Scope of Services
Marsh Dieback Emergency Response – Task II.4
February, 2001

Integrative approach to understanding the causes of salt marsh dieback: temporal tracking of plant and soil characteristics in established sites.

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Objectives

The objectives of this study are to characterize vegetation, soils, and physical parameters in dieback and healthy marshes and to quantify changes over time in those sites.

Background

Dieback of *S. alterniflora* in Louisiana marshes was first documented in 1968 (Smith 1970), and since that time it has been noted that relatively small areas of *S. alterniflora* or *S. patens* marsh dieback are common within the Louisiana coastal zone (Mendelssohn and McKee 1988, Webb et al. 1995). The current situation, however, is occurring on a much larger scale, leading to concern that accelerated wetland conversion to open water may result. During a season when salt marshes, dominated by the perennial grass *Spartina alterniflora,* are typically healthy and support rapidly growing plants, resource managers and biologists documented an unprecedented extent of stressed, dying, and dead vegetation. Extensive brown patches of *Spartina alterniflora* were first observed in the coastal marshes of southeastern Louisiana by G. Linscombe during an aerial survey in May 2000 south of Blue Hammock Bayou and east of Fourleague Bay. On June 7, 2000, we conducted a quantitative fixed-winged survey to document the spatial extent and severity of the affected area in southeast Louisiana, and we established a study site on the ground near the south end of Bay Junop. We noted similar areas of brown *S. alterniflora* marsh in southwestern Louisiana in August 2000, along with stressed areas of *Spartina patens* throughout the coastal brackish marshes. By the fall of 2000, it appeared that the phenomenon had continued to expand in range throughout the growing season. Other saltmarsh species, including *Distichlis spicata*, *Avicennia germinans*, and *Batis maritima*, did not appear to be affected to the same extent as the *Spartina* species and continued to grow in dieback areas.

While the cause of the widespread dieback has not yet been identified, it is believed that a number of interacting factors may be involved. These factors include environmental conditions associated with a 2-year drought in south Louisiana. Environmental conditions linked to drought include increased air, soil, and water temperatures, reduced freshwater input from rainfall and river flows, increased salinity, and changes in the concentration of potential phytotoxins such as hydrogen sulfide and various metals. The physicochemical factors influenced by the drought may act to exacerbate effects of potential biotic stressors, including pathogens (e.g., fungi, viruses), and herbivory. This proposal describes a one-year field study to identify the potential physicochemical causal factors for the dieback, and to characterize impacts to existing plant communities due to the phenomenon.

Changes in the distribution of plant species along environmental gradients, such as that associated with decreased salinity with increased distance from a source of salt water, are common in nature. *Spartina alterniflora*, as the dominant macrophyte in salt marshes along much of the Atlantic and Gulf of Mexico coasts of the United States, has been the focus of many studies describing environmental influences on its distribution and productivity (e.g., Mendelssohn et al. 1981, Howes et al. 1986, Pezeshki and DeLaune 1995). Hwang and Morris (1994) demonstrated that this species can adapt to 40 ppt salinity through structural (stomatal density) modifications. Plant growth rate and productivity, however, are generally lower at salinities above mean seawater strength (32-35 ppt) and under highly reduced soils conditions (Howes et al. 1981, Mendelssohn et al. 1981). Several studies have linked hydrogen sulfide, a phytotoxin, to reduced *S. alterniflora* productivity in anoxic soils (DeLaune et al. 1983, Pezeshki et al. 1988, Koch and Mendelssohn 1989, Koch et al. 1990). Webb et al. (1995) demonstrated that growth of *S. alterniflora* in a deteriorating marsh was increased by increased elevation at ambient salinities. They attributed the growth increase to reduced sulfide and greater nutrient concentrations; they concluded that salinity was not important to the plant dieback at their study site and that excessive submergence was the primary controlling factor. Hester et al. (1998) identified high lethal salinity levels for 25 clones of *S. alterniflora*, ranging from 83 to 115 ppt. A study by Naidoo et al. (1992) provided evidence for the detrimental effects of a water deficit on this species at a typically nonstressful salinity level. This field study will address biological and physicochemical changes in the *S. alterniflora* population and in the soils and waters of the stressed environment and compare these data to a nearby healthy site.

Rationale and Approach

We established one ground site (BM2) in June 2000 in the Bay Junop area, and an associated healthy reference site (BMGOOD) approximately 7 km away, in August 2000. Since August 2000 my field crew has been collecting ground data at those two sites approximately every 2 weeks through November 1, then monthly through February 2001. At the impacted site we identified 4 vegetation zones based on color and vegetation characteristics in June; the healthy reference site was considered a single zone. Zones of *Spartina alterniflora* at the impacted site included black standing culms, dark brown with some frayed leaves, light brown with many frayed leaves, and standing black culms with new green shoots. We set up several transects to measure boundaries of the zones and track them over time, and in each zone we randomly placed four square-meter quadrats. In each quadrat we count and record the number and height of live and dead stems. For dead stems we noted whether leaf material is present or absent and, if present, whether the dead leaves are intact or frayed. For live plants we counted and measured the leaves and classified each live plant as to color category (>90% green, 50 – 90 % green, or <50% green) and tagged each live stem. In or adjacent to each quadrat we collect interstitial water samples at depths of 0 cm (surface), 15 cm, and 30 cm below the sediment surface for porewater chemistry (salinity, conductivity, pH, Eh, sulfides, nutrients). Wells were established in each zone to measure water level, salinity, etc., during each site visit. A staff gauge was established to serve as a benchmark and elevations were surveyed in using a laser system and total station surveying equipment. Elevations on the site will be tied in to nearby water level gauges that have been in operation for several years to determine absolute elevations, and water level history for the site will then be backcasted.

At the Bay Junop dieback site, plant death continued throughout the summer of 2000. We found that the size of dieback patches increased dramatically over the course of only a few weeks, and grazing by shredder snails *(Littorina irrorata*) converted some dead areas with standing vegetation to bare, unvegetated mudflats over short time scales (one or 2 months). Many of the environmental stressors that may have caused salt marsh dieback are linked to moisture deficits in the marsh subsurface. The levels, and thus effects, of many of these stressors may also change over relatively short time periods. Thus, the optimum sampling regime must link with data collected frequently and early in the dieback process, and must be continued on a frequent basis throughout the study period. However, frequent field visits are expensive. We propose herein to continue to collect data at the Bay Junop sites on a monthly basis unless data indicate that changes are occurring more rapidly. If so, we will revert back to a bi-weekly data collection schedule until data indicate that the rate of change has once again slowed.

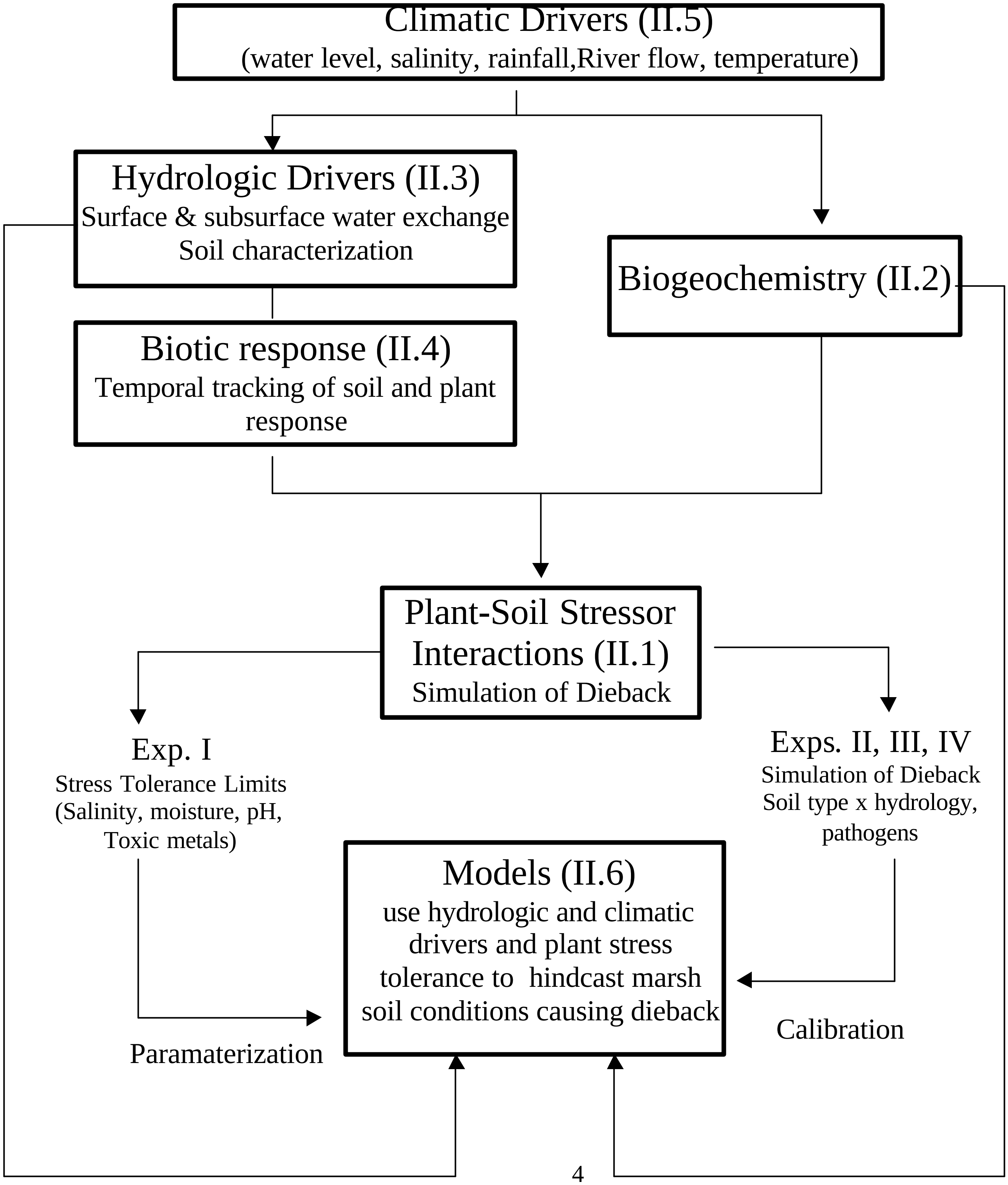
In addition to the current pair of stressed (Bay Junop, or BM2) and reference (Bayou du Large, or BMGOOD) sites in the western Terrebonne Basin, two additional pairs of stressed and reference sites will be established in the eastern Terrebonne Basin, probably Lake Pelto and Lake Barre, in association with collaborative studies (see below). If possible, vegetation plots will be set up at the Old Oyster Bayou site in western Terrebonne Basin to link with a long-term elevation dataset established there by Don Cahoon (see collaboration below). A total of seven sites (three pairs of stressed and reference sites, plus Old Oyster Bayou as a historical reference site) will be established.

Collaboration With Other Causation Tasks

The current proposed task (II.4: temporal tracking of plant and soil characteristics in established sites) is one of several collaborative tasks that will provide an integrative approach to understanding the causes of the Year 2000 marsh dieback. Each of the causation tasks and their linkages to each other are presented in Figure 1. An analysis of Climatic Drivers (Task II.5 – PI: E. Swenson, LSU) will determine the degree to which the larger scale environmental drivers of climate, riverine discharge, coastal water levels and salinities were anomalous in the time leading up to and during the 2000 marsh dieback. Also, Task II.5 will provide the historical climatic data for Task II.3, Hydrological Drivers (PI: C. Swarzenski, USGS). Task II.3 will determine if the relationship between marsh water exchange and soil character differs between interior dieback marshes and interior marshes that did not dieback, and will link with historical data from Old Oyster Bayou (Cahoon, USGS-NWRC), historical water level gauges, and newly-established sites in the Terrebonne Basin. At the same field sites, we will compare changes in hydrologic drivers identified in Task II.3 with the resulting biotic response via Task II.4. The importance of the climatic and hydrologic drivers in affecting soil biogeochemistry and generating potential plant stressors will be evaluated in Task II.2, Biogeochemistry (PI: R. Twilley, ULL). Task II.1, Plant-Soil Stressor Interactions (PI: I. Mendelssohn, LSU) will determine if the levels of plant stressors created in Task II.2, could have caused the mortality of *Spartina alterniflora* without affecting other salt marsh species that survived the brown marsh event. Task II.1 is closely coupled to Task II.2 by a common experiment. As shown in Figure 1, the above tasks will provide input into Task II.6, the development of Coupled Hydrological-Ecological Models (PI: R. Twilley, ULL), which is essential in integrating the data gathering tasks and in providing a synthesis and predictive capability for these findings. Tasks II.1 - II.5 were specifically designed to generate the data needed to successfully develop, paramaterize, and calibrate the models. The field portions of this group of tasks

(Tasks II.2, II.3, II.4) are also linked to Michot's special Task 3 (aerial surveys) in that all ground sites will be scored on the aerial surveys and will be used to ground-truth and interpret aerial classification of marsh dieback zones. An additional proposed study in Task II.1 (PI: R. Howard, USGS-NWRC), will use plants collected at the same study sites established by Michot in Task II.4 to experimentally test the effects of genetics, pathogens, metals, and various stressors.

Figure 1. Diagram showing relationships of collaborative tasks.



Methods

Vegetation Assessments.

Data collection will continue at the established stressed and reference sites and the new sites, as noted above. At the impacted site we will continue to sample quadrats in the 4 vegetation zones identified based on color and vegetation characteristics observed in June 2000. The healthy reference site is considered a single zone. Zones of *Spartina alterniflora* at the Bay Junop impacted site, in June 2000, included black standing culms, dark brown with some frayed leaves, light brown with many frayed leaves, and standing black culms with new green shoots; zone boundaries have degraded since June 2000. At new sites, zones will be established as appropriate early in the growing season of 2001. We will establish transects to measure boundaries of the zones and track them over time. In each zone we will randomly place four meter-squared plots. At the Bay Junop site we will continue to stem-tag all live plants in each $1m^2$ plot of the highly degraded zones, and in 1/16th m^2 of the plots in zones with many live plants. Plants will continue to be categorized as 1) > 90 % green (live), 2) 50 - 90% green, 3) < 50% green (stressed). The number of live and dead leaves on each tagged plant will be counted during each site visit. The height of each plant will be measured and the presence or absence of inflorescence will be noted. In 1/16th of each plot the density and height of dead stems will be recorded. Dead stems will be categorized as 1) dead and intact, 2) dead with frayed leaves or 3) culm with no leaves. The presence or absence of inflorescence on dead stems will be noted. In these same subsampled plots, the number of snails will be counted. At all sites, the number of dead and live plants in each plot will be counted, the height of the tallest dead stems in each subplot will be measured, and the average height of dead stems in each subplot will be visually estimated.

Physicochemical Assessments

At all sites, porewater samples will be collected from the center of each plot at the surface (if surface water is present) and at depths of 15 and 30 cm using a plastic siphon and syringe. Salinity, pH and water temperature will be measured on site. Pore water will be filtered through ashed GF/F filters (ashed at 480 C for 4 hrs) or disposable pre-ashed GF/F filters). A 5 ml aliquot of filtered pore water will be treated with dilute antioxidant buffer and analyzed within 24 h for sulphides with a Lazar Micro Ion Sulphide Sensing Electrode and digital pH meter. Filtered porewater samples will be placed on ice until returned to the lab and will then be frozen until assayed for NH_4, N+N, NO_2 and PO_4.

Sediment redox potential (Eh) measurements will be measured at 0, 15 and 30 cm with a platinum wire and standard calomel electrode standardized with quinhydron. Shallow water (50cm depth) PVC wells were established in each zone to measure water level and salinity at each existing study site and will be placed at the new stressed and reference study sites. A staff gauge will be established to serve as a benchmark and elevations will be surveyed in using a laser system and total station surveying equipment. Elevations on the site will be tied in to nearby water level gauges that have been in operation for several years to determine absolute elevations, and water level history for the site will then be hindcasted.

Quarterly reports will be generated in Adobe Acrobat version 4, data sets will be generated as Microsoft Excel 2000 files and metadata will be written for all data gathering activities**.** These products will be submitted quarterly to the BTNEP Office. A draft report and final data sets will be submitted within 45 days of completion of sampling. The Final Report and Executive Summary will be submitted within 45 days of submission of the draft report.

Importance of Results

Data collected and reports compiled can be used in connection with associated field studies of hydrology, soil chemistry, precipitation, evapotranspiration and soil permeability, as well as greenhouse studies of stressors examined in controlled experiments to determine impacts on the plant populations and to hindcast recent events which led to the current phenomenon.

References

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Project Schedule / Milestones

	Project Year Quarter				
	2-01	3-01	4-01	1-02	2-02
Vegetation Assessments	X	X	X	X	
Physicochemical Assessments	X	X	X	X	
Data Analyses	X	X	X	X	
Quarterly Report Preparation	X	X	X	X	
Data Set Preparation	X	X	X	X	
Draft Report Preparation				X	
Draft Report Submission					X
Draft Data Set Submission					X
Final report Submission					X

Project Personnel

Principal Investigator:
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Signed:

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Thomas C. Michot Date

Supplemental Information – Selection Criteria

Staff

Project personnel will be able to begin working as soon as funding is secured. The three contract employees listed under the NWRC budget request will be retained using the NWRC on-site support services contractor (currently Johnson Controls World Services).

Previous Commitment

Dr. Michot and NWRC have made a significant contribution of USGS staff time, funds, and supplies in early efforts to study the marsh dieback phenomenon. In collaboration with D. Cahoon and C. Swarzenski, Michot collected plant and physicochemical data from a stressed site (Bay Junop) and a nearby reference site (Bayou DuLarge) beginning in June 2000. At the Bay Junop site we identified five distinct zones based on color and physical appearance of the plants, ranging from green patches of living plants to brown and black patches of dead plants in various stages of degradation. Data were collected bi-weekly from August through October, then monthly through the present. For both live and dead *S. alterniflora* stems we recorded counts and heights; for the live plants we also recorded the number of live and dead leaves and stress categories. We measured salinity, sulfides, pH, NH_4, N+N, PO_4, and Eh in interstitial waters at 15 cm (root zone) and 30 cm (below the root zone) soil depths, and in the surface waters for each plot, as well as in the bayou adjacent to each site. This study documented that no recovery occurred in a zone that had complete mortality of aboveground tissues at the time of collection. Results of this study were presented at the 'Coastal Marsh Dieback Conference' in Baton Rouge, January 2001.