional paired, whole-water/filtered-water approach (by factors ranging from 1.5 to 10-fold). Approximately 85% of the P and 50% of the OC are sediment-associated.

Filtered-water-associated (dissolved) trace element concentrations are markedly lower than those determined during the historical NASQAN program; many were below their respective detection limits. This probably resulted from the use of clean sampling, processing, and analytical protocols, and should not be viewed as an indication of improved water quality. Where sufficient data for both filtered water and suspended sediment samples are available, it appears that ≥75% of most trace elements (Cu, Zn, Cr, Ni, Ba, As, Fe, Mn, and Al), and about 50% of the Li, are transported by suspended sediment; on the other hand, Sr transport is dominated by the dissolved phase.

ADVANCED COASTAL CIRCULATION MODELING - MISSISSIPPI RIVER DELTA AND SURROUNDING WATERS

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Our ability to accurately predict the future of an estuarine system such as the Mississippi River delta and plan for its maintenance and restoration depends on understanding the interrelated physical and biogeochemical processes at work. A sophisticated coastal circulation model is the foundation of any advanced predictive system that promotes such understanding. By coupling the circulation model with remote and in-situ observations, processes driving dynamics within the estuary are unraveled and one can begin to answer questions, for example, associated with the fate of pollutants, the health of fish nurseries, and the movement of the shoreline.

An advanced numerical model retains economic advantages as a virtual laboratory that can be exercised to examine the consequences of natural and anthropogenic changes to the estuary. Just such a model is developed and applied the Mississippi River delta and surrounding coastal waters. The model incorporates the range of important dynamical forcings such as tides, winds, and river discharge, and represents the shoreline and bathymetry at very fine scales. Process studies are conducted to examine the relative influence of each forcing mechanism on coastal circulation patterns. Lagrangian tracers introduced into the computed circulation field serve as reasonable indicators of how the circulation pattern affects the motion of sediment particles or passive biological constituents. Tracer pathways are then compared to measured nutrient distributions in the quest to separate biological and physical processes. Also demonstrated is the utility of combining computed circulation fields with optical signatures obtained from remote sensing.

THE SOCIAL SCIENCE OF COASTAL HABITAT RESTORATION

Shirley Laska
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Coastal habitat restoration science includes a broad range of natural and physical science disciplines blended to develop the best habitat restoration plan and implementation. And, in the case of Louisiana, we need to achieve also the best outcome for coastal communities-sustainability of the natural renewable resources and habitable land. Increasingly, successful habitat restoration is also aided by the inclusion of social science to achieve the restoration goals. This presentation explores the contribution currently being made by social science to habitat restoration in general and to the Louisiana coastal restoration efforts in particular.

PREDICTING THE EFFECT OF MANAGEMENT ACTIONS ON VEGETATION RESPONSE: CHALLENGES AND DATA LIMITATIONS FOR CONCEPTUAL AND SIMULATION MODELS.

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In order to evaluate coastal restoration options, a conceptual model of the controlling physical factors and the function of the resulting vegetation response is necessary. It is generally assumed that salinity and flooding are the controlling physical factors, however climate and nutrient levels have been shown to be important as well. Recently, a coarse conceptual model for changing vegetation composition and emergent plant production was used to predict the effects of large scale restoration on an annual basis for fifty years into the future. Currently, a model is under development to use a slightly less coarse simulation model. The data that form the foundation for these models are very sparse in many areas. Only the effect of salinity on primary production of the dominant plant species has been well documented. The effect of climate has been documented for both *Spartina alterniflora* and *Panicum hemitomon* dominated marshes. Data limitations prevent accurate description of the effects of flooding frequency and duration as well as nutrient limitation on primary production.

MISSISSIPPI RIVER BASIN RESTROATION AND THE RESTORATION OF THE MISSISSIPPI DELAT

John Day (johnday@lsu.edu) and William Mitsch
LSU and Ohio State Univ.

An ecological and hydrologic restoration of the Mississippi-Ohio-Missouri (MOM) Basin in the United States is proposed as part of the solution to the reoccurring hypoxic conditions in the Gulf of Mexico. Nitrate-nitrogen is the cause of this eutrophication in the Gulf and its source is mainly due to increased fertilizer use in the American Midwest. In that same Midwest, the land has also been artificially drained and 80 to 90 percent of the original wetlands have been lost. Our proposed restoration involves the strategic creation and restoration of 2.2 million ha of wetlands in the MOM basin where in-field wetlands intercept agricultural runoff and diversion wetlands are overflowed by flooding river water. Case studies that total 50 wetland-years of data from Illinois, Ohio, and Louisiana are summarized as the basis for the restoration area estimate. Benefits of this restoration, in addition to solving the Gulf hypoxia, include water quality improvement, reduction of public health threats, habitat creation, and flood mitigation that will accrue to the locations in the MOM basin where the restoration occurs. Before the restoration commences, there is a need for formal and rigorous large-scale research in the basin to reduce uncertainties.

A REVIEW OF THE BRIEF HISTORY OF TERRACES

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By the early 2000's, at least 100km of terraces had been built throughout coastal Louisiana as wetland restoration or mitigation projects. The popularity of terraces is based on the assumptions that (1) terraces initiate growth of emergent vegetation on the terraces, (2) terraces reduce wavy energy that in turn slows erosion of adjacent marsh, and (3) terraces increase the abundance of Submerges Aquatic Vegetation (SAV) in the pond by reducing wave energy and turbidity. Terraces clearly have created emergent marsh, but their effects on adjacent marsh, SAV, fish, and wildlife are poorly documented. Effects on fish and crustaceans have been studied three times; all found that terraces increased the abundance of nekton but failed to support a nekton community similar to marsh edge. Effects on SAV have been studied only twice; neither found that common species were affected. Shoreline erosion has been studied only once; erosion was reversed in terrace ponds as well as the unterraced pond during the year after construction. New data are needed from a range of marsh types and conditions to determine how well terraces are helping restoration and mitigation planners achieve their goals.

LA BARRIER ISLAND AND SHORELINE PROTECTION AND RESTORATION: TACTICS, STRATEGIES, ADAPTIVE MANAGEMENT, AND FUTURE DIRECTIONS

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Barrier islands and mainland shorelines define the boundary and geomorphic framework of Louisiana's Gulf Coast. Erosion, submergence and man's activities threaten the integrity of this critical first line defense against the transgressive processes of coastal land loss. Gulf shoreline erosion has accelerated from –10 per year in the 20th century to -30 feet per year by 2005. Early tactics at coastal protection prior to the 1980's focused on small-scale hard coastal structures such as groins, breakwaters, and seawalls with limited results. Concurrently, navigation channels were dredged and jetty systems built. All of these coastal structures created down drift erosional shadows that damaged adjacent shorelines. In the 1980's saw the nourishment and restoration of beaches and dunes at Grand Isle and the Isles Dernieres. With CWPPRA saw the implementation of barrier island restoration projects using dredged material from local sediment sources at Whiskey Island, Trinity Island, and East Island. A combination of dredged material and seawall rehabilitation were used to restore East Timbalier Island. At Raccoon Island a demonstration project of detached breakwaters were built. Back barrier vegetative plantings were also conducted in the Chandeleur Islands and Grand Terre Island. The beneficial use of dredge material is ongoing at Breton Island, Grand Terre Island, Caminada-Headland, and East Island. Through CWPPRA Adaptive Management (AM) important lessons were learned from these projects about tactics, proportionality, costs and future directions. From a tactical perspective, dredged material-based projects produced greater benefits in terms of sustainability, habitat and costs. Hard coastal structures preformed poorly in terms of sustainability, habitat, costs and proportionality to the crisis of coastal land loss. AM analysis also indicated regional barrier system restoration offered more promise in addressing large-scale coastal land loss. The future direction of LA's barrier island and mainland shoreline restoration program should be the consolidation of proposed site specific CWPPRA projects with larger planned LCA projects to maximumize the economy of scale as to cost, sustainability, habitat creation, and preservation of LA human resources.

PHYTOPLANKTON COMMUNITY RESPONSE TO NUTRIENT ENRICHMENTS IN AN ESTUARINE COASTAL REGION INFLUENCED BY PULSED RIVER DIVERSIONS (CAERNARVON, LOUISIANA)

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The effects of pulsed river diversions into coastal marshes and shallow bays are increasingly regarded as vital to wetland function and structure along the coast of Louisiana. Sediment input may build marshes, but accompanying high riverine nutrient levels potentially cause eutrophication and harmful cyanobacterial blooms in downstream estuaries. A PHYTO-PAM Phytoplankton Analyzer (WALZ) was used as an efficient tool to estimate the contribution of the major algal groups (chlorophyta, diatoms/dinoflagellates and cyanobacteria) to the overall production and nutrient dynamics in the Caemarvon/Breton Sound region. In addition to seasonal sampling for phytoplankton community composition at several monitoring stations enrichment experiments (50 μM nitrate, 3 μM phosphate) were run in summer 2002 and spring 2003 with phytoplankton from 3 selected stations, located in increasing distance from the diverson structure While the available light limited the algae in the vicinity of the diversion structure, the downstream stations showed increasing nitrate and decreasing light limitation. During summer cyanobacteria and green algae benefited most from the added nitrate with biomass gains of 300 to 700 % over 5 days

QUESTIONS POSED BY A REVIEW OF TWO HYDROLOGIC RESTORATION PROJECTS IN THE BARATARIA HYDROLOGIC BASIN

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Monitoring data and reports for the GIWW to Clovelly (BA-02) and the Jonathon Davis (BA-20) hydrologic restoration (HR) projects were reviewed in order to identify information gaps, which, if addressed, would improve our ecosystem management efforts in Barataria Basin and elsewhere. Based on this analysis, it is argued that additional research is needed that would improve our understanding of the relative importance among three key ecosystem drivers: hydrologic interconnections that allow increased marine processes; rates of relative sea level rise (RSLR); and, decreased alluvial processes. This analysis also underscores the need to develop a more thorough understanding of the degree to which HR projects actually control water exchange. This question has at least three components: water exchange control at the level of the individual structure; at the level of the entire project perimeter; and, control through time considering concomitant high water/high salinity events, inevitable extreme events, and operational mandates. Inferences based mainly on salinity data suggest that these two projects have had minimal impact on water exchange. Additionally, the need for conceptual ecological models is stressed in order to provide a more organized framework than currently exists upon which to organize working hypotheses about the Barataria Basin and to help provide for continued improvement in ecosystem planning, project design, monitoring, and adaptive management.

RESTORING THE MISSISSIPPI DELTA: AN INTEGRATED APPROACH BASED ON ECOSYSTEM FUNCTIONING

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Delta formation resulted from a complex set of processes where forces leading to delta growth were greater than the forces leading to delta deterioration. Delta growth resulted from riverine input through land formation at active distributary mouths, functioning of distributaries, crevasse splay formation, and overbank flooding. A skeletal framwork of distributary ridges and barrier islands protected the delta from salt water intrusion and physical forces. In existing wetlands, vertical accretion resulted mainly from organic soil formation. The forces leading to delta deterioration were reduction of riverine input, an increase in physical forces, and saltwater intrusion, all of which led to vegetation stress and death. Human impacts led to a reduction of riverine input, pervasive alteration of hydrology, deterioration of barrier islands, and an increase in relative sea level rise due to increased eustatic sea level rise and subsidence due to oil and gas extraction. Delta restoration should be a comprehensive plan based on system functioning and includes reconnection of the river to the deltaic plain, barrier island restoration, use of dredged sediments for wetland restoration, and hydrologic restoration. This plan should take into consideration broader trends including activities in the Mississippi basin, global climatic change, and energy cost and availability. The delta serves as a model for the management of other coastal areas, especially with respect to accelerated sea level rise.

THE RECENT EMERGENCE OF ACADEMIC SCIENCE IN COASTAL RESTORATION: REFLECTIONS OF A RECOVERING SCIENTIST.

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The State of Louisiana, the US Army Corps of Engineers and other federal agencies have embarked on an ambitious program to restore/rehabilitate the entire Mississippi River deltaic complex. This evolving restoration program is now about 14 years of age and its "voice" has been changing, especially with respect to the role of science.

For a small state, Louisiana has an unusually high number of coastal scientists but, until recently, relatively few active researchers were formally involved in coastal restoration planning efforts. At least ten factors have contributed to this pardoxical situation: (1) public naivety re science; (2) political concern about "perpetual studies;"(3) agency resistance to formal research and modeling; (4) funding limitations; (5) professional turf issues; (6) academic disdain for applied research; (7) competition with the issue of Gulf hypoxia; (8) the oxymoron of science coordination; (9) misplaced scientific "egalitarianism;" and (10) tradition blinders.

Beginning around 2000, several incidents and issues prompted a recognition of the need for more science, for example: (1) the "brown marsh" incident of August, 2000; (2) growing controversies re subsidence; (3) cypress logging for a growing mulch market; and (4) water quality issues, such as the risk of eutrophication from river diversion projects. Academic science suddenly started becoming "in vogue" and gaining acceptance in the program to design a fix for Louisiana's dysfunctional coastal ecosystem.

In addition, various prominent planning and oversight committees voiced calls for more science, including: the Governor's Coastal Advisory Task Force, commissioned by Gov. Foster following the Coastal Summit; the Framework Development Team established by the State; and the National Technical Review Committee (NTRC) commissioned by the Corps.

Meanwhile, two programs set up to foster coastal research and science coordination have been scoring early successes in terms of addressing high priority issues. These are the sponsor of this symposium, Coastal Restoration and Enhancement through Science and Technology (CREST), which is funded by NOAA; and the Governor's Applied Coastal Science Program, which is state funded through the Governor's Office of Coastal Activities.

Finally, the Louisiana Coastal Area restoration program (LCA) is currently developing a formal Science & Technology Program as a fundamental element of the overall restoration effort, with a director, staff and dedicated budget and an office located at LSU. In short, Louisiana's coastal scientists and engineers are likely to play a highly prominent role in coastal restoration into the future.

RESULTS AND RECOMMENDATIONS FOR SHORELINE PROTECTION IN DIVERSE ENVIRONMENTS IN COASTAL LOUISIANA

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Shoreline protection techniques have been utilized in coastal Louisiana along navigation channels, interior lakes, coastal bays, and in open gulf environments. The coastal restoration techniques have ranged from "soft structures", such as vegetation plantings, to hard structures such as fore-shore rock dikes and breakwaters. A review of shoreline protection projects, constructed in these diverse environments, revealed varying degrees of success and resulted in lessons learned and recommendations for improving existing projects, and for improving the implementation of future projects. When vegetative plantings are utilized, environmental conditions must be accurately assessed, species planted must be chosen carefully, and future potential extreme events must be considered. Prior to construction, a professional soil analysis with deep soil borings should be performed. Post-construction follow-up is equally important to prevent additional structural problems. The LDNR has defined and applied methods of generating reliable, cost-effective shoreline position data. Direct measurements of the distance from the vegetated shoreline to a reference survey marker, surveys recording the configuration of the shoreline using differentially corrected Global Positioning System (GPS) data, and Geographic Information System (GIS) analysis of aerial photography have been utilized. Shoreline protection can be a critical component of larger hydrologic restoration projects and can work in concert with other restoration techniques to address problems with land loss in coastal Louisiana.

RESTORATION SUCCESS OF BACKFILLED CANALS

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Many marsh restoration techniques have been used in Coastal Louisiana, yet few techniques have been monitored for long term success. An exception to this is the backfilling of oil and gas canals, which has been monitored for more than twenty years. A successfully backfilled canal restores soil and plant communities on the former spoil areas, creates shallow water habitat, increases nekton access to the marsh, and restores local hydrology by removing elevated spoil banks. The 30 backfilled canals in this study occurred in many different settings, and a wide range of restoration success was observed. Backfilling decreased the length in 20% of canals, the width in 56% of canals and the depth in all canals. The average percent recovery of bulk density and water content on the former spoil areas were 61% and 75% respectively. Complete removal of spoil banks was the most important factor governing backfilling□s success. When spoil was not adequately removed upland vegetation flourished, and the remaining elevated material acted as a levee altering water flow through the marsh. However, spoil that was returned to marsh elevation allowed marsh vegetation to flourish, partially restored marsh soils, and restored local hydrology. This study indicates the success of backfilling continues to increase over time, although complete restoration, particularly of soils, will take longer than twenty years. Improving the completeness of spoil removal, coupled with appropriate site selection, could speed up restoration and enhance future success levels.

PONCHARTRAIN BASIN ENVIRONMENTAL CLEARINGHOUSE

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The growing interest in environmental issues and regulations yields a need for scientists, state and federal planners to have quicker access to information to aid in the decision making process that affects the Pontchartrain Basin's dynamic coastal zone. Currently there exists no continuous medium of exchange for the discussion of environmental issues in the basin. Science occurs largely in the universities, and planning and development in the parishes and cities of the basin. Exchanges are infrequent. The Ponchartrain Basin Environmental Clearinghouse creates a common platform for the public distribution of scientific information, the co-mingling of science, government and public, and helps increase the abilities of the political jurisdictions to compete for funding to protect habitat and mitigate the negative effects of development. The project serves as a much needed decision making tool for the Pontchartrain Basin by both allowing users to share data such as scientific reports online via a searchable database, and providing a fully interactive online GIS mapping server for geographic data. The mapping server allows members of both the scientific and planning community as well as the general public to view and query geographic data such as satellite imagery, habitat/land change, geology, soil classes, flood zones, infrastructure and a number of additional layers. Much like a standard GIS setting, the user has the ability to seamlessly interact with geographic data, create, and print maps. PIES sees this project as a powerful tool for research and awareness in the Ponchartrain Basin, and encourages continued support and cooperation to ensure it's long-term success.

RESTORATION EFFORTS OF THE LOUISIANA COASTAL PRAIRIE IN SOUTHWEST LOUISIANA

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The Coastal Prairie was once a rich and valuable ecosystem to Louisiana, the United States, the Western hemisphere, and the biosphere. Unfortunately, the Coastal Prairie has been terribly fragmented and endangered due to human development. Since the 1890's, the geographic range of the Prairie has dwindled from 2.5 million acres to a few acres of railroad right of ways (USGS 2001). In essence, many of the wetland and Prairie plant species ecotypes have been extirpated from the native range. These ecotypes are naturally adapted species to the localized conditions of South Louisiana (McMillian 1960). The McNeese Wetland Station has developed a collaborative project to provide plant life histories and materials for expansion of remnant coastal and educational outreach. The project provides a selected seed and stock source of endangered plant materials that are utilized in restoration efforts of the coastal prairie.

PHYTOREMEDIATION OF LEAD CONTAMINATED SOILS USING WILD OATS *(AVENA SATIVA)*

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Avena sativa, commonly known as wild oats, belong to the family *Poaceae*. The goal of this research is to determine the amount of lead (Pb) that can be removed by the plants and its morphological and physiological effects on the plant over a period of time. Phytoremediation is remediation of contaminated soil using higher plants. Pre-prepared soils were amended with 10, 25, 50, and 100ppm of Pb, with four replicates for each treatment in a Randomized Complete Block (RCB) design; before sowing 5 seeds in each pot. Each pot was filled with approximately 300 g of soil mix. The plants were allowed to grow for approximately 2 weeks and on the seventh day of growth 2 leaves were taken from each pot to conduct a chlorophyll analysis at 649 and 665 nm using a Spectronic 20D+ instrument. The results of the chlorophyll analysis indicated that 25 ppm Pb has a negative effect on both chlorophyll a and b (5.48±0.37 and 8.63±0.81, respectively). The necrosis and chlorosis was examined in the plants after approximately a month of growth and it showed a significantly high amount of chlorosis in all of the pots starting off at the tips and slowly moving down the leaves toward the leaf bases. The tissue death was on the very tips making that portion of the leaves feel dry and brittle to the touch. Further research on effects of Pb on primary productivity and Pb absorption in oat tissues and soil medium are in progress.

EFFECTS OF TERRACES ON VEGETATION, NEKTON, AND WATERBIRDS

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Beginning in the mid-1990's, terraces became a popular restoration and mitigation technique to counter marsh loss in coastal Louisiana, which averaged 220 km^2/yr between 1978 and 2000. Terraces are discontinuous ridges of dredged material placed in marsh ponds at elevations so they will flood at high tide. Terraces are expected to reduce wave energy and thereby (1) slow erosion of adjacent marsh, (2) increase the abundance of submerged aquatic vegetation (SAV) in the adjacent pond, and (3) initiate growth of emergent vegetation on the terraces.

Only one previous study of terraces occurred in brackish marsh, which is the most common marsh type in Louisiana, and none have examined the effects of terraces on wildlife. Since early 2004, we have been comparing abundance of SAV and nekton in g in three hydrologically distinct pairs of terraced and unterraced brackish ponds. Preliminary results suggest that terraces increased the abundance of SAV during the growing season, and increased the abundance of nekton but altered the diversity of fish and crustaceans. Beginning in January 2005, we also begun to study waterbirds because they are the most likely group of wildlife to be affected.

LOUISIANA DIGITAL COAST: AN ONLINE DATA REPOSITORY

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In 2002, the National Oceanic and Atmospheric Administration (NOAA), Coastal Services Center (CSC), determined there was a need to have a repository of detail digital information for the coastal zones of Louisiana and Mississippi in an effort to support and manage the rapid economic growth and environmental protection of these areas. As a result, the Louisiana/Mississippi digital coast initiative was proposed and the University of New Orleans (UNO) and University of Southern Mississippi (USM) partnered to create the Louisiana/Mississippi digital coast data repository. At present, many levels of government are becoming increasingly dependent on digital spatial data, and the information needed to manage economic and natural resources. An improved, widely available spatial information infrastructure is needed to provide the framework for addressing these issues while at the same time maintaining pace with the evolving information technology sector. The Louisiana Digital Coast provides this function by offering a number of online services (e.g., content management, GIS/RS mapping, reference library, and point source data).

Today the Louisiana Digital Coast incorporates 34 parishes and provides vital geospatial and point source information via the internet. These online resources are being made available to various governmental agencies, academia, and the private and general public sectors to support a wide-range of coastal activities (e.g., coastal restoration and management, beach erosion, shoreline change, land usage, population changes, agricultural density, urbanization studies, etc.). The Louisiana Digital Coast repository is an important part of the information technology investment needed to support sound ecologic conservation, management, and economic growth.

CWPPRA - ISLES DERNIERES RESTORATION PROJECT

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The barrier shoreline system with the highest rate of coastal erosion in Louisiana is the Isles Dernieres located in Terrebonne Parish. Transgressive barrier island systems surround the Mississippi River delta plain and provide important protection to the estuarine-based natural resources and the human infrastructure found landward of these critical shorelines. In the late 1990's, the Coastal Wetland Planning, Protection, and Restoration Act (CWPPRA) implemented four restoration projects that proved gulf shoreline restoration science can reverse long-term trends of coastal erosion in Louisiana. West to east along Louisiana's coast, the CWPPRA barrier island restoration projects being evaluated by this report include: Raccoon Island (TE-29), Whiskey Island (TE-27), Trinity Island (TE-24), and East Island (TE-26). After a decade of implementation, CWPPRA has initiated an Adaptive Management process to assess and learn from the implementation of the restoration projects built to date. Through the use of high spatial resolution aerial photography, this report depicts the cost effectiveness of placing hydraulic fill with vegetation to build dunes and back barrier marshes verses the use of segmented breakwaters and rubble mound seawalls.

SEED DISPERSAL IN A CREATED SALT MARSH IN LOUISIANA

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Seed dispersal may be critical in the revegetation of salt marshes created from dredge sediments. Some created marshes however, have associated characteristics that may limit seed dispersal, such as surrounding levees and inappropriate elevations. The purpose of this study was to survey seed dispersal by water and wind on a created salt marsh in Louisiana. We compared seed dispersal dynamics on a marsh created in 1999 to a nearby reference marsh. A seed flotation study was also conducted for 9 species of salt marsh seed to determine their inherent potential to disperse by water and the possible influence of salinity on hydrochory potential. Although, all of the salt marsh seeds had hydrochory potential because of their ability to float, there were differences among species in their flotation ability over time. In both created and reference marshes however, seeds dispersed more by wind or gravity than by water and there was a strong correlation between existing vegetation and the species of seed captured by seed traps. The species differences in the created and reference marshes are influenced by water level and elevation. These studies suggest that many species are capable of naturally invading created salt marshes depending on their inherent ability to colonize these environments via wind and water.

ISLES DERNIERES RESTORATION SOIL CHEMISTRY

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The Isles Dernieres is a transgressive barrier island arc located 21km south of Cocodrie, Louisiana. During the past two decades Trinity and Whiskey Islands have been eroding at rates >35m/yr. The Isles Dernieres Barrier Island Stabilization Project, implemented in 1998 utilized material from Lake Pelto for dune and marsh restoration of East, Trinity, and Whiskey Islands. The 1998 restoration increased the overall height and width of the islands but marsh habitat has not developed on the restored material behind the barriers. This study characterizes the physical and chemical properties of soil from restored and natural back-barrier salt marsh on the Isles Dernieres to determine a restoration time-frame in which, restored marsh soils develop to conditions more similar to natural marsh soils. Additionally, the goal was to identify the soil properties in restored marsh that could be modified to enhance back-barrier marsh habitat. Sixty soil cores from four different vegetation density classes in restored marsh and nine soil cores from natural marsh were analyzed to determine bulk density, soil moisture content, grain size, sorting, pH, conductivity, total carbon, and total nitrogen. Marsh type had a significant effect on all measured soil properties, and vegetation density in restored marshes had no significant effect on any soil properties with the exception of bulk density. Variations in the soil properties of restored and natural back-barrier salt marsh are primarily the result of differences in soil texture and elevation.

A COMPARISON OF SITES RESTORED USING DEDICATED DREDGED MATERIALS IN TWO DIFFERENT COASTAL REGIONS OF LOUISIANA

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Marsh restorations using dedicated dredged materials have been increasing in frequency over the past several decades. Little data has been recorded documenting settling rates of these new marshes. We compare two restorations using dedicated dredged materials, which were part of separate studies in coastal Louisiana. The first was created in August 2000 and measured from June 2001 until April 2003. The second was in the Chenier Plain of western Louisiana pumped in January 2002 and measured from July until November of 2002. Both sites were not planted but instead were left for plants to colonize naturally. Unfortunately, there was no reference site in the Chenier Plain to compare with that restoration. Soil elevations and vertical soil accretion was measured at each of the sites. Soil elevation increased 0.63 mm/year at the Deltaic Plain site, though the reference site lost -2.95 mm/year, while the Chenier Plain site experienced a decrease in soil elevation at the rate of 23.6 mm/year. Vertical soil accretion at the Deltaic Plain site was 23.81 mm/year, compared to 18.64 mm/year in the reference site, but was only 13.0 mm/year at the Chenier Plain site. At the Deltaic Plain study site, vertical soil accretion was out-pacing elevation loss and that site appeared likely to survive, at least in the short term. Soil elevation losses for the Deltaic Plain reference site were similar to those previously reported. The Chenier Plain vertical soil accretion was not enough to offset subsidence during the study period. If that trend continued, that site might not survive.

COMMUNITY-BASED COASTAL SAV AND MARSH RESTORATION: PROMOTING STEWARDSHIP THROUGH HANDS-ON EDUCATION.

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Lake Pontchartrain is an important nursery ground for shrimp, blue crab and other fisheries, and provides critical wildlife habitat. Shoreline marsh and submersed habitats around the lake have been negatively impacted. For instance, wetlands along a 25 mile stretch of shoreline running from South Point in the east to St. Charles Parish in the west have been devastated by armoring for shoreline stabilization and levees for hurricane protection. Swamp, marsh and SAV historically extended about ¼ mile from the current shoreline, but only small patches remain. To improve marsh and SAV habitats, a series of restoration projects have been conducted to find the best practices for Lake Pontchartrain and to create long-term, self-sustainable community based stewardship through hands-on education programs. Our most recent restoration projects engaged local urban and regional schools in growing plants and learning about land loss and habitat degradation in the Louisiana coastal zone. The progress of these projects could be used as a model to promote the expansion of volunteer restoration projects throughout Louisiana coastal communities.

DISTRIBUTION OF *CYLINDROSPERMOPSIS RACIBORSKII* IN TWO LOUISIANA WATERSHEDS INFLUENCED BY RIVER DIVERSIONS

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Blooms caused by toxic blue-green algae have repeatedly produced episodes of wild and domestic animal illness and death. The responsible cyanobacteria belong to about 40 genera including the most recently found toxin-producing cyanobacterium, *Cylindrospermopsis*. Since 2002, *Cylindrospermopsis raciborskii* was abundant in water samples of Caernarvon/Breton Sound (LA), which poses a potential risk of a bloom of this species in that area. Recently (9/04) we found abundant biomasses of this species in the whole Atchafalaya Basin, down from Krotz Springs to Morgan City. Monitoring these areas for the presence of *Cylindrospermopsis* is essential in assessing the potential for bloom formation. However, detection and quantification of *Cylindrospermopsis* is problematic since it is not easily distinguished from suspended sediment or other types of algae. Given this, we are developing a real-time PCR assay for detection of *Cylindrospermopsis raciborskii.* In this assay, detection of amplified target DNA requires annealing of fluorescent-labeled probes, resulting in added level of specificity compared with assays based on traditional PCR methodology. Using this sensitive technique it will be possible to detect even low densities of this species instantly, allowing the creation of real-time species abundance distribution maps, enabling managers to respond immediately to increases in biomass of this harmful species and for timely notification of possible health risks to the public.

SOCIOECONOMIC EFFECTS OF COASTAL RESTORATION PROJECTS

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This poster illustrates a process to identify and analyze the socioeconomic effects of five completed coastal restoration projects and from these data anticipate the potential impacts of two proposed projects. Despite being well thought out from an engineering/ecological/geologic perspective, many coastal restoration efforts have been challenged by inadequate prior assessment of the ways in which they would affect the human communities that live within the impact area (Laska et.al, 1992). The result has been socioeconomic impacts that were unrecognized and recognized impacts that were unresolved. Litigation and excessive settlements arising from the unmitigated impacts of restoration projects are themselves lessons that predicting the likely social and economic effects of the projects should be a priority because response of a purely reactionary nature is no longer an effective option. It is imperative that these impacts, both positive and negative, should be identified and a mitigation plan developed prior to project implementation in an effort to maximize positive and minimize negative socioeconomic effects of coastal restoration projects.

STREAM CLASSIFICATION OF LOUISIANA COASTAL RIVERS: A TOOL FOR WATERSHED RESTORATION

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In recent years, the focus on issues regarding water quality has shifted from local site-specific view of a problem towards a holistic view where the health and integrity of entire watersheds are of concern. The Florida parishes are located east of the Mississippi River and north of Lake Pontchartrain. The drainage network of the Florida parishes is served by five main watersheds: the Tickfaw, Amite, Tangipahow, Tchefuncte, and Natalbany. The degradation of these watersheds is evidenced by posted lake use warnings related to water quality and the extensive physical modifications such as straightening of channels, man-made canals, and sand and gravel mining in the floodplain. Rapid urban development within the Florida parishes will result in further watershed degradation and water-quality impairment.

The goal of this project was to map the streams within the five watersheds with respect to a Reach Sensitivity Index (RSI). The RSI classification scheme is based on stream geomorphology, hydrology, and ecological characteristics. Data from 100 field sites were used along with USGS 7.5 minute topographic maps and DOQQ 1-meter resolution aerial imagery to classify stream reached according to the RSI scheme. Because the RSI approach requires careful field analysis of watersheds, other key issues related to watershed health and restoration can be identified. Key anthropogenic impacts observed throughout the watersheds are related to sand and gravel mining, stream manipulation, profuse litter, as well as overall water quality. The stream classification will be the basis for developing strategies for watershed restoration options to restore natural hydrological and ecological functions of impaired streams.

ASSESSMENT OF COST-EFFECTIVE METHODS OF ENHANCING VEGETATION SUCCESS IN BARRIER ISLAND RESTORATION PROJECTS

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A key aspect of effective restoration of barrier islands is the successful and timely establishment of vegetation. Our research to date has focused on 1) utilizing black mangrove propagules in backbarrier marsh plantings and 2) improving the success of sea oats and bitter panicum plantings in the dune environment. The black mangrove propagule experiment assessed broadcasting vs. trenching, mulching with bagasse vs. un-mulched, and fertilized vs. unfertilized at high marsh and upper high marsh elevations at both Trinity Island and the Caminada-Moreau Headland. Survivorship was poor regardless of treatment due to a combination of poor viability of the fall 2003 cohort of mangrove propagules and excessive sediment erosion or sediment deposition at the field study sites. The sea oats and bitter panicum planting experiment assessed the effects of bagasse mulching, fertilization schedule, and site, and was expanded to include an evaluation of humic acid amendment. Results to date indicate that Trinity Island is a more stressful site (higher soil salinity and pH, lower soil moisture) with correspondingly lower plant survival and cover than the Caminada-Moreau Headland. Thus far, the addition of bagasse mulch has not resulted in greater soil moisture or significantly affected cover. However, both rates of broadcast fertilization are showing benefits of rapidly enhancing dune grass aerial cover and spread, with bitter panicum showing the greatest response.

MODELING SWAMP SUCCESSION IN COASTAL LOUISIANA

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Coastal swamps are among the rapidly vanishing wetland habitats in Louisiana. The decline of coastal swamps has been attributed to the negative impacts of increased flooding, nutrient and sediment deprivation, and salt-water intrusion. Immediate wetland preservation and restoration activities based on scientific understanding are required to ensure the future of these valuable ecosystems. River diversions have been proposed as a promising tool for wetland restorations (e.g., Boesch et al. 1994). The full impact of river diversions, however, may take decades to develop, and no long-term data (i.e., 50-500 years) will be available within the time frame during which current restoration decisions need to be made. A computer simulation modeling approach can be used to address questions about the long-term effects of river diversions. A small-scale Mississippi River diversion has been proposed to restore the degraded Maurepas swamps, located in the western portion of the Lake Pontchartrain basin in southeastern Louisiana. In this presentation, we describe a computer simulation model that combines the biological resolution and flexibility of an individual-based forest succession model with a simulated dynamic environment. The model is constructed to investigate how multiple stressors interact to produce changes in a baldcypress-tupelo swamp with regards to composition and productivity in the Lake Maurepas wetlands. The development of the individual based forest succession model for the Maurepas basin benefits from earlier fieldwork and will provide much needed insight into the succession dynamics of a coastal swamp.

SHALLOW SUBSIDENCE AND THE USE OF DEDICATED DREDGE MATERIALS FOR COASTAL MARSH RESTORATION IN THE LOUISIANA CHENIER PLAIN

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Dedicated dredged materials have been used to restore degraded marshes for many years, however, the long term function and value for restoration has not yet been established. Multiple sites in the Chenier Plain of Louisiana have been restored with dedicated dredged materials. Over the last twenty-one years six sites located at Sabine National Wildlife Refuge, in southwestern Louisiana, have been restored using the technique. These sites, along with a reference site, have been monitored for over 24 months. While the restored sites have been subsiding, vertical soil accretion from sediments has been accumulating, but at rates that are leaving a deficit in marsh surface elevation. Below ground production from established vegetation has followed season and colonizing trends. The oldest site, twenty one years, seems to have taken on the ecological and seasonal patterns of the surrounding marshes, while the younger restored sites are still settling and establishing vegetation. The sites are dependent on sediment deposition to maintain elevation for proper marsh ecological functioning. If the trends continue the restored marshes may be lost to subsidence and other ecological factors in the future.

MAMMAL BIODIVERSITY AS A COMPONENT OF LOUISIANA COASTAL WETLAND RESTORATION MONITORING – A MODEL FROM JEAN LAFITTE NATIONAL PARK.

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Established in 1978, the Barataria unit of Jean Lafitte N.P. has been used modified by people of the region for over 200 years and is currently undergoing major urbanizing impacts. As is true for most of coastal Louisiana, the state of knowledge of mammal biodiversity is incomplete. The marsh habitats that comprise nearly 70% of Barataria have experienced significant physical and biotic change. During the past 50 years, the combined effect of disrupting freshwater flow and saltwater intrusion has caused significant habitat degradation. Of direct relevance to ongoing assessments of coastal wetland restoration projects, JLNP is in the path of (and therefore directly impacted by) the Davis Pond Diversion Project. A mammal inventory and monitoring program was initiated in 2003 and is reported here. Live-trapping small and medium-sized mammals, bat monitoring, and motion-triggered cameras have confirmed occurrence and habitat use of more than 27 species. Louisiana coastal restoration projects are not designed and have not supported biodiversity studies of mammals and other important biotic components of these ecosystems. If restoration and maintenance of functional wetland systems is indeed a goal of these initiatives, then current planning for biomonitoring must be broadened to include these and other organisms.

VEGETATION PLANTINGS VERSUS NATURAL SUCCESSION: COMPARISON OF GROWTH DIFFENCES AT A MARSH RESTORED WITH DREDGED SEDIMENT

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A restoration project using dredged sediment was completed in the summer of 2000 at a deteriorating brackish marsh in southeastern Louisiana. In May 2001, clones of the following four species were planted on the dredge soil: *Distichlis spicata*, *Phragmites australis*, *Schoenoplectus californicus*, and *Schoenoplectus robustus*. To monitor natural succession, not-planted plots were also established. Additional plots were established on nearby non-dredge areas as reference sites. Percent cover by species was measured in 1-m^2 quadrats over 2 years. There was 100% survival of planted species through the first growing season, and all species exhibited rapid vegetative spread. Although colonization occurred at not-planted sites, cover remained significantly lower there than at reference and planted sites in the first growing season. By the conclusion of the study, however, cover at the not-planted sites was equivalent to that at the reference sites. Final cover at the planted sites exceeded that at the other sites; this effect was due primarily to *P. australis* growth. Species richness varied between sites and was highest at the reference and lowest at the not-planted sites. Species composition also varied: the predominate species at the sites, by cover, were *P. australis* (planted dredge), *Spartina alterniflora* (not-planted dredge), and *Spartina patens* (reference). Differences in vegetation structure and composition at the planted sites may indicate that marsh functions differ as well.

FRESHWATER AND NUTRIENT INPUTS IN A RIVER-DIVERSION ESTUARY

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Almost all wetlands of the Mississippi deltaic plain are isolated from riverine input due to flood control levees along the Mississippi River. This has altered water and nutrient budgets and is a primary cause of the massive wetland loss in the delta. In this study, we quantified freshwater and nutrient inputs to the Breton Sound estuary, which is receiving a freshwater reintroduction from the Mississippi River in an effort to restore the deteriorating wetlands. The inputs and losses calculated for three annual (2000, 2001, and 2002) water budgets included precipitation, potential evapotranspiration, the diversion, stormwater pumps, and groundwater. The inputs of ammonium (NH_4-N), nitrate, total nitrogen (TN), and total phosphorus (TP) were determined for each of the water sources.

There was a different precipitation pattern for each of the years calculated. Overall, precipitation contributed 48-57% of freshwater input, while the diversion structure accounted for 33-48%. The net input of groundwater was 3 to 4 orders of magnitude less than diversion input and precipitation. Atmospheric deposition was the largest contributor of NH_4-N, accounting for 62-72% of the total 1.39×10^5 to 1.96×10^5 kg of NH_4-N input, followed by the diversion. The diversion was the greatest source of nitrate (7.78×10^5 to 1.64×10^6 kg), contributing 77-88% of total nitrate input, as well as 77-79% of the overall TN input. The diversion contributed 81-98% of TP input, which ranged from 0.17 to 0.29 $gPm^{-2}y^{-1}$. Annual loading rates of NH_4-N and NO_3-N were 0.16-0.22 and 1.6-2.2 $gNm^{-2}y^{-1}$, respectively.

NEKTON HABITAT USE AND RESPONSES TO WETLAND RESTORATION IN THE MISSISSIPPI RIVER DELTA, LOUISIANA

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Construction of levees along the Mississippi River has greatly reduced delivery of sediments to deltaic marshes, thereby increasing subsidence and loss of coastal wetlands. Resource managers cut artificial crevasses in levees to restore flow, accumulation of sediments, and colonization of marsh vegetation. We evaluated patterns of habitat use and the responses of nekton to restoration of this deltaic ecosystem. A combination of 1-m^2 throw traps and minnow traps were used to collect fishes every other month from adjacent plots of emergent marsh (primarily *Sagittaria*) and submerged aquatic vegetation (e.g., *Myriophyllum*, *Potamogeton*) at 11 crevasse wetlands throughout the Mississippi River delta. These wetlands ranged from relatively young created wetlands to mature natural wetlands. In addition to sampling marsh and submerged aquatic vegetation, we also collected nekton from beds of invasive *Phragmites* that dominate much of this deltaic landscape. Topminnows, livebearers, gobies, and sleepers were numerically dominant fishes, whereas caridean shrimp and zygopteran larvae were numerically dominant invertebrates. Abundance and community composition varied considerably during the study period. Nekton abundance was highest in the late summer and early fall and then declined considerably as above ground vegetation senesced through the winter and spring. *Phragmites* provided an extensive over-wintering habitat. Salinity varied during the sampling period, which resulted in shifts in the relative abundance of freshwater and estuarine species. There were few differences in the abundance and composition of nekton communities in young and old crevasse wetlands, indicating that restoration of marsh habitat in the delta is succeeding from a fisheries perspective.

MARSH ELEVATION CHANGE UNDER INCREASED NUTRIENT LOADING, RISING SEA LEVELS, AND DISTURBANCE

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Marsh surface elevation change was measured along Bayou Lacombe located in St. Tammany Parish beginning in July 2004. These elevations were measured utilizing 15 SET's (Sediment Elevation Tables) evenly dispersed between 3 blocks in which treatments were randomly assigned. Within each block, SET plots were subjected to high N (40 g N m^{-2} yr^{-1}), high P (30 g P m^{-2} yr^{-1}), high N and high P combination, or a lethal disturbance (Rodeo herbicide broadcast over the vegetation). Feldspar marker horizons were also placed within each SET plot to measure the accretion on each plot. Data indicate that increased flooding associated with Hurricane Ivan in September 2004 did not lead to vertical sediment accretion. However, data from SET's showed a positive soil elevation change. Blocks located a shorter distance from Lake Pontchartrain or secondary bayous connected to Bayou Lacombe had a smaller positive elevation change than that of the more hydrologically isolated block. Although no soil accretion was seen at this site the marsh still increased in elevation due primarily to flood waters below the soil surface. Increased flooding has the capacity to lead to expansion of the soil and a positive elevation change in this semi-floating marsh. Additionally, increased flooding above the soil surface with water from a secondary bayou or Lake Pontchartrain may have caused sufficient downward pressure to reduce the positive elevation change in blocks located near these sources.

THE EFFECT OF THE CAERNARVON FRESHWATER DIVERSION ON WATER QUALITY IN THE BRETON SOUND ESTUARY

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Water quality transects were carried out in the major waterways of the Breton Sound estuary starting in September 2000 and continuing through August 2002. Twenty discrete water samples were taken in the basin for nutrient analysis, and turbidity, salinity, temperature and fluorescence were measured continuously with a flow-through system. Nitrate concentrations were as high as 80 umol/L-NO_x near the diversion and decreased with distance from the structure. The same trend was observed for TN, with concentrations ranging from 100-280 umol/L near the diversion, and decreasing with distance from the structure. Phosphate concentrations were typically >1.5umol/l-PO_4 during the late spring- early summer and lower during late winter-early spring. Total Phosphorus concentrations were temporally variable within the estuary, with higher concentrations during the summer months (>3 umol/l), and lower values during the winter months (<2 umol/l). Silicate concentration were higher in the upper and lower basin during the summer (>110umol/l), and lower concentrations were observed during winter-early spring (<45umol/l). Discharge through the Caernarvon structure had an overwhelming effect on salinity throughout the Breton Sound estuary, even at moderate to low discharge. Total suspended sediment generally decreased with distance from the diversion structure, but there was also widely fluctuating TSS levels at outer reaches of the estuary associated with storm events. Chlorophyll *a* generally peaked during the summer in the mid-estuary, and was inversely correlated to discharge. These results suggest river diversions may be used to process Mississippi River water prior to reaching offshore waters where eutrophication has become a recent concern, as well as enhancing marsh formation and stability, and preventing salt water intrusion from degrading Louisiana's remaining coastal wetlands.

DECISION-TREE CLASSIFICATION OF NATURAL HABITATS USING HIGH-RESOLUTION REMOTELY SENSED IMAGERY

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While high-resolution imagery may be useful for mapping and monitoring land cover and land use change, it requires the development of accurate and repeatable techniques that can be extended to a broad range of environments and conditions. A technique that is being widely used in many remote-sensing applications today is based on a decision tree approach. Decision tree classifiers are simple, nonparametric in nature, and computationally efficient, providing a substantial advantage over traditional classification methods. In this study, a decision tree classification technique was used to map land cover and land use in the St. Tammany Parish, LA area, a region comprised of a diverse range of natural habitats. The decision tree algorithm is based on region level features that are extracted based on spectral and textural characteristics of the imagery and auxiliary information such as geographic data. A combination of field data, NASA Airborne Visible and Infrared Imaging Spectrometer imagery (AVIRIS), Digital Globe Quickbird satellite imagery, and supporting geographic information system (GIS) coverages, including land use maps from the 1988 National Wetlands Inventory (NWI) and National Land Cover Database (NLCD) from the National Oceanic and Atmospheric Administration were used as input to the decision tree classifier. Classifications were performed using 1982 and 2004 imagery for the following land cover classes: marsh, wetland forest, upland forest, agricultural-grassland, shrub-scrub, urban, and water. This report discusses the development of these maps and methods, including the results in land cover and land use change.

WATER AND SEDIMENT BUDGET ANALYSES FOR THE CHENIER PLAIN

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The hydrologic and ecologic characteristics of Chenier Plain are unique and quite challenging. Understanding the hydrology and ecology of the region is essential in order to successfully implement a regional restoration plan. However, accurate accounting of water and sediment volumes in the region has always been lacking. Such information is critically needed for the success of future modeling efforts that can be used to assess a region-wide restoration plan and strategies. Therefore, effort is underway to develop comprehensive regional water and sediment budget analyses for the Chenier Plain. The effort includes collection of field measurements, followed by a thorough and rigorous analysis of the water and sediment budgets. The open-water measurements collected, as part of this project, will be coupled with the Coastwide Reference Monitoring System-Wetlands (CRMS). Information both in the open water bodies and in the marsh will be used to validate the numerical models for crucial parameters such as hydro-period and marsh salinities. The numerical models will also be used to perform budget analyses including fresh water inflows, water and salt exchange through openings of the Chenier Plain to the Gulf of Mexico, evaporation, evapotranspiration, precipitation, and sediment transport.

ANALYSIS OF GEOMPRPHIC HISTORY AND RESTORATION EFFORTS AT RACCON ISLAND

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Louisiana barrier islands are rapidly eroding due to extreme storm events, cold fronts, relative sea level rise and subsidence. Raccoon Island is one of the fastest eroding barrier islands in south Louisiana and in the United States. Raccoon Island is of importance because it is home to the first federally funded restoration project, home to the only shorebird rookery west of the Mississippi River in Louisiana and was impacted by two major storms. The objective of this study is to analyze the restoration efforts and the geomorphic history of Raccoon Island in order to address the most effective restoration method for saving Louisiana's barrier islands.

Geomorphic history, shoreline changes, coastal processes, hard and soft restoration activities, and the pre and post 2002 storm geologic framework of Raccoon Island were analyzed in this study. The highest rates of erosion took place west of the CWPPRA TE-29 breakwater demonstration and the highest rates of deposition occurred on the western recurved spit of Raccoon Island. Post storm geologic framework shows an onlapping swash bar paralleling the shoreline, which is the source of sand nourishment for the shoreline and recurved spit. Coastal scientists must analyze geological processes, the effects of hard and soft restoration templates, and the effects of extreme storm events before implementing restoration projects that could sacrifice the longevity of Raccoon Island.

COMPOSITION AND NITROGEN STORAGE CAPACITY OF CAERNARVON- BRETON SOUND PHYTOPLANKTON COMMUNITIES

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The influences of Mississippi River diversions, such as the Caernarvon-Breton Sound area diversion, on nutrient processing in the water column are quantitatively not well understood. The magnitude of these processes, however, is significant, and largely dependent on the planktonic composition and density. Denitrification is a desirable pathway, eliminating nitrogen from estuarine waters. Plankton organisms, which particularize nitrate, can either funnel nitrate toward or away from denitrification. Buoyant, motile, slowly sinking plankton (e.g. many green algae and cyanobacteria) keep nitrogen particularized in the water column, stripping it away from sediment-bound denitrification, whereas faster settling plankton (e.g. diatoms) provide a vector to accumulate nitrogen compounds at the sediment-water interface, favoring denitrification. In order to quantify the nitrogen processes in the water column and gain insight into the fate of diversion-derived nitrogen, we monitored key phytoplankton groups of the area over the last four years at 15 stations distributed over the Caernarvon-Breton Sound area with a pulse-amplitude-modulation planktometer. Using published Chl. to nitrogen ratios for diatoms we calculated seasonal nitrogen storage in the algae. These data will help to improve nutrient budgets for the region.

HABITAT FRAGMENTATION AND SHORELINE HARDENING MODIFY THE HABITAT CHARACTERISTICS, DISTRIBUTION AND DENSITY OF SALTMARSH INFAUNA, EPIFAUNA AND NEKTON.

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Shallow-water, salt marsh habitats have long been established as important habitats for a variety of estuarine fish and crustaceans, yet little work has been done to assess the affects development and fragmentation have on this habitat. The goal of this study was to examine habitat characteristics and associated marsh faunal composition along a gradient of shoreline development, habitat fragmentation and disturbance on the eastern distributary of the Pascagoula River, MS. Three numbered zones (i.e. treatments) were defined along this gradient, beginning with severe alteration at the river's mouth (1), to natural conditions 5 km upstream (3), with an intermediate zone midway between (2). Variables quantified include water quality, sediment total organic content, grain-size distribution, infaunal density/distribution and nekton density/distribution. Measurements for each metric were taken adjacent to both 'restricted' or hardened shoreline and 'unrestricted' or natural marsh areas along the gradient of development. All habitat data were analyzed using PCA, producing two factors that accounted for 69.5% of all habitat variability. Graphic presentation of these two factors shows distinct grouping of samples by treatment and to a lesser extent shoreline type within treatment. Density of infauna was greater in unrestricted samples, though the significance was marginal ($p=0.089$) and statistically equal across treatments ($p=0.970$). However, epifauna/nekton densities were significantly greater in unrestricted samples than restricted ($p=0.005$) and greater in the intermediate zone than both the natural zone ($p=0.034$) and the zone of highest impact ($p=0.008$).

GEOLOGIC FRAMEWORK AND THE TIME-SCALE OF RESTORATION IN COASTAL LOUISIANA

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To be successful in the re-establishment of coastal Louisiana to a dynamic, environmentally vibrant, and safe landscape, restoration must be proportional to land loss. Restoration in its simplest form should be defined as the rate of land gain must equal or exceed the rate of land loss. Since the beginning of Louisiana's coastal restoration initiatives and the combination of WRDA, CWPPRA, USACE, and State of Louisiana projects built between 1990 and 2005, the rate of coastal land loss has persisted at approximately –24 square miles per year. Much effort and analysis has focused on establishment of the ecological endpoints of restoration. Lessons learned from the Holocene evolution of the Mississippi River delta plain demonstrate that land gain through distributary diversion operate at time scales that exceed the needs of our society. To date, diversions have proven problematic and the gain of new land is limited. The success of diversions has been in their ability to regulate salinity. The geomorphic history of delta complexes such as the Lafourche or St. Bernard demonstrates that diversions will be a restoration tool that operates on decadal time-scales. The planning and implementation of diversions must move ahead. But diversions will not meet the needs of our society for decades to come. The restoration tool that will meet the immediate needs of our society is dedicated sediment delivery through dredging. Dedicate dredging has restored barrier islands, beaches, marshes, and ridges on time-scales of a year. Dedicated dredging has built roads, Interstate Highways, golf courses, and subdivisions at time scales of 1-5 years. To meet our societal needs, dedicated dredging must be elevated in priority ahead of diversions. Opportunities exist to consolidate near-term dredging projects associated with barrier shoreline restoration from offshore and riverine sources to built marshes, ridges, and submergence aquatic habitat in close proximately. Opportunities exist to move sediment from inland bays to protect levee systems and low-lying communities. Small dredge demonstration and the USACE beneficial use programs have confirmed dedicated dredging is practical and cost-effective. We should not get bogged down in the debate about dredge holes and the perceived problems with them. We must move forward with the use of sediment from a variety of sources using common sense. Only by gaining inland dredging experience can we develop the operational standards to further the implementation of our inland-dedicated dredging program. To turn the tide on coastal land loss we must concentrate on geomorphic land building first followed by ecological landscaping.

THE IMPORTANCE OF *RANGIA CUNEATA* CLAM RESTORATION TO THE HOLISTIC REHABILITATION OF THE LAKE PONTCHARTRAIN ESTUARY

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Lake Pontchartrain is a large, shallow, water-quality impaired estuary located north of New Orleans, Louisiana, USA. From 1933 to 1990, accumulated shells of *Rangia cuneata* were dredged from the bottom and used for the construction of roads, parking lots, levees, and the production of cement. Shell dredging decreased water clarity, large clam density, and sediment stability. Under favorable conditions, Rangia clams dominate the benthos and densities can be as high as 1896 clams/m^2 and dry weight biomass as high as 70 g/m^2. However, clams are absent in a 250 km^2 hypoxic area caused by salinity stratification from saltwater intrusion through a navigation canal, the Mississippi River Gulf Outlet, constructed in 1963. High salinity and hypoxic episodes, as a result of salinity stratification, at times reduce clam densities throughout the estuary. By reducing saltwater intrusion, this hypoxic area can be restored and the occurrence of lake-wide hypoxic events decreased. Increased clam density and distribution should increase total water filtration rates and shell production. Studies are in progress to determine the effects of increased water filtration from clam restoration on turbidity, phytoplankton composition and abundance, and water-borne pathogens. Increasing the density of clams in the lake should improve water clarity which will increase submersed aquatic vegetation and add shell to stabilize the mud bottom. These improvements should lessen effects of eutrophication, improve recreational water quality and greatly expand essential fish habitat.

ACUTE TOXICOLOGICAL STUDIES OF LEAD IN GRASS SHRIMP

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The Grass shrimp (*Palaemontes pugio*) are small crustacean species of the phylum Arthropoda. They are significant members of aquatic ecosystem food chain/food web they inhabit because of their predator/prey interactions. The goal of this research project is to determine the amount of Pb that would be accumulated by the tissues of the grass shrimp. The specific objectives of this research are to: 1. Investigate the morphological and behavioral deformities; 2. Determine the effective concentration (EC_{50}) and lethal concentration (LC_{50}) of Pb; and 3. Determine the amount of Pb that would be retained by the tissues. Salinity, temperature, and Pb in water were measured at the collection site and found to be 4 parts per thousand (ppt), 32^0C, and <0.05ppm, respectively. The subjects were acclimated for 72-96 h in three 10-gallon aquaria. Lead nitrate was used to prepare 0.5, 1, 3, 5, and 10 ppm concentrations. Acute toxicological tests were conducted in 3 replicates and 4 subjects for each treatment in filtered water collected from the local bayous including the banks of runoff canals. Subjects were exposed to known Pb concentrations for 3, 6, 9, 12, 24, 48, and 72h. EC_{50} tests indicated 20ppm Pb in test media was lethal beyond 24h exposure. Results indicated that ≥50% mortality of subjects (LC_{50}) after 48 and 72h exposure to 10 and 5 ppm Pb concentrations, respectively. Tissue analysis for Pb concentrations indicated maximum concentration (2129 and 1068 ppm) of Pb in 10 and 5 ppm treatments, respectively @ 48 hour exposure.

RESTORATION ECOLOGY OF SALT MARSH POPULATIONS AND COMMUNITIES: EXPERIMENTAL AND OBSERVATIONAL STUDIES AT THE SABINE NATIONAL WILDLIFE REFUGE IN THE CALCASIEU ESTUARY

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Salt marsh restoration is increasingly important in the Gulf Coast marshes of Louisiana because of coastal wetland loss, and recently, much wetland has been created using dredged sediment. To understand better the ecology of these dredge spoil wetlands, we have conducted a series of integrated studies on vegetation colonization, succession, productivity, reproduction and dispersal, interactions among plant and animal species, and genetic diversity of the dominant species at several sites of different ages created from dredged sediment. Together, these studies reveal a high degree of complexity of physical and biological interactions that comprise the restored and reference communities. Colonization of the mudflats by Spartina alterniflora and Salicornia bigelovii is relatively rapid, while for other species often dominant in Louisiana marshes (e.g., Distichlis spicata and S. patens) recruitment is much slower. Spartina alterniflora is the early dominant at all elevations in the sites, although it is more abundant at lower elevations. At high elevations, woody shrubs (Iva frutescens and Baccharis halimifolia) eventually become dominant. The development of genetic and genotypic diversity in the colonizing S. alterniflora population is rapid, although genotypic diversity declines probably due to clone-clone competition in later years. Genetic and genotypic studies also showed that S. alterniflora: a) suffers very high inbreeding depression and consequently virtually all viable seedling offspring are produced by outcrossing among genets, b) has rates of outcrossing that are positively correlated with genotypic diversity indicating the importance of having many genotypes in a restored marsh population, c) tends to have seedling recruitment, and thus effective maintenance of genetic diversity, when open space is available, which is generally early in site development or following large or patchy disturbance, d) exhibits an association between clone size and heterozygosity in the oldest marshes, further indicating the importance of outcrossing and genetic diversity in this species, e) has different clones that grow and reproduce at different rates and interact with site microtopography in a complex fashion, and f) clonal types produced significantly different effects in facilitative and competitive interactions with other plant species. Aboveground productivity of S. alterniflora was similar to that found in other studies in the region, but belowground productivity was lower in young created sites. As a function of this productivity and eventual decomposition, soil organic matter increased with site age, but the trajectory suggested that it will be several decades before organic matter will be equivalent to that in natural marshes. Population development of S. alterniflora in created saline marshes is dependent on seed sources for colonization, genotype and genotype x environment interactions on clonal growth and sexual reproduction, degree of outcrossing among clonal genotypes, the level of heterozygosity in the developing population, and reciprocal facilitative interactions with the fiddler crab Uca spp (see related poster). Community development is affected by species-specific dispersal and colonization rates, competition among dominant species, facilitation of some patchily distributed species by S. alterniflora, and species x environment interactions. Restoration studies should include assessments of population trajectories of community development.

MARSH ELEVATION CHANGE ALONG A NATURAL GEOLOGIC GRADIENT

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The change of marsh surface elevation along a natural gradient away from an unaltered distributary was measured in a St. Bernard marsh along Bayou LaLoutre. SET (Sediment Elevation Table) stations were placed along five zones with zone 1 located closest to the bayou and zone 5 located 5 km N/NE of the bayou. Vertical soil accretion was measured using feldspar markers at each station. Sampling began in spring 2003 and continues on a semi-annual basis. Zone 1 maintains a negative elevation throughout the study despite an increase in accretion rates. Zones 2-4 fluctuate from a positive to negative elevation change in Feb 03- Aug 03 then a negative to positive elevation change during the summer of 2004. Zone 5, which is located furthest from the bayou, maintains a positive increase in elevation and accretion throughout the entire study. The increase in marsh elevation for every zone during the summer of 2004 can be attributed to the landfall of Hurricane Ivan in September, when a 1 m storm surge deposited 16 mm of sediment on the marsh surface. It is apparent that as distance from the bayou increases so does marsh stabilization. The marsh closest to the bayou cannot maintain a positive elevation.

REDUCING THE EFFECTS OF DREDGED MATERIAL LEVEES ON COASTAL MARSH FUNCTION: SEDIMENT DEPOSITION AND NEKTON UTILIZATION

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Dredged material levees in coastal Louisiana are normally associated with pipeline canals or, more frequently, canals dredged through the wetlands to allow access to drilling locations for mineral extraction. The hydrologic impact on marshes behind the levee is of concern to coastal resource managers due to the potential impact on sediment transport and deposition, and the effect on estuarine organism access to valuable nursery habitat. This study examined the effects of gaps in dredged material levees, compared to continuous levees and natural channel banks, on these two aspects of marsh function. Field studies for sediment deposition were conducted biweekly for a year and nekton samples were collected in spring and fall. Variation in nekton density among study areas and landscape types was great in part due to the inherent sampling gear issues and in part because of differences in characteristics among areas. Nekton densities were generally greater in natural compared to leveed and gapped landscapes. Differences in landscape type did not explain patterns in sediment deposition. The gaps examined appear to be too restrictive of marsh flooding to provide efficient movement of floodwaters onto the marsh during moderate flooding events. The 'trapping' effect of the levees increases sediment deposition during extreme events. Gapping material levees may be an effective method of partially restoring upper marsh connection to nekton, but this method may work best in lower elevation marshes where nekton use is greater.

SUBSIDENCE IN A MANAGED MARSH: SHORT-TERM VS. LONG-TERM STUDIES

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In 1996, a short-term study was conducted in a Fourchon marsh east of Bayou Moreau, which compared elevation change in a semi-impounded marsh with that of a natural reference marsh. The site was reoccupied and re-sampled in 2003 to determine the long-term changes in both environments. SET (Sediment Elevation Table) stations were used in both studies to evaluate changes in marsh elevation. More detailed studies concluded in 1996 that the managed marsh impeded tidal flow and that short-term sedimentation rates were lower than the reference marsh. Newly acquired 2003 data shows that over a year both marshes are losing elevation with the reference marsh having a higher rate -6.11 mm/yr than the impounded marsh -0.06 mm/yr. It is evident in the two short-term studies that results are highly variable, the marsh elevation change was positive in 1996 and negative in 2003, which may due to number of external factors including seasonal changes and tropical storm landfalls. Over the six years when no measurements were taken both marshes had positive elevation changes, the impoundment at a rate of 4.03 mm/yr and the reference marsh at 2.13 mm/yr. The long-term study shows an overall pattern of positive change for both marshes with the impoundment having twice as much increase in elevation. In order to fully understand the processes which control sedimentation and subsidence in coastal marshes, longer studies are needed to distinguish the true trend.

NUTRIENT DYNAMICS RELATED TO RIVER DIVERSIONS: PELAGIC AND BENTHIC FLUXES AND PHYTOPLANKTON COMMUNITY RESPONSE

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Nutrient rich Mississippi water is discharged into the Breton Sound at the Caernarvon diversion (south of New Orleans) in a pulsed pattern from winter to late spring. The function of wetland soils as nutrient sinks in response to the input of the eutrophic river water was monitored through several seasons. Nutrient fluxes and denitrification rates were measured in incubated non-vegetated sediment cores from areas located in increasing distance from the diversion structure. The observed strong seasonal and spatial variability was related to ambient nutrients levels, temperature, carbon supply, and benthic organism distribution. Pelagic nutrient fluxes were assessed during spring diversion events. Over a two-year period the pelagic nutrient conversion exceeded or at least equaled benthic uptake. Parallel to the nutrient flux studies phytoplankton community composition was monitored using a WALZ phytoplankton analyzer. Seasonal grid surveys covering the entire investigation area were linked to nutrient enrichment studies during spring and summer seasons. While the phytoplankton was light limited in the vicinity of the diversion structure, the downstream areas showed increasing nitrate and decreasing light limitation. In summer cyanobacteria and green algae benefited most from added nitrate with biomass gains ranging from 300 to 700 % within 5 days.

HIGH QUALITY SAND FROM THE PASS-A-LOUTRE DISTRIBUTARY MOUTH BAR: A POSSIBLE SAND SOURCE FOR BARRIER ISLAND RESTORATION

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Two strategically located cores tested the sand availability and sand quality of the distributary mouth bar associated with Pass-a-Loutre's northern branch (North Pass), Mississippi River delta. A sand body approximately 8m thick was encountered in the 30 m long core, LSU-1, which was acquired in the mouth of North Pass. Sand quality within this interval fell within the size range common to the sand that comprises Louisiana's barrier islands (fine sand range; 0.136-0.229 mm). This sand body occurs -12.5 m below the seabed, a depth well within suction dredging capability.

It was possible to test the lateral continuity of the North Pass distributary mouth bar with only one core, LSU-2. This core was located 3 km laterally from the distributary. Little sand was found in this core. The distributary mouth bar sand associated with North Pass disappears laterally in less than 3 km. It is anticipated that the sand body found in LSU-1 follows the distributary. Assuming a distributary mouth bar sand body of 8 m thick and 2 km wide that extends 1 km seaward from the mouth of North Pass, a total of 16 x 10^6 m^3 of sand would be available for restoration purposes.

A second sand resource, the thin transgressive sand sheet that is migrating over the Pass-a-Loutré distributaries, offers another possible sand resource. It represents the reworking of the distributary mouth bar and channel sands by wave-related processes in response to the steady decrease in discharge down Pass-a-Loutré over the last three decades, a product of engineering practices at Head-of-Passes by the U.S. Army Corps of Engineers. This transgressive sand body is thin, 2-3 m thick, but represents a sizeable volume of sand. Assuming the sand body to be 2 m thick, 30 m wide, and 10 km long, about 6 x 10^5 m^3 of sand would be available for restoration projects.

PLANT RECRUITMENT IN A RESTORED MARSH

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A massive die-off of *Spartina alterniflora* occurred in salt marshes of southern Louisiana in the year 2000. Restoration of these marshes is important to preserve valuable fisheries habitat and to ameliorate the effects of storms on Louisiana's coastal communities. One technique employed to restore marshes denuded by the die-off involves the addition of sediment slurries. Although marsh creation with dredged material has been used for many years, the use of hydraulically dredged sediment slurries to restore degrading marshes in rapidly subsiding environments has received little attention. We examined how the five following treatment-levels, which were created by the addition of sediment slurries, affected initial plant recruitment: high (28-36 cm above ambient marsh), medium (20-25 cm), and low (13-18 cm) elevations, vegetated (areas that were vegetated at the start of the study) and pop-ups (sections of the former substrate sitting on top of the sediment slurry). We compared vegetation and soil physico-chemical properties within these treatment areas with two reference denuded marshes and two reference healthy marshes, which did not receive slurry amendments. Two years following slurry application, the low elevation areas had a vegetative cover of 85% and were most similar to the healthy reference marshes (98%) and significantly higher than the reference denuded marshes (14%). Medium and high elevation sites had a vegetative cover (28% and 11%, respectively) considerably lower than the healthy reference marshes. Thus, creating areas of low elevation with sediment slurries is a viable way to restore denuded marshes in south Louisiana.

COASTWIDE REFERENCE MONITORING SYSTEM (CRMS) UPDATE

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The Louisiana Department of Natural Resources, Coastal Restoration Division, has initiated the Coastwide Reference Monitoring System (CRMS) to monitor coastal Louisiana for restoration project effects and hydrologic basin trends over the next several decades. The 611 CRMS sites are randomly distributed across the coastal zone over an array of marsh types. At each of the monitoring sites, water level, surface and porewater salinity, sediment elevation and accretion, soils, and emergent vegetation characteristics will be monitored. Information on CRMS site locations, monitoring frequency, site construction and data collection progress, future data availability, and public access will be provided.

WATERSHED LEVEL DYNAMIC SUBSIDENCE MODELLING IN SOUTHERN LOUISIANA

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Breton Sound is located on the southeastern side of the progradational delta lobe of the Mississippi River. It formed by subsidence subsequent to the abandonment of the St. Bernard delta complex 4000 ybp. Since 1956 approximately 3,400 acres of marsh in Breton Sound have been lost naturally, as part of the delta cycle. However, this process has been accelerated by oil and gas activities, saltwater intrusion and sediment and nutrient starvation from reduced freshwater inflow. The Caenarvon freshwater river diversion became a operational in 1991 to pump up to 8000 cfs of Mississippi River water into the headlands of the Breton Sound estuary with the goal of mitigating this wetland loss. The project seeks to accomplish this by controlling salinity and supplementing nutrients and sediments from the Mississippi River. The bays are important to oyster production and as breeding areas for shrimp and food fishes, while the marsh areas produce food for a number of animals including alligators, and a large amount of migratory waterfowl. In addition, the area acts as a sink for the excessive amounts of nutrients in the Mississippi River, helping to reduce the annual hypoxic zone off the coast of Louisiana. In 2002 the Louisiana Department of Natural Resources added levees and other water control structures to better utilize flow of water from the diversion. 6 Sonde discrete water sampling monitors were placed in important hydrologic locations throughout the area to further understanding about the effects of the control structures on water flow through the system. Water levels were measured once each hour for a period of three years starting in 2001, providing data both before and after structure installation. Analysis of the data demonstrates the effectiveness of the structures' ability to deliver water to places that were previously hydrologically isolated. The dataset itself provides a very high temporal resolution for an extended period of time. This yields more complete information about velocity and amplitude of a pulse of water's movement through the system than was previously available. Understanding the residence time of the pulse will allow more efficient and effective management of the diversion.

DEVELOPMENT OF IMPROVED SEA OATS POPULATIONS FOR COASTAL RESTORATION

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Coastal erosion is a major threat to the Louisiana economy and environment. Development of superior and adaptive plant materials in native plant species is important to accelerate the coastal restoration efforts. Our focus is to develop sea oats *(Uniola paniculata)* populations with improved adaptation, tillering, spread, and seed production to enhance success of vegetation in dune environments. Eighty-nine sea oats accessions have been collected from eight south east Atlantic and Gulf coast states. These accessions are currently being evaluated in replicated trials at two locations: Holly beach (Louisiana) and Gulf Port (Mississippi). Based on field data taken so far, it is apparent that some accessions consistently perform better than others in both locations. A preliminary DNA fingerprinting study involving 19 representative sea oats accessions indicated three major groupings of genetically related accessions in relation to geographic origin. There were significant variations at all three levels (among states, among accessions within states and within individual plants). The highest significant variation was observed among the states suggesting influence of geographic distance on genetic variation. After we gather more performance data on sea oats accessions, it will be combined with molecular data to identify suitable accessions for maintenance of adequate genetic diversity in the coastal vegetation in Louisiana and adjoining states.

AGRONOMIC AND SALT TOLERANCE EVALUATION OF 48 CALIFORNIA BULRUSH (*SCHOENOPLECTUS CALIFORNICUS*) ACCESSIONS

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Forty-eight NRCS California bulrush (*Schoenoplectus californicus*) accessions collected from various growing regions in Louisiana that experienced high salinity were evaluated for their agronomic performance and their salt tolerance. Salt tolerance evaluation was carried out in the greenhouse in 2002 and 2003 using a randomized complete block design with 3 replications. Each entry was grown under flooded conditions and continuously exposed to four salt concentrations of 0, 6, 12, and 18 parts per thousand (ppt) for 9 months. To simulate ocean conditions, salinity was created using "Instant Ocean Synthetic Salt Mix" (Premium Aquatics, Inc.). There was a significant difference in salt tolerant levels among the accessions. Among 48 entries tested, eight accessions appear to possess higher salt tolerance. At a salt concentration of 18 ppt, most entries could not survive while the eight tolerant lines continued to produce small shoots at slow rates. These lines are being increased in the field and will be used as parental lines to develop greater salt tolerant lines through conventional breeding methods. Agronomic evaluation to determine their productivities is being conducted in the field under both freshwater and controlled salt environments. Results will be discussed.

TISSUE CULTURE AND CELLULAR SELECTION TO DEVELOP SALT TOLERANT CALIFORNIA BULRUSH FOR USE IN SALTMARSH EROSION CONTROL AND WETLAND RESTORATION

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California bulrush (*Schoenoplectus californicus*) is a perennial, deep water, grass-like plant species native to marshes, swamps, seeps, washes, and floodplains. It has an extensive network of rhizomes that form dense colonies of 15 to 20 feet in diameter in a single year from the growth of its adventitious shoots. It is a freshwater marsh plant that can only tolerate salt concentrations of up to 6 parts per thousand. Greater salt tolerance in California bulrush will increase its role in erosion control and saltmarshes restoration. A tissue culture protocol has been established to facilitate cellular selection to develop improved salt tolerant California bulrush. Calli were induced from immature flowers of approximately 1 inch in length using Murashige & Skoog (MS) medium supplemented with 4 parts per million (ppm) of 2,4-D. Plant regeneration was obtained by plating the calli on N6 basal medium containing plant growth regulators 0.5 ppm NAA and 2 ppm BAP. Cellular selection was conducted by exposing calli to a toxic salt concentration for 8 weeks. The surviving calli were rescued and placed on regeneration medium. A total of 34 plants have been recovered and currently are being grown in the greenhouse for further evaluation.

INVASIVE *PHRAGMITES AUSTRALIS* FROM THE MISSISSIPPI RIVER DELTA – CLONAL MORPHOLOGICAL DIFFERENCES AND A NEW EXPANDING GENOTYPE.

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In the active delta of the Mississippi River, *Phragmites australis* occurs in large contiguous stands of predominantly two clonal genotypes which have been named 'patchy' and 'background' because of their landscape growth patterns. Additionally, there are clones of far less common types - including several recombinants as well as an expanding type. This study investigates morphological variability among and within the two predominant genotypes and two recombinant types. Eight morphological variables were measured on culms from eight clonal populations within three subdeltas - six populations were from the two dominant genotypes, whereas two populations were of two recombinant genotypes. All eight populations were genetically assessed from previous isozymic analysis. There was significant variability in culm, leaf and panicle morphology between the two predominant genotypes. Morphological differences also were found within genotypes among three subdeltas and demonstrate phenotypic plasticity within these populations. Morphological variability across subdeltas is likely the result of one of several factors, including water depth, substrate quality and/or growth strategies. In addition to this morphological study, documentation is made that an expanding type is increasing in coverage from two known sites to more than 10 sites over less than 10 years. The results have both ecological and management consequences.

ESTABLISHMENT OF VEGETATIVE PLANTINGS AS A RESTORATION MEASURE ON MARSH TERRACES

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Wetland deterioration is a significant environmental problem in coastal Louisiana. Wetland loss is attributed to a variety of biotic and abiotic factors such as subsidence, sea level rise, hydrologic modification, and herbivory that operate on various temporal and spatial scales. A sound approach for reducing wetland loss and restoring deteriorated wetlands is the addition or retention of sediment to increase marsh elevations to a level that will support wetland plants (Mendelssohn and McKee 1988, DeLaune et al. 1990, Wilsey et al. 1992). Although the use of dredge material (beneficial-use sediments) appears promising in this regard, there are a number of major limitations that will continue to restrict their wholesale and large-scale use across Louisiana's deteriorating coast.

Terracing is a relatively new restoration technique being used in shallow water marshes that offers an alternative application to beneficial-use dredging. Although terraces have proven to be a cost-effective technique with the potential of preserving and restoring significant portions of Louisiana's coastal marshes, little published information is available on the success or failure of vegetative plantings in conjunction with terracing restoration.

The Establishment of Vegetative Plantings as a Restoration Measure on Marsh Terraces study will provide, when completed, a more comprehensive understanding of the hydrologic-soil-plant responses that are essential before terracing restoration can approach the scientific standards required for acceptance of expensive, large-scale wetland restoration projects. Successful terrace systems implemented in deteriorating marshes can play a major role in this process, yet information that will maximize the likelihood for success is lacking. This research will add to the knowledge base, will advance coastal restoration technology, and will develop mechanisms that will provide coastal wetland project planners, designers, and builders with additional management strategies that will better incorporate vegetative diversity and productivity into terrace engineering.

SUBAQUEOUS PLATFORM DEFLATION IN SOUTHEAST LOUISIANA SALTMARSHES AND IMPLICATIONS FOR WETLAND RESTORATION PROJECTS

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Louisiana land loss continues at an alarming rate as marshland transitions to open water, and freshwater diversions and marsh restoration projects have been implemented or are planned to address this loss. This study examines the magnitude and impact of wave-induced subaqueous platform erosion that occurs during and following subsidence of the subaerial marsh, and will make comparisons of areas impacted by freshwater diversion projects from areas relatively unimpacted. For the project, study and control sites have been chosen in Breton Sound, where the Caernarvon freshwater diversion structure has been operational since 1991; Barataria Bay, where the Davis Pond diversion has been active since 2003; and the Deltas National Wildlife Refuge (DNWR), where marshes are still receiving significant freshwater and sediment from the Mississippi River. Study grids are established along marsh fringes in bay-fronting, gulf-fronting, and interior ponds that have a variety of orientations and open water fetch to predominant wave attack and in recent years (since the 1930s) have shown significant wetland loss. Subaqueous platform elevation and stratigraphy are examined with vibracores and transit elevation transects and detailed bathymetric maps of the 1 km grids are also made with an Odom Hydrotrak HT100 fathometer. Preliminary results suggest marsh erosion and subsidence induced deflation is variable, so there is no single concave "profile of equilibrium" that develops along the shallow subaqueous platform. These differences are likely attributable to the antecedent geology that create differences in strength and water content of marsh substrata, shoreline orientation to wave attack, or the presence of submerged aquatic vegetation (SAV) that serves to stabilize the substrata. Predominant in many sites, once the aerial marsh has submerged, a portion of the peat deposits is preserved below more recent onlapping bay bottom sediments.